SCHOOL OF
ECONOMICS AND
MANAGEMENT

Master's Programme in Economic Growth, Population and Development

Relative Deprivation and Terrorism in the Sahel

by

Aarne Walter Hakomäki

aarnehako@gmail.com

Abstract

The Sahel has emerged as a global hotspot for terrorist activity during the first decades of the 21st century. Few empirical studies have been carried out to investigate the causes of this phenomenon. The overarching literature on the determinants of terrorism has also failed to establish conclusive mechanisms and channels of causation. Studies have found economic shocks to increase the likelihood of civil conflict. This study examines if this mechanism holds for terrorism in the Sahel between 1985-2019. As the Sahel region is largely reliant on agriculture as the main economic activity, agricultural shocks are considered as the trigger terrorism. A Possible threat of reverse causality between agriculture and terrorism is taken into account with a rainfall instrument. The results show no significant relationship between agricultural shocks and terrorism in the Sahel during the period of the study, suggesting that terrorism in the region is tied more deeply into political, cultural and historical factors.

Programme Code EKHS22
Master's Thesis (15 credits ECTS)
May 2022
Supervisor: Jutta Bolt
Examiner: Igor Martins
Word Count: 12,520

Acknowledgements

I would like to thank my supervisor Jutta Bolt for the great guidance and support she gave me during this thesis project.

Table of Contents

List of Tables

List of Figures

1 Introduction

Soon after the collapse of the Soviet Union and the end of the Cold War, a new enemy emerged to threaten the global liberal order – transnational terrorism (Sandbrook & Romano, 2004). Prevention of terrorism, transnational and domestic, quickly became one of the most important security policy issues for the international community (Abadie, 2006). Military interventions, spearheaded by the United States, in Afghanistan and Iraq were justified with the global war on terror and toppling "rogue" governments detrimental to world peace (Nchalla & Shirima, 2016). Much of the early attention in the media and policy circles was given to the terrorism plagued regions in the Middle East and Somalia. Over the past decade and a half, however, a new hot spot for terrorist organizations has arisen in the Sahel (Harmon, 2014; Middendorp & Bergema, 2019). Six countries in the region are among the 20 most impacted by terrorism in 2021, according to Global Terrorism Index (2021). Boko Haram, formed in northern Nigeria and operating in neighboring countries as well, became known as the deadliest terrorist organization in the world (Omotuyi, 2022). Northern Mali fell under the control of Ansar Dine, a group with a Jihadist and Tuareg nationalist ideology, in 2012, with the capitol, Bamako, threatened to be overrun if not for a French and West African military intervention (Harmon, 2014). In the media and policy discussions, these kinds of events have brought the Sahel region international infamy as a center and source of global insecurity (Middendorp & Bergema, 2019).

The rise of terrorism as a global security concern has brought with it also vibrant debate into the best ways to combat it. While military action is still seen as a policy of last resort, focusing on development policies has recently been promoted as the more efficient way to prevent terrorism from taking root (Shinn, 2016). Proponents of the development strategy argue that people are driven to radical ideologies through discontent with their socioeconomic situation (Krueger & Malečková, 2003; Ross, 1993). Development goals, such as better education, poverty reduction and reduced inequalities, are commonly included in antiterrorism rhetoric and policy packages (Shinn, 2016). Empirical research on the determinants of terrorism, however, has not found conclusive evidence to support these policies.

One of the more debated determinants of terrorism is poverty (Abadie, 2006; Feridun & Sezgin, 2008; Iheonu & Ichoku, 2021). Policy makers, together with some academics, often argue that

eradicating poverty will lead to a world without terror, as people with their livelihoods secured are more difficult to radicalize (Abadie, 2006; Shinn, 2016; Yin, 2017). Empirical findings on the relationship, again, are mixed. Some studies find a positive relationship between poverty and terrorism to exist, while many find no reliable relationship (Benmelech & Berrebi, 2007; Iheonu & Ichoku, 2021; Piazza, 2013; Yin, 2017). Benmelech and Berrebi (2007) even find evidence suggesting that terrorists in Palestine tend to come from relatively well-off backgrounds. A strand of literature building on the theoretical framework of Gurr (1970), argues that it is not absolute deprivation that drives people to terrorism, but relative deprivation (Ross, 1993). Unexpected negative shocks in incomes and standards of living cause discontent, which can be turned into radicalization.

The literature suggests that the mechanisms of radicalization are complex. Cultural and ethnic divisions, institutional factors and historical contingencies play an important role in determining how poverty impacts terrorism (Elu & Price, 2019). Thus, learning about the determinants of terrorism and creating effective prevention policies require studies with regional and country-level scopes. While the Sahel has become a more common region of interest for researchers, few empirical studies have been carried out on the determinants of terrorism. This study aims to fill this gap in the literature. Building on the framework of Gurr (1970), this study sets to examine the linkage between economic shocks and terrorism in the Sahelian countries.

The main economic activity in the Sahel is agriculture (Doso Jnr, 2014). Furthermore, agriculture in the region largely comprises of small-scale subsistence farming, with rainfall providing irrigation. Widespread poverty, inequality and corruption help make the region vulnerable to shocks in agricultural output (Potts, Henderson & Campbell, 2013). Miguel, Satyanath and Sergenti (2004) find that negative income shocks, primarily linked to agriculture, increase the likelihood of civil conflict in Africa. As they argue, economic shocks and conflict are more tightly connected in countries that are heavily reliant on only agriculture as the main economic activity, as people have less alternatives in the case of bad harvests. This study aims to test whether this mechanism also exists for terrorism specifically in the Sahel. The research question I attempt to answer is the following: *How do agricultural shocks impact terrorism in the Sahel?*

The framework of Gurr's (1970) relative deprivation theory builds the basis for the mechanisms and channels I expect agricultural shocks to impact terrorism through. The farmers in the Sahel

region base their expectations of yields on the yields of previous years. If the yields of a particular year fall short of expectations, discontent arises. This discontent, with few options for alternative sources of income, makes people prone to radicalization and recruitment into terrorist organizations active in the area. From this mechanism, the hypothesis of this study is derived:

H1: Negative agricultural shocks lead to increased terrorist activity in the following year.

To answer the research question, an empirical strategy is devised. The data for terrorism is measured in the number of incidents per year in a country and is, thus, presented in count form. Agricultural shocks on the other hand are measured as the percentage change in output per harvested area in a country, and is, thus, a continuous variable. Following prior literature, a negative binomial model is utilized to investigate the impact of agricultural shocks on terrorism (Daxecker & Prins, 2013; Gleditsch & Polo, 2016; Kis-Katos, Liebert & Schulze, 2011). A negative binomial model is considered the right choice when the dependent variable is a count variable and the explanatory variable is a continuous one and when the dependent variable is overdispersed, as is the case for this study (Hausman, Hall & Griliches, 1984; Wooldridge, 2010).

As the literature suggests, the relationship between agriculture and terrorism may run both ways (Adelaja & George, 2019; Noubissi & Njangang, 2020). This threat of reverse causality is taken into account by augmenting the empirical strategy of this study with an instrumental variable. Rainfall, as utilized by Miguel, Satyanath and Sergenti (2004), captures variation in agricultural yields and its distribution is considered independent of terrorism. Furthermore, rainfall is considered to only impact civil conflict, including terrorism, through its impact on agriculture in the Sahel (Hendrix & Salehyan, 2012; Miguel, Satyanath & Sergenti, 2004; Sandholt Jensen & Skrede Gleditsch, 2009). Thus, rainfall is utilized as an instrument for agricultural shocks to capture exogenous impacts they may have on terrorism. The instrumental strategy takes inspiration from Wooldridge (2015) by taking a control function (CF) approach. This approach is different from a traditional two-stage least squares approach and is more applicable for the negative binomial model used in this study.

The sample of this study includes nine countries[1] with territory in the Sahel region. The sample includes observations from the years 1985-2019. The sample period is chosen to encompass the recent rise of terrorism in the region, but also to include years before that to provide a fuller understanding of the determinants of terrorism. The region suffered from a severe drought in 1983 and 1984 (Doso Jnr, 2014). This event, due to its severity, is considered a humanitarian crisis that does not fit within the scope of this study. Thus, the period after the drought represents a coherent period for the study. The overall number of observation points in the sample is 315, which is considered satisfactory. The data for terrorism is gathered from the Global Terrorism Database (GTD) (Global Terrorism Database, 2022). GTD is widely used in the literature because of its comprehensive scope and detailed reporting of terrorist incidents (Gleditsch & Polo, 2016; Iheonu & Ichoku, 2021; Kis-Katos, Liebert & Schulze, 2011). Data on agricultural yields are gathered from the Food and Agricultural Organization of the United Nations (FAO) (FAOSTAT, 2022). Rainfall data is gathered from the Center for Hydrometeorology and Remote Sensing data portal (CHRS) (Nguyen, Shearer, Tran, Ombadi, Hayatbini, Palacios, Huynh, Braithwaite, Updegraff, Hsu, Kuligowski, Logan & Sorooshian, 2019).

The results of this study do not find a significant relationship between agricultural shocks and terrorism. The absence of a significant relationship is found to be robust to different specifications of the model and to changes in the sample. Alternative measures for both terrorism and agricultural shocks are also considered, but this does not change the findings on the relationship. Thus, according to this study, relative deprivation arising from agricultural shocks cannot explain the rise of terrorism in the Sahel region.

The rest of this paper is structured in the following way. Section 2 discusses prior literature and important concepts used in this study. The theoretical framework is also established in section 2. Section 3 presents the data used in this study. Sources, limits and summary statistics are discussed. Section 4 provides a description of how the empirical model of the study is chosen and constructed with specific attention given to endogeneity issues. Section 5 presents the findings of the study, followed by a discussion relating the results to the hypothesis and prior literature. Section 6 presents concluding remarks and areas for future research.

[1] Burkina Faso, Cameroon, Central African Republic, Chad, Mali, Mauritania, Nigeria, Niger and Senegal

2 Theory

In this section, the theoretical base of this study is presented. First, the definition of terrorism is discussed. Second, prior research on the determinants of terrorism is presented, followed by an overview of terrorism in the Sahel region. Finally, the theoretical framework applied in this study is presented.

2.1 Literature Review

2.1.1 Defining Terrorism

Terrorism, despite its common usage in policy and everyday discussion, is often not a clearly defined term (Burgoon, 2006; Shinn, 2016). In academic studies, terrorism is considered as violence or threat of violence against civilians and non-combatants by non-state actors with a political, economic or religious motive (Elu & Price, 2019; Solomon, 2015a, pp.2–7). This study utilizes data from the Global Terrorism Database (GTD) maintained by the National Consortium for the Study of Terrorism and Responses to Terrorism (START). The specific definition START uses for terrorism in the GTD is the following: threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation (Global Terrorism Database, 2022).

The earliest considerations of terror as a means of gaining or holding on to power go back to the first civilizations, but modern terrorism, as considered by Rapoport (2002), is divided into four phases: anarchist, anticolonial, new-left and religious. The common definitions of terrorism, and the phases of modern terrorism, only consider terror perpetrated by non-state actors (Solomon, 2015a, pp.2–7). Historically, however, terror has also been a common tool for authoritarian governments to hold on to power. Modern terrorism, on the other hand, is centred around revolution, though revolution has had different characteristics for different phases (Rapoport, 2002). The dominant phase during the time period considered in this study is the religious phase. However, a simplistic view of modern terrorism phases ignores the multidimensional reality of terrorist organizations. For example, while considered religious

groups, the Taliban of Afghanistan have a strong Pashtun nationalistic agenda and Ansar Dine of northern Mali dream of an independent Tuareg state (Solomon, 2015a, pp.15–19). Furthermore, radical Islamist terrorist groups are often presented as working towards a unified goal of a global jihad, which ignores the local nuances different groups operate within (Dowd & Raleigh, 2013). In fact, while cooperation between global terrorist organizations like Al-Qaeda and local groups exist, the majority of Islamist terrorists' goals are to transform the political field of their respective country or region (Afriyie, 2019; Solomon, 2015a, pp.15–19).

