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Assessing the Impact of Climate Extreme Events and Conflicts on Internal Displacement in Burkina Faso

Koffi Doh David ADZAVON[1], Safiétou SANFO [2], Ossadzifo Kwami WONYR [3], Christine Furst [4]

January 2025

Contact:

Koffi Doh David ADZAVO,adzavon.k@edu.wascal.org
Safiétou SANFO, sanfo.s@wascal.org
Ossadzifo Kwami WONYR, wonyra.ossa@gmail.com

[1] West African Science Service Centre on Climate Change and Adapted Land-use (WASCAL), Ecole Doctoral Informatics for Climate Change (ED-ICC), Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso ; Chair Energy and Prosperity, Fondation du Risque, France and Competence center, West African Science Service Centre on Climate Change and Adapted Land-use (WASCAL).
[2] Competence center, West African Science Service Centre on Climate Change and Adapted Land-use (WASCAL) ; Laboratoire de Développement Agricole et Transformation de l'Agriculture (DATA), Université Thomas Sankara, Ouagadougou, Burkina Faso.
[3] Université de Kara, Department of Economics and Management (FASEG), Kara – Togo.
[4] Martin Luther University Halle-Wittenberg.

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Assessing the Impact of Climate Extreme Events and Conflicts on Internal Displacement in Burkina Faso

Koffi Doh David ADZAVON[$§], Safiétou SANFO[§†], Ossadzifo Kwami WONYRA[⁑], Christine Furst[⁂]*

[*] *West African Science Service Centre on Climate Change and Adapted Land-use (WASCAL), Ecole Doctoral Informatics for Climate Change (ED-ICC), Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso.*

[$] *Chair Energy and Prosperity, Fondation du Risque, France*

[§] *Competence center, West African Science Service Centre on Climate Change and Adapted Land-use (WASCAL)*

[‡] *Laboratoire de Développement Agricole et Transformation de l'Agriculture (DATA), Université Thomas Sankara, Ouagadougou, Burkina Faso.*

[⁑] *Université de Kara, Department of Economics and Management (FASEG), Kara – Togo*

[⁂] *Martin Luther University Halle-Wittenberg*

[*] *adzavon.k@edu.wascal.org*
sanfo.s@wascal.org
wonyra.ossa@gmail.com

Abstract

This study investigates the dynamic relationship between climate extreme events, conflicts, and internal displacement in Burkina Faso. Using monthly data on floods, storms, violent and non-violent conflicts, and demonstrations from 2018 to 2022, the analysis shows that, unlike storms, floods have affected all regions of the country. Demonstrations are less frequent, while violent and non-violent conflicts are more common in the Sahel and Eastern regions and spread to other areas. We applied the dynamic modeling approach to model and identify both short and long run relationships. The results reveal that, in the short run, violent events, demonstrations, and storms are associated with increased internal displacement. The speed of adjustment (21.2%) indicates a rapid return to equilibrium. In the long run, violent events and storms are positively associated with internal displacement, while floods show no significant effect. This study highlights the need for effective conflict management policies and climate measures to mitigate the effects of extreme events in Burkina Faso.

Keywords: climate extreme events; conflicts; internal displacement; Internal Migration; Burkina Faso.

1 Introduction

Internal displacement in West Africa, particularly in the Sahelian zone, is generally linked to factors such as climate extreme climate events (Mouhamed et al., 2013), a decline in cropland productivity, soil degradation (Doso, 2014; Ogbue et al., 2024), poverty and hunger (Narem, 2024; Schnitzer & Stoeffler, 2024), conflicts between regions, armed conflicts and civil strife (Kim & Kim, 2024; Marivoet et al., 2024; Radil & Walther, 2024). Attractive factors, such as well-developed social facilities and accessible educational centers, often encourage people, especially young individuals, to leave their current place of residence. Many are drawn to new regions or communities that provide essential infrastructure, training opportunities, and resources needed for personal and professional growth. As a result, from the late 19th century onward, the intensity of migratory flows across different regions of Africa steadily increased, occurring both within national borders and across international boundaries (Konseiga, 2005). Faced with the need to find better jobs, desperate for the slightest social courtesy and frightened by the prospect of a life of toil for a derisory wage, many young men and women are increasingly abandoning the countryside for the cities (Aikaeli et al., 2021; Iruonagbe, 2009; Singer, 1973). This has contributed to a rapid increase in the urban population across African cities (Iruonagbe, 2009). However, these inflows have also placed significant pressure on urban infrastructure, leading to challenges such as rising rates of delinquency, inadequate sanitation, and mounting environmental issues. As cities struggle to accommodate these growing populations, they face difficulties in providing essential services, maintaining public safety, and managing environmental sustainability (Tacoli et al., 2015). The case of Burkina Faso, a Sahelian country, at the heart of West Africa, is an example where internal migrants are more directed to the country's biggest cities, such as Ouagadougou and Bobo-Dioulasso (Bjarnesen, 2013; Nielsen, 2019). As the number of migrants without stable settlements in Burkina Faso's cities continues to rise, urban areas are confronted with pressing challenges, including increasing rates of roadside begging and significant public health problems, such as heightened risks of diseases like malaria driven by urban transmission dynamics and limited health infrastructure (Gnémé et al., 2019; Rotberg, 2020; Soma et al., 2018). These issues are frequently documented as direct or indirect impacts of climate change and other environmental factors contributing to internal displacement among migrants in Burkina Faso (Arisco et al., 2023; De Longueville et al., 2019; Tourre et al., 2017).

Since the 2010s in the Sahel, attacks by armed groups have caused instability. In the case of Burkina Faso, terrorist attacks became increasingly frequent in 2015, resulting in thousands of deaths and forcing almost several thousand people to leave all their possessions and wealth and flee their homes (Issaev et al., 2022a; Sidorova & Zherlitsyna, 2023; Zherlitsina, 2023). Like any other country, Burkina Faso is affected by the effects of climate change. Drought periods, cool days, cold nights, the average daily number of wet days, and rainfall intensity are commonly mentioned problems in Burkina Faso (De Longueville et al., 2016). In Burkina Faso, variations in climatic conditions have had both positive and negative effects on maize, cowpea, millet, and sorghum yields (Sanou et al., 2023; Sossou et al., 2019). The sudden changes and increasing number of internally displaced people in the Sahelian region draw our attention. In 2019, the country counted 50,000 internally displaced people. In the third quarter of the year 2021, the National Emergency Relief and Rehabilitation Council (CONASUR) has announced a displacement of more than one million internally displaced people (Brons, 2021). Therefore, based on this, we have chosen to focus on the figures for the number of internally displaced people in Burkina Faso. Our definition of internally displaced persons is taken from the guiding principles on internal displacement, which state that internally displaced persons are people who have had to leave their homes because of war, violence, human rights violations, or natural disasters but who have not crossed a border into another country (Fisher & others, 2006).

This study investigates the dynamics of internal displacement in Burkina Faso by focusing on climate extreme events and conflicts. Our primary research question examines how these events contribute to fluctuations in displacement, particularly in the Sahelian context, where displacement dynamics are less studied. While much of the existing literature has focused on singular drivers, either conflict (Brons, 2021; Demuynck, 2022; Kafando & Sakurai, 2024; Lamarche, 2021; Sylvestre et al., 2024; Zamkowska, 2022a) or environmental change (Ceola et al., 2023; Howorth & O'Keefe, 1999; Lassailly-Jacob & Peyraut, 2016; Peterson, 2024; Sanfo et al., 2017; Schlef et al., 2018), a notable gap exists in understanding how these factors interact and compound displacement outcomes over time. What sets this research apart is its holistic approach, which not only examines the ongoing armed conflicts and terrorist activities identified as factors that influence internal displacement within Burkina Faso but also considers additional factors such as extreme events and other forms of conflicts that may contribute to internal displacement.

To facilitate this analysis, we first analyzed the data and derived insights showing that floods have reached all regions of Burkina Faso, whereas storms do not affect every part of the country but have recently been recorded in most regions. Demonstrations are relatively uncommon, whereas violent and non-violent conflicts are particularly concentrated in the Sahel and Eastern regions and spread to other areas. We observed that storms are not confined to the rainy season, as is typically the case with floods; rather, they also occur in the preceding months, before the onset of the rains. Second, we employed the Autoregressive Distributed Lag (ARDL) modeling approach, using monthly time series data on internally displaced persons, incidents of floods and storms, and conflict events, as summarized in Table 1 (section 3). The results indicate that in the short run, violent events, demonstrations, and storms are positively associated with an increase in internal displacement. However, in the long run, only violent conflicts and storms maintain a significant association with internal displacement.

