Transhumant Pastoralism, Climate Change and Conflict in Africa

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Abstract: We consider the effects of climate change on seasonally migrant populations that herd livestock—i.e., transhumant pastoralists—in Africa. Traditionally, transhumant pastoralists benefit from a cooperative relationship with sedentary agriculturalists whereby arable land is used for crop farming in the wet season and animal grazing in the dry season. Rainfall scarcity can disrupt this arrangement by inducing pastoral groups to migrate to agricultural lands before the harvest, causing conflict to emerge. We examine this hypothesis by combining ethnographic information on the traditional locations of transhumant pastoralists and sedentary agriculturalists with high-resolution data on the location and timing of rainfall and violent conflict events in Africa from 1989–2018. We find that reduced rainfall in the territory of transhumant pastoralists leads to conflict in neighboring areas. Consistent with the proposed mechanism, the conflicts are concentrated in agricultural areas; they occur during the wet season and not the dry season; and they are due to rainfall's impact on plant biomass growth. Since pastoralists tend to be Muslim and agriculturalists Christian, this mechanism accounts for a sizable proportion of the rapid rise in religious conflict observed in recent decades. Turning to policy responses, we find that development aid projects tend not to mitigate the effects that we document. By contrast, the effects are reduced when transhumant pastoralists have greater power in national government, suggesting that more equal political representation is conducive to peace.

Key words: Transhumant pastoralism, sedentary agriculture, seasonal migration, conflict, weather.

JEL classification: N10; Q54; Z1.

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1. Introduction

Climate change is one of the most important challenges facing society. A fundamental concern is that more frequent extreme weather events may lead to violent conflict and political instability in fragile parts of the world. Many African countries are believed to be especially vulnerable to this threat, due in part to low economic development, weak state capacity, and a high reliance on crop agriculture. In this paper, we study a particularly important characteristic of African economic and cultural life that is susceptible to the deleterious effects of climate change. It is estimated that 22% of Africa's population obtains the majority of its income from animal husbandry, and 43% of the continent's land mass is used to support pastoral activities (FAO, 2018). Many of Africa's pastoral ethnic groups engage in the practice of *transhumance*, which is the seasonal movement of grazing animals. Transhumance creates interdependent relationships that are potentially sensitive to the increased frequency of droughts brought on by climate change in Africa.

In typical years, neighboring transhumant pastoral and sedentary agricultural groups coexist in a symbiotic relationship that is characterized by seasonal migration. In the wet season, agriculturalists cultivate crops on more productive lands while transhumant pastoralists exploit more marginal lands that produce sufficient plant biomass (or *phytomass*) for their livestock. After the final harvest, transhumant pastoralists migrate along well-established corridors to arrive at the agricultural farmlands for the dry season, where they benefit from the year-round availability of phytomass while providing organic fertilizer in exchange.

In low precipitation years, however, there may be insufficient phytomass produced on the marginal grazing lands to sustain pastoralists' livestock. This shortage forces pastoralists to migrate to agricultural farmlands before the dry season begins. If the animals arrive before the final harvest, tensions can arise due to damaged crops and competition for resources, such as water and pasture. The issue is well-known, with many documented examples (Moritz, 2010, Kitchell, Turner and McPeak, 2014, Brottem, 2016).

Whether this mechanism results systematically in violent conflict is an empirical question. On the one hand, neighboring groups may avoid conflict if they believe droughts to be sufficiently rare events. In this case, the symbiotic relationship is worth preserving. On the other hand, groups may have updated their expectations about the frequency of droughts due to climate change. In this case, the symbiotic relationship is unsustainable, and frictions may emerge in the form of conflict events. A related empirical question concerns the recent rise of extremist-religious violence in Africa. Given that transhumant pastoral groups tend to be Muslim and sedentary agriculturalists tend to be Christian, it is possible that this mechanism also affects violence involving self-styled religious groups.

Our study examines these empirical questions. We measure the incidence of conflict using geocoded event data from two sources, the Uppsala Conflict Data Program (UCDP) and the Armed Conflict Location & Event Data Project (ACLED). To determine the identity of transhumant pastoral groups, we use data from the *Ethnographic Atlas* (Murdock, 1967), which contains information on the economic and cultural practices of pre-colonial ethnic societies worldwide. We construct ethnicity-level measures of transhumant pastoralism that combine ethnographic information on the historical importance of animal herding in the society, as used by Becker (2019), with information on the historical mobility of an ethnicity. We assign the characteristic to territories across the continent using information on the traditional boundaries between ethnic groups in Africa from Murdock (1959).

We begin with a descriptive cross-sectional analysis to study whether violence is more prevalent in land outside of the territory of groups that are transhumant pastoral. We examine variation across 0.5-degree grid cells, which is around 55km $\times$ 55km at the equator. For each cell, we identify the 'nearest neighboring' ethnic group, which is the ethnic group, among all ethnic groups that border a cell's own ethnic group, that is geographically closest to the cell. We find that grid cells that have a transhumant pastoral nearest neighbor experience more conflict. When we distinguish between types of conflict, we find that the effect is present for conflicts that involve state actors, such as the police or military, as well as for smaller-scale conflict events involving non-state actors. This is consistent with accounts wherein agricultural landowners are often aided or supported by state forces, while transhumant pastoral ethnic groups are identified as non-state forces.

We then turn to the central question of the analysis, which is whether adverse rainfall that occurs in the territories of transhumant pastoralists leads to conflict in nearby agricultural lands. Examining variation across grid cells and years, we estimate a specification that includes grid-cell fixed effects, which account for time-invariant factors, and country-year fixed effects, which account for common macro-level factors that vary by country and year. The coefficient of interest is for an interaction between the measure of transhumant pastoralism of a grid cell's nearest neighboring ethnic group and the average amount of rain in that ethnic group's territory in a year. The estimate tells us whether the incidence of conflict in a cell is influenced by precipitation in the nearest neighboring ethnic territory where the nearest neighbor is transhumant pastoral.

We find that, consistent with the hypothesis, less precipitation in a cell's nearest neighboring ethnic group increases conflict in the cell, but only if the neighbor is transhumant pastoral. The estimated effects are sizable and significant. We find that a one standard deviation decline in rainfall experienced by the median transhumant pastoral ethnic group raises the risk of conflict in a nearby grid cell by around 24%, or 0.8 percentage points (from a mean of 3.5% to 4.3%). The same shock experienced by a non-transhumant pastoral group has a negligible and statistically insignificant effect (around 2%, or 0.08 percentage points).

The specifications that we estimate allow for any direct effects of rainfall occurring in the grid cell itself and for any *intra*-ethnic effects of rainfall occurring in the same ethnic territory as the grid cell. It also allows for the possibility that these effects might differ if the cell's own ethnic group is transhumant pastoral. We find that these estimated effects are small and statistically insignificant. Thus, while we estimate sizable adverse spillover effects when there is less rainfall in a neighboring transhumant pastoral ethnic group, we find no clear evidence that less rainfall in a given cell or in the cell's own ethnic group affects conflict in that cell.

Our estimates are consistent with the hypothesis that low rainfall induces transhumant pastoralists to migrate early—that is, before the end of the growing season—to agricultural farmlands, resulting in damaged crops, competition for resources, and conflict. This interpretation has a number of falsifiable predictions that we can take to the data. First, we check that the estimated effects are due to nearest neighbors being transhumant pastoral; namely, the combination of being both mobile and pastoral. We show that there are no significant effects arising from nearest neighbors who are either mobile but not pastoral or pastoral but not mobile. Second, we check that the conflicts that arise due to adverse rainfall in transhumant pastoral ethnic territories are concentrated in agricultural land rather than non-agricultural land. Third, we obtain very similar estimates when we examine the spillover effects of phytomass growth rather than rainfall. This indicates that adverse rainfall induces conflict because it reduces the availability of plant matter for animal grazing.[1] Fourth, we check that there is no spillover effect when we substitute precipitation with temperature. This is informative, since in the tropical and subtropical climates of the African continent, rainfall is more important for plant growth than temperature. This finding is additionally reassuring since many studies have shown that temperature is linked to conflict through a variety of mechanisms that are unrelated to our hypothesis. Fifth, we examine the timing of the spillover effects within the year. We find that the estimated effects of rainfall on conflict are concentrated during the growing season, when crops are being cultivated, but not during the dry season, when the land is left fallow. This is consistent with our hypothesis that conflict occurs when there is competition for resources. Last, we simultaneously confirm the predictions for phytomass, the timing of conflicts during the wet season, and the location of conflicts on agricultural land.

We then turn to additional questions of interest, starting with whether our findings are able to explain part of the recent rise in religious conflict involving jihadist groups in Africa since 2000. Since transhumant pastoral groups are more likely to be Muslim and sedentary agricultural groups are more likely to be Christian, conflicts between the two groups may be viewed as—or evolve into—religious violence. To investigate this, we separate conflict events into ones that involve jihadist actors and ones that do not. We find that our mechanism affects the incidence of both jihadist and non-jihadist conflict similarly. However, since jihadist conflicts were very rare prior to 2000, these similar marginal effects imply a much larger rate of growth for jihadist conflicts in the past two decades. Importantly, we control for the religious composition of the nearest neighbor in this exercise, finding that transhumant pastoralism in the nearest neighboring group is considerably more important than religion in predicting the incidence of jihadist conflicts due to adverse rainfall.

We next consider the important question of what can be done to mitigate the effects that we find. We first examine the role of international aid projects, focusing specifically on projects aimed at curbing the effects of environmental degradation, such as irrigation, forestry, conservation, land improvement, and other agricultural projects. To test for the effects of such aid projects, we allow our main estimated effect to vary by the cumulative presence of foreign aid projects in a country and year starting in 1947. We find suggestive evidence that our documented effects are independent of these aid projects.

We also consider the effects of state-protected conservation areas, which aim to prevent

[1] We use rainfall for the main analysis because the phytomass series begins in 1999, which is ten years later than the start of our conflict data series. Rainfall data are available for the full period.

environmental degradation and promote decarbonization. While these conservation projects may attenuate the effects of climate change, some have argued that they can exacerbate transhumant pastoral conflict by limiting the movements of herds and contributing to the scarcity of grazing pastures. To test this, we allow our main estimated effect to vary by the share of land in a country that is designated as conservation land at each point in time. We find that our estimated effects are greater in magnitude when countries have more land that has protected conservation status. This result suggests that conservation areas, while potentially beneficial in other ways, may exacerbate conflict stemming from adverse rainfall shocks in transhumant pastoral territories.

The last factor we consider is political power. In the absence of political power-sharing, minority groups may have strong incentives to fight (Mueller and Rohner, 2018). Greater representation of pastoral groups in national government may therefore mitigate conflict arising from low rainfall in pastoral territories. We test this using the Ethnic Power Relations dataset. We calculate, for each year and country, the power held by transhumant pastoral groups in national politics, and we allow our estimated effects to vary depending on this measure. We find that the estimated effects approach zero as transhumant pastoral groups gain a higher share of national power. This suggests that when both sides have fair representation in government, a peaceful resolution between pastoral groups and farmers is more likely.

Our analysis uncovers how relations between transhumant pastoral and sedentary agricultural groups are undermined by episodes of low rainfall, which are becoming more frequent in Africa due to climate change. The mechanisms that underlie the analysis are informed by the rich ethnographic literature on the nature of transhumance and its implications for seasonal interactions between sedentary farmers and herders in Africa (Lewis, 1961, Jacobs, 1965, Konczacki, 1978, Dyson-Hudson and Dyson-Hudson, 1980). Our findings add to this descriptive literature and to more recent studies that document how adverse climate shocks have affected African pastoral groups (Little, Smith, Cellarius, Coppock and Barrett, 2001, McPeak and Barrett, 2001, Maystadt and Ecker, 2004, Bollig, 2006) and in particular how they affect relations between pastoral and agricultural groups (Benjaminsen, Alinon, Buhaug and Buseth, 2012).

Our focus on transhumant pastoralism is complementary to studies that focus on either one of the two dimensions of this practice—seasonal migration or pastoralism—and their connection to conflict and economic development. Various studies have shown the importance of seasonal migration for helping to alleviate poverty (Bryan and Mobarak, 2014, Morten, 2019). Others have examined the long-term consequences of animal husbandry on cultural traits associated with gender (Becker, 2019) and the importance placed on maintaining one's honor (Grosjean, 2014, Cao, Enke, Falk, Giuliano and Nunn, 2021). A number of studies have examined the long-term consequences that a noteworthy nomadic pastoral group, the Mongols, had on state development in China due to the threat of invasion, which was, in part, due to climate shocks (Bai and Kung, 2011, Ko, Koyama and Sng, 2018).

Our findings also shed light on the salience of cross-ethnicity divisions, contributing to a line of inquiry that tries to understand how certain events can heighten or alleviate intergroup hostilities (Hjort, 2014, Yanagizawa-Drott, 2014, Depetris-Chauvin, Durante and Campante, 2020, Lowe, 2021). Our analysis also provides insight into the recent finding in Depetris-Chauvin and Özak (2020) that conflict tends to occur near ethnic boundaries. Our findings suggest that one important mechanism underlying the relationship could be the disruption of the traditional symbiotic relationship between pastoralists and sedentary farmers. Eberle, Rohner and Thoenig (2020) also show that conflict at the boundaries between nomadic and non-nomadic groups is greater when temperatures are higher, consistent with existing studies showing that heat can increase violence through a variety of mechanisms, including psychological channels (Hsiang, Burke and Miguel, 2013, Hsiang and Burke, 2014, Baysan, Burke, González, Hsiang and Miguel, 2019). Our analysis indicates that the direct 'heat and hate' thermal stress effect on conflict documented in Eberle et al. (2020) is distinct from the inter-ethnic spillover effect of rainfall and phytomass documented here, which is due to the disrupted seasonal migration of transhumant groups.

We contribute directly to the literature on climate and conflict by providing new evidence that documents a precise mechanism through which climate change affects inter-group violence (see Miguel, Satyanath and Sergenti, 2004, Solow, 2013, Hsiang and Burke, 2014, Burke, Hsiang and Miguel, 2015). We also contribute to the wider literature on the determinants of conflict within Africa, including studies that explore the importance of historical factors (e.g., Besley and Reynal-Querol, 2014, Depetris-Chauvin, 2015, Michalopoulos and Papaioannou, 2016, Moscona, Nunn and Robinson, 2020); ethnic or social factors (Montalvo and Reynal-Querol, 2005, Esteban, Mayoral and Ray, 2012, Rohner, Thoenig and Zilibotti, 2013, Arbatli, Ashraf, Galor and Klemp, 2020); and economic factors, especially shocks to the opportunity cost of conflict, which can be challenging to distinguish empirically from shocks that affect other drivers of conflict (Dube and Vargas, 2013, McGuirk and Burke, 2020).

