PROAKSARA

Review of International Economic, Taxation, and Regulations

Journal homepage: https://ojs.proaksara.com/index.php/rietr

Climate Change and Agricultural Exports in Sub-Saharan Africa: The Mediating Roles of Institutional Capacity

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ARTICLE INFO

Article History
Received : 25.01.2025
Revised : 21.02.2025
Accepted : 18.03.2025

Article Type :
Research Article

ABSTRACT

This study investigated the effect of climate change on agricultural exports in Sub-Saharan Africa (SSA) region taking into consideration the mediating effects of four (4) institutional capacity variables. The study covered 29 sampled SSA countries from 2013 to 2022. The study adopts the System Generalized Method of Moments (SGMM) estimation technique. The System Generalized Methods of Moments (SGMM) reveals that climate change positively influences agricultural exports. However, government effectiveness and accountability had a negative significant effect on agricultural exports. Interaction effects show that government effectiveness, political stability, regulatory frameworks, and accountability positively mediating the effect of climate change on agricultural exports but rule of law has a negative mediating effect. Robustness tests (Hansen J and serial correlation tests) both confirm that the model and instruments are reliable. The study submits that, the SSA region can optimize the benefits of climate change while addressing regulatory and legal constraints by leveraging on effective governance and institutional frameworks. Lastly, the SSA government builds robust, effective institutions to improve governance and accountability.

Keywords: Climate Change, Agricultural Exports, Sub-Saharan Africa, Mediating Roles, Institutional Capacity

1. INTRODUCTION

Although an increased agricultural export is key to sustained economic growth, diversification and improved standard of living, high foreign exchange earning capacity, high revenue base, and rising employment, among others (inter-sectoral complementarity) (Ozekhome, 2022), efforts at increasing agricultural exports in the SSA region have so far, not yielded the desired results. Various identifiable factors advanced over the years include, but are not limited to, adverse climate change, poor institutional capacity/support, poor macroeconomic policy environment, structural rigidities and the high cost of importing capital machinery in the agricultural sector. Many SSA countries, including Nigeria, lag considerably behind the world's developed countries in the ability to mitigate the adverse effects of climatic changes/conditions and in the quality of institutions needed to drive rapid agricultural production capacity for exports.

Ozekhome & Okeowo (2022) stressed that the challenges above have substantially contributed to the region's poor agricultural output partly because of a lack of resolution to tackle the challenges headlong. Food and agricultural exports are greatly influenced by weather conditions and the policy and institutional framework (Food and Agriculture Organization, 2011). Without a doubt, the effects of erratic changes in weather patterns (i.e., climate change) present significant challenges for the populations of poor and economically fragile countries, particularly for countries that are highly vulnerable to crisis and instability (Maino & Emrullahu, 2022). Therefore, this rationalizes why the unfavourable climate conditions in SSA have been an urgent issue.

Given the consensus of a shift in earth's climatic status by the end of this century (The Intergovernmental Panel on Climate Change, 2018), there are national, regional, and international concerns about the impacts of climate change on agriculture in the short, medium, and long-run and the role institutional capacity plays as an intermediating variable in the nexus. These concerns have led to increased empirical investigations into the nexus between climate change, institutional capacity and agricultural output. Weak governance, poor institutional framework, and conflicts also significantly affect their economies, particularly through the agricultural export capacity channel, exacerbating their vulnerability to climate change. Numerous macroeconomic gains in greater productivity abound by investing in resilient infrastructures and climate adaptive change technologies. Conflict over land and natural resources, access to basic social services and other measures have also increasingly been associated with climate change's effects (Navone, 2021).

On the role institutional capacity plays in climate change-agricultural exports, robust institutional settings help mitigate climate change's unfavourable impact on agricultural production for exports. Institutional capacity thus moderates the effect of climate change and its vulnerability on agricultural output (Abegunde et al., 2019; International Monetary Fund, 2017). Similarly, good and favourable institutional setups (which include policy responses, initiatives, strategies, and the needed structure) help achieve the agricultural export strategy. Thus, the export drive may not be achieved without strong legal and political backing institutions supported by effective government capacity. Institutional capacity strengthens structural transformation towards export diversification (International Monetary Fund, 2017; Ozekhome, 2022). The institutional framework is the pivot for climate change adaptation and mitigation. Adaptation to and mitigation of climate change cannot be achieved without strong institutional structures that support policy responses and initiatives. Climate change adaptation and mitigation can only be successful with good institutional backing (Hallegatte et al., 2017; International Monetary Fund, 2017). SSA's average institutional quality index hovered around -15.8 within the period 1990-2015, according to the World Bank (2021). The weakness manifests mainly in poor legal framework, weak government capacity to implement the right policies and necessary reforms for a structural transformation, sickening corruption, lack of transparency and accountability and socio-political instability and tensions (Ozekhome & Okeowo, 2022).

Nevertheless, this study stands out as most of the pioneering works in this respect are based on developed countries. Developing regions, such as SSA, are more vulnerable to climatic shifts because of the agriculture-dependent structure of the economies, poverty, credit constraints, dearth of adaptive technology, and the rain-fed character of farm products (Allen et al., 2014). Burke et al. (2015) attribute the cause of economic output loss emanating from climate change to the already hot conditions of developing regions (including SSA). Thus, this study contributes to the extant body of knowledge as it expands the frontier of knowledge in the field by seeking to provide insights on whether and the extent to which the interaction of institutional quality with climate change moderates the adverse effect of climate change on agricultural exports in SSA, through climate adaptive and mitigation policy frameworks. Again, this study stands out in its use of recent methodologies to analyze the relationships.