The rest of the study is structured as follows: Section 2 provides an overview of the relevant literature; Section 3 presents an in-depth description of the study area, data, and methodology. Section 4 presents our results, and we discuss the empirical results in Section 5; Section 6 offers conclusions.

2 Literature review

a- Climate extremes and migration

Around the theme of people's displacement, there is a body of work. However, in sub-Saharan Africa, migration remains a vast field with many subjects yet to be discovered and explored. Several studies have focused on climate change as a determining factor in migration. Climate change causes extreme precipitation (O'Gorman, 2015); a decrease in precipitation leads to an increased risk of drought in some areas (Zou et al., 2005); increased precipitation leads to an increased risk of flooding in other areas (Pielke & Downton, 2000; Zou et al., 2005); and more tropical storms and other extreme weather events (Seneviratne et al., 2012). In Burkina Faso, Long dry spells, floods, a hotter temperature, and extremes of precipitation are adversely influencing rural yields (Benot et al., 2015; Borona et al., 2015). Thus, surveying the effect of worldwide temperature increment on the generation of these distinctive crops' wheat, rice, maize, and soybean has appeared negative temperature impacts surrender at the worldwide scale. Each one-degree Celsius increment in worldwide temperature would, on average, decrease global yields of wheat by 6.0%, rice by 3.2%, maize by 7.4%, and soybean by 3.1% (Zhao et al., 2017). Therefore, according to the IPCC reports, the rise in global temperature will result in environmental-related risks such as floods, drought, dry spells, sea-level rise, and many others (Djalante, 2019). There are numerous reasons why environmental disasters pose such a colossal challenge for African farming (Dodson et al., 2004; Nanjira & Daniel, 1991). Evidence from 49 papers all focused on people's perception of climate change and variability in West Africa revealed that dry spells, shorter rainy seasons, drought and decrease in total amount were denoted in all the countries (De Longueville et al., 2020). Especially in Burkina Faso, most people believe the climate has become warmer over the last 30 years (73%). They also think that there has been less rain (97%) and that the rainy season is becoming shorter, with a late start and an early end (De Longueville et al., 2020). Studies show that this shortage in agricultural productivity in sub-Saharan Africa causes food insecurity (Muzari, 2016), and usually leads to displacement (Crush, 2013; Osman & Abebe, 2023). In the Sahel region of Africa known as a zone for breeding, due to this water stress caused by drought, people move (Blanco, 2020) and studies find that these rainfall deficits, which force herders to become nomadic with their livestock, cause significant damage to farmers and are also a source of conflict between farmers and herders (McGuirk & Nunn, 2024). Thus, climate change and the repetitive occurrence (frequency) of climate extreme events become major causes of internal displacement in the region (Ferris & Stark, 2012). Faced with problems like land degradation, reduced crop productivity and incomes, water scarcity, and environmental disasters, internal migration, such as rural-urban migration, becomes an adaptive measure for the affected population. This appears in Burkina Faso within a study held on the cause of intervillage migration (Sanfo et al., 2017).

b- Conflicts as a driver of migration

Conflicts, in their various forms, are a major driver of population displacement, especially in Africa, where they are frequently linked not only to political instability, civil unrest, and competition over resources but also to escalating insecurity in border regions and declining agricultural productivity (Gluhbegovic, 2016; McGuirk & Nunn, 2024). This insecurity limits access to essential resources and disrupts local economies. Scholars have demonstrated that conflicts disrupt local food markets, reducing demand and limiting competition (Bar-Nahum et al., 2020). In countries where people are more focused on agriculture, evidence in Nigeria and Colombia has proven that prolonged conflict leads households to engage in low-yield and short-term farming practices to minimize risks, ultimately reducing agricultural productivity (Arias et al., 2019; George et al., 2021). Conflict disrupts dietary diversity, weakens resilience, and hampers food availability, leading to food scarcity and ultimately, displacement, as observed in Burkina Faso (Béné et al., 2024). Households in regions like Côte d'Ivoire and Gaza exposed to violence experience reduced dietary diversity and weakened resilience due to limited adaptive resources, making displacement a common outcome (Brück et al., 2019; Dabalen & Paul, 2014; Hassoun et al., 2024; Kamta et al., 2020). Understanding these dynamics is essential for designing effective food security policies (Breisinger et al., 2015). In the Sahel region, factors such as weak governance, and economic decline have contributed to a rise in violent extremism in many Sahelian countries since their independence in the 1960s (Debrah, 2021; Lounnas, 2021). These conflicts have increased over the past decade and pose major challenges for countries in the Sahelian region (Juvan, 2024; Kazeem, 2024).

In northern Mali, the National Movement for the Liberation of Azawad (MNLA), supported by Islamist groups such as Al-Qaeda in the Islamic Maghreb (AQIM), the Movement for Unity and Jihad in West Africa (MUJAO), and Ansar Dine, aims to drive government forces out of the region (Christopoulos & Walter, 2012; O'Luanaigh, 2019; Paradela-López & Jima-González, 2024). In Burkina Faso, the year 2015 is the year that attracted attention. Before that, the country was considered a bit calm in terms of terrorism but after 2015, the very safe country began to face an unprecedented increase in terrorist activity (Issaev et al., 2022b). This has resulted in a massive displacement of the population from the north of Burkina Faso. The effects of these violent actions have affected the economic sectors and the population, contributing to increased poverty, reduction of economic growth, reduced investment in the country, and political insurgency leading to short-lived coups d'etat in the country (Eizenga, 2023; Kaboré, 2023; Kambou & Khariss, 2020).

The situation in Burkina Faso exemplifies the complex and interconnected relationship between climate change, conflicts, and internal displacement. To address the challenges posed by climate change and conflicts in Burkina Faso and mitigate their impact on internal displacement, it is crucial to adopt a comprehensive approach that addresses both the root causes and consequences of these challenges (Cepero et al., 2021; Knaepen & Vajpeyi, 2022).

3 Data and method

3.1 Data

The data used in this study are gathered from several sources. They are climate extreme events data, conflict data, and internal displacement data, all concerning Burkina Faso. Some have been downloaded from online open-source data platforms, and others have been collected from the public administration. In the case of climate extreme events, we collected the time series data on the number of floods, and the number of storms. For conflict data, we have downloaded them through the ACLED database after having permission. It concerns different types of conflicts such as violent events, non-violent actions, and demonstrations. Table 1 below presents the categories of data sets collected and the duration covered by each, while in Table 2 we provide an explanation of the different types of conflict following ACLED definitions (*ACLED (Armed Conflict Location and Event Data)*, 2024).

Table 1: Summary table of the data

<table>
<tr><td>Datasets</td><td>Data Sources</td><td>Duration</td></tr>
<tr><td rowspan="3">Climate extreme events</td><td>SP/CONASUR Burkina Faso (National Council for Emergency Relief and Rehabilitation)</td><td rowspan="5">07-2018– 12-2022</td></tr>
<tr><td>FIRE SERVICE brigade of Burkina Faso (firefighter)</td></tr>
<tr><td>EM-DAT (International Disaster Database)[1]</td></tr>
<tr><td>Conflicts</td><td>ACLED (Armed Conflict Location and Event Data)[2]</td></tr>
<tr><td>Internal displacement data</td><td>SP/CONASUR Burkina Faso</td></tr>
</table>

[1] https://www.emdat.be/

[2] https://acleddata.com/data/

Table 2 : Explanation of the different types of conflicts

General category	Type of conflicts	Definition
Violent events	Battle	Battles are violent clashes between at least two armed groups. Battle types are distinguished by whether control of a location is unchanged because of the event; whether a non-state group has assumed control of a location, or whether a government has resumed control of that location. (Armed crash, Government regains territory, non-state actor overtakes territory)
	Explosions and remote violence	Explosions/Remote violence refers to events where an explosion, bomb, or other explosive device was used to engage in conflict. (Chemical weapons, Air/drone strikes, Suicide bombs, grenades, missile attacks, remote explosives)
	Violence against civilians	Violence against civilians involves violent attacks on unarmed civilians. (Sexual violence, civilians attacks, Abduction/ forced disappearances)
Non-violent actions	strategic developments	Strategic developments include incidences of looting, peace talks, high-profile arrests, non-violent transfers of territory, recruitment into non-state groups, changes to group/activity, disrupted weapon use, and agreements.
Demonstrations	Protests	Protests are non-violent demonstrations, involving typically unorganized action by members of society. (Peaceful protests, protests with interventions)
	Riots	Riots are violent demonstrations, often involving spontaneous action by unorganized, unaffiliated members of society. (Mob violence)

