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Research article

Energy justice, democracy and deforestation

Alex O. Acheampong [a,b], Eric Evans Osei Opoku [c,*]

[a] Bond Business School, Bond University, Gold Coast, Australia
[b] Centre for Data Analytics, Bond University, Gold Coast, Australia
[c] Nottingham University Business School China, University of Nottingham Ningbo China, China

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ABSTRACT

This paper contributes to the debate on the determinants of deforestation, a menace that is posing threat to sustainable development particularly in tropical developing regions. Specifically, the paper focuses on the effect of energy justice and democratization. The main contribution to the literature hinges on the emphasis on energy justice - operationalized as rural-urban equality in access to electricity and clean fuels and technologies for cooking - and its interaction with democracy. Using a panel data of 47 sub-Saharan African countries over the period 2000–2020 and the dynamic two-step generalized method of moment estimator, the results generally indicate that improvement in rural-urban equality in access to electricity and clean fuels and technologies for cooking is associated with a reduction in deforestation. Democracy is similarly found to be associated with reduction in deforestation. The conditional effect analysis largely depicts an intensified reducing effect of energy justice on deforestation in the presence of improved democratic practices. The results though robust to an alternative estimator, the Driscoll-Kraay estimator, differ when sub-regional analysis is considered. The paper aligns with the Sustainable Development Goals, particularly Goals 7, 13, 15 and 16.

1. Introduction

In transitioning to net-zero carbon emissions, deforestation remains an important factor of consideration. As a result, it has become part of the policy foci in achieving sustainable development. Global demand for goods and services is directly linked to the demand for natural resources, including forest resources (Ponce, Del Río-Rama, Álvarez-García and Oliveira, 2021a). Forests are resources of global importance, providing habitat for biodiversity. Globally, forest endowment provides habitat for 80%, 75%, and 68% of amphibian, bird, and mammal species, respectively. According to the Food and Agriculture Organization (FAO), tropical forests alone hold nearly 60% of the entire vascular plant species (FAO, 2022). The preservation of biodiversity is hence primarily reliant on the manner in which the forests are consumed and exploited globally. Although about 18% of total forest cover is officially dedicated as a protected area, biodiversity continues to be endangered by deforestation (FAO, 2022). The forest ecosystem also makes the earth habitable to humans, not discrediting its food and water provision, economic, entertainment, spiritual, health, and cultural benefits.

A major threat to the forests is deforestation, which is in part caused by the reliance on forest resources for energy (FAO, 2022; International Energy Agency [hereafter, IEA], 2022; IEA, International Renewable Energy Agency, United Nations Statistics Division, World Bank, & World Health Organisation [hereafter, WHO], 2022). The FAO estimates that about a third (approximately 2.6 billion) of the world's population depends on woodfuel and other biomass as sources of energy, mainly for cooking (FAO, 2022). Many people worldwide use woodfuel because they lack modern energy and because it is the cheapest form of energy (IEA, 2022; UN, 2021b). Dependence on wood as energy is highest in Africa, as about 63% of the population is estimated to use wood fuel, compared to 38% in Asia and Oceania and 15% in Latin America and the Caribbean. Considering the heavy reliance on forest wood for energy in Africa and other developing regions, energy justice remains key in protecting and conserving the forest.

Energy justice is rooted in environmental/climate justice ethos, which is the "recognition and remediation of the disproportionately high and adverse human health or environmental effects …" (Baker et al., 2019, p. 14). Individuals' vociferous rights about their energy and environmental demands and energy democracy of countries are underpinned within the broader governance, institutional and democratic framework of countries. Thus, to minimize deforestation and the reliance on traditional biomass as energy sources in developing countries,

* Corresponding author.
E-mail addresses: aacheamp@bond.edu.au (A.O. Acheampong), eric-evans-osei.opoku@nottingham.edu.cn, eekoopoku@gmail.com (E.E.O. Opoku).

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Table 1
Summary statistics and variable description.

Variable	Variable	Mean	Std. Dev.	Min	Max	Source
Deforestation	lnnfp	18.818	2.103	11.268	22.840	WDI
Rural-urban equality in access to clean fuels and technologies for cooking	Clean_dis	0.220	0.260	0.000	2.000	Authors
Rural-urban equality in access to electricity	Elec_dis	0.304	0.266	0.008	1.036	Authors
Electoral democracy	Polyarchy	0.434	0.193	0.067	0.840	V-DEM
Liberal democracy	Libdem	0.303	0.191	0.005	0.730	V-DEM
Participatory democracy	Partipdem	0.258	0.128	0.008	0.545	V-DEM
Deliberative democracy	Delibdem	0.328	0.190	0.019	0.789	V-DEM
Egalitarian democracy	Egaldem	0.294	0.155	0.045	0.698	V-DEM
GDP per capita	lnrgdpc	7.110	0.970	5.555	9.740	WDI
Trade openness	lntrade	4.111	0.577	−0.243	5.416	WDI
Foreign direct investment	lnfdi	0.880	1.348	−6.166	4.638	WDI
Urbanization	lnurb	14.772	1.516	10.619	18.516	WDI
Foreign aid	lnoda	19.738	1.378	12.794	23.208	WDI
Education	lnsse	3.628	0.588	1.780	4.695	WDI
Control of corruption	CC	−0.630	0.642	−1.849	1.420	WGI

countries' governance and institutional architecture feature prominently. Enrici and Hubacek (2016) assert that weak institutional capacity and governance render deforestation as "business as usual," and many efforts put in place to curb the menace would not be materialized. Buizer et al. (2014) note that there is a clear political relationship between forests and climate change. They emphasize that governance, which is a set of procedures that shape behavior and practices to solve shared challenges, is imperative in forest management and politics. Luttrell et al. (2014) highlight that forest reforms leading to conservation, sustainability, and reduced emission require strong political support as corrupt governance practices may impede the eradication of unsustainable forest practices (Sundström, 2016). Klopp (2012) argues that improved public oversight and regulation of the forest are connected to democratization.

Considering the environmental consequences of deforestation, a large body of literature has examined their determinants and mitigation measures. In the economics literature, three main strands of empirical emphases could be identified; i) Firstly, studies examining the impact of economic growth/income on deforestation (Ahmed et al., 2015; Ajanaku and Collins, 2021; Bhattarai and Hammig, 2001; Ewers, 2006). Many studies on economic growth have also analyzed the environmental Kuznets curve– the hypothesized inverted "U-shaped" relationship between economic growth and environmental degradation (deforestation). ii) Secondly, studies looking at the relationship between energy

Table 2
Unconditional effect of Energy Justice and Democracy on Deforestation (Dynamic system-GMM estimates).

Variables	1	2	3	4	5	6	7	8	9	10
L.lnnfp	0.923***	0.888***	0.912***	0.871***	0.885***	0.883***	0.902***	0.869***	0.893***	0.854***
	(0.019)	(0.014)	(0.016)	(0.015)	(0.021)	(0.015)	(0.017)	(0.016)	(0.019)	(0.011)
lnrgdpc	−0.007	0.064*	−0.018	0.081**	−0.030	0.071**	−0.002	0.074**	−0.029	0.010
	(0.034)	(0.034)	(0.025)	(0.032)	(0.028)	(0.029)	(0.025)	(0.030)	(0.029)	(0.027)
lntrade	0.035	0.037	0.043*	0.048	0.053	0.034	0.035	0.044	0.033	−0.040
	(0.031)	(0.025)	(0.026)	(0.032)	(0.033)	(0.026)	(0.022)	(0.029)	(0.034)	(0.024)
lnfdi	0.003	0.017***	−0.002	0.020***	−0.004	0.018***	−0.001	0.018***	0.001	0.028***
	(0.006)	(0.006)	(0.004)	(0.006)	(0.005)	(0.003)	(0.003)	(0.004)	(0.005)	(0.005)
lnurb	0.034*	0.071***	0.038***	0.083***	0.055***	0.078***	0.046***	0.090***	0.047***	0.077***
	(0.019)	(0.019)	(0.011)	(0.016)	(0.013)	(0.016)	(0.009)	(0.016)	(0.015)	(0.015)
lnoda	0.040*	0.074***	0.055***	0.090***	0.075***	0.081***	0.051***	0.087***	0.055***	0.050***
	(0.023)	(0.017)	(0.018)	(0.013)	(0.019)	(0.012)	(0.014)	(0.019)	(0.016)	(0.008)
lnsse	0.079*	0.257***	0.061*	0.322***	0.146***	0.259***	0.114***	0.294***	0.087**	0.338***
	(0.041)	(0.037)	(0.034)	(0.037)	(0.044)	(0.037)	(0.037)	(0.043)	(0.036)	(0.034)
Clean_dis	−0.388***		−0.364***		−0.458***		−0.448***		−0.397***	
	(0.122)		(0.073)		(0.111)		(0.104)		(0.103)	
Elec_dis		−0.732***		−0.787***		−0.757***		−0.780***		−0.662***
		(0.087)		(0.089)		(0.079)		(0.085)		(0.085)
Polyarchy	−0.398**	−0.404**								
	(0.155)	(0.178)								
Libdem			−0.204	−0.586***						
			(0.187)	(0.189)						
Partipdem					−0.870***	−0.606**				
					(0.258)	(0.263)				
Delibdem							−0.596***	−0.493**		
							(0.221)	(0.197)		
Egaldem									−0.500**	−1.028***
									(0.215)	(0.137)
Constant	0.094	−1.538***	−0.054	−2.098***	−0.268	−1.725***	−0.003	−1.955***	0.305	0.000
	(0.655)	(0.527)	(0.515)	(0.530)	(0.551)	(0.454)	(0.515)	(0.453)	(0.599)	(.)
Observations	298	250	298	250	298	250	298	250	298	250
Hansen	27.136	24.968	27.710	24.225	26.224	23.063	28.026	24.055	25.660	32.137
Hansen P-value	0.754	0.841	0.728	0.867	0.793	0.901	0.713	0.872	0.815	0.510
AR (1)	0.004	0.009	0.005	0.008	0.005	0.011	0.004	0.010	0.005	0.007
AR (2)	0.720	0.581	0.711	0.566	0.741	0.579	0.709	0.554	0.729	0.658
No of instruments	43	43	43	43	43	43	43	43	43	43

Standard errors in parentheses. Hansen-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for first and second-order autocorrelation in first differences. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 3
The moderating effect of Energy Justice and Democracy on Deforestation (Dynamic system-GMM estimates).

Variables	1	2	3	4	5	6	7	8	9	10
L.lnnfp	0.902***	0.841***	0.860***	0.814***	0.843***	0.815***	0.827***	0.804***	0.867***	0.826***
	(0.017)	(0.013)	(0.019)	(0.014)	(0.027)	(0.014)	(0.023)	(0.015)	(0.025)	(0.014)
lnrgdpc	0.078***	0.025	0.077	0.025	0.029	0.016	0.088**	0.018	0.086***	0.025
	(0.022)	(0.027)	(0.051)	(0.030)	(0.035)	(0.032)	(0.037)	(0.035)	(0.023)	(0.036)
lntrade	0.035	0.015	0.023	0.042	−0.035	−0.036	0.024	0.016	0.045	0.033
	(0.037)	(0.021)	(0.041)	(0.027)	(0.028)	(0.038)	(0.019)	(0.024)	(0.037)	(0.027)
lnfdi	−0.000	0.018	0.006	0.021***	−0.007	0.015**	−0.002	0.020***	0.000	0.017**
	(0.008)	(0.011)	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)
lnurb	0.057***	0.144***	0.090***	0.153***	0.128***	0.178***	0.136***	0.184***	0.078***	0.134***
	(0.021)	(0.016)	(0.024)	(0.021)	(0.027)	(0.019)	(0.018)	(0.010)	(0.023)	(0.017)
lnoda	0.048*	0.082***	0.044	0.105***	0.051***	0.082***	0.069***	0.098***	0.056***	0.096***
	(0.027)	(0.015)	(0.030)	(0.011)	(0.015)	(0.015)	(0.016)	(0.014)	(0.016)	(0.013)
lnsse	0.104**	0.304***	0.213***	0.376***	0.243***	0.334***	0.216***	0.395***	0.208***	0.329***
	(0.046)	(0.061)	(0.051)	(0.028)	(0.067)	(0.035)	(0.066)	(0.030)	(0.074)	(0.051)
Polyarchy	0.121	0.004								
	(0.210)	(0.307)								
Clean_dis	0.128		0.018		0.420**		0.483***		0.102	
	(0.316)		(0.209)		(0.207)		(0.123)		(0.273)	
Polyarchy × Clean_dis	−1.750***									
	(0.437)									
Elec_dis		0.422*		0.148		0.742***		0.382**		0.143
		(0.218)		(0.215)		(0.212)		(0.165)		(0.191)
Polyarchy × Elec_dis		−1.853***								
		(0.239)								
Libdem			−0.367	−0.257						
			(0.338)	(0.199)						
Libdem × Clean_dis			−2.121***							
			(0.640)							
Libdem × Elec_dis				−1.786***						
				(0.321)						
Partipdem					−0.359	0.244				
					(0.264)	(0.244)				
Partipdem × Clean_dis					−3.674***					
					(0.521)					
Partipdem × Elec_dis						−4.029***				
						(0.564)				
Delibdem							−0.055	−0.080		
							(0.271)	(0.211)		
Delibdem × Clean_dis							−3.129***			
							(0.278)			
Delibdem × Elec_dis								−2.235***		
								(0.268)		
Egaldem									−0.344	−0.326
									(0.251)	(0.300)
Egaldem × Clean_dis									−2.408***	
									(0.472)	
Egaldem × Elec_dis										−1.794***
										(0.276)
Total effects	**−0.631*** **	**−0.382*** **	**−0.625*** **	**−0.393*** **	**−0.528*** **	**−0.297*** **	**−0.543*** **	**−0.351*** **	**−0.606*** **	**−0.384*** **
	(0.139)	**(0.133)**	**(0.108)**	**(0.132)**	**(0.111)**	**(0.084)**	**(0.093)**	**(0.097)**	**(0.154)**	**(0.122)**
Constant	−0.817	−1.900***	−0.608	−2.304***	−0.555	−1.805***	−1.332**	−2.376***	−0.937**	−1.813***
	(0.542)	(0.381)	(1.306)	(0.292)	(0.397)	(0.414)	(0.653)	(0.276)	(0.469)	(0.428)
Observations	298	250	298	250	298	250	298	250	298	250
Hansen	27.945	24.247	27.333	23.967	28.017	23.917	28.005	24.767	27.169	24.050
Hansen P-value	0.672	0.835	0.702	0.846	0.668	0.847	0.669	0.815	0.710	0.843
AR (1)	0.005	0.010	0.004	0.010	0.004	0.009	0.003	0.009	0.004	0.010
AR (2)	0.727	0.835	0.793	0.637	0.722	0.701	0.793	0.589	0.803	0.665
No of instruments	43	43	43	43	43	43	43	43	43	43

