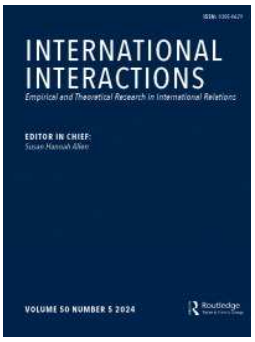

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Climate Harshness, Opportunity, and Environmental Violence

Britt Koehlein[a], Justin Schon[b] and Ore Koren[a]

[a]Indiana University Bloomington; [b]Office of Homeland Security Statistics

ABSTRACT
Will climate change affect how armed actors behave toward civilians? Scholars analyzed different links between environmental variability and war, but research on links between the former and violence against civilians is very limited. Focusing on the Sahara Desert transition zone, which stretches across the entire African continent, we argue that climate harshness raises the willingness of actors to engage in competitive violence over resources. An underlying condition is this violence happens in times of greater environmental security, which provides opportunity for actors to engage in violence. We test this argument using statistical analysis of a newly released climate-conflict geospatial dataset and find support for this theoretical expectation. The conclusion outlines both research and policy implications.

KEYWORDS
Civilian victimization; climate change; environmental conflict; geospatial analysis

PALABRAS CLAVE
Severidad climática; oportunidades y violencia ambiental

MOTS-CLÉS
Rigueur climatique; opportunité et violence environnementale

RESUMEN
¿Tendrá algún efecto el cambio climático sobre el comportamiento de los agentes armados hacia la población civil? Los académicos analizaron diferentes vínculos entre la variabilidad ambiental y la guerra. Sin embargo, la investigación en materia de los vínculos entre la variabilidad ambiental y la violencia contra los civiles es muy limitada. Nos centramos en la zona de transición del desierto del Sáhara, que se extiende por todo el continente africano, para argumentar que la dureza del clima aumenta la voluntad de los agentes con relación a participar en la violencia competitiva por los recursos. Una de las condiciones subyacentes consiste en que esta violencia ocurre en tiempos de mayor seguridad ambiental, lo que brinda oportunidades para que los agentes participen en la violencia. Probamos esta hipótesis mediante el análisis estadístico de un conjunto de datos geoespaciales de conflictos climáticos, el cual ha sido recientemente publicado, y que nos proporciona apoyo para esta expectativa teórica. Esta conclusión esboza tanto las implicaciones que tiene la investigación como las que tienen las políticas.

RÉSUMÉ
Le changement climatique modifiera-t-il le comportement des acteurs armés à l'égard des civils ? Les chercheurs ont analysé différents liens entre la variabilité environnementale et la guerre, mais la recherche sur les liens de la première avec la

CONTACT Ore Koren okoren@iu.edu Department of Political Science, Indiana University Bloomington, Bloomington, IN, USA.
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violence à l'égard des civils reste très limitée. En nous concentrant sur la zone de transition du désert du Sahara, qui s'étend sur tout le continent africain, nous affirmons que la rigueur climatique soulève la question de l'inclination des acteurs à prendre part à une violente concurrence pour les ressources. Une condition sous-jacente existe : cette violence intervient à des moments où la sécurité environnementale est plus forte, ce qui confère aux acteurs une opportunité de faire preuve de violence. Nous évaluons cet argument à l'aide d'une analyse statistique d'un ensemble de données géospatial sur les conflits liés au climat récemment publié et trouvons des éléments pour venir étayer cette attente théorique. La conclusion présente les implications pour la recherche comme pour la politique.

In December 2021, farmers in Nigeria's Yobe State lost the yields from "over 100 hectares of farmland to Boko Haram terrorists and criminal herdsmen" (Sahara Reporters 2021). Located in northern Nigeria, Yobe State is part of the Sahel, a strip of land that borders the Sahara Desert from the south, where the climate is harsh for much of the year (Olagunju et al. 2021). Interestingly, this attack happened despite the fact that, "the farmers have really done well…overall production has been good" (Nigerian Tribune 2021). Such violence seems to contradict narratives, prevalent in policy circles (e.g. Muggah and Cabrera 2019; United Nations 2021), about how climate harshness and environmental degradation may increase conflict in susceptible areas. One explanation is that climate variations can produce different impacts across different contexts and, potentially, types of violence (e.g. von Uexkull and Buhaug 2021). Surprisingly, however, the impact of climate harshness and environmental variability on violence against civilians, specifically, received far less attention than their impact on civil war broadly (for two comprehensive reviews: Martin-Shields and Stojetz 2019; von Uexkull and Buhaug 2021). While both armed conflict and violence against civilians can overlap geospatially, the underlying logics are often distinct and should be examined separately (Kalyvas 2006; Valentino 2014; Weinstein 2007).[1]

As a result, we know very little about how climate harshness and environmental variability impact human security in rural areas, for instance, by creating incentives for armed actors to perpetrate massacres, and even to engage in mass killing. Some studies analyzed relationships between climate, conflict, and violence against civilians (e.g. Bagozzi, Koren, and Mukherjee 2017; Koren and Bagozzi 2017), but the focus is often on specific stressors (e.g. droughts, food insecurity) and contexts (e.g. ongoing conflict), rather than on the general relationship between environmental variability (broadly

[1]For illustration, the correlation between violence against civilians and armed conflict involving all actors is only 0.48 for the Armed Conflict and Location Dataset (ACLED) and 0.25 for the Geolocated Event Data (GED), both of which are discussed below, suggesting a large share of these events do not overlap spatially and temporally. Below we discuss the theoretical and empirical distinctions between armed conflict and violence against civilians in greater detail.

defined), climate, and violence. Correspondingly, our understanding of the underlying mechanisms that might drive civilian risk is still limited.

This study addresses these theoretical and empirical limitations by developing and testing a conditional theory to explain the intersection between harsh climate, environmental variability, and violence against civilians. In developing our theory, we draw on conflict research frameworks that conceptualize its onset as resulting from both the *willingness* to engage in violence and the *opportunity* to do so (Siverson and Starr 1991). Climate-conflict nexus studies often emphasize the willingness of troops to use violence as an explanation for their fighting frequency (e.g. Maystadt and Ecker 2014; von Uexkull et al. 2016; Weinberg and Bakker 2015), and the same is true for studies that explore environmental motivations for civilian targeting (e.g. Koren and Bagozzi 2017). In this study, we utilize a recenly developed approache in environmental science research to identify Sahara transition zones, where climate conditions are harsh for most of the year, but where—unlike in full Sahara Desert areas—people regularly reside and where socioeconomic and agricultural activity takes place mostly year-round. Note that while we do use a binary operatonalization, we are not arguing that these areas are uniformly harsh, but rather that they are harsher compared to areas completely outside the transition zone.

Opportunity, meanwhile, is considered less often, but has also been shown to be important in enabling conflict to occur (Hendrix and Salehyan 2012; Salehyan and Hendrix 2014; Schon, Koehnlein, and Koren 2023; Witsenburg and Adano 2009). To approximate opportunity from an *environmentally-centric* perspective, we incorporate into our theory the role of seasonality, which—although used in some studies of the climate-conflict nexus (e.g. Crost et al. 2018; Landis 2014; Raleigh and Kniveton 2012)—has not (to our knowledge) been explored by scholars of environmentally-driven violence against civilians, especially at the subnational level. We integrate seasonal variability as defining the opportunity to engage in violence into theoretical frameworks that focus on the climate-harshness as determining the willingness of actors to engage. While armed troops may have greater willingness to engage in violence within climate-harsh locations, they will act on these incentives primarily *when* environmental conditions are improved. In these times, more resources are available, and the weather is more conducive for conducting raids, facilitating military operations, and allowing groups and military organizations—especially those living off locally-sourced food—to support their troops.