While most of the previous studies (Abegunde et al., 2019; Emediegwu et al., 2022; International Monetary Fund. African Dept., 2020) have relied on static panel estimation techniques which did not take cognizance of the dynamic structural and time-varying peculiarities of the different economies incorporated in the studies. This study considers these limitations by employing the panel system Generalized Methods of Moments (GMM). Again, the study contributes to the academic discourse on sustainable diversification that can enhance sustainable growth for the lagging SSA counties. To this end, this study is relevant as it would enable SSA governments, policymakers, and stakeholders to understand the dynamics of climate change, institutional quality, and agricultural exports nexus in terms of the empirically oriented policy perspective to be generated from this study. The study, therefore, enables them to determine policy and institutional interventions for mitigating the negative impact of externally generated shocks from climate changes on agricultural exports. The study also provides useful insight to investors, individuals, and domestic and foreign donor/support agencies/multilateral funding institutions like the Foods and Agricultural Organization (FAO) on areas of global collaboration, policy coordination, and harmonization concerning agriculture. Finally, the study will serve as a stepping stone for further research in the academic community on the subject matter.

The broad objective of this study is to empirically examine the relationships among climate change, institutional capacity and agricultural exports in SSA countries. The specific objectives are to:

1. Determine the extent to which climate change influences agricultural exports in SSA countries.
2. Investigate the impact of institutional capacity on agricultural exports in SSA countries.
3. Examine whether institutional capacity mediates the effects of climate changes on agricultural exports in SSA.

2. LITERATURE REVIEW

2.1. Stylized Facts on Climate Change in SSA

Available statistics indicate, for instance, that one-third of the world's droughts occur in SSA and the frequency of storms and flows in this region is on a rising trend (International Monetary Fund. African Dept., 2020). Rising temperatures, rising sea levels, and rainfall anomalies have translated into an acceleration of climate-induced natural disasters in the SSA region. Table 1 shows the trends in proxies for climate change.

Table 1. Trends in Proxies for Climate Change (1980-2020)

Average Temperature	1.2 °C
Precipitation Average	810.5mm
Average Annual rainfall	92.5-mm

Source: WDI (2022)

According to Juana et al. (2013), the climate trend in Africa shows an increased temperature of about 0.7 °C average, including a rise in the temperature trend of all SSA regions. The summer temperature in Africa is projected to rise at about 1.5 °C above baseline until 2050, while a high-emission set-up in sub-Saharan Africa is expected to hit warming till the end of the century, attaining 5 °C above the baseline by 2100 (Harvell et al., 2002). A decline in rainfall in the semi-arid region of the sub-Sahara and increased rainfall in East and Central Africa combine to reinforce the adverse effects of climate change. A higher temperature leads to poor agricultural output and agricultural export capacity. For instance, a 1ºC temperature increase generates a 1.2 percentage decline in agricultural output (Maino & Emrullahu, 2022). These trends are expected to continue for a considerable period, coupled with an upsurge in sea level and the frequency of drought and flood (Juana et al., 2013). With the region's weak capacity to implement climate-change adaptive technology and resilient infrastructure to boost agricultural productivity, agricultural exports inevitably grow very slowly.

2.2. Institutional Capacity in SSA

Sub-Saharan Africa lags behind on institutional capacity and agricultural exports as the World Bank (2021) shows that the region is challenged by a poor/weak institutional framework that militates against growth and structural transformation. The region's institutional quality stood at an average of 0.65 in 1990-2005 and 0.01 within 2012-2021. A standard deviation of 2.21 implies a higher level of variability/divergence in institutional strength among SSA countries, with some performing very low compared to the average and others performing high in the institutional quality index, with countries like Botswana, South Africa, Cape Verde and Seychelles performing highly above the average in the region. Analogously, the mean institutional quality index for the SSA region in 2022 was -0.96 with a standard deviation of 1.86, showing wide variation and dispersion from the observed mean, implying that most SSA countries performed below average in institutional quality.

The World Bank (2022) reported an institutional performance index of 6.7 for Latin America and the Caribbean, 3.2 for the Middle East and North Africa, 5.3 for Europe and Central Asia, South Asia 4.9 and OECD High-Income countries 9.35. The institutional environment in SSA is weak, particularly regarding the rule of law, government effectiveness policy, political stability and control of corruption (Maino & Emrullahu, 2022). Most SSA countries are characterized by incessant conflicts and internal wrangling or are impaired by political instability, a pointer to weak institutional capacity in the region.

Tables 2 show institutional quality across several regions of the world, including SSA countries, measured on five key institutional quality variables: government effectiveness (Geff), political stability (Polstab), regulatory quality (Regulatory framework), Rule of Law and accountability (Acc).

Table 2. Institutional Capcity: Regional Averages/ Comparison (2012-2021)

Region	GEFF	PolStab	Reg	Rule of Law	Acc
Europe & Central Asia	1.1	1.21	1.25	1.87	1.95
Latin America & Caribbean	0.76	0.95	1.17	1.55	1.76
Middle East & North Africa	0.82	0.11	1.02	0.92	0.52
OECD	1.93	2.35	2.28	2.43	2.23
South-Asia & Esat Asia	1.77	1.67	1.98	2.02	2.15
Sub-Saharan Africa	-0.02	-1.72	-0.72	0.76	-0.71
West Africa (ECOWAS)	-1.56	-1.12	-1.65	-0.89	-1.1.9

Source: Author's calculation: Underlying Data from World Bank World Development Indicators (WDI)

2.3. Agricultural Exports in SSA

Available statistics reveal that between 1988 and 2014, the growth in world agricultural exports was US$1,448.6 billion, rising from a small US$83.4 billion to US$1,532 billion, a 1.736.93 per cent growth rate. Comparably, agricultural exports from SSA rose by US $41.7 billion, from US US$2.7 billion to US$44.3 billion (UN COMTRADE). Consequently, SSA's share in world agricultural exports declined from 3.3 per cent in 1988 to 2.9 per cent in 2014. In contrast, the proportion of processed and semi-processed agricultural export products from SSA was approximately 75 per cent of global agricultural exports (Fukase & Martin, 2018).