Standard errors in parentheses. Hansen-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for first and second-order autocorrelation in first differences. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

consumption and deforestation (Bakehe and Hassan, 2022; Makame, 2007; Ponce et al., 2021a). iii) Thirdly, studies examining the effect of political, institutional, and governance architecture on deforestation (Bhattarai et al., 2009; Buitenzorgy and Mol, 2010; Cary and Bekun, 2021).

This study examines the effect of an aspect of energy justice (measured as rural-urban equality in access to electricity and clean fuels and technologies for cooking) and democracy on deforestation. The study specifically provides empirical answers to these questions: (i) Does energy justice escalate or address deforestation in sub-Saharan Africa (SSA)? (ii) Does democratization contribute to deforestation in SSA? (iii) Does democracy condition the impact of energy justice on deforestation in SSA? (iv) Does regional difference matter in analysing the effect of energy justice and democracy on deforestation in SSA? Our contribution to and differentiation from existing literature are as follows; firstly, this study focuses on rural-urban equality in access to electricity and clean fuels and technologies for cooking relative to the use of mainly general energy consumption that inundates the literature. The use of energy consumption does not demonstrate access, equality, justice, and the drive toward modern and clean energy. Access to electricity aligns with the Sustainable Development Goals (SDG) 7 of the United Nations, which seeks to "ensure access to affordable, reliable, sustainable and

Table 4
Robustness of the unconditional effect of Energy Justice and Democracy on Deforestation (Driscoll-Kraay estimates).

Variables	1	2	3	4	5	6	7	8	9	10
lnrgdpc	−0.785***	−0.654*	−0.706***	−0.580**	−0.811***	−0.594*	−0.691***	−0.591**	−0.747***	−0.706**
	(0.116)	(0.315)	(0.099)	(0.276)	(0.141)	(0.299)	(0.079)	(0.262)	(0.103)	(0.287)
lntrade	0.716***	0.728*	0.683***	0.748**	0.600***	0.546*	0.660***	0.710**	0.632***	0.716*
	(0.207)	(0.376)	(0.172)	(0.351)	(0.184)	(0.298)	(0.169)	(0.331)	(0.191)	(0.376)
lnfdi	−0.114***	−0.001	−0.126***	−0.013	−0.134***	−0.027	−0.133***	−0.020	−0.122***	−0.005
	(0.018)	(0.022)	(0.018)	(0.022)	(0.018)	(0.019)	(0.016)	(0.029)	(0.019)	(0.024)
lnurb	0.746***	0.865***	0.696***	0.817***	0.708***	0.794***	0.735***	0.875***	0.668***	0.803***
	(0.088)	(0.038)	(0.101)	(0.056)	(0.110)	(0.067)	(0.102)	(0.045)	(0.103)	(0.063)
lnoda	0.389***	0.434***	0.423***	0.490***	0.408***	0.461***	0.428***	0.468***	0.429***	0.472***
	(0.084)	(0.090)	(0.096)	(0.124)	(0.111)	(0.125)	(0.108)	(0.125)	(0.091)	(0.108)
lnsse	0.800***	1.163***	0.789***	1.175***	0.834**	1.200***	0.819***	1.206***	0.931***	1.335***
	(0.234)	(0.173)	(0.241)	(0.180)	(0.306)	(0.220)	(0.209)	(0.172)	(0.237)	(0.222)
Clean_dis	−1.090***		−1.187***		−1.122***		−1.062***		−1.051***	
	(0.191)		(0.219)		(0.160)		(0.233)		(0.227)	
Elec_dis		−1.025		−1.012		−1.408		−0.858		−0.657
		(0.922)		(0.925)		(0.850)		(0.870)		(0.855)
Polyarchy	−2.691***	−3.219***								
	(0.565)	(0.898)								
Libdem			−2.703***	−3.328***						
			(0.468)	(0.911)						
Partipdem					−4.139***	−4.886***				
					(1.212)	(1.570)				
Delibdem							−3.029***	−3.633***		
							(0.545)	(0.971)		
Egaldem									−3.857***	−4.755***
									(0.464)	(1.086)
Constant	1.290	−3.509*	0.631	−4.929*	1.960	−2.767	0.030	−5.068*	1.245	−3.592
	(1.092)	(1.856)	(1.298)	(2.379)	(1.217)	(1.764)	(1.453)	(2.569)	(1.152)	(2.100)
Observations	318	266	318	266	318	266	318	266	318	266
R2	0.841	0.832	0.839	0.830	0.842	0.835	0.849	0.841	0.851	0.847

Standard errors in parentheses.*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

modern energy for all." This study also makes a case for rural access to electricity. This is done for two main reasons; i) access to electricity and clean fuels and technologies for cooking deficits are most significant in rural areas. Globally, nearly 80% of the rural population has no access to electricity (International Energy Agency, 2022). Also, nearly 93% of the rural population lacks access to clean fuels and technologies for cooking (International Energy Agency, 2022). ii) relative to urban users, rural users spend less on energy, largely because of the abundance of wood at their exposure that can be almost "freely" harvested (UN, 2021b). iii) rural folks have low purchasing (affordability) power relative to urban dwellers. Rural folks, on average, tend to be poorer and more disadvantaged compared to urban folks and depend more deeply on their local environment to meet basic needs (Tanner and Johnston, 2017).

Secondly, relative to previous studies, this study employs the latest and most comprehensive proxies of democracy from the Varieties of Democracy (V-DEM) project. Previous studies have mainly used democracy proxies from the Polity Project and Freedom House (Cary and Bekun, 2021; Ehrhardt-Martinez, Crenshaw and Jenkins, 2002; Li and Reuveny, 2006). Nevertheless, these proxies have been criticized for being inadequate to broadly capture democracy. Specifically, they have been criticized on the basis of definition, precision, coverage and sources, coding, aggregation, and validity and reliability tests (Coppedge et al., 2011, 2019; Coppedge et al., 2016). These proxies also focus more on elections; however, democracy is more than simply elections (Coppedge et al., 2016). The V-Dem project presents indices based on extended indicators that are multidimensional, relevant to democracy (at a highly disaggregated level), and based on data collection processes that enhance precision, validity, transparency, and legitimacy (Coppedge et al., 2011, 2016, 2019). It captures wide-ranging concepts of what democracy is or ought to be (Coppedge et al., 2019). The V-Dem project ideally captures electoral, liberal, majoritarian, consensual, participatory, deliberative, and egalitarian democracy. Considering that the effect of democracy on deforestation has been inconclusive (Li and Reuveny, 2006; Midlarsky, 1998), it is in the right direction to employ these more comprehensive measures of democracy to ascertain the impact of democracy. This study is the first to use these democracy indices in the context of deforestation.

Thirdly, this study examines the moderation effect of energy justice (rural-urban equality in access to electricity and clean fuels and technologies for cooking) and democracy on deforestation. This is the first study to empirically examine this relationship. A just energy transition is stimulated by energy justice, which tackles matters of fairness and equity regarding the energy system, and incorporates features of energy democracy (Baker et al., 2019; Domegni and Azouma, 2022; Mang-Benza et al., 2023). Energy democracy champions the idea that communities/individuals should have a say and agency in shaping their energy demands and future (Baker et al., 2019). With enhanced energy democracy, access to sustainable and modern energy and electricity will be expanded to all to achieve universal coverage or to a large section of the population (Mang-Benza et al., 2023). Energy democracy is embedded in the overarching political democracy of a country. Hence, the more politically democratic a country is, the more energy democracy might be enhanced, and the more energy democratic a country is, access to electricity might be expansive.

Lastly, this study focuses on SSA, which provides an interesting setting for this study. The forest transition theory postulates that the rate of deforestation depends on the level of development. As in some developed countries, forest areas have increased in recent years, and in many developing countries, deforestation is worsening (Ponce et al., 2021a). SSA is an economically emerging market with a number of its countries growing as part of the fastest in the world. Many of the activities that enhance this growth, such as mining, construction, plantations, and lumbering, are parts of the activities contributing to deforestation. Deforestation is popular among low-income tropical countries due to the high level of poverty and population growth (Ajanaku and Collins, 2021; Culas, 2007). SSA is principally a tropical zone, and tropical deforestation is of great concern due to the importance of tropical forests in biodiversity conservation and the limiting of the greenhouse effect (Arroyo-Rodríguez et al., 2020; Culas, 2007; Rendón-Sandoval et al., 2020). Despite this, forests in SSA are depleting

Table 5
Robustness of the conditional effect of Energy Justice and Democracy on Deforestation (Driscoll-Kraay estimates).

Variables	1	2	3	4	5	6	7	8	9	10
lnrgdpc	−0.477***	−0.802***	−0.410***	−0.776***	−0.627***	−0.810***	−0.438***	−0.782***	−0.435***	−0.795***
	(0.058)	(0.279)	(0.062)	(0.252)	(0.056)	(0.273)	(0.071)	(0.241)	(0.053)	(0.233)
lntrade	0.515***	0.440**	0.528***	0.534***	0.374***	0.302**	0.475***	0.472***	0.539***	0.506***
	(0.117)	(0.162)	(0.103)	(0.167)	(0.078)	(0.119)	(0.115)	(0.160)	(0.117)	(0.168)
lnfdi	−0.110***	−0.000	−0.119***	0.005	−0.153***	−0.044**	−0.125***	−0.021	−0.124***	0.005
	(0.037)	(0.023)	(0.029)	(0.025)	(0.035)	(0.017)	(0.039)	(0.024)	(0.029)	(0.028)
lnurb	0.862***	1.009***	0.824***	0.976***	0.883***	0.992***	0.872***	1.022***	0.809***	0.969***
	(0.063)	(0.084)	(0.063)	(0.088)	(0.082)	(0.091)	(0.082)	(0.090)	(0.062)	(0.089)
lnoda	0.245**	0.303**	0.270**	0.350**	0.212*	0.267*	0.266*	0.317**	0.285***	0.318**
	(0.105)	(0.113)	(0.107)	(0.128)	(0.121)	(0.136)	(0.128)	(0.140)	(0.099)	(0.113)
lnsse	0.687***	0.972***	0.701***	1.004***	0.747***	0.992***	0.680***	1.000***	0.744***	0.992***
	(0.147)	(0.077)	(0.169)	(0.097)	(0.193)	(0.077)	(0.136)	(0.086)	(0.159)	(0.102)
Clean_dis	2.867***		1.581***		2.258***		2.004***		2.212***	
	(0.616)		(0.482)		(0.327)		(0.376)		(0.512)	
Polyarchy	0.287	0.840**								
	(0.186)	(0.294)								
Polyarchy × Clean_dis	−9.080***									
	(0.971)									
Elec_dis		4.984***		3.944***		4.041**		3.990***		4.777***
		(1.232)		(1.087)		(1.442)		(1.085)		(0.831)
Polyarchy × Elec_dis		−9.653***								
		(0.913)								
Libdem			0.251	0.880**						
			(0.147)	(0.343)						
Libdem × Clean_dis			−8.814***							
			(1.108)							
Libdem × Elec_dis				−9.817***						
				(1.080)						
Partipdem					0.975*	1.769***				
					(0.479)	(0.432)				
Partipdem × Clean_dis					−12.961***					
					(0.832)					
Partipdem × Elec_dis						−14.257***				
						(1.844)				
Delibdem							0.037	0.494**		
							(0.244)	(0.188)		
Delibdem × Clean_dis							−8.546***			
							(0.539)			
Delibdem × Elec_dis								−9.234***		
								(0.920)		
Egaldem									−0.198	0.522
									(0.188)	(0.340)
Egaldem × Clean_dis									−9.842***	
									(1.119)	
Egaldem × Elec_dis										−11.528***
										(0.801)
Total effects	**−4.761*****	**−3.124*****	**−4.853*****	**−3.223*****	**−4.805*****	**−3.729*****	**−4.739*****	**−3.296*****	**−4.657*****	**−3.269*****
	(0.334)	**(0.651)**	**(0.461)**	**(0.617)**	**(0.232)**	**(0.527)**	**(0.394)**	**(0.427)**	**(0.430)**	**(0.518)**
Constant	0.382	−2.029	−0.070	−3.065**	2.081	−0.462	−0.205	−2.666	−0.107	−2.019*
	(2.018)	(1.178)	(2.313)	(1.251)	(1.726)	(1.388)	(2.275)	(1.688)	(1.990)	(1.134)
Observations	318	266	318	266	318	266	318	266	318	266
R2	0.901	0.887	0.898	0.885	0.899	0.892	0.905	0.894	0.899	0.899