Source: ACLED data definition (Project, 2019)**.**

3.2 Description of the study area

Burkina Faso is a landlocked West African country bordered by Mali in the northwest, Niger in the northeast, Benin in the southeast, Togo, and Ghana in the south, and the Ivory Coast to the southwest. The country is quite large, it covers an area of 274,222 km² and has 13 regions. According to the fifth general census of the population and housing of Burkina (2019), the population is 20.5 million inhabitants. Its capital is Ouagadougou, which hosts most of the population, more than 2.45 million people (INSD-2019). A significant portion of Burkina Faso's workforce is engaged in agriculture, which plays a crucial role in the nation's economy (Séogo & Zahonogo, 2023). The country's farmers are smallholders and engaged in subsistence agriculture, and there are many lack access to modern farming techniques (Crawford et al., 2016; Sorgho et al., 2020). The main crops grown are sorghum, pearl millet, maize, groundnuts, rice, and cotton (Lykke et al., 2002). Burkina Faso has an essentially tropical climate with two distinct seasons. Burkina Faso's climate also makes its crops vulnerable to insect attacks, including locusts and crickets, which destroy crops and further hamper food production (Hippolyt et al., 2023). Out of these, land degradation is one of the famous problems farmers are facing. Recent studies show Burkina Faso has reached an unprecedented level for more than 3.45 million people facing food security issues (Merem et al., 2019; Tkaczyk & Moseley, 2023).

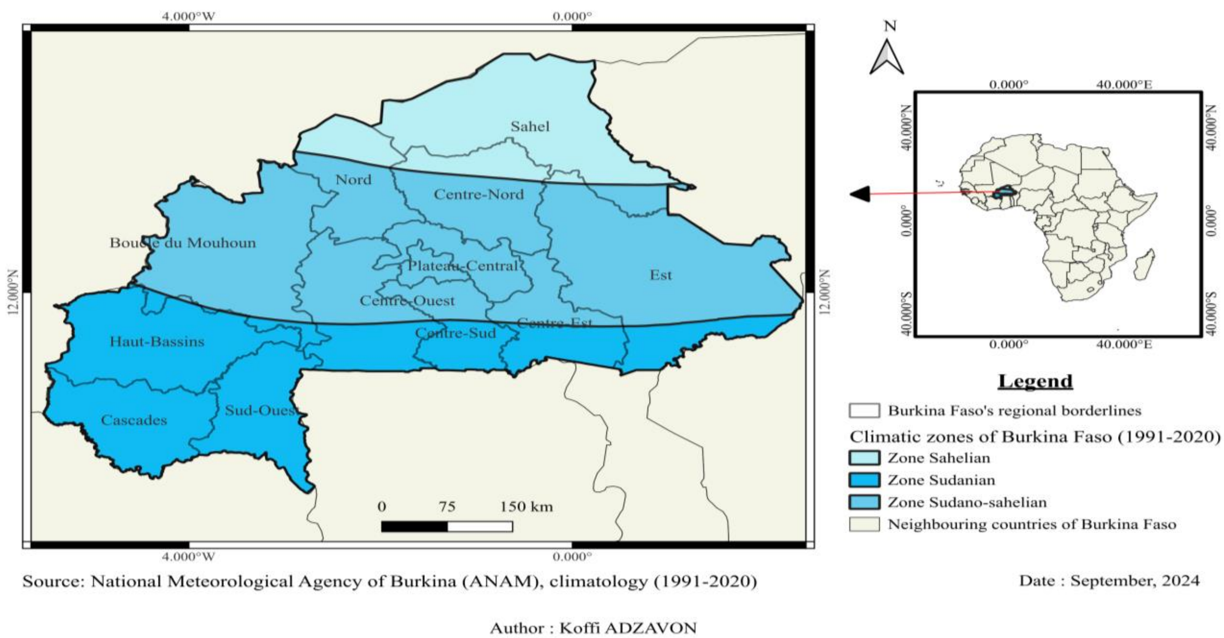


Figure 1: Map of the study area (Burkina Faso in West Africa and agroclimatic zones)

3.2 Descriptive analysis of the different events

Insights into the frequency of climate extreme events deepen our understanding of their locations (figure 2). It depicts the frequency of each type of extreme event by region. From 2018 to 2022, all the regions experienced floods. The most affected regions were the Boucle du Mouhoun, the Centre-Nord and the Haut-Bassins each with more than 80 cases of floods during the study period. The less affected are the regions of Centre, the Est, the Cascade, Centre-Est, and the Centre-Sud. These regions have less than 20 cases of floods during the five years while in the other regions, the number of floods is over 20 cases but less than 60 cases of floods. Over time, all the regions are not affected by storms. The storms are more present in the country's northern regions (Sahel, Nord, Centre-Nord) but also in some regions in the center and the south (Centre-Sud, Plateau Central). Regions like Boucle du Mouhoun, Sud-Ouest, Centre-Est, and Centre-Ouest had very few cases of storms, while others, such as Est, Centre, Cascade, and Boucle du Mouhoun, did not experience storms. Examining their evolution over time (Figure 2), floods generally occurred during the rainy season, except in 2020 when there were no flood cases. For instance, in August 2018, up to 200 cases of floods were recorded nationally. The country also experienced numerous storm cases, particularly before and during the rainy seasons.

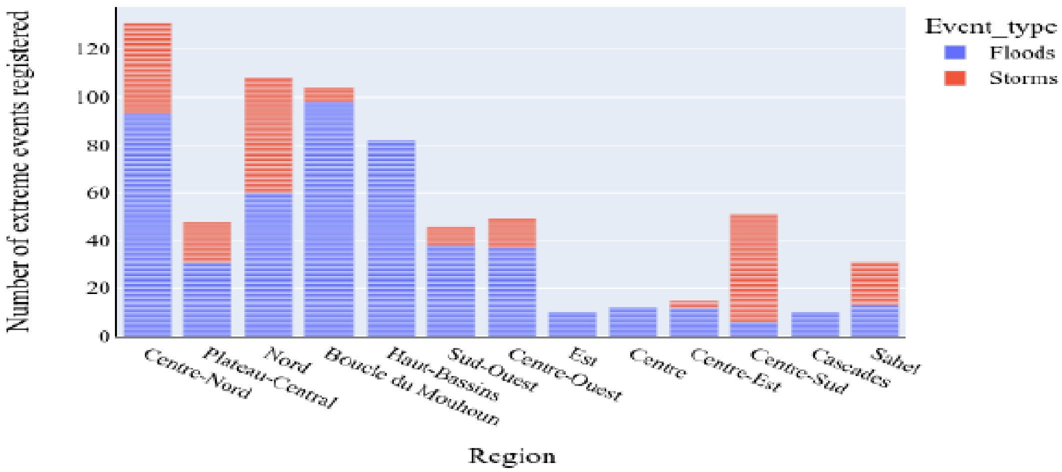


Figure 2: Climate extreme events by region from 2018-2022.
Source : SP/CONASUR, EM-DAT.

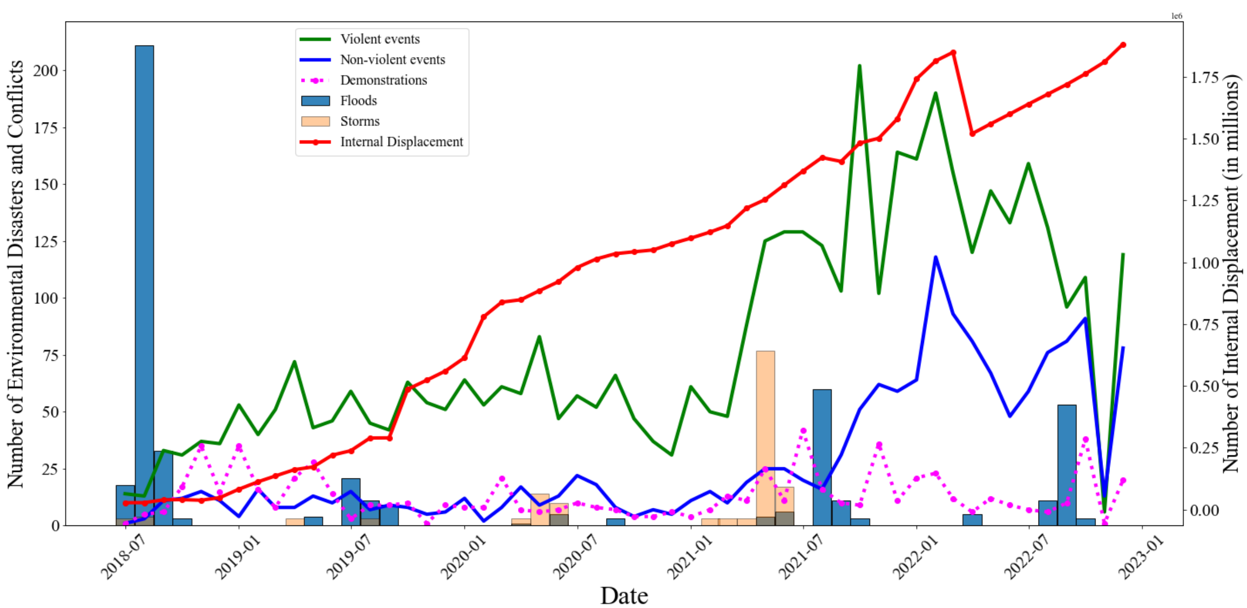


Figure 3 : Evolution of climate extreme events, conflicts, and Internal displacement from 2018 to 2022. Source: ACLED data, SP/CONASUR, EM-DAT, Fire Service (Burkina Faso)