Having developed a conditional theory linking harsh-climate induced willingness and environmental opportunity, we test these claims quantitatively, using regression analysis. We rely on AfroGrid: a 0.5-degree grid-cell (i.e. a square of 55 × 55 km, which decreases in size toward the poles) month (hereon, cell-month) dataset with information on conflict events, disaggregated by actor and conflict type, location, and timing; climate—including rainfall, temperature, and droughts; and environmental health, which we operationalize using the Normalized Difference Vegetation Index (NDVI); across the entire African continent (Schon and Koren 2022). We analyze how this moderated relationship affects violence by state and—separately—nonstate actors. By being able to leverage three different political violence datasets, each of which uses different standards and approaches to measure a slightly different aspect of violence against civilians, we can identify what types of violence are more sensitive to these hypothesized dynamics. Across these numerous analyses we find robust support for the logic that: (1) rates of attacks against civilians by all types of actors within Sahara transition zones *are higher* when environmental conditions improve and more agricultural resources are available, compared with the continental baseline, although (2) these actors significantly *reduce* their violence in the same regions during times of low environmental security (scarcity), and (3) outside of the Sahara transition zone when environmental conditions are improved. We also conduct several auxiliary analyses to test the sensitivity of our results and examine how these dynamics vary across features such as conflict intensity and regime type. Our theory therefore provides a more nuanced explanation for the potential links between climate, the environment, and violence against civilians. In the conclusion we outline some of its implications for researchers and policymakers.

Distinguishing Violence against Civilians from Armed Conflict

Environmental contexts have been shown to shape violence and security dynamics globally. For instance, climate change is posited to increase the rate of natural disasters, including droughts, floods, and heatwaves, thereby generating new pressures that can feed into violence patterns (Ash and Obradovich 2020; Hendrix and Salehyan 2012; Theisen, Gleditsch, and Buhaug 2013). These shocks' impact on violence can also vary based on the existence of local safety nets, a history of disaster mitigation, and other political and socioeconomic features that can engender a natural disaster (Gaillard, Clavé, and Kelman 2008; Reinhardt and Ross 2019). Yet, while researchers studied the intersections between climate shocks and armed conflict rather extensively (see, e.g. Von Uexkull and Buhaug 2021), surprisingly, much less attention has been given to how environmental stressors shape patterns of civilian targeting and victimization (including killing, beating, and sexual violence).

Why is it important to study the impacts of climate stress and environmental variability on violence against civilians separately from their impacts for armed conflict? First, strategic behaviors concerning resource availability and the impact of climate harshness therein may not affect conflict and violence against civilians in the same way. Researchers showed that civilian targeting often arises as a distinct form of violence, and while such violence often overlaps with armed conflict, armed groups apply a distinct logic in choosing whether and to what degree to perpetrate it (Kalyvas 2006; Valentino 2014; Weinstein 2007). Pressures to secure valuable resources can motivate armed organizations to engage in warfare, or to capture areas where resources are available (Collier and Hoeffler 2004), meaning these actors might adjust their strategies to emphasize their sourcing, for instance moving into "breadbasket" territories or regions where cash crops are produced (Crost et al. 2018; Jaafar and Woertz 2016; Koren and Bagozzi 2017; Schon, Koehnlein, and Koren 2023). Farmer-herder conflicts, involving local actors such as militias, vigilantes, and civil defense forces, can also follow sourcing dynamics. These motivations can be shaped not only by need, but also by ambition to loot resources (e.g. cattle) for prestige or profit (e.g. to serve as a dowry) (Detges 2014; Döring 2020; Van Weezel 2016). Sourcing dynamics do not necessarily lead to violence; depending on territory and seasonal features, armed-conflict related sourcing behaviors may even lead to lower rates of attacks on civilians (Jaafar and Woertz 2016; Koren and Bagozzi 2017); but in other locations, civilians may still experience violent raids by armed actors, even without active conflict (Hultman 2009).

Violence against civilians, then, co-varies with sourcing-driven conflicts—which may be exacerbated by climate harshness—but also be shaped by tactical incentives that involve the need to appropriate resources. Armed troops might engage in looting and raiding behaviors not only to substantiate their operational capacity, but also to appropriate resources for personal consumption, for instance food for sustenance, cash crops for selling on open markets, and money and goods stored in farms (e.g. to pay the workers during the harvest season) for personal use (Crost et al. 2018; Koren and Bagozzi 2017). They may also seek to appropriate resources simply to prevent other armed actors from obtaining these resources, thereby depriving them of their fighting capacity (Hultman 2009; Koren 2018, 2019; Linke and Ruether 2021). While we discuss in more detail how incentives for violent appropriation may vary in the following sections, it is important to highlight that, as mentioned above, such behaviors do not necessitate territorial control or even armed conflicts to take place. As the example mentioned at the beginning of this study illustrates, in following appropriation incentives, troops seeking to obtain agricultural and water resources may raid farms that are outside of their immediate area of operations, or attack civilians even during times when there is no active conflict, meaning that investigating how resource-appropriation related violence varies based on climate and environmental variabilities should be theorized distinctly, rather than as a part of an overly generalized climate-conflict nexus framework.

Distinguishing Climate Harshness from Environmental Security

For our purposes, *environmental security* is defined as the "health" of a given location with respect to agricultural production, soil erosion, deforestation, and air and water quality, among others (e.g. Græger 1996). Definitions of environmental security often focus on the sustainable utilization of the environment, especially with respect to agricultural productivity and the availability of nonrenewable resources such as water (Buzan, Wæver, and Wilde 1998). There is also a broader view of environmental security that covers a wide array of social, cultural, economic, and political factors, as well as climatic and environmental conditions, in its conceptualization of environmental security (Barnett 2001; Dabelko and Dabelko 1995; Gemenne et al. 2014; Levy 1995). This broad view is expansive and richly nuanced, but it also creates the risk of overspreading our focus, which may lead to overidentification and measurement biases among other inferential problems.

Accordingly, we adopt a more focused view of environmental security, which emphasizes vegetation health via pathways such as productivity and water using a method developed by Schon, Koehnlein, and Koren (2023), which we discuss below. Using this approach, we measure monthly vegetation health at the local level comparably across the entire African continent, while theoretically separating the immediate effects of environmental security features from that of climate proxies, which are generally used in such analyses, and the use of which may lead to inferential biases. We acknowledge that vegetation health does not capture the entirety of the environmental security spectrum, but it does cover key dimensions of environmental security with theoretical relevance for our focus on appropriation behaviors by armed actors. In these regards, distinguishing climate factors—including rainfall and temperature—from environmental security features is a key contribution of the study. Some areas could have relatively high levels of environmental security via agricultural productivity and water security pathways even in locations that face climate harshness, for instance, if people use drought-resistant crops, or build reservoirs.

One aspect of climate harshness often linked to violence is desertification, namely the transition of fertile regions into arid land due to reduced rainfall and other features that reduce vegetation health (Maystadt and Ecker 2014; von Uexkull et al. 2016). We specifically focus on the expansion of the Sahara Desert—the largest desert in Africa—southward into greener areas within the Sahel.[2] Our decision to focus on the Sahara transition zone is directly motivated not only by the fact that it has been

[2]The Sahel passes through different parts of Mali, Senegal, Mauritania, Niger, Burkina Faso, Cameroon, Nigeria, Central African Republic, Chad, Ethiopia, Eritrea, Algeria, Sudan, and South Sudan.

analyzed in past climate-conflict research (e.g. Benjaminsen et al. 2012; Detges 2014; Hendrix and Salehyan 2012; Raleigh 2010; Raleigh and Dowd 2013; Raleigh, Nsaibia, and Dowd 2021), but also that this region exhibits marked variability in environmental security features, including agricultural productivity and water security.