Standard errors in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

the fastest globally. The FAO's Forest Resource Assessment (FRA) indicates that Africa had the greatest net loss of forest area in the decade ending 2020 (FAO, 2020), while other regions, such as Europe and Asia, had a net gain. The SSA sub-region (Eastern, Southern, Western, and Central Africa) accounted for most of the forest losses in the African region. For example, between 2010 and 2015, the region lost about 15.6 million hectares of forest (International Institute for Environment and Development (IIED, 2022)). The limelight on SSA is also substantiated by the fact that it is the most energy-poor region in the world, and the greatest proportion of its population depends on forest resources such as firewood and charcoal as source of household energy (IEA, 2022; International Energy Agency, 2022; UN, 2021b). About 27% of the population in SSA rely on charcoal as cooking energy relative to a global average of 3% (International Energy Agency, 2022).

This study is relevant as it contributes greatly to the SDGs agenda, particularly Goal 15, which is about "life on earth" and seeks to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss." It is also in line with many international calls and initiatives. For example, at the COP26 in 2021, 30 financial institutions' CEOs with more than $8.7 trillion in assets and investments committed to contributing to actions to eliminate deforestation to reduce emissions. Also, more than 140 countries' governments pledged through the Glasgow Leaders' Declaration on Forests and Land Use to work together to phase out forest loss by 2030 and invest in activities that sustain and conserve the forest. If not checked, the current trend of deforestation and other forest loss activities would undermine the SDGs, especially SDGs 13a and 15. The United Nations' Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme supports governments and global efforts in reducing deforestation and forest degradation emissions and contributes to activities enhancing sustainable management of forests and conservation. The REDD+ is an implementation mechanism recognized by the Paris Agreement (Article 5 of the Agreement), where Parties re-iterated the

Table 6A
Regional estimates of the conditional effect of Energy Justice and Democracy on Deforestation (Driscoll-Kraay estimates).

Variables	1	2	3	4	5	6	7	8	9	10
	West Africa									
lnrgdpc	−0.949***	−1.354***	−0.933***	−1.451***	−0.814***	−1.350***	−0.849***	−1.411***	−0.848***	−1.364***
	(0.121)	(0.307)	(0.151)	(0.337)	(0.117)	(0.330)	(0.134)	(0.366)	(0.127)	(0.352)
lntrade	−0.312**	−0.189	−0.272**	−0.200	−0.173	−0.030	−0.264*	−0.171	−0.212*	−0.087
	(0.115)	(0.142)	(0.120)	(0.135)	(0.121)	(0.179)	(0.126)	(0.159)	(0.116)	(0.162)
lnfdi	0.020	0.255***	0.034	0.272***	−0.020	0.223***	−0.010	0.231***	0.006	0.241***
	(0.091)	(0.057)	(0.101)	(0.048)	(0.097)	(0.062)	(0.104)	(0.066)	(0.108)	(0.067)
lnurb	1.656***	1.566***	1.626***	1.532***	1.659***	1.597***	1.611***	1.510***	1.610***	1.517***
	(0.080)	(0.094)	(0.089)	(0.103)	(0.110)	(0.114)	(0.102)	(0.116)	(0.098)	(0.117)
lnoda	−0.402***	−0.193	−0.342***	−0.140	−0.349***	−0.179	−0.307**	−0.098	−0.279***	−0.066
	(0.104)	(0.141)	(0.100)	(0.143)	(0.102)	(0.135)	(0.109)	(0.132)	(0.086)	(0.144)
lnsse	0.711***	0.732***	0.690***	0.713***	0.828***	0.725***	0.847***	0.717***	0.766***	0.678***
	(0.112)	(0.163)	(0.080)	(0.180)	(0.089)	(0.183)	(0.099)	(0.191)	(0.084)	(0.179)
Clean_dis	0.344		0.266		0.182		0.184		0.213	
	(0.298)		(0.287)		(0.223)		(0.282)		(0.269)	
Elec_dis		0.841		0.915		1.147*		1.220*		1.085
		(0.568)		(0.597)		(0.636)		(0.669)		(0.639)
Polyarchy	1.728***	1.715***								
	(0.518)	(0.318)								
Libdem			1.262**	1.547***						
			(0.502)	(0.347)						
Partipdem					1.333**	1.944***				
					(0.543)	(0.360)				
Delibdem							0.821	1.145***		
							(0.494)	(0.304)		
Egaldem									1.035**	1.362***
									(0.484)	(0.348)
Constant	6.538**	5.364**	6.013**	5.855**	4.077**	4.227*	4.534**	5.047*	4.025**	3.765
	(2.366)	(2.264)	(2.528)	(2.663)	(1.761)	(2.113)	(2.156)	(2.494)	(1.923)	(2.186)
Observations	101	79	101	79	101	79	101	79	101	79
R^2	0.934	0.961	0.932	0.960	0.928	0.958	0.928	0.958	0.928	0.958

Standard errors in parentheses. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

encouragement to implement REDD + activities and that these should be an integral element of the Paris Agreement. The study also supports SDGs Goal 16, which broadly seeks to promote just, peaceful, and inclusive societies.

The remainder of the paper is organized as follows. The next section provides a brief literature review on the topic. The third section presents the data and empirical methodology. The fourth section presents and discusses the empirical results. Section five concludes the paper.

2. Literature review

2.1. The state of global forests

Forests cover about 31% of the earth's surface (about 4.06 billion hectares). Between 2010 and 2020, about 420 million hectares of forest cover were lost (FAO, 2022). Even though the rate of deforestation has been decreasing globally, 10 million hectares of forests were lost annually between 2015 and 2020 (IIED, 2022). Africa, however, remains the region with the fastest deforestation rate. Rainforests and total forests in Africa account for about 25% and 17% of all forests globally (IIED, 2022). These forests serve as a home for the region's biodiversity. The FRA estimates the mean annual rate of net forest loss in Africa to be rising; 3.28 million hectares lost annually between 1990 and 2000, 3.40 million hectares annually between 2000 and 2010, and 3.94 million hectares annually between 2010 and 2020 (FAO, 2020). Regarding deforestation, the FRA indicates that about 49 million hectares were deforested between 2000 and 2018 in Africa, signifying a 23% drop in deforestation. This translates to a fall from 3.01 million hectares annually to 2.33 million hectares during the 2000 to 2018 period (FAO, 2020). It is appropriate to make a distinction between deforestation and net forest loss. According to the FAO, as deforestation is the conversion of forest to another land use irrespective of whether it is human-induced or not, net forest loss is the difference between the entire losses resulting from deforestation and gains, which may be as a result of natural forest regeneration or afforestation (FAO, 2020, 2022).

Increasing population puts further pressure on the forests and other natural resources (van 't Veen et al., 2021). It is estimated that by 2060, the global consumption of all natural resources (including forests) will increase to about 190 billion tonnes from 92 billion tonnes in 2017 due to the rise in population and affluence (FAO, 2020, 2022). With the current pace of population growth, annual biomass generation is estimated to also increase from 24 billion tonnes in 2017 to about 44 billion tonnes in 2060. Biomass describes all biologically produced matter used in generating heat and cooking, including wood, crops, animal wastes, etc. (Demirbas, 2000; IEA, 2022; International Energy Agency, 2022). The use of woodfuel has several other adverse effects, apart from the contribution to biodiversity loss; an enormous amount of time is wasted in searching for wood and other biomass (International Energy Agency, 2022; Mang-Benza et al., 2023). Women, in particular, bear much of this brunt, drastically reducing their time for recreation, income-generating and productive activities. The use of woodfuel also poses severe health challenges. It contributes greatly to household air pollution – which causes stroke, ischaemic heart disease, chronic obstructive pulmonary disease, eye problems, and lung cancer — which accounts for about 4 million premature deaths annually globally (WHO, 2021). Fisher et al. (2021) estimate that as air pollution accounted for about 1.1 million deaths in Africa, close to 697,000 deaths were attributable to household air pollution. Woodfuel and charcoal production contributes to deforestation. Charcoal production alone is estimated to cause about 7% of tropical deforestation (van 't Veen et al., 2021). The production of charcoal is projected to rise by 5% by 2100, increasing the pace of deforestation (van 't Veen et al., 2021). Deforestation has serious ecological implications since it destroys the ecosystem and the natural habitats of wildlife. Deforestation also creates favorable conditions for

11	12	13	14	15	16	17	18	19	20
Eastern Africa									
−1.250**	−0.481	−0.505	−0.158	−1.131**	−0.528	−0.693	−0.176	−0.207	−0.121
(0.446)	(1.076)	(0.496)	(0.755)	(0.456)	(0.976)	(0.436)	(0.858)	(0.384)	(0.430)
1.289*	0.421	0.737	0.175	0.814	0.035	0.823	0.033	0.260	−0.316
(0.678)	(1.097)	(0.628)	(0.862)	(0.641)	(0.894)	(0.617)	(0.905)	(0.522)	(0.584)
−0.060**	0.017	−0.079**	0.025	−0.047	0.031	−0.114***	−0.016	−0.076*	0.079
(0.028)	(0.047)	(0.032)	(0.052)	(0.028)	(0.045)	(0.034)	(0.040)	(0.042)	(0.046)
0.516***	0.631***	0.777***	0.927***	0.559***	0.657***	0.660***	0.917***	0.728***	1.067***
(0.159)	(0.128)	(0.256)	(0.136)	(0.194)	(0.102)	(0.224)	(0.154)	(0.248)	(0.234)
0.464**	0.332*	0.423**	0.291*	0.481***	0.371**	0.465***	0.318*	0.423**	0.228
(0.168)	(0.186)	(0.152)	(0.164)	(0.153)	(0.157)	(0.141)	(0.158)	(0.153)	(0.174)
0.219	0.145	−0.137	−0.080	0.112	−0.016	−0.004	−0.139	−0.010	−0.033
(0.369)	(0.160)	(0.415)	(0.190)	(0.394)	(0.118)	(0.346)	(0.162)	(0.338)	(0.364)
−0.350		0.315		−0.068		−0.199		0.388	
(0.594)		(0.894)		(0.703)		(0.725)		(0.892)	
	−1.673		−0.029		−0.985		0.017		2.047***
	(2.778)		(1.243)		(2.220)		(1.984)		(0.552)
−2.909***	−3.320								
(0.674)	(2.020)								
		−5.569***	−6.234***						
		(0.441)	(1.386)						
				−4.709***	−5.195**				
				(0.746)	(2.287)				
						−4.264***	−5.504***		
						(0.489)	(1.493)		
								−8.532***	−11.239***
								(0.503)	(0.903)
5.764	5.659	1.284	1.631	6.238	6.803	2.629	2.180	2.342	3.358
(4.900)	(6.107)	(5.586)	(5.230)	(5.000)	(6.306)	(4.891)	(5.431)	(4.653)	(4.491)
115	97	115	97	115	97	115	97	115	97
0.892	0.889	0.908	0.905	0.899	0.896	0.902	0.900	0.927	0.935

the emergence of deadly pathogens that pose serious health risks to humans (FAO, 2022).

