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Glasgow climate change conference (COP26) and its implications in sub-Sahara Africa economies

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ABSTRACT

Alternative energy has been hailed as a feasible resolution to the environmental degradation and energy problems that have plagued Sub-Saharan Africa (SSA) recently. The expansion of the clean energy sector, on the other hand, relies on economic growth, effective governance, and financial considerations. As a result, it is important to investigate the links between these variables in SSA. This study investigated the influence of economic growth, institutional quality, foreign direct investment (FDI), and financial development on renewable energy at the national threshold in SSA using a two-step difference GMM model based on panel data collected from 2002 to 2019. The outcome shows that economic growth and all three financial development indicators (FD1, FD2 and FD3) have a positive significant relationship with renewable energy. Furthermore, for SSA countries, FDI, as well as all six proxy factors for institutional quality, had a negative significant influence on renewable energy. Our empirical findings propose a variety of policies that might help the renewable energy sector grow.

1. Introduction

There is a lot of inequity in the globe when it comes to access to modern energy [1], and Sub-Saharan African (SSA) nations are at the top of the list. Almost all African economies in the Sub-Saharan area face a lack of consistent energy supply [2]. Yet, with the continuous mounting climate change concerns, African countries are expected to transition to a more friendly energy system. A low-carbon revolution is desperately needed in Sub-Saharan Africa to defeat energy poverty [3]. Glasgow Climate Change Conference (COP26) is a route that opened up such a debate. COP26 was a significant global event that advocates the urgent need to address climate change and its impact on economies, particularly in sub-Saharan Africa. This conference presented a unique opportunity for nations to come together and collaborate on solutions to combat the devastating effects of climate change. Making it an imperative agenda for SSA states. Nevertheless, the SSA nations' environmental initiatives have not yet produced significant results. The governments of the SSA must thus exert much greater effort to improve environmental efficiency.

SSA shares minimal obligation for the manifestation of man-made temperature variation than other regions of the world, yet it has been disproportionately affected [4]. This current misalignment of challenges, strategy framings, and remedies points to a series of unresolved ethical quandaries in how the energy transition is conceived at global power centres [5]. To fight the universal pollution crisis, each nation must choose a green energy source, such as renewable energy, to safeguard that economic progress is not sacrificed at the expense of the environment [6].

Also, the energy mix transition's reliance on public funding necessitates democratisation, which can be accomplished through public accountability. Citizens in contributing and recipient economies have a right and an obligation to know about and participate in how public

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money is used to address climate change, and this can be done via transparency and accountability. Therefore, considering how political and economic reflections impact green energy evolutions is critical to efficient strategy formation and supporting developments to justifiable energy structures. As it stands, clean energy advocates and social and environmental activists have rallied around a demand for energy democracy during the last decade [7]. Energy democracy, in particular, attempts to authorize low-income and minority societies [7].

In support of the above assertion, effective governance is required to implement environmental policies promoting renewable power while discouraging non-renewable energy sources. A capable and stable administration can create a corruption-free society and enforce a rigorous rule of law in the country which will be advantageous in establishing and implementing environmental policies in the society [8,9]. On the other hand, a weak and ineffective institutional framework may allow corporations to violate environmental quality norms and laws to maximize profit [10]. As a result, new research paradigms and discourses on energy consumption and climate justice are being established. Climate justice moves the focus from purely economic and market considerations to an ethical and political awareness of the importance of equity, civil rights, and environmental safety and stability [11,12]. While increased emissions are linked to population size, economic success, and reliance on foreign direct investment, it's also important to consider how governance influences CO_2 since nations' systems and their ability to reduce the environmental impacts through decision-making, and policies [13].

Changes in the energy system nowadays need far more than a technological upgrade [14]. According to Ref. [15]; the shift from fossil fuels to renewable sources is increasingly being acknowledged for its political as well as technological and economic dimensions. Political dynamics, on the other hand, have received less study. While renewable energy creates new potential for sustainable energy generation, it also creates new regulatory and governance difficulties since it involves so many parties [16]. Renewable energy's fast implementation has far-reaching geopolitical repercussions.

Another strand of clean energy research has focused on three primary fields of study: policy studies [17–19]; Destek & Sinha,2020; [20,21], social-economic [22], energy transitions [19–21]; and energy transition [23]. However [24], acknowledge that energy politics is underdeveloped and often overlooked in the literature. In recent years, a call for closer attention to the politics of socio-technical development has resulted in a modest but growing literature [25–28]. As [28] put it, "Politics is a constant companion of socio-technical transformations, serving as context, arena, barrier, enabler, arbiter, and manager of repercussions alternately (and frequently concurrently)." For such a powerful tool, we must understand its role in clean energy transition and, importantly, in emerging economies. Furthermore, institutional and governance elements such as the rule of law, government efficacy, corruption control, political stability, regulatory quality, and voice and accountability would be critical in assisting the energy sector streamlining goals [29].

