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The Impact of Climate Change and Governance on Migration in Africa

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Abstract

This paper examines the effect of climate and governance shocks on international migration in 45 African countries over the period 2000-2021. Because of missing data on governance variables, the study covers only 45 countries in Africa as a whole. We adopt a panel data approach using fixed-effect and random-effect models. The results show, on the one hand, that climate shocks have a positive impact on emigration and, on the other hand, that good governance through the quality of institutions has a negative effect on emigration. However, these results show that improving the quality of institutions alone is not enough to reduce migration due to climate change. These results therefore point to economic policy implications. The two main recommendations are: 1) to improve the resilience of populations in the face of climate change in order to reduce population displacements caused by this phenomenon; 2) to strengthen the quality of institutions in African countries in order to limit population displacements caused mainly by corruption and political instability.

Keywords

Governance, Climate Change, Migration, Africa

1. Introduction

Human migration is multi-causal and triggered by a complex set of factors, including protracted crises, internal conflicts, socio-economic factors, emerging health crises and more traditional seasonal and subsistence factors (Foresight, 2011; Murtaza, 2020; Stojanov et al., 2021; Czaika & Reinprecht, 2022). Socio-economic, political and environmental factors are linked to other variables (age, gender, education, wealth, marital status, preferences, ethnicity, religion, language) that lead

to the decision to stay or migrate (Piguet, 2020; Armijos-Orellana et al., 2022). In other words, migration can be defined as a historical phenomenon that is common to all peoples and multidimensional. It refers to all types of population movement for political, social, economic or personal reasons, which involve a change in the place of habitual residence, whatever the cause, composition or duration, including in particular movements of workers, refugees, displaced or uprooted persons. (Barudy, 1992; IOM, 2019; Czaika & Reinprecht, 2022).

The history of human migration highlights a common strategy for managing the risks associated with socio-economic factors, environmental change and climate change, as evidence of migration is very old but more recent patterns of migration have emerged in response to the continuing effects of climate change (Blake et al., 2021; McLeman, 2013; Ionesco et al.., 2017; Cattaneo et al., 2019). Climate-related migration has become a discourse in its own right, and many areas of development, humanitarian, research and policy, but especially governance, aim to capture its complexity (Ferris, 2020). Within these migratory flows, South-North migratory flows occupy a central place (Dicken, 2015). Thousands of people from developing countries move to developed countries every year, attracted by the promise of a better life and opportunities that do not exist in their countries of origin (Lee, 2013). Migration has become a crucial issue in the political debate, generating a strong sense of fear and uncertainty on every continent, particularly in Africa.

There are currently more than 258 million international migrants in the world, compared with 220 million in 2010 and 191 million in 2005 and at the end of 2017 there were 68.5 million displaced persons, almost double the figure for 1997 according to the International Organisation for Migration (IOM, 2019). It has also established that nearly 5.3 million people settled in countries of the Organisation for Economic Co-operation and Development (OECD) in 2018, i.e. 2% more than the previous year, and 300,000 Africans arrived in these northern countries (OECD, 2019). As a result, Africa is likely to be the region with the highest rate of asylum seekers at the end of the century (Missirian & Schlenker, 2017). The causes of this migration are highly contextual and depend on the history of migration and the economic, political and demographic dynamics, as well as the social and environmental factors, of the countries concerned (Black et al., 2011; Martin et al., 2014).

Studies conclude that climate change and the quality of governance could increase the number of migrants (Bohra-Mishra et al., 2017; Mueller et al., 2020). One of the greatest challenges facing the African continent in the fight against migration is to determine the causes linked specifically to the continent and to propose pragmatic and sustainable solutions to the consequences of these massive population movements, both at the level of the country of origin and the host country. Despite its macroeconomic performance and explosive demographic growth, Africa remains the poorest continent in the world, with almost half its population living on less than a dollar a day (Delaunay & Guengant, 2019). Several factors seem to explain this state of affairs, including poor gov-

ernance, political instability and conflict, and the absence of democracy.

In addition, the lack of socio-economic opportunities, corruption, limited infrastructure, disease and inadequate healthcare are possible factors that could explain migratory flows (Fall, 2017). There is also a risk that dependence on natural resources will prevent Africa from coping with the effects of climate change (Fall, 2017). Despite the early effects and because of poverty, African countries risk not having the means to cope with the effects of climate change (Fall, 2017; Brown, 2008). Huge socio-economic problems caused by explosive urban population growth and the effects of climate change (González et al., 2018). The effects of climate change and poor governance in Africa are having a direct impact on the social structure of local populations, which could force large numbers of people to leave their homes and communities (Lam et al., 2016). Unlike previous articles that have studied the causes of migration (Ariu et al., 2016; Burrios et al., 2016; Bardsley & Hugo, 2010), this article differs from the previous ones by taking into account several governance indicators and those of climate change to explain the causes of migration in Africa. Moreover, in a context where the resilience of populations is becoming increasingly weak in African countries, the empirical results of this article will, on the one hand, reopen the debate on Africa's development policies in terms of population mobility, and on the other hand, formulate public policies to deal with this thorny issue of population displacement.

Against a backdrop of poor governance in most African countries, are the effects of climate change influencing migration in Africa? The aim of this article is to determine the effect of climate change and certain governance indicators on migration in Africa. Specifically, the aim is to determine the effect of temperature variability correlated with greenhouse gas (CO_2) emissions and rainfall on migration, and to determine the effect of governance variables on migration. Given the high level of exposure and vulnerability to climate risks, and the evidence that populations respond to climatic variations and poor governance by migrating to other parts of the world, we argue for the sensitivity of migration flows to climatic variations and poor governance on migration in Africa. The rest of the article is organised as follows. Section 2 summarises the literature on migration. Section 3 describes and defines the data. Section 4 discusses the methodology. Section 5 presents and comments on the results. Section 6 concludes the article.