A key advantage of studying environmental-security driven violence against civilians using an opportunity and willingness framework is in incorporating a variety of potential environmental drivers of violence into one theory. This approach can explain when climate induced scarcity may drive violence, as some studies suggest (e.g. Ash and Obradovich 2020; Bagozzi, Koren, and Mukherjee 2017; Burke et al. 2009; Maystadt and Ecker 2014), and when attacks are more sensitive to demand-based incentives (e.g. Adano et al. 2012; Döring 2020; Ide, Kristensen, and Bartusevičius 2021; Koren 2018; Linke and Ruether 2021; Salehyan and Hendrix 2014; Witsenburg and Adano 2009). The growing emphasis on the role of context has helped in partly resolving this debate (von Uexkull and Buhaug 2021), but we are still missing a comprehensive theory that reconciles the two perspectives when violence against civilians, specifically, is concerned.

An Interactive Theory of Environmental Violence

Climate Harshness and the Willingness for Violence

Climate/climate-change induced stress is understood as a set of conditions that may threaten an actor's wellbeing and way of life (Mason 2014). Such stressors can exacerbate inequalities, intensify agricultural resource competition, place strains on sustenance systems, and ultimately harm the state and its authority (Ayana et al. 2016; Adano et al. 2012; Döring 2020; Ide 2016; von Uexkull et al. 2016). Communal conflicts have been shown to be sensitive to precipitation shocks, presumably due to resource competition and scarcities (Hendrix and Salehyan 2012; Raleigh and Kniveton 2012; Salehyan and Hendrix 2014). This finding is in line with an earlier study by Homer-Dixon (1994), for instance, which finds that dam construction in Mali contributed to the value of land in these areas rising, prompting Moor elites to pass legislation that abrogated the rights of non-Moors to this land fueling political tensions and social conflicts. A later study by von Uexkull et al. (2016) similarly links droughts to conflict via the ethnic marginalization pathway. Other studies similarly link government responses to potential scarcities arising from such stressors, highlighting the role of government responses and adaptability in reducing conflict risk (Detges 2014; Döring 2020; Quiroz Flores and Smith 2013; Regan and Kim 2020).

Theoretically, there are two reasons climate harshness is linked to willingness for violence. First, climatic stress can generate greater armed actor willingness to perpetrate violence by increasing the vulnerability of already-vulnerable populations (Bagozzi, Koren, and Mukherjee 2017; von Uexkull et al. 2016). Individuals in climate-harsh areas, "especially those residing in countries characterized by very low socioeconomic development" (von Uexkull et al. 2016, 12394) are easy targets for armed actors seeking to prey on local populations, especially considering they often depend on locally sourced agriculture for sustenance (Koren and Bagozzi 2017). Second, the willingness for attacking civilians might increase in climate-harsh areas due to information problems and resource appropriation incentives (e.g. Kalyvas 2006; Koren and Bagozzi 2017; Valentino 2014). If, as some scholars argue (Burke et al. 2009; Gleick 2014; Homer-Dixon 1994), armed conflict intensifies in scarcity-susceptible areas, it is possible that sourcing dynamics could also lead to greater rates of civilian targeting to facilitate appropriation (as discussed above).

This brings us back to Sahara transition zones as areas especially susceptible to climate-driven violence. Several conflict "hot spots" within the Sahara transition zone not only experience high levels of violence against civilians, but also exhibit a marked similarity along different socioeconomic and political dimensions, as well as their susceptibility to harsh climatic conditions. Moreover, degradation of these Sahara boundary areas into desert is a process that happens over relatively long periods of time, with some zones being designated as desert in some years and as transition zones in others.

Note that Sahara transition zones are definitionally distinct from the Sahel. The latter is a region where Sahara transition zones exist, and its definition is time immutable within our sample. In contrast, "Sahara transition zones" is a term that allows us to capture locations where climate shifts make the risk of desertification (the encroaching Sahara Desert) high; these zones are hence time mutable and can shift on an annual basis within our sample. As such, using Sahara transition zone desertification is a more effective measure of climate change than other oft-used measures such as annual variations in droughts or rainfall, seeing that definitions of climate—for example as employed by the International Panel on Climate Change (IPCC)[3]—usually use a 30-year window. Accordingly, our evaluation of the role of willingness due to climate harshness in shaping violence against civilian patterns first suggests the following hypothesis:

> H1: Sahara Desert transition zones will experience a higher rate of violence against civilians attacks than other locations.

In these regards, it is important to acknowledge that regime type can directly impact environmental violence dynamics via pathways such as seeking to achieve stated development goals, protecting environmental

[3]See: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_AnnexVII.pdf.

resources, and providing civilian protection or—at the very least—refraining from using violence (e.g. Olson 1993; Weiss 1998; Midlarsky 1998; Neumayer 2002). Considering the local level focus of our theory and the mechanisms discussed below, we do not derive clear expectations with respect to the role of regime type, and—while we empirically account for all country level features (including regime type) in our models below—we believe the specific question as to how regime type affects these dynamics would warrant an entire study on its own (as we discuss in the conclusion). However, we do recognize that impacts may vary across democracies (and anocracies) and autocracies. For instance, in autocracies the lack of institutional accountability may make all types of actors—state, nongovernmental, and antistate—as likely to be subject to the environmental security dynamics we hypothesize, and hence as likely to engage in violence against civilians to act on appropriation opportunities. However, in democracies, formal government forces, and maybe even informal/semi-formal pro-government groups, might be less likely to engage in violence over environmental security dynamics or in general, while rebel groups will not be subject to such constraints and hence more likely to follow environmental appropriation incentives to use violence. Accordingly, as part of our sensitivity analyses, we estimate two sets of models that separate autocracies and democracies, and discuss some of the implications of the results and how some of them vary across regime types.

Environmental Variations and Opportunity for Conflict

Focusing only on climate harshness as the sole generator of violence has two shortcomings. First, while studies often expect climate harshness to increase the rate of attacks on civilians or have—at best—no effect, scenarios where stress might *lower* the risk of violence are generally excluded from analysis. Yet, we know that armed actors often avoid fighting when climate conditions are bad, seeing such conditions limit their fighting and mobilization capacity (e.g. for supporting soldiers, improving mobility) (e.g. Adelaja et al. 2019; Koren and Bagozzi 2017). Second, the emphasis on willingness and climate harshness leads to overpredicting violence, considering these conditions are prevalent within areas where conflict is already prevalent (Adams et al. 2018).

Therefore, researchers now give more attention to the role of *opportunity*, namely the conditions that shape the immediate feasibility and timing of armed conflict between combatants (e.g. Salehyan and Hendrix 2014; Witsenburg and Adano 2009). For instance, Ide et al. (2020, 102063) find that the risk of conflict following a climatic disaster increases, and that "[i]mproved opportunity structures for armed groups to escalate violence in ongoing conflicts is the main mechanism behind this link." Similarly, Koren (2018, *982*) finds "that—on average—violent conflict is not the direct result of food scarcity, but of abundance… areas with more food resources are more valued by different actors, and as a result attract more conflict."