Table 3. Dominant Agricultural Export products in SSA Countries

S/N	Countries	Dominant Agricultural Exports
1	Angola	Coffee, Sisal, Sugar cane, Banana, Cotton
2	Benin	Cotton, Cashew, Shea butter, cooking oil and raw copper.
3	Botswana	Livestock and cattle rearing, Diamond, gold
4	Burkina Faso	Cotton
5	Cameroun	Sawn wood, cocoa, cotton, coffee
6	Central African Republic	Maize, rice, sorghum and millet
7	Chad	Cotton, gum Arabic and livestock
8	Congo, Dem. Rep	Coffee, palm oil, rubber, cotton, sugar, tea and cocoa
9	Congo, Rep.	Coffee, Sawn timber, wood products
10	Cote d'Ivoire	Cocoa, rubber, kolanuts, cashew and yams
11	Equatorial Guinea	Cocoa
12	Ethiopia	Coffee, oil seeds, pulses, live plants and cut flowers.
13	Gabon	Rubber and palm oil
14	Ghana	Cocoa seed/beans, cashew nuts, peanuts, groundnuts
15	Guinea	Cashew, cocoa, and coffee
16	Liberia	Rubber, oil palm, cocoa and timber
17	Madagascar	Rice, coffee, cloves, vanilla
18	Mali	Cotton and cereals (including rice, millet, sorghum and wheat).
19	Mauritania	Cattle, hides and skins, and gum Arabic
20	Mozambique	Sugar, tobacco, cotton and cashew nuts
21	Namibia	Livestock, meat products, and grapes
22	Niger	Livestock, millet and sorghum
23	Nigeria	Palm oil, Sorghum, Cocoa, rubber, groundnut, Oil, fruits, seeds
24	Sierra Leone	Cocoa beans, coffee, livestock
25	South Africa	Citrus, table grapes, wine and a range of deciduous fruits
26	Sudan	Livestock, oil, Arabic gum, cotton
27	South Sudan	Millet, Groundnut
28	Swaziland	Citrus, sugar, pineapples and cotton, tobacco, fruits and vegetables, raw sugar, sawn woods
29	Tanzania	Cashew nuts, coffee, cotton, sisal, sugar and tea
30	Zambia	Sugar, tobacco, gemstone and cotton.
31	Zimbabwe	Tobacco

Source: Author's compilation: Underlying data from FAO, World fact book and World Bank World Development Indicators

Table 3 shows the distribution of primary agricultural produce across Africa. According to statistics from the International Monetary Fund (IMF) (2020), the major agricultural exports in Angola include coffee, sisal, sugar cane, bananas, and cotton. In Benin, Cotton, cashews, shea butter, cooking oil, and raw copper are prominent exports. While known for livestock and cattle rearing, Botswana also exports diamonds and gold, though these are not strictly agricultural products. In Cote d'Ivoire, Cocoa, rubber, kola nuts, cashew nuts, and yams are key agricultural exports. Citrus fruits, table grapes, wine, and various deciduous fruits are major exports in South Africa. Meanwhile, tobacco is the dominant agricultural export in Zimbabwe.

Overall, some countries, like Botswana, include non-agricultural products (e.g., diamonds and gold) among their top exports, highlighting the diversity of their export base. However, countries like Ethiopia and Madagascar have a variety of agricultural exports, including coffee and spices. Lastly, the table reflects some common crops and products across the region, such as cotton, Cocoa, and coffee.

2.4. Synthetized Literature and Gaps in the Empirical Literature Reviewed

Various gaps were recorded based on the extensive empirical review presented in Table 4. Firstly, a critical area that the empirical literature has not considered in the climate change-agricultural output nexus is the fledging issue of the impact of institutional capacity on the climate change-agricultural productivity nexus, particularly the moderating role of quality institutional settings in mitigating the effect of climate change through the adaptive framework. Apart from the critical role institutions play in providing the required environment for agricultural export-induced growth, institutions provide favourable settings for climate change- mitigating adaptive mechanisms through quality structures and relevant policies.

Secondly, While the dominant literature (Abegunde et al., 2019; Abidoye & Odusola, 2015; Animashaun & Ajibade, 2020; Dessalegn Obsi Gemeda & Akalu Dafisa Sima, 2015; Emediegwu et al., 2022; International Monetary Fund. African Dept., 2020) studies have largely focused on the traditional climate change- economic activities nexus, emphasis has not been laid on agricultural export capacity, given the economic and structural peculiarity of the SSA region as being heavily dependent on agricultural exports for their economic sustenance, in addition to the policy drive and push for economic diversification, sustainable and diversified food production, through greater agricultural productivity, by delinking most of SSA economies from the over-bearing dependence on the volatile influence of mineral resources.

Thirdly, whereas efforts have been made to investigate the impact of climate on agriculture in SSA empirically (Animashaun & Ajibade, 2020; Blanc, 2012; Brini, 2021), as well as the nexus between climate change and adaptation (Omer & Capaldo, 2023; Totin et al., 2018; Wen et al., 2023), e.t.c, there is a paucity of evidence, if any, at unravelling the dynamics through which the climate change can be mitigated on agricultural output/ agricultural export capacity, which the study intends to bring to the fore in the subject matter. Furthermore, while the extant literature has largely utilized direct and indirect estimation approaches, with the exception of a few studies that employed GMM (see, for instance, Animashaun & Ajibade (2020)), this study will fill this omission gap by employing the dynamic system-GMM estimation that effectively accounts for country's heterogeneity, structural and peculiar economic characteristics, unobserved fixed and time-variant effects in modelling the climate change-institutional capacity-agricultural exports nexus, which to the best of my knowledge, is appropriate for a study of this nature.