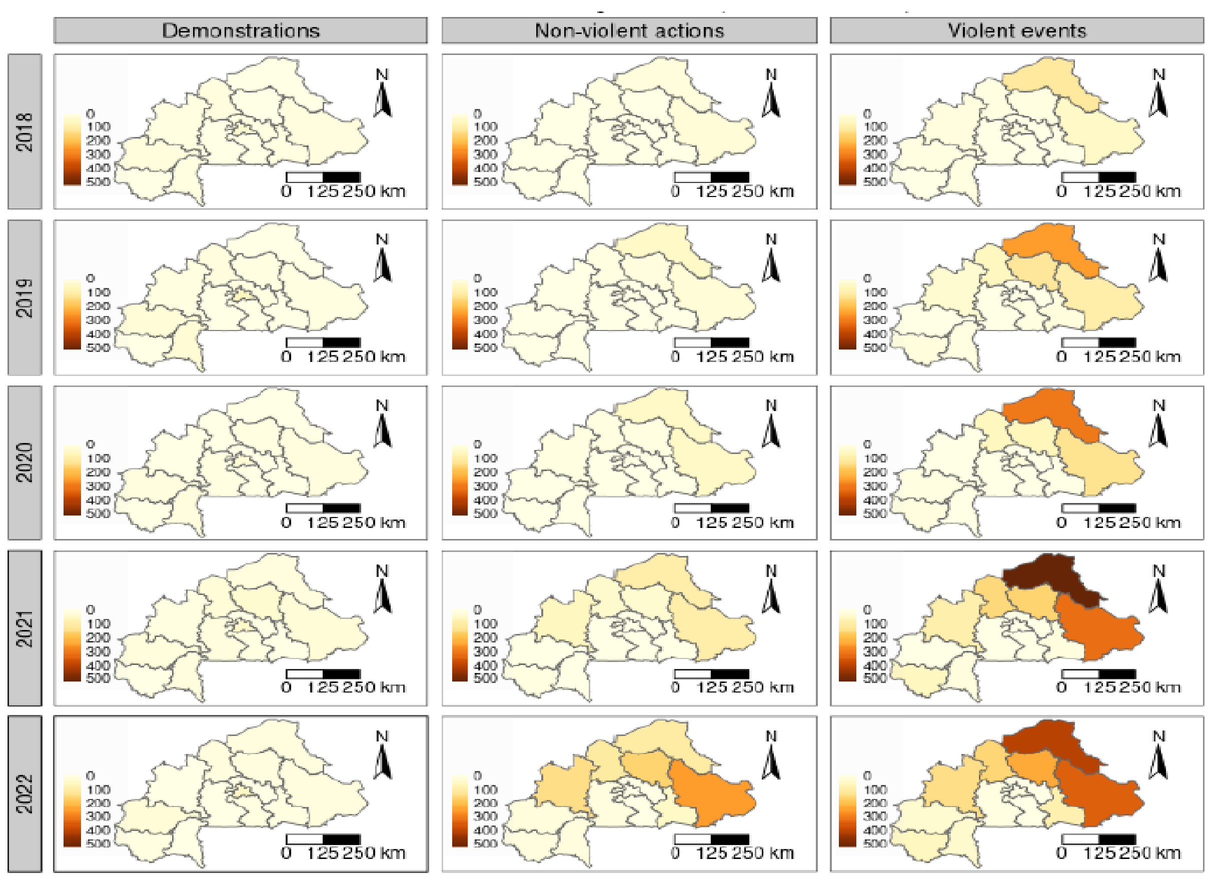


Figure 4 : Spatial evolution of conflicts by region from 2018 to 2022, Source : ACLED data

The analysis of conflict events shows that demonstrations are rare in Burkina Faso, as the consistent results indicate (Figure 3). This means that demonstrations are almost non-existent in Burkina Faso, but they are slightly more prevalent in the Center region (Ouagadougou) and Haut-Bassins than in other regions (Bobo-Dioulasso). Non-violent conflicts are also a type of conflict that commonly occurs in Burkina Faso. This conflict type is currently on the rise in the country. From 2018 to 2020, we observed that non-violent conflicts were relatively low. However, in 2021, there was a significant increase, and it continued to escalate in 2022. In 2021, non-violent conflicts were more prevalent in the Sahel and East regions than in Boucle de Mouhoun, Nord, and Centre-Nord regions. In 2022, non-violent conflicts underwent a significant evolution, especially in the Est region compared to others. These conflicts evolved in the north and east, while the central and southern regions were less affected. Between July 2018 and the end of April 2019, displacement started in some regions such as the Sahel, Centre-Nord, Centre, and the Est (Figure 4). After July, internal displacement was recorded in other regions and continued to increase up to December 2022. Thus, displaced people are from all regions of the country. The evolution of internally displaced persons is very concerning in Burkina Faso. In 2022, the country accounted for more than 1.8 million internally displaced people (Figure 2). Two regions are the push zones of displaced people, especially the Centre-Nord and Sahel regions. Displacement started early in these two regions and intensified over time. We can see that the number of internally displaced people has also increased in the Nord, Boucle du Mouhoun, and Est regions since June 2020, and it has grown over time. The new regions from which internally displaced people are coming are the Centre-Est and Sud-Ouest. In the other regions, people are displaced, but the number is less than 50,000.