Climate change is one of the major downsides of using woodfuel and deforestation. Trees and forests are significant means for combating climate change. Deforestation is the single largest source of land-use change emissions (Singh, 2008). Stopping deforestation and conserving forests could prevent the emission of about 3.6 gigatonnes of carbon dioxide equivalent (GtCO2e) annually between 2020 and 2050, 14% of what is required up to 2030 to maintain the earth's temperature below 1.5 °C (FAO, 2022). Forests play an essential role in global carbon management, operating both as a source (deforestation and other forest degradation activities) and sink and reservoir (through photosynthesis and storage in biomass and soils) of greenhouses gases (Buizer et al., 2014). The total carbon stock contained in forests was estimated to be about 662 billion tonnes in 2020 (FAO, 2022). Deforestation releases carbon stored in plants and soils, thus serving as the second largest source of anthropogenic (human-induced) carbon emissions (Enrici and Hubacek, 2016). Deforestation also destroys economic activities and the culture of those dependent on forests for their livelihoods. It also reduces the generation of forest products and causes flooding, desertification, and soil degradation (Ajanaku and Collins, 2021; Culas, 2007). In some developing countries, particularly those in SSA, the use of forest resources as energy sources is prominent among a large section of the population, which contributes largely to deforestation in these countries. (FAO, 2020, 2022). Hence, ensuring energy justice, in view of expanding access to modern and sustainable energy for all, might be essential in curtailing deforestation (Makame, 2007; Ponce et al., 2021a).

2.2. *Energy justice and deforestation*

Energy justice refers to "the goal of achieving equity in both the social and economic participation in the energy system …" (Baker et al., 2019, p. 5). Energy justice aims to make energy accessible, affordable, clean and democratically managed for all communities (Baker et al., 2019; Domegni and Azouma, 2022). The energy justice agenda is in line with and support Goal 7 of the SDGs, which seeks to "ensure access to affordable, reliable, sustainable and modern energy for all." Investments in clean energy and electrification offer opportunities to reduce reliance on unsustainable biomass for energy, hence reducing the rate of deforestation. Even though the major causes of deforestation have been agricultural activities, the effect of forest resources as energy sources cannot be neglected (International Energy Agency, 2022). The over-reliance on forest resources in tropical regions makes tropical forests face a greater risk of deforestation (van 't Veen et al., 2021).

Access to clean energy remains one of the key factors of sustainable development (Mang-Benza et al., 2023). Globally, there has been improvement in access to clean energy; for example, the population without electricity has dropped from about 1.4 billion in 2010 to 754 million in 2021, and access to clean fuels and technologies for cooking from about 3 billion to 2.4 billion for the same period (IEA, 2022). Despite the impressive gain over the years, there was a rise of about 200 million people in the SSA region with no access to clean fuels and technologies for cooking within the period. People without access to electricity and modern cooking technologies in Africa are about 600 million (about 80% of the global figure) and 965 million, respectively. The IEA projects that those without access to clean fuels and technologies for cooking in Africa could reach a billion by 2030. With the current pace of fuel price increases globally, about 75 million people are likely to lose access to electricity, and 100 million people may be pushed back to using traditional biomass for cooking, rescinding some progress made towards addressing deforestation.

Despite the progress made, about 113 and 128 countries, a chunk of which are in SSA, have not attained universal access to electricity and clean fuels and technologies for cooking, respectively (IEA, 2022). In developing countries, the wealthiest households consume about nine times more modern energy than the poorest (IEA, 2022). To reduce the reliance on traditional biomass, access to clean fuels and technologies for cooking needs to rise about 2.7 times between now and 2030 (IEA, 2022). Traditional use of biomass for energy leads to deforestation (International Energy Agency, 2022). Clean fuels and technologies for cooking would prevent deforestation triggered by biomass-fuelled cooking (UN, 2021b). Access to modern energy by all reduces deforestation and its attendant adverse consequences and drastically reduces people's exposure to household pollution, claiming many lives prematurely in developing countries. Energy transition and expansion of access to clean fuels and technologies for cooking remain crucial.

The existing empirical literature largely indicates that sustainable energy consumption is associated with a reduction in deforestation. For example, using data from high, middle- and low-income countries from 1990 to 2018, Ponce et al. (2021a) show that an increase in clean or renewable energy usage is associated with a rise in forest cover. Similarly, Bakehe and Hassan (2022), using data from 92 countries from 2000 to 2015, find that access to clean fuels and technologies for cooking reduces deforestation. However, in splitting the sample, they find that the effect of access to clean fuels and technologies for cooking on deforestation is negative for Africa and Asia-Oceania. Tanner and Johnston (2017), using data from 158 countries for the years 1990, 2000, and 2010 found that rural electrification reduces deforestation. Also, collecting primary household data from Zanzibar (Tanzania), Makame (2007) shows that the majority of people using energy technologies that consume much wood contribute greatly to forest deterioration.

A look at the existing literature shows that limited studies have assessed the impact of access to electricity and clean fuels and technologies for cooking on deforestation. However, these studies were mute on whether equality in access to energy between rural and urban populations has a significant role in deforestation. The study, therefore, distinguishes and contributes to the literature by exploring if energy justice measured with rural-urban equality in access to electricity and clean fuels and technologies for cooking impacts deforestation in SSA.

2.3. Democracy and deforestation

In the extant literature, one of the important factors considered to influence both access to modern energy and deforestation is the political structure of countries. The political ecology literature ideally forms the foundation for the study of the relationship between political factors and environmental matters. It highlights that if good governance promotes the sustainable management of natural resources, developing countries with increasing populations may not have to battle environmental degradation (Tanner and Johnston, 2017). This draws the essence of the political system in influencing the environment and matters concerning it. Deacon (2009) narrates that a country's political system (whether democratic or non-democratic) is vital in the distribution of environmental resources. The nexus between democracy and the environment has been a subject of inconclusive controversy. Some scholars argue that democratic countries are more environmentally benign and have better environmental performance (Acheampong et al., 2022; Fiorino, 2018; Ryden et al., 2020; Rydning and Vadlamannati, 2017). Fiorino (2018), for example, contends that relative to nondemocratic countries, democratic ones invest more in environmental technologies that protect the environment (including the forests). Freedom of speech and the press remains critical element of the democratic debate on environmental performance, including forest conservation (Luttrell et al., 2014).

Payne (1995) opines that in democratic countries, citizens are much more aware of environmental matters owing to the relatively more unrestrained press and freedom of speech. People have the right to raise their voices and demonstrate on issues (including environmental issues) affecting them (Buitenzorgy and Mol, 2010). This right may be curtailed in nondemocratic countries, and people may not be able to be vociferous about issues affecting the environment. Policymakers in democratic countries whose citizens are concerned about environmental issues will be required to show commitment to tackling these issues (Buitenzorgy and Mol, 2010). Democratic governments are also noted to be listening governments as they are more receptive and accountable to public opinion (Rydning and Vadlamannati, 2017). Political rights that come with democracy promote citizens' involvement in politics and matters that affect their lives (Ryden et al., 2020). With this, citizens can push common interests like environmental sustainability. This makes citizens more involved in governance and improves their accessibility to resources and facilities essential to their existence. Also, in democratic countries, several nongovernmental organizations (NGOs) and civil society organizations (CSOs) are on the ground, raising pressure on the government about environmental matters. With the threat and fear of losing elections and further agitations, governments may heed their citizens' calls to protect the environment (Li and Reuveny, 2006; Ryden et al., 2020). With increasing liberal democratic institutions, pressure on political leaders to enforce rule of law and citizens' judicial rights can enhance compliance with legislation and international treaties (Li and Reuveny, 2006; Ryden et al., 2020). Moreover, democratic governments are more likely to participate in international organizations and accords and may be forced to enforce environmental regulations they sign on to.

Many empirical studies have supported the claim that democracy can have environmental benefits, hence negatively associated with deforestation. For instance, for a sample of 120 countries from 1970 to 1985, Deacon (2009) found that deforestation rates tended to be greater in autocracies and lower in parliamentary democracies. Using data from 1990 to 2000 for 177 countries, Buitenzorgy and Mol (2010) find evidence of the environmental Kuznets curve hypothesis for the democracy-deforestation relationship, which explains that deforestation increases at the early stages of democracy; however, it reduces as democracy reaches a certain high level. Their results further indicate that transitional democracies are more deforested than autocratic or more developed democracies. They also find that democracy is more important in explaining deforestation than income. In replicating and updating (data and methodology) of Buitenzorgy and Mol (2010), Cary and Bekun (2021) find democracy to be associated with decreased rates of deforestation. Similarly, Li and Reuveny (2006) find that democracy reduces deforestation and other types of environmental degradation using a sample of 143 countries from 1961 to 1997. Shandra (2007) finds similar evidence for 73 countries from 1990 to 2000. Using data from 14 developing countries from Latin America, Africa, and Asia from 1972 to 1994, Culas (2007) finds that enhancing institutions for secure property rights and improved environmental policies can considerably decrease deforestation.

Some scholars have, however, argued that the environment might benefit less from political democracy. Some argue that due to the long-term commitment to environmental sustainability activities (like pollution abatement), governments may rather commit resources to pressing areas with speedy results to ensure re-election (Akalin and Erdogan, 2021; Bernauer and Koubi, 2009). Similarly, Midlarsky (1998) argues that due to budget constraints, democratic governments may consider pressing economic issues as imperatives. Besides, the influence of elitism on the environment may be more apparent in democracies. The influence of elites, such as elite businessmen whose trades relate to the forest and the environment, can induce governments' response to degradation. Economic inequality can lead to policy structures influenced by elites to protect their interests (Tanner and Johnston, 2017). With this, the interests of the marginalized population (such as the poor and rural folks) about environmental issues may not be protected. The government could easily fall prey to prioritizing the interests of the elites, especially if they fund elections and other activities of government (Murshed, 2020). Along this line, Klopp (2012) argues that the formation of patronage networks in democracies can deteriorate the state of the forest. Klopp (2012) defines patronage as using resources to incentivize patrons for political gain. Patronage leads to the formation of preferential groups within a country that undercut the legal mandate and ability of the state to act for the common good of the citizenry (Klopp, 2012). Patronage networks rewarded with forest resources may degrade the resource without recourse to sustainability and conservation. Political elites in many developing countries consider forests a great wealth source (McCarthy and Tacconi, 2011).

Furthermore, because governments need no consensus with citizens in autocracies before taking initiatives (Potter and Wang, 2022), protecting the environment may be easier and faster. Consensus and consultations that may occur in democracies may delay or nullify environmental punitive actions of the government. Moreover, the level of development of a country or region may influence the impact of democracy on the environment. This aligns with the forest transition concept that economic development leads to forest recovery (Caravaggio, 2020; Klooster, 2003; Lorenzen et al., 2020). Rydning and Vadlamannati (2017) argue that in developing countries (or countries with a lower level of economic development), citizens might exert pressure on democratic governments to increase investment and industrialization to boost economic growth to expand job opportunities. This quest to increase jobs may come at the expense of the environment. Besides, people in poor countries may be more concerned about jobs and making ends meet than protecting the environment due to the high unemployment rate (WorldBank, 2019).

Some empirical literature has supported the counter position that autocracy may generate better environmental performance, or at least democracy may have no effect on deforestation. For example, using data on 156 countries, Midlarsky (1998) finds a positive relationship between democracy and deforestation. For a sample of less developing countries over the period 1980–1995, Ehrhardt-Martinez et al. (2002) find that strong democracy could contribute to deforestation. Rydning and Vadlamannati (2017), using data from 139 countries for the period 1992–2012, find that democracy has a negative impact on forest coverage. However, in accounting for the level of economic development, democracy was found to affect forest coverage positively. Some other studies, such as Damette and Delacote (2012) (for 59 developing countries over the period 1972–1994), found no significant relationship between democracy and deforestation.

Scrutiny of the existing studies largely indicates that the polity index – which generally focuses on electoral democracy – has been used to proxy for democracy (Buitenzorgy and Mol, 2010; Cary and Bekun, 2021; Ehrhardt-Martinez et al., 2002; Li and Reuveny, 2006; Rydning and Vadlamannati, 2017). Nevertheless, electoral democracy is inadequate to capture the wholeness of democracy as for proper attainment of "rule by the people," democracy transcends just elections (Coppedge et al., 2019). This study employs the latest and most comprehensive democracy proxies from the V-DEM project. The narrow measure of democracy employed in previous studies might drive the existing results. The V-Dem offers distinct indices of five varieties of democracy: participatory, deliberative, egalitarian, liberal, and electoral democracy. Each of these democracy variables is discussed in detail in the data section. A strand of the literature has also considered the effect of corruption on forest management (see Sundström, 2016, for an expansive literature). This study however contrasts with this. Our emphasis is on the broader ideological concept or political system of democracy and autocracy. Democracy involves promoting and protecting citizens' political rights, freedom for people to choose political leaders through elections, freedom of press and speech, etc. Corruption is a defect and a moral decadence of the economic, social, and governing systems, which can happen in either democratic or autocratic regimes. Corruption is an illegality, but neither democracy nor autocracy is. Corruption, as Transparency International explains, is the abuse of entrusted power for private gain. Nevertheless, in line with this previous literature, we also account for the control of corruption in some of the estimations to ascertain the robustness of the results.