Another aspect highlighted by opportunity-centric studies is the importance of contextual factors in shaping these dynamics: "the relationship between [natural] disasters and conflict is highly conditional, occurring almost exclusively in countries with ethnic exclusion, low levels of human development and large populations" (Ide et al., 2020, 102063) or because "conflict in areas with higher yields might be more frequent in countries that are more vulnerable to climate-induced scarcities" (Koren, 2018, 1003). These conclusions are in line with other studies on the role of environmental opportunity (e.g. Crost and Felter 2020; Hendrix and Haggard 2015; Weinberg and Bakker 2015; Linke and Ruether 2021; Schon, Koehnlein, and Koren 2023). These dynamics should be especially evident when violence against civilians is concerned. Attacks against civilians for the purpose of resource appropriation or due to improved environmental conditions may increase, all else equal, in months when more resources are available in susceptible countries and regions (e.g. Bagozzi, Koren, and Mukherjee 2017; Beardsley and McQuinn 2009; Koren and Bagozzi 2017). Here, we consider three relevant mechanisms.

First, armed actors may attack civilians to facilitate resource appropriation—including agricultural produce and livestock—for the purpose of consumption or trade (Bagozzi, Koren, and Mukherjee 2017; Crost and Felter 2020; Koren 2018). In times of scarcity, less is available for looting so armed actors are less likely to roam around in search of resources to appropriate. Actors may also need to conserve resources. Periods of higher availability provide more resources—crops and livestock—and hence more opportunity to engage in appropriation (e.g. following harvest times, or when people bring resources to the market). For instance, in November 2020, the rebel group Boko Haram initiated an attack in northern Nigeria where, "[a]t least 110 civilians were ruthlessly killed and many others were wounded in this attack on rice producers… who were bringing in their rice harvest on Sunday" (Manawatu Standard 2020). With greater resource availability and more opportunities for looting and appropriation, environmentally secure times can lead to more interactions between different armed actors and civilians, as the former roam around in search of crops or grazing land for cattle (Döring 2020). As the rate of these interactions rises, so does the potential for violence.

A second mechanism by which environmental security can shape seasonal opportunities for violence is via improving water security. In this case, higher seasonal availability of water around wells and waterholes leads to more interactions and greater competition over access (e.g. for livestock) which can create more violence, especially in areas with limited institutional mechanisms to mitigate conflict (Döring 2020). The rates of raiding and livestock theft between pastoralist communities can also rise during the wet season due to increased vegetation (easier to hide), healthier animals, and the availability of more potential raiders (Detges 2014). Greater greenery levels can correspond to more vegetation around bodies of water, which helps to approximate where and when rain-fed water availability is higher.

Finally, seasonal opportunity may cause violence to arise preemptively, where armed actors target resources in order to prevent them from being consumed by other parties (Koren 2019; Linke and Ruether 2021). In some conditions, this may even lead to so-called "scorched earth" policies, where the local population is routed to eliminate agricultural production and by extension, the enemy's ability to fight (Valentino 2014). These mechanisms are especially relevant in rural agrarian regions where both civilians and armed actors heavily rely on agriculture sourced locally, for instance as grown food or cattle grazing land (Bagozzi, Koren, and Mukherjee 2017; Döring 2020; Koren 2018, 2019). As in the first case, this incentive can lead to more interactions between armed actors and civilians over resources such as agricultural produce, livestock, and water, which can result in more violence designed to remove civilians or terminate production. For instance, as part of its counterinsurgency strategy again Boko Haram during the winter of 2020, "[t]he Nigerian military has burned and forcibly displaced entire villages," with farmers lamenting "[e]verything was burned, even our food…our crops, our cattle. Even the trolley we used for getting water. Only the metal dishes are there, but everything else is burned" (Amnesty International 2020).

In areas where agricultural production is relatively stable or where socioeconomic conditions are otherwise improved, trade and local capacities free both civilians and armed actors from relying on locally sourced crops, at least to some extent. If the government provides social safety nets, environmental grievances are less acute, and therefore the willingness to engage in violence is lower (Ide et al. 2020; Koren and Bagozzi 2017). Accordingly, we expect violence to conditionally intensify (1) in locations with desert-like climate conditions for part, or even most of, the year, where there is little government assistance to develop the willingness to carry out violence, (2) but only when there is sufficiently high opportunity due to environmental security within these regions for different armed actors to carry out violence. As mentioned above, we refer to (1) as falling within a "transition zone" between Sahara Desert and non-desert locations as an especially susceptible region, and as areas at specific risk of desertification due to (and which are measured based on standards used to approximate) climate change. However, *intra*-annually, we expect that violence within these areas—the subsequent condition in our theory—will rise during months when environmental security and, by extension, agricultural resource abundance and water security are higher, which provide greater opportunity for actors to engage in their willingness for resource appropriation. Accordingly, we derive our second hypothesis as follows:

> H2: Sahara Desert transition zones will experience a higher rate of violence against civilians attacks only during times when environmental security levels are higher.

Quantitative Analysis

Data and Methods

Our quantitative analysis relies on AfroGrid, a new data framework that includes multiple conflict, socioeconomic, climate, and environmental variables (Schon and Koren 2022). We analyze the January 2003—December 2018 period, based on the availability of the environmental health (NDVI) indicator. In addition to incorporating spatially disaggregated data in an accessible way—all information is measured at the 0.5-degree cell (i.e. a square of 55×55 km at the equator which increases in size toward the poles, hereon "cell")—AfroGrid improves on past data frameworks by using month as the temporal unit, which is crucial in allowing us to test seasonal variations in agricultural productivity as suggested in hypothesis H2.

Violence against civilians exhibit marked variability across actor, types, and degrees, and research finds that there is significant variation in terms of quality and coding standards across different datasets (Eck 2012). For instance, while violence by state forces is often more severe (Valentino 2014), violence involving nonstate actors may be more sensitive to climate and environmental variations (e.g. Ide 2016; Koren and Bagozzi 2017; Van Weezel 2016; von Uexkull et al. 2016). We therefore make the first distinction between violence by state and nonstate actors. Moreover, within the nonstate actor category, different types of groups are more likely to perpetrate violence in response to our hypothesized environmental security pathways. For instance, nonaligned or pro-government actors, including local civil defense forces or ethnic militias, may engage in social conflicts due improved access to watering holes (Detges 2014; Döring 2020) or agricultural produce (Koren and Bagozzi 2017). Additionally, state forces and rebels engaged in active civil war might be interested in winning the support of locals. In comparison, "roving bandit" militias might be less concerned with gaining local support, and therefore less sensitive about using violence, even if doing so might alienate civilians. These issues hence require making another distinction between rebels and other nonaligned and progovernment nonstate actors. Finally, there are issues related to the severity of violence. For instance, if the dynamics we hypothesize could be achieved by armed actors using intimidation as well as more severe violence, then using a dataset that also codes events without any casualties (including incidents of coercion and sexual violence) would be helpful. If, alternatively, these dynamics are more likely to lead to more severe forms of violence, then using a dataset that used higher thresholds of deaths would be important. If these dynamics are more likely to influence actors engaged in civil war, then a dataset that specifically focuses on violence within these contexts is warranted.

Building on these points, to operationalize violence against civilians, we use data from three different datasets incorporated into AfroGrid: the Armed Conflict Location and Event Dataset (ACLED) (Raleigh et al. 2010), the Uppsala Conflict Data Program's Georeferenced Event Dataset (UCDP GED) (Sundberg and Melander 2013), and the PITF Worldwide Atrocity Data (WAD) (Schrodt and Ulfelder 2016). Using these data, we create seven cell-month dependent variables, measuring: (1) all attacks against civilians initiated by state forces (ACLED); (2) all attacks against civilians initiated by rebels (ACLED); (3) all attacks against civilians initiated by ethnic and political militias (nonstate actors who are pro-government or nonaligned) (ACLED); (4) all attacks against civilians involving state forces (GED); (5) all attacks against civilians by pro- and anti-government non-state actors (GED); (6) all massacres of civilians initiated by state forces (WAD); and (7) all massacres of civilians by pro- and anti-government nonstate actors (WAD).