Table 4. Summary of Empirical Findings

S/N	Name of Author/ Year of study	Period of Study	Country/ Region of study	Methodology	Findings
1.	Hsiang (2016)	1981-2013	USA	Climate metric decomposition system	Changes in climate exert detrimental impacts on economic activities/output
2.	Sova (2017)	1970-2018	Sample of developing countries	Panel quantile regression	Climate change and its vulnerability indices conflict in poor countries.
3.	Hallegatte et al. (2017)	1990-2012	Large sample of African and Asian countries	GMM	Institutions are critical to agricultural productivity, particularly in the building of

					economic resilience against climate change in developing countries
4.	International Monetary Fund (2017)	2015	90 developing countries	Panel ARDL	Strong institutions help to promote agrarian revolution through adaptation to climate change, drive growth and ensure stability through effective policy decisions.
5.	Harari & Ferrara (2018)	2005-2012	Africa	System –GMM	Climate change reduces agricultural output and induces conflict in Africa.
6.	Kompas et al. (2018)	2017	31 developing countries	GMM	Individual country-level variation in weather induces productivity differentials in agriculture, Also, adoption of the Paris climate accord results to beneficial outcomes I n agriculture.
7.	Liu et al. (2018)	2007- 2017	132 countries	Panel quantile regression and dynamic system-GMM based on a metric system.	Climate change, cohesion and economy, are significantly associated in Africa. Africa and South America have worse conditions with respect to climate change compared to Europe.
8.	Kutya (2019)	2000-2015	Africa	Panel data	Climate change is negatively associated with agricultural output performance and adoption of climate adaptation strategies can raise productivity of agriculture.
9.	Rudebusch (2019)	1980-2007	SSA	Spatial analysis	Climate change causes lower agricultural productivity and induces conflict in fragile states of Africa.
10.	Abegunde et al. (2019)	2015	Africa	Conceptual and descriptive Statistics	Climate change has adverse impacts on agricultural output and adoption of climate- smart-agriculture leads to improvement in agricultural output.
11.	Tol (2023)	2014	African and Asian countries	Descriptive and counterfactual sensitivity approaches	Climate change, particularly, temperature is negatively associated with farm output. A reduction in severe temperature raises the productivity of agriculture. Thus, adoption of climate mitigation adaptation policies and strategies will significantly improve output of agriculture.
12.	Ezeh & Lu (2019)	2012-16	SSA countries	Descriptive statistic	Poor government investments in institutional framework impacts output. The study further finds that lack of strong institutions diminishes growth/output.
13.	International Monetary Fund. African Dept. (2020)	1983-2017	SSA	GMM	Economic activity in a given month decreases by 1% for an average temperature of 0.5°C above the month's 30-year average.
14.	Animashaun and Ajibade (2020)	1985-2017	SSA countries	GMM	Specifically, country-level variations in temperature, precipitation and social and economic adaptive capacities are related to the economic

					performance of SSA countries. Also, an increase in temperature (in contrast to precipitation) accounts significantly for a decline in economic performance.
15.	Klapkiv et al. (2020)	2000-2019	Ukraine	Conceptual and descriptive statistics and	Strong institutions promote agricultural output and economic activities in Ukraine. Weak institutional capacity breeds conflict and corruption, and thus poor economic outcomes.
16.	Kahn et al. (2021)	2023	Cross-country involving developed and developing countries	GLS and counter-factual analysis	Frequent changes in temperature negatively and significantly influence per capita income but not significant in the case of precipitation
17.	Ntinyari & Gweyi-Onyango (2020)	1982-2015	SSA countries	Panel Quantile regression	Climate change, greenhouse emissions and agricultural fertilizer use, affect SSA's agricultural output.
18.	Brini (2021)	1990-2019	African countries	Dynamic GMM	Climate change induces negative and significant impact on agricultural output.
19.	Sandalli (2021)	2000-2017	SSA countries	Panel quantile regression and spatial analysis	Variations in temperature negatively affect economic output although no robust relationship is found between precipitation and income growth.
20.	Amegavi et al. (2021)	1995-2018	51 African countries	Panel quantile regression approach	Climate adaptation readiness has a significant negative impact on climate vulnerability in the region. Further findings show that Central Africa has the highest climate vulnerability, while South and North Africa have the lowest vulnerability in Africa.
21.	Ozekhome (2022)	1980 -2021	Nigeria	ARDL	Institutional quality is positively related to export expansion in the long-run, while macroeconomic instability is inversely related. Strengthening the institutional capacity is thus critical to export expansion drive.
22.	Maino & Emrullahu (2022)	1980- 2019	20 fragile SSA countries	panel fixed effects and panel quantile regression	Fragility is connected to structural weaknesses, government failure, and lack of institutional structures, with intensified risk of climate change
23.	Emediegwu et al. (2022)	1970–2016.	African countries		Variations in weather have significant contemporaneous effects on output of millet.
24.	Tao et al. (2023)	1996-2021	Sample of Asian and European countries.	Dynamic GMM estimation technique	A spatial link and dependence between climate change and technological innovation exists..
25.	Omer & Capaldo (2023)	1995-2019	South-Africa	ARDL	Climate mitigation induces greater output, productivity growth, as well as higher employment and reduces inequality.