Therefore, our study provides a threefold contribution to literature, especially since the advent of the next Cops 17 is almost due, and there is a need to reassess Cops 16. First, our work expressly shows the implications of the Glasgow Climate Change Conference (COP26) in Sub-Saharan African economies by focusing on its advocacy for renewable energy and sustainable development in promoting economic growth and resilience in the region. This approach provides insights into how the COP26 summit and its outcomes can support the transition to low-carbon and climate-resilient economies in Sub-Saharan Africa and the potential challenges and opportunities associated with this process. Second, our study also explores the implications of the COP26 summit on financing climate action in Sub-Saharan Africa.

This includes an analysis of the available funding mechanisms and instruments for climate-related investments and the potential barriers and constraints to accessing and leveraging these resources for sustainable development in the region. This approach provides valuable insights into the role of the COP26 summit in shaping the funding landscape for climate action in Sub-Saharan Africa and the potential implications for economic growth and resilience in the region. Finally, the study evaluates the political climate in SSA and reaccesses the role of green governance to provide an enabling environment to incentivize clean energy projects and lead the charge through policy augmentation and implementation. Also, the existing literature is lacking in determining whether or not political measures, in addition to traditional metrics, aid in reducing carbon emissions and improving environmental quality. Thus, by focusing on the role of renewable energy and sustainable development, as well as the financing of climate action, this research work could provide novel and relevant insights into the implications of the COP26 summit for Sub-Saharan African economies.

2. Literature review

On the subject of renewable energy, there is a considerable quantity of literature. Many studies looked into the most effective ways to increase the scope of the use of this energy source. Economic development, according to the conclusions of several of these studies, is important for the expansion of renewable energy sources. When it comes to making investment choices, the pace of economic growth is the most important factor that investors carefully consider [30]. A positive connection between these two coefficients is generally regarded as being true in the scientific literature. When a country experiences economic development, this attracts the interest of potential investors [31].

This situation is very comparable for investors in renewable energy projects. From a different point of view, renewable energy investors prefer to locate their operations in nations with high economic development rates [32]. [33] investigated the association between economic growth and renewable energy consumption in 15 of the world's most populous economies that consume renewable energy. They realized that there was a favourable link between the two of them. Furthermore [34] evaluated this connection in the context of current economies. Additionally, they pointed out that these countries came to a similar conclusion as well [35,36]. discovered that economic growth has a beneficial impact on the expansion of renewable energy investments.

In contrast [37], found a negative correlation between African countries' GDP growth and their use of renewable energy. According to Ref. [38]; there is a threshold impact between GDP growth and renewable energy use, with the former increasing the latter only when per capita GDP exceeds 5000 USD. Studies on the GDP-renewable energy generation nexus in the SSA bloc, however, are extremely rare, and the results are discordant regarding the GDP-renewable energy consumption nexus. For an economic bloc like the SSA with low per capita GDP and poorer economic progress, these inconsistencies are unpalatable in terms of renewable energy production and consumption with economic progress, necessitating fresh research with an updated dataset, which is why we chose this study.

Furthermore, the development of financial resources is another important measure of the progress of renewable energy infrastructure investments [39]. The biggest problem with renewable energy costs is that they require a lot of money at the start [40]. This circumstance provides a significant impediment to the improvement of these projects. As a result, sufficient funding should be made available to renewable energy investors to maximize the number of projects [41]. Renewable energy investors would choose to invest in a nation that has developed its financial infrastructure, owing to the ease with which it may obtain financing [42]. Using data from China [43], investigated the connection between financial development as well as renewable energy. The study demonstrated that financial changes had a beneficial impact on the number of initiatives being undertaken. Aside from that [44], concentrated on the linkage between carbon dioxide emissions, financial development, and the intake of renewable energy sources. They came to the same conclusion as well [45,46]. revealed that financial development helps to improve renewable energy resources greatly. In addition [47], found a positive impact of financial growth on clean energy consumption in 22 emerging economies, Khoshnevis [48] in China [49], across and Khan et al. (2020) in 192 nations.

[40] examined the effects of financial development on the use of renewable energy in 34 developing nations with upper-middle incomes between 1994 and 2015. The empirical findings showed that the use of renewable energy and financial growth have a long-term association. The need for renewable energy is also increased by financial development [50]. revealed that while financial development has a detrimental influence on renewable energy usage, economic expansion supports it in China. According to Ref. [46]; the use of renewable energy is influenced by both positive and negative changes in financial developmental activities. The short-term impact of changes in overall and stock-based financial development indicators on renewable energy usage in the USA is primarily negative. However, very scant studies focused on the financial development-renewable energy production nexus in any region, especially in the SSA bloc.