2. Literature Review

This section presents, on the one hand, the main theories that address the issue of the link between climate change, governance and migration and, on the other hand, summarises some empirical results on the effects of climate change and governance on migration.

2.1. Theoretical Background

Several theories link climate change, migration and governance. In this paper,

we present a few that we feel are relevant. The theory of climatic migration put forward by Myers, & Kent (1995), which states that environmental changes, including climate change, can cause massive population migrations due to environmental degradation. Kälin & Shrepfer (2012), Gemenne & Cournil (2010) and Miguel et al. (2004) all follow Myers in theorising the need for effective global governance to deal with climate-related migration, emphasising the crucial role of international institutions in managing these migratory flows. They also theoretically underline the role of climate change in increasing violent conflict, leading to mass migration. Migration is therefore a response to the instability created by climate change.

In addition to this theory, which simply justifies the possible causes of migration, De Haas (2007) have proposed the theory of the costs and benefits of climate migration to analyse the economic costs and benefits of climate migration, taking into account factors such as the increased productivity of migrants in the host areas. In addition, on a theoretical level, some authors see climate change as a global public good because its effects are not limited to national borders. Two main theories were forward for managing this common good. These are, on the one hand, the theory of global public goods authored by Kaul et al. (1999) and, on the other hand, the theory of environmental governance proposed by Ostrom et al. (2003). Overall, these two theories point to the need for effective global governance to deal with the problems associated with climate change and the resulting migration. In other words, these theories explore how people will need to coordinate their actions sustainably manage common resources, including those affected by climate change. The effects of climate change know no borders, so obviously, some countries suffer more than others do, or some countries suffer these effects because of other countries.

This situation raises the issue of environmental externalities and climate justice. To address the issue of environmental externalities, Coase (1960) and Pigou (1920) proposed the theory of environmental externalities, which shows that migration considered an externality of climate change, with economic and social impacts that go beyond national borders. This theory also examines how national and international policies can develop to mitigate the negative effects of these externalities. Nevertheless, to address these externalities, or the climate justice induced by the effects of climate change, Sen (1993) and Rawls (1993) proposed the theory of climate justice to examine issues of equity in the distribution of the costs and benefits associated with the effects of climate change, particularly in relation to climate-induced migration. It also examines how public responsibilities and internal governance influence the distribution of the costs and benefits associated with climate change.

Rather than focusing directly on the effects of climate change, Ostrom (1990) and Ostrom et al., (2003) proposed the theory of institutional adaptation and resilience respectively, examining how institutions can adapt to the effects of climate change and respond to environmental challenges. As a result, quality institutions as essential for managing the problems associated with climate and migration. In

other words, this theory focuses on how societies can adapt to climate change and develop resilience to the impacts, thereby influencing migratory movements. Nordhaus (1993, 1994) and Romer (1990) have developed the economic theory of the carbon market to help deal with the effects of climate change. This theory proposes the use of market mechanisms, such as carbon markets, to mitigate climate change and its effects, with implications for migration and governance.

2.2. Empirical Review

Through empirical studies, several authors have analysed the link between climate change, governance and migration. This section summarises some of the results of these empirical studies. The lack of consensus in the empirical findings on the relationship and direction of causality between climate change and migration is partly due to the inherent complexity of the migration process itself. Moreover, climate change may induce, constrain or have no impact on migration, depending on the particular characteristics of the climate shock and the region of occurrence. Indeed, results from cross-national studies based on household surveys and micro-censuses report mixed evidence (Gray & Wise, 2016). While rising temperatures are associated with emigration in Uganda, emigration tends to decrease with rising temperatures in Burkina Faso and Kenya. However, no relationship was found between migration and temperature anomalies in Nigeria and Senegal (Gray & Wise, 2016; Nawrotzki & Bakhtsiyarava, 2016).

Similarly, macro-level studies also report inconsistent results with migrations increasing with higher temperature on the one hand (Cai et al., 2016) and no relationship found in other studies (Beine & Parsons, 2015). The inconsistency in these results is largely due to the heterogeneity of the measurements, methods and data used (Beine & Jeusette, 2018). Nevertheless, the results of some work show that climate shocks are causes of migration (Barrios Puente et al., 2016). Bardsley and Hugo (2010) used data from the National Aeronautics and Space Administration (NASA) to examine the effect of rainfall levels lagged behind the historical average on the migration of small Mexican communities to the United States. The results showed that higher levels of precipitation significantly reduce migration from Mexico to the United States, and a level of precipitation 20 per cent higher than normal leads to a forecast 10.3 per cent reduction in migration.

Dallmann and Millock (2017) show that the effect of drought frequency on interstate migration in India is stronger in states with a higher share of net domestic product from agriculture. Cai et al. (2016) show that rising temperatures in agriculture-dependent countries lead to migration to Organisation for Economic Co-operation and Development countries. Similarly, in a study of international migration, Gröschl and Steinwachs (2017) show that drought increases migration, but only for middle-income countries, which are neither rich enough to have insurance nor poor enough to lack the resources to migrate, suggesting that liquidity constraints play an important role in the complex relationship between climate change and migration. Like climate change, governance affects migration directly or indirectly through socio-political factors. For example,

Bernauer et al., (2012) show that when institutional responses to environmental challenges are weak, this can lead to violent conflict which, in turn, leads to forced population migration.