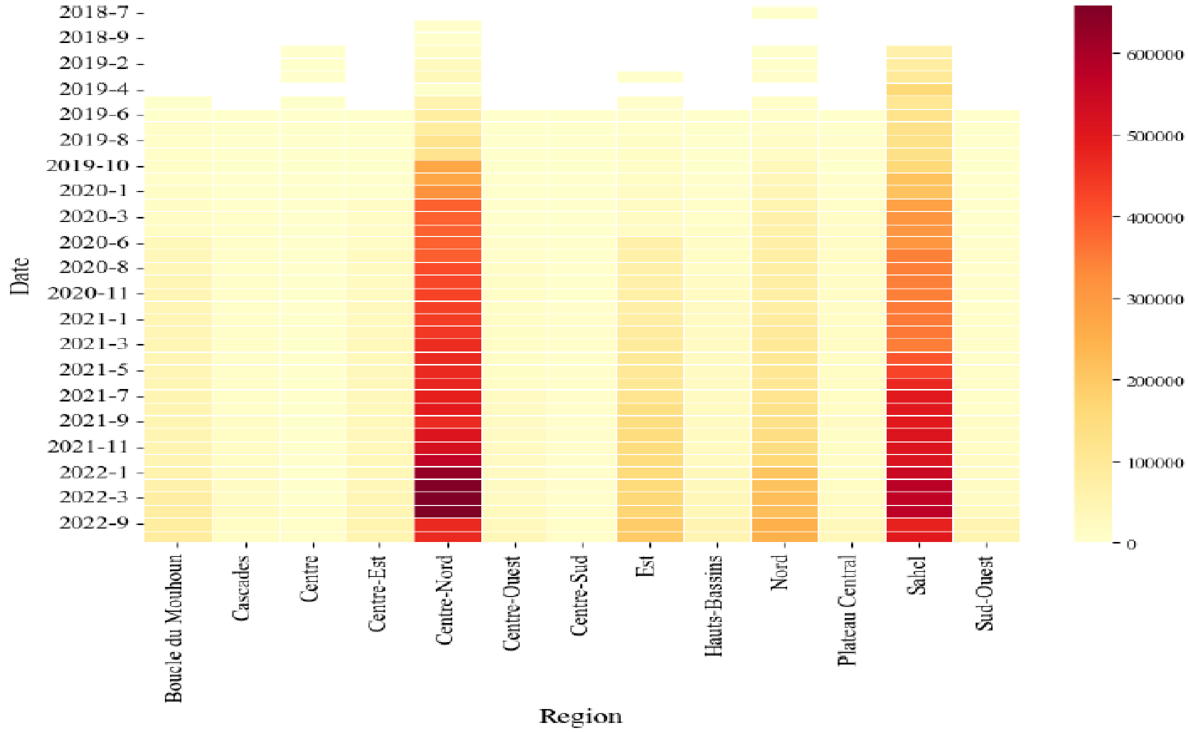


Figure 5 : Internal displaced people by month, Source : SP/CONASUR

Correlation analysis

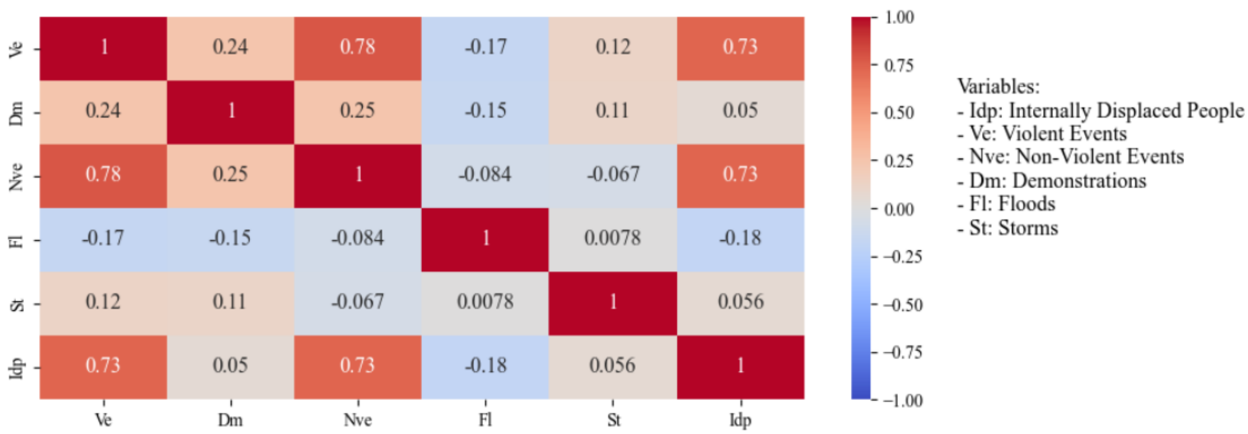


Figure 6 : Correlation matrix between variables

The correlation matrix highlights significant relationships between some variables, while others appear to be less interrelated. It indicates that the number of internally displaced people (Idp) has a strong positive relationships with both violent events (Ve) and non-violent events (Nve), showing that higher occurrences (frequency) of these events are associated with greater displacement. In contrast, Idp has weak or very low correlations with demonstrations (Dm), floods (Fl), and storms (St), suggesting these factors have minimal association with displacement numbers. The correlation pattern suggests that displacement tends to be more closely linked to conflict-related events than to extreme events or demonstrations.

3.3 Econometric model specification

To understand the relationship between extreme events, conflicts and internal displacement, we adopted the ARDL (Autoregressive Distributed Lag) modeling approach. This method is a widely used approach in econometrics for analysing short run as well as in the long run relationships between variables. ARDL model is suitable for this case study because apart from capturing both short and long run relationships, it performs reliably with smaller datasets, which is useful if data is limited, and incorporates an error correction mechanism that reveals how variables return to equilibrium after shocks. It also accommodates variables with mixed integration orders (I(0) and I(1)), allowing flexibility without strict pre-testing. Unlike traditional methods, it allows for assigning different lag lengths to various variables in the model and provides unbiased estimates for both the long-term relationships and the long-run coefficients. Issues related to endogeneity and autocorrelation are effectively addressed using this approach (Harris & Sollis, 2003; Nkoro et al., 2016; Pesaran et al., 1995, 2001). To address issues of variance stabilization and non-normalization of the distribution, a natural logarithm was applied to all variables, which were then incorporated into the empirical model equation (Ekwaru & Veugelers, 2018; Neocleous et al., 2011). Therefore, our equation to explain the internal displacement in Burkina Faso can be written mathematically as follows:

$$lnIdp = f(lnVe, lnNve, lnDm, lnFl, lnSt) \quad (1)$$

Where:

$lnIdp, lnVe, lnNve, lnDm, lnFl, lnSt,$ are respectively the natural logarithm form of the number of internally displaced people, number of Violent events, number of Non-violent events, number of Demonstrations, number of Floods and the number of Storms.

The ARDL model approach to cointegration implies the estimation of the conditional error correction (EC) form (Pesaran et al., 2001). Hence, the ARDL $(p, q_1, q_2, q_3, q_4, q_5)$ the model will be specified as:

$$\Delta lnIdp_t = a + \sum_{i=1}^{p} \theta_i \, \Delta lnIdp_{t-i} + \sum_{i=0}^{q_1} \beta_i \, \Delta lnVe_{t-i} + \sum_{i=0}^{q_2} \gamma_i \, \Delta lnNve_{t-i} + \sum_{i=0}^{q_3} \varphi_i \, \Delta lnDm_{t-i} + \sum_{i=0}^{q_4} \omega_i \, \Delta lnFl_{t-i} + \sum_{i=0}^{q_5} \pi_i \, \Delta lnSt_{t-i} + \delta_1 \, ln\, Idp_{t-1} + \delta_2 \, ln\, Ve_{t-1} + \delta_3 \, ln\, Nve_{t-1} + \delta_4 \, ln\, Dm_{t-1} + \delta_5 \, ln\, Fl_{t-1} + \delta_6 \, ln\, St_{t-1} + \varepsilon_t \quad (2)$$

The F-test helps to test the existence of the long-run relationship of the variables. In the case of an existing long-run relationship, the F-test indicates which variable we must normalize. The null hypothesis for no cointegration among variables of the equation is H0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$, against the alternative hypothesis $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq 0$. In case of evidence of a long run relationship of the variables, which simply means that there's a cointegration the following model will be estimated:

$$lnIdp_t = \alpha_1 + \sum_{i=1}^{p} \theta_{1i} \, \Delta lnIdp_{t-i} + \sum_{i=0}^{q_1} \beta_{1i} \, \Delta lnVe_{t-i} + \sum_{i=0}^{q_2} \gamma_{1i} \, \Delta lnNve_{t-i} \; \sum_{i=0}^{q_3} \varphi_{1i} \, \Delta lnDm_{t-i} + \sum_{i=0}^{q_4} \omega_{1i} \, \Delta lnFl_{t-i} + \sum_{i=0}^{q_5} \pi_{1i} \, \Delta lnSt_{t-i} + \mu_t \quad (3)$$

The short run ARDL specification dynamic can be derived by adding the error correction term (ECT):

$$\Delta lnIdp_t = a + \sum_{i=1}^{p} \theta_{2i} \Delta lnIdp_{t-i} + \sum_{i=0}^{q_1} a_{2i} \Delta lnVe_{t-i} + \sum_{i=0}^{q_2} \gamma_{2i} \Delta lnNve_{t-i} \sum_{i=0}^{q_3} \varphi_{2i} \Delta lnDm_{t-i} + \sum_{i=0}^{q_4} \omega_{2i} \Delta lnFl_{t-i} + \sum_{i=0}^{q_5} \pi_{2i} \Delta lnSt_{t-i} + \rho ECT_{t-1} + \varepsilon_t \quad (4)$$

Where the ECT_{t-1} is defined as follows:

$$ECT_t = lnIdp_t - \alpha_1 - \sum_{i=0}^{q_1} \beta_{1i} \Delta lnVe_{t-i} + \sum_{i=0}^{q_2} \gamma_{1i} \Delta lnNve_{t-i} \sum_{i=0}^{q_3} \varphi_{1i} \Delta lnDm_{t-i} + \sum_{i=0}^{q_4} \omega_{1i} \Delta lnFl_{t-i} + \sum_{i=0}^{q_5} \pi_{1i} \Delta lnSt_{t-i} \quad (5)$$

4 Results and discussions

4.1 Stationarity

With time series data, unit root testing helps to see whether our data is stationary. In the simplest way, stationary data means that the data is taking constant mean and variance while its contrary is non-stationary data which indicates that the data has a unit root that can cause spurious estimation results (Nkoro et al., 2016). To address those issues, we can differentiate the data to make it stationary. Many methods have been used so far such as the test of Augmented Dickey-Fuller (ADF), the test of Phillippe-Perron (PP), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), where the ADF test is effective in the presence of autocorrelated error, the PP test is recommended in the presence of heteroscedastic errors, and the KPSS test decomposes a series into three components (deterministic part, random part, white noise) with the null hypothesis of stationarity (Adel, 2022; Herranz, 2017).