In addition, a comprehensive assessment of studies on the impact of political variables like democracy on environmental stewardship has been published. However, only a tiny corpus of research has been created on the institutional factors of renewable energy consumption. The impacts of fundamental institutional factors such as lobbying efforts, ideology, democracy, and corruption on renewable energy production and consumption have been the focus of all of the projects that may be evaluated in this group [51,52]. revealed that lobbying efforts had a detrimental influence on the deployment of renewable energy in European economies [53]. studied the conventional and institutional factors of renewable energy in ECO member countries from 1992 to 2012. Political stability, according to the study, has a positive influence on the use of renewable energy sources.

In contradiction to popular belief, corruption has been found to have a negative influence on the adoption of renewable energy [54]. investigated the political, economic, and ecological drivers of renewable energy in 26 EU economies between 2004 and 2011. Political aspects of renewable energy production and use have been highlighted as corruption, lobbying, and ideology. According to the conclusions of the analysis, lobbying and per capita income have a negative impact on renewable energy consumption, whereas corruption control and left-wing administrations have a positive impact [55]. investigated the relationship between democracy and renewable energy in more than 100 countries. In the investigation, all of the criteria of institution quality that were employed had a favourable influence on the intake of renewable energy. Similarly [56], examined the relationship between institutional quality and renewable energy in 38 nations between 1990 and 2015. According to the report's results, institutional quality has a long-term favourable impact on the usage of renewable energy. Despite having weak institutional quality in this region, it is surprising that no research has been done on the SSA bloc on the interaction between institutional quality and renewable energy production. We thus undertook this study to fill up this research gap.

3. Data and methods

3.1. Data and model

As a means of achieving the goal, data used covers the period 2002 to 2019 for 31 countries in sub-Saharan Africa including Angola; Burkina Faso; Cape Verde; Cameroon; Central African Republic; Democratic Republic of the Congo; Equatorial Guinea; Gabon; Guinea; Ghana; Ivory Coast; Kenya; Lesotho; Madagascar; Malawi; Mali; Mauritius; Mozambique; Namibia; Nigeria; Republic of the Congo; Rwanda; Sao Tome and Principe; Sierra Leone; Senegal; South Africa; Sudan; Tanzania; Togo; Uganda; and Zambia. Except for renewable energy which was obtained from the U.S energy information administration database, all of the data for this investigation was derived from the World Development Indicators (WDI, 2021). The choice of these coefficients is following the 2030 Sustainable Development Goals (SDGs). However, Table 1 below presents more details on the coefficients utilized for this estimation.

Several studies have examined the connection between energy generation and macroeconomic and institutional variables [57]. Consequently, the empirical model of this study can be ascertained as follows:

$$REN = f(RGDPPC, FD, FDI, INSTITUTION)$$

INSTITUTION variables are represented by ROL, GOV, COC, RQI, VOA, and POL.

$$LREN_{it} = \alpha_0 + \beta_1 RGDPPC_{it} + \beta_2 LFD_{it} + \beta_3 LFDI_{it} + \beta_4 ROL_{it} + \beta_5 GOV_{it} + \beta_6 COC_{it} + \beta_7 RQI_{it} + \beta_8 VOA_{it} + \beta_9 POL_{it} + \varepsilon_{it} \tag{1}$$

Where REG = renewable energy generation; RGDPPC is the real GDP per capita; FDI = foreign direct investment net inflow (Bop); Financial development (FD) is proxied by 3 indicators, namely (i) domestic credit to the private sector (% of GDP), i.e., FD1 (ii) domestic credit provided by the financial sector (% of GDP) (DCFS), i.e., FD2 and (iii) domestic credit provided to the private sector by banks (% of GDP) (DCPB), i.e., FD3. FD2 and FD3 are estimated to check for the robustness of study objectives. L represents the natural logarithm for the variables. $\beta_1 \ldots \beta_9$ represent the slope coefficients; α_0 is the intercept term.

3.2. Methodology

The generalized method of moments (GMM) approach was used in our investigation, which was based on a dynamic panel. Specifically, this approximation method was selected for this work because, according to Refs. [58,59]; and Blundell and Bond (1998), it is acceptable for panels with a limited predefined timeframe (T and N), and hence a large number of individual economies. That is, the number "N" is larger than the number "T." Furthermore, the GMM estimator is shown to be consistent in that it congregates in likelihood to beta as the sample size increases to an infinite number of samples in appropriate circumstances. The linearity connecting our coefficients, and the fact that our model contains only one dynamic coefficient that takes into account its previous comprehension, are all significant. Moreover, the explanatory coefficients are not rigidly exogenous; as a result, they are associated with the past and with the error term, as in the previous example. There

Table 1
Variable description.