In a study of the determinants of migration, Burrows and Kinney (2016) show that the type and quality of a country's governance explains the migration of people. But there are many other governance factors, such as political stability, corruption, the effectiveness of government action and the government's ability to provide services that seem more relevant in explaining migration. Bertocchi and Strozzi (2008) pay particular attention to the role of institutional factors other than economic and demographic factors, demonstrating that the quality of political institutions measured by the level of democracy and voting rights in the destination country is a determining factor in migration. Their results concluded that political institutions are the main factor attracting migration. Bergh et al. (2015) show that the quality of institutions in migrants' countries of origin has a positive and significant influence on emigration. According to the authors, it's the lack of reliable information about the institutions in the host country and the institutions in the country of origin that explains the decision to emigrate.

Similarly, Ariu et al. (2016) used governance data from the World Bank to try to explain migration based on the quality of governance in the country of origin of potential migrants. The results show that net migration flows determined by the poor quality of institutions in migrants' countries of origin as well as the good quality of institutions in destination countries. Using a panel of 118 developing and developed countries, Dutta and Roy (2011) find that political stability is associated with a low rate of emigration of highly skilled workers. Thus, political stability reduces the likelihood of brain drain. Other studies such as Dimant et al. (2013) analysed the impact of corruption in the country of origin and emigration. The results showed a positive relationship between corruption in the country of origin and emigration. They explained that corruption and embezzlement of public funds in public administrations prevent the implementation of employment policies and create a shortfall in funding for integration projects.

3. Data and Variable Descriptions

The data used for this paper come exclusively from the World Bank database covering the period from 2000 to 2021 for 45 African countries. Because of missing data on governance variables, the study covers only 45 countries in Africa as a whole. Details of the description and definition of the variables used in this paper and the sources of the data given in **Table 1** below. Emigration is the dependent variable. The explanatory variables are, on the one hand, governance variables (control of corruption, voice and accountability, government effectiveness, political stability, quality of regulation, rule of law), unemployment, vulnerable employment and, on the other hand, two variables characterising climate change, namely temperature and rainfall.

Table 1. Data sources and variable descriptions.

Variable Descriptions	Notation	Sources
Emigration (emigr): In this article, this variable specifically captures the number of people who emigrate out of the country per year. This calculation is deduced by the author based on the stock of international migrants and net migration available in the WDI database.	emigr	WDI, 2022
Precipitation (precip): This is the long-term average of the height (in space and time) of the country's annual precipitation. Annual precipitation is calculated from monthly data is defined as any type of water falling from clouds, whether in liquid or solid form.	precip	WGI, 2022
Temperature: It measures the annual Average Temperature Values. Annual temperature is calculated by using the monthly data.	temp	WGI, 2022
Greenhouse gaz emission (Ghg): It measures the total greenhouse gas emissions in kt of CO_2 equivalent.	ghg	WGI, 2022
Control of Corruption (cc): It measures the spread of corruption in society in all its forms. In addition, it measures the takeover of state property by private interests and elites. The measure is assessed on a scale ranging from −2.5 to 2.5.	cc	WGI, 2022
Voice and accountability (Va): It measures citizens' perceptions of their ability to participate in the election of their government, as well as freedom of expression, association, and the press. The measure is assesse on a scale ranging from −2.5 to 2.5.	va	WGI, 2022
Government effectiveness (ge): It measures the public service quality, civil service quality and independence from political pressures, policy formulation, and implementation quality, and the credibility of the government's commitment to such policies. The measure is assesse on a scale ranging from −2.5 to 2.5.	ge	WGI, 2022
Political Stability and Absence of Violence/ Terrorism (ps): It measures public perceptions of the likelihood that the government will be destabilized or overthrown through unconstitutional or violent means, including politically motivated violence and terror. The measure is assessed on a scale ranging from −2.5 to 2.5.	ps	WGI, 2022
Regulatory quality (rq): Is a metric that measures public perceptions of the government's ability to develop and implement sound policies and regulations that allow and promote private sector growth. The measure is assessed on a scale ranging from −2.5 to 2.5.	rq	WGI, 2022
Rule of Law (rl): It evaluates the level of public confidence and compliance with social rules, especially the fulfillment of contracts concluded, in addition to the quality of services provided by the police, as well as human rights, courts and the potential for crime and violence. The measure is assessed on a scale ranging from −2.5 to 2.5.	rl	WGI, 2022
Governance index (gov_index): arithmetic mean of the six dimensions of governance defined by the World Bank (cc, va, ge, ps, rq, rl)	gov_index	Authors
Population (pop): Total population based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values are midyear estimates.	pop	WGI, 2022
Unemployment rate (Unempl): Unemployment refers to the share of the labor force that is without work but available for and seeking employment.	unempl	WGI, 2022
Vulnerable employment (empl): Vulnerable employment is contributing family workers and own-account workers as a percentage of total employment.	empl	WGI, 2022
GDP: Gross domestic product per capita (GDP/capita): An indicator of the level of economic activity. It is the value of GDP divided by the number of inhabitants in a country.	Gdp	WGI, 2022

Source: Authors' compilation.

Consequently, we add other control variables to the climate change and governance variables, which generally considered determinants of population mobility and economic performance in the literature logarithm of Unemployment (lUnempl), logarithm of volatile employment (lmploy), the logarithm of total population (lpop) and and the logarithm of real GDP (lgdp). Table 2 below gives the descriptive statistics for the main variables in the model.