As shown in Table 3, the unit root test results indicate the variables' integration order. Specifically, LnIdp and LnVe are found to be integrated of order 1 (I(1)), as they are non-stationary at the level but become stationary after first differencing. On the other hand, LnNve, LnDm, LnFl, and LnSt are stationary at the level (I(0)), meaning they do not require differencing. These results ensure that the ARDL model can be appropriately applied to this dataset for analysis, as none of the variables are integrated of order 2 (I(2)).

Table 3 : Unit root testing

Variab-les	Intercept				Intercept and Trend			
	ADF t-statistics	Prob.*	5% critical values	Order of Integrat-ion	ADF t-statistics	Prob.*	5% critical values	Order of Integrat-ion
Lnidp	-6.748638	0.0000	-2.918778	I(1)***	-6.681241	0.0001	-3.498692	I(1)***
Lnve	-13.24094	0.0000	-2.918778	I(1)***	-13.26188	0.0000	-3.498692	I(1)***
Lnnve	-9.854916	0.0000	-2.918778	I(1)***	-3.637180	0.036	-3.496960	I(0)**
Lndm	-6.470125	0.0000	-2.917650	I(0)***	-6.406800	0.0000	-3.496960	I(0)***
Lnfl	-5.989995	0.0000	-2.917650	I(0)***	-6.115303	0.0000	-3.496960	I(0)***
Lnst	-5.698434	0.0000	-2.917650	I(0)***	-5.650491	0.0001	-3.496960	I(0)***

Source: Author computation; ***Significant at 5% level*
****Significant at 1% level*

4.2 Optimal lag selection for the Model

As for all dynamic models, the optimal lag selection is based on information criteria. Therefore, we have the Akaike Information criteria (AIC), the Schwarz Information criteria (SIC) and the one of Hannan Quin (HQ). To determine the optimal lag (p*, q*), we select the minimum value given among the result of the criteria. From our computation, six (6) was found as the maximum lag to be included in the model as shown in Table 4. This also respect the global literature around the maximum lag for monthly data (Hall, 1994; Kripfganz & Schneider, 2023). After that, we computed the optimal lag for each variable to ensure the most accurate model specification. This approach allows us to determine the appropriate lag length for each variable, improving the model's fit and accuracy. From the 20 best models identified, we selected the ARDL model with the lag order (1,6,0,5,5,6) because it produced the smallest value within the range of -3.11 to -3.12, as shown in Figure 7. This process ensures the selected lag structure minimizes errors and enhances the reliability of the results.

Table 4 : Best lag selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1684.729	NA	1.58e+23	70.44705	70.68095	70.53545
1	-155.035	223.2701	3.10e+21	66.50144	68.13874*	67.12018
2	-1508.530	66.36061	2.24e+21	66.10542	69.14613	67.25451
3	-1436.090	87.53210	5.94e+20	64.58708	69.03116	66.26651
4	-1408.968	25.99143	1.29e+21	64.95701	70.80452	67.16679
5	-1349.427	42.17546	1.06e+21	63.97610	71.22701	66.71623
6	-1217.186	60.61015*	9.10e+19*	59.96609*	68.62040	63.23656*

Source: Author computation *(*) specifies the best lag with each criteria*

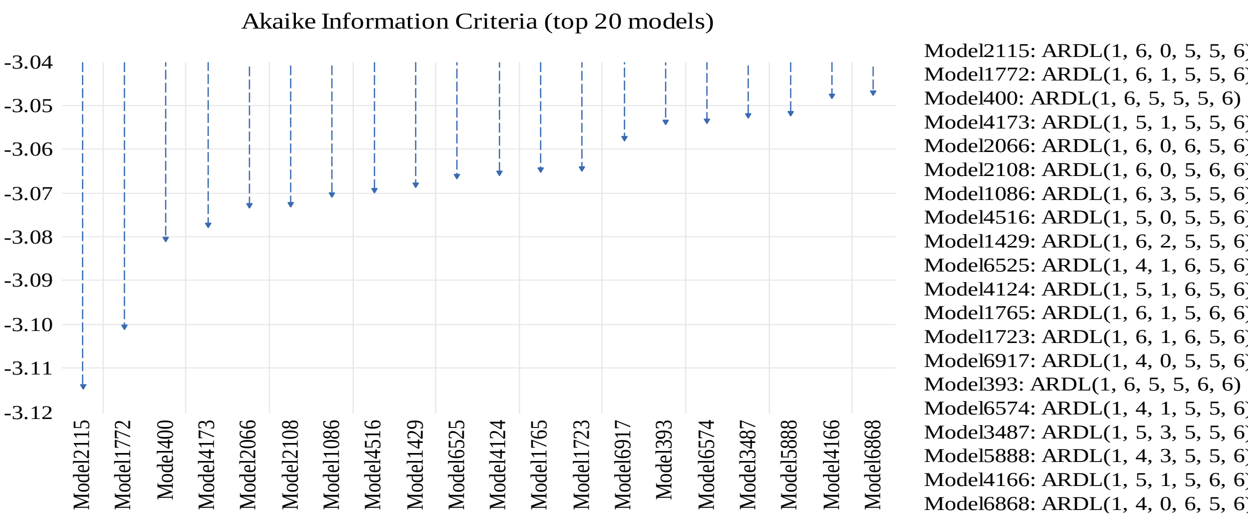


Figure 7: Summary of the best model selection process

4.3 The bounds test or co-integration test

The test procedure is such that the Fisher values obtained should be compared with the critical values simulated for several cases and different thresholds. The upper bound includes the values for which the variables are integrated at order 1 I(1) and the lower bound concerns the variables at level I(0). The result of the test, presented in Table 5, show that the value of the F-statistic (26.09468) is greater than the value of the upper band I(1) at 5% level of significance (3.79) and even at the other significance level (1%: I(1) = 4.68 ; 2.5%: I(1)= 4.18 ; 10%: I(1) = 3.35). This means that we should reject the hypothesis of non-co-cointegration and accept the hypothesis of cointegration. The acceptance of this hypothesis implies that there is a long-term relationship that we should estimate.

Table 5 : F-statistic of cointegration relationship

Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
F-statistic	26.09468	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68

Source: Author computation

4.4 Result of the ARDL model (1,6,0,5,5,6)

Table 6 : Error correction model

ECM Regression Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob
C	2.193451	0.151970	14.43340	0.0000
D(LnVe)	0.057385	0.016104	3.563430	0.0021
D(LnVe(-1))	-0.293875	0.030770	-9.550675	0.0000
D(LnVe(-2))	-0.313353	0.037030	-8.462229	0.0000
D(LnVe(-3))	-0.216528	0.038695	-5.595762	0.0000
D(LnVe(-4))	-0.110131	0.037074	-2.970590	0.0079
D(LnVe(-5))	-0.056173	0.028528	-1.969019	0.0637
D(LnDm)	0.006275	0.009580	0.655033	0.5203
D(LnDm(-1))	0.152581	0.016363	9.324712	0.0000
D(LnDm(-2))	0.131063	0.015395	8.513367	0.0000
D(LnDm(-3))	0.093809	0.014812	6.333272	0.0000
D(LnDm(-4))	0.034412	0.010876	3.163975	0.0051
D(LnFl)	-0.005192	0.001594	-3256690	0.0042
D(LnFl(-1))	-0.011157	0.001816	-6.142617	0.0000
D(LnFl(-2))	-0.011838	0.001667	-7.101921	0.0000
D(LnFl(-3))	-0.009081	0.001701	-5.337867	0.0000
D(LnFl(-4))	-0.009172	0.001625	-5.644097	0.0000
D(LnSt)	0.006656	0.002529	2.631979	0.0164
D(LnSt(-1))	-0.018497	0.002724	-6.791005	0.0000
D(LnSt(-2))	-0.006240	0.002669	-2.338520	0.0304
D(LnSt(-3))	-0.007891	0.002317	-3.405400	0.0030
D(LnSt(-4))	-0.003928	0.002181	-1.800978	0.0876
D(LnSt(-5))	-0.008816	0.002094	-4210718	0.0005
CointEq(-1)*	-0.211888	0.015067	-14.06308	0.0000
R-squared	0.947756	Mean dependent var	0.076515	
Adjusted R-squared	0.897689	S.D dependent var	0.123225	
S.E. of regression	0.039415	Akaike info criterion	-3.322501	

Sum squared resid	0.037285	Schwarz criterion	-2.386901
Log Likelihood	103.7400	Hannan-Quinn criterion	-2.968937
F-statistic	18.92977	Durbin-Watson Stat	2.257840
Prob (F-statistic)	0.000000		

Source: Author computation

***LnIdp**: Logarithm of Internally Displaced People,*
***LnVe**: Logarithm of Violent Events,*
***LnNve**: Logarithm of Non-Violent Events,*
***LnDm**: Logarithm of Demonstrations,*
***LnFl**: Logarithm of Floods,*
***LnSt**: Logarithm of Storms.*

The results presented in Table 6 correspond to the short-run analysis. These findings indicate the presence of disequilibrium in the short run. For instance, for the first month when a violent event occurs, it leads to displacement but for the lag periods, it does not. Also, for the storms, we observe this variability which shows that there is a disequilibrium in the short run results. The Error correction (EC) term tells us about how the disequilibrium in our short run result is corrected. Thus, the EC (CointEq(-1)) has a negative coefficient of -0.211888 indicating that the deviation of the short run results from the long-run equilibrium relationship between the variables converges back towards the equilibrium at the speed of 21.2%. The R-squared value which tells us how well our model explains the variability in the dependent variables, gives 0.947756 indicating that the model explains 95% of the variability in the LnIdp. The Adjusted R-squared of 90% indicates that the model's explanatory power is reliable even after adjusting for the number of explanatory variables.