One important aspect of our study is the spillover nature of the effect we identify—rainfall in one location (transhumant pastoral territories) affects conflict in another (sedentary agricultural territories). Our approach can be interpreted as recovering the exact structure of one mechanism behind the spatial spillovers observed in the existing climate-conflict literature (e.g., Guariso and Rogall, 2017, Harari and La Ferrara, 2018). While prior studies take a more empirical approach towards characterizing the nature of spillovers, our analysis starts with a specific mechanism that is motivated by the ethnographic literature. We then build our estimator to capture this mechanism while accounting for other, more general forms of spillover. In this way, our strategy is similar to other studies that also specify a particular spillover mechanism ex-ante that is then brought to the data (e.g. König, Rohner, Thoenig and Zilibotti, 2017).

Lastly, our findings emphasize the important role of migration in understanding the broader relationship between climate change and conflict (Black, Bennett, Thomas and Beddington, 2011, Bosetti, Cattaneo and Peri, 2021). While the literature has tended to focus on climate change and permanent migration (e.g., Barrios, Bartinelli and Strobl, 2006, Marchiori, Maystadt and Schumacher, 2012, Cattaneo and Peri, 2016), our findings highlight the role of seasonal migration in mediating the relationship between climate change and conflict.

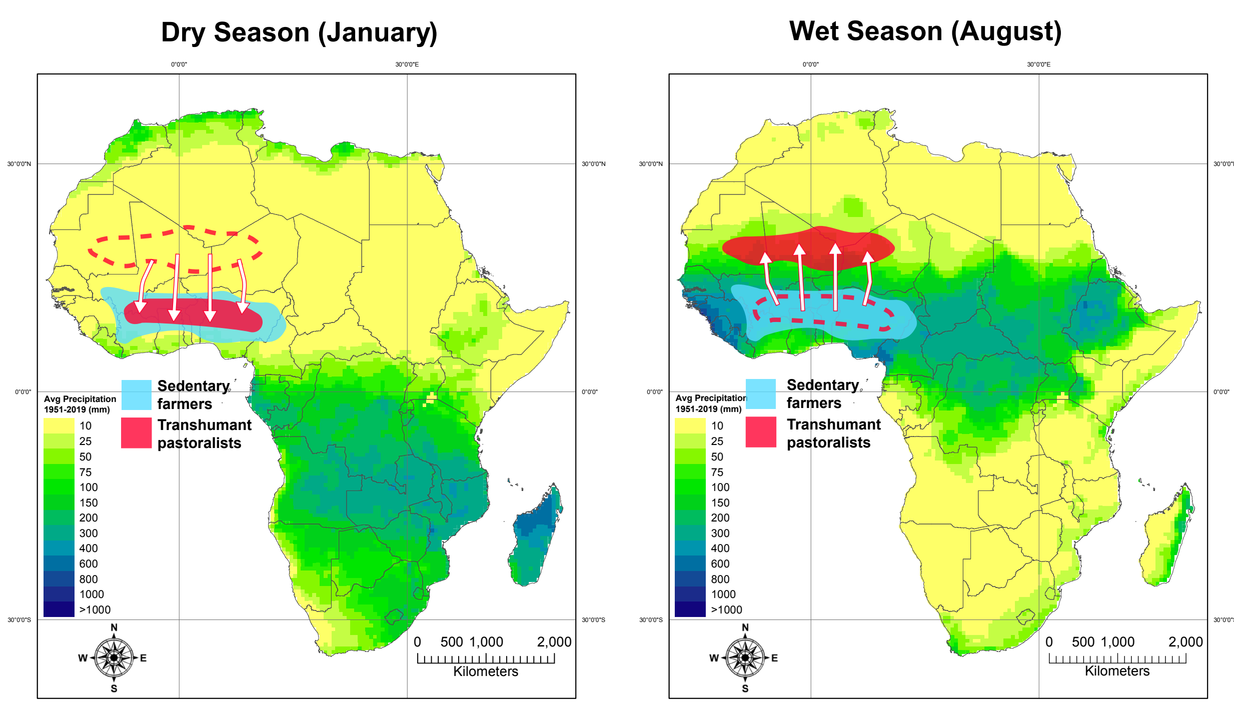
The paper is organized as follows. In Section 2, we provide a description of the traditional symbiotic relationship between transhumant pastoralists and sedentary farmers in Africa. We also discuss recent changes in climate on the continent and how this has affected the nature of the herder-farmer relationship. In Section 3, we describe the data used in the main analysis. In Section 4, we examine the cross-sectional relationship between transhumant pastoralism and conflict in neighboring areas. In Section 5, we estimate the effect of lower rainfall in transhumant pastoral territory on conflict in neighboring locations. In Section 6, we present a series of auxiliary tests of causal mechanisms. In Section 7, we turn to the implications of our findings, including an examination of extremist-religious conflict and factors that may mitigate the effects that we estimate. Section 8 concludes.

2. Background and Context

A. Transhumant Pastoralism

A defining feature of transhumant pastoralism is that it results in regular seasonal interactions with sedentary agricultural groups. Neighboring herders and farmers develop a symbiotic relationship that allows both groups to share resources in an efficient and mutually beneficial manner.

In most of Africa, seasons are determined primarily by precipitation rather than temperature, a fact highlighted by the typical description of the seasons as either the wet (i.e., growing) or dry (i.e., fallow) season. The time of year when seasons occur depends on where one is on the continent, particularly whether one is north or south of the equator. The seasonal variation



(a) Rainfall and migration during the dry season.

(b) Rainfall and migration during the wet season.

Figure 1: Rainfall and seasonal migration in Africa.

is shown in Figure 1, which reports rainfall across the continent in two months, January and August. January, shown in Figure 1b, is a dry season month for most of the continent that lies north of the equator. For the continent south of the equator, the month is part of the wet season. By contrast, in August, which is shown in Figure 1b, the north experiences a wet season and the south a dry season.

The figure also provides a stylized illustration of transhumant migrations that occur in West Africa. Hypothetical sedentary agricultural groups are shown in blue and transhumant pastoral groups in red. During the wet season, when crops are cultivated, pastoralists keep their livestock on marginal grazing land that is not suitable for agriculture but supports the growth of wild grasses that provide sustenance to animals. During the dry season, this growth no longer occurs. As a result, herds are moved to the more fertile farmlands that are used for agriculture during the wet season but are left fallow during the dry season. This movement is shown by the arrows in Figure 1a. Animal herds are allowed to graze on the farmland during this period. This arrangement benefits both the pastoralists, who enjoy the dry-season production of animal feed, and the farmers, whose land is improved by the animals' manure, a form of nitrogen-rich organic fertilizer. At the end of the dry season, herds are moved from the agricultural lands and return to the more marginal grazing lands. This is shown by the arrows in Figure 1b.

Thus, due to the seasonal movements of herds, both sedentary farmers and transhumant pastoralists are able to exploit the land efficiently and cooperatively. Stenning (1959, p. 6), in his study of the pastoral Fulani, describes the symbiotic relationship between them and their agricultural neighbors, the Uda'en: "Pastoral life is pursued not in isolation, but in some degree of symbiosis with sedentary agricultural communities... there have existed, possibly for many centuries, arrangements for pasturing cattle on land returning to fallow, and for guaranteeing cattle tracks and the use of water supplies. Pastoral Fulani did not, and do not, merely graze at will, but obtained rights to the facilities they required from the acknowledged owners of the land."

As a consequence of these traditional relationships, extensive transhumance is common in the parts of Africa with ecological zones that have these features, the largest region being the Sahel. The general patterns of the routes are shown on the map in Figure 2, which is simply an illustrative schematic developed by the FAO and does not show actual routes. Except in a few cases, with very small samples, information about the exact routes remain undocumented. From these studies, which are summarized in Appendix Table A1, one can see many aspects that are relevant for our analysis. The distance between the origin and destination varies considerably, ranging from tens of kilometers to hundreds of kilometers. When tracked, the distances travelled along the routes are found to be much longer, since they follow a meandering path.[2] Although the routes are meandering, there tends to be a general orientation toward north-south. Some routes follow an east-west orientation, especially near the west-facing coastal areas. Routes commonly cross ethnic boundaries and sometimes national boundaries.

[2]One study from eastern Senegal found that the total distance traveled was between 827 and 1,762 kilometers, depending on the corridor. Another from central Cameroon documented distances of between 633 and 763 kilometers.

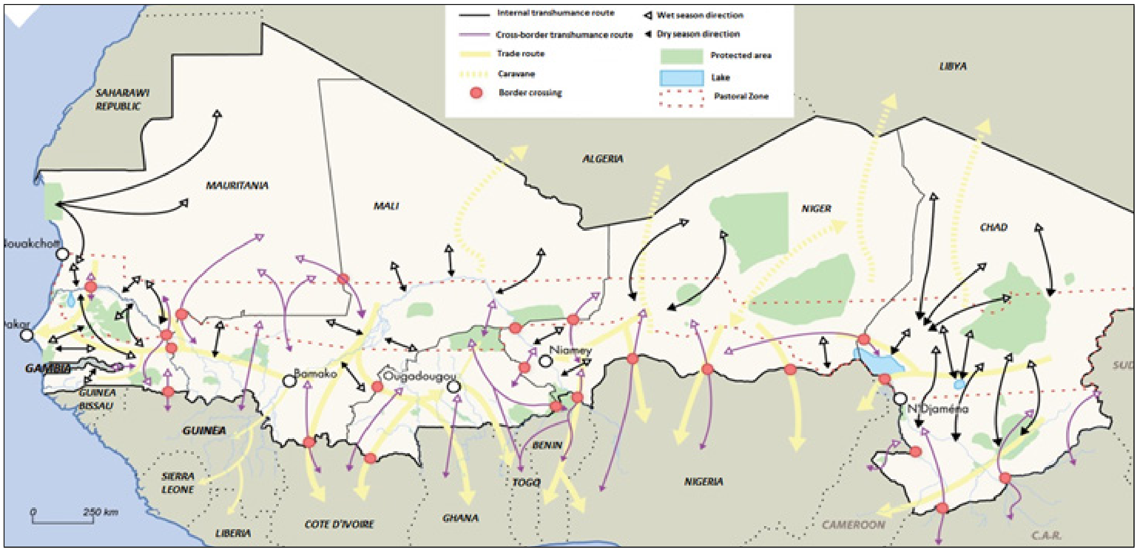


Figure 2: Seasonal transhumance routes of nomadic pastoralists in West Africa. *Source*: Diop et al. (2012).

B. Effects of Climate Change

For much of the African continent, particularly the Sahel region, the most salient consequence of climate change has been rainfall that is persistently below the long-run average. Increasing temperatures, particularly outside of Africa, tend to reduce precipitation on the continent. For example, increased Atlantic sea-surface warming causes lower rainfall and more droughts in the Western part of the continent (Shanahan, Overpeck, Anchukaitis, Beck, Cole, Dettman, Peck, Scholz and King, 2009), while warming in the Middle East, South Asia, and particularly the Indian Ocean affects precipitation in Eastern Africa (Cook and Vizy, 2013).

The recent effects of global warming on precipitation within the continent can be seen in Figure 3, which shows annual wet-season rainfall from 1901–2017 for the Sahel, a region that is particularly relevant for our analysis. It is clear that since the late 1960s, there has been a reduction in annual precipitation (Nicholson, Fink and Funk, 2018). Between 1970 and 2017, annual average rainfall was below the long-run (1900–2017) mean in 36 of the 47 years (Rustemeier, Becker, Finger, Schneider and Ziese, 2020). Although, there is some slight attenuation in recent years, it is clear that global warming is associated with reduced rainfall (Biasutti, 2018, Herrmann and Mohr, 2012).

During this same time, the region has seen an increase in the frequency and severity of conflicts between sedentary agriculturalists and transhumant pastoralists. According to numerous accounts, the new climate regime has led to more variation in the timing and location of transhumance movements, causing migrations that are earlier in the season and deeper into agricultural lands (Ayantunde, Asse, Said and Fall, 2014). A plausible explanation for the concurrent trends is the reduction in living organic plant matter, known as *phytomass*, which provides sustenance for grazing herds. Rainfall has been shown to be the primary determinant of living organic plant matter on the continent (Hein, 2006). While temperature is also a factor, its importance for plant growth is primarily due to its indirect effect on rainfall (Biasutti, 2018).

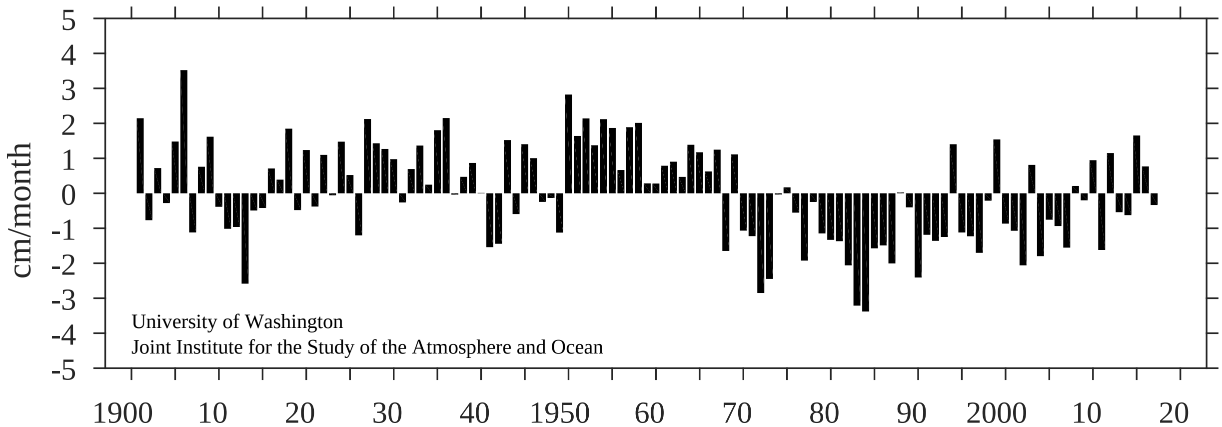


Figure 3: Climate change and historical precipitation in the Sahel. *Source*: Sahel Precipitation Index. University of Washington. June through October averages over 20-10^{o}N, 20^{o}W-10^{o}E. 1900–2017. `http://research.jisao.washington.edu/data/sahel/`

Our own calculations are consistent with this prevailing evidence. While temperature changes are important at a macro-level due to their effect on spatial and temporal rainfall patterns, at a local level within Africa, temperature is not the primary determinant of phytomass growth. As we explain below, we find that the share of annual variation in phytomass explained by rainfall is around six times higher than the share explained by temperature. By contrast, in more temperate regions outside of Africa, such as North America or Europe, temperature is positively associated with plant growth and it explains a higher share of variation in plant growth than does precipitation (Moles et al., 2014). Thus, while temperature is the primary constraint for plant growth in temperate climates, rainfall is the primary constraint in tropical climates.