Table 2. Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Emig	990	12.39214	1.269907	8.703975	15.39823
Ltemp	990	3.466147	0.1375377	3.092447	3.745147
Lunempl	990	1.989371	0.8829076	−1.139434	3.568321
Lempl	990	4.031135	0.5364503	2.178155	4.547541
Lpop	990	16.02418	1.532597	11.87558	19.17868
Lprecip	990	6.444062	1.057212	2.895912	8.070906
cc	990	−0.6116244	0.5876633	−1.848734	1.24492
va	990	−0.5671411	0.7148272	−2.196764	.9825176
ge	990	−0.7228518	0.6015094	−2.445096	1.16092
ps	990	−0.5812671	0.9244423	−3.312951	1.22360
rq	990	−0.6530248	0.6147597	−2.547726	1.196947
rl	990	−0.6584352	0.6423636	−2.590877	1.023956
gov_index	990	−0.6323907	0.6107245	−2.410851	0.8757154

Source: Authors' compilation.

Table 3 as below shows the correlations between the different variables taken in pairs. The analysis deduced from these data highlights a substantial and significant negative correlation at the 5% threshold between the emigration variable and each of the governance indicators, as well as with the level of precipitation and the unemployment rate. However, an inverse relationship, marked by significance, presumed between emigration and the variables population, temperature and vulnerable employment.

4. Methodology

4.1. Model Specification

To analyse the effects of climate change and institutional governance on migration, six different models specified as follows:

$$lemigr_{it} = \theta_0 + \theta_1 ltemp_{it} + \theta_2 inst_{it} + \theta_3 ltx\_unempl_{it} + \theta_4 lempl_{it} + \theta_5 lGDP_{it} + \theta_6 lpop_{it} + \varepsilon_{it} \quad (1)$$

$$lemig_{it} = \theta_0 + \theta_1 ltemp_{it} + \theta_2 inst * ltemp_{it} + \theta_3 ltx\_unempl_{it} + \theta_4 lempl_{it} + \theta_5 lGDP_{it} + \theta_6 lpop_{it} + \varepsilon_{it} \quad (2)$$

Table 3. Correlation matrix between variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) lemigr	1.0000												
(2) ltemp	0.2738***	1.0000											
(3) lunempl	−0.2045***	−0.0171	1.0000										
(4) lempl	0.1240***	−0.0015	−0.6095***	1.0000									
(5) lpop	0.7676***	0.3034***	−0.4116***	0.1932***	1.0000								
(6) lprecip	−0.1047***	−0.6851***	−0.2976***	0.4280***	−0.1410***	1.0000							
(7) cc	−0.3713***	−0.0459	0.2814***	−0.5281***	−0.3539***	−0.1070***	1.0000						
(8) va	−0.3120***	−0.1321***	−0.0053	−0.2830***	−0.2194***	0.1476***	0.7572***	1.0000					
(9) ge	−0.1346***	−0.0112	0.1719***	−0.6095***	−0.0930***	−0.1267***	0.8366***	0.7040***	1.0000				
(10) ps	−0.4841***	−0.1910***	0.2152***	−0.3708***	−0.5140***	0.0571*	0.7252***	0.6653***	0.6629***	1.0000			
(11) rq	−0.1560***	−0.0603*	0.0893***	−0.4891***	−0.1166***	0.0109	0.7975***	0.7302***	0.8893***	0.6739***	1.0000		
(12) rl	−0.2510***	−0.0453	0.1641***	−0.5296***	−0.2040***	−0.0983***	0.8718***	0.7857***	0.9036***	0.7679***	0.8800***	1.0000	
(13) gov_index	−0.3348***	−0.1012***	0.1704***	−0.5084***	−0.2998***	−0.0106	0.9150***	0.8602***	0.9105***	0.8548***	0.9084***	0.9581***	1.0000

Source: Authors' compilation.

$$lemig_{it} = \theta_0 + \theta_1 lprecip_{it} + \theta_2 inst_{it} + \theta_3 ltx\_unempl_{it} + \theta_4 lempl_{it} + \theta_5 lGDP_{it} + \theta_6 lpop_{it} + \varepsilon_{it} \quad (3)$$

$$lemigr_{it} = \theta_0 + \theta_1 lprecip_{it} + \theta_2 inst * lprecip_{it} + \theta_3 ltx\_unempl_{it} + \theta_4 lempl_{it} + \theta_5 lGDP_{it} + \theta_6 lpop_{it} + \varepsilon_{it} \quad (4)$$

$$lemigr_{it} = \theta_0 + \theta_1 lghg_{it} + \theta_2 inst_{it} + \theta_3 ltx\_unempl_{it} + \theta_4 lempl_{it} + \theta_5 lGDP_{it} + \theta_6 lpop_{it} + \varepsilon_{it} \quad (5)$$

$$lemigr_{it} = \theta_0 + \theta_1 lghg_{it} + \theta_2 inst * lghg_{it} + \theta_3 ltx\_unempl_{it} + \theta_4 lempl_{it} + \theta_5 lGDP_{it} + \theta_6 lpop_{it} + \varepsilon_{it} \quad (6)$$

In these equations, $lemigr_{it}$ represents the logarithm of the number of emigrants in year t for country i. The three climate change variables used are the logarithm of temperature ($ltemp_{it}$), the logarithm of average precipitation ($lprecip_{it}$) and the logarithm of greenhouse gas emissions ($lghg_{it}$). The variable $inst_{it}$ represents each of the seven governance indicators used (the six classic World Bank governance indicators and the synthetic governance index calculated by the authors). Finally, $lunempl_{it}$ represents the logarithm of the unemployment rate, $lempl_{it}$ the vulnerable employment rate, $lgdp_{it}$ the logaithm of real GDP and $lpop_{it}$ the logarithm of the total population.

4.2. Estimating Technique

There are several panel data estimation techniques developed by econometricians. In this study, we use a linear panel data approach with interaction between variables to capture the effect of climate change, institutional quality and their

interaction on migration in 45 African countries over the period 2000-2021. The approach consists of estimating a fixed-effects model and a random-effects model and then making a decision using the Hausman (1978) test.