2.1.2 Determinants of Terrorism

The extent to which terrorism can be explained by socioeconomic factors remains debated. An upsurge in attempts to explain why people turn to terrorism has taken place since the start of the global war on terror in 2001 (Sanso-Navarro & Vera-Cabello, 2020). Gurr (1970) developed the relative deprivation theory to explain tendency for political violence. This theory states that when the material well-being expectations of people are not met, they become prone to radicalization and political violence. While Gurr (1970) developed his theory to explain mass political unrest and uprisings, it has been applied to specifically terrorism as well (Gleditsch & Polo, 2016; Piazza, 2013; Ross, 1993). Terrorism, according to Ross (1993) can be considered political violence and can sometimes be difficult to distinguish from guerrilla warfare. Because of this similarity, many of the factors established by Gurr (1970), like poverty, inequality and political disenfranchisement, are commonly used to explain terrorism.

Ross (1993) divides the theories attempting to explain terrorism into three categories: structural, psychological and rational. Structural theories argue that terrorism can be explained through political, economic and environmental factors. Psychological theories attempt to explain the decision to join a terrorist organization through group dynamics within terrorist organizations and the dynamic between terrorism and the society at large. Rational theories try to explain joining a terrorist group through a cost-benefit choice.

The intuition behind explaining terrorism through socioeconomic factors is easily understandable (Iheonu & Ichoku, 2021). Poverty or inequality creates an environment of injustice, which radicalizes people and drives them to seek to impact society through violent means. This intuition has also been popularized through frequent usage by politicians when outlining antiterrorism policies (Shinn, 2016; Yin, 2017). The empirical evidence, however, has

not established a conclusive relation between socioeconomic factors and terrorism. Ross (1993) finds that structural factors, including poverty, inequality and states' abilities among others, interact with each other in different ways, which may lead to terrorism. Abdel Jelil et al. (2018) and Sanso-Navarro and Vera-Cabello (2020) find that a lack of economic prospects and unemployment predict a rise in terrorism. Piazza (2013) finds that cost of living and price volatilities increase the risk of terrorism, as economic uncertainty creates political grievances.

Contradicting evidence has also been found which show either no relation between socioeconomic factors and terrorism or in some cases higher socioeconomic stance related to increased terrorism. Yin (2017) finds no evidence for economic development hampering terrorism in China. The findings of Benmelech and Berrebi (2007) are often cited in the literature, as they find that terrorist organization members in Palestine tend to be more educated and have a higher standard of living than the general public. In these cases, it seems that the decision to pursue terrorism is only based on ideology. However, some arguments have been developed arguing that highly educated individuals join terrorist organizations because of greater opportunities for leadership roles (Ismail & Amjad, 2014; Yin, 2017). The findings on the impact of socioeconomic factors on terrorism vary depending on the region or country of interest. While studies have found that Middle Eastern terrorists tend to be more educated and from better off backgrounds than the general public, poverty and inequality seem to have a larger impact on terrorism in Africa (Asongu, Le Roux & Singh, 2021; Benmelech & Berrebi, 2007; Iheonu & Ichoku, 2021; Krueger & Malečková, 2003; Sageman, 2004).

The strong linkage between poverty and terrorism in Africa has been argued to be related to the extreme level and widespread nature of poverty on the continent (Iheonu & Ichoku, 2021). Shinn (2016) argues that transnational terrorism tends to be tied more to strictly ideology, while socioeconomic factors are more important for domestic terrorism. The majority of terrorism in Africa targets local governments and population (Dowd & Raleigh, 2013). Thus, Shinn (2016) believes alleviating poverty is extremely important for curbing terrorism in Africa. Terrorist organizations have been reported to offer their fighters monthly wages that far exceed average incomes (Solomon, 2015b, p.66). For many people living in absolute poverty, joining a terrorist organization can be a rational choice. This view is supported by tentative success of programs attempting to reintegrate Boko Haram defectors back into society in Nigeria (Foucher, 2021). Defectors are more likely to reintegrate successfully when economic opportunities are better. Especially radical Islamist terrorist organizations have been successful in establishing generous

monthly compensation for fighters and separate governing apparatuses in their regions, with funds flowing in from various Salafist charities in the Persian Gulf countries (Solomon, 2015a, p.36).

The relationship between economic factors and terrorism are also debated in the literature on the determinants of civil conflict in general and other militant activities like piracy (Daxecker & Prins, 2013; Jablonski & Oliver, 2013; Djankov & Reynal-Querol, 2010; Justino, 2012; Kuhn & Weidmann, 2015). Justino (2012) explains that it has become a stylised fact that civil wars are likelier in poorer countries. Furthermore, the participation of the poorest and most disenfranchised people in said conflicts tend to be high. This, she explains, is commonly thought to be due to material incentives. The finding that the level of economic development being directly related to civil wars has been contested and a strand of literature argues that poverty loses its explanatory power in civil conflicts when country-specific characteristics are taken into account (Djankov & Reynal-Querol, 2010). The role of disenfranchised groups, both politically and economically, in civil wars has, however, been found to be meaningful in cross-country and panel studies (Kuhn & Weidmann, 2015). These findings suggest that relative poverty is a stronger source of discontent than absolute poverty.

Some overlap does exist in the mechanisms discussed in terrorism and piracy literature. Jablonski and Oliver (2013) find evidence suggesting that poor labour market opportunities are related to increased instances of piracy globally. The methodology and channels they consider are to a great extent related to those used in civil conflict and terrorism literature. Daxecker and Prins, (2013) find that the attraction of piracy is increased in regions with poor governance and rule of law. Poor economic opportunities and regions outside the reach of central governments are prevalent in the Sahel (Harmon, 2014). Thus, the findings on piracy offer some support for the relationship between economic factors on terrorism in the region.

2.1.3 Economic Shocks and Civil Conflict

The relationship between economic shocks and terrorism remains a relatively under researched topic. Some research looking into the impact of food prices suggests that a link exists (Piazza, 2013). The role of economic shocks has been examined more frequently in the literature on civil conflicts (Bazzi & Blattman, 2014; Hendrix & Salehyan, 2012; Hodler & Raschky, 2014; Miguel, Satyanath & Sergenti, 2004; Sandholt Jensen & Skrede Gleditsch, 2009). This strand of literature is largely based on the mechanisms and channels of the relative deprivation theory

of Gurr (1970). The literature has found economic shocks to increase the likelihood of civil conflict arguing that unexpected decreases in income make it easier for militant groups to recruit new members. Bazzi and Blattman (2014) find that increasing food prices may lead to onsets of violence. Miguel, Satyanath and Sergenti (2004) find a similar relationship between negative agricultural shocks and civil conflict. Some evidence suggests that positive economic shocks increase the likelihood of conflict, as times of plenty increase the rewards of state capture (Hendrix & Salehyan, 2012). This mechanism, however, is not supported by all studies (Bazzi & Blattman, 2014; Hodler & Raschky, 2014).

Economic shocks tend to function as a trigger for smaller-scale conflicts and violence (Bazzi & Blattman, 2014; Miguel, Satyanath & Sergenti, 2004). Larger civil wars, Bazzi and Blattman (2014) argue, are often caused by severe political divisions, whereas small-scale violence can erupt due to unexpected economic shocks. Furthermore, economic shocks are only useful at predicting the onset of conflicts (Bazzi & Blattman, 2014; Miguel, Satyanath & Sergenti, 2004). The mechanisms underlying the duration of conflicts are determined by other factors.

Terrorism is commonly seen as a subset of civil conflict (Gurr, 1970; Ross, 1993). This suggests that similar mechanisms would be at play for terrorism. However, few empirical studies have examined the linkage. As terrorism includes ideological, political or religious motives, it may not erupt as spontaneously as other types of violence (Elu & Price, 2019). It is possible that the indoctrination and radicalization required for terrorist activity take more time and is not as responsive to temporary shocks.

2.1.4 Terrorism in the Sahel

The Sahel region is a semi-arid grass and shrubland area bordered by the Sahara Desert in the north and the humid tropical savannah in the south (Herrmann, Anyamba & Tucker, 2005). Multiple countries hold territory within the region. The Sahelian countries are often characterised by high political instability, corruption and poverty rates (Echeverria Jesus, 2015). The geography of the region combined with low levels of rule of law have created vast ungoverned areas in the border regions of the countries (Barkindo, 2020). These areas are often far from the countries' capital cities and the reach of the central governments. Historically, the Sahel has been a hub for cross-regional caravan trade (Harmon, 2014). Colonial impacts, like arbitrarily drawn borders and subsequent ethnic and cultural rivalries, caused much of the

intraregional economy to move underground. The informal nature of the cross-border economy developed to accommodate illegal activities from smuggling to drug trafficking (Harmon, 2014; Tamekamta, 2021).

Increasingly, the Sahel has become infamous as a global hotspot for Islamist terrorism (Benedikter & Ouedraogo, 2019; Echeverria Jesus, 2015; Harmon, 2014; Raleigh, Nsaibia & Dowd, 2021). The collapse of northern Mali in 2012 under terrorist rule, and subsequent French and West African military intervention, and the abduction of over 230 schoolgirls in northern Nigeria in 2014 captured global headlines and asserted the Sahel as a region of interest for global security studies (Harmon, 2014; Solomon, 2015a, p.1). The most well-known terrorist group in the Sahel region is the *Jamaatu Ahlis Sunnah Laddaawatih Wal-Jihad* of north-eastern Nigeria, commonly known as Boko Haram (Dowd & Raleigh, 2013). The group has been active since 2009, targeting civilians, the Nigerian state and international actors (Solomon, 2015c, pp.85–86). The group has also spread its influence into neighbouring Niger, Chad and Cameroon, taking advantage of the weak interstate security cooperation in the region (Barkindo, 2020; Solomon, 2015c, p.135). A splinter group of Boko Haram, the Islamic State West Africa Province (ISWAP) has also become a major terrorist threat in the region (Middendorp & Bergema, 2019). Both Boko Haram and ISWAP are considered Salafist jihadist movements, but are also influenced by ethnic divisions and grievances according to Solomon (2015c, pp.96–98). He adds that the support for the groups comes mainly from within the Hausa-Fulani ethnic group, the majority ethnic group of northern Nigeria and neighbouring regions. Because of this, the crisis around the Lake Chad Basin is not simply a conflict of religious terrorism but also of longstanding ethnic tensions (Elu & Price, 2019; Solomon, 2015c, pp.96–98). The areas where support for Boko Haram and ISWAP is found tend to be the poorest and least developed regions, with inequality fuelling the violence.