Relying on these three datasets and employing these seven distinct operationalizations allows us to empirically incorporate all the concerns discussed above regarding the diversity of violent outcomes in response to the interaction of climate harshness and environmental security. ACLED has the highest sensitivity level—it measures all events qualitatively defined as politically violent, regardless of whether there were any deaths—and covers the widest set of actors (we focus on three: state, rebel, and militia forces) and types of violence (we focus on violence against civilians). This allows us both to estimate whether intimidation was affected by the hypothesized dynamics, and to explore whether civilian victimization by social-conflict actors such as nonaligned and progovernment militias is sensitive. The GED codes "events linkable to a UCDP/PRIO Armed Conflict, a UCDP Non-State Conflict or a UCDP One-Sided Violence" (Högbladh 2024, 3). All the campaigns included in these datasets involved at least 25 state-rebel, nonstate actor, or civilian deaths, respectively. As such, the GED allows us to examine whether dynamics occurring as part of a major campaign are similarly sensitive to the intersection of climate harshness and seasonal environmental security. The WAD employs the highest measurement threshold—at least five civilian deaths—which helps in verifying that our theory holds for the most extreme cases of violence by both state and nonstate actors.

Turning to our key explanatory variables, we use the Normalized Difference Vegetation Index (NDVI) to create two indicators, one measuring climatic stress and another one measuring environmental variability and use their interaction to test our conditional hypothesis H2. NDVI is a continuous variable with a range of $0 \Leftrightarrow 1$ measuring vegetation and agricultural productivity on land. The NDVI data included in AfroGrid were obtained from the MODIS Terra monthly satellite data (Busetto and Ranghetti 2016; Didan 2015; Schon and Koren 2022).

In constructing this indicator, we follow the approach by Schon, Koehnlein, and Koren (2023). Briefly, we first regress annual rainfall at our 0.5-degree grids on annual average NDVI indicator for the same unit, for each year in our data. In line with Herrmann, Anyamba, and Tucker (2005), our estimate predicted NDVI value for 200 mm rainfall is 0.192. For any grid cell that fails to reach that 0.192 NDVI threshold for 1–11 months in a given year, we designate it as a transition zone (=1, =0 otherwise). We retain only values within the 10-degree to 20-degree North latitude, to ensure we only capture the Sahara region. For our purposes, desertification refers to, as mentioned above, the steady increase in the Sahara Desert's size. Considering its slow rate of occurrence and the aforementioned use of 30-year windows for measuring climate change, desertification trends southwards are not notable during our study period, especially considering the impact of other measures (e.g. dams, reservoirs) on slowing down climate change's impacts. However, by incorporating *dynamic* measures of environmental and climatic features together, our indicator can effectively measure fluctuations in climatic conditions between years that lead to some grid cells being part of the transition zone in some years and not others. Moreover, as mentioned above, in using a binary variable to measure Sahara transition zones, we are not arguing that these areas are uniformly harsh, but rather that they are harsher compared to areas completely outside the Sahara transition zone. This desertification-risk areas indicator therefore extends on past research that uses only rainfall-based measures, while incorporating long-term precipitation trends and is hence unable to capture the directly observed nature of climate harshness. This Sahara transition zone includes numerous 'hot spots,' including the border region of Mali-Burkina Faso-Niger and Lake Chad's surrounding area of Niger-Nigeria-Cameroon, among other human and food insecure areas (Benjaminsen et al. 2012; Raleigh 2010; Raleigh, Nsaibia, and Dowd 2021). For illustration, Figure 1 reports a map showing the range of Sahara TZ across the continent.

Our proxy of environmentally driven opportunity ($NDVI\ (mean)_{it-1}$) is local productivity (as discussed above), lagged by one month to account for the time it may take for resources to accumulate locally. We acknowledge that NDVI might be less than ideal compared with more contextual indicators. However, NDVI is a coarse indicator available across the entire continent over the entire period of concern, which is necessary for cross-national comparison. Within the Sahara Transition Zone, there is a relatively consistent range of climatic and environmental conditions, compared with, say, heavily forested areas, where NDVI might not be as useful an indicator. NDVI can measure variation in greenery levels within this zone, and hence, we argue that it serves the needs of our analysis. Accordingly, to test hypothesis H2—the intersection of willingness and opportunity from a climate- and environmentally-centric perspective—we interact these two variables, and include $\textit{Sahara transition zone}_{it}$ X $\textit{NDVI (mean)}_{it-1}$ in addition to each constitutive term, as done in past research (Schon, Koehnlein, and Koren 2023). Indeed, if the results were driven by NDVI approximating other features—e.g. because higher rates of violence increase in forest areas outside of the Sahel—we would expect bias

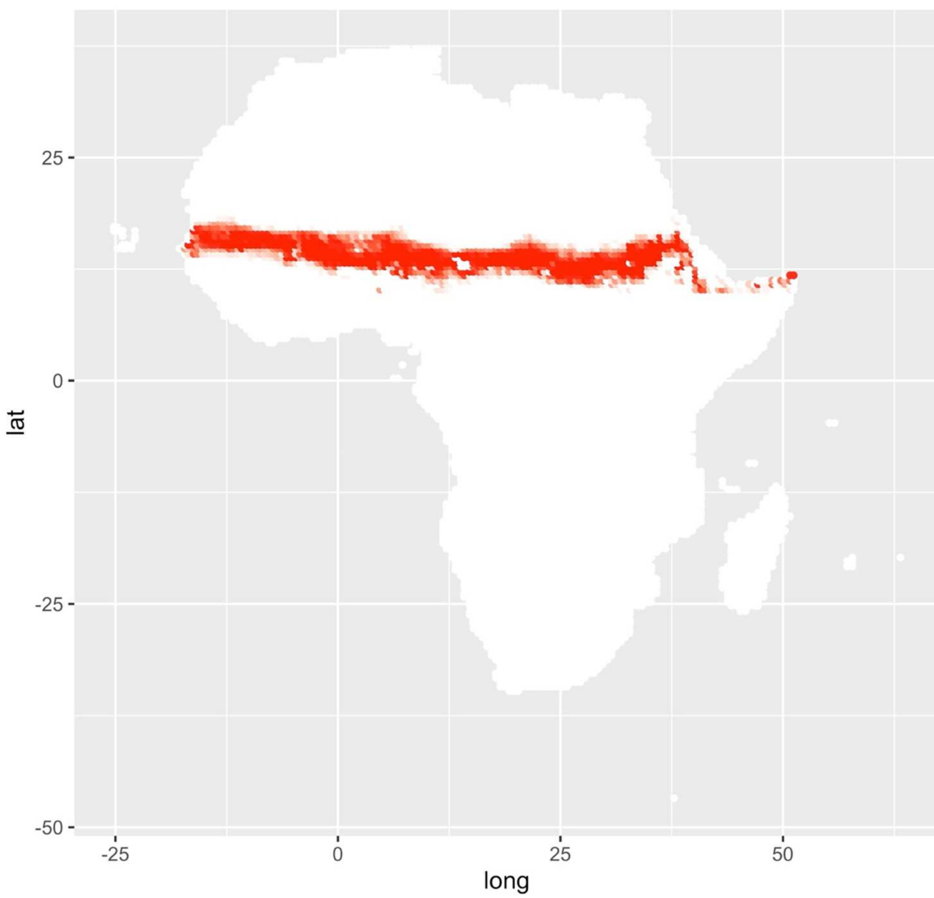


Figure 1. Map of Sahara transition zones (red) in Africa (color density represents the number of months the cell was designated as a transition zone).

to push our results away from a positive sign (seeing greenery in Sahara Transition Zone areas is lower). Moreover, we would expect the coefficient of the constituent NDVI term in the interaction to be positive all models if this bias is a concern (as we show below, opposite is true, suggesting this is not a concern).