4.2.1. Fixed-Effects Model

The fixed-effects model considers individual heterogeneity and temporal heterogeneity as parameters to estimate. It therefore assumes the existence of unobservable and estimable effects that are stable over time (individual effect) and/or common to all individuals/countries (temporal effect). Controlling for fixed effects is necessary to ensure that the X_{it} are uncorrelated with the error terms (i.e. that there is strict exogeneity of the X_{it}), which ensures that there is no heterogeneity bias. Another way of eliminating fixed effects is to estimate the model by studying the deviations from individual means, and to apply the OLS method to this model.

The "within" estimator does not allow the fixed effects to be estimated, but the estimated coefficients of the explanatory variables will be the same as in the fixed effects model. The two models are therefore equivalent. An alternative to the within model is the between model. This consists of focusing on the permanent differences between individuals, while eliminating cyclical differences. To obtain this result, we calculate the average values associated with each individual and then apply the OLS method to the individual averages. The model can have written as follows:

$$Y_i = \alpha + \beta X_i + \epsilon_i$$

In contrast to the "within" estimate, the "between" estimate is based solely on variations between countries (inter-country), without taking into account intra-individual variations.

4.2.2. Random Effects Model

In the case of this model, we will assume that μ_i (estimation error term) and ϑ_{it} (The usual regression error varies over time and according to individual dimensions) are random and independent of each other.

$$\mu_i \sim IID\left(0, \sigma_\mu^2\right)$$

$$\vartheta_{it} \sim IID\left(0, \sigma_v^2\right)$$

We can use (2.4) to calculate the variance-covariance matrix as follows:

$$\Omega = E\left(uu'\right) = Z_\mu E\left(\mu\mu'\right) Z'\mu + E\left(\vartheta'\vartheta\right)$$

This structure of the variance-covariance matrix shows that the variances are homoscedastic $\text{var}\left(\mu_{it}\right) = \sigma_\mu^2 + \sigma_v^2$ on the diagonal (for the same individual) and that there is correlation between different individuals. The GLS estimator (GCM) requires the inversion of the variance-covariance matrix Ω. This estimator is given:

$$\hat{\beta}_{GLS} = \left[\frac{X'QX}{\sigma_v^2} + \frac{X'\left(P - \bar{J}_{NT}\right)X}{\sigma_1^2}\right]^{-1}\left[\frac{X'QY}{\sigma_v^2} + \frac{X'\left(P - \bar{J}_{NT}\right)X}{\sigma_1^2}\right]$$

$$\hat{\beta}_{GLS} = \left[W_{XX} + \Phi^2 B_{XX} \right]^{-1} \left[W_{Xy} + \Phi^2 B_{Xy} \right]$$

$$\Phi^2 = \sigma_v^2 / \sigma_1^2 \quad \text{et} \quad \sigma_1^2 = T\sigma_\mu^2 + \sigma_v^2$$

We note that:

$$W_{XX} = X'QX \ , \quad B_{XX} = X'\left(P - \bar{J}_{NT} \right) X$$

We show that the within and between estimators are:

$$\hat{\beta}_{within} = X'QX$$

$$\hat{\beta}_{between} = X'\left(P - \bar{J}_{NT} \right) X$$

$$\hat{\beta}_{GLS} = W_1 \hat{\beta}_{within} + W_2 \hat{\beta}_{between}$$

A priori, it would be more realistic to assume heterogeneity of individual effects. In fact, the countries in our sample have institutional differences that are likely to influence their level of growth, apart from the effect captured by the explanatory variables. The effects of omitted or unobservable variables are therefore not reasonably homogeneous for each country. It is therefore useful in this case to take account of these individual effects, in order to carry out a more detailed analysis of our explanatory variables and to be able to draw more rigorous and relevant conclusions. In the remainder of this work, we will first model the situation using fixed effects, and then random effects. The application of an appropriate test will be useful in choosing between the two models described above. The Hausman test can used to make this choice.

4.2.3. Hausman Test (1978)

The Hausman test applied to determine the appropriate panel model and the way in which the effects will specified. This involves testing the following hypotheses:

Null hypothesis (H0): The differences between the estimated coefficients of the fixed-effects (b_{FE}) and random-effects (b_{RE}) models are non-systematic and therefore insignificant.

H0: $E\left[\left(b_{FE} - b_{RE} \right) \left(b_{FE} - b_{RE} \right)' \right] = O$

Alternative hypothesis (H1): The differences between the estimated coefficients of the fixed-effects (b_{FE}) and random-effects models (b_{RE}) are systematic and therefore significant.

H1: $E\left[\left(b_{FE} - b_{RE} \right) \left(b_{FE} - b_{RE} \right)' \right] \neq O$

The differences between the coefficients ($b_{FE} - b_{RE}$) calculated for each estimated coefficient and the cross-product matrix of these differences compared with zero to test the null hypothesis. It is important to note that the null hypothesis (H0) implies that the coefficients of the fixed-effects and random-effects models do not differ systematically. If null hypothesis rejected, this suggests that one of the models is more appropriate as the other for panel data analysis.

In practice, the Hausman test uses a test statistic that approximately follows a chi-square distribution under the null hypothesis. This statistic calculated from

the differences between the coefficients and the variance-covariance matrix of the differences. If the test statistic is significantly different from zero, this indicates that the null hypothesis rejected and that one of the models is preferable to the other in terms of its fit to the data.

5. Empirical Results

This section presents the empirical results as well as discussions and comments on these results.