Ethnonationalism, religious extremism and inequality are also heavily interlinked in the Tuareg insurgencies. The Tuareg are a nomadic people inhabiting regions in the Sahel within Mali, Niger, and Burkina Faso, as well as areas in Algeria and Libya (Harmon, 2014). Ethnic and regional tensions have flared into rebellions and insurgencies often during the independence of Mali. Failed Tuareg insurgencies in the 1990s and early 2000s led to many Tuareg nationalists finding refuge in Muammar Gaddafi's Libya. After the fall of Gaddafi, many of these people returned to their home countries heavily armed, creating instability in the region and eventually leading to the Tuareg uprising in northern Mali in 2012 (Raleigh, Nsaibia & Dowd, 2021). The

uprising was spearheaded by the National Movement for the Liberation of Azawad (MNLA), a secular-nationalist movement (Harmon, 2014). However, soon the rebellion was captured by Ansar Dine, a Salafist jihadist movement heavily tied to the Tuareg rebellions of the 1990s. After the rebellion was defeated by a French and West African intervention, Ansar Dine continued its terrorist activities from the rugged periphery of northern Mali.

These organizations are not an exception in the greater picture of terrorism in the Sahel. Much of the terrorist activity in the region is not tied only to radical religious beliefs, but is impacted by ethnic divisions, economic inequalities and political grievances (Afriyie, 2019; Harmon, 2014; Solomon, 2015c, pp.96–98). Thus, while incidents have increased and extremist groups have grown in infamy with the rise of transnational Islamist terrorism, many determinants for terrorism are local of origin and have been brewing for a long time (Afriyie, 2019; Dowd & Raleigh, 2013; Elu & Price, 2019).

A purer form of separatist nationalism movement in the Sahelian countries is represented by the Movement of Democratic Forces of Casamance (MFDC) in Senegal. MFDC has been active since 1982, making the conflict the longest running in the Sahelian countries (Foucher, 2019). While it has been ongoing for three decades, the conflict has been relatively low in intensity when compared with that of the Lake Chad Basin since 2009.

2.2 Theoretical Framework

The theoretical framework this study utilizes is the *relative deprivation* (RD) theory. RD is a concept often used in sociology, helping to explain aggressive behaviour through psychological and societal conditions. It was applied to civil conflict by Gurr (1970) in his seminal work *Why men rebel?* The RD framework argues that people tend to grow frustrated to their conditions when their realized outcomes do not match their expectations. People are usually well equipped at weathering even harsh conditions without discontent, as long as it matches their expectations, Gurr (1970) explains. When there is no hope or expectation of better outcomes, people are less likely to be discontented and may even be happy to just hold on to what they have (Runciman, 1966). Outcomes lower than expected, however, lead to frustration and discontent, which can be politicised and realized in violent action under the right conditions (Gurr, 1970, pp.12–13).

According to Gurr (1970, pp.24–27), values drive our expectations and desires. The most relevant values for this study are *welfare* values, as explained by Gurr (1970). These values include food, shelter and health services. When people construct expectations of the levels of food and shelter that they anticipate attaining, they feel entitled to realize those expectations. Entitlement here means a justifiable and realistic expectation of outcome, not simply a faint hope of something to attain (Gurr, 1970, p.27). Expectations are usually based on the level of attainment reached in previous periods. Negative shocks in the level of attainment, relative to expectations, can lead to discontent among a collective, Gurr (1970) argues.

The causal mechanism of political violence in Gurr's (1970, p.319) theory starts from a motivational cause, discontent. How discontent progresses to violence is determined by the cognitive determinants, *normative* and *utilitarian justifications* for violence. *Normative justifications* for political violence are defined as the attitudes and beliefs people hold on the intrinsic desirability of taking violent actions (Gurr, 1970, p.157). *Utilitarian justifications* on the other hand represent the beliefs people hold of the extent political violence will help them achieve material rewards.

Gurr (1970, p.11) lists terrorism as a subset of political violence. Thus, the causes of political violence in general apply to terrorism in particular as well. His RD framework for political violence has been applied in prior studies on the determinants of terrorism (Ross, 1993; Suleiman & Aminul Karim, 2015). The similarity of terrorism to other types of political violence and conflict, especially in the Sahelian case, further supports the application of the RD framework in this study (Ross, 1993; Solomon, 2015a).

In this study the trigger for discontent arises from negative shocks in the agricultural output of the subsistence farmers in the Sahel. The cognitive determinants, *normative* and *utilitarian justification*, are shaped by surrounding conditions. *Normative justification* of terrorism may be nurtured by ethnonationalist or religious causes or general dissatisfaction with the political status quo. *Utilitarian justification* can be met by the relatively generous wages distributed by terrorist organizations (Solomon, 2015b). A simple monetary cost-benefit calculation, however, is unlikely to be the most accurate. As Becker (1968) explains, criminal activity requires a payoff that matches the risks related to it. Terrorism entails risk, which in turn requires a higher payoff, especially if a person does not possess a strong *normative justification* for violence. This may explain why terrorist organizations offer such generous incomes. If discontent, arising from lower-than-expected agricultural product, is successfully politicised through cognitive

determinants, people turn to terrorism as a manifestation of their grievances. From this theoretical framework, I derive the hypothesis of this study:

H1: Negative shocks in agricultural output lead to increased terrorism.

3 Data

In this section the data used for the empirical study is presented. I begin with explaining the sample selection. Next, the dependent, explanatory and instrumental variables are explained. Finally, an overview of the control variables is presented. Summary statistics for all variables can be found in the appendix.

3.1 The Sample

The sample for this study comprises of nine African countries with territory within the Sahel region: Burkina Faso, Cameroon, Central African Republic, Chad, Mali, Mauritania, Niger, Nigeria and Senegal. The size of the Sahelian parts of these countries vary from extensive with Mali and Niger to marginal with Cameroon. The importance of the Sahelian regions, however, is relatively large for all countries due to the interconnected security threats and high poverty rates that plague them. Some countries commonly included in the Sahelian countries had to be excluded from the sample. The partition of Sudan into two countries in 2014 introduces discontinuity in the data. Thus, it is excluded from the sample. Eritrea is excluded because of lack of reliable data on most variables of the study.

The study considers terrorism in the Sahel between the years 1985 and 2019. To paint a better picture of the relationship between terrorism and agricultural shocks in the Sahel, the sample includes a larger time period than the recent years characterised by rapid increases of terrorism. 1985 is considered a suitable starting point for the study due to the severe drought the region suffered from in 1983 and 1984 (Doso Jnr, 2014). This drought, due to its severity, represents a major political and humanitarian crisis for the countries of the region and could impact the results in unexpected ways. The period after the drought includes less long-term environmental shocks, which makes the results of the study more generalizable. The final number of observations in the sample is 315.

3.2 Terrorism

The theoretical framework for this study predicts that agricultural shocks increase the amount of people recruited by terrorist organizations. To the author's knowledge, no reliable and extensive database exists for the number of people active in different terrorist organizations. However, the size of the organizations can be assumed to be directly related to the frequency of their activities, as shown by Clauset and Gleditsch (2012). As data for terrorist incidents is available, this is to be considered as a viable proxy.

The Global Terrorism Database (GTD) (2022), maintained by START, is commonly used in the literature to study terrorism. It includes information about terrorist incidents from around the world between 1970 and 2019. Information includes the date of the incident, country, region, type of incident, number of injured and victims and, when known, the group responsible. The number of terrorist incidents in a given year will be used as the main dependent variable in this study. In the countries of the sample, 7768 terrorist incidents took place between 1985 and 2019. As Figure 1 shows the number has grown exponentially since the late 2000s. To a large degree this increase is due to the emergence of Boko Haram and other Salafist jihadist groups in the Lake Chad Basin, as well as the eruption of the Mali insurrection of 2012.

The main variable *terrorism*, thus, is the number of terrorist incidents in a country in a given year. The variable is reported in count form, taking integer values from zero upwards. The mean value for *terrorism* is 23.3 in the full sample. The number of incidents varies significantly by country-year, as the standard deviation is 91. Because of the difference between the mean and the standard deviation, the data can be considered overdispersed. The largest single value for a country-year is that of Nigeria in 2014, which suffered from 713 terrorist incidents. Out of the countries in the sample, Mauritania has suffered the least from terrorism. The highest number of incidents in a single year in Mauritania during the sample period was five in 2009. The data for terrorism incidents also includes many zero-values across the full sample, as not all countries recorded a terrorist incident every year. A zero-value is recorded at almost half of all observations, 145 out of 315.

The GTD is an open-source database. It includes information gathered from reported terrorist incidents (Global Terrorism Database, 2022). There is a possibility that some terrorist incidents go unreported and because of that remain outside of the database. Thus, the real number of

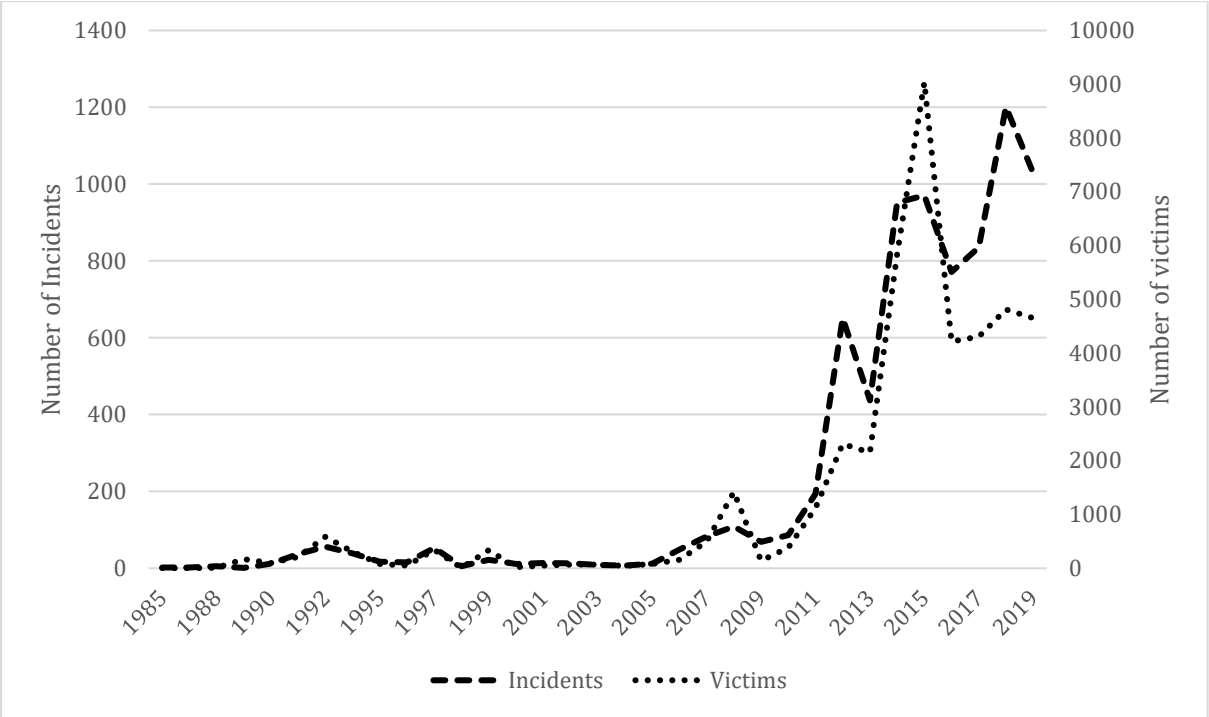

Figure 1. Number of terrorism incidents and victims Source: Author's creation based on data from Global Terrorism Database (2022).

terrorist incidents in the sample countries can be higher than what the data reports. However, this is expected to be of marginal magnitude and is not considered a threat to the validity of the results of this study.