Given the importance of rainfall for phytomass growth on the African continent, our analysis focuses on this particular climate variable. Specifically, our interest is in identifying one important consequence of rainfall scarcity, a salient feature of climate change in many parts of Africa.

3. Data

A. Description, Sources, and Validation

Our analysis examines the relationship between conflict, rainfall (or phytomass), and transhumant pastoralism. Below, we describe the data and the measurement of each variable.

Conflict Our baseline set of conflict variables are from two sources of geocoded data: the Uppsala Conflict Data Program (UCDP), which covers 1989–2018, and the Armed Conflict Location & Event Data project (ACLED), which covers 1997–2019.[3] We use both sources throughout our analysis since they each have strengths and weaknesses. While the UCDP data has longer temporal coverage, the ACLED data has more comprehensive coverage of smaller-scale conflicts.

[3]For further details about the UCDP conflict data see Sundberg and Melander (2013) and for ACLED see Raleigh, Linke, Hegre and Karlsen (2010).

In the UCDP data, conflict events are two-sided battles or one-sided attacks that satisfy certain criteria. To be included, a conflict event must have at least one fatality and the pair of actors involved in the event (i.e., the conflict dyad) must have produced at least 25 fatalities in at least one calendar year throughout the series. Finally, at least one of the actors involved in the event must be an "organized actor," such as the state or a politically organized rebel group or militia.

The ACLED data has weaker criteria for inclusion. There is no requirement for a certain number of fatalities in a calendar year or a conflict event. The ACLED data is thus better equipped to capture more small-scale, localized conflict events.

Using the reported locations of conflict events, we create measures of the presence of conflict in 0.5-degree grid cells during a calendar year. Our primary measures are indicator variables that equal one if each of the following types of conflict occurs: *All* conflicts; *State* conflicts, where the state is involved as a participant in the event; and *Non-State* conflicts, where only non-state actors are involved.[4]

Summary statistics for the conflict measures are reported in Appendix Table A2. The unconditional probability of ACLED conflict incidence is much higher than that of UCDP incidence. As expected, the difference is largest for non-state conflicts: 8% for ACLED versus 2% for UCDP. Thus, we place particular importance on the ACLED data in our analysis of non-state conflicts.

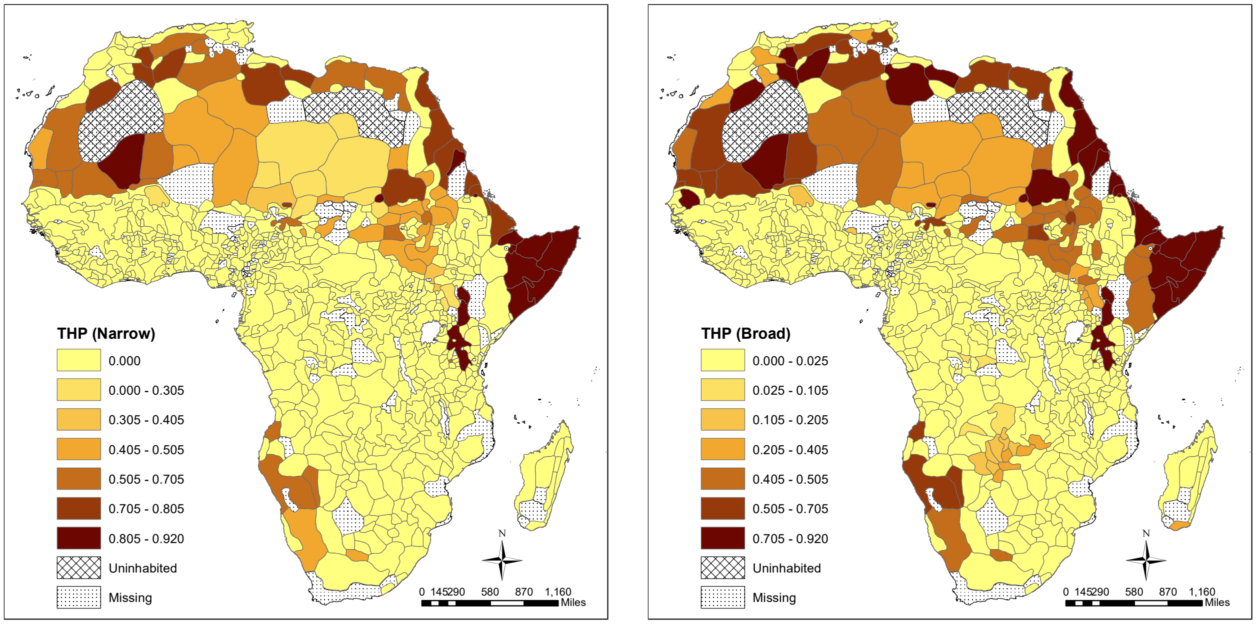
Transhumant Pastoralism To identify transhumant pastoral societies, we use information from the *Ethnographic Atlas*, a database of 1,265 ethnic groups assembled by George Peter Murdock. We construct a composite index that captures the two key aspects of transhumant pastoralism.

The first key aspect is that the group moves seasonally; namely, that they are mobile. There is extensive information in the *Ethnographic Atlas* on the mobility of ethnic groups traditionally. Variable v30 of the database codes groups as falling within one of the following categories that describe the nature of settlement: (1) Nomadic or fully migratory; (2) Seminomadic; (3) Semisedentary; (4) Compact but impermanent settlements; (5) Neighborhoods of dispersed family homes; (6) Separated hamlets; (7) Compact and relatively permanent; and (8) Complex settlements.

Although transhumance is not measured explicitly, nearly all forms of movement today are seasonal. Nomadic activity that is not seasonal is now rare. Thus, we take being traditionally nomadic as a proxy for being seasonally mobile. We create two indicator variables that allow for two definitions: our 'narrow' definition of transhumance includes only groups that are 'nomadic or fully migratory' or 'seminomadic'; while our 'broad' definition of transhumance additionally includes groups that are 'semisedentary' or that have 'compact but impermanent settlements.' The variants differ in whether groups that are semi-mobile are coded as being transhumant (broad measure) or not (narrow measure). We denote this variable $Transhumant_e$, where e indexes ethnic groups in our sample.

The second key aspect of transhumant pastoralism is the herding of animals. To capture this dimension, we build on a measure developed in Becker (2019), which combines information on

[4]When constructing the ACLED measures, we focus on "battles" and "violence against civilians," which are analogous to the two- and one-sided events in the UCDP data (conditional on the exclusion threshold). We omit non-violent events such as protests and strategic developments.



(a) Narrow definition

(b) Broad definition

Figure 4: Cross-ethnicity spatial variation in transhumant pastoralism.

the fraction of subsistence that is from animal husbandry (measured on a 0-1 scale, from variable v4 in the *Ethnographic Atlas*) with an indicator variable that equals one if the primary large animal is suitable for herding (from variable v40). Animals that require herding include sheep, goats, equine animals, camels, and bovine animals, but not pigs, for example. Becker's measure is constructed as the interaction between these two measures. It ranges from 0 to 1 and it proxies for the fraction of an ethnic group's subsistence that is from herded animals. We denote this variable $Pastoral_e$.

We construct a measure of 'transhumant pastoralism' by interacting the two components: $Transhumant_e \times Pastoral_e$. The resulting variable, which we denote $TranshumantPastoral_e$, measures the fraction of a transhumant group's subsistence that is from pastoralism.

Since our measure is based on traditional practices from ethnographic sources rather than current practices from contemporary surveys, it is predetermined and therefore unaffected by the episodes of conflict that we explain empirically. Reassuringly, the measure is still predictive of contemporary pastoralism. This can be seen in Appendix Figure A1, which shows the positive relationship between the contemporary ownership of animals, measured in DHS surveys, and the traditional transhumant pastoralism of the ethnic group of the respondent.

To assign this variable to spatial units, we match each society from the *Ethnographic Atlas* to the ethnic territories mapped by Murdock (1959). Using a variety of sources, documented in Kincaide, McGuirk and Nunn (2020), we match around 96% of the ethnic territories on the map to an ethnic group in the *Ethnographic Atlas*.

Figure 4 shows the spatial distribution of the transhumant pastoralism measure. The intensity of transhumant pastoralism is consistent with expectations based on the location of land most suitable for animal grazing rather than agriculture. This can be seen in Appendix Figure A2, which shows the spatial distribution of land suitable for transhumant pastoralism and sedentary agriculture, taken from Beck and Sieber (2010), and the boundaries of ethnic groups with some form of traditional mobility. It is clear that the ecological environment is an important determinant of this characteristic.

Rainfall and Phytomass Pastoral groups rely on rain to produce the phytomass needed to sustain their livestock. Our rainfall variable measures average monthly precipitation during a calendar year in a 0.5 degree cell. The data is from the Global Precipitation Climatology Centre and is based on interpolated land-surface precipitation data from approximately 85,000 rain gauges across the globe (Rustemeier et al., 2020). The variable, which covers the full duration of our conflict series (1989–2019), is measured in centimeters per month.

We verify the importance of rainfall for plant growth using satellite data on dry matter vegetation (i.e., phytomass). The phytomass data is derived from satellite images provided by the Copernicus Global Land Service and is available at the 1km pixel level weekly from 1999-2019. We aggregate the data to the 0.5 degree cell-year level and measure the final variable in average kilograms of plant growth per hectare per day.

We estimate the determinants of phytomass growth at the cell-year level. We model phytomass as a function of average annual precipitation and temperature, while conditioning on cell fixed effects and country-by-year fixed effects. The estimates reported in Appendix Table A5 confirm the importance of precipitation for vegetation growth. Consistent with the environmental science literature (e.g., Waha, Müller and Rolinski, 2013, D'Onofrio, Sweeney, von Hardenberg and Baudena, 2019), we find that rainfall is a significant determinant of phytomass growth and is a more important factor than temperature. After accounting for the fixed effects, rainfall explains 3.6% of the residual variation while temperature explains 0.6%; the F-statistic for rainfall is 136, while for temperature, it is 31; and we estimate that a within-cell standard deviation rise in rainfall increases phytomass growth by 1.61% of the mean, while the equivalent rise in temperature decreases phytomass by 0.53%.

Since it is the main driver of phytomass growth on the African continent, we proceed using rainfall as our primary climate variable. We use rainfall rather than phytomass as our baseline measure since it is available for a much longer time series. In sensitivity checks, we show that the estimates are nearly identical when we use either phytomass or phytomass predicted by rainfall.

B. Summary of the Data

The descriptive statistics for our main variables (conflict, transhumant pastoralism, and rainfall) and all other covariates used in the analysis are reported in Appendix Table A2. We present in separate panels variables that vary at the cell-year, cell, ethnic-group-year, and ethnic group levels. At the cell-year level, the incidence of any conflict is 3% when using the UCDP data and 8% when using the ACLED data. The average precipitation is 5.65 centimeters per month and the average temperature is 24.5 degrees Celsius. Looking at ethnicity characteristics, one can see that the average measure of transhumant pastoralism is 0.08 when the narrow measure is used and 0.09 when the broad measure is used.

In Appendix Table A3, we report summary statistics separately for groups that are transhumant pastoral and groups that are not. In column 1, we report averages for groups with a measure of transhumant pastoralism greater than zero; in column 2, we report averages for groups with a measure of transhumant pastoralism equal to zero; and in column 3, we estimate the difference in means. We find that transhumant pastoralism is associated with less conflict (for both UCDP and ACLED), less precipitation, less phytomass, higher temperatures, less land suitable for agriculture, and more land suitable for transhumant pastoralism. It is also associated with lower population, fewer nighttime lights, less national political power, a higher share of Muslim people, and a lower share of Christian people today. Looking at historical ethnographic traits, we see that transhumant pastoral groups, not surprisingly, practiced less agriculture and were more developed politically (as measured by levels of political authority beyond the local community).

These comparisons make clear that transhumant pastoralism is not randomly allocated across the continent. The practice is determined in part by ecological conditions. In addition, transhumant pastoralism is associated with other factors, namely historical jurisdictional hierarchy and political power today. These facts highlight the importance of our auxiliary analyses which look for evidence of our specific mechanism of interest, test for the importance of other ethnicity-level traits, and examine the importance of contemporary political power.

4. Cross-Sectional Patterns

We begin our analysis by presenting cross-sectional evidence on the relationship between being near transhumant pastoral groups and conflict. We examine variation at the level of a 0.5 degree grid cell (approx. 55km $\times$ 55km at the equator). The full sample comprises 9,691 cells nested in 780 ethnic territories across the African continent. These are shown for a region in Mali in Figure 5 that is traditionally inhabited by the Masina, Dogon, Zenega, Songhai, and others. The map also shows the location of UCDP conflicts from 1989–2018.

For each cell, we identify the neighboring ethnic group that is most relevant for that cell. As illustrated by Figure 5, cells within an ethnic territory can have different neighbors that are relevant. For example, consider cells located within the Masina ethnic territory. The relevant neighboring ethnic group varies depending on where a given cell is located in the territory. For the cells in the northwestern portion of the Masina territory, the relevant neighbor is the Zenega; for those in the eastern portion, the relevant neighbor is Udalan; and for cells in the southeastern portion, the relevant neighbor is the Dogon, Mossi, or Deforo. This generates rich variation in nearest neighbor characteristics even when holding constant the characteristics of one's own ethnic group. We identify each cell's 'nearest neighbor' (or 'neighbor' for short) as the ethnic group that is geographically closest to a cell's centroid among all ethnic groups that are contiguous to the ethnic group in which the cell is located.[5]

[5]For cells that lie within multiple ethnic territories, we determine the ethnic group of a cell by the location of its centroid.