26.	Wen et al. (2023)	1995-2019.	107 developed and developing countries	System-GMM estimation approach	Socio-economic climate vulnerability reduces green investment, while physical vulnerability increases investment output.
27.	Abid et al. (2023)	1981-2018	18 European countries	Panel quantile regression	Climate change mitigation is incapable of stimulating output growth when based on an aggregative or comprehensive approach.
28.	Wen et al. (2023)	1995-2019	107 developed and developing countries	Sysrem-GMM	Climate vulnerability reduces green investment output, and on the other hand, climate change mitigation and climate change adaptation technologies enhance output.
29.	Husssein (2023)	1991- 2015	31 SSA countries	Two-step system-GMM estimation	Investment-enhancing democratic institutions as well as regulatory institutions have significant positive impact on economic outcomes. However, interacting institutions with other variables render conflict-preventing institutions to have an insignificant impact on output productivity and growth.
30.	IMF (2023)	1990-2021	Saudi-Arabia	ARDL	Sustaining the momentum of institutional and economic reforms enhances export drive away from oil to other critical-growth driving strategic sectors.

Source: Author's Compilation, 2023

3. RESEARCH METHODS

3.1. Population of the Study

This paper covered all the 46 SSA countries spanning from 2013 to 2022. However, 29 SSA countries were sampled, which are Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Congo Democratic Republic, The Republic of Congo, Cote D'Ivoire, Equatorial Guinea, Ethiopia, Gabon, Ghana, Guinea, Liberia, Madagascar, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Sierra Leone, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. The justification for the choice of these countries is that they account for over 80% of the total Gross Domestic Product in SSA, 85% of the total agricultural capacity in SSA and 60% of SSA countries (African et al., 2013; IMF, 2022). The countries are also characterized by adverse and abrupt weather changes and poor institutional capacity that tend to affect agricultural production/ export even though the region boasts of abundant natural resources, including human (large population), as well as material and natural resources like minerals, agricultural produce, rich vegetation, forestry and even wildlife.

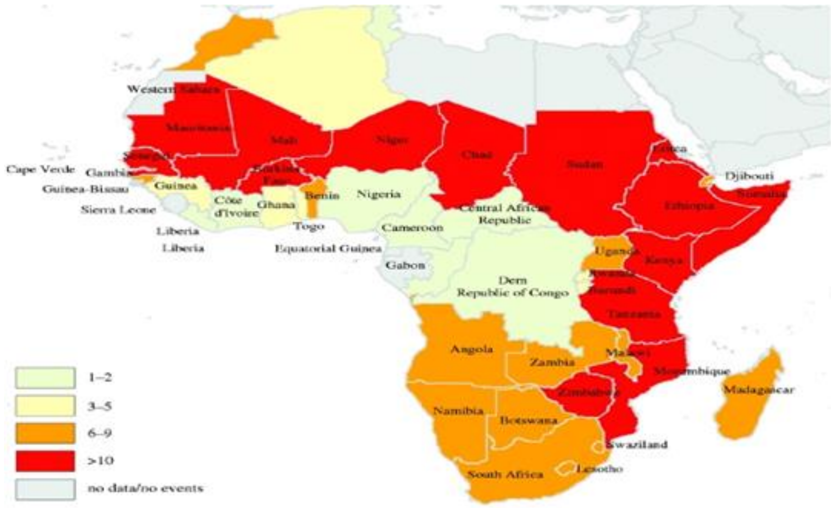

Figure 1. Africa Map showing Sub-Saharan African countries and vulnerability of drough from 1970 till 2014

Source: Adapted from Animashaun and Ajibade (2020)

3.2. Sources of Data and Time Frame

Data on climate change were obtained from the Climate Watch CAIT data set. All the other data were sourced from the World Development Indicators (WDI) of the World Bank, ranging from 2013 to 2022 for 28 sampled SSA countries. The Justification for the included Variables, Variable Definition and Measurement are presented thus:

3.2.1. Agricultural Exports

Agricultural exports, the dependent variable, were measured as the share of agricultural exports in total exports (expressed as the ratio of agricultural exports to total exports per cent). This is a major departure from extant studies such as Animasahaun and Ajibade (2020), IMF (2020) and Emediegwu et al. (2022), which focused on agricultural outputs. Suffice it to say that an increase in agricultural output does not automatically translate to an increase in exports as policy and institutional variables.

3.2.2. Climate change

Climate change refers to unpredictable alterations in climate patterns, such as temperature and weather conditions, over time. It connotes unexpected variations in weather conditions, such as temperature, rainfall, drought, flood, heat, cold and biodiversity, with consequences for agriculture. Climate variability implies the changeability of climate conditions over time.

3.2.3. Institutional Quality

Institutions are critical for driving macroeconomic outcomes. They influence policies and their implementation. Good institutional quality enables the right policy formulation and provides strong anchors and mechanisms for driving agricultural exports. In other words, robust institutions are the bedrock for achieving set outcomes. In addition, good institutional settings enhance climate change adaptation and mitigation solutions. Good institutions provide a supportive framework for steering macroeconomic objectives in the case of imperfections or limiting factors in the working system (Acemoglu et al., 2001).

Similarly, a quality institutional framework helps mitigate climate change and its unfavourable economic impact (Abegunde et al., 2019; Nyiwul, 2019). Similarly, a supportive institutional framework drives adaptive climate change policies, initiatives, and strategies (Hallegatte et al., 2017; International Monetary Fund, 2019; Partey et al., 2018). Institutional quality would be measured by the composite index of institutional quality developed by the World Bank.