Some regressions will also be run with *terrorism intensity* as the dependent variable. *Terrorism intensity* is a variable indicating the number of victims per attack. The data comes from the GTD. I include as victims the number of killed or wounded in a particular attack. Much like the incident variable, this variable has a large variance. The mean value for *terrorism intensity* in the full sample is 7.5 and the standard deviation is 23.6.

3.3 Agricultural Shocks

As this study aims to explain the relationship between agricultural shocks and terrorism, the main explanatory variable of interest is a measure of staple crops yield growth.[2] The main staple crops for subsistence farmers in the Sahel are millet, sorghum and sometimes maize (Doso Jnr, 2014). The Sahel region has distinct climate conditions, which regulate the types of crops that are suitable for cultivation. Many of the countries in the sample possess territory outside of the Sahel with different climate conditions as well. For example, the South of Nigeria has vastly different conditions for farming than the Sahelian north of Nigeria (Mereu et al., 2015). In the south of Nigeria, cassava and yams are the common staple crops instead of sorghum and millet. By choosing the growth of sorghum and millet yields as the explanatory variable of interest, I mean to target the agricultural shocks predominantly in the Sahel. The inclusion of maize production was considered for inclusion into the group of staple crops of the Sahel, but it is more widespread in its cultivation than sorghum and millet and, thus, does not only depend on the Sahelian regions.

The data for the production quantities (tonnes) and harvested areas (hectares) of Sorghum and millet in the countries of the sample is collected from the Food and Agriculture Organization of the United Nations' (FAO) database (FAOSTAT, 2022). The staple crops yield is the ratio of total production quantity of sorghum and millet and the total cultivated area of sorghum and millet for a country in a year. Thus, staple crops yields are measured as tonnes per hectare. The mean value for the staple crops yields in the full sample is 1.58 tonnes per hectare and the standard deviation is 0.62. The variable has a rising trend line on average over time. There exists variance between countries. Nigeria and Cameroon tend to produce the highest amounts, while Mauritania tends to produce the least. In 2019 the difference between staple crops production of the highest and lowest producer countries, Cameroon and Mauritania, was almost 2.5 tonnes per hectare.

To account for shocks in agricultural output, staple crops yields are operationalized in a growth format. It is common to use GDP growth as a variable for economic shocks in conflict literature (Miguel, Satyanath & Sergenti, 2004). In this study, staple crops yields are used in a similar

[2] Output per capita was also considered, but output per harvested area captures external shocks better.

way. Staple crops yield growth is measured as the change of tonnes harvested per hectare from the previous year: $staple\ crops\ growth_{it}\ \frac{tonnes\ per\ hectare_{i,t} - tonnes\ per\ hectare_{i,t-1}}{tonnes\ per\ hectare_{i,t-1}}$, where the subscripts *i* and *t* mark the country and year of the observation, respectively. This way the variable represents the percentage change of staple crops yield relative to the previous year. A shock in staple crops yields in a given year is not expected to impact terrorism immediately, but in a lagged manner. Thus, *staple crops growth* is lagged one year behind the dependent variable *terrorism* in the regressions of this study.

3.4 Rainfall

As there exists a threat of reverse causality of terrorism having an impact on agriculture, I employ rainfall changes as an instrumental variable for agriculture. The data is collected from the Center for Hydrometeorology and Remote Sensing (CHRS) data portal. The long-term precipitation dataset PERSIANN-CDR (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks - Climate Data Record) is utilized (Nguyen et al., 2019). This data is available from 1983 onwards at different frequencies downloadable at the country level. The annual precipitation is used in this study.

Some literature on the Sahel region note that the decreasing rainfall, desertification and drying up of the Lake Chad have impacted the region negatively (Freeman, 2017; Middendorp & Bergema, 2019). However, studies researching climate change and its impacts on the Sahel find that rainfall has tended to increase since the 1980s (Hendrix & Salehyan, 2012; Olsson, Eklundh & Ardö, 2005). Similarly, they find that Lake Chad has in fact been replenishing since the alarming levels often cited from the 1980s.

The data from CHRS supports the notion of an increasing rainfall trend in the Sahelian countries since 1985. When divided into decades, rainfall levels are on average lower in the 1980s than the more recent decades. The variance of rainfall, however, also increases as the mean goes up. Perhaps annual rainfall has become more volatile while on average the amounts have increased.

As with the *staple crops growth* variable, rainfall will be operationalized as a variable measuring change: $rainfall\ change_{it}\ \frac{rainfall_{i,t} - rainfall_{i,t-1}}{rainfall_{i,t-1}}$. Thus, we get a percentage change in rainfall relative to the previous year.

Rainfall shocks are operationalized in this manner in studies by Miguel, Satyanath and Sergenti (2004) and Sandholt Jensen and Skrede Gleditsch (2009). Hendrix and Salehyan (2012), on the other hand, suggest that a measure indicating the difference from a long-term mean in rainfall is a better indicator for rainfall shocks. They argue that a percentage change relative to the previous year fails to account for the fact that even a large percentage decrease in rainfall from a relatively wet year might not mean a major setback for agriculture, but rather a return to normal. This reasoning brings out valid points. However, as this study is based on the RD framework, I am interested in deviations from expected outcomes as triggers. The rainfall data shows an increasing trend in time. Thus, the mean will be heavily impacted by the overall trend. I find it a more convincing argument that farmers base their expectations on the rainfall of the previous year than a long-term average. Thus, *rainfall change* will be primarily measured as a growth variable. Deviation from a long-term mean will, however, be used as a robustness check.

3.5 Control Variables

To control for omitted variable bias, a set of control variables are collected and utilized in this study. These variables control for some time-variant socioeconomic factors that are not captured in time-invariant fixed effects. Directions for choosing the control variables is taken from the existing literature.

Political stability is considered an important determinant for terrorism. Countries with unstable political systems tend create conditions for sub-national actors to find safe spaces to operate from (Kis-Katos, Liebert & Schulze, 2011). Similarly, a stable political system can impact the investment decisions of farmers. In this study a dummy variable for coup d'états is used to proxy political stability. Other proxy possibilities exist, however, they often do not cover the full period of this sample. The coup d'état data is collected from the Integrated Network for Societal Conflict Research (INSCR) database maintained by the Center for Systemic Peace (INSCR, 2022).

The INSCR coup d'état dataset includes information on successful and failed coup attempts. In this study both successful and failed coups are considered a sign of political instability. The variable is a dummy variable taking the value 1 if there was a coup attempt in a country in a specific year and 0 otherwise. Much like the explanatory variable and the instrumental variable, the coup d'état dummy is lagged one year behind the dependent variable terrorism, to account

for possible endogeneity issues. Across the full sample, coup attempts happened during nine percent of all country-year observations. The frequency of coup attempts across the period is relatively stable. Differences between countries, however exist. Some countries in the sample have experienced a low amount of coup attempts, like Senegal with zero and Cameroon with three percent of the year observations. Others have had a relatively large number of coups, like Mauritania, Chad and Central African Republic all with coups attempted during over 13 percent of the sample years.

It is commonplace in the literature to control for the level of economic development (Iheonu & Ichoku, 2021; Kis-Katos, Liebert & Schulze, 2011; Miguel, Satyanath & Sergenti, 2004). Most studies use GDP per capita as an indicator for economic development and this study follows that custom. Countries with a higher level of GDP per capita tend to be better equipped at curbing terrorism and providing internal security (Miguel, Satyanath & Sergenti, 2004). Higher GDP per capita tends to also be linked with higher productivity in agriculture. Thus, it is necessary to be controlled for.

The data used in this study is collected from the World Development Indicators (WDI) database maintained by the World Bank (World Development Indicators, 2022). *GDP per capita* is lagged one year behind the dependent variable *terrorism*, as is often done in the literature (Kis-Katos, Liebert & Schulze, 2011). The data is reported in constant 2015 United States Dollars. The mean value for the *GDP per capita* is 917.5 in the full sample and the standard deviation is 527.4. Level differences exist between the countries, but growth, apart from Nigeria which has experienced relatively significant GDP per capita growth, has been unremarkable for all countries over the sample period. In the regressions, *GDP per capita* is operationalized in hundreds of dollars to allow for simpler interpretation of the results.

While terrorism in the Sahel is predominantly domestic and regional, global events and influences may still have an impact on the capabilities, strengths and motivations of the various terrorist groups. For example, financial support from various organizations in the Persian Gulf countries has been increasing the strength of radical Salafist jihadist groups in Africa (Solomon, 2015a). Also, some terrorist groups in the Sahel have pledged allegiance to transnational terrorist groups like Al-Qaeda and the Islamic State (IS). It is debated how closely tied the Sahelian groups like ISWAP are actually to IS, but major developments in global terrorism can be assumed to have at least some impact on the likelihood of terrorism in the sample countries.

To account for global trends, dummy variables are created for two of the most notable transnational terrorism events of recent times: the attack on the World Trade Center towers in New York City on September 11th of 2001 by Al-Qaeda and the fall of Mosul under IS in June of 2014. The variables *post-2001* and *post-2014* are coded as dummy variables taking the value 1 in the years following the incident and 0 otherwise.

4 Methodology

In this section the methodology utilized in this study is presented. First, the negative binomial model is presented. Second, the problems arising from the data and model are discussed, which bring us to the addition of a control function approach into the base model. The control function approach and the instrumental approach connected to it are explained in the final part of this section.

4.1 The Model

4.1.1 Negative Binomial Model

Empirical studies on terrorism have often utilized OLS, Poisson and negative binomial regressions (Asongu, Le Roux & Singh, 2021; Bravo & Dias, 2006; Gleditsch & Polo, 2016; Iheonu & Ichoku, 2021; Kis-Katos, Liebert & Schulze, 2011; Lee, 2013). As the dependent variable *terrorism* is reported in count form, a non-linear model is considered suitable. The most common models suggested in the prior literature are Poisson and negative binomial models (Kis-Katos, Liebert & Schulze, 2011; Lee, 2013). Again, the nature of the data provides guidance on the choice of model. Because terrorism incidents are sporadic and the variance in the data is larger than the mean, the data is considered overdispersed. Overdispersion in count data creates issues for regular Poisson models, which can be corrected by employing a negative binomial model (Daxecker & Prins, 2013). Overdispersion is present in the data used for this study as well. Because of this, a negative binomial model will be utilized in this study.

Count data is usually assumed to follow a Poisson distribution (Wooldridge, 2010, pp.604–605). Negative binomial distribution is a more general form of the Poisson distribution, including an extra parameter allowing the variance to exceed the mean, unlike normal Poisson distribution (Hausman, Hall & Griliches, 1984). The negative binomial model can be viewed as a Poisson model, where the Poisson parameter itself is generated randomly according to a gamma distribution. Because of this property it has proven to be an efficient way to account for overdispersion in count data variables. Hausman, Hall and Griliches (1984) developed a

specification of the negative binomial model to include time-invariant country fixed effects. Thus, utilizing a negative binomial model for panel data is possible, and also used in this study. This method has been used to study the determinants of terrorism by Kis-Katos, Liebert and Schulze (2011) and Kis-Katos, Liebert and Schulze (2014).The base specification of the negative binomial model used in this study follows that of Wooldridge (2015) and Kis-Katos, Liebert and Schulze (2014), taking the form:

$$(1) \qquad \Pr(Y_{it} = y_{it} | x_{it1}, x_{it2}, x_{it3}, x_{it4}, x_{it5}, \delta_i) = \frac{\Gamma(\lambda_{it}+y_{it})}{\Gamma(\lambda_{it})\Gamma(y_{it}+1)} \left(\frac{1}{1+\delta_i}\right)^{\lambda_{it}} \left(\frac{\delta_i}{1+\delta_i}\right)^{y_{it}} ,$$

with parameters λ_{it} and δ_i, where λ_{it} = exp($x_{itk}\beta$) and δ_i is a country specific dispersion parameter. The term Y_{it} represents the dependent variable *Terrorism*; x_{it1} represents the explanatory variable, *staple crops growth*; x_{it2}, x_{it3}, x_{it4} and x_{it5} represent the control variables *Coup, Post-2001, Post-2014* and *GDP per capita*, respectively; i and t denote the countries and years in the sample, respectively; $\Gamma(\cdot)$ denotes the gamma function. The model specification can be estimated with fixed effects or random effects, but fixed effects are typically preferred, as they are less restrictive by allowing arbitrary correlation between the country specific dispersion parameter and the explanatory variables (Kis-Katos, Liebert & Schulze, 2014). Following previous literature, fixed effects are considered in this study as well.