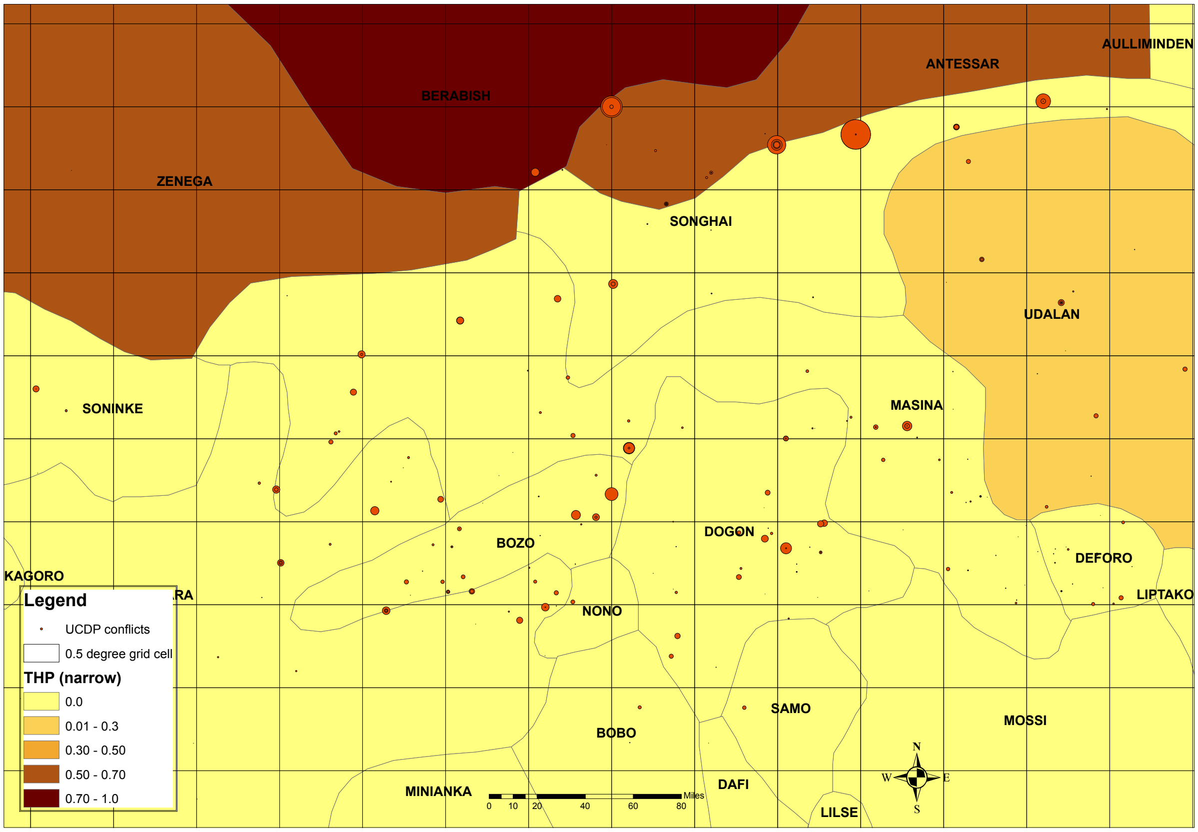


Figure 5: Structure of Data and Analysis. The figures shows 0.5-degree cells, along with the boundaries of the ethnic groups, their names, and their measure of transhumant pastoralism (THP) using the narrow definition of transhumant.

With this data structure, we then estimate the following equation:

$$y_{iet} = \gamma_1\, \mathit{TranshumantPastoral}_i^{\mathit{Neighbor}} + \gamma_2\, \mathit{TranshumantPastoral}_e^{\mathit{OwnGroup}} + \gamma_3 \ln(pop_i) + \alpha_t + \eta_{iet}, \quad (1)$$

where i indexes 0.5-degree grid cells, e ethnic groups, and t years (1989–2018 or 1997–2019). The dependent variable, y_{iet}, is conflict incidence in cell i, which lies within the traditional territory of ethnicity e, and in year t. The variable $\mathit{TranshumantPastoral}_i^{\mathit{Neighbor}}$ is the measure of transhumant pastoralism for the nearest neighboring ethnic group to cell i. The variable $\mathit{TranshumantPastoral}_e^{\mathit{OwnGroup}}$ is the same measure of transhumant pastoralism, but for the ethnicity in which the cell is located. Lastly, $\ln(pop_i)$ is the natural log of the population of cell i, measured in 1990. The parameter of interest is γ_1, which represents the (associational) effect of the nearest neighboring ethnic group's transhumant pastoralism on conflict in a cell. Standard errors are adjusted for two-way clustering at the level of a cell and a climate zone-year.

Estimates of equation (1) are reported in Table 1. Panel A reports estimates using the narrow definition of transhumance, while panel B reports estimates using the broad measure. Each column reports estimates using a different measure of conflict as the dependent variable: total conflicts, state-involved conflicts, and non-state conflicts, each measured using either the UCDP (columns 1–3) or ACLED (columns 4–6) data.

Table 1: Cross-Sectional Evidence of Conflict Spillover from Nearest Neighboring THP Territory: Cell Level

	Indicator for the presence of conflict					
	UCDP			ACLED		
	(1) I(Any)	(2) I(State)	(3) I(Nonstate)	(4) I(Any)	(5) I(State)	(6) I(Nonstate)
Panel A: Transhumant definition includes only groups that are migratory or nomadic (narrow definition)						
Neighbor Transhumant Pastoral [γ_1]	0.0273***	0.0253***	0.0057**	0.0702***	0.0534***	0.0698***
	(0.0054)	(0.0049)	(0.0025)	(0.0095)	(0.0077)	(0.0095)
Transhumant Pastoral [γ_2]	0.0081	0.0063	0.0017	0.0208**	0.0134*	0.0200**
	(0.0057)	(0.0046)	(0.0028)	(0.0097)	(0.0077)	(0.0097)
Panel B: Transhumant definition includes all groups without fully permanent settlements (broad definition)						
Neighbor Transhumant Pastoral [γ_1]	0.0301***	0.0288***	0.0050**	0.0671***	0.0534***	0.0667***
	(0.0053)	(0.0049)	(0.0023)	(0.0089)	(0.0074)	(0.0089)
Transhumant Pastoral [γ_2]	0.0076	0.0058	0.0012	0.0188**	0.0126*	0.0181*
	(0.0054)	(0.0044)	(0.0026)	(0.0093)	(0.0074)	(0.0093)
Dep. Var. Mean	0.035	0.025	0.016	0.085	0.055	0.085
Year FE & ln Population	Yes	Yes	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	420	336	336	336
Cell Clusters	7,690	7,690	7,690	7,690	7,690	7,690
Observations	230,700	230,700	230,700	184,560	184,560	184,560

Note: All outcome variables measure conflict incidence at the level of a cell-year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. The variable ln population is the natural log of the population of a grid-cell in 1990. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

In all specifications, we find that having a nearest neighbor that is transhumant pastoral is associated with significantly more conflict. While this relationship is present for all conflict measures, it is much smaller for non-state conflicts measured using the UCDP data. As discussed, this is not surprising given that the UCDP data has more restrictive inclusion criteria that lower its coverage of smaller-scale conflicts not involving the state.

5. Rainfall Scarcity and Agro-Pastoral Conflict

We now turn to our baseline equation which estimates whether adverse rainfall in transhumant pastoral territories results in conflict in neighboring lands.

Estimating Equation We estimate a variant of equation (1) that traces the effect of rainfall in a neighboring transhumant pastoral territory on conflict in a cell. The equation is given by:

$$\begin{aligned} y_{iet} = \; & \gamma_0^s\, Rain_{it}^{Neighbor} + \gamma_1^s\, Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \\ & + \gamma_2^s\, Rain_{et}^{OwnGroup} + \gamma_3^s\, Rain_{et}^{OwnGroup} \times TranshumantPastoral_e^{OwnGroup} \\ & + \gamma_4^s\, Rain_{it}^{OwnCell} + \gamma_5^s\, Rain_{it}^{OwnCell} \times TranshumantPastoral_e^{OwnGroup} \\ & + X_{iet}'\Gamma + \alpha_i^s + \alpha_{c(i)t}^s + \eta_{iet}^s, \end{aligned} \tag{2}$$

where y_{iet} is an indicator for the incidence of conflict in cell i in ethnic group e and year t; $Rain_{it}^{Neighbor}$ measures average precipitation in the nearest neighboring ethnic group to cell i in year t;[6] $TranshumantPastoral_{i}^{Neighbor}$ is the transhumant pastoral index measure for that neighboring ethnic group; $Rain_{et}^{OwnGroup}$ measures precipitation in group e in year t; $TranshumantPastoral_{e}^{OwnGroup}$ is the transhumant pastoralism index for ethnicity e; and $Rain_{it}^{OwnCell}$ measures precipitation in cell i in year t. The vector X'_{iet} includes additional covariates that we include in auxiliary robustness and sensitivity checks; α_i denotes cell fixed effects, which capture time-invariant differences across grid cells; and $\alpha_{c(i)t}$ denotes country-year fixed effects, which capture any variation across time that is common to all grid cells in a country. To account for serial and spatial dependence, our standard errors are two-way clustered at both the cell and climate zone-year levels.

The parameter γ_1^s represents the differential effect of rainfall in a neighboring ethnic territory on conflict in cell i when the neighboring ethnicity is transhumant pastoral relative to when it is not transhumant pastoral. A negative estimate of γ_1^s indicates that, consistent with our hypothesis, dry weather in pastoral territories causes additional conflict in neighboring cells.

It is important to note that this specification accounts flexibly for many factors that have been previously studied in the conflict literature. The cell fixed effects α_i^s capture all time-invariant determinants of conflict, such as geography, national boundaries, historical factors, and ethnic traits (e.g., Besley and Reynal-Querol, 2014, Michalopoulos and Papaioannou, 2016, Moscona et al., 2020). The country-year fixed effects $\alpha_{c(i)t}^s$ capture time-varying national-level factors such as changes in country GDP, national political or legal institutions, country-level ethnic fractionalization and polarization, resource endowments, and international geo-political characteristics, all of which have been prominent in the cross-country literature on conflict (e.g., Collier and Hoeffler, 1998, 2004, Fearon and Laitin, 2003, Ross, 2004, Esteban et al., 2012). The control for rainfall in a cell, $\gamma_4^s Rain_{it}^{OwnCell}$, captures the direct effects of rainfall on the opportunity costs or logistics of fighting (e.g., Miguel et al., 2004, Jia, 2014, Burke et al., 2015, Harari and La Ferrara, 2018). The control for rainfall in the territory of a cell's ethnic group, $\gamma_2^s Rain_{et}^{OwnGroup}$, captures intra-ethnic spatial spillover effects, which are also potentially important determinants of conflict in a location (Harari and La Ferrara, 2018). We allow these measures to vary by the index for transhumant pastoralism in a cell's ethnic group.

Results Estimates of the parameters in equation (2) are reported in Table 2 for the narrow definition of transhumant pastoralism and in Appendix Table A4 for the broad definition. Each column reports estimates for one of our six conflict measures. The first set of coefficients, reported under the heading 'Nearest Neighboring Ethnic Group,' are for the effect of variables that measure rainfall experienced by the nearest neighboring ethnic group, γ_0^s, and its interaction with the neighbor's transhumant pastoralism index measure, γ_1^s.

We find that less rainfall in a cell's nearest neighboring ethnic group leads to more conflict in the cell, but only if the neighbor is transhumant pastoral. While the estimated effects for non-transhumant pastoral groups are never statistically different from zero, the differential effects for

[6] An alternative strategy is to create an indicator for adverse rainfall events (i.e., shocks). We prefer our continuous measure of rainfall, which allows rainfall scarcity to have effects that are proportional to the reduction in rainfall.

Table 2: Effect of Rain Shock in Nearest Neighboring THP Territory on Conflict in a Cell: Narrow Definition of Transhumance

	Indicator for the presence of conflict					
	UCDP			ACLED		
	(1) I(Any)	(2) I(State)	(3) I(Nonstate)	(4) I(Any)	(5) I(State)	(6) I(Nonstate)
Nearest Neighboring Ethnic Group						
Rain [γ_0^s]	-0.0005	0.0001	-0.0005	-0.0007	0.0004	-0.0008
	(0.0006)	(0.0006)	(0.0005)	(0.0011)	(0.0009)	(0.0011)
Rain × Transhumant Pastoral [γ_1^s]	-0.0110***	-0.0121***	-0.0012	-0.0096**	-0.0092***	-0.0096**
	(0.0033)	(0.0031)	(0.0021)	(0.0038)	(0.0035)	(0.0038)
Own Ethnic Group						
Rain [γ_2^s]	0.0001	0.0014	-0.0002	0.0007	0.0014	0.0005
	(0.0010)	(0.0009)	(0.0007)	(0.0013)	(0.0010)	(0.0013)
Rain × Transhumant Pastoral [γ_3^s]	-0.0014	-0.0046	0.0017	-0.0011	-0.0079	0.0005
	(0.0047)	(0.0048)	(0.0038)	(0.0065)	(0.0062)	(0.0065)
Own Cell						
Rain [γ_4^s]	-0.0002	-0.0005	-0.0001	-0.0004	-0.0007	-0.0002
	(0.0007)	(0.0006)	(0.0005)	(0.0010)	(0.0009)	(0.0010)
Rain × Transhumant Pastoral [γ_5^s]	0.0041	0.0056*	-0.0008	0.0046	0.0052	0.0032
	(0.0035)	(0.0032)	(0.0024)	(0.0051)	(0.0039)	(0.0051)
Nearest Neighboring Ethnic Group: Additional Calculations						
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:						
Rain	-1.88	0.57	-3.51	-0.95	0.83	-1.13
p-value	[0.40]	[0.83]	[0.36]	[0.53]	[0.67]	[0.46]
Rain × Transhumant Pastoral	-37.51	-57.26	-8.68	-13.60	-20.12	-13.64
p-value	[0.00]	[0.00]	[0.58]	[0.01]	[0.01]	[0.01]
Rain + Rain × Transhumant Pastoral	-39.39	-56.68	-12.19	-14.55	-19.29	-14.76
p-value	[0.00]	[0.00]	[0.43]	[0.01]	[0.01]	[0.00]
Dep. Var. Mean	0.035	0.025	0.016	0.085	0.055	0.084
Cell FE	Yes	Yes	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	420	322	322	322
Cell Clusters	7,722	7,722	7,722	7,722	7,722	7,722
Observations	231,660	231,660	231,660	177,606	177,606	177,606

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* refers to the ethnic territory that contains cell i. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

transhumant pastoral neighbors are always negative and, in all columns but one, are statistically significant. Consistent with prior findings, the estimates for non-state conflict using the high-threshold UCDP data are much smaller in magnitude and imprecisely estimated.