3.3. Estimation Technique

The study adopts the System Generalized Method of Moments (SGMM) estimation technique. The system GMM was introduced by Arellano & Bond (1991), Arellano and Bover (1995), and Blundell & Bond

(1998) as suitable for estimating dynamic models of panel data. It helps overcome the problem of unobserved period and country-specific effects and the joint endogeneity of most explanatory variables with economic growth. Country and time-fixed effects are used to control for country heterogeneity and the effects of common outcome shocks across countries. The system GMM is chosen over other types of GMM estimators, like the first difference GMM, because it is more robust in cases of missing data and accounts for simultaneity bias and reverse causality. It also allows lagged values of the dependent variables to enter the equation as instruments rather than explicitly as regressors. Prior to the main empirical estimation, the data series would be investigated using preliminary statistical tools, including descriptive (summary) statistics to show the relationship and initial characterization among the dataset) correlation matrix to examine the nature and degree of the relationships among the variables, as well as a pre-diagnostic cross-sectional dependence test to examine the correlations in the residuals within the cross-sections of the panel. These preliminary tests and analyses are to ensure a good fit. Similarly, several key post-diagnostic tests such as Sargan's test, Hansen-J statistics and Arellano-Bond serial correlation test were conducted to check for the robustness of model results.

3.4. Model Specification

3.4.1. Theoretical Model

The theoretical basis of this study is the pollution halo theory of climate change-cum- institutional outcome nexus. The driving force for its adoption lies in its ability to critically explain climate change and institutional capacity in moderating the effects of climate change on outcomes through robust climate adaptation and mitigation approaches (see IMF, 2017; Hallegatte et al., 2017 IMF, 2019, 2020). The theory further states that through robust and favourable environmental regulations and policies, developing countries may be able to compete against the low availability of infrastructure compared to developed countries.

Following Jones [1998], the aggregate production function is captured as

Y= IKα (AL)1- α (3.1)

Where Y= Real output (i.e., real GDP (a measure of economic growth), I denote the influence of an economy's infrastructure on the productivity of its input. K and K are capital, decomposition human and physical capital. A measure of the efficiency of inputs, reflecting total factor productivity or technology. L is labour stock, α and 1- α characterize the elasticity of output concerning capital and labour, respectively,

Modifying Jones [1998], agricultural export productivity is captured as

Y= CIKα(AL)1- α (3.2)

Where Y= output, C is climate change, I denotes the influence of a country's social infrastructure, which refers to institutions and government policies on the productivity of its inputs (see Abhuzeid, 2012), K is capital stock, disintegrated into human and physical capital. A is a measure of technology (i.e. total factor productivity, i.e. a measure of the efficiency of factor inputs in agriculture, L is labour stock, α and 1- α, indicate the elasticity of output concerning capital and labour, respectively, where α is a parameter between 0 and 1 (Ozekhome, 2019). Inherent in this model is, thus, the view that the infrastructure of an economy (I), relating to the government policies and institutions that constitute the economic environment, are important determinants of output and moderating the effect of climate change on output. Institutions and government policies affect agricultural exports using the total factor productivity and investment channels. Consequently, variations in the intensity of agricultural export output among SSA countries could arise from differences in government policies and institutions that mitigate the impact of climate change on output. A country that attracts considerable investments in the form of human capital, technology transfer from abroad and skills of individuals will thus be one in which (a) the institutions and laws favour production, (b) the economy is open to international trade and competition in the global marketplace and (c) the economic institutions are stable (adapted from Jones, 1998)

Taking the rate of change of output concerning the variables,

$\frac{\partial(Y)}{\partial(C)} < 0$; $\frac{\partial(Y)}{\partial(I)} > 0$; $\frac{\partial(Y)}{\partial(K)} > 0$, and $\frac{\partial(Y)}{\partial(A)} > 0$ (3.3)

Equation (3.3) shows the respective rate of change of agricultural export output (Y) concerning climate change (C), institutions (I), capital stock (K), and total factor productivity (i.e. technological progress or efficiency of factor inputs) (A).

3.4.2. Empirical Model

Following the theoretical framework, to empirically investigate the extent to which climate change and institutional capacity and their interaction impact agricultural exports, an adapted form of the model used by the IMF (2022) is utilized. It is based on the need to model the relationship in the context of the implied variables. In empirical form, the links among climate change, institutional capacity and agricultural exports are captured as:

$$AGE_{it} = f(CLC_{it}, INST_{it}\ X_{it}) \qquad (3.4)$$

Where is the dependent variable, which is Agricultural exports, CLC is climate change, INST represents institutional capacity/quality, the subscript I represents the country in a given period, and t is a year-fixed specific effect, is a vector of other regressors, i.e. policy control variables, included in the model as control variables which are essential in an agricultural export model for the SSA region but are not correlated with the error term, in line with literature that influence agricultural exports and in turn impacts on the relationship (see Animashaun & Ajibade, 2020). Incorporating these variables to produce the extended version leads to the following system-GMM model specified:

$$AGE_{it} = \alpha_0 + \alpha_1 AGE_{it-1} + \alpha_2 CLC_{it} + \alpha_3 GOE_{it} + \alpha_4 POS_{it} + \alpha_5 RGF_{it} + \alpha_6 ROL_{it} + \alpha_7 ACC_{it} + \alpha_8 CLC_{it} * GOE_{it} + \alpha_9 CLC_{it} * POS_{it} + \alpha_{10} CLC_{it} * RGF_{it} + \alpha_{11} CLC_{it} * ROL_{it} + \alpha_{12} CLC_{it} * ACC_{it} + \varepsilon_{it} \qquad (3.6)$$