5.1. Estimation of the Relationship with Temperature without Interaction

The estimation results reveal that climatic variables, and more specifically temperature levels, have a positive influence on migratory movements. In contrast, institutional quality has a negative and significant impact on emigration. In other words, all other things being equal, an improvement in the quality of governance seems to reduce migratory flows (Table 4).

Table 4. Result of temperature relationship estimation without interaction

	(1) gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
ltemp	0.237	0.212	0.251	0.185	0.204	0.193	0.215
	(0.594)	(0.480)	(0.479)	(0.482)	(0.476)	(0.482)	(0.480)
ltx_unempl	0.130	0.152***	0.159***	0.151***	0.148***	0.156***	0.158***
	(0.056)	(0.053)	(0.053)	(0.053)	(0.052)	(0.053)	(0.053)
lempl	0.722***	0.624***	0.577***	0.653***	0.630***	0.678***	0.630***
	(0.226)	(0.175)	(0.175)	(0.175)	(0.173)	(0.175)	(0.174)
lpop	0.016	0.323***	0.367***	0.311***	0.258**	0.289***	0.305***
	(0.178)	(0.107)	(0.103)	(0.107)	(0.105)	(0.108)	(0.106)
lGDP_cons	0.318***	0.241***	0.215***	0.254***	0.237***	0.263***	0.260***
	(0.096)	(0.079)	(0.078)	(0.080)	(0.077)	(0.080)	(0.079)
inst	−0.574***	−0.160**	−0.176***	−0.184***	−0.194***	−0.240***	−0.249***
	(0.089)	(0.070)	(0.055)	(0.066)	(0.030)	(0.067)	(0.067)
cons	0.396	−2.029	−2.083	−2.189	−0.894	−2.205	−2.292
	(2.894)	(2.060)	(2.049)	(2.064)	(2.050)	(2.067)	(2.055)
N	990	990	990	990	990	990	990
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F/Wald chi^2	16.0***	152.3***	158.8***	152.7***	188.4***	156.6***	160.3***
r^2	0.095	0.057	0.061	0.062	0.093	0.068	0.066

Source: Autors. Note: ***, ** and *: represent significance levels at 1%, 5% and 10% respectively. Values in parentheses represent estimator standard deviations. The "institution" variable is set for one of the six governance variables and the governance index calculated by the authors.

5.2. Estimation of Temperature Relationship with Interaction

Table 5 shows the estimation results of the model linked to temperature with interaction. The table shows that temperature level has a positive influence on migratory movements. Nevertheless, this finding is not statistically significant largely. However, for a level of governance, temperature has a negative and significant influence on emigration.

Table 5. Result of the estimation of the relationship with temperature and interaction.

	(1) gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
ltemp	0.172	0.189	0.225	0.154	0.187	0.155	0.175
	(0.593)	(0.480)	(0.479)	(0.482)	(0.476)	(0.483)	(0.480)
inst*ltemp	−0.164***	−0.046**	−0.050***	−0.053***	−0.055***	−0.067***	−0.072***
	(0.025)	(0.020)	(0.016)	(0.019)	(0.009)	(0.019)	(0.019)
ltx_unempl	0.130**	0.152***	0.159***	0.150***	0.147***	0.156***	0.157***
	(0.056)	(0.053)	(0.053)	(0.053)	(0.052)	(0.053)	(0.053)
lempl	0.709***	0.625***	0.577***	0.651***	0.628***	0.677***	0.626***
	(0.226)	(0.175)	(0.176)	(0.175)	(0.173)	(0.175)	(0.174)
lpop	0.016	0.324***	0.369***	0.311***	0.260**	0.292***	0.307***
	(0.178)	(0.107)	(0.103)	(0.107)	(0.105)	(0.108)	(0.106)
lGDP_cons	0.315***	0.240***	0.213***	0.253***	0.234***	0.261***	0.258***
	(0.096)	(0.079)	(0.078)	(0.080)	(0.077)	(0.080)	(0.079)
cons	0.751	−1.948	−1.987	−2.060	−0.800	−2.064	−2.124
	(2.901)	(2.064)	(2.052)	(2.066)	(2.054)	(2.069)	(2.056)
N	990	990	990	990	990	990	990
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F	16.0***	151.7***	157.9***	152.6***	187.4***	155.7***	160.0***
r^2	0.095	0.057	0.06	0.062	0.093	0.067	0.066

Source: Autors. Note: ***, ** and *: represent significance levels at 1%, 5% and 10% respectively. Values in parentheses represent estimator standard deviations.

5.3. Estimation of the Relationship with Non-Interacting Precipitation

The results shown in the table below based on the model estimation that includes rainfall without interaction. These results reveal that the level of precipitation has a mixed effect on emigration. As for institutional quality, it has a negative and significant effect on emigration. In other words, all other things being equal, better quality governance seems to reduce migratory movements (Table 6).

Table 6. Result of the estimation of the relationship with precipitation without interaction.