Model (1) will work as the baseline specification for this study. However, there exists a threat of reverse causality between the explanatory and dependent variables. Terrorism and conflict can be seen as having an impact on agriculture, through loss of labour and destruction of land and capital (Adelaja & George, 2019; Noubissi & Njangang, 2020). Thus, the baseline model is expected to produce biased results. For this reason, an instrumental variable approach is implemented.

4.1.2 Control Function

A common strategy to account for endogeneity in the prior literature on the determinants of terrorism has been to utilize lagged explanatory variables (Feridun & Sezgin, 2008; Kis-Katos, Liebert & Schulze, 2014). Miguel, Satyanath and Sergenti (2004) criticize this approach as inadequate. They argue that people may anticipate conflict or violence and adjust their actions accordingly. They suggest the use of a rainfall variable as an instrument for economic growth. The channels linking rainfall to conflict and violence are expected to run through its impact on

agriculture (Hendrix & Salehyan, 2012; Miguel, Satyanath & Sergenti, 2004; Sandholt Jensen & Skrede Gleditsch, 2009). For this study, a rainfall instrument seems especially suitable. Much of the agricultural land in the Sahel is reliant on rainfall for irrigation (Buontempo, Booth & Moufouma-Okia, 2012; Haggblade, Me-Nsope & Staatz, 2017). Furthermore, agriculture in the region is vulnerable to droughts because of the aridness of the region (Haggblade, Me-Nsope & Staatz, 2017; Potts, Henderson & Campbell, 2013). To properly account for endogeneity, I implement lagged explanatory variables and controls in addition to an instrumental approach.

A valid instrument needs to fulfil three conditions (Angrist & Pischke, 2014, p.128):

1. *Instrument relevance*
2. *Instrument independence*
3. *Instrument exclusion*

Instrument relevance in this study requires that the instrument, *rainfall change*, has a causal effect on the endogenous variable, *staple crops growth*. As the vast majority of agriculture in the Sahel is rainfed, this causation is expected. This can also be shown to be the case through running the first stage regression, where *staple crops growth* is the dependent variable and *rainfall change* is the explanatory variable. A rule of thumb check for instrument relevance is that the F-value of the instrument is greater than 10. The first stage regression (presented in Table 2 in Section 5) suggests that *rainfall change*, indeed, is a relevant instrument for *staple crops growth*.

Instrument independence is satisfied if the instrument is randomly assigned, or as good as random (Angrist & Pischke, 2014, p.128). In effect, this means that the instrument is unrelated to possible omitted variables we would like to control for. While human induced climate change can have an impact on rainfall patterns in the long run, it is unlikely that any human behaviour in this model has a meaningful impact on *rainfall change* (Galgano, 2019). Thus, it can be assumed to fulfil the independence condition.

The third condition, *instrument exclusion*, requires that the instrument impacts the dependent variable only through the endogenous explanatory variable (EEV) (Angrist & Pischke, 2014, p.128). Thus, for this study, this means that the *rainfall change* variable impacts *terrorism* only through its impact on *staple crops growth*. Prior literature has identified droughts and floods as important phenomena relating rainfall shocks to conflict (Hendrix & Salehyan, 2012). The channel for droughts leading to conflict has been shown to be through their impact on

agriculture. Flooding, however, can have an impact on infrastructure, migration and general dissatisfaction towards governance. Thus, flooding could pose a threat to the *exclusion* condition. However, as a semi-arid region, the Sahel is much more prone to droughts and rarely suffers from extreme levels of excess rainfall (Doso Jnr, 2014; Porkka et al., 2021). Together with this information and the prior usage of rainfall as an instrument in conflict studies, I consider the *instrument exclusion* condition to be fulfilled.

Because the instrumental variable and the EEV are both continuous variables and the dependent variable is a count variable some considerations for the model need to be made. In essence, it is desirable to predict a linear model in the first stage and a non-linear model in the second stage. Wooldridge (2015) advocates for a Control Function (CF) approach in cases like this. The CF approach allows the first stage regression to be run as a linear function. The predicted residuals from the first stage are then used as a control variable in the second stage regression. In this study, the first stage linear function is predicted with a fixed effects OLS model. The first stage regression takes the following specification:

$$(2) \qquad x_{it1} = \alpha z_{it} + \rho_2 x_{it2} + \rho_3 x_{it3} + \rho_4 x_{it4} + \rho_5 x_{it5} + \nu_i + \epsilon_{it} \ ,$$

where x_{it1} represents the EEV *agricultural shock*; z represents the instrumental variable *rainfall change*; $x_{it2}, x_{it3}, x_{it4}$ and x_{it5} represent the same control variables as in model (1): *coup, post-2001, post-2014* and *GDP per Capita*, respectively; ν denotes the country-specific time-invariant fixed effects; ϵ denotes the econometric error; α and ρ represent the coefficients for the variables; i and t denote the country and year, respectively.

From model (2), I can obtain the predicted residual $\widehat{\epsilon_{it}}$. This predicted residual term will then be included as a control variable into the regression of model (1), the second stage of our CF approach. This procedure ensures that the coefficients we derive for the impact of *staple crops growth* on *terrorism* are exogenous, according to Wooldridge's (2015) approach. Model (3) augments the negative binomial model with the control function approach, taking the following specification:

$$(3) \qquad \Pr(Y_{it} = y_{it} | x_{it1}, x_{it2}, x_{it3}, x_{it4}, x_{it5}, \widehat{\epsilon_{it}}, \delta_i) = \frac{\Gamma(\lambda_{it}+y_{it})}{\Gamma(\lambda_{it})\Gamma(y_{it}+1)} \left(\frac{1}{1+\delta_i}\right)^{\lambda_{it}} \left(\frac{\delta_i}{1+\delta_i}\right)^{y_{it}} \ ,$$

where the predicted first stage residual $\widehat{\epsilon_{it}}$ is included as a control variable.

5 Empirical Analysis

In this section the results of this study are presented. First, the results estimated with the main models are shown. Second, a battery of robustness checks and specifications are presented. Third, the results, their implications and the study's possible limitations are discussed.

5.1 Results

I begin with estimating the base model which is assumed to suffer from endogeneity. Model specification (1) is a negative binomial model without the CF approach. The results can be found in column 1 of Table 1. The coefficients in a negative binomial regression are reported in log counts and their interpretation is done according to log count differences (Kis-Katos, Liebert & Schulze, 2011). The interpretation of the coefficient for *staple crops growth* in model (1) is done as follows: a percentage point increase in *staple crops growth* implies a change of $(e^{-0.402} - 1) * 100\% = -33\%$ in the dependent variable *terrorism*. However, this result is not statistically significant. According to the model, the variables indicating major transnational terrorist attacks and events, *Post-2001* and *post-2014*, have strong significant impacts on *terrorism*. According to the model, if a country-year observation takes place after 2001 terrorism incidents increase by 112%, and by 398% if the country-year observation takes place after 2014. This, however, does not necessarily mean that the attacks lead to increases in terrorism as there are many unexplained mechanisms at play. But it does show that terrorism has been on the rise since the 2000s. *GDP per capita* has a positive and significant impact on *terrorism* in the model of the first column. The variable is measured in hundreds of Dollars (constant 2015 USD). Thus, the coefficient implies an increase of 4.7% in *terrorism* when *GDP per capita* increases by a hundred USD.

Column 2 of Table 1 presents the results for the CF approach of model specification (3), where residuals from the first stage regression are included as a control variable. Surprisingly, the model predicts very similar results to column 1, the model assumed to suffer from endogeneity. The coefficients for all variables are almost identical to those of column 1. The main difference

is found in the standard error of *staple crops growth*, as it becomes larger in column 2 with respect to column 1. The control function residual term, *first stage residual*, is not statistically different from zero, implying that no endogeneity is present (Wooldridge, 2015). According to the regression of column 2, like that of column 1, the impact of *staple crops growth* on *terrorism* is not significantly different from zero.

The model in column 3 is a restricted sample, excluding Nigeria from the model. This is done because of fears of Nigerian observations driving the overall results too strongly. The number of terrorist incidents are the highest in Nigeria and its geographic characteristics make it distinctively different from the rest of the sample, as only a small portion of it is situated in the Sahel.

The restricted sample model of column 3 does indeed present differing results to those of columns 1 and 2. However, the differences come from changes in magnitudes of the coefficients and not in their significance of direction, except for the coefficient of *GDP per capita* which becomes negative but insignificant. This implies that the impact of *GDP per capita* in the full sample is driven by the Nigerian economy, as it experienced the most significant growth during the period.

Table 1. Regression results for staple crops growth on terrorism.

	(1)	(2)	(3)
Dependent variable *Terrorism*	NB	NB/CF	NB/CF (restricted)
Staple crops growth	-0.402	-0.370	-0.191
	(0.388)	(0.702)	(0.748)
Coup	0.385	0.381	0.428
	(0.257)	(0.264)	(0.280)
Post-2001	0.705***	0.705***	0.611**
	(0.173)	(0.173)	(0.194)
Post-2014	1.605***	1.605***	1.804***
	(0.183)	(0.183)	(0.199)
GDP per capita	0.0457*	0.0456*	-0.0414
	(0.0218)	(0.0220)	(0.0325)
First stage residual		-0.0431	-0.109
		(0.777)	(0.819)
Observations	315	315	280
Number of countries	9	9	8

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table 2 presents the results of the first stage regressions of the control function approach. Column 1 presents the first stage results for the full sample model, and column 2 presents the restricted sample model. The first stage regressions confirm that the instrument, *rainfall change*, is a relevant instrument for *staple crops growth*. The results of column 1 show that a percentage point increase in rainfall relative to the previous year leads to a 0.785 percentage point increase in staple crops output relative to the previous year. These results are also highly significant. The relevance can be checked through an F-test as well. The rule of thumb level for a relevant instrument is an F-value of 10 (Stock & Watson, 2007, p.490). The F-values for *rainfall change* are 83 for column 1 and 73 for column 2. Thus, confirming that the instruments are indeed relevant. The same set of control variables are included in the first stage regressions as in the second stage. The controls do not have a significant impact on *staple crops growth*. This is not surprising, as rainfall is expected to be the most important variable impacting staple crops output in the Sahel.

The impact of *staple crops growth* on terrorist incidents is not significant, according to my results. We can also look at the intensity of terrorism. Table 3 presents the results for the models

Table 2. First stage regression results.