Variable	Abbreviation	Source
Renewable power generation (billion kilowatt-hours)	REN	The U.S. Energy Information Administration
GDP per capita (2015 US$ constant)	RGDPPC	WDI
Domestic credit to the private sector (% of GDP)	FD1	WDI
Domestic credit provided by the financial sector (% of GDP)	FD2	WDI
Domestic credit to the private sector by banks (% of GDP)	FD3	WDI
Foreign direct investment, net inflows (BoP, current US$)	FDI	WDI
Rule of law index (−2.5 weak; 2.5 strong)	ROL	WDI
Government effectiveness index (−2.5 weak; 2.5 strong)	GOV	WDI
Control of corruption (−2.5 weak; 2.5 strong)	COC	WDI
Regulatory quality index (−2.5 weak; 2.5 strong)	RQI	WDI
Voice and accountability index (−2.5 weak; 2.5 strong)	VOA	WDI
Political stability index (−2.5 weak; 2.5 strong)	POL	WDI

are also stationary specific effects, heteroscedasticity, and autocorrelation concerning specific nations, but these consequences do not appear across nations or different classes of economies.

Our model and projections satisfy all of the criteria listed above, and as a result, they were suitable for evaluation. It enabled us to add more instruments while also improving the accuracy and robustness of our projected results. An excessive number of instruments in the framework can lead to the overfitting of endogenous constructs, which can lead to biases in the outcomes [60]. Even though the literature is still not able to identify which number is too many or too small, we made certain that suitable instrumental coefficients were chosen to avoid this abnormality. For this empirical problem, in particular, it is not recommended that you use the ordinary least squares (OLS) method to estimate it since the yi,t-1 has a link with the fixed effects in the error term and causes biases in the dynamic panel model.

For instance, if economic growth has a significant negative shock in 2010 due to factors that were not incorporated in our model, this will appear in the error term because it was not one of the regressors that we evaluated. It is also possible to eliminate this problem by employing the GMM estimation method, which prevents the development of this clear link between an endogenous variable and the error term. To tackle this issue, the endogeneity in the model was eliminated by changing the data, which resulted in the first difference modification, commonly known as the ", two-step difference GMM," which eliminated the fixed effects. It was decided to include the instrumental coefficients with the lag yi,t-1, which were not linked with the fixed effects, in the framework. The general equation for the GMM is as follows:

$$\mathrm{Yit} = \beta_i + \sum_{j=1}^{n} \beta_j \ \mathrm{Xjit} + \gamma \mathrm{j} \mathrm{Y}(\mathrm{it}-1) + \varepsilon \mathrm{it} \tag{2}$$

Where Y_{it} denotes the dependent coefficient (renewable energy). The subscripts "I" and "t" denotes panel data coefficients whiles "j" denotes the industrial fluctuations. The term $Y_{(it\text{-}1)}$ is the lag of the dependent coefficient.

4. Results and discussions

This section delves into the details of the findings. The part begins with a summary statistics analysis and a correlation coefficient analysis. Table 2 shows the fundamental measures of central tendency and dispersion for the variables under consideration, which we find interesting. Over the analyzed time, LFDI has the greatest average, followed by LRGDPPC, while LREN has the lowest average. The mean value of indicators of institutional quality ranged from −0.47 to −0.70. In terms of standard deviation, renewable energy generation is more volatile than the other indicators studied. While financial development is less volatile than FDI and GDP, the institutional quality indicators have the least volatility among the variables studied. Following that, as shown in Table 3, this study also seeks to look at the pairwise correlation between the research variables.

Table 2
Summary statistics.

Variable	Mean	Std. Dev.	Min	Max
LREN	−0.31	1.93	−4.61	2.82
LRGDPPC	7.14	1.04	5.62	9.93
LFD1	2.60	0.92	−0.71	5.08
LFD2	2.84	0.96	−1.56	4.79
LFD3	2.55	0.88	−0.80	4.67
LFDI	19.45	1.78	12.15	23.01
ROL	−0.64	0.63	−1.79	1.08
GOV	−0.70	0.59	−1.85	1.04
COC	−0.61	0.60	−1.77	0.94
RQI	−0.57	0.54	−1.68	1.13
VOA	−0.48	0.72	−1.98	0.97
POL	−0.47	0.91	−2.70	1.20

Between FDI and REN, there is a positive statistically significant ($p < 0.01$) relation observed. This implies that increased renewable energy generation is accompanied by increased foreign direct investment. COC, POL, and REN show a substantial negative trend. Except for GOV and RQI, clean energy generation shows a negative relationship with the majority of institutional quality indicators. It's worth noting, however, that certain explanatory factors have a substantial association, which is examined independently in our econometric definition. As a result, we were able to validate that our data is free of multicollinearity. However, since Pearson correlation analysis has been criticized, there is a need for further econometrics analysis, which will be addressed in the next part of this research.