To assess the magnitude of the estimates, in the second panel, we report the predicted effect (expressed as a percentage of the dependent variable mean) of a one-standard-deviation reduction in rainfall. According to the estimates, this adverse rainfall shock causes an increase in conflict that is equal to 37.5% of the mean of total UCDP conflict (column 1); for the ACLED measure of conflict, which has a higher mean, the equivalent figure is 13.6% (column 4).

If we take into account the deficiency of the UCDP non-state conflict measure, the evidence suggests that rainfall in the territory of transhumant pastoral nearest neighbors affects both state and non-state conflict. This implies that herder-farmer conflicts can involve state agents such as police, conservation officers, or the military, or they can occur absent government involvement.

The tables also report the coefficients for $\gamma_2^s \dots \gamma_5^s$, which are the estimated effects of rainfall in the cell's own ethnic group e and in cell i itself, and the differential effects of the rainfall measures when the ethnic group is transhumant pastoral. These are reported under the headings 'Own Ethnic Group' and 'Own Cell.' Each of the estimated coefficients is small in magnitude and almost never statistically different from zero. (Only one of 24 coefficients is significant, and that is at the 10% level.) Thus, while we find that less rainfall in the territory of the nearest neighboring transhumant pastoral groups leads to greater conflict, there is no evidence of effects for own-cell or own-group rainfall shocks.

Robustness and Sensitivity Checks We now turn to the sensitivity of our estimates. We have shown that the estimates using the narrow and broad definitions of transhumant pastoralism are qualitatively identical. Thus, for the remainder of the paper, we use the narrower definition as our baseline measure. In addition, we limit our focus to four baseline outcome variables. We retain both measures of overall conflict, but use the UCDP measure of state conflict (because of the longer time series) and the ACLED measure of non-state conflict (because of the better coverage of smaller-scale conflicts due to the lower threshold for inclusion).

A potential concern is that transhumant pastoralists might also have other characteristics that are important for mediating the relationship between adverse rainfall and nearby conflict. Given this, we check the sensitivity of our findings to accounting for other potentially important characteristics of neighboring ethnic groups; namely, pre-colonial political centralization, the presence of segmentary lineage organization, and a traditional belief in a religion with a moralizing high god, such as Islam.[7] We re-estimate a variant of equation (2) controlling each additional characteristic of a cell's nearest neighbor interacted with the neighbor's rainfall. The estimates, which we report in Appendix Table A6, show that our findings remain robust to the inclusion of these additional controls.

Another potential concern is that transhumant pastoral groups tend to live in locations where rainfall is more scarce. Thus, our findings might be biased by the differential spillover effects for nearest neighbors that experience less rainfall in general. We check for this by estimating our baseline equation while controlling for the rainfall of the nearest neighbor interacted with the group's average rainfall during the period of our analysis, 1989–2019.[8] As shown in Appendix Table A7, the estimates of interest are nearly identical with the inclusion of this control.

[7]Pre-colonial political centralization, which is measured by the levels of jurisdictional hierarchies beyond the local community, has been shown to be an important determinant of public goods provision and economic development (Gennaioli and Rainer, 2007, Michalopoulos and Papaioannou, 2013), both of which are relevant for conflict. Segmentary lineage organization has been shown to be associated with conflict (Moscona et al., 2020). The presence of a moralizing high god is believed to be an important factor for cooperation, conflict, and long-term economic growth (Norenzayan, 2013) and, as noted, many of the conflicts in the Sahel region of Africa have a religious dimension to them.

[8]For ease of interpretation, we normalize the measure to lie between zero and one.

It is possible that our measure of rainfall is correlated with other time-varying macro-level factors that differentially affect the presence of conflict adjacent to transhumant pastoral groups. Rainfall could be capturing the effects of other factors that are also trending over time, such as the availability of firearms, population density, better communication technologies, and so forth (Acemoglu, Fergusson and Johnson, 2020, Manacorda and Tesei, 2020). To account for this, we include a control for a linear time trend interacted with each cell's nearest neighbor's measure of transhumant pastoralism. While this control captures factors trending linearly over time, other factors exhibiting more irregular movements may also be important for conflict, such as commodity prices (Berman, Couttenier, Rohner and Thoenig, 2017, McGuirk and Burke, 2020). To account for this, we also interact the measure of a cell's nearest neighbor's transhumant pastoralism with numerous aggregate price indices that may affect conflict differently across space. These include price indices for energy (coal, crude oil, and natural gas), metals and minerals (aluminum, copper, iron ore, lead, nickel, steel, tin, and zinc), and precious metals (gold, platinum, and silver), as well as a price index for agricultural products (oils and meals, grains, and other food such as bananas, meat, and sugar).[9] The estimates with these additional covariates, reported in Appendix Table A8, are similar in magnitude and remain highly significant.

Our final check examines the robustness of our conclusions to various methods of calculating standard errors, including clustering by country; clustering by country and climate-zone; and allowing for spatial correlation within 1,000 kilometers of a cell. As we report in Appendix Table A10, the precision of our estimates is similar in each case.

6. Testing for Specific Mechanisms

Our findings are consistent with adverse rainfall shocks inducing transhumant pastoral groups to migrate to nearby agricultural lands before the harvest, resulting in conflict with sedentary farmers. This explanation yields a number of additional testable predictions that we now take to the data. These are: (1) the effects are due to the combination of mobility and pastoralism (i.e., transhumant pastoralism) rather than either mobility or pastoralism alone; (2) transhumant pastoral rainfall should primarily affect conflict on agricultural lands; (3) since rainfall matters because it affects plant growth, we should observe similar patterns if we use phytomass rather than rainfall; (4) we should not observe the same patterns if we examine other climatic traits, like temperature, that are less important for plant growth in Africa; and (5) transhumant pastoral rainfall should primarily affect conflict during the wet season (when groups are competing for resources) and not the dry season (when they are not).

Test 1: Importance of transhumant pastoralism rather than mobility or pastoralism alone. Our mechanism of interest suggests that both aspects of transhumant pastoralism are necessary; namely, that groups move seasonally and they engage in animal herding. If an ethnic group is

[9] The data are from the World Bank's "Pink Sheet" commodity price index dataset. All indices are based on real prices.

Table 3: Robustness to Controlling for the Components of Transhumant Pastoralism

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain	-0.0014	0.0005	-0.0020	-0.0021
	(0.0011)	(0.0008)	(0.0015)	(0.0015)
Rain × Pastoral	0.0043	-0.0022	0.0069	0.0067
	(0.0044)	(0.0035)	(0.0061)	(0.0061)
Rain × Transhumant	0.0040	0.0020	0.0029	0.0031
	(0.0025)	(0.0018)	(0.0039)	(0.0039)
Rain × Transhumant Pastoral	-0.0191***	-0.0128**	-0.0186**	-0.0187**
	(0.0069)	(0.0057)	(0.0088)	(0.0088)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain	-4.79	2.14	-2.82	-2.94
p-value	[0.19]	[0.58]	[0.19]	[0.17]
Rain × Transhumant Pastoral	-65.53	-60.74	-26.48	-26.61
p-value	[0.01]	[0.02]	[0.04]	[0.03]
Rain + Rain × Transhumant Pastoral	-70.31	-58.61	-29.30	-29.56
p-value	[0.01]	[0.04]	[0.04]	[0.03]
Dep. Var. Mean	0.0351	0.0253	0.0845	0.0842
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	7,722	7,722	7,722	7,722
Observations	231,660	231,660	177,606	177,606

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

characterized by only one of the two—they move without animals or they have animals but do not move—then we do not expect to observe the same effects.

To test for this, we estimate a version of equation (2) that also includes each component of the transhumant pastoralism measure—mobility indicator and the pastoralism index—interacted with rainfall. By including each component interaction, we are accounting separately for the role of mobility and for the role of pastoralism. This is particularly important given the recent findings in Eberle et al. (2020), which show the importance of mobility for mediating the effects of temperature on conflict. This also addresses potential concerns arising due to factors associated with pastoralism, such as the presence of a "culture of honor" and revenge-taking (Nisbett and Cohen, 1996, Grosjean, 2014, Cao et al., 2021), which may be more acute in the absence of rainfall. These effects are captured by the inclusion of the pastoralism measure (along with relevant interactions) in the equation directly.

The estimates from the equation including the component interactions are reported in Table 3. We find that our estimates of interest are robust to these additional controls and that the coefficients for the controls themselves are small and insignificant. This suggests that it is the seasonal movement of migrating herd animals that is important for our findings and not either mobility or the presence of herd animals alone.

Test 2: Concentration of conflict on agricultural land. The second testable prediction that arises from our interpretation is that conflict due to adverse rainfall shocks in the territory of transhumant pastoral groups should be concentrated in land that is agricultural. Using information from variable v5 of the *Ethnographic Atlas*, we split the sample between cells that are located within the territory of ethnic groups whose traditional reliance on agriculture for subsistence exceeded 50% and those whose reliance was less than 50%. We then re-estimate equation (2) separately for agricultural and non-agricultural cells.

The estimates, reported in Table 4, show that our main effects are driven primarily by conflict in agricultural cells. While the estimated coefficient for the interaction of interest, γ_1^s, is large in magnitude and statistically significant for agricultural cells, it is much smaller in magnitude, varies in sign, and is never statistically different from zero in non-agricultural cells. Thus, consistent with our interpretation, it is agricultural grid cells that are primarily responsible for the effects reported in Table 2.

Test 3: Similar effects for phytomass. Our hypothesis implies that a lack of rainfall in the territory of transhumant pastoral groups leads to conflict because it reduces the amount of vegetation available for herd animals, which are moved to more fertile agricultural lands as a consequence. If this is the case, we should find that adverse phytomass growth in the territory of neighboring transhumant pastoral groups should be associated with increased conflict in precisely the same manner as adverse rainfall shocks.

We test for this by re-estimating equation (2) using the measures of phytomass in place of rainfall. The estimates, reported in Panel A of Table 5, are very similar for UCDP and even greater in magnitude for ACLED. For example, looking at overall conflict, we find that a one standard deviation decrease in phytomass in the territory of a neighboring transhumant pastoral group increases conflict by 37.95% of the mean incidence when the UCDP measure is used (column 1) and by 32.09% when the ACLED measure is used (column 3). The equivalent effects of rainfall are 37.5% and 13.6%.[10]

Unlike rainfall, one might be concerned that our satellite measure of phytomass growth is itself endogenous to both conflict and the location of grazing animals. To address this concern, we create a *Phytomass Suitability Index*, which is phytomass predicted by rainfall at the level of a cell and a year. Aggregating this measure to the level of an ethnic group and the level of a

[10]The robustness of our findings to the use of the phytomass measure rather than rainfall alleviates potential concerns that imprecision in the gridded rainfall data might affect our estimates. While the rainfall data is based on a dense set of underlying weather gauges, the creation of a gridded measure does rely on reanalysis. By contrast, the phytomass measure, which is based on satellite images measured weekly at the 1km pixel level, does not rely on any reanalysis or any interpolation.

Table 4: Effect of Rain in Nearest Neighboring THP Territory on Conflict in Agricultural and Non-Agricultural Cells

	Conflict in Agricultural Cells				Conflict in Non-Agricultural Cells			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group								
Rain [γ_0^s]	-0.0006	0.0002	-0.0002	-0.0004	0.0000	-0.0001	-0.0105***	-0.0103***
	(0.0007)	(0.0006)	(0.0011)	(0.0011)	(0.0026)	(0.0024)	(0.0036)	(0.0036)
Rain × Transhumant Pastoral [γ_1^s]	-0.0119**	-0.0121***	-0.0172***	-0.0180***	-0.0053	-0.0062	0.0052	0.0056
	(0.0047)	(0.0039)	(0.0056)	(0.0057)	(0.0056)	(0.0051)	(0.0064)	(0.0064)
Own Ethnic Group								
Rain [γ_2^s]	0.0000	0.0014	-0.0001	-0.0002	-0.0057	-0.0028	-0.0022	-0.0027
	(0.0010)	(0.0009)	(0.0014)	(0.0013)	(0.0046)	(0.0038)	(0.0067)	(0.0068)
Rain × Transhumant Pastoral [γ_3^s]	0.0089	0.0056	-0.0190	-0.0157	0.0043	-0.0013	0.0079	0.0097
	(0.0134)	(0.0078)	(0.0176)	(0.0188)	(0.0084)	(0.0084)	(0.0115)	(0.0116)
Own Cell								
Rain [γ_4^s]	-0.0003	-0.0005	-0.0005	-0.0003	0.0011	-0.0024	-0.0001	0.0001
	(0.0007)	(0.0006)	(0.0010)	(0.0010)	(0.0031)	(0.0019)	(0.0048)	(0.0048)
Rain × Transhumant Pastoral [γ_5^s]	-0.0074	-0.0065	0.0168	0.0156	-0.0001	0.0064	0.0054	0.0036
	(0.0101)	(0.0077)	(0.0141)	(0.0145)	(0.0060)	(0.0048)	(0.0087)	(0.0087)
Nearest Neighboring Ethnic Group: Additional Calculations								
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:								
Rain	-1.76	1.00	-0.27	-0.45	0.02	-0.51	-22.95	-22.73
p-value	[0.38]	[0.68]	[0.84]	[0.74]	[1.00]	[0.97]	[0.00]	[0.00]
Rain × Transhumant Pastoral	-36.26	-51.62	-21.37	-22.41	-25.83	-40.08	11.27	12.26
p-value	[0.01]	[0.00]	[0.00]	[0.00]	[0.34]	[0.22]	[0.42]	[0.39]
Rain + Rain × Transhumant Pastoral	-38.02	-50.62	-21.65	-22.86	-25.81	-40.59	-11.69	-10.47
p-value	[0.01]	[0.00]	[0.00]	[0.00]	[0.31]	[0.19]	[0.33]	[0.39]
Dep. Var. Mean	0.039	0.028	0.097	0.096	0.025	0.019	0.055	0.055
Cell FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	390	390	299	299	390	390	299	299
Cell Clusters	5,482	5,482	5,482	5,482	2,240	2,240	2,240	2,240
Observations	164,460	164,460	126,086	126,086	67,200	67,200	51,520	51,520

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* refers to the ethnic territory that contains cell i. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

nearest neighbor for each year, we then estimate a version of equation (2) where the six rainfall variables are replaced by six corresponding Phytomass Suitability Index variables. Estimates using the phytomass suitability indices are reported in Appendix Tables A11 and A12, where Table A11 uses a phytomass suitability index predicted by a linear function of rainfall and Table A12 uses a measure that is predicted by a quadratic function (i.e., rainfall and rainfall squared). The estimates are similar in both magnitude and precision to our baseline estimates.[11]

Test 4: No effects for temperature. According to our interpretation, we should not find the same effects for temperature as we do for rainfall or phytomass since it is not as important for plant growth in Africa. While it is well documented that temperature is linked to conflict through

[11] An alternative approach is to instrument the six phytomass variables—i.e., phytomass and phytomass interacted with transhumant pastoralism measured at the level of the cell, the cell's ethnic group, and the cell's nearest neighbor—with the corresponding measures of rainfall. The disadvantage of this approach is that it requires that we instrument each of the six endogenous variables with all six instruments. It also restricts the data to observations for which there is phytomass data. Nevertheless, for comparison, we estimate this specification using two-stage least squares and report the results in Appendix Table A13. The effects are again similar, although they are estimated with less precision.