3. Data and methodology

3.1. Empirical models

Following previous studies on deforestation, such as Nguyen and Su (2021), Bakehe and Hassan (2022), and Mak Arvin and Lew (2009), the general empirical model for estimating the effect of energy justice and democracy on deforestation is stated in equation (1).

$$lnnfp_{i,t} = \alpha_0 + \beta_1 Demo_{i,t} + \beta_2 Energyjust_{i,t} + \theta_1 X_{i,t} + v_i + \mu_t + \varepsilon_{i,t} \tag{1}$$

where $lnnfp_{i,t}$ is the natural logarithm of net forest depletion (our proxy for deforestation) of country i at year t. $Demo_{i,t}$ are the democracy variables (electoral, liberal, participatory, deliberative, and egalitarian democracy) of country i at year t. $Energyjust_{i,t}$ is the energy justice variables (rural-urban equality in access to electricity and rural-urban equality in access to clean fuels and technologies for cooking) of country i at year t. $X_{i,t}$ is a set of control variables (GDP per capita, trade openness, foreign direct investment, urbanization, education, and foreign aid) that are included in the deforestation model. α_0, β_1, β_2 and θ_1 are the unknown coefficients to be estimated. Also, v_i *and* μ_t represent individual and time-specific effects, respectively. $\varepsilon_{i,t}$ is the disturbance error term.

This study extends the empirical model (1) to capture the interactive effect between democracy and energy justice on deforestation. This hypothesis is based on the argument in the democracy-inequality literature that through democracy, political power can be extended to the poor in society and lead to the development of pro-poor policies that ensure fair distribution and mitigate inequality (Acemoglu et al., 2015; Meltzer and Richard, 1981). By extension, the study claims that democracy can ensure a fair share of energy resources across space and among people, thereby ensuring energy justice. Democracy ensuring energy justice could contribute to forest conservation. Equation (2) is formulated to estimate the interactive effect of democracy and energy justice on deforestation.

$$\begin{aligned} lnnfp_{i,t} = {} & \alpha_0 + \beta_1 Demo_{i,t} + \beta_2 Energyjust_{i,t} + \beta_3 (Demo \times Energyjust)_{i,t} \\ & + \theta_1 X_{i,t} + v_i + \mu_t + \varepsilon_{i,t} \end{aligned} \tag{2}$$

Given that equation (2) tests the hypothesis that the effect of energy justice on deforestation is conditioned by democracy, this study follows Brambor, Clark, and Golder's (2006) recommendation to calculate the marginal/total effects based on the interaction terms. Therefore, equation (3) is applied to estimate the marginal effect (total effect) of energy justice on deforestation conditioned by the presence of democracy. Equation (3) is obtained by differentiating deforestation with respect to energy justice.

$$\frac{\partial lnnfp}{\partial Energyjust} = \beta_2 + \beta_3 DEMO \tag{3}$$

As suggested by Brambor et al. (2006), the interpretation of interaction models differs significantly from linear additive models. Therefore, from equation (3), the marginal/total effect of energy justice on deforestation is conditioned on democracy. When the interaction between democracy and energy justice is statistically significant, the total effect of energy justice on deforestation would be evaluated at the mean of democracy variables.

3.2. Data description

This study used panel data from 47 SSA countries for the period between 2000 to2020[1]. In this study, the adjusted savings of net forest depletion was used as the measure for deforestation. According to World Bank, the net forest depletion is calculated as the product of unit resource rents and the excess of roundwood harvest over natural growth. Therefore, the higher the net forest depletion, the higher the deforestation, and vice versa. The data on this variable is obtained from the World Development Indicators (WDI) database of the World Bank.

The energy justice variables were computed. Baker et al. (2019) argue that energy justice aims to make energy accessible, affordable, clean, and democratically managed for all communities. Therefore, the study operationalized energy justice to be equal energy access between rural and urban areas. The first measure, rural-urban equality in access to clean fuels and technologies for cooking, is computed as the ratio of rural access to clean fuels and technologies for cooking to urban access to clean fuels and technologies for cooking. Similarly, rural-urban equality in access to electricity is calculated as the ratio of rural access to electricity to urban access to electricity. The higher the value for rural-urban equality in access to clean cooking fuels and technologies, and electricity, the high energy justice, and vice versa. The approach for calculating the measures is consistent with the literature (for instance, Opoku and Acheampong, 2023; Trotter, 2016). In the literature, Opoku and Acheampong (2023) examined the effect of energy justice, measured by rural-urban equality in access to clean fuels and technologies for cooking and electricity on economic growth and found that energy justice promotes economic growth. Trotter (2016) also found that democratic institutions reduce rural versus urban electrification inequality as measured by the ratio of rural access to electricity to urban access to electricity. The access to electricity and clean fuels and technologies for cooking variables used for the computation were sourced from WDI.

Democracy is measured with five high-level indices, comprising participatory, deliberative, liberal, electoral, and egalitarian democracy. Participatory democracy represents the values of direct rule and active participation by citizens in all political procedures. This component of democracy accentuates non-electoral forms of political involvement, such as through the activities of civil society (Coppedge et al., 2011). The deliberative aspect captures the value that political decisions that go into the activities of public interest or good should be based on reverential and rational discourse at all levels instead of being driven by emotional requests, solidary attachments, parochial interests, or force. The egalitarian component captures the ideal of power disseminated evenly among all citizens irrespective of class, ethnicity, and orientation of any form or other social group. The liberal constituent of democracy represents the intrinsic value of protecting individual and minority rights against potential domination by the majority and state tyranny generally. The electoral component of democracy encompasses the core value of political rulers being responsible toward citizens through sporadic elections (Coppedge et al., 2011). The electoral democracy index captures various indicators of an elected executive index, the clean elections index, the freedom of expression index, the freedom of association index, and the suffrage indicator (Coppedge et al., 2011, 2019). Electoral democracy is very pivotal as it serves as the basis of the other indices of democracy. Its essence is embedded in the fact that without elections, democracy cannot be effectively practiced. Data on the electoral, liberal, participatory, deliberative, and egalitarian democracy variables were obtained from the Coppedge et al. (2018) Variety of Democracy (V-DEM) database.

[1] Appendix Table 1A shows the countries included in the analysis. This sample size was chosen due to data availability. The electricity data provided by the World Bank starts from the year 2000, and currently ends in the year 2020.

Consistent with the deforestation literature such as Nguyen and Su (2021), Rudel (2013), Ponce, Del Río-Rama, Álvarez-García, and Oliveira (2021b), Tacconi (2017), Hecht et al. (2006) and Yameogo (2021), variables such as GDP per capita, trade openness, foreign direct investment, urbanization, education, and foreign aid, were included as control variables. GDP per capita is measured with GDP per capita (constant 2015 US$). Trade openness is proxied with trade (Export + Import) (% of GDP), and foreign direct investment is measured with net inflows of foreign direct investment (% of GDP). Urban population is used to measure urbanization, and foreign aid is measured with net official development assistance and official aid received (constant 2020 US$). We also account for corruption in our model. Corruption is measured using the control of corruption index which captures perceptions 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 (Kaufmann et al., 2011). The index ranges from −2.5 to 2.5, with higher values corresponding to less corruption and lower values corresponding to higher corruption (Kaufmann et al., 2011). Data on these control variables are obtained from the WDI and World Governance (WGI) database. The summary statistics for the variables are presented in Table 1. For the purpose of estimation, the variables were log-transformed except the democracy and energy justice variables.

3.3. Estimation techniques

From the generally reduced form equations formulated above, this paper uses Blundell and Bond's (1998) two-step dynamic system-generalized method of moment (dynamic system-GMM)[2] as its primary estimator. This estimation technique is appropriate for addressing endogeneity that may arise from reverse causality or variable omission bias. Based on the GMM assumption, endogeneity can be accounted for using the differencing approach to eliminate the unobserved country and time effects, as demonstrated in equations (3) and (4).

$$\begin{aligned} lnnfp_{i,t} - lnnfp_{i,t-1} = {} & \alpha_0 \left(lnnfp_{i,t-1} - lnnfp_{i,t-2} \right) + \beta_1 \left(Demo_{i,t} - Demo_{i,t-1} \right) \\ & + \beta_2 \left(Energyjust_{i,t} - Energyjust_{i,t-1} \right) + \theta_1 \left(X_{i,t} - X_{i,t-1} \right) \\ & + \left(\varepsilon_{i,t} - \varepsilon_{i,t-1} \right) \end{aligned} \tag{4}$$

$$\begin{aligned} lnnfp_{i,t} - lnnfp_{i,t-1} = {} & \alpha_0 \left(lnnfp_{i,t-1} - lnnfp_{i,t-2} \right) + \beta_1 \left(Demo_{i,t} - Demo_{i,t-1} \right) \\ & + \beta_2 \left(Energyjust_{i,t} - Energyjust_{i,t-1} \right) \\ & + \beta_3 \left(Demo \times Energyjust_{i,t} - Demo \times Energyjust_{i,t-1} \right) \\ & + \theta_1 \left(X_{i,t} - X_{i,t-1} \right) + \left(\varepsilon_{i,t} - \varepsilon_{i,t-1} \right) \end{aligned} \tag{5}$$

The use of Arellano and Bond's (1991) first difference generalized method of moment technique to address endogeneity by removing unobserved time and country effects would generate bias estimates because of asymptotic and considerable bias when the number of countries (*N*) exceeds the time (*T*). The Blundell and Bond (1998) two-step system-generalized method of the moment addresses this limitation by using the lagged differences of the dependent variable as instruments for equations in levels and first difference. The Blundell and Bond (1998) two-step system-generalized method of the moment is the suitable estimator since it provides reliable estimates with smaller *T* and large *N*. Given that the number of countries ($N = 47$) exceeds the years considered ($T = 20$) in this study, applying Blundell and Bond's (1998) estimator would, therefore, yield reliable estimates. The reliability of the Blundell and Bond (1998) two-step system-generalized method of

[2] The *xtabond2* command used for estimating the two-step dynamic system-generalized method of the moment.

moment estimates is evaluated using the Hansen test, first (AR(1)) and second order (AR(2)) autocorrelation.

Endogeneity is not the only econometric issue that may confront panel data estimation. Econometric issues such as cross-sectional and temporal dependency are inherent issues that confront panel data analysis. Driscoll and Kraay's (1998) estimator is used as the alternative estimator to check the robustness of the findings. This estimator assumes that the error structure is heteroscedastic, autocorrelated up to some lag, perhaps correlated between the panels. Finally, the estimator handles missing data series, performs well on both (un)balanced panels, and further yields efficient estimates when cross-sectional and temporal dependence are present (Hoechle, 2007).

4. Results and discussion

(I) Estimated results on the relationship between energy justice and deforestation.

Table 2 presents the estimates from the dynamic system-GMM estimator. The results generally show that energy justice and democracy variables contribute significantly to reducing deforestation. Specifically, rural-urban equality in access to electricity and clean fuels and technologies for cooking has a statistically significant negative effect on deforestation. The estimated coefficients show that rural-urban equality in access to clean fuels and technologies for cooking reduces deforestation by 0.364–0.458 points, ceteris paribus. Rural-urban equality in access to electricity reduces deforestation by 0.662–0.787 points, ceteris paribus. These findings show that improving equality in energy accessibility between rural and urban areas would contribute substantially to forest conversation in SSA. The literature shows that rural dwellers have less access to electricity and clean fuels, and technologies for cooking than urban dwellers (International Energy Agency, 2022). The implication is that rural inhabitants depend significantly on firewood and charcoals for their daily activities, such as cooking and lighting. Rural populations depending primarily on firewood and charcoal exert pressure on the forest due to over-exploitation, thereby increasing deforestation. As depicted by our results, the policy suggestion is that ensuring that the rural population has equal access to energy like the urban population would reduce their overdependence on firewood and charcoals for their household activities, thereby contributing to forest conservation. Equality in energy access between rural and urban areas can be achieved through political commitment, enforcing the implementation of rural electrification and clean fuels and technologies for cooking programmes, and extending and upgrading rural infrastructure facilities. Also, financing remains crucial in addressing the rural-urban inequality in energy access. However, most SSA governments have accumulated excessive debt, making it challenging to use external borrowing to improve energy justice in the region. Given the region's financial constraints, the role of the private sector in enhancing energy justice cannot be underestimated. Given the role of the private sector in technological innovation, it can deliver a crucial role in escalating rural electrification and rural access to clean fuels and technologies for cooking through off-grid and mini-grid solutions. In addition, through the public-private partnership, the private sector can help overcome the region's financial constraints and further aid in tackling the affordability problem and the high cost of reaching rural dwellers most efficiently (UN, 2021a).