We add several control variables, used in past studies (Linke and Ruether 2021; Schon, Koehnlein, and Koren 2023; Von Uexkull et al. 2016), to our models. To account for local development, we include the corrected annual nighttime light emissions indicator (NTL_{it}) from AfroGrid (Li et al. 2020). To account for population, we include local population densities from the WorldPop dataset (Tatem 2017). Another potential concern in geospatial analysis relates to the possibility that some actors might be more likely to attack specific regions during specific times. Accordingly, to account for temporal dependencies, we include a lag of each respective dependent variable, as well as a time trend and fixed effects by month to account for seasonal effects that are unrelated to environmental variations. To account for constant country specific features that can also affect these trends (including the possibility that violence by specific actors might be more likely in some countries), each model also includes fixed effects by country. Summary statistics for all variables (including those used in the robustness models) are reported in Table A1, Supplemental Appendix.

Building on econometric research recommendations (Angrist and Pischke 2009), we estimate a set of ordinary least squares (OLS) models based on the following equation:

$$Shadow\,Economy_{it} = \beta_1 Terrorism_{t-1} + \beta_2 Democracy_{t-1} + controls_{t-1} + \varepsilon \tag{1}$$

Where y_{it} is a vector of each of our respective dependent variables, and $y_{it\text{-}1}$ the respective lag; z_{it} measures if a grid cell was in the Sahara transition zone in each year, $n_{it\text{-}1}$ is the one-month lag of average NDVI values, and z_{it} X $n_{it\text{-}1}$ is their interaction. l_{it} and p_{it} are annual controls for (logged) nighttime light emissions and (logged) population densities, τ_t is the time trend, m_t are fixed effects by month, ω_j are fixed effects by country, and ε_i are standard errors, where the data were pooled by grid cell.[4]

Results

Table 1 reports estimates from seven OLS models, one for each of the dependent variables discussed above. The findings suggest that *Sahara transition zone*$_{it}$ X *NDVI (mean)*$_{it-1}$ has a *conditional* effect on violence

[4]This was done using the "cluster()" option included in the "survival" package in R.

Table 1. Determinants of violence against civilians in Africa, Jan 2003—Dec 2018.

	ACLED			GED		PITF	
	State	Rebel	Militia	State	Nonstate	State	Nonstate
Sahara Transition $Zone_{it}$	−0.002**	−0.002**	−0.003**	0.001*	−0.004*	−0.0001	−0.001***
	(0.001)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.0001)	(0.0001)
$NDVI_{i(t-1)}$	−0.003***	−0.001*	−0.004***	−0.002***	−0.002***	−0.0001	−0.001***
	(0.001)	(0.0005)	(0.001)	(0.0003)	(0.0003)	(0.0001)	(0.0002)
Sahara Transition $Zone_{it}$ X $NDVI_{(it-1)}$	0.006***	0.009***	0.019***	0.001	0.004**	0.001**	0.002*
	(0.003)	(0.002)	(0.005)	(0.001)	(0.002)	(0.0004)	(0.001)
$DV_{i(t-1)}$	0.441***	0.352***	0.569***	0.230***	0.411***	0.196***	0.198***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log NT $(sum)_{it}$	0.001***	0.0003***	0.002***	0.0004***	0.0002***	0.00005***	0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.00003)	(0.00004)	(0.00001)	(0.00002)
Log $Population_{it}$	0.002***	0.001***	0.003***	0.001***	0.001***	0.0001***	0.0003***
	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.00001)	(0.00003)
Log τ_t	0.001***	0.003***	0.005***	−0.0004**	0.002***	0.0001**	0.001***
	(0.0003)	(0.0003)	(0.001)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Constant	−0.001	−0.023***	−0.018**	0.007***	−0.018***	−0.001	−0.004***
	(0.004)	(0.004)	(0.007)	(0.002)	(0.002)	(0.001)	(0.001)
Observations		1,947,324		1,947,324		1,947,324	
R^2	0.200	0.127	0.337	0.055	0.171	0.039	0.044
Adj. R^2	0.200	0.127	0.337	0.055	0.171	0.039	0.044

Standard errors in parentheses based on pooled data estimates; logging was done in base 10; fixed effects by month and country were included in each model although none is reported. DV stands for 'dependent variable.' ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

against civilians by both state and nonstate actors, as well as across different thresholds of severity of violence. The coefficient for the constitutive term *Sahara transition* $zone_{it}$ coefficient is negative across all models and is statistically significant across all but two. This means that Sahara transition zones, in the absence of environmental security, are less likely than average to suffer attacks on civilians, which suggests that hypothesis H1 is invalid. The results therefore suggest that climate-induced willingness is insufficient in explaining the timing and rates of attacks on civilians by both state and nonstate armed actors: without accounting for seasonality and environmental security in conditioning harsh climate's impacts and providing opportunities for violence, Sahara transition zones experience *fewer* political violence events by all actors, on average, than the rest of the African continent.

Most interestingly, *Sahara transition* $zone_{it}$ X *NDVI* $(mean)_{it-1}$ has a positive and statistically significant coefficient (to at least the $p < 0.1$ level) across all excluding one (State GED) of our violence against civilians models. As hypothesis H2 implies, Sahara transition zones experience more violence against civilians only during months where environmental conditions (and hence, opportunity) are improved. Moreover, as per the discussion of the dependent variables above suggest, these results are consistent across state, rebels, and militias, as well as state and nonstate actors' decision to generally perpetrate both low-level violence (ACLED) and more severe forms of massacres (WAD).

Violence by rebels and militias engaged in violence as part of an ongoing campaign (as defined by the GED and discussed above) is also sensitive to our conditional interaction (GED nonstate), but violence by state forces engaged in civil war (GED state) is not. The results therefore suggest that climate-conflict nexus narratives would benefit from incorporating seasonal variability and its impact more thoroughly, although the interactive effects must be ascertained visually to ensure the results are substantive; and, moreover, that state forces engaged in broader campaigns of violence are a possible exception to such dynamics. Finally, *NDVI (mean)*$_{it-1}$ has a negative and statistically significant coefficient across all models but one (*State PITF*), suggesting that outside of Sahara transition zones, i.e. where there is environmental opportunity but not climate related harshness, more productivity is associated with less violence against civilians.