Table 5: Estimates Using Phytomass and Temperature Rather than Rainfall

	Indicator for the presence of conflict			
	(1) UCDP I(Any)	(2) UCDP I(State)	(3) ACLED I(Any)	(4) ACLED I(Nonstate)
	Panel A: Effect of Phytomass			
Nearest Neighboring Ethnic Group				
Phytomass	0.0001	0.0001	0.0003	0.0004
	(0.0005)	(0.0004)	(0.0006)	(0.0006)
Phytomass × Transhumant Pastoral	-0.0043**	-0.0041**	-0.0085***	-0.0086***
	(0.0018)	(0.0016)	(0.0018)	(0.0018)
Effect of 1 Std. Dev. Phytomass Shock as % of Dep. Var. Mean:				
Phytomass	0.62	0.73	1.30	1.44
p-value	[0.88]	[0.88]	[0.55]	[0.51]
Phytomass × Transhumant Pastoral	-37.95	-50.73	-32.09	-32.70
p-value	[0.02]	[0.01]	[0.00]	[0.00]
Phytomass + Phytomass × Transhumant Pastoral	-37.33	-50.00	-30.79	-31.26
p-value	[0.01]	[0.01]	[0.00]	[0.00]
Dep. Var. Mean	0.037	0.027	0.087	0.087
Climate-Zone-Year Clusters	280	280	294	294
Cell Clusters	7,722	7,722	7,722	7,722
Observations	154,440	154,440	162,162	162,162
	Panel B: Effect of Temperature			
Nearest Neighboring Ethnic Group				
Temperature	0.0019	0.0028**	0.0027	0.0026
	(0.0016)	(0.0013)	(0.0027)	(0.0027)
Temperature × Transhumant Pastoral	0.0022	0.0047	0.0030	0.0029
	(0.0037)	(0.0035)	(0.0045)	(0.0045)
Effect of 1 Std. Dev. Temp. Shock as % of Dep. Var. Mean:				
Temp.	4.70	9.33	3.16	3.02
p-value	[0.24]	[0.04]	[0.32]	[0.35]
Temp. × Transhumant Pastoral	5.55	15.89	3.48	3.42
p-value	[0.54]	[0.18]	[0.52]	[0.52]
Temp. + Temp. × Transhumant Pastoral	10.25	25.22	6.64	6.43
p-value	[0.26]	[0.04]	[0.15]	[0.16]
Dep. Var. Mean	0.032	0.024	0.068	0.068
Climate-Zone-Year Clusters	364	364	252	252
Cell Clusters	7,722	7,722	7,722	7,722
Observations	200,728	200,728	138,968	138,968
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* and *Own Cell* covariates are controlled for but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

many potential channels, we do not expect temperature to matter for conflict through our specific interaction of interest.

We test for this by re-estimating equation (2) using temperature in place of rainfall. The findings, reported in Panel B of Table 5, show that we do not observe the same patterns in the data when we use temperature rather than rainfall. We estimate a fairly precise zero coefficient for the interaction between the temperature of a cell's nearest neighbor and the neighbor's measure of transhumant pastoralism. This is consistent with our observation that, unlike rainfall, temperature is not a first-order determinant of phytomass growth.[12] As a final test, we examine estimates using an alternate Phytomass Suitability Index where phytomass is predicted by temperature alone. Mirroring the estimates above, we find no effects for phytomass that is predicted by temperature (see Appendix Table A14) or by temperature and temperature squared (Appendix Table A15).

Overall, the estimates indicate that the established mechanisms linking temperature to conflict in the literature cannot account for the effects we find here.[13] This is particularly important given the recent evidence that higher temperatures at the border between nomadic and sedentary populations increases conflict. These null effects provide added assurance that our mechanism is distinct from the 'heat and hate' effects documented in Eberle et al. (2020).

Test 5: Concentration of conflict during the wet season. The fourth test focuses on the timing of conflict within a year. Our mechanism of interest implies that adverse rainfall in transhumant pastoral territories only generates conflict in nearby farmland during the wet season. A lack of rain during the wet season forces transhumant pastoral groups to migrate early to neighboring farmlands, when land is still being used for cultivation, which generates conflict. By contrast, during the dry season, there is no tension since land is fallow and animal grazing benefits both groups.

We verify this prediction using a number of tests. In the first, we estimate a variant of equation (2) where the dependent variable is a measure of conflict that is specific to each of the two seasons. Because the length of the seasons differ across locations, we transform the dependent variable to be a monthly average, either: (1) the fraction of months that have at least one conflict incident, or (2) the average number of conflict incidents per month.

To separate wet-season conflicts from dry-season conflicts, we use data from the MIRCA2000 global dataset (Portmann, Siebert and Döll, 2010), which provides information on the beginning and end of the growing season as of the year 2000 at a 5 arc minute (9.2 km at equator) resolution. We use the starting and final months of the growing season for the 'main crop' of a cell, defined as the crop with the greatest harvested area in the cell. Our sample is therefore restricted to cells that contain some harvested cropland and experience both seasons. Among these cells, the average duration of the main crop's wet season is 5.75 months.

To ensure that we capture all conflict events due to the joint use of resources, we define wet-season conflict as conflict events that begin during either the main crop's growing season or within a month after it ends. This allows for conflict events that coincide with the harvesting

[12]Interestingly, we do find evidence of a direct relationship between temperature and conflict, as in the existing literature. Specifically, we estimate that, in general, higher temperatures experienced by the ethnic group of a cell result in more conflict in that cell.

[13]As reported in Appendix Table A16, if we include both rainfall and temperature, our estimated rainfall spillover effects from transhumant pastoral neighbors remain large and statistically significant, while we observe no equivalent spillover effect from temperature shocks.

Table 6: Effects of Neighbor's Rainfall on Conflict during the Wet and Dry Seasons

	Wet Season UCDP Conflict		Dry Season UCDP Conflict	
	(1) Incidence Year Equiv.	(2) No. Events Year Equiv.	(3) Incidence Year Equiv.	(4) No. Events Year Equiv.
	Panel A. Annual Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Annual Rain	0.0008	0.0039	-0.0022	-0.0017
	(0.0023)	(0.0048)	(0.0032)	(0.0113)
Annual Rain × Transhumant Pastoral	-0.0346***	-0.1294**	-0.0152	-0.0669
	(0.0128)	(0.0613)	(0.0116)	(0.0444)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Annual Rain × Transhumant Pastoral	-46.32	-94.31	-18.60	-44.40
p-value	[0.01]	[0.04]	[0.19]	[0.13]
	Panel B. Seasonal Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Seasonal Rain	0.0013	0.0037	-0.0015	0.0008
	(0.0016)	(0.0041)	(0.0022)	(0.0073)
Seasonal Rain × Transhumant Pastoral	-0.0184*	-0.0834*	-0.0043	-0.0103
	(0.0104)	(0.0486)	(0.0103)	(0.0214)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Seasonal Rain × Transhumant Pastoral	-41.73	-102.80	-6.75	-8.69
p-value	[0.08]	[0.09]	[0.68]	[0.63]
Dep. Var. Mean	0.090	0.165	0.098	0.181
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	420	420
Cell Clusters	4,632	4,632	4,632	4,632
Observations	138,960	138,960	138,960	138,960

Note: The unit of observation is a 0.5-degree grid-cell and year. "Incidence" is per-month UCDP conflict incidence in either the wet season or the dry season as defined in the main text. "Number" is per-month number of UCDP conflict events. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* and *Own Cell* covariates are included in the regressions but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

period, which may extend beyond the estimated final month of the main crop's growing season according to the MIRCA2000 data. Dry-season conflicts are events that begin at any point during the rest of the year.[14]

The estimates are reported in Panel A of Table 6. We find that our baseline effects are primarily due to conflict events that occur in the wet season. The estimated effects on wet-season conflict are about twice the magnitude and much more precisely estimated than the effects on dry-season conflict. This is particularly striking because, without understanding the nature of conflict that arises from transhumant pastoralism, one might expect rainfall to have the largest effect on conflict during the dry season, when fresh water is particularly scarce.

The second test that we implement also measures season-specific rainfall. Thus, we estimate the relationship between rainfall in a season and conflict in that season and we do this separately

[14]When dating conflicts, we use the earliest date indicated when multiple dates or a time interval is reported. Thus, we focus on the first incident within a conflict event—which is our object of interest—rather than other incidents that are more likely to be a continuation of previous clashes.

Table 7: Effects of Neighbor's Phytomass on Conflict during the Wet and Dry Seasons

	Wet Season UCDP Conflict		Dry Season UCDP Conflict	
	(1)	(2)	(3)	(4)
	Incidence Year Equiv.	No. Events Year Equiv.	Incidence Year Equiv.	No. Events Year Equiv.
	Panel A. Annual Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Annual Phytomass	0.0009	0.0037	0.0009	0.0034
	(0.0015)	(0.0035)	(0.0015)	(0.0033)
Annual Phytomass × Transhumant Pastoral	-0.0089**	-0.0385*	-0.0009	-0.0155
	(0.0041)	(0.0219)	(0.0044)	(0.0175)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Annual Phytomass × Transhumant Pastoral	-30.71	-70.21	-2.87	-25.72
p-value	[0.03]	[0.08]	[0.84]	[0.37]
	Panel B. Seasonal Phytomass and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Seasonal Phytomass	0.0006	-0.0000	0.0006	-0.0006
	(0.0012)	(0.0036)	(0.0012)	(0.0056)
Seasonal Phytomass × Transhumant Pastoral	-0.0064**	-0.0218*	-0.0030	-0.0301
	(0.0032)	(0.0128)	(0.0042)	(0.0223)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Seasonal Phytomass × Transhumant Pastoral	-32.56	-57.92	-12.40	-65.71
p-value	[0.05]	[0.09]	[0.48]	[0.18]
Dep. Var. Mean	0.096	0.182	0.106	0.200
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	280	280	280	280
Cell Clusters	4,632	4,632	4,632	4,632
Observations	92,640	92,640	92,640	92,640

Note: The unit of observation is a 0.5-degree grid-cell and year. "Incidence" is per-month UCDP conflict incidence in either the wet season or the dry season as defined in the main text. "Number" is per-month number of UCDP conflict events. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* and *Own Cell* covariates are included in the regressions but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

for both wet and dry seasons. The estimates, reported in Panel B of Table 6, show a similar pattern. Our baseline finding is driven by adverse rainfall in the wet season causing conflict in the wet season rather than adverse rainfall in the dry season causing conflict in the dry season.

Test 6: Combinations of predictions. The last exercise that we undertake is to combine the prediction about the timing of the effects (wet season rather than dry season) with the importance of phytomass and the location of conflict events (agricultural land). Panels A and B of Table 7 reproduce the estimates from Table 6, but using phytomass growth rather than rainfall. As shown, the same pattern emerges in the data. It is during the wet season that we see effects of phytomass growth on conflict.

We next incorporate the prediction about the location of conflicts by re-estimating the specifications reported in Tables 6 and 7, but for agricultural cells and non-agricultural cells separately. The estimates, reported in Appendix Tables A17 and A18 respectively, show that the seasonal patterns we identify (for both rainfall and phytomass) are strongly present in agricultural cells but much less so in non-agricultural cells.

These specific patterns—on the timing of the effects during the year, the location of the effects across groups, and the centrality of plant growth—are precisely what one would expect according to our hypothesis: reduced rainfall in transhumant pastoral territories induces herders to move to agricultural lands prior to the harvest, generating competition for resources that ultimately results in conflict.

7. Learning from the Estimates

The estimates reported to this point provide evidence consistent with first-hand accounts of the effects of climate change on conflict between transhumant pastoral groups and farmers. In this section, we explore the broader implications of this finding.

A. Understanding the Roots of Religious Extremism

We begin with the question of whether our estimated relationship can help to explain the rise in religious conflict in Africa in the past two decades. This trend is shown in Figure 6, which reports the average conflict incidence across cells in our UCDP data between 1989 and 2018 for events that involve at least one actor that is labeled as being a jihadist group and for those events that do not.[15] Jihadist conflicts have increased significantly since 2000, while non-jihadist conflicts have remained relatively stable.

[15]We identify jihadist conflict events as those for which the word "jihad" is present in either actor's name or in the source headline. We also examined any events for which the word "Islam-" appears in the source headline. For these, we manually examined the actors involved in the conflict and identified the event as being a jihadist conflict if one of the actors is explicitly jihadist. The groups identified include the following: Islamic State, Boko Haram, Al-Qaeda in the Islamic Maghreb (AQIM), Movement for Oneness and Jihad in West Africa (MUJAO), Benghazi Revolutionaries Shura Council, Ansar Dine, Ansaroul Islam, Mujahideen, Signed-in-Blood Battalion, Ansar al-Sharia in Libya (ASL), al-Murabitun, Macina Liberation Front (FLM), Jama'at Nasr al-Islam wal Muslimin (JNIM), Ansar al-Sunnah, Derna Protection Force (DPF), and Al-Shabaab.