(II) Estimated results on the relationship between democracy and deforestation.

For the democracy variables, the estimates in Table 2 show that electoral, liberal, participatory, deliberative, and egalitarian democracy have statistically significant negative effects on deforestation. The estimated coefficients show that electoral liberal, participatory, deliberative, and egalitarian democracy variables are associated with a reduction in deforestation by 0.398–0.404, 0.586, 0.606–0.870, 0.493–0.596, and 0.500–1.028 points, respectively, ceteris paribus. These results provide evidence that democracy of all forms could contribute significantly to forest conservation. These results support the strand of the literature claiming that democracy promotes environmental protection. This is the case as democracy enhances public opinion (with a relatively freer press and freedom of speech), affords rights to citizens to demonstrate and register their frustrations about environmental degradation, and governments are compelled to show commitment to local and global environmental issues (Li and Reuveny, 2006; Ryden et al., 2020) (Buitenzorgy and Mol, 2010) (Rydning and Vadlamannati, 2017).

(III). Estimated results on the relationship between the control variables and deforestation.

With respect to the control covariates, the findings in Table 2 show that GDP per capita mostly has a statistically significant positive effect on deforestation. Thus, increasing GDP per capita could drive deforestation. Achieving higher GDP per capita requires using environmental resources, including forest resources such as timber, to produce goods such as furniture, wood carvings, construction materials, and paper, whose monetary value forms part of measuring economic growth. Additionally, higher GDP per capita suggests that other economic sectors, such as construction, manufacturing, and service sectors, are also growing. The construction, service, and manufacturing sectors depend much on forest resources to support their activities. For instance, timber beams are used in the construction of railways, roads, housing, and the erection of electricity poles in some developing countries. Also, as GDP per capita increases, all things being equal, household income increases, thereby increasing their demand for timber products. Contextually, SSA relatively has lower GDP per capita. SSA, therefore, depends massively on the extraction of forest resources to sustain its economic growth and the livelihood of its people, thereby contributing to deforestation. Also, given SSA's quest to promote sustained economic development, there is less pressure from its people for governments to implement stringent policies to curb increasing deforestation in the region. Our result supports Ewers's (2006) evidence of showing that there is a strong positive relationship between economic growth and deforestation, especially for developing countries.

Contrary to the findings of previous studies such as Tsurumi and Managi (2014), Abman and Lundberg (2020), and Nathaniel and Bekun (2020), our estimates show that trade openness largely has a statistically insignificant positive effect on deforestation. The results also indicate that foreign direct investment has a statistically significant positive effect on deforestation at a 1% level, indicating that inflows of foreign direct investment to SSA could be associated with the rise of deforestation. From the estimated coefficients, deforestation increases by 0.017%–0.028%, ceteris paribus. This result provides support for the environmental pollution-haven hypothesis (EPHH). The EPHH postulates that environmentally degrading firms that find it costly to operate their businesses in developed countries because of their draconian environmental laws and policies would relocate to developing countries with less stringent environmental regulations (Doytch and Narayan, 2016; Opoku et al., 2022). SSA is conceived as one of the regions with lax environmental laws and regulations, making the region attractive to foreign investors engaged in activities like lumbering and others that contribute to deforestation. For instance, in Ghana and DR Congo, just to mention a few, some foreigners have been cited for engaging in illegal logging and mining activities called "galamsey," which contribute substantially to deforestation in these countries (Antwi-Boateng and Akudugu, 2020; Hilson and Maconachie, 2020; Partzsch and Vlaskamp, 2016; Sovacool, 2019). The evidence that foreign direct investment could contribute to deforestation is congruent with an aspect of the literature showing that foreign direct investment could be environmentally unfriendly in developing countries (Lokonon and Mounirou,

Table 6B
Regional estimates of the conditional effect of Energy Justice and Democracy on Deforestation (Driscoll-Kraay estimates).

Variables	1	2	3	4	5	6	7	8	9	10
	Central Africa									
lnrgdpc	−0.552**	−0.516***	−0.531**	−0.490***	−0.562**	−0.527***	−0.526***	−0.486***	−0.482**	−0.445***
	(0.193)	(0.165)	(0.186)	(0.158)	(0.202)	(0.169)	(0.177)	(0.147)	(0.174)	(0.149)
lntrade	0.440***	0.273	0.434***	0.261	0.482***	0.328	0.458***	0.249	0.364***	0.174
	(0.132)	(0.261)	(0.137)	(0.259)	(0.141)	(0.277)	(0.145)	(0.253)	(0.109)	(0.220)
lnfdi	−0.047	−0.055	−0.048	−0.057	−0.045	−0.057	−0.060	−0.075	−0.055	−0.064
	(0.067)	(0.054)	(0.067)	(0.054)	(0.069)	(0.058)	(0.067)	(0.055)	(0.067)	(0.054)
lnurb	0.289	0.133	0.308	0.155	0.262	0.106	0.344*	0.212	0.348*	0.200
	(0.190)	(0.164)	(0.182)	(0.155)	(0.191)	(0.170)	(0.189)	(0.151)	(0.190)	(0.154)
lnoda	0.373**	0.449***	0.358**	0.428***	0.388**	0.473***	0.341**	0.374***	0.357**	0.411***
	(0.139)	(0.118)	(0.132)	(0.117)	(0.143)	(0.132)	(0.126)	(0.091)	(0.134)	(0.097)
lnsse	1.237***	1.308***	1.203***	1.266***	1.272***	1.355***	1.207***	1.242***	1.177***	1.228***
	(0.284)	(0.209)	(0.278)	(0.196)	(0.301)	(0.225)	(0.276)	(0.176)	(0.273)	(0.181)
Clean_dis	−0.537		−0.554		−0.597		−0.448		−0.421	
	(0.827)		(0.800)		(0.890)		(0.741)		(0.720)	
Elec_dis		−0.405		−0.453		−0.440		−0.569		−0.463
		(0.491)		(0.505)		(0.540)		(0.521)		(0.477)
Polyarchy	−0.777*	−0.884***								
	(0.382)	(0.274)								
Libdem			−0.841***	−0.953***						
			(0.255)	(0.203)						
Partipdem					−0.658	−1.004*				
					(0.620)	(0.534)				
Delibdem							−1.246**	−1.485***		
							(0.441)	(0.452)		
Egaldem									−1.428**	−1.518***
									(0.554)	(0.506)
Constant	6.194***	7.331**	6.085***	7.286**	5.956***	6.853*	5.828***	7.777**	5.652***	7.254**
	(2.030)	(3.363)	(1.924)	(3.285)	(1.936)	(3.567)	(1.855)	(3.240)	(1.837)	(3.108)
Observations	44	36	44	36	44	36	44	36	44	36
R^2	0.921	0.869	0.922	0.872	0.920	0.867	0.924	0.878	0.924	0.876

Standard errors in parentheses. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

2019; Acheampong, 2022).

Urbanization is observed to have a statistically significant positive effect on deforestation at a 10% level or better. The estimated coefficients indicate that deforestation increases by 0.034%–0.077% when urbanization increases by 1%, ceteris paribus. This result posits that increasing urbanization could contribute to deforestation in SSA. There are several ways through which urbanization could lead to deforestation. First, Katzman (1977) posits that urbanization is associated with increasing food demand. This shows that increasing urbanization results in expanding agricultural lands to produce foods and transportation infrastructure to hinterlands to transport these foodstuffs to the urban centers. Urbanization pushing expansion in agricultural lands and transportation infrastructure suggests a contraction of forest cover lands, hence escalating deforestation. Also, from the growth pole theory, urbanization is an economic growth engine (Perroux, 1950). Therefore, urbanization serving as a concentration for industries impacts changes in the rural landscape, including changes in forest cover. Generally, urban sprawling, indicating expansion in the built environment, accelerates deforestation (Browder, 2002; Ortiz et al., 2021). This outcome affirms the evidence in previous literature, such as Nathaniel and Bekun (2020) and Ehrhardt-Martinez, Crenshaw, and Jenkins (2002), that urbanization intensifies deforestation.

The findings indicate that the coefficients of the foreign aid variable show a statistically significant positive effect on deforestation at a 10% level or better. The estimates show that a 1% increase in foreign aid is associated with about 0.040%–0.338% increase in deforestation, ceteris paribus. First, the findings can be linked to moral hazards. If foreign aid, such as conservation aid, is provided to address deforestation, it does not encourage policymakers to design and enforce strict regulations to address deforestation. In addition, foreign aid meant for managing environmental degradation, including deforestation in developing countries, may not be actually used for its intended purpose. For instance, Bare et al. (2015), Miller (2014) indicate that foreign aid, such as conservation aid, is spent chiefly on livelihood programmes rather than initiatives that could combat deforestation. In Africa, for instance, Miller (2014) shows that 70% of conservation aid is spent on mixed projects while 30% is spent on forest conservation projects. Our finding that foreign aid could escalate deforestation aligns with Bare et al. (2015) and Mak Arvin and Lew's (2009) findings for developing countries.

Finally, the estimates show that education has a statistically significant positive effect on deforestation at a 10% level or better, indicating that education may be associated with an increase in deforestation in the sample considered. It is conjectured that education enables people to make reasonable and efficient use of resources. However, this is not always the case, as increasing education promotes consumerism. Education increases job opportunities for knowledgeable and skilled labour, thus increasing their income. As the income of these people increases, their demand for goods (including timber products) also increases, thus contributing to the exploitation of forest resources. Consistently, Mena, Bilsborrow, and McClain (2006), Pichón (1997), and Pan and Bilsborrow (2005) revealed that education is associated with deforestation.

4.1. *Does democracy moderate the effect of energy justice to reduce deforestation?*

Results reported in Table 3 indicate that all the democracy variables moderate the effect of energy justice to reduce deforestation. For instance, the interactive term of electoral and rural-urban equality in access to clean fuels and technologies for cooking is negative and statistically significant at a 1% level. At the same time, the interactive term of electoral and rural-urban equality in access to electricity is negative

11	12	13	14	15	16	17	18	19	20
Southern Africa									
−1.078***	−1.136***	−0.989***	−1.064***	−1.068***	−1.106***	−0.992***	−1.059***	−1.223***	−1.253***
(0.243)	(0.162)	(0.234)	(0.160)	(0.225)	(0.158)	(0.234)	(0.167)	(0.265)	(0.161)
0.386**	1.028***	0.322*	0.974***	0.110	0.796***	0.166	0.839***	0.611***	1.274***
(0.174)	(0.130)	(0.181)	(0.139)	(0.146)	(0.118)	(0.146)	(0.118)	(0.155)	(0.135)
0.055	0.040	0.063	0.046*	0.054	0.030	0.070	0.047	0.046	0.021
(0.064)	(0.023)	(0.069)	(0.024)	(0.072)	(0.029)	(0.075)	(0.030)	(0.065)	(0.022)
0.621***	0.807***	0.585***	0.776***	0.564***	0.756***	0.618***	0.805***	0.644***	0.840***
(0.106)	(0.047)	(0.114)	(0.049)	(0.097)	(0.045)	(0.120)	(0.061)	(0.104)	(0.043)
0.269***	0.226***	0.269***	0.222***	0.221***	0.175***	0.254***	0.203***	0.261***	0.194***
(0.048)	(0.056)	(0.040)	(0.048)	(0.051)	(0.055)	(0.046)	(0.053)	(0.054)	(0.056)
1.296***	1.738***	1.249***	1.694***	1.301***	1.692***	1.285***	1.690***	1.401***	1.789***
(0.254)	(0.096)	(0.285)	(0.089)	(0.277)	(0.116)	(0.299)	(0.118)	(0.270)	(0.107)
2.783***		2.868***		2.894***		2.912***		3.820***	
(0.779)		(0.692)		(0.548)		(0.643)		(0.911)	
	1.840***		1.904***		1.857***		1.935***		2.319***
	(0.316)		(0.264)		(0.251)		(0.275)		(0.326)
−2.921***	−2.585***								
(0.276)	(0.109)								
		−3.400***	−2.977***						
		(0.379)	(0.092)						
				−5.060***	−4.339***				
				(0.481)	(0.192)				
						−3.474***	−2.977***		
						(0.368)	(0.134)		
								−3.889***	−3.146***
								(0.371)	(0.167)
6.585**	0.462	6.748**	0.681	9.613***	3.291	7.130**	1.215	5.813**	−0.082
(2.536)	(2.247)	(2.878)	(2.503)	(2.689)	(2.524)	(2.833)	(2.633)	(2.267)	(2.387)
58	54	58	54	58	54	58	54	58	54
0.849	0.890	0.840	0.882	0.852	0.880	0.847	0.882	0.847	0.884

and statistically significant at a 1% level. From the total effect estimates[3], electoral democracy reinforces rural-urban equality in access to clean fuels and technologies for cooking and electricity to reduce deforestation by 0.382–0.631 points, ceteris paribus. Also, the interactive term of liberal democracy and rural-urban equality in access to clean fuels and technologies for cooking and liberal democracy and rural-urban equality in access to electricity is negative and statistically significant at a 1% level. Thus, from the total effect estimates, liberal democracy facilitates rural-urban equality in access to clean fuels and technologies for cooking and electricity to reduce deforestation by 0.393–0.625 points, ceteris paribus.