Where α_0 is intercept or mean, the subscript it represent the ith country in a given time period; α_1 *is the coefficient of the lag of the dpendent variable*, α_2 and α_3 are the coefficients of the main independent variables of interest and α_4 *and* α_8 are the coefficients of the interaction variables, whileα_5 $\alpha_6\alpha_7\alpha_9$, $\alpha_{10}$of the policy control (intervening) variables. *A* country - specific fixed effect is assumed for the disturbance term as follows:

$$\varepsilon_{it} = e_i + \mu_{it} \qquad \text{……………………………………………………………………………………………(3.7)}$$

Where ε_{it} represents error term. It entails e_i, which represents country-specific fixed effects that are time invariant, while, μ_{it} is assumed to be independent and normally distributed with mean zero (0) and constant variance σ_μ^2 both over time and across firms, that is, $\mu_{it} \approx n(0, \sigma_\mu^2)$. The model therefore indicates a dynamic panel approach with the System-Generalized Method of Moment (S-GMM) estimator. Basically, the system-GMM estimator for dynamic panel data models combines moment conditions for the model in first differences with moment conditions for the model in levels. The estimator addresses the triple-problems of endogeneity of regressors, measurement error as well as omitted variables. The dynamic system-GMM estimator provides highly precise and less biased estimates, asymptotically efficient, robust to heteroscedasticity and consistent estimates compared to the ordinary or first-differenced-GMM estimator (Blundell & Bond, 1998).

Based on theory and evidence, we expect the *a priori* signs of the coefficients to be given as; α_2 - α_7 > 0; α_1 *and* $\alpha_8 < 0$, and $\alpha_9 >< 0$. In other words, increases institutional capacity, human capital, population growth and (i.e. the interaction between climate change and institutional quality), are expected to positively affect agricultural exports, while climate change and inflation would negatively impact on the environment of agricultural exports. Finally, exchange rate may either positively or negatively impact agricultural exports depending on the inclination of the theoretical and empirical evidence, which is either way.

4. RESULTS AND DISCUSSION

4.1. Preliminary Analysis

Before presenting the main regression estimates, summary statistics was presented in Table 5. Table 5 reveals the summary statistics for the regressor (climate change), the regressed (Agricultural Export to GDP ratio), and the mediating variables (institutional capacity variables). The average climate change index (percentage change in CO_2 emissions) was 0.14 but deviated by 0.11, suggesting that climate change impacts clustered around the mean value. It highlights differing levels of climate impacts across the region. The sampled SSA countries recorded a minimum climate change value of 0.04 and a maximum value of 0.55 within the reviewed period.

The average agricultural exports in SSA (% of GDP) show considerable fluctuations, with a mean of 0.86% and a high standard deviation of 2.21%. It implies that while agriculture is a critical sector for some SSA countries, its contribution to GDP is highly variable. Moreover, all the institutional quality variables in the SSA region are fragile, as indicated by their negative mean values of -0.44, -0.46, -0.49, and -0.30, respectively. Additionally, all the institutional quality variables deviate significantly from their mean values, as evidenced by their standard deviations of 0.61, 0.76, 0.54, 0.56, and 0.59, respectively.

Table 5. Summary Statistics

Variables	OBS	Mean	Std. Dev.	MIN	MAX
Climate Change (CLC)	290	0.14	0.11	0.04	0.55
Agriculture Export to GDP ratio (AGE)	290	0.86	2.21	0.00	12.80
Government effectiveness (GOE)	290	-0.57	0.61	-1.79	1.16
Political stability (POS)	290	-0.44	0.76	-2.35	1.11
Regulatory framework (RGF)	290	-0.46	0.54	-1.89	1.20
Rule of Law (ROL)	290	-0.49	0.56	-1.63	1.02
Accountability (ACC)	290	-0.30	0.59	-1.47	0.94

Source: E-Views Version 9.0 (2024)

Table 6 accounts for the correlation among the variables reviewed. The correlation analysis evidenced that Climate Change (CLC), Government effectiveness (GOE), Political stability (POS), Regulatory framework (RGF) and Rule of Law (ROL) are positively linked to Agriculture Export to GDP ratio (AGE). However, accountability (ACC) is negatively linked to the agricultural export-to-GDP ratio (AGE). None of the regressors reported coefficient values above 0.8, suggesting no serious multicollinearity issues were recorded.

Table 6. Correlation Analysis

	AGE	CLC	GOE	POS	RGF	ROL	ACC
AGE	1.0000						
CLC	0.3416	1.0000					
GOE	0.5991	0.2401	1.0000				
POS	0.1505	0.2428	0.6693	1.0000			
RGF	0.2573	0.1924	0.0054	0.0060	1.0000		
ROL	0.7249	0.2123	0.0141	0.0960	0.0172	1.0000	
ACC	-0.1135	0.2633	0.0235	0.0269	0.0522	0.0011	1.0000

To further ascertain this, the multi-collinearity test was conducted. The estimate is presented in Table 7. Table 7 reported that all the variables did not face multi-collinearity problems since their VIF values were below 10. To further substantiate this, their TOV was above 0.10. On average, they reported VIF values of 1.8826 and TOV of 0.9250.

Table 7. Multi-collinearity test

Multi-collinearity Test	CLC	GOE	POS	RGF	ROL	ACC	**Average**
VIF	1.1110	1.7828	2.0683	3.9257	0.3490	2.0585	**1.8826**
TOV	0.9001	0.5609	0.4835	0.2547	2.8651	0.4858	**0.9250**

Note: VIF-Variance Inflation Factors; TOV=Tolerance Value

4.2. Regression results

This section presents two regression estimates. The first section of the regression estimate (Table 8) examined the effect of climate change on agricultural exports in the SSA region without considering the interaction effects of institutional capacity. Meanwhile, the second regression estimate incorporated the interaction effects of institutional capacity into the model.