This study's econometric estimation approach is based on dynamic panel data analysis techniques like the two-step difference GMM. We hypothesized that GMM with a two-step difference is a reliable approach, and standard error is consistent and fair. As a consequence, the study can be carried out using the GMM estimates. The findings of GMM estimations were solely presented in this study since GMM is an efficient and consistent estimator both practically and theoretically [61].

Results exhibit that the calculated coefficient of FD1 is ranged from 0.185 to 0.481% terms, which is positive and significant, showing that financial development positively influences clean energy generation in the SSA block (Table 4). In terms of renewable energy consumption, our findings are consistent with [40] for 34 developing nations [47], for 22 emerging economies [62], for EU member states and [63] for oil and non-oil SSA. The generation and consumption of clean energy in emerging and underdeveloped countries, like SSA countries, is heavily dependent on private sector investment alongside government initiatives.

The private sector's investment is featured by credit availability, suggesting that the more credit available to the private sector, the larger the investment in renewable power generation. The intensive usage of renewable energy resources and generation of electricity from these resources rely upon three main aspects, including the accessibility and saturation of resources, the development of technology to be used for each resource, and the market regulations that governments would administer for the handle of these resources [64]. One of the primary barriers to developing nations embracing renewable energy is the lack of technical competence required to establish the appropriate power systems [40], and SSA countries are no exception.

These nations have sufficient resources, such as wind, solar, hydropower, and other renewable energy sources, to use and produce clean energy; nevertheless, they require suitable financial facilities from the private sector to engage in renewable power generation. Governments can successfully encourage the use of renewable fuels if all of these challenges are solved. Thus, financial development has a significant impact on renewable energy generation in the SSA blocks.

Interestingly, in terms of the relationship between institutional quality indicators and renewable energy generation, institutional quality indicators have a negative and statistically significant effect on renewable energy generation, except for models for GOV, RQI, and VOA, which have insignificant negative effects on renewable energy generation. Most prior studies reported a favourable relationship between institutional quality and renewable energy usage [47,56,65]; nonetheless, our finding is intriguing and contentious to the previous research.

It is probable that funds for improving the diversification of the energy portfolio into renewable energy systems and technologies are not utilized correctly since the institutions in SSA are weak and ineffective. Furthermore, SSA nations are still in an institutional transformation phase. For example, following the revolution, corruption and bribery were visible and persistent in SSA blocks, which must be addressed well before the renewable energy transition. On the flip side, institutional quality, according to Ref. [66]; is critical for structural adjustment, since it diversifies energy consumption, promotes service-centric economic growth, and maintains environmental quality. Furthermore [67], ended

Table 3
Pairwise correlation.

	LREN	LRGDPPC	LFD1	LFD2	LFD3	LFDI	ROL	GOV	COC	RQI	VOA	POL
LREN	1											
LRGDPPC	−0.0749	1										
	0.135	–										
LFD1	−0.0111	0.3831[a]	1									
	0.825	0.0000	–									
LFD2	−0.0967	0.3134[a]	0.7421[a]	1								
	0.0615	0.0000	0.0000	–								
LFD3	−0.029	0.3684[a]	0.9894[a]	0.7402[a]	1							
	0.5636	0.0000	0.0000	0.0000	–							
LFDI	0.5393[a]	0.3156[a]	0.0841	0.0019	0.0554	1						
	0.0000	0.0000	0.0981	0.9714	0.2763	–						
ROL	−0.0769	0.2676[a]	0.6749[a]	0.5277[a]	0.6699[a]	−0.0811	1					
	0.1248	0.0000	0.0000	0.0000	0.0000	0.1108	–					
GOV	0.0557	0.3115[a]	0.7189[a]	0.5288[a]	0.6984[a]	0.0052	0.9087[a]	1				
	0.2664	0.0000	0.0000	0.0000	0.0000	0.9192	0.0000	–				
COC	−0.1982[a]	0.1647[a]	0.6583[a]	0.4953[a]	0.6519[a]	−0.1827[a]	0.8862[a]	0.8659[a]	1			
	0.0001	0.0009	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	–			
RQI	0.0768	0.2454[a]	0.7530[a]	0.5807[a]	0.7351[a]	0.0216	0.8841[a]	0.9170[a]	0.8030[a]	1		
	0.125	0.0000	0.0000	0.0000	0.0000	0.6708	0.0000	0.0000	0.0000	–		
VOA	−0.023	0.1408[a]	0.6698[a]	0.5643[a]	0.6596[a]	−0.0751	0.8659[a]	0.8192[a]	0.8135[a]	0.8102[a]	1	
	0.6464	0.0046	0.0000	0.0000	0.0000	0.1397	0.0000	0.0000	0.0000	0.0000	–	
POL	−0.2531[a]	0.3685[a]	0.4377[a]	0.3041[a]	0.4427[a]	−0.1422[a]	0.7472[a]	0.6151[a]	0.6645[a]	0.5802[a]	0.6560[a]	1
	0.0000	0.0000	0.0000	0.0000	0.0000	0.005	0.0000	0.0000	0.0000	0.0000	0.0000	–