Similarly, the interactive term of participatory democracy and rural-urban equality in access to clean fuels and technologies for cooking and participatory democracy and rural-urban equality in access to electricity are negative and statistically significant at a 1% level. This result suggests that in the presence of participatory democracy, rural-urban equality in access to clean fuels and technologies for cooking and electricity reduces deforestation by 0.297–0.528 points, ceteris paribus. Further, the interactive term of deliberative democracy and rural-urban equality in access to clean fuels and technologies for cooking and deliberative democracy and rural-urban equality in access to electricity is negative and statistically significant at a 1% level. The total effect estimates suggest that deliberative democracy reinforces rural-urban equality in access to clean fuels and technologies for cooking and electricity to reduce deforestation by 0.351–0.543 points, ceteris paribus. Finally, the interactive term of egalitarian democracy and rural-urban equality in access to clean fuels and technologies for cooking and egalitarian democracy and rural-urban equality in access to electricity is negative and statistically significant at a 1% level. The total effect coefficient shows that egalitarian democracy enhances rural-urban equality in access to clean fuels and technologies for cooking and electricity to reduce deforestation by 0.384–0.606 points, ceteris paribus.

These observations indicate that democratic regimes may enhance rural-urban equality in access to clean fuels and technologies for cooking and electricity to reduce deforestation. These moderating effect results suggest that enhancing democratic practices in SSA could contribute to the achievement of equality in access to energy between rural and urban people. Democracy contributes to designing and implementing pro-poor policies that address injustice in allocating public goods, thereby promoting equality (Acemoglu et al., 2015; Meltzer and Richard, 1981). Evidence provided by Trotter (2016) suggested that democracy, as measured with Polity IV, bridges the gap between rural and urban people in having access to electricity in SSA. The suggestion is that deforestation would be less in SSA when democracy facilitates the development of energy policies and infrastructure facilities that promote equality in energy access between rural and urban areas. Theoretically, this analysis contributes to the energy democracy literature, which promotes the idea that individuals should be part of the decision-making defining their energy demands and energy future (Baker et al., 2019). With this, access to modern energy will increase among the population.

4.2. Are the results robust to an alternative econometric estimator?

After controlling for cross-sectional and temporal dependency, the Driscoll-Kraay estimator generates results consistent with the results from the two-step generalized method of moment estimator regarding the signs and significance levels. For example, as shown in Table 4, the findings appear that rural-urban equality in access to clean fuels and technologies for cooking has a statistically significant negative effect on deforestation, with an estimated coefficient, which ranges between

[3] The total effect estimates are evaluated at the mean of the democracy variables.

1.051 and 1.187 points, ceteris paribus. Also, rural-urban equality in access to electricity reduces deforestation but is largely statistically insignificant. The robustness check estimates further show that electoral, liberal, participatory, deliberative, and egalitarian democracy have a statistically significant negative effect on deforestation at a 1% level. These results further collaborate with our earlier findings that democratization and improvement in rural-urban equality in access to energy could enhance forest conservation.[4]

Again, the interactive effect results from the Driscoll-Kraay estimator are consistent with our earlier findings. The interactive results suggest that improved democratization would facilitate energy justice to mitigate deforestation. As displayed in Table 5, for example, the electoral democracy interacts with rural-urban equality in access to clean fuels and technologies for cooking and rural-urban equality in access to electricity to have a negative and statistically significant effect on deforestation at a 1% level. From the total effect estimates presented[5], when there is an improvement in electoral democracy, rural-urban equality in access to clean fuels and technologies for cooking and electricity reduces deforestation by 3.124–4.761 points, ceteris paribus. Liberal democracy also moderates the effect of rural-urban equality in access to clean fuels and technologies for cooking and rural-urban equality in access to electricity to minimize deforestation and is statistically significant at a 1% level. The total effect coefficients show that in the presence of liberal democracy, rural-urban equality in access to clean fuels and technologies for cooking and electricity reduces deforestation by 3.223–4.853 points, respectively. Similarly, participatory democracy moderates the impact of rural-urban equality in access to clean fuels and technologies for cooking and rural-urban equality in access to electricity to exert a significant negative effect on deforestation at a 1% level. The total effect coefficients show that with improvement in participatory democracy, rural-urban equality in access to clean fuels and technologies for cooking and electricity reduce deforestation by 3.729–4.805 points, ceteris paribus.

Further, deliberative democracy interacts with rural-urban equality in access to clean fuels and technologies for cooking and rural-urban equality in access to electricity to exert a negative effect on deforestation and is statistically significant at a 1% level. From the total effect coefficients, with improvement in deliberative democracy, rural-urban equality in access to clean fuels and technologies for cooking and electricity reduce deforestation by 3.296–4.739 points, ceteris paribus. Finally, egalitarian democracy moderates the impact of rural-urban equality in access to clean fuels and technologies for cooking and electricity to have a negative relationship with deforestation and is statistically significant at a 1% level. The total effect coefficients indicate that when there is an enhancement in egalitarian democracy, rural-urban equality in access to clean fuels and technologies for cooking and electricity reduces deforestation by 3.269–4.657 points, ceteris paribus.

4.3. Regional evidence on the effect of energy justice and democracy on deforestation

Our analysis so far has been silent on the variations in results based on regional heterogeneities in SSA. This section broadens the analysis by probing if there are differences in the impact of energy justice and democracy on deforestation across the sub-regions within SSA. The system-generalized method of the moment estimator generates unbiased estimates when *N* is greater than *T*. However, given that the subsamples do not satisfy this condition, the Driscoll-Kraay estimator was used to estimate the results for the regions. The results for West and Eastern Africa regions are presented in Table 6A, and Table 6B displays the results for Central and Southern Africa regions. From the regional perspective, the results presented in Table 6A pointed out that in West Africa, rural-urban equality in access to electricity and clean fuels and technologies for cooking has a positive effect on deforestation; however, it is only rural-urban equality in access to electricity that has a statistically significant effect (see Models 7 and 8). In Eastern Africa, except for Model 20, where rural-urban equality in access to electricity has a statistically significant positive effect on deforestation, the impact of rural-urban equality in access to electricity and clean fuels and technologies for cooking is largely insignificant. Similarly, in Eastern Africa, the impact of rural-urban equality in access to electricity and clean fuels and technologies for cooking is largely insignificant. For Southern Africa, the impact of rural-urban equality in access to electricity and clean fuels and technologies for cooking on deforestation is positive and largely statistically significant at a 1% level. These estimates demonstrate that the impact of regional differences matters in assessing the impact of rural-urban equality in access to energy on deforestation in SSA.

Tables 6A and 6B shows that the democracy variables have a statistically positive effect in West Africa. The estimated coefficients imply that in West Africa, electoral liberal, participatory, deliberative, and egalitarian democracy is associated with an increase in deforestation by 1.715–1.728, 1.262–1.547, 1.333–1.944, 1.145, and 1.035–1.362 pointsrespectively, ceteris paribus. This evidence shows that democracy may enhance deforestation in West Africa. Contrarily, in Eastern, Central, and Southern Africa, the democracy variables have a statistically significant negative effect on deforestation. The estimated coefficients show that in Eastern Africa, electoral liberal, participatory, deliberative, and egalitarian democracy could reduce deforestation by 2.909, 5.569–6.234, 4.709–5.195, 4.264–5.504, and 8.532–11.238 points respectively, ceteris paribus. For Central Africa, electoral liberal, participatory, deliberative, and egalitarian democracy are associated with a reduction in deforestation by 0.777–0.884, 0.841–0.953, 1.004, 1.246–1.485, and 1.428–1.518 points, respectively, ceteris paribus, while in Southern Africa, electoral liberal, participatory, deliberative, and egalitarian democracy are associated with a reduction in deforestation by 2.585–2.921, 2.977–3.400, 4.339–5.060, 2.977–3.474 and 3.146–3.889 points, respectively, ceteris paribus. These findings show that the different forms of democracy play a significant role in forest conservation in the Eastern, Central, and Southern parts of SSA. These outcomes demonstrate that the impact of democracy on deforestation is not homogenous among SSA's sub-regions. These findings concur with Acheampong et al. (2022) claim that democracy could exacerbate environmental degradation in West Africa while minimizing environmental degradation in Eastern, Central, and Southern parts of SSA. The democracy variable scores have been relatively higher in Western Africa than in Eastern, Central, and Southern Africa (Acheampong et al., 2022). The democratic practices in West Africa may be associated with excessive capitalism leading to the over-exploitation of forest resources to enhance profiteering.

From Tables 6A and 6B, GDP per capita is observed to have a statistically significant negative effect on deforestation across all the sub-regions. Trade openness has a negative and statistically significant effect on deforestation in West Africa; however, in Central and Southern Africa, trade openness has a positive and statistically significant effect on deforestation. Trade openness is observed to have a statistically significant relationship with deforestation in Eastern Africa. Foreign direct investment has a positive and statistically significant effect on deforestation in West Africa, while its impact in Eastern Africa is negative and statistically significant. In Central and Southern Africa, no statistically significant relationship exists between foreign direct investment and deforestation. Except in Central Africa, urbanization positively and statistically significantly affects deforestation in West, Eastern, and Southern Africa. While foreign aid is observed to have a statistically significant negative effect on deforestation in West Africa, it has a statistically significant positive effect on deforestation in Eastern, Central, and Southern Africa. Also, while education has a statistically significant

[4] The study focuses on the main variables of interest here.

[5] The total effect estimates are evaluated at the maximum of the democracy indices. Maximum values are to prove how an increase in democratic practices in SSA would aid forest conservation through energy justice.

Table 7
Unconditional effect of energy justice and democracy on deforestation after accounting for control of corruption (Dynamic system-GMM estimates).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
L.lnnfp	0.896***	0.894***	0.914***	0.888***	0.882***	0.895***	0.905***	0.863***	0.892***	0.844***
	(0.019)	(0.012)	(0.011)	(0.018)	(0.019)	(0.020)	(0.012)	(0.033)	(0.018)	(0.023)
lnrgdpc	−0.019	0.116***	−0.007	0.143***	−0.025	0.110***	−0.007	0.109**	−0.030	0.062
	(0.035)	(0.029)	(0.030)	(0.034)	(0.030)	(0.030)	(0.034)	(0.044)	(0.035)	(0.044)
lntrade	0.025	0.029	0.027	0.039	0.057*	0.008	0.031	0.054	0.027	0.072*
	(0.027)	(0.034)	(0.025)	(0.034)	(0.032)	(0.037)	(0.028)	(0.037)	(0.029)	(0.041)
lnfdi	0.001	0.015***	−0.001	0.014**	−0.009	0.014***	−0.003	0.014***	−0.002	0.015***
	(0.005)	(0.003)	(0.006)	(0.005)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.006)
lnurb	0.051***	0.071***	0.047**	0.084***	0.070***	0.058**	0.058***	0.119***	0.059***	0.129***
	(0.019)	(0.021)	(0.019)	(0.028)	(0.024)	(0.023)	(0.020)	(0.039)	(0.015)	(0.034)
lnoda	0.034**	0.059***	0.030*	0.065***	0.056**	0.066**	0.034*	0.067***	0.030*	0.069***
	(0.014)	(0.013)	(0.017)	(0.012)	(0.022)	(0.033)	(0.019)	(0.019)	(0.016)	(0.011)
Clean_dis	−0.438***		−0.339***		−0.450***		−0.364***		−0.403***	
	(0.121)		(0.119)		(0.080)		(0.126)		(0.133)	
lnsse	0.058**	0.274***	0.035	0.317***	0.115***	0.240***	0.058*	0.325***	0.072**	0.399***
	(0.024)	(0.033)	(0.027)	(0.039)	(0.037)	(0.054)	(0.030)	(0.042)	(0.036)	(0.037)
Polyarchy	−0.243*	−0.523***								
	(0.124)	(0.196)								
CC	−0.038	−0.011	−0.016	0.025	0.000	−0.039	−0.009	0.024	0.000	0.072*
	(0.028)	(0.039)	(0.036)	(0.041)	(0.060)	(0.083)	(0.036)	(0.042)	(0.027)	(0.041)
Elec_dis		−0.872***		−0.923***		−0.811***		−0.878***		−0.836***
		(0.100)		(0.120)		(0.091)		(0.117)		(0.118)
Libdem			−0.296*	−0.747***						
			(0.156)	(0.222)						
Partipdem					−0.854*	−0.599				
					(0.492)	(0.639)				
Delibdem							−0.434***	−0.789***		
							(0.163)	(0.258)		
Egaldem									−0.503***	−1.306***
									(0.154)	(0.250)
Constant	0.628	−1.665***	0.390	−2.198***	0.014	−1.470***	0.290	−2.115***	0.747	−1.839***
	(0.612)	(0.541)	(0.517)	(0.456)	(0.613)	(0.558)	(0.601)	(0.479)	(0.615)	(0.494)
Observations	281	237	281	237	281	237	281	237	281	237
Hansen	26.424	24.705	27.264	25.888	26.351	26.697	27.497	25.015	26.630	23.336
Hansen p-value	0.745	0.818	0.705	0.769	0.748	0.732	0.694	0.805	0.735	0.867
AR (1)	0.003	0.005	0.003	0.006	0.003	0.006	0.003	0.007	0.003	0.007
AR (2)	0.900	0.620	0.897	0.573	0.884	0.638	0.907	0.583	0.895	0.616
No. of instruments	43	43	43	43	43	43	43	43	43	43

Standard errors in parentheses. Hansen-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for first and second-order autocorrelation in first differences. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

positive effect on deforestation in West, Central, and Southern Africa, it has an insignificant effect on deforestation in Eastern Africa.