Table 8. System Generalized Methods of Moments (SGMM)

Dependent Variable: AGE				
Sample: 1 290				
Included observations: 290 (29 Countries over 10 Years)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
AGE(-1)	0.2630	0.0909	2.8926	0.0041
CLC	0.3351	0.1067	3.1414	0.0019
GOE	-0.4124	0.1830	-2.2534	0.0251
POS	0.0778	0.1960	0.3969	0.6918
RGF	-0.0370	0.2853	-0.1298	0.8968
ROL	0.0511	0.6426	0.0796	0.9366
ACC	-0.4260	0.0436	-9.7637	0.0000
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
CLC*GOE	0.2913	0.0791	3.6840	0.0003
CLC*POS	0.3793	0.1873	2.0254	0.0440
CLC*RGF	0.3062	0.0713	4.2965	0.0000
CLC*ROL	-0.8835	0.2766	-3.1936	0.0016
CLC*ACC	0.1793	0.8291	2.0254	0.0440
Constant	2.3738	0.1871	12.6856	0.0000
Wald $\chi2$	14.1141	Prob.> $\chi2$		0.0000

Source: E-Views version 9.0 (2024)

From Table 8, the coefficient for AGE(-1) (lagged agricultural export ratio) is positive and significant (p-value of 0.0041). By implication, past agricultural export performance is a major driver of the current period's value. Table 8 confirms that climate change improves agricultural exports, which could reflect either beneficial climatic conditions or improved adaptation strategies. Meanwhile, government effectiveness and accountability negatively impact agricultural exports, potentially due to increased regulation or oversight. However, political stability, the regulatory framework, and the rule of law have minimal effects on agricultural exports in the SSA region. These insights can guide policymakers and stakeholders in crafting strategies that address governance structures and climate adaptation while balancing effectiveness with export incentives.

The study confirmed that government effectiveness (GOE), political stability (POS=0.3793), regulatory framework (RGF= 0.3062), and accountability (ACC=0.1793) all positively interact with climate change (CLC) and agricultural exports. By implication, effective government institutions improve the beneficial effects of climate change on agricultural exports. It suggests that well-implemented government policies and effective administration can help capitalize on favourable climatic conditions, improving agricultural output and exports. However, the rule of law (ROL= -0.8835) has a negative interaction effect, suggesting that stringent legal frameworks might inhibit the positive impacts of climate change on agricultural exports. It may be due to stringent regulations or regulatory oversight. These findings can help policymakers and stakeholders design and implement strategies that leverage governance and institutional strengths to optimize the benefits of climate change for agricultural sectors while addressing potential constraints imposed by legal and regulatory frameworks.

4.3. Post-Estimation (Robustness) Tests

The Hansen test (Hansen J test) was introduced into the model to address two major issues. First, the test was introduced to determine whether the instrument variables were valid. Being valid suggests that the instrument variables are correlated with the endogenous regressor but are uncorrelated with the residual (error term). Secondly, the test was introduced to test whether the model has more instruments than necessary. The decision rule is that if the Hansen J statistic is above 5%, it is that the instruments are valid and that the model is well-specified. Table 9 attested that the S-GMM instrumental variables are valid, contemporaneously exogenous and well-specified since the Hansen J statistic is above 5%. To further attest to this, the serial correlation test failed to reject the null hypothesis of no autocorrelation among the residuals. This further affirmed that the model is robust.

Table 9. Post-Estimation (Robustness) Tests

Arellano-Bond Serial Correlation Test					Hansen Test	
Test order	**m-Statistic**	**rho**	**SE(rho)**	**Prob.**	**J-statistic**	**Prob(J-statistic)**
AR(1)	-0.0181	-0.2603	14.3600	0.9855	3.299697	0.069293

Source: E-Views version 9.0 (2024)

5. CONCLUSIONS

The study reiterates that while increasing agricultural exports is crucial for sustained economic growth, diversification, improved living standards, and other benefits such as enhanced foreign exchange earnings, high revenue bases, and rising employment (Ozekhome, 2022), efforts in the SSA region have not yet achieved the desired outcomes. On this premise, the study investigates the effect of climate change on agricultural exports in SSA, considering the moderating effects of various institutional capacity variables. Climate change (measured by CO_2 emission changes) has an average value of 0.14, with substantial variation, while agricultural export-to-GDP ratios show considerable fluctuation with a mean of 0.86%. Institutional quality variables exhibit negative mean values, reflecting general fragility. The System Generalized Methods of Moments (SGMM) reveals that climate change positively influences agricultural exports. However, government effectiveness and accountability had a negative significant effect on agricultural exports. Interaction effects show that government effectiveness, political stability, regulatory frameworks, and accountability positively mediate the effect of climate change on agricultural exports, implying that strong institutions enhance the benefits of climate change.

In contrast, the rule of law has a negative mediating effect, suggesting that stringent legal frameworks may limit the positive impacts of climate change on exports. Robustness tests (Hansen J and serial correlation tests) confirm the validity of the model and instruments, affirming that the findings are reliable. The study submits that the SSA region can optimize the benefits of climate change while addressing regulatory and legal constraints by leveraging effective governance and institutional frameworks. The SSA government must improve government effectiveness, political stability, and regulatory frameworks. Again, there is a need for the SSA government to re-evaluate and reform stringent legal frameworks that may hinder agricultural exports. Lastly, the SSA government builds robust, effective institutions to improve governance and accountability.

Although the study has contributed meaningfully to existing studies, it is still not without limitations. First, the study is limited to only 290 observations. Future researchers should increase their time frame to longer to cover a wider scope and more robust findings. Another limitation lies in the number of variables used. The current study did not incorporate control variables such as inflation, population, and exchange rates into the model. Future researchers should think towards that area. Lastly, future research should categorize agricultural products exported more.

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