Next, we use the estimates from each respective model to calculate the change in *Sahara transition zone*$_{it}$'s coefficient (i.e. when the variable is changed from =0 to =1) on the expected number of conflicts across the range of *NDVI (mean)*$_{it-1}$ (0 ⇔ 1) over the 2003–2018 period for each type of violence. These marginal effects are plotted along with their 95% confidence intervals in Figure 2. Looking first at the low-threshold violence plots (ACLED), violence by state, rebel, and militia forces within Sahara transition zones is below average when environmental security conditions are bad but increases and is above average when these conditions improve. Moving to the GED plots, we observe the same for violence by nonstate actors, but not by state forces, which is always above average in these Sahara transition zones. One potential explanation is that state forces engaged in a campaign are inherently more likely to use violence against civilians in these regions (e.g. Valentino 2014), but more assessment should be conducted to verify this issue. Examining severe atrocities (WAD), violence by nonstate actors is in-line with the other datasets, while violence by state forces falls somewhere between the low threshold (ACLED) and civil war violence (GED) levels. Substantively, the predicted monthly rates of violent attacks in Sahara transition zones experience *decline* by about 0.001–0.005 from the average number of attacks against civilians when NDVI is at its minimum (=0) but *increase* by 0.01–0.06 when NDVI is at its maximum (i.e. =1). Considering the average violence rates in our sample range from 0.0001 (*State violence (GED)*) to 0.01 (*Militia violence (ACLED)*), these are substantively meaningful results, and correspond to an increase of 50%–490% in the predicted number of attacks against civilians within Sahara transition zones as environment security is changed from its minimum to its maximum.

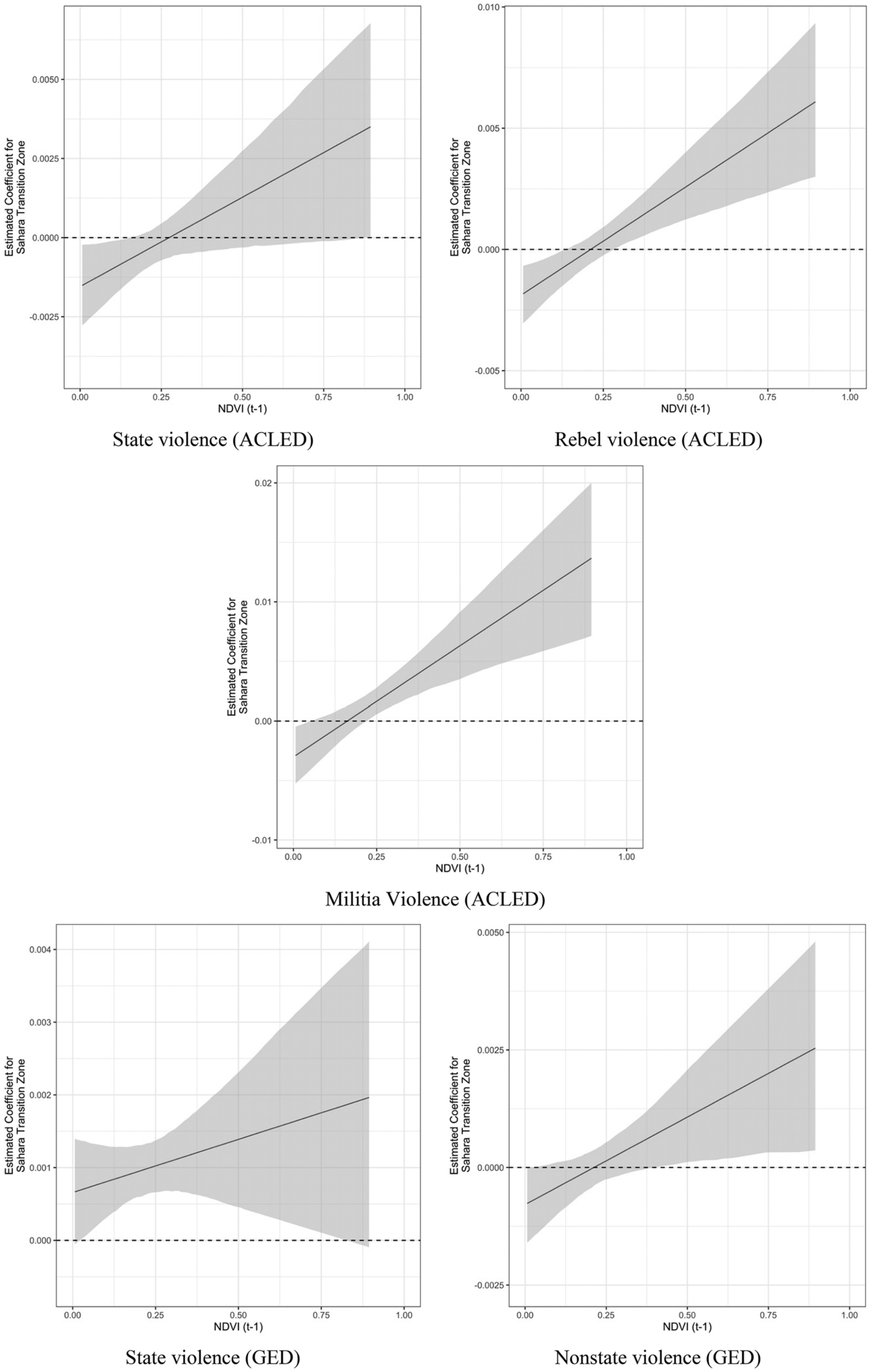
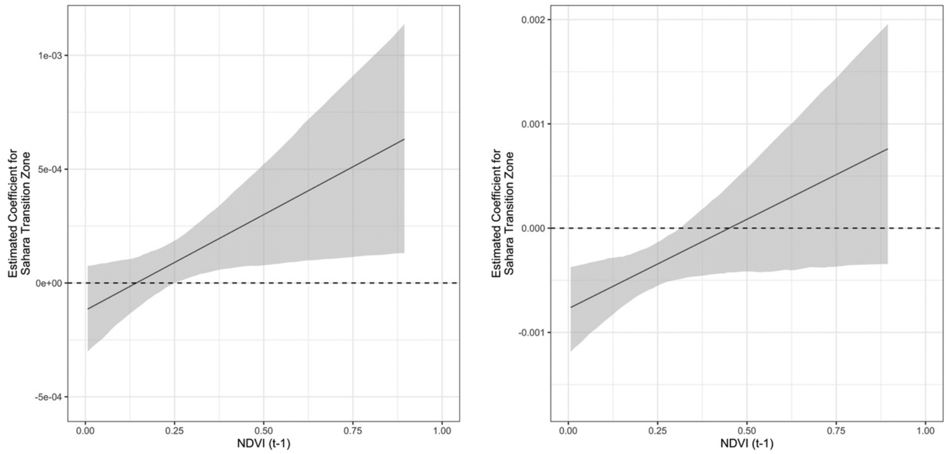


Figure 2. Change in frequency of attacks against civilians in Sahara Transition Zones.



State violence (PITF) Nonstate violence (PITF)

Figure 2. Continued.

Accounting for Alternative Explanations

As we discuss in detail in the Supplemental Appendix, we also conduct several sets of robustness analyses to evaluate the sensitivity of our findings to different modeling and specifications choices. To this end, in the Supplemental Appendix, we estimate several sets of models that do the following: (1) removing countries that never experienced civil war to address "inflation" concerns (Table A2); (2) adding to all models controls for contemporaneous armed conflicts and one-month conflict lags (from GED), which measure armed conflict incidents involving states and rebels with at least one casualty occurring as part of a civil war with 25 or more deaths (Table A3); (3) estimating geometrically weighted regressions accounting for spatial violence incidence, which—due to computational limitations—we were forced to estimate only a much smaller subset of cell-months located only in Sahel countries, omitting, in effect, around two-thirds of our sample (Table A4); (4) distinguishing between authoritarian (Table A5) and (5) democratic (Table A6) country-years (using Bjørnskov and Rode's 2020 data) to evaluate whether and how the impacts of this conditional relationship vary across regime types; and (5) using a smaller subsample where we relied on the more robust Coarsened Exact Matching (CEM) approach (Iacus, King, and Porro 2012) to match Sahara transition zones with locations outside of the transition zones that shared similar climate conditions (using monthly precipitation and temperature levels) (Table A7).