	(1)	(2)
Dependent variable	OLS-FE	OLS-FE
Staple crops growth		(restricted)
Rainfall change	0.653***	0.655***
	(0.0716)	(0.0767)
Coup	0.0647	0.0734
	(0.0479)	(0.0536)
Post-2001	0.0141	0.0131
	(0.0292)	(0.0318)
Post-2014	-0.0149	-0.0231
	(0.0405)	(0.0454)
GDP per capita	0.00434	0.00785
	(0.00762)	(0.0137)
Observations	315	280
R-squared	0.230	0.231
Number of countries	9	8

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table 3. Regression results for staple crops growth on terrorism intensity.

VARIABLES *Terrorism intensity*	(1) NB	(2) NB/CF	(3) NB/CF (restricted)
Staple crops growth	-0.550	-0.937	-0.657
	(0.357)	(0.654)	(0.730)
Coup	0.407	0.469	0.531
	(0.276)	(0.289)	(0.310)
Post-2001	0.616***	0.621***	0.613**
	(0.180)	(0.180)	(0.203)
Post-2014	0.785***	0.775***	1.139***
	(0.201)	(0.201)	(0.218)
GDP per capita	0.0332	0.0360	-0.0576
	(0.0188)	(0.0192)	(0.0314)
First stage residual		0.533	0.287
		(0.756)	(0.835)
Observations	315	315	280
Number of countries	9	9	8

Restricted sample
Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

of Table 1, when the dependent variable is *terrorism intensity*, which measures victims per attack. Much like the results for terrorist incidents, *staple crops growth* has a negative but insignificant coefficient when looking at the intensity of terrorism.

The *post-2001* and *post-2014* dummies have large positive impacts on *terrorism intensity*, much like in Table 1. The coefficients for *GDP per capita* behave similarly in Table 3 as they do in Table 1 in direction of impact but are no longer significant in the full sample models. The coefficients of the *coup* variable are positive but insignificant, much like in the models of Table 1.

5.2 Robustness

The insignificant relationship between staple crops output growth and terrorism seems quite robust to various sets of control variables. When the models of Table 1 are run without any control variables, the impact remains negative but insignificant. The magnitude of the

coefficient becomes slightly smaller than in the full model specification. The results can be found in the appendix.

Hendrix and Salehyan (2012) argue that using a rainfall change from the previous year is not a suitable operationalization method. Instead, they employ a deviation from the mean rainfall as a rainfall shock variable. The choice of rainfall data operationalization for this study was discussed in section Section 3.4. The deviation from the mean variable is used here as a robustness check. As the rainfall data is employed in a different manner, it is necessary to also employ the agricultural output shock variable in the same way. Thus, both staple crops output and rainfall are measured as deviation from the mean. The values are then divided by the standard deviation, as suggested by Hendrix and Salehyan (2012)

The results, shown in Table 4, are quite distinct from those of Table 1. Surprisingly, column 2, presenting the results for the control function approach, returns a positive and significant coefficient for the impact of staple crops output deviation on terrorism incidents. However, the first stage residual is also significant. This is a sign of unreliable standard errors, according to

Table 4. Regression results staple crops deviation from the mean on terrorism.

VARIABLES *Terrorism*	(1) NB	(2) NB/CF	(3) NB/CF
Staple crops deviation	-0.00446	0.977*	0.893
	(0.0850)	(0.394)	(0.660)
Coup	0.352	0.634*	0.659
	(0.278)	(0.299)	(0.390)
Post-2001	0.594**	-0.00141	0.223
	(0.185)	(0.299)	(0.491)
Post-2014	0.801***	0.398	1.234**
	(0.204)	(0.256)	(0.466)
GDP per capita	0.0314	0.0541**	0.0681
	(0.0189)	(0.0210)	(0.0750)
First stage residual		-1.039*	-1.043
		(0.406)	(0.640)
Observations	315	315	315
Number of countries	9	9	9
Bootstrap SE	No	No	Yes

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Wooldridge (2015). In this situation, he advises for the use of bootstrapped standard errors. This strategy is employed in column 3, and the impact of staple crops output on terrorist incidents becomes insignificant again.

The large positive magnitude of the *staple crop deviation* coefficient can be due to correlation with the overall rising trend of rainfall found in the data. When year fixed effects are introduced into the regressions of Table 4, the impact of staple crop deviation becomes negative and insignificant with bootstrapped standard errors. These results can be found in the appendix.

Similar problems with unreliable standard errors should not plague the results of Table 1 as is a concern for the results of Table 4. Wooldridge (2015) explains that if the first stage residuals are not significant as control variables no correction is strictly necessary. To show that this is not a threat to the validity of the results of Table 1, model specification (3) is estimated with bootstrapped standards errors. The results make little impact on the results, which can be found in the appendix.

The results so far over the full time period have failed to find a significant relation between agricultural output growth and terrorism. As Figure1 shows, an exponential growth in terrorism over time has taken place in the Sahel. Thus, it is reasonable to divide the sample into two different periods to examine if there are differences in the impact of *staple crops growth* on *terrorism*. In most cases, the increasing trend in terrorist attacks starts after the turn of the millennium. Thus, I will consider a model including only the years before 2001, and another model including the years from 2001 onwards. These results are presented in Table 5. Column 1 presents the results for the pre-2001 period and column 2 presents the results for the post-2001 period. Overall, the results for the two periods are quite similar. The coefficient for *staple crops growth* in the prior period is much larger in magnitude than that of the later period. However, both coefficients are insignificant. The model for the later period also includes the *post-2014* dummy, which is positive and significant. The coefficient for *GDP per capita* is positive in both columns, but significant only in column 2, possibly due to strong GDP per capita growth in Nigeria.

Table 5. Regression results with time restrictions.

Dependent variable *Terrorism*	(1) NB/CF (1985-2000)	(2) NB/CF (2001-2019)
Staple crops growth	-2.550	-0.206
	(2.448)	(0.685)
Coup	0.314	0.521
	(0.417)	(0.383)
Post-2014		1.453***
		(0.199)
GDP per capita	0.0193	0.0919***
	(0.0720)	(0.0268)
First stage residual	2.902	-0.657
	(2.554)	(0.789)
Observations	153	171
Number of countries	9	9

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

5.3 Discussion

In this section I will link the findings of this study to the existing literature and discuss their limits and merits. The results find no significant relationship between agricultural shocks and terrorism in the Sahel. Prior literature on economic shocks and conflict have generally found a relationship to exist (Hendrix & Salehyan, 2012; Miguel, Satyanath & Sergenti, 2004). However, the mechanisms and direction of the relationship have been debated. These studies were larger in scope, while this study aims to shed light on this relationship in a particular part of the world and on a particular type of violence. The prior studies studied civil conflict in a more general scope. The results of this study imply that civil conflict in general and terrorism should not necessarily be considered to be caused by the same factors. As this study finds no significant relationship, it implies that other drivers and determinants are apparent in the Sahel.

Before discussing the possible reasons for the findings of this study, I will first relate the findings to the theoretical framework and the hypothesis. The theoretical framework tested for the Sahelian case is the RD theory of civil conflict by Gurr (1970). The theory states that worse than expected economic outcomes act as triggers for civil unrest. Thus, the hypothesis was derived for this study, that negative agricultural shocks lead to increased terrorism. As shown, this hypothesis is not accepted, given the results of this study. The application of the theory

relies on the proper estimation of deviations from the expected outcomes. This is, of course, difficult to do and requires assumptions to be made by the author. Thus, also the ability of the RD framework to explain terrorism in the Sahel is found to be weak only within these conditions.

Many of the previous studies focusing on the determinants of terrorism include large country samples (Kis-Katos, Liebert & Schulze, 2011; Li & Schaub, 2004; Piazza, 2013). Some also consider country specific case studies (Adelaja & George, 2019; Benmelech & Berrebi, 2007; Yin, 2017). No prior quantitative studies on the socio-economic determinants of terrorism in the Sahel exist, to the author's knowledge. Thus, the findings of this study act as a first estimation on the topic. Some parallels can still be drawn between this study and the previous literature on the subject. The results found in this study are perhaps most closely related to those found by Kis-Katos, Liebert and Schulze (2011), which also contradict theories finding deprivation as a determinant of terrorism. From their extended findings some speculations can be made on the drivers of terrorism in the Sahel as well.

Kis-Katos, Liebert and Schulze (2011) find that failed states tend to cultivate terrorism instead of deprivation. Already existing conflict, anarchy and instability creates room for terrorist movements to develop and flourish. Most of the countries in the sample of this study are ranked near the top of the Fragile States Index in 2019, the most recent year included in this study (The Fund for Peace, 2022). The instability created by fragile states may be further increased by the clustered position of these countries around the Sahel. This has, as Harmon (2014) argues, created many largely ungoverned spaces for criminals, insurgents and terrorists to function in the Sahelian peripheries of the countries. The coup d'état indicator had no significant impact on terrorism in most model specifications of this study. This variable was meant to capture the impact of political turmoil on terrorism. While no impact is observed, this may not necessarily capture all ways that political instability surfaces. To properly study the impact of state failure on terrorism, better indicators should be considered. Because state failure is not properly considered in this paper, I do not claim it as an important determinant of terrorism in the Sahel, but simply present it as a possible factor.

Transnational influences may also be a major factor explaining the rise of terrorism in the Sahel. For this, some tentative evidence is found in the results. The dummy variables indicating the *post-2001* and *post-2014* periods were highly significant in all model specifications. However, it must be admitted that these variables capture a lot more than just the impact of major

transnational terrorist attacks. Much of the literature agrees that no proper global terrorist front exists, but some loose affiliations have been confirmed between the groups active in the Sahel and active in other terrorist hotspots of the world (Dowd & Raleigh, 2013; Solomon, 2015a). International linkages between terrorists tend to be strongest within the Salafist jihadist organizations. As Solomon (2015a) explains, financial support flowing from different Salafist organizations in especially the Persian Gulf countries has spread radical Salafist Islam in many African countries, including those considered in this study. This support, he claims, can also be linked to groups such as Boko Haram helping their recruitment efforts. Furthermore, transnational influences may not need to be formal cooperation between terrorist groups. Major attacks by terrorists abroad may provoke and embolden similarly minded groups' activities domestically. Especially the financial linkages between radical movements and their impact on terrorism across the globe require further research.

This study finds no significant linkage between relative deprivation and terrorism. Does this mean that absolute deprivation is a more suitable determinant of terrorism in the Sahel? According to the limited findings in the form of GDP per capita functioning as a control variable, a small link between economic development and terrorism exists. The general findings of previous literature on economic development and terrorism have found mixed results, ranging from negative to positive relationships (Burgoon, 2006; Li & Schaub, 2004; Yin, 2017). The findings of this study show some support for the arguments of higher GDP attracting terrorism, as supported by (Yin, 2017). These findings, however, were sensitive to sample restrictions and mainly driven by the economic development of Nigeria. Thus, this study can claim to add little to this existing debate.

Agricultural shocks do not, according to this analysis, act as a trigger for terrorism in the Sahel. Terrorist incidents have, despite this, increased exponentially since the turn of the millennium. No linkage was found between agricultural shocks and terrorism when samples were restricted to pre-2001 and post-2001 years either. This study can claim no meaningful differences to exist in the determinants and mechanisms that cause terrorism during these two time periods. But something must have acted as a trigger for the exponential increase of attacks. The timing of the increase aligns well with the onset of the Lake Chad basin crisis and the rise of Boko Haram (Elu & Price, 2019; Solomon, 2015c). The rise of Boko Haram has been explained through high poverty rates and inequality, but little empirical evidence has been found to support this. This study cannot find support for this mechanism either. What then drives people to commit acts of

terror against each other? Relative deprivation in the form of agricultural shocks does not act as a trigger for terrorism in the Sahel. Different channels like state fragility and activity of radical religious preachers should be given more attention in future research.