Table 7: Long run model

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Lnve	1.465514	0.214997	6.816443	0.0000
Lnnve	-0.158877	0.129106	-1.230591	0.2335
Lndm	-0.556042	0.181122	-3.069985	0.0063
Lnfl	0.049344	0.035296	1.398034	0.1782
Lnst	0.137757	0.036721	3.751449	0.0014
C	10.35195	0.768770	13.46560	0.0000

Source: Author computation

***LnIdp**: Logarithm of Internally Displaced People,*
***LnVe**: Logarithm of Violent Events,*
***LnNve**: Logarithm of Non-Violent Events,*
***LnDm**: Logarithm of Demonstrations,*
***LnFl**: Logarithm of Floods,*
***LnSt**: Logarithm of Storms.*

In the long run, the model results, as presented in Table 7, show that violent events have a significant and positive effect on the number of internally displaced people. This indicates that a one percent increase in the number of violent events in Burkina Faso leads to an approximately 1.47% increase in the number of internally displaced people.

We also observe a negative coefficient for non-violent events (-0.158877), indicating that a one percent increase in non-violent events leads to a decrease of 0.16% in the number of internally displaced people. However, this coefficient is not statistically significant, suggesting that conclusions based on this result may not be reliable for decision-making. For the demonstration, the result of the estimation gives in the long run a negative coefficient (-0.556042). This result lets us understand that demonstration encourages a decrease in internally displaced people in Burkina

Faso. From that, we can say that an increase of one percent in demonstration reduces internal displacement to 0.56%. This result of the estimation is statistically significant (0.0063).

The result shows a positive coefficient (0.049344) for flood events, indicating that floods are drivers of internal displacement. However, the result is not statistically significant ($p = 0.1782$), suggesting that the relationship between floods and internally displaced people in the long run may not be robust, and decisions based on this relationship may be unreliable. According to the estimated coefficients of the model, storms have a significant positive long-run effect on the number of internally displaced people in Burkina Faso. The coefficient (0.137757) specifies that a one percent increase in the number of storm events in Burkina Faso is associated with a 0.14% increase in the number of internally displaced people, holding other factors constant.

4.5 The Heteroscedasticity Test

The objective of conducting this test is to determine whether the variance of the residuals is constant. For this we have two assumptions. The first is called homoscedasticity (when the variance of the residual is constant) and the second is called heteroscedasticity (when the variance of the residual is not constant). It's preferable to have homoscedasticity rather than heteroscedasticity. Our results show that the variance in the residuals for this model is homoscedastic, indicating that our model is free from heteroscedasticity.

Table 8: Breusch-Pagan-Godfrey's heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey Null hypothesis: Homoskedasticity			
F-Statistic	0.491684	Prob.F(28,19)	0.9572
Obs*R-squared	20.16725	Prob.Chi-Squared (28)	0.8583
Scaled expalained SS	2.928451	Prob.Chi-Squared (28)	1.0000

Source: Author computation

4.6 Autocorrelation Test

For the autocorrelation test, Breusch-Godfrey is one of the most powerful among many we know. This test uses the residues of the model. This is based on a hypothesis of which there is no serial correlation of any order up to p. The result of our test shows that we should accept this hypothesis and reject the alternative hypothesis which states that the model is not suffering from serial correlation.

Table 9: Breusch-Godfrey's Serial Correlation Test:

Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags			
F-Statistic	0.298288	Prob.F(2,17)	0.7459
Obs*R-squared	1.627340	Prob.Chi-Squared (2)	0.4432

Source: Author computation

4.7 Parameter Stability Test (CUSUM Graph)

The parameter stability test is based on the cumulative sum (CUSUM) of recursive residuals and plot the cumulative sum with 95% confidence bands. In the previous section, which is the chapter on the methodology we define the assumptions. The result shows that the model parameters are stable because our CUSUM plot and the CUSUM of the square falls between that upper and the lower band.

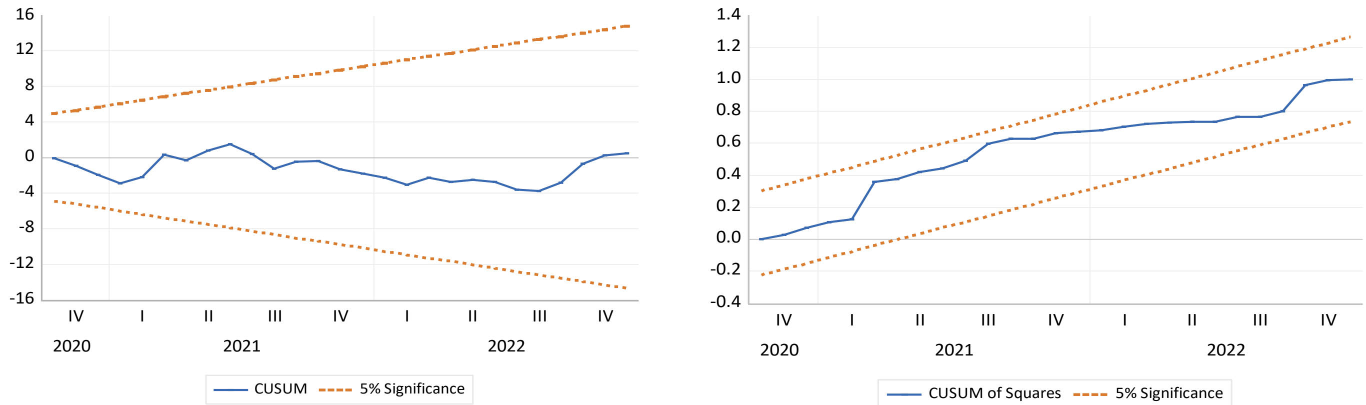
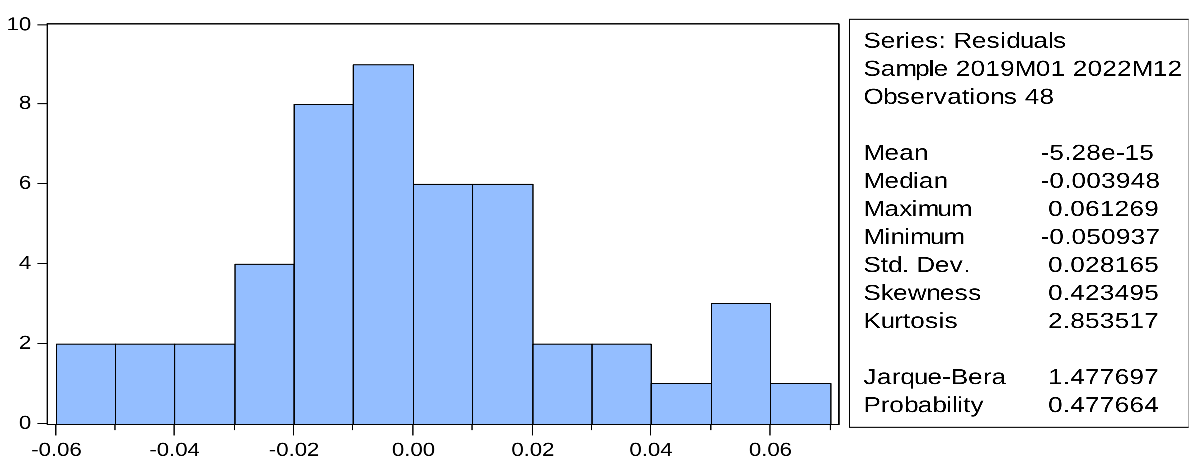


Figure 6: Stability Test (CUSUM and CUSUMSQ Test) Source: Author computation

4.8 Normality Test for Residuals (Histogram and Jarque-Bera Test)

The Jarque-Bera test for normality is one of the tests that measure if sample data has skewness and the courtesies that are like a normal distribution. The Jarque-Bera test statistic is always positive, and if it is not close to zero, it shows that the sample data do not have a normal distribution.