Generally, our results maintain their sign, magnitude, and statistical significance across these models, although two issues are worth noting. First, in the geospatially weighted regression models (Table A4), despite losing two thirds of our sample and accounting for spatial political violence dependencies, *Sahara Transition Zone*$_{it}$ *X NDVI* $_{(it\text{-}1)}$'s coefficient maintains its positive sign across all models and its statistical significance in four cases: ACLED (state), ACLED (rebels), ACLED (militias) and PITF (nonstate). One interpretation of the results would be that—at this robustness threshold—only the more sensitive types of violence (as discussed above) are those that were perpetrated by nonstate actors and involved relatively low intensity levels of violence, although it is important to bear in mind that the lack of significance might be caused by the loss of nearly 66% of our sample, which can induce a type II error. Second, in Tables A5 and A6, we find that low level violence (ACLED) by state forces, rebels, and militias all covaries with higher environmental variability in Sahara transition zones within autocracies, but only for rebels in democracies (columns 1–3). We also find that violence by rebels in civil wars (GED) maintains its impact in autocracies, but that this is not the case for state violence or for democracies (columns 4–5). We also find that the relationships between higher environmental security in Sahara transition zones and large-scale massacres (PITF) is only robust in democracies (columns 6–7). One potential explanation is that, because most democracies in Africa are quasi-democratic regimes or anocracies, this result may represent a case of "murder in the middle," where such regimes are at the highest risk of engaging in mass violence (e.g. Ulfelder 2012).

Scope Conditions

Before discussing the implications of our results, we must acknowledge several scope conditions that may affect the interpretation. First, as we discuss above, our operationalization of the Sahara transition zone includes latitude bands to ensure that the transition zone we capture is located along the boundary of the Sahara Desert. These latitude bands are wider than the actual expected range of Sahara transition zone, to ensure we cast a wide net to capture such transition zones. While we believe the benefits of this approach outweigh its potential downsides, this creates a risk that we might conflate transition zone and non-transition zone cells, thereby leading to false inferences with regards to the environmental drivers of violence in the Sahel.

Second, we could have operationalized our climate harshness band using a different range, for instance, the 300–500 mm rain band. However, within the our analysis of the Sahel, a region that has been highlighted as potentially sensitive to climate-change induced violence, the rain band we cover (which other studies, e.g. Ember et al. 2012, have suggested as potentially being related to climate induced violence), this operationalization includes farms as well as other types of cropland, which are key reason as to why we believe studying environmental variability, rather than just climate harshness, is important.

Third, we could have also focused on all climate-harsh areas rather than only on such cells at the boundary of the Sahara Desert. However, in this study we sought to make two comparisons: (1) specifically compare dynamics of violence *across* the Sahara transition zone and violence occurring elsewhere in the continent (including in other areas with similar levels of desertification); and (2) compare violence rates occurring *within* the Sahara transition zones across different monthly environmental variability levels. In these regards, our results might not be relevant to violence occurring in the southern part of Africa, which unfolds across a different set of contexts that may present a different set of determinants. We leave this across-context evaluation to future work.

Finally, we also acknowledge that NDVI is a relatively coarse metric. However, for our purposes, an indicator was needed that would be cross-nationally comparable and standardized regardless of context and location. NDVI satisfies that need. Future work could expand on this measure, e.g. by studying individual sub-national locations or adding more nuanced contextualized indicators that provide more nuance than an NDVI-based indicator.

Conclusion

Our theoretical and empirical assessments suggest several relevant research and policy implications. Confirming hypothesis H2 first illustrates the importance of distinguishing between climate and environmental variations. This distinction allows researchers to study the underlying motivations related to each aspect, improving researchers' ability to incorporate complex relationships. Moreover, it shows that policy solutions can improve environmental security levels (e.g. by planting drought resistant crops, building stronger dams, improving food security and fertilizer use, constructing water reservoirs) even if they do not adequately address climate stressors. Policymakers may also achieve more effective outcomes by targeting each aspect separately (e.g. protecting civilian producers and granaries during and following harvest).

Our second contribution is in connecting climate harshness and environmental variability to more general frameworks that highlight the role of willingness and opportunity (Siverson and Starr 1991; Valentino 2014). Doing so opens new doors for integrating political violence scholarship into environmental conflict research. It also pushes research beyond the focus on primarily armed conflict involving armed organizations and more toward other types of violence that are less extensively studied and, potentially, might be more susceptible to environmental variability's impacts (e.g. Bagozzi, Koren, and Mukherjee 2017; Koren and Bagozzi 2017). For policymakers, we show that climate-induced grievances do not noticeably drive violence against civilians, at least unless a resource-driven opportunity is provided. Civilian protection policies should therefore seek to defend prized resources (e.g. crops, food, cattle, water areas) rather than focus on climate-induced grievances.

Our third contribution is in highlighting the importance of accounting for the *timing* of triggers of violence in environmental conflict research. Distinguishing between climate harshness and seasonal environmental security features—including agricultural productivity and water security—can help in identifying times of higher risk for civilians. Failing to incorporate environmental variability into analytics of climate- and environmental-security research means that any results generated by this scholarship are lacking almost by definition. For policymakers, the focus on timing can help in optimizing targeted policies and their deployment closer to periods of high risk, alleviating resource constraints by placing limits on deployment times.

Finally, our study highlights the contextual nature of climate- and environmental conflict dynamics. In these regards, we made sure to operationalize our indicator of climate harshness—Sahara transition zones—based on relatively long weather trends that can effectively capture climate change's effects. The results suggest that the underlying drivers of violence are often unrelated to climate and the environment, but rather include a history of conflict, socioeconomic factors, inequalities, state capacity, and political openness (Adams et al. 2018; Buhaug et al. 2014). That is not to say that climate change and its implications are irrelevant or may not become more central drivers of violence in the future. But it does behoove researchers to more carefully consider violence against civilians dynamic within their immediate context, and consider climate solutions that have positive extraneities with respect to conflict, for instance, via community building and improvements in local resilience and general preparedness.

Beyond these contributions, the findings also suggest future directions of research that can be pursued to expand our understanding of the relationship between climate, environmental variability, and violence. As we mentioned above, one promising direction relates to the role of political institutions. Our results in Tables A5–A6 illustrate that formal government and pro-government organizations in democracies are significantly less likely to engage in low intensity violence compared with their authoritarian counterparts, suggesting that more accountable political institutions may help in reducing the risk of predation, at least by the state. Future research can explore these dynamics more thoroughly, perhaps using local level measures of political institutions.

Another direction would be to explore the role played by international and nongovernmental organizations (IOs and INGOs). For instance, policies that relate to climate mitigation have been shown to potentially feed into ongoing patterns of violence or intensifying grievances that—given the opportunity (as per our findings)—engender new ones (e.g. Gilmore and Buhaug 2021). Considering the prevalence of such local level interventions in the Sahel, such policies might potentially confound the impact of the interactive environmental variability and climate harshness dynamics we hypothesize. As such, we believe that an especially beneficial direction of research is to examine how climate mitigation and adaptation policies and the related externalities can shape environmental conflict, as well as what are some of the ways or features of such policies that can contribute to reducing conflict risk and improving resilience.

Disclosure statement

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ORCID

Justin Schon http://orcid.org/0000-0003-3021-5128
Ore Koren http://orcid.org/0000-0001-9011-1510

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