6 Conclusion

The rise of terrorism as a global security risk has led to a surge of interest into its determinants to identify efficient prevention policies. A strand of literature argues that socioeconomic factors are the underlying reasons driving people to terrorism and that development policies aiming to eradicate poverty and inequalities will also curb terrorism. This point of view is often championed by policy makers and politicians as well. Empirical evidence identifying a relationship between poverty and terrorism, however, remains inconclusive. Studies have often found differing results depending on the choice of countries and periods of interest. This may be due to the complex mechanisms linking terrorism to the cultural, ethnic and religious fabrics of countries. Because of this, this study took a specific interest into a single region in Africa, the Sahel, to evaluate the impact economic shocks on terrorism.

The Sahel has become a global hotspot of terrorist activity during the first decades of the 21st century. The violent rise of Boko Haram in the Lake Chad Basin and the Mali crisis of 2012 have brought the Sahel region international notoriety. Defeating the terrorist threat has proven difficult for the central governments of the Sahelian countries plagued by poverty and corruption. Little empirical research, however, has been carried out on the determinants of terrorism in the Sahel. Thus, this study aimed to fill this gap in the literature. The scope of the study includes data on terrorism between the years 1985 and 2019 from nine Sahelian countries.

The theoretical framework of this study relied on the relative deprivation theory of civil unrest, developed by Gurr (1970). The theory states that lower than expected economic outcomes lead to discontent, which can lead to radicalization and terrorism. The level of terrorism in the study is measured by the number of terrorist incidents suffered by a country in a year. The economic activity in the Sahel largely comprises of small-scale agriculture. Thus, agricultural shocks were selected as the indicator of economic shocks. Furthermore, to account for possible endogeneity between agricultural shocks and terrorism, changes in rainfall were considered as an exogenous instrument for agricultural shocks.

A negative binomial regression model was chosen as the most suitable method to carry out the empirical research. The negative binomial model was augmented with the instrumental variable

through a control function approach. As the theory requires, agricultural shocks must predate the decision to join a terrorist organization. For this reason, the agricultural shock and change in rainfall variables were lagged one year in the model.

The results of the study fail to establish a significant relationship between agricultural shocks and terrorism in the Sahel. These results hold for a battery of robustness checks, including changes in the sample specification and alternative variable measures. This study cannot claim that the relative deprivation theory of civil conflict does not hold for terrorism. But, within the specifications of this study, it does not hold for terrorism in the Sahel when agricultural shocks are considered. Thus, much still remains unexplained. The results found the years after major international terrorist incidents in 2001 and 2014 to capture large increases in terrorism in the Sahel as well. This, however, does not necessarily mean that these events directly inspired terrorist activity in the Sahel, as they also captured many other unexplained events and effects.

As this study does not find a significant relationship between agricultural shocks and terrorism in the Sahel, few exact policy implications can be drawn. This study, however, does establish a good basis for further empirical research into the determinants of terrorism in the Sahel. Prior literature has found failed states and spaces outside the reach of governments to be auspicious breeding grounds for terrorists. Some authors have argued that financial flows from international radical Salafist organizations into the Sahel have caused the sudden rise of radical preachers and helped to radicalize and indoctrinate people into violent actions. Research into these topics can prove vital in explaining the causes of the sudden rise of Sahel as a global terrorist hot spot.

References

Abadie, A. (2006). Poverty, Political Freedom, and the Roots of Terrorism, *The American Economic Review*, vol. 96, no. 2, pp.50–56.

Abdel Jelil, M., Bhatia, K., Brockmeyer, A., Do, Q.-T. & Joubert, C. (2018). Unemployment and Violent Extremism: Evidence from Daesh Foreign Recruits, Working Paper, Washington, DC: World Bank, Available Online: https://openknowledge.worldbank.org/handle/10986/29561 [Accessed 18 May 2022].

Adelaja, A. & George, J. (2019). Effects of Conflict on Agriculture: Evidence from the Boko Haram Insurgency, *World Development*, vol. 117, pp.184–195.

Afriyie, F. A. (2019). BURKINA FASO: An Inquisition of Ansaroul Islam Insurgency in West Africa and Its Emerging Threat, *Conflict Studies Quarterly*, no. 29, pp.3–16.

Angrist, J. D. & Pischke, J.-S. (2014). Mastering ’metrics : The Path from Cause to Effect, Princeton University Press.

Asongu, S. A., Le Roux, S. & Singh, P. (2021). Fighting Terrorism in Africa: Complementarity between Inclusive Development, Military Expenditure and Political Stability, *Journal of Policy Modeling*, vol. 43, no. 5, pp.897–922.

Barkindo, A. (2020). The Sahel: A New Theatre for Global Jihadist Groups?, *Counter Terrorist Trends and Analyses*, vol. 12, no. 2, pp.21–26.

Bazzi, S. & Blattman, C. (2014). Economic Shocks and Conflict: Evidence from Commodity Prices, *American Economic Journal: Macroeconomics*, vol. 6, no. 4, pp.1–38.

Becker, G. S. (1968). Crime and Punishment: An Economic Approach, *Journal of Political Economy*, vol. 76, no. 2, pp.169–217.

Benedikter, R. & Ouedraogo, I. (2019). Saving West Africa from the Rise of Terrorism: Burkina Faso’s ‘Emergency Program for the Sahel’ and the Need for a Multidimensional Strategy, *Global Change, Peace & Security*, vol. 31, no. 1, pp.113–119.

Benmelech, E. & Berrebi, C. (2007). Human Capital and the Productivity of Suicide Bombers, *The Journal of Economic Perspectives*, vol. 21, no. 3, pp.223–238.

Bravo, A. B. S. & Dias, C. M. M. (2006). AN EMPIRICAL ANALYSIS OF TERRORISM: DEPRIVATION, ISLAMISM AND GEOPOLITICAL FACTORS, *Defence and Peace Economics*, vol. 17, no. 4, pp.329–341.

Buontempo, C., Booth, B. & Moufouma-Okia, W. (2012). The Climate of the Sahel, Paris: OECD, pp.57–75, Available Online: https://www.oecd-ilibrary.org/development/global-security-risks-and-west-africa/the-climate-of-the-sahel_9789264171848-4-en [Accessed 18 May 2022].

Burgoon, B. (2006). On Welfare and Terror: Social Welfare Policies and Political-Economic Roots of Terrorism, *The Journal of Conflict Resolution*, vol. 50, no. 2, pp.176–203.

Clauset, A. & Gleditsch, K. S. (2012). The Developmental Dynamics of Terrorist Organizations, *PLOS ONE*, vol. 7, no. 11, p.e48633.

Daxecker, U. & Prins, B. (2013). Insurgents of the Sea: Institutional and Economic Opportunities for Maritime Piracy, *The Journal of Conflict Resolution*, vol. 57, no. 6, pp.940–965.

Djankov, S. & Reynal-Querol, M. (2010). POVERTY AND CIVIL WAR: REVISITING THE EVIDENCE, *The Review of Economics and Statistics*, vol. 92, no. 4, pp.1035–1041.

Doso Jnr, S. (2014). Land Degradation and Agriculture in the Sahel of Africa: Causes, Impacts and Recommendations, *Journal of Agricultural Science and Applications*, vol. 03, pp.67–73.

Dowd, C. & Raleigh, C. (2013). The Myth of Global Islamic Terrorism and Local Conflict in Mali and the Sahel, *African Affairs*, vol. 112, no. 448, pp.498–509.

Echeverria Jesus, C. (2015). Risks and Threats in the Western Sahel Radicalization and Terrorism in the Sub-Region Notes, *Paix et Securite Internationales - Journal of International Law and International Relations*, vol. 3, pp.167–184.

Elu, J. U. & Price, G. N. (2019). The Causes and Consequences of Terrorism in Sub-Saharan Africa: A Recapitulation, in E. Chenoweth, R. English, A. Gofas, & S. N. Kalyvas (eds), *The Oxford Handbook of Terrorism*, [e-book] Oxford University Press, pp.606–620, Available Online: http://oxfordhandbooks.com/view/10.1093/oxfordhb/9780198732914.001.0001/oxfordhb-9780198732914-e-33 [Accessed 2 April 2022].

FAOSTAT. (2022). , Available Online: https://www.fao.org/faostat/en/#data [Accessed 22 May 2022].

Feridun, M. & Sezgin, S. (2008). REGIONAL UNDERDEVELOPMENT AND TERRORISM: THE CASE OF SOUTH EASTERN TURKEY, *Defence and Peace Economics*, vol. 19, no. 3, pp.225–233.

Foucher, V. (2019). The Mouvement Des Forces Démocratiques de Casamance: The Illusion of Separatism in Senegal?, in L. de Vries, P. Englebert, & M. Schomerus (eds), *Secessionism in African Politics*, [e-book] Cham: Springer International Publishing, pp.265–292, Available Online: http://link.springer.com/10.1007/978-3-319-90206-7_10 [Accessed 18 May 2022].

Foucher, V. (2021). Getting Boko Haram Fighters to Defect, *Crisis Group*, Available Online: https://www.crisisgroup.org/africa/west-africa/nigeria/getting-boko-haram-fighters-defect [Accessed 19 April 2022].

Fragile States Index | The Fund for Peace. (2022). , Available Online: https://fragilestatesindex.org/ [Accessed 23 May 2022].

Freeman, L. (2017). Environmental Change, Migration, and Conflict in Africa: A Critical Examination of the Interconnections, *The Journal of Environment & Development*, vol. 26, no. 4, pp.351–374.

Galgano, F. A. (2019). The Environment–Conflict Nexus, in F. Galgano (ed.), *The Environment-Conflict Nexus*, [e-book] Cham: Springer International Publishing, pp.1–17, Available Online: http://link.springer.com/10.1007/978-3-319-90975-2_1 [Accessed 2 April 2022].

Gleditsch, K. S. & Polo, S. M. T. (2016). Ethnic Inclusion, Democracy, and Terrorism, *Public Choice*, vol. 169, no. 3–4, pp.207–229.

Global Terrorism Database. (2022). , Available Online: https://start.umd.edu/gtd/ [Accessed 19 May 2022].

Global Terrorism Index. (2021). *Vision of Humanity*, Available Online: https://www.visionofhumanity.org/maps/global-terrorism-index/ [Accessed 19 May 2022].

Gurr, T. R. (1970). Why Men Rebel, Princeton University Press.

Haggblade, S., Me-Nsope, N. M. & Staatz, J. M. (2017). Food Security Implications of Staple Food Substitution in Sahelian West Africa, *Food Policy*, vol. 71, pp.27–38.

Harmon, S. A. (2014). Terror and Insurgency in the Sahara-Sahel Region: Corruption, Contraband, Jihad and the Mali War of 2012-2013, [e-journal], Available Online: https://www.africabib.org/rec.php?RID=383667526 [Accessed 18 May 2022].

Hausman, J., Hall, B. H. & Griliches, Z. (1984). Econometric Models for Count Data with an Application to the Patents-R & D Relationship, *Econometrica*, vol. 52, no. 4, pp.909–938.

Hendrix, C. S. & Salehyan, I. (2012). Climate Change, Rainfall, and Social Conflict in Africa, *Journal of Peace Research*, vol. 49, no. 1, pp.35–50.

Herrmann, S. M., Anyamba, A. & Tucker, C. J. (2005). Recent Trends in Vegetation Dynamics in the African Sahel and Their Relationship to Climate, *Global Environmental Change*, vol. 15, no. 4, pp.394–404.