[a] Represents a 1% level of significance.

Table 4
Estimation of dynamic panel data Financial Development (FD1) proxied by (i) domestic credit to the private sector (% of GDP) (DCPS).

Dependent variable: *LREN*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.LREN	0.396***	0.389***	0.409***	0.382***	0.405***	0.394***	0.369***	0.370***
	(0.114)	(0.108)	(0.118)	(0.114)	(0.109)	(0.116)	(0.105)	(0.118)
LRGDPPC	0.523	0.258	0.466	0.231	0.320	0.439	0.425	0.358
	(0.394)	(0.403)	(0.435)	(0.390)	(0.440)	(0.390)	(0.375)	(0.354)
LFD1	0.185**	0.481***	0.252	0.464***	0.369**	0.281**	0.269***	0.335
	(0.0899)	(0.186)	(0.169)	(0.165)	(0.159)	(0.141)	(0.0970)	(0.443)
LFDI	−0.0219	−0.0200	−0.0215	−0.0206	−0.0180	−0.0231	−0.0211	−0.0163
	(0.0220)	(0.0177)	(0.0218)	(0.0166)	(0.0206)	(0.0220)	(0.0206)	(0.0181)
LFD1 x ROL		0.298*						−0.0919
		(0.160)						(0.694)
ROL		−0.781*						0.527
		(0.436)						(1.865)
LFD1 x GOV			0.0809					−0.595
			(0.146)					(0.583)
GOV			−0.208					1.414
			(0.335)					(1.636)
LFD1 x COC				0.325**				0.654*
				(0.143)				(0.389)
COC				−0.765**				−1.606
				(0.339)				(1.058)
LFD1 x RQI					0.216*			0.692
					(0.113)			(0.771)
RQI					−0.541			−1.940
					(0.340)			(2.193)
LFD1 x VOA						0.104		−0.479
						(0.111)		(0.420)
VOA						−0.362		1.049
						(0.266)		(1.154)
LFD1 x POL							0.0949*	0.0725
							(0.0532)	(0.180)
POL							−0.336***	−0.189
							(0.118)	(0.473)
Observations	312	312	312	312	312	312	312	312

Corrected Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

by looking at the varied trends in institutional, economic, and environmental aspects of Haiti, concluding that the nation cannot sustain renewable energy deployment without upgrading its institution's quality.

On top of this, before the transition to sustainable and clean energy, SSA must make a paradigm change to better institutional governance. The linkage between institutional quality and financial development should be encouraged in such a way that strong governance opens up a new door for improved clean energy transition investment because this study reported that the interaction effect of financial development and institutional quality indicators on renewable energy generation is positive (Table 4).

The outcomes of the nexus between financial development, foreign direct investment, institutional quality, and renewable energy generation are then subjected to robustness assessments to ensure their accuracy. On top of that, we employ a variety of financial development proxy factors. We utilize domestic credit supplied by the financial sector (percentage of GDP), i.e. FD2, and domestic credit given to the private sector by banks (percentage of GDP), i.e. FD3 as the two proxy variables.

Tables 5 and 6 present the empirical findings of sensitivity analysis. For the aggregate sample of 31 nations, Table 5 shows that the coefficient sign of FDI, FD, ROL, GOV, COC, RQI, VOA, and POL is comparable to the main regression and some coefficients are somewhat significant. Furthermore, both the financial sector-based and bank-based financial development indexes have a positive significant influence on renewable energy generation, which is consistent with the regression results using domestic credit-based primary financial development in Table 4. From the above discussion, it is obvious that the findings for the two-step difference GMM are robust and appropriate for policy directions in the context of clean energy generation of 31 SSA countries.