	(1) gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
lprecip	−4.534	−0.041	0.002	−0.047	−0.039	−0.033	−0.041
	(3.417)	(0.103)	(0.103)	(0.104)	(0.104)	(0.105)	(0.103)
ltx_unempl	0.133**	0.157***	0.167***	0.156***	0.154***	0.165***	0.162***
	(0.057)	(0.055)	(0.055)	(0.055)	(0.054)	(0.055)	(0.055)
lempl	0.667***	0.533***	0.473**	0.564***	0.568***	0.593***	0.564***
	(0.236)	(0.187)	(0.188)	(0.186)	(0.184)	(0.186)	(0.186)
lpop	0.180	0.401***	0.455***	0.392***	0.342***	0.376***	0.378***
	(0.196)	(0.111)	(0.107)	(0.111)	(0.110)	(0.112)	(0.111)
lGDP_cons	0.236**	0.187**	0.159*	0.198**	0.190**	0.207**	0.213**
	(0.104)	(0.083)	(0.082)	(0.083)	(0.081)	(0.083)	(0.083)
inst	−0.560***	−0.189***	−0.181***	−0.216***	−0.180***	−0.249***	−0.247***
	(0.092)	(0.073)	(0.057)	(0.068)	(0.031)	(0.068)	(0.070)
cons	29.940	−0.700	−0.956	−0.931	0.037	−1.122	−1.111
	(22.213)	(1.584)	(1.564)	(1.580)	(1.579)	(1.582)	(1.572)
N	990	990	990	990	990	990	990
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F/Wald Chi^2	16.0***	149.9***	155.7***	151.6***	176.1***	153.4***	155.5***
r^2	0.096	0.059	0.061	0.065	0.088	0.069	0.066

Source: Autors. Note: ***, ** and *: represent significance levels at 1%, 5% and 10% respectively. Values in parentheses represent estimator standard deviations.

5.4. Estimation of the Relationship with Precipitation with Interaction

Table 7 shows the estimation results of the precipitation model with interaction. From this table, it emerges that the level of precipitation has a negative influence on migratory movements. However, this finding is not statistically significant. On the other hand, for a certain level of governance, precipitation has a negative and significant influence on emigration.

5.5. Estimated Relationship with Non-Interacting Greenhouse Gases

The results shown in Table 8 derived from the model estimate including greenhouse gas emissions in the absence of interaction. These results show that there is a negative trend in emigration in response to greenhouse gas emissions. Similarly, institutional quality exerts a negative and significant effect on emigration. In other words, all other things being equal, better-quality governance seems to reduce migratory movements.

Table 7. Result of the estimation of the relationship with precipitation and with the interaction.

	(1) gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
lprecip	−0.075	−0.055	−0.020	−0.067	−0.059	−0.060	−0.062
	(0.103)	(0.103)	(0.101)	(0.105)	(0.103)	(0.105)	(0.104)
inst*lprecip	−0.070***	−0.023**	−0.030***	−0.030***	−0.030***	−0.037***	−0.034***
	(0.013)	(0.011)	(0.009)	(0.011)	(0.005)	(0.011)	(0.011)
ltx_unempl	0.152***	0.161***	0.166***	0.161***	0.154***	0.163***	0.167***
	(0.054)	(0.055)	(0.055)	(0.055)	(0.054)	(0.055)	(0.055)
lempl	0.526***	0.546***	0.477**	0.577***	0.573***	0.594***	0.579***
	(0.184)	(0.187)	(0.187)	(0.186)	(0.184)	(0.187)	(0.186)
lpop	0.297***	0.414***	0.443***	0.396***	0.339***	0.377***	0.384***
	(0.112)	(0.111)	(0.107)	(0.111)	(0.109)	(0.112)	(0.111)
lGDP_cons	0.239***	0.183**	0.170**	0.198**	0.194**	0.209**	0.212**
	(0.083)	(0.083)	(0.082)	(0.083)	(0.081)	(0.084)	(0.084)
cons	−0.147	−0.747	−0.904	−0.912	0.123	−0.995	−1.097
	(1.572)	(1.587)	(1.558)	(1.582)	(1.575)	(1.584)	(1.573)
N	990	990	990	990	990	990	990
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F/Wald Chi^2	174.1***	147.6***	158.7***	149.0***	177.2***	151.2***	152.9***
r^2	0.085	0.057	0.062	0.063	0.087	0.067	0.063

Source: Autors. Note: ***, ** and *: represent significance levels at 1%, 5% and 10% respectively. Values in parentheses represent estimator standard deviations.

Table 8. Result of the estimate of the relationship with the non-interacting greenhouse gas.

	(1) gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
lghg	−0.389***	−0.420***	−0.419***	−0.403***	−0.397***	−0.402***	−0.435***
	(0.105)	(0.107)	(0.107)	(0.107)	(0.105)	(0.106)	(0.106)
ltx_unempl	0.126**	0.127**	0.139**	0.126**	0.127**	0.137**	0.136**
	(0.055)	(0.057)	(0.056)	(0.056)	(0.055)	(0.056)	(0.056)
lempl	0.657***	0.689***	0.631***	0.747***	0.649***	0.775***	0.735***
	(0.224)	(0.229)	(0.230)	(0.228)	(0.224)	(0.228)	(0.227)
lpop	0.256	0.559***	0.633***	0.490***	0.380**	0.412**	0.538***
	(0.187)	(0.187)	(0.180)	(0.189)	(0.181)	(0.189)	(0.181)
lGDP_cons	0.395***	0.293***	0.257***	0.320***	0.313***	0.352***	0.325***
	(0.097)	(0.099)	(0.096)	(0.099)	(0.095)	(0.099)	(0.098)

Continued

inst	−0.555***	−0.145*	−0.153***	−0.202***	−0.200***	−0.284***	−0.273***
	(0.088)	(0.074)	(0.059)	(0.071)	(0.031)	(0.073)	(0.072)
cons	−0.326	−2.379	−2.520	−2.344	−0.065	−2.039	−2.937
	(2.156)	(2.177)	(2.158)	(2.161)	(2.161)	(2.155)	(2.141)
N	990	990	990	990	990	990	990
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F/Wald Chi^2	19.0***	12.5***	13.1***	13.3***	19.2***	14.5***	14.5***
r^2	0.108	0.074	0.077	0.078	0.109	0.085	0.085

Source: Authors. Note: ***, ** and * represent significance levels at 1%, 5% and 10% respectively. Values in brackets represent probabilities.

Table 9. Result of the estimation of the relationship with the greenhouse gas and with interaction.

	(1) Gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
lghg	−0.407***	−0.425***	−0.424***	−0.408***	−0.399***	−0.420***	−0.441***
	(0.105)	(0.107)	(0.107)	(0.107)	(0.105)	(0.106)	(0.106)
Inst*lghg	−0.060***	−0.019**	−0.014**	−0.027***	−0.020***	−0.031***	−0.028***
	(0.009)	(0.008)	(0.006)	(0.007)	(0.003)	(0.007)	(0.007)
ltx_unempl	0.122**	0.124**	0.139**	0.119**	0.126**	0.136**	0.134**
	(0.055)	(0.056)	(0.056)	(0.056)	(0.055)	(0.056)	(0.056)
lempl	0.610***	0.686***	0.637***	0.740***	0.611***	0.781***	0.679***
	(0.224)	(0.228)	(0.231)	(0.227)	(0.224)	(0.227)	(0.227)
lpop	0.174	0.520***	0.627***	0.419**	0.341*	0.373**	0.517***
	(0.189)	(0.188)	(0.180)	(0.190)	(0.182)	(0.190)	(0.182)
lGDP_cons	0.422***	0.310***	0.259***	0.346***	0.322***	0.371***	0.329***
	(0.097)	(0.099)	(0.096)	(0.099)	(0.095)	(0.099)	(0.098)
cons	0.711	−2.111	−2.453	−1.772	0.515	−1.700	−2.392
	(2.174)	(2.180)	(2.164)	(2.168)	(2.172)	(2.157)	(2.147)
N	990	990	990	990	990	990	990
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F/Wald Chi^2	20.3***	13.0***	12.8***	14.3***	19.9***	15.2***	14.4***
r^2	0.115	0.076	0.076	0.084	0.113	0.089	0.084

Source: Autors. Note: ***, ** and *: represent significance levels at 1%, 5% and 10% respectively. Values in parentheses represent estimator standard deviations.

5.6. Estimation of the Relationship with Interacting Greenhouse Gases

Table 9 shows the estimation results of the model linked to greenhouse gas

emissions with interaction. This analysis shows that greenhouse gas emissions have a significant and negative influence on migratory movements. Furthermore, for a certain level of governance, greenhouse gases have a negative influence on emigration.

6. Conclusion and Recommendation

The issue of migration has given rise to a number of studies, the results of which are both convergent and divergent. Many of these studies have focused on identifying and analysing the determinants of international migration. The results of these earlier studies generally pointed to climate change as the main determinant of international migration. These contradictory results continue to drive passions about the determinants of international migration in Africa. The aim of this article is therefore to analyse climate shocks and governance as possible or likely causes of mass population movements in 45 African countries. To achieve this objective, we used a fixed-effects panel model with data for the period 2000 to 2021. The results highlighted several conclusions. The worsening of climatic conditions in the countries leads to an increase in emigration. However, good governance, characterised by control of corruption, the voice and responsibility of citizens, government effectiveness, political stability, the quality of regulations and the rule of law, has a negative impact on emigration.

The analysis of the interaction between the climate variable and the institutional variables revealed that the improvement in the quality of institutions in Africa is not yet sufficient to mitigate the positive effect of climate on emigration. On the contrary, deteriorating climatic conditions inhibit the reducing effect of institutional quality on emigration. These results point to economic policy implications.

The two main recommendations are: 1) to improve the resilience of populations in the face of climate change in order to reduce population displacements caused by this phenomenon. People's resilience can be improved through projects to mitigate or adapt to the effects of climate change, financed either by the country of origin of the displaced persons or co-financed by technical and financial partners;

2) to strengthen the quality of institutions in African countries in order to limit population displacements caused by corruption and political instability, among other things. In addition, national and international structures must undertake to strengthen bilateral and regional cooperation to provide the necessary framework for the development of migration policies. These policies must take into account both the security dimension and economic development. Equally, the design of migration policies and the implementation of programs must aim to integrate migrants into national development plans and strategies. The contribution of civil society to a participatory approach in the development of policies in favour of host countries and countries of origin, taking into account the various stakeholders, both candidates for migration and governments in the

framework of migration measures and policies.

The results of the empirical estimates and the economic policy recommendations formulated in this manuscript are intended to help decision-making in the countries of origin and host countries of migrants to address the problems of population displacement due to the effects of climate change.

This article also reveals a number of limitations. In most African countries, the availability and quality of data on migration, particularly international migration, is problematic. This constraint prevents us from effectively combating migration. However, to deepen the debate on the causes of migration, future articles will have to take into account factors such as the official language of the migrant's country of origin and host country; the distance separating the host country from the migrant's country of origin; historical, colonial and cultural factors between the migrant's host country and the country of origin.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Annexe

The table of Chi2 statistics for the Hausman tests performed is in the appendix.

Table A1. The chi2 statistics for the Hausman tests performed.

	(1) gov_index	(2) cc	(3) va	(4) ge	(5) ps	(6) rq	(7) rl
Non-interactive temperature	13.75**	7.62	6.36	9.65	10.15	10.58	8.22
Interaction temperature	13.38**	8.59	8.74	10.2	9.9	10.55	9.06
Precipitation without interaction	23.73***	18.57***	16.86***	20.32***	21.19***	21.10***	19.60***
Interaction precipitation	13.73**	7.49	6.31	9.54	10.12	10.34	8.07
Emissions without interaction	12.58	8.96	9.09	9.9	10.36	10.37	9.12
greenhouse gases with interaction	24.8***	17.79***	16.16***	20.67***	21.15***	21.66***	18.07***

Source: Autors calcul.