Hodler, R. & Raschky, P. A. (2014). Economic Shocks and Civil Conflict at the Regional Level, *Economics Letters*, vol. 124, no. 3, pp.530–533.

Iheonu, C. O. & Ichoku, H. E. (2021). Poverty and Terrorism in Africa: Understanding the Nexus Based on Existing Levels of Terrorism, *Poverty & Public Policy*, vol. 13, no. 3, pp.254–272.

INSCR Data Page. (2022). , Available Online: http://www.systemicpeace.org/inscrdata.html [Accessed 23 May 2022].

Ismail, A. & Amjad, S. (2014). Determinants of Terrorism in Pakistan: An Empirical Investigation, *Economic Modelling*, vol. 37, pp.320–331.

Jablonski, R. S. & Oliver, S. (2013). The Political Economy of Plunder: Economic Opportunity and Modern Piracy, *The Journal of Conflict Resolution*, vol. 57, no. 4, pp.682–708.

Justino, P. (2012). War and Poverty, *IDS Working Papers*, vol. 2012, no. 391, pp.1–29.

Kis-Katos, K., Liebert, H. & Schulze, G. G. (2011). On the Origin of Domestic and International Terrorism, *European Journal of Political Economy*, vol. 27, pp.S17–S36.

Kis-Katos, K., Liebert, H. & Schulze, G. G. (2014). On the Heterogeneity of Terror, *European Economic Review*, vol. 68, pp.116–136.

Krueger, A. B. & Malečková, J. (2003). Education, Poverty and Terrorism: Is There a Causal Connection?, *The Journal of Economic Perspectives*, vol. 17, no. 4, pp.119–144.

Kuhn, P. M. & Weidmann, N. B. (2015). Unequal We Fight: Between- and Within-Group Inequality and Ethnic Civil War*, *Political Science Research and Methods*, vol. 3, no. 3, pp.543–568.

Lee, C. (2013). Democracy, Civil Liberties, and Hostagetaking Terrorism, *Journal of Peace Research*, vol. 50, no. 2, pp.235–248.

Li, Q. & Schaub, D. (2004). Economic Globalization and Transnational Terrorism: A Pooled Time-Series Analysis, *The Journal of Conflict Resolution*, vol. 48, no. 2, pp.230–258.

Mereu, V., Carboni, G., Gallo, A., Cervigni, R. & Spano, D. (2015). Impact of Climate Change on Staple Food Crop Production in Nigeria, *Climatic Change*, vol. 132, no. 2, pp.321–336.

Middendorp, T. & Bergema, R. (2019). The Warning Signs Are Flashing Red: The Interplay Between Climate Change and Violent Extremism in the Western Sahel, *ICCT Research Papers*, vol. 10, no. 3, pp.1–8.

Miguel, E., Satyanath, S. & Sergenti, E. (2004). Economic Shocks and Civil Conflict: An Instrumental Variables Approach, *Journal of Political Economy*, vol. 112, no. 4, pp.725–753.

Nchalla, B. M. & Shirima, C. P. (2016). The Law of Armed Conflict and the Question of the Global War on Terror: A Critical Review, *Tuma Law Review*, vol. 4, pp.206–242.

Nguyen, P., Shearer, E. J., Tran, H., Ombadi, M., Hayatbini, N., Palacios, T., Huynh, P., Braithwaite, D., Updegraff, G., Hsu, K., Kuligowski, B., Logan, W. S. & Sorooshian, S. (2019). The CHRS Data Portal, an Easily Accessible Public Repository for PERSIANN Global Satellite Precipitation Data., *Scientific data*, vol. 6, no. 1, p.180296.

Noubissi, E. & Njangang, H. (2020). The Impact of Terrorism on Agriculture in African Countries, *African Development Review*, vol. 32, no. 4, pp.730–743.

Olsson, L., Eklundh, L. & Ardö, J. (2005). A Recent Greening of the Sahel—Trends, Patterns and Potential Causes, *Journal of Arid Environments*, vol. 63, no. 3, pp.556–566.

Omotuyi, S. (2022). Franco-Nigerian Détente? Nigeria, France and the Francophone States of the Lake Chad Region in the Era of the Boko Haram Terrorism, *African Identities*, vol. 20, no. 1, pp.26–41.

Piazza, J. A. (2013). The Cost of Living and Terror: Does Consumer Price Volatility Fuel Terrorism?, *Southern Economic Journal*, vol. 79, no. 4, pp.812–831.

Porkka, M., Wang-Erlandsson, L., Destouni, G., Ekman, A. M. L., Rockström, J. & Gordon, L. J. (2021). Is Wetter Better? Exploring Agriculturally-Relevant Rainfall Characteristics over Four Decades in the Sahel, *Environmental Research Letters*, vol. 16, no. 3, p.035002.

Potts, M., Henderson, C. & Campbell, M. (2013). The Sahel: A Malthusian Challenge?, *Environmental and Resource Economics*, vol. 55, no. 4, pp.501–512.

Raleigh, C., Nsaibia, H. & Dowd, C. (2021). The Sahel Crisis since 2012, *African Affairs*, vol. 120, no. 478, pp.123–143.

Rapoport, D. (2002). The Four Waves of Rebel Terror and September 11, *Anthropoetics*, vol. 8, no. 1, pp.4–7.

Ross, J. I. (1993). Structural Causes of Oppositional Political Terrorism: Towards a Causal Model, *Journal of Peace Research*, vol. 30, no. 3, pp.317–329.

Runciman, W. G. (1966). Relative Deprivation and Social Justice : A Study of Attitudes to Social Inequality in Twentieth-Century England.

Sageman, M. (2004). Understanding Terror Networks, Philadelphia: University of Philadelphia Press.

Sandbrook, R. & Romano, D. (2004). Globalisation, Extremism and Violence in Poor Countries, *Third World Quarterly*, vol. 25, no. 6, pp.1007–1030.

Sandholt Jensen, P. & Skrede Gleditsch, K. (2009). RAIN, GROWTH, AND CIVIL WAR: THE IMPORTANCE OF LOCATION, *Defence and Peace Economics*, vol. 20, no. 5, pp.359–372.

Sanso-Navarro, M. & Vera-Cabello, M. (2020). The Socioeconomic Determinants of Terrorism: A Bayesian Model Averaging Approach, *Defence and Peace Economics*, vol. 31, no. 3, pp.269–288.

Shinn, D. (2016). Poverty and Terrorism in Africa: The Debate Continues, *Georgetown Journal of International Affairs*, vol. 17, no. 2, pp.16–22.

Solomon, H. (2015a). Understanding the Terrorist Threat in Africa and the Limitations of the Current Counter-Terrorist Paradigm, in H. Solomon (ed.), *Terrorism and Counter-Terrorism in Africa: Fighting Insurgency from Al Shabaab, Ansar Dine and Boko Haram*, [e-book] London: Palgrave Macmillan UK, pp.1–19, Available Online: https://doi.org/10.1057/9781137489890_1 [Accessed 7 April 2022].

Solomon, H. (2015b). Ansar Dine in Mali: Between Tuareg Nationalism and Islamism, in H. Solomon (ed.), *Terrorism and Counter-Terrorism in Africa: Fighting Insurgency from Al Shabaab, Ansar Dine and Boko Haram*, [e-book] London: Palgrave Macmillan UK, pp.67–84, Available Online: https://doi.org/10.1057/9781137489890_4 [Accessed 7 April 2022].

Solomon, H. (2015c). Nigeria's Boko Haram: Contesting Ethnic, Religious and Regional Identities, in H. Solomon (ed.), *Terrorism and Counter-Terrorism in Africa: Fighting Insurgency from Al Shabaab, Ansar Dine and Boko Haram*, [e-book] London: Palgrave Macmillan UK, pp.85–103, Available Online: https://doi.org/10.1057/9781137489890_5 [Accessed 7 April 2022].

Stock, J. H. & Watson, M. W. (2007). Introduction to Econometrics, 2. ed., Addison Wesley.

Suleiman, M. N. & Aminul Karim, M. (2015). Cycle of Bad Governance and Corruption: The Rise of Boko Haram in Nigeria, *SAGE Open*, vol. 5, no. 1, p.2158244015576053.

Tamekamta, A. Z. (2021). Terrorism and Privatization of State Spaces in the Sahel: Case of the Polisario Front, *Revista Universitara de Sociologie*, vol. 2021, no. 1, pp.186–196.

Wooldridge, J. M. (2010). Econometric Analysis of Cross Section and Panel Data, 2. ed., MIT.

Wooldridge, J. M. (2015). Control Function Methods in Applied Econometrics, *The Journal of Human Resources*, vol. 50, no. 2, pp.420–445.

World Development Indicators | DataBank. (2022). , Available Online: https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country=PER [Accessed 20 May 2022].

Yin, W. (2017). Rooted in Poverty?: The Political Economy of Terrorism in Xinjiang, *Japanese Journal of Political Science*, vol. 18, no. 1, pp.41–66.

Appendix A

Table A. Summary statistics.

Variable	Obs	Mean	Std. dev.	Min	Max	Source
Terrorism	315	24.66032	93.3829	0	713	GTD
Terrorism intensity	315	265.0381	1126.439	0	12481	GTD
Staple crops yield	315	0.788298	0.30332	0.13841	1.614778	FAOSTAT
Staple crops growth	315	0.035398	0.250268	-0.69666	2.672355	FAOSTAT
Rainfall	315	781949.5	535948.9	111794.1	1927636	CHRS
Rainfall change	315	0.025193	0.177967	-0.55372	1.030397	CHRS
Coup	315	0.076191	0.265725	0	1	INSCR
GDP per capita	315	9.130083	5.238095	3.217663	26.88267	WDI

Appendix B

Table B. Staple crops growth on terrorism without control variables.

	(1)	(2)	(3)
Dependent variable *Terrorism*	NB	NB/CF	NB/CF (restricted)
Staple crops growth	-0.236	-0.426	-0.314
	(0.367)	(0.731)	(0.744)
First stage residual		0.240	0.0464
		(0.797)	(0.818)
Observations	315	315	280
Number of countries	9	9	8

Restricted sample
Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Appendix C

Table C. Staple crops deviation from the mean on terrorism with year FE.

	(1)	(2)	(3)
Dependent variable	NB	NB/CF	NB/CF
Terrorism			
Staple crops deviation	-0.0551	0.314	0.182
	(0.0937)	(0.515)	(0.731)
Coup	0.0997	0.262	0.397
	(0.289)	(0.364)	(0.558)
Post-2001	2.790**	2.438*	2.714
	(1.056)	(1.161)	(4.646)
Post-2014	0.265	-0.0346	0.451
	(0.454)	(0.612)	(1.073)
GDP per capita	0.0187	0.0481	0.0975
	(0.0194)	(0.0447)	(0.0998)
First stage residual		-0.381	-0.433
		(0.523)	(0.730)
Observations	315	315	315
Number of icountry	9	9	9
Bootstrap SE	No	No	Yes
Year FE	Yes	Yes	Yes

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Appendix D

Table D. Staple crops growth on terrorism with bootstrapped standard errors.

	(1)
Dependent variable	NB/CF
Terrorism	
Staple crops growth	-0.370
	(0.803)
Coup	0.381
	(0.338)
Post-2001	0.705***
	(0.167)
Post-2014	1.605***
	(0.215)
GDP per capita	0.0456
	(0.0299)
First stage residual	-0.0431
	(0.823)
Observations	315
Number of countries	9
Bootstrap SE	Yes

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05