This study uses a panel pos-estimation diagnostic test to ensure that the results are legitimate. The calculated statistics for AR (1) showed a significant sign at the 5% and 10% level in models 1, 2, and 3, however those for AR (2) were not significant at any level of significance, indicating that second-order autocorrelation did not affect the results (Table 7). The Sargan test estimated results were insignificant in all models (Tables 4–6), implying that the H_1 is not accepted while the H_0 of exogenous instrumental factors is accepted. This result indicated that the instrumental variable selection in the equations was appropriate. The results of the Hansen test are likewise supported by the Sargen test.

5. Conclusion and policy recommendations

Following the Paris Climate Change Conference (COP21) in 2015 and the Glasgow Climate Change Conference (COP26) in 2021, cleaner energy is seen as a critical aspect of minimizing environmental damage. Keeping this objective in mind, significant research exists on the drivers of renewable and fossil fuels energy use. However, no single research that adds institutional quality indicators, FDI, and financial development, as novel factors of renewable energy generation in SSA blocks exists to our knowledge. Therefore, the study's main aim is to look at the link between FDI, financial development, institutional quality, and renewable energy generation in 31 SSA economies. The impact of institutional quality and financial development on the link between FDI inflows and renewable energy generation is the subject of our research.

This study employed institutional quality and financial development as policy factors, which is aiming to imitate FDI to foster clean energy generation. In addition, as mentioned before, three proxied factors for financial development and six regarded indicators variables of institutional quality are included in our research. Data from 31 SSA nations from 2002 to 2014 was used to attain the objective of this study. This study employs a dynamic panel estimate approach such as a two-step difference GMM to cover the aforementioned research gap.

In SSA nations, our evidence-based study shows that the quality of institutions and financial development play a moderating role in creating cleaner energy. First, our research demonstrates a favourable association between renewable energy generation and financial development, even though most institutional quality measures have a negative impact on renewable energy output. On the contrary, our research revealed that economic growth and FDI had an insignificant influence on renewable electricity generation. Our research also shows that the interaction between FD and institutional quality measures enhances

Table 5
Estimation including financial development (FD2).

Dependent variable: *LREN*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.LREN	0.255***	0.225**	0.245***	0.217**	0.240***	0.255***	0.235***	0.231**
	(0.0930)	(0.105)	(0.0863)	(0.0956)	(0.0873)	(0.0980)	(0.0813)	(0.0943)
LRGDPPC	0.986***	0.616**	0.526*	0.730***	0.754***	0.870***	0.654**	0.602
	(0.258)	(0.288)	(0.277)	(0.278)	(0.265)	(0.270)	(0.264)	(0.437)
LFD2	0.0302	0.483	0.306	0.413	0.357**	0.119	0.108*	0.120
	(0.0443)	(0.334)	(0.189)	(0.341)	(0.181)	(0.157)	(0.0586)	(0.215)
LFDI	−0.0171	−0.0213	−0.0142	−0.0129	−0.0141	−0.0210	−0.0116	−0.00684
	(0.0179)	(0.0195)	(0.0187)	(0.0172)	(0.0162)	(0.0186)	(0.0147)	(0.0146)
LFD2 x ROL		0.433						−0.0218
		(0.301)						(0.460)
ROL		−1.176						0.0540
		(0.806)						(1.420)
LFD2 x GOV			0.324					−0.0395
			(0.220)					(0.359)
GOV			−1.036*					−0.0577
			(0.597)					(1.067)
LFD2 x COC				0.392				0.0445
				(0.289)				(0.207)
COC				−1.063				0.0419
				(0.859)				(0.673)
LFD2 x RQI					0.334*			0.241
					(0.177)			(0.383)
RQI					−0.859*			−0.686
					(0.457)			(1.261)
LFD2 x VOA						0.0899		−0.242
						(0.135)		(0.231)
VOA						−0.276		0.686
						(0.391)		(0.793)
LFD2 x POL							0.113*	0.0845
							(0.0676)	(0.141)
POL							−0.348*	−0.343
							(0.183)	(0.434)
Observations	288	288	288	288	288	288	288	288

Corrected Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 6
Estimation including financial development (FD3).