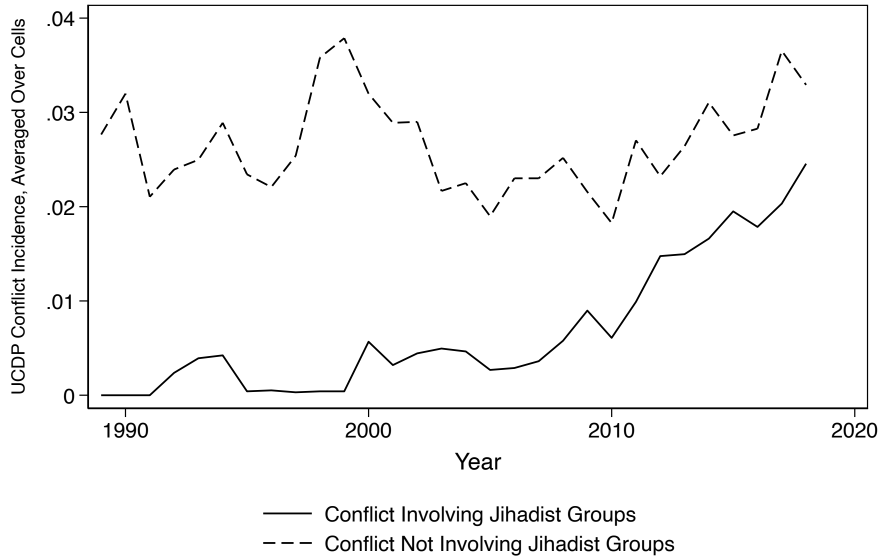


Figure 6: Total Jihadist and non-Jihadist Conflicts over Time in Africa

One apparent explanation for this is a rise in religious grievances or tensions between Islamic and Christian groups. However, our findings raise the possibility that this trend is instead (or also) due to the increased frequency of adverse rainfall shocks in transhumant pastoral territories. In our data, groups with a value of transhumant pastoralism that is non-zero are 56.5% Muslim and 27.8% Christian, whereas groups with a value of transhumant pastoralism equal to zero are 24.6% Muslim and 48.4% Christian (see Appendix Table A3). Since the conflicts that we study often involve a largely Muslim group on one side and a largely Christian group on the other, they may take the appearance of—or soon develop into—religious conflict. Tensions between farmers and herders have been known to generate support for jihadist groups, which facilitates recruitment.[16] Jihadist groups may therefore become involved in conflicts between farmers and herders that arise due to reduced rainfall.

We test for this possibility by estimating our baseline specification—equation (2)—separately for jihadist and non-jihadist conflicts. The estimates are reported in columns 1 and 2 of Table 8. We find statistically significant and quantitatively similar estimates for the coefficient on our interaction term for both types of conflict. This suggests that our mechanism applies equally to both jihadist and non-jihadist conflict. The predicted effects of a one-standard-deviation rainfall shock in terms of the mean of the dependent variable, reported in the second panel of the table, are about three times greater for jihadist conflicts (82%) than non-jihadist conflicts (27%). This is because our measure of jihadist conflict has a lower mean incidence, which can be seen in Figure 6, particularly prior to 2000.

In columns 3 and 4, we check whether our findings are simply because transhumant pastoral groups are more likely to be Islamic, which may be correlated with other factors—such as low educational mobility, as in Alesina, Hohmann, Michalopoulos and Papaioannou (2020)—that

[16]For case study evidence supportive of this, see Benjaminsen and Ba (2019) who argue that land-use conflicts are a fundamental determinant of the support for jihadist expansion by pastoral groups in the Mopti region of central Mali.

Table 8: Jihadist Violence

	Conflict in All Grid Cells			
	(1) I(Jihadist)	(2) I(Non-Jihadist)	(3) I(Jihadist)	(4) I(Non-Jihadist)
Nearest Neighboring Ethnic Group				
Rain	-0.0000	-0.0006	0.0006	0.0002
	(0.0003)	(0.0006)	(0.0005)	(0.0020)
Rain × Transhumant Pastoral	-0.0051**	-0.0063**	-0.0056**	-0.0056*
	(0.0022)	(0.0026)	(0.0025)	(0.0030)
Rain × Share Muslim			-0.0020	-0.0016
			(0.0015)	(0.0025)
Rain × Share Christian			-0.0003	-0.0007
			(0.0006)	(0.0028)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain	-0.34	-2.54	9.08	0.72
p-value	[0.94]	[0.31]	[0.21]	[0.93]
Rain × Transhumant Pastoral	-82.03	-27.05	-82.42	-21.41
p-value	[0.02]	[0.01]	[0.03]	[0.06]
Rain + Rain × Transhumant Pastoral	-82.37	-29.60	-73.34	-20.70
p-value	[0.02]	[0.01]	[0.04]	[0.12]
Dep. Var. Mean	0.007	0.028	0.008	0.032
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	420	420
Cell Clusters	7,722	7,722	6,507	6,507
Observations	231,660	231,660	195,210	195,210

Note: The unit of observation is a 0.5-degree grid-cell and year. "Jihadist" is an indicator variable that equals one if at least one UCDP conflict event occurs in a cell-year involving a self-styled jihadist group, as defined in the main text. "Non-Jihadist" is an indicator variable that equals one if at least one UCDP conflict event occurs in a cell-year that does not involve a self-styled jihadist group. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* and *Own Cell* covariates are included in the regressions but not reported. In columns 3 and 4, the covariates also include own ethnic group rainfall interacted with the share muslim and the share christian, as well as own cell rainfall interacted with the same two variables. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

interact with low rainfall in a manner that results in conflict spillovers. To account for the importance of religion, we measure the estimated proportion of each ethnic group that is Christian and Muslim (as of 2020) and include as controls in equation (2) interactions between each religion measures and each of our three rainfall measures (own cell, own ethnic group, and nearest neighboring ethnic group).[17] The estimated effects of interest are nearly identical in magnitude and significance after accounting for contemporary religion.[18]

Our findings suggest that extremist-religious violence responds to adverse rainfall in almost the same manner as other types of violence, implying that atavistic grievances are not the sole determinant of religious conflicts.

B. Policy Responses: Development Aid Projects and Protected Conservation Areas

Development Aid Projects In recent decades, many development organizations have designed interventions to combat the adverse effects of climate change. Examples include projects that aim to enhance agricultural productivity, improve irrigation infrastructure, or expand protected conservation areas. A potential solution to the effects that we document is to implement more of these interventions. However, given the specifics of the mechanism that we uncover, it is not clear whether these policies will help. The conflict that we identify is due to adverse rainfall causing pastoral groups to migrate to nearby farmlands before harvest. Improving the agricultural productivity of farmland does not necessarily solve this underlying problem. Moreover, irrigation projects potentially facilitate the conversion of marginal lands to farmland, thus reducing the land available to pastoral groups for grazing. Land privatization and the creation of protected conservation lands that ban animal grazing are also likely to have the same effect. In general, any policy that constrains the land available to pastoralists in response to adverse rainfall can potentially increase the likelihood that they come into conflict with farmers during the growing season.

Against this backdrop, we examine whether our documented effects are stronger or weaker in the presence of such projects. To do this, we allow our effects of interest to differ depending on the stock of aid projects present in a country and year. We measure the presence of aid projects in a country over time using data from the *Aid Data* repository, which reports detailed information on all bilateral and multilateral foreign aid projects from 1947-2013. We measure the cumulative number of project locations that have been implemented in each country prior to that year (since 1947) and normalize this by the number of cells in a country.[19] We denote this variable $ForeignAid_{ct}$.

[17]The data are constructed using information from the *World Religion Database*, which reports information on the populations of 18 religions for each language group in the world. The data are reported with Ethnologue identifiers which we match to our *Ethnographic Atlas*. There are typically multiple *Ethnologue* groups that match to one *Ethnographic Atlas* group. We create *Ethnographic Atlas* level measures by creating population-weighted averages across all *Ethnologue* groups that match to one *Ethnographic Atlas* group.

[18]We come to the same conclusion if we examine our baseline measure of aggregate conflict incidence. We find that controlling for contemporary religion does not alter our baseline estimate.

[19]For example, if one umbrella program is implemented in ten locations, it is measured as ten project locations.

We then estimate the following equation, which allows our effect of interest to vary by the prevalence of foreign aid projects in a country:

$$\begin{aligned} y_{iet} \;=\;& \psi_0^s\, Rain_{it}^{Neighbor} + \psi_1^s\, Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \\ & + \psi_2^s\, Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times ForeignAid_{ct-1} \\ & + \psi_3^s Rain_{it}^{Neighbor} \times ForeignAid_{ct-1} + \psi_4^s TranshumantPastoral_i^{Neighbor} \times ForeignAid_{ct-1} \\ & + \psi_5^s\, Rain_{et}^{OwnGroup} + \psi_6^s\, Rain_{et}^{OwnGroup} \times TranshumantPastoral_e^{OwnGroup} \\ & + \psi_7^s\, Rain_{it}^{OwnCell} + \psi_8^s\, Rain_{it}^{OwnCell} \times TranshumantPastoral_e^{OwnGroup} \\ & + \alpha_i^s + \alpha_{c(i)t}^s + \xi_{iet}^s, \end{aligned} \tag{3}$$

where $ForeignAid_{ct}$ is as described above and all indices and other variables are as defined in equation (2). The estimates of interest are ψ_1^s, which is our main spillover effect when transhumant pastoral groups are in a country with no previous foreign aid, and ψ_2^s, which shows how our effect of interest differs depending on the amount of past foreign aid projects in a country.

The first analysis that we undertake divides foreign aid projects into two categories: those that are agricultural and those that are not. We identify agricultural projects as those for which the reported sector code is "Agriculture" and non-agricultural projects as all others. We allow our estimated effects of interest to differ depending on the cumulative presence of both types of projects in a country and year. The estimates are reported in Panel A of Table 9. We find no evidence that agricultural aid reduces the effects of rainfall in transhumant pastoral territory on conflict in nearby cells. While the point estimates are imprecise, their sign and magnitudes suggest that agricultural aid may exacerbate the effects of interest.

To investigate whether the estimates mask heterogeneous effects, we create even finer categories of aid projects, distinguishing between irrigation projects, forestry projects, conservation projects, land projects, other agricultural projects, and other non-agricultural projects.[20] The estimates, which are reported in Panel B of Table 9, do not indicate that any of these types of aid can alleviate the effects of adverse rainfall shocks in transhumant pastoral areas on conflict.

Finally, because $ForeignAid_{ct}$ varies over time as well as between countries, we estimate a version of (3) that additionally controls for $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times \alpha_c^s$ and $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times \alpha_t^s$; that is, our double interaction of interest interacted with country fixed effects and with year fixed effects. By including these fixed effects interactions, we exploit only within-country variation over time rather than cross-country variation in $ForeignAid_{ct}$. In effect, this implies that our triple-interaction effect of interest, ψ_2^s, is identified using a difference-in-differences style estimator rather than a cross-country estimator. The results of this procedure are presented in Appendix Table A20. The coefficients for $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor}$ are evaluated at the mean value of each fixed effect. The results again suggest that, if anything, agricultural projects may exacerbate the effects that we uncover.

[20] We measure these variables by searching for relevant keywords in the set of variables that contain the project descriptions or sectors. The keywords are, respectively, "irrigat" for irrigation; "forest" for forestry; "conserv" for conservation; and "land", "tenure" or "titling" for land. We define the residual projects as agricultural or non-agricultural as in the first analysis.

Table 9: Heterogeneity by the Presence of International Aid Projects

	Conflict in All Grid Cells			
	(1) UCDP I(Any)	(2) UCDP I(State)	(3) ACLED I(Any)	(4) ACLED I(Non-State)
	Panel A: Heterogeneity by International Agricultural Aid			
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0129***	-0.0122***	-0.0038	-0.0036
	(0.0038)	(0.0035)	(0.0039)	(0.0039)
Rain × Transhumant Pastoral × Total Agriculture Aid	-0.0059	-0.0068	-0.0113	-0.0117
	(0.0064)	(0.0055)	(0.0074)	(0.0075)
Rain × Transhumant Pastoral × Total Non-Agriculture Aid	0.0004	0.0004	0.0005	0.0005
	(0.0004)	(0.0004)	(0.0005)	(0.0005)
	Panel B: Heterogeneity by International Aid Types			
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0115***	-0.0117***	-0.0103**	-0.0100**
	(0.0044)	(0.0041)	(0.0050)	(0.0049)
Rain × Transhumant Pastoral × Irrigation Projects	0.0145	-0.0066	-0.0281	-0.0261
	(0.0295)	(0.0284)	(0.0398)	(0.0395)
Rain × Transhumant Pastoral × Forestry Projects	0.0386*	0.0103	0.0540	0.0474
	(0.0222)	(0.0188)	(0.0372)	(0.0368)
Rain × Transhumant Pastoral × Conservation Projects	0.0079	-0.0079	-0.0188	-0.0237
	(0.0273)	(0.0184)	(0.0355)	(0.0351)
Rain × Transhumant Pastoral × Land Projects	-0.0481	-0.0071	-0.0131	-0.0146
	(0.0575)	(0.0532)	(0.0596)	(0.0594)
Rain × Transhumant Pastoral × Other Agriculture Projects	-0.0181*	-0.0067	-0.0173	-0.0146
	(0.0099)	(0.0088)	(0.0140)	(0.0138)
Rain × Transhumant Pastoral × Other Non-Agriculture Projects	0.0006	0.0003	0.0008	0.0008
	(0.0005)	(0.0004)	(0.0005)	(0.0005)
Dep. Var. Mean	0.032	0.024	0.068	0.068
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	364	364	252	252
Cell Clusters	7,722	7,722	7,722	7,722
Observations	200,772	200,772	138,996	138,996

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Conservation Areas The next analysis that we undertake looks specifically at the stock of protected conservation lands in a country at a point in time. While conservation is an important tool for environmental protection, it can also be disruptive for pastoral groups. Lands that are converted into conservation areas may contain transhumant pastoral corridors or grazing pastures. Since conservation lands typically either forbid the use of protected lands for grazing or impose regulations or fees when use is allowed, their expansion may disrupt existing transhumant migration routes and cooperative arrangements with farmers (Bergius, Benjaminsen, Manganga and Buhaug, 2020, Cavanagh, Weldemichel and Benjaminsen, 2020).

Table 10: Heterogeneity by the Presence of Conservation Lands

	Conflict in All Grid Cells			
	(1) UCDP I(Any)	(2) UCDP I(State)	(3) ACLED I(Any)	(4) ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0033	-0.0037	0.0010	0.0011
	(0.0044)	(0.0042)	(0.0061)	(0.0061)
Rain × Transhumant Pastoral × Conservation Land (km^2/cell)	-0.1004	-0.1301*	-0.1754**	-0.1789**
	(0.0708)	(0.0710)	(0.0750)	(0.0751)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain × Transhumant Pastoral when Conservation at 10th pctile	-12.7	-19.8	1.0	1.2
p-value	[0.42]	[0.34]	[0.91]	[0.90]
Rain × Transhumant Pastoral when Conservation at 90th pctile	-52.1	-90.3	-28.1	-28.6
p-value	[0.01]	[0.00]	[0.00]	[0.00]
Dep. Var. Mean	0.033	0.024	0.078	0.078
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	7,517	7,517	7,517	7,517
Observations	225,510	225,510	172,891	172,891

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. Relevant covariates at the *Own Ethnic Group* and *Own Cell* levels are controlled for but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

We measure the presence of conservation lands in a country using data from *Protected Planet*, a global database of protected areas and other conservation measures.[21] We compile panel data that measure the total conservation area in km^2 in a country-year, normalized by the number of cells in the country.

We estimate a variant of equation (3) using the measure of conservation rather than a measure of foreign aid. The estimates, reported in Table 10, suggest that conservation lands exacerbate the effects of adverse rainfall experienced by transhumant pastoral groups. To illustrate this, in the second panel of the table, we report the predicted effect (relative to the mean of the dependent variable) of a one-standard-deviation reduction in rainfall for different values of the conservation land variable. We find that lower rainfall in a neighboring transhumant pastoral territory has no significant effect on conflict in countries with minimal conservation land (i.e., at the 10th percentile). However, in countries with a large share of protected conservation land (i.e., at the 90th percentile) the same shock increases conflict by 28-90%.

In Appendix Table A21, we additionally include controls for $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times \alpha_c^s$ and $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times \alpha_t^s$. Again,

[21]The database was accessed via the URL `protectedplanet.net` on May 16, 2021.

we evaluate the coefficient for $Rain_{it}^{Neighbor} \times TranshumantPastoral_{i}^{Neighbor}$ at the mean value of each fixed effect. The results of this exercise support our conclusion above. They are consistent with the expansion of conservation areas leading to more constraints faced by herders, which results in a larger effect of adverse rainfall in pastoral territories on nearby conflict.

C. Rainfall Scarcity, Pastoral Representation in Government, and Conflict

We have established that conflict induced by adverse rainfall in transhumant pastoral territories often involves the state. This suggests that national political economy forces may play an important role in either moderating or amplifying this relationship. In this section, we test whether the same spillover effects are present when pastoral groups have more political power.

The motivation for the test comes from the fact that pastoral groups are less likely to be afforded grazing rights when they are excluded from national politics. In this scenario, state forces will serve to protect the property rights of landowning farmers via restrictions or outright bans on grazing, which have recently been implemented in a number of countries (Avuwadah, 2021). Another less obvious example are land titling programs, which weaken the legitimacy of customary use rights that are important to pastoral groups (Boone, 2019).

Numerous studies have documented cases of policy bias against pastoral groups. Often, this stance is explicit, with transhumant pastoralism being viewed as inefficient or outdated. For example, the former president of Tanzania, Jakaya Kikwete, has expressed such views on numerous occasions. In his 2005 inaugural speech to Parliament, he argued: "Our people must change from being nomadic cattle herders to being modern livestock keepers." In a 2006 press conference, he asserted: "We are producing little milk, export very little beef, and our livestock keepers roam throughout the country with their animals in search for grazing grounds. We have to do away with archaic ways of livestock farming." (Mattee and Shem, 2006, p. 4).

We measure the extent to which political power in a country is held by transhumant pastoral groups using information from the Ethnic Power Relations (EPR) Database, which documents the nature of political power held by ethnic groups. We use this information to construct a measure of the total amount of political power held by an ethnic group e in country c in year t, which we denote by $Power_{ect}$. The categories, and their numerical values, are given by: (0) Fully excluded from politics (self exclusion or discrimination); (1) Powerless; (2) Junior partner in government; (3) Senior partner in government; (4) Dominant power; and (5) Monopoly power.

Our interest is in the share of political power in a country that is held by transhumant pastoral groups. We measure the total amount of political power in country c in year t by aggregating the power held by all ethnic groups e: $\sum_e Power_{ect}$. We measure the amount of power held by transhumant pastoral groups by: $\sum_e TranshumantPastoral_e \times Power_{ect}$. Our measure of the share of power held by transhumant pastoral groups in a country and year is then:

$$Power_{ct}^{THP} = \frac{\sum_e TranshumantPastoral_e \times Power_{ect}}{\sum_e Power_{ect}}.$$

The distribution of the measure across countries and years is shown in Appendix Figure A3. It is clear that the amount of political power held by pastoral groups is limited. The median value of $Power_{ct}^{THP}$ is 0.09, and a third of the observations have a measure that is equal to zero, indicating transhumant pastoral groups do not hold any political power. The highest value of the measure is 0.61, which is for Mauritania from 1989–2017, when the Delim, Trarza, Regeibat, Zenega, Tajakant, and Berabish pastoral groups were represented as junior partners in government.

Using the transhumant political power measure, we estimate a variant of equation (2) that allows our effect of interest to differ depending on the extent to which transhumant pastoral groups hold political power in that country in year $t-1$, $Power_{ct-1}^{THP}$. We use a lagged measure, which helps to address the potential for reverse causality—that is, conflict in year t affecting a change in power in year t. The estimating equation is:

$$
\begin{aligned}
y_{iet} \quad = \quad & \phi_0^s \, Rain_{it}^{Neighbor} + \phi_1^s \, Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \\
& + \phi_2^s \, Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times Power_{c(i)t-1}^{THP} \\
& + \phi_3^s Rain_{it}^{Neighbor} \times Power_{c(i)t-1}^{THP} + \phi_4^s TranshumantPastoral_i^{Neighbor} \times Power_{c(i)t-1}^{THP} \\
& + \phi_5^s \, Rain_{et}^{OwnGroup} + \phi_6^s \, Rain_{et}^{OwnGroup} \times TranshumantPastoral_e^{OwnGroup} \\
& + \phi_7^s \, Rain_{it}^{OwnCell} + \phi_8^s \, Rain_{it}^{OwnCell} \times TranshumantPastoral_e^{OwnGroup} \\
& + \alpha_i^s + \alpha_{c(i)t}^s + \xi_{iet}^s,
\end{aligned} \tag{4}
$$

where all indices and variables are as in equation (2). The estimates of interest are ϕ_1^s, which is our main spillover effect when transhumant pastoral groups have no political power, and ϕ_2^s, which tells us how much the estimated spillover effect changes as transhumant pastoral groups gain more political power.

Estimates of equation (4) are reported in Table 11. We find that the estimated coefficient for the interaction between a nearest neighbor's rainfall and that neighbor's measure of transhumant pastoralism, $\hat{\phi}_1^s$, is negative and statistically significant for all four measures. This is the estimated effect for a country where the share of power held by transhumant pastoral groups is zero. The estimated coefficient for the triple interaction, $\hat{\phi}_2^s$, is positive and generally significant, indicating that the effect of rainfall in the territory of a neighboring transhumant pastoral group on conflict is closer to zero when transhumant pastoral groups have more national political power.

To assess the importance of the estimated heterogeneity, in the bottom panel of each table we calculate the predicted effect and statistical significance of $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor}$ at different values of $Power_{c(i)t-1}^{THP}$. The first predicted effect that we report is for a value of $Power_{c(i)t-1}^{THP}$ that is equal to the 10th percentile of its distribution, which is zero. Below this, we report the same statistic calculated at the 90th percentile (0.303). We find that for country-years in which no transhumant pastoral groups share political power, the estimated spillover effect is large. For example, a one-standard-deviation decrease in rainfall is associated with an increase of conflict of 58% for all conflicts using the UCDP measure and 82% for all conflicts using the ACLED measure. When a country is at the 90th percentile of transhumant pastoral political power, these effects are not statistically different from zero. In addition, they are very small: 7% for UCDP and 7% for ACLED.

In Appendix Table A22, we report estimates from an equation that also includes controls for $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times \alpha_c^s$ and $Rain_{it}^{Neighbor} \times TranshumantPastoral_i^{Neighbor} \times \alpha_t^s$.

Table 11: Heterogeneity by Share of Political Power Held by Transhumant Pastoral Groups: Using the Narrow Definition of Transhumance

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Non-State)
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0158**	-0.0151***	-0.0513***	-0.0513***
	(0.0062)	(0.0054)	(0.0091)	(0.0091)
Rain × Transhumant Pastoral × THP Power Share	0.0458**	0.0367*	0.1834***	0.1824***
	(0.0231)	(0.0211)	(0.0392)	(0.0393)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain × Transhumant Pastoral when THP Power at 10th pctile	-58.1	-74.0	-81.6	-82.0
p-value	[0.01]	[0.01]	[0.00]	[0.00]
Rain × Transhumant Pastoral when THP Power at 90th pctile	-7.2	-19.4	6.8	6.3
p-value	[0.64]	[0.32]	[0.52]	[0.56]
Dep. Var. Mean	0.033	0.024	0.075	0.075
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Years	406	406	308	308
Cells	7,018	7,018	7,015	7,015
Observations	195,975	195,975	149,290	149,290

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

The country fixed effects interacted with our double interaction of interest ensures that we use only within-country variation in $Power^{THP}_{c(i)t-1}$ to produce our estimates of interest. As reported, we find qualitatively identical results.

These results suggest that political power may play an important role in determining when episodes of low rainfall in pastoral areas lead to conflict and when they do not. They are consistent with evidence that, in the absence of political power-sharing, minority groups have stronger incentives to fight (Mueller and Rohner, 2018). Although we cannot make a causal interpretation, the estimates are robust to using a lagged measure of political power, which allays concerns about reverse causality, and to including controls for fixed effects interacted with our double interaction of interest, which ensures that we use only within-country variation over time. When transhumant pastoral groups are afforded a higher share of political power, reduced rainfall in their home territories cease to induce the same outbreak of conflict in neighboring areas.

8. Conclusions

We have studied the question of whether climate change is responsible for disrupting longstanding relationships between transhumant pastoralists and neighboring sedentary agriculturalists in Africa. Traditionally, transhumant pastoralists benefit from a cooperative relationship with sedentary agriculturalists whereby arable land is used for farming in the wet season and grazing in the dry season. Our findings confirm anecdotal accounts that decreased rainfall in transhumant pastoral territories is forcing herders to migrate to neighboring agricultural territories before the harvest, resulting in competition for resources and the emergence of conflict.

The core of our analysis documents a relationship between adverse rainfall in the territories of transhumant pastoralists and conflict in the territory of neighboring ethnic groups. To test for the mechanism of interest—disruption to the seasonal migrations of transhumant pastoralists—we confirm the effects through a series of falsification exercises. We found that the conflicts induced by rainfall scarcity are concentrated in nearby agricultural lands and tend to occur during the wet season, which is when land is still used for cultivation, and not during the dry season, when land is left fallow and available for grazing. We also found that the effect of rainfall operates through its influence on phytomass growth, which grazing animals require for sustenance.

Our estimates also shed light on a specific form of conflict that has become more pervasive in Africa in recent decades, namely religious violence. Transhumant pastoral groups tend to be Islamic, while sedentary agriculturalists tend to be Christian. Our estimates indicate that a large proportion of extremist-religious violence involving jihadist groups is due to the mechanism we document rather than primordial grievances alone. Our counterfactual exercise implies that if rainfall were one standard deviation higher during our study period, jihadist conflict would be lower by 31%.

Our analysis also generates important policy implications. We examined whether policies that are commonly used to combat the effects of environmental degradation can alleviate the destructive effects that we identify in this article. We found no evidence that implementing agricultural development aid projects or expanding protected conservation areas contribute to the reduction of conflict that occurs due to reduced rainfall in transhumant pastoral locations. These findings suggest that such projects do not address the root cause of the conflict and may even be counterproductive.

By contrast, we did find evidence that political economy factors are important. The estimated effects are closer to zero when pastoral ethnic groups have a greater share of national political power. Since transhumant pastoral groups are typically under-represented in national politics, this suggests that a more equitable distribution of political power could have significant dividends in the form of peace. Indeed, if taken literally, our estimates imply that more equitable politics could fully eliminate the effects of adverse rainfall on conflict that we document.

Finally, our findings highlight the importance of understanding the ethnic and cultural context when studying conflict and climate change. In particular, they illustrate the value of understanding pastoral populations and their way of life, which remains understudied and underappreciated in development economics despite comprising perhaps more than a fifth of Africa's population.

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Online Appendix (Not for Publication)

Additional Data Details

For ACLED and UCDP, we use as consistent a coding procedure as possible so that, in the end, the primary difference between the two measures is the lower barrier to entry in ACLED.

For the ACLED measure, we restrict the "type" of events to what ACLED calls "violent events". Formally, this is type 1 ("battles") and type 6 ("violence against civilians"). We do not include "explosions/remote violence" (this includes chemical weapons, air strikes, bombs, shelling)—these are very rare.

The "types" that we do not include are "non-violent actions" and "demonstrations." Our results are almost identical when we allow for a broader definition.

We then separate by actors in a way that mimics the UCDP definitions:

- Any: Any violent event
- State: Events involving the state. These are interaction codes that either begin or end with a 1.
- Non-State: Events not involving the state, which means all interaction codes that neither begin nor end with 1

For UCDP, the categories are off-the-shelf but for one adjustment. We combine one-way and two-way events involving the state for our measure of state conflict and we combine those not-involving the state for our measure of non-state conflict.

Appendix Figures