4.4. Accounting for corruption

In this section, we account for control of corruption (CC) in the model.[6] We replicated the results in Table 2 using the dynamic system-GMM estimator. We test if the unconditional effect of democracy and energy justice variables will be statistically insignificant or if their estimated signs will change after controlling for corruption. The results on the unconditional effect of energy justice and democracy variables are reported in Table 7. The coefficients of control of corruption are generally statistically insignificant except in Model 10 (Table 7) where it turns slightly significant (at 10% level). The results hence depicts that corruption does not play a significant role in influencing deforestation. Also, the results presented in Table 7 show the energy justice variables, which are rural-urban equality in access to electricity and rural-urban equality in access to clean fuels and technologies for cooking, still have statistically significant negative effect on deforestation at a 1% level. Similarly, Table 7 shows that electoral, liberal, participatory, deliberative, and egalitarian democracy have statistically significant negative effects on deforestation at a 5% level or better. These findings imply that accounting for corruption in our models does not change our earlier established impact of energy justice and democracy variables on deforestation.

The anonymous reviewer further argues that "*a corrupted system impacts democracy; therefore, our analysis of deforestation as a function of democracy is potentially missing the point that the association is due to corruption levels*." We, therefore, examined the interactive effect of corruption and democracy variables on deforestation. The interactive effect results are presented in Table 8. In Table 8, the results indicate that the interaction between control of corruption and democracy variables (electoral, liberal, participatory, and deliberative democracies) are positive but statistically insignificant [see Models 1–4]. The implication is that the effect of electoral, liberal, participatory, and deliberative democracies on deforestation are not moderated or conditioned by corruption. However, in Model 5, the results indicate that the interaction between egalitarian democracy and control of corruption is negative and statistically significant at 1%. This evidence shows that the role of an egalitarian democracy in reducing deforestation is strengthened whenever control of corruption increases. In summary, we argue that the role of corruption in conditioning democracy to affect deforestation depends on how democracy is conceptualized and measured in empirical analysis.

[6] We thank an Anonymous Reviewer for this comment. The Reviewer suggests that "*corruption brings the possibility of endogeneity in our model; thus, corruption provokes land degradation and also likely decreases energy justice and democratic conditions*." This issue raised by the reviewer implies that our failure to control corruption in our models could lead to endogeneity. In response to this, we accounted for corruption in our models.

Table 8
Interactive effect of democracy and control of corruption on deforestation after accounting for control of corruption (Dynamic system-GMM estimates).

	Model 1	Model 2	Model 3	Model 4	Model 5
L.lnnfp	0.850***	0.851***	0.858***	0.822***	0.809***
	(0.017)	(0.014)	(0.018)	(0.021)	(0.023)
lnrgdpc	−0.095***	−0.089***	−0.118***	−0.088***	−0.067*
	(0.024)	(0.016)	(0.025)	(0.022)	(0.038)
lntrade	0.038	0.025	0.069*	0.029	0.153**
	(0.046)	(0.045)	(0.038)	(0.035)	(0.072)
lnfdi	0.008	0.011*	0.008	0.002	−0.005
	(0.008)	(0.006)	(0.008)	(0.008)	(0.011)
lnurb	0.118***	0.123***	0.108***	0.154***	0.179***
	(0.022)	(0.022)	(0.030)	(0.024)	(0.043)
lnoda	0.050***	0.048***	0.074***	0.052***	0.060***
	(0.018)	(0.015)	(0.019)	(0.016)	(0.013)
lnsse	0.025	0.032	0.065**	0.102**	0.248***
	(0.050)	(0.059)	(0.032)	(0.052)	(0.088)
Polyarchy	−0.107				
	(0.286)				
CC	0.014	−0.046	−0.256	0.292	0.988***
	(0.192)	(0.151)	(0.181)	(0.199)	(0.318)
Polyarchy # CC	−0.163				
	(0.431)				
Libdem		−0.306			
		(0.357)			
Libdem # CC		0.083			
		(0.398)			
Partipdem			−0.724*		
			(0.395)		
Partipdem # CC			1.048		
			(0.679)		
Delibdem				−0.685***	
				(0.258)	
Delibdem # CC				−0.956	
				(0.592)	
Egaldem					−2.213***
					(0.511)
Egaldem # CC					−2.977***
					(1.024)
Constant	0.622	0.587	0.141	0.540	−0.291
	(0.493)	(0.407)	(0.510)	(0.443)	(0.765)
Observations	281	281	281	281	281
Hansen	26.434	26.861	25.952	26.522	27.316
Hansen p-value	0.439	0.417	0.466	0.435	0.393
AR (1)	0.004	0.003	0.003	0.002	0.001
AR (2)	0.815	0.889	0.964	0.696	0.288
No. of instruments	37	37	37	37	37

Standard errors in parentheses. Hansen-test refers to the over-identification test for the restrictions in system-GMM estimation. The AR (1) and AR (2) tests are the Arellano–Bond tests for first and second-order autocorrelation in first differences. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

5. Conclusion, policy implications, and directions for future research

The global climate change crisis has compelled global leaders to join forces to address the drivers of climate change. Forest plays a very substantive role in the fight against climate change by removing and storing carbon emissions from the atmosphere. Given the climate change mitigation effect of forests, national and international policymakers have intensified efforts to address the rising deforestation rate, especially in developing countries. A central question in this study is, "*Can countries address* deforestation *within the framework of energy justice and democratization*?" However, this question, which is very important for informing policies and contributing to scholarly discussions, is not addressed much in the literature from an empirical perspective. This study, therefore, addresses this research question by examining the role of energy justice and democracy on deforestation in SSA, a region with a relatively high deforestation rate, inadequate energy accessibility, and relatively less strong institutional capacity.

This study applied the dynamic two-step generalized method of moment estimator to estimate the impact of energy justice and democracy on deforestation using a panel of 47 SSA countries between 2000 and 2020. This study measured energy justice using rural-urban equality in access to electricity and clean fuels and technologies for cooking. To capture the multi-dimensionality of democracy, this study used high-level democracy indices such as participatory, deliberative, egalitarian, liberal, and electoral democracy. Our results pointed out that improving rural-urban equality in access to electricity and clean fuels, and technologies for cooking reduces deforestation. Similarly, participatory, deliberative, egalitarian, liberal, and electoral democracy were found to reduce deforestation for the entire SSA region. The interactive effect analysis further demonstrated that when there is improvement in democratic practices, the forest conservation effect of rural-urban equality in access to electricity and clean fuels and technologies for cooking intensifies. These findings were observed to differ among the sub-regions within SSA and are robust to the Driscoll-Kraay estimator. These results are robust even after accounting for control of corruption. For instance, our analysis pointed out that democracy is associated with increasing deforestation in West Africa and decreasing deforestation in Southern, Eastern, and Central Africa. Also, improving rural-urban equality in access to electricity and clean fuels and technologies for cooking increases deforestation in Southern Africa, but their effect remains insignificant in the rest of the sub-regions. Generally, urbanization, foreign direct investment, foreign aid, education, and trade openness were revealed to drive deforestation in SSA.

This study's outcomes have significant practical implications for energy transition, democratization, forest management, and the attainment of SDG13 in SSA. From an energy justice perspective, our analysis clearly highlights that achieving equality in energy access between rural and urban populations could contribute to forest protection and conservation in SSA. In SSA, there is vast inequality in access to electricity and clean fuels, and technologies for cooking between rural and urban populations, and our findings call for the need to bridge this inequality. First, the energy inequality gap can be closed through education and awareness programmes. Available evidence suggests that some rural folks find it challenging to deploy clean fuels and technologies for cooking for the household activities such as cooking due to safety and cultural reasons (Stanistreet et al., 2019; Williams et al., 2020). Bridging access to the energy gap between rural and urban populations demands policymakers prioritize the need for public education and awareness of safety procedures to follow on using clean fuels and technologies for cooking. In addition, inequality in energy access can be closed by sensitizing rural folks to use clean fuels and technologies for cooking for their health and the protection of the environment. These programmes would contribute to demystifying the negative perceptions of using clean fuels and technologies for cooking in rural areas. Secondly, energy accessibility inequality between rural and urban folks has been driven by challenges such as poor infrastructure developments (road networks), poor human capital in managing energy infrastructure, and urban bias policies. Therefore, this study recommends that equality in energy access between rural and urban areas can be achieved through political commitment, implementing rural electrification and clean fuels and technologies for cooking programmes, skills training and extension, and upgrading rural infrastructure. Third, it is more costly in monetary terms to use clean fuels and technologies for cooking (e.g., LPG, cooking stoves, and LPG cylinders) than dirty fuels (e.g., firewood, charcoal, etc.) by rural folks; therefore, discouraging rural population to use the clean fuels and technologies for cooking. The study recommends that to make the rural population adopt and sustain the usage of clean fuels and technologies for cooking demand, policymakers should design and implement rebate policies that would make these technologies more affordable. Rural and distant communities faced infrastructure challenges, making an extension of national grid to these areas costly. As a solution, investment and expansion of mini-grid and off-grid solutions to rural and distant communities is another mechanism to support energy transition and inclusiveness and further reduce the cost that would be incurred if the national grid were to be extended to these vulnerable communities. Facilitating mini-grid and off-grid solutions could be supported by policies that create the enabling environment for the private sector to invest in these energy solutions.

The REDD + programme is also considered one of the major initiatives in battling deforestation. REDD + reduces deforestation through the conservation and sustainable management of forests and helping developing countries in converting their political commitments to action (UN-REDD, 2022). The initiative promotes the participation and inclusion of indigenous peoples and local communities in forest-based climate solutions. The REDD + programme enhances democratization as it employs a strong human rights-based approach. The programme is directly connected with the rights of indigenous people and local communities, who are residents and custodians of forests. It enhances social inclusion and equity in forest matters and management. Hence, the adoption of REDD+ is a way of empowering people affected by forests, enhancing democratization, and ensuring justice to mitigate deforestation.

From a political economy and ecology perspective, our evidence shows that enhancing democratic practices in SSA would contribute to addressing deforestation. This study suggests that democratic practices that ensure direct rule and active participation by citizens in all political decisions; protection of individual and minority rights against majority domination and state tyranny; freedom of expression, association, and voting; distribution of political power equally to citizens, and political decisions relating to activities that are of public interest would enhance forest conservation in SSA. These democratic practices would provide fertile grounds for improving forest conservation through energy democracy and justice. This study claims that forest management policies that neglect the role of the efficacy of political institutions and energy justice would fall short of achieving its purpose. Therefore, it is recommended that policymakers should prioritize the efficacy of political institutions and energy justice when designing forest management policies in SSA. In summary, this study suggests that policies that enhance democratization and energy justice between rural and urban populations would contribute to forest management and mitigate climate change in SSA.

Despite the numerous strengths of our paper, there is still an avenue for future research. This study operationalizes energy justice only to capture rural-urban equality in access to electricity, clean fuels and technologies for cooking. However, the definition of energy justice is broad; therefore, future studies can provide alternative measures beyond rural-urban equality in access to energy to assess their contribution to forest conservation. In addition, our study focuses only on SSA; however, future research can extend our study to other developing regions with higher deforestation rates and energy poverty, such as South Asia, the Caribbean, and Latin America. Such extension would help to appreciate the contribution of energy justice and democratic regimes in managing forests in developing countries.

CRediT authorship contribution statement

Alex O. Acheampong: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Eric Evans Osei Opoku:** Conceptualization, Methodology, Formal analysis, Writing – original draft.

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.

Data availability

Data will be made available on request.

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Appendix

Appendix Table 1A
Sub-Saharan African countries included in the analysis.

Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

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