Dependent variable: *LREN*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.LREN	0.398***	0.392***	0.411***	0.382***	0.406***	0.394***	0.368***	0.366***
	(0.114)	(0.105)	(0.118)	(0.113)	(0.110)	(0.115)	(0.101)	(0.108)
LRGDPPC	0.535	0.307	0.483	0.251	0.351	0.476	0.434	0.395
	(0.396)	(0.444)	(0.446)	(0.419)	(0.463)	(0.400)	(0.399)	(0.350)
LFD3	0.173**	0.411**	0.232	0.429**	0.333**	0.241*	0.256***	0.297
	(0.0863)	(0.197)	(0.174)	(0.171)	(0.157)	(0.132)	(0.0986)	(0.313)
LFDI	−0.0216	−0.0201	−0.0206	−0.0202	−0.0175	−0.0223	−0.0212	−0.0150
	(0.0217)	(0.0183)	(0.0211)	(0.0159)	(0.0208)	(0.0218)	(0.0209)	(0.0188)
LFD3 x ROL		0.240						−0.0968
		(0.173)						(0.641)
ROL		−0.621						0.520
		(0.475)						(1.700)
LFD3 x GOV			0.0742					−0.609
			(0.150)					(0.615)
GOV			−0.189					1.435
			(0.331)					(1.730)
LFD3 x COC				0.301*				0.638
				(0.155)				(0.424)
COC				−0.684*				−1.536
				(0.365)				(1.149)
LFD3 x RQI					0.193*			0.662
					(0.113)			(0.582)
RQI					−0.476			−1.819
					(0.336)			(1.608)
LFD3 x VOA						0.0723		−0.472
						(0.106)		(0.390)
VOA						−0.290		1.028
						(0.259)		(1.086)
LFD3 x POL							0.0983*	0.0965
							(0.0511)	(0.182)
POL							−0.343***	−0.250
							(0.112)	(0.484)
Observations	312	312	312	312	312	312	312	312

Corrected Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

Table 7
Post-estimation diagnostic tests of two-step difference GMM model.

The model with Financial Development proxied by (i) domestic credit to the private sector (% of GDP) (DCPS)		
Tests	**Statistic**	**P value**
Hansen Test	$chi^2(20) = 27.11$	0.132
Sargan Test	$chi^2(20) = 281.41$	1.000
AR (1) Test	$z = -2.05$	0.041
AR (2) Test	$z = -1.10$	0.273
The model with Financial Development proxied by (ii) domestic credit provided by the financial sector (% of GDP) (DCFS)		
Tests	**Statistic**	**P value**
Hansen Test	$chi^2(20) = 26.89$	0.139
Sargan Test	$chi^2(20) = 282.24$	1.000
AR (1) Test	$z = -2.04$	0.041
AR (2) Test	$z = -1.15$	0.249
The model with Financial Development proxied by (iii) domestic credit provided to the private sector by banks (% of GDP) (DCPSB)		
Tests	**Statistic**	**P value**
Hansen Test	$chi^2(20) = 22.21$	0.329
Sargan Test	$chi^2(20) = 274.81$	1.000
AR (1) Test	$z = -1.68$	0.094
AR (2) Test	$z = -2.03$	0.243

clean power generation, which improves environmental quality, consequently, it may reduce the positive impacts of FD on CO_2 emissions.

The following policy implications can be prescribed based on the findings of this study. Renewable energy generation is an extensive investment-centric sector in SSA nations; as a result, the government should encourage FD to captivate purchasing environmentally benign and modern technology to establish renewable power plants. Financial development, according to the analysis, promotes the encouraging effects, implying that governments should emphasize finance's inhibitory influence, e.g., financial sectors could promote clean technology or offer loans to high-tech enterprises to boost energy efficiency. Companies can face the problem of funding giant green energy projects by implementing ISO 14001, a standard developed by the International Standards Organization.

Hence, local credit providers should set up green funds to finance energy transformation projects in SSA countries. Since the institutional quality indicators had a detrimental effect on clean electricity generation owing to weak governance in SSA blocks, institutional quality should offer proper laws, rules, and private property rights in energy creation. Furthermore, political peace and stability, democratic accountability, bureaucracy, and anti-corruption are all linked to the availability of renewable energy resources. Additionally, property rights protection might cause a spike in investment. In this context, strengthening governance and property rights, which in turn, shield investors from risk can boost renewable energy investment. Aside from revisiting institutional quality reforms, SSA countries must also work to increase administrative transparency, which can lead to a prosperous interaction influence of financial development and good governance on clean energy generation.

Although our study has an important contribution to energy research, particularly SDG 7 considering the institutional quality, financial development and FDI in mind, it suffers from various limitations which can be addressed in future research. The scope of our analysis is confined to a few indicators; however, other variables such as government R&D spending, fossil fuel subsidies, and the global innovation index might be employed in future studies. Future research should also look at other economic regions and the World Bank's income cluster to see what factors influence the production of renewable power.

CRediT authorship contribution statement

Festus Fatai Adedoyin: Writing, Validation, Visualization, Validation, Visualization. **Festus Victor Bekun:** Supervision, and Corresponding. **Md Emran Hossain:** Data curation, writing. **Elvis kwame ofori:** Conceptualization, Formal analysis, Methodology. **Bright Akwasi Gyamfi:** Writing – original draft. **Murat Ismet Haseki:** Writing – original draft, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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