Source: Author computation

Figure 7: Histogram of Jarque-Bera Test (residual normality test)

5 Discussion

The primary objective of this study is to explore the dynamics of internal displacement in Burkina Faso, with a specific focus on the interaction between extreme climate events and conflicts. By examining both the short-term and long-term relationships in this Sahelian country, the research seeks to clarify how these factors influence fluctuations in internal displacement. This contribution not only enhances the understanding of displacement dynamics in Burkina Faso but also provides insights applicable to the broader Sahelian context.

Our results indicate that violent conflicts are linked to internal displacement in Burkina Faso, with a significantly higher coefficient than other variables. This finding is consistent with the information provided by some publications (Demuynck, 2022; Hagberg & Kibora, 2023; Zamkowska, 2022b; Zherlitsina, 2023), which indicated that Burkina Faso has been experiencing a significant increase in violent events that have affected the local population, leading to displacement. Usually, when there are conflicts, mainly armed conflicts, people run away from the affected areas fearing the conflicts (Birkeland, 2009; Lischer, 2007; Tesfaw, 2022). Violent conflicts from observation and intuition are very high drivers of people displacement. Therefore, this finding is not surprising, given that Burkina Faso has been experiencing a surge in violent conflicts during the time covered by this research study. Particularly in the northern and eastern regions of the country (figure 3) where the internally displaced people are coming from (figure 4).

Demonstration events are usually events that include protests and riots. They are often seen as an important form of political expression and can help to raise awareness about social and political issues. From our knowledge, protests can negatively and positively affect democratic participation. On one hand, protests can help to mobilize and empower citizens and can serve as a mechanism for holding political leaders. Protests can help build social networks and coalitions that can lead to greater engagement and participation, and on the other hand, protests can lead to polarization and social fragmentation and some may even become violent. Particularly in Burkina Faso, Engels (2015) showed in its publication that Burkina Faso's people use protests and riots to claim a structural change. At the same time, they use protestation to raise their voice in case reclaim their rights, the minimum of subsistence and political issues (Harsch, 2009). However, our short run results indicate that demonstrations can drive internal displacement within the first four months following their occurrence. In the initial month of the event, we observe that while the coefficient remains positive, it is weak and not significant. In contrast, during the first and second months, the coefficients are positive, significant, and relatively high. This suggests that many people tend to move in the initial two months when these protests occur. However, as these areas become less populated over time, displacement associated with the demonstrations decreases significantly but is still positive. This indicates that people continue to be displaced even though it's not in mass as in the first two months. This is likely since some protests or riots become violent (Newburn, 2021; Rød & Weidmann, 2023), and the intensity of this violence can strongly influence people's decisions to leave their homes temporarily or even relocate permanently. In this sense, our finding is consistent with many different studies (Badiora, 2017; Czaika & Kis-Katos, 2009; Priya, 2012).

Storms cause significant damage to infrastructure, homes, and crops, leading to displacement and migration of people. Evidence in West Africa showed that storms have caused significant damage to households, agriculture, and economic loss mortality resulting in the displacement of people from their homes (Ferris & Stark, 2012). Bayar & Aral (2019), in their analysis of climate-related hazards in different African countries, showed that Burkina Faso is not at the shelter of extreme events. Hence, the statistically significant positive long-run effect of storms on the number of internally displaced people highlights the importance of understanding the role of extreme climate events in causing displacement and migration, particularly in vulnerable regions such as Burkina Faso. Studies have revealed that Sahelian storms are very strong (Taylor et al., 2017). Our result is also supported by scholars throughout their studies in various locations where they find that occurring storms increase displacement in both the short and long term (Berlemann & Tran, 2021; Micallef et al., 2019; Molua et al., 2020; Paglino, 2024).

While this study provides valuable insights, a notable limitation is the exclusion of drought as a variable, despite its recognized importance in the Sahel region. This decision is justified by the fact that drought indices typically require a long reference period (e.g., 30 years or more) to accurately capture the severity and cyclical nature of droughts. However, the data used in this study is based on a much shorter-term monthly dataset, which is insufficient for calculating robust drought indices (Beguería et al., 2014; Hayes et al., 2002; Zargar et al., 2011). For instance It has been suggested that the probability of precipitation occurrence should be calculated over periods of 3, 6, 12, 24, or 48 months, with at least 30 years of data recommended for reliable analysis (Cheval, 2015; McKee et al., 1993, 1995). Additionally, previous research highlights the significant role of droughts in driving internal displacement and conflict, particularly in Africa. Some argued that climate conditions, including droughts, are robustly linked to civil conflict in Africa, with warmer temperatures exacerbating the risk of civil war and migration (Burke et al., 2009, 2010; Thalheimer et al., 2023). In contrast, some studies, suggest that climate alone may not be the primary cause of conflict, but rather an influencing factor alongside other socio-political dynamics (Buhaug, 2010; Buhaug & Von Uexkull, 2021).

Although this work added value to the current literature on the direct link between how climate extreme events and conflicts contribute to people's displacement, there is a pressing need to expand our findings and broaden the scope to include emerging topics, such as losses and damages caused by extreme weather events. Given the impacts of extreme weather events on displacement and livelihoods, further research could quantify economic and social losses in affected regions. This would provide a more nuanced understanding of how these losses contribute to vulnerability and influence migration patterns. While our study addresses the direct relationship between climate events and conflicts on displacement, future research could examine indirect pathways for instance, how climate change exacerbates competition for resources, leading to conflict and, subsequently, displacement. Future work could analyze which socioeconomic and institutional factors (e.g., community networks, governmental response, international aid) contribute to resilience in affected populations, and how these can mitigate displacement or improve adaptation. Research on how urban infrastructure can alleviate or exacerbate the challenges of displacement could be valuable, especially as displaced populations increasingly seek refuge in urban areas. This would provide insight into the preparedness and responses of urban centers facing sudden population inflows. Another avenue could be exploring how long-term land degradation influences migration or displacement, specifically for communities dependent on agriculture, and what measures could mitigate these effects.

6 Conclusion and recommendations

This study provides a comprehensive examination of the drivers of internal displacement in Burkina Faso, focusing on both conflict-related events and extreme weather phenomena. Our findings reveal that violent events significantly increase internal displacement in the country, underscoring the direct link between conflict and forced migration. This aligns with regional trends and highlights the destabilizing role of violence, particularly in Burkina Faso's northern and eastern areas where conflict intensity is high. In contrast, non-violent events show no significant effect, suggesting that not all political actions lead to displacement and that violent disturbances are the primary drivers within this category.

Our analysis also shows that demonstrations contribute to displacement in the short term, particularly in the first two months following the event, likely due to the violent potential of some protests. Over time, as these areas become less populated, the displacement effect diminishes, indicating the temporary nature of this impact. This finding provides a nuanced understanding of how political expression through protest can influence migration dynamics, with implications for understanding the conditions under which demonstrations might evolve into drivers of displacement.

In terms of climate extreme vents, storms significantly drive internal displacement in the long run, likely due to the substantial destruction they cause to infrastructure, homes, and livelihoods. Although floods show a positive but non-significant effect, storms alone emphasize the necessity of preparedness for climate-induced displacement. This result underscores Burkina Faso's vulnerability to climate-related shocks and the need for targeted strategies to address these risks, especially given the increasing frequency and severity of extreme weather events in the Sahel.

Overall, this research contributes valuable insights into the complex dynamics of internal displacement in Burkina Faso, highlighting how both conflict and climate factors intersect to influence migration patterns. Expanding the scope of analysis in these directions will be essential to inform policy interventions that protect vulnerable populations and promote resilience against both conflict-driven and climate-induced displacement.

Acknowledgments

This work was funded by The Federal Ministry of Education and Research (BMBF) through the West African Science Service Centre on Climate Change and Adapted Land-use (WASCAL) Graduate School Programs, specifically the Doctoral School of Informatics for Climate Change (ED-ICC) of the University of Joseph Ki-Zerbo. Special acknowledgments to the WASCAL Competence Center and the different institutions that provided the different data to conduct the study.

The author koffi Doh David ADZAVON acknowledges the support of the Chair Energy and Prosperity, under the aegis of la Fondation du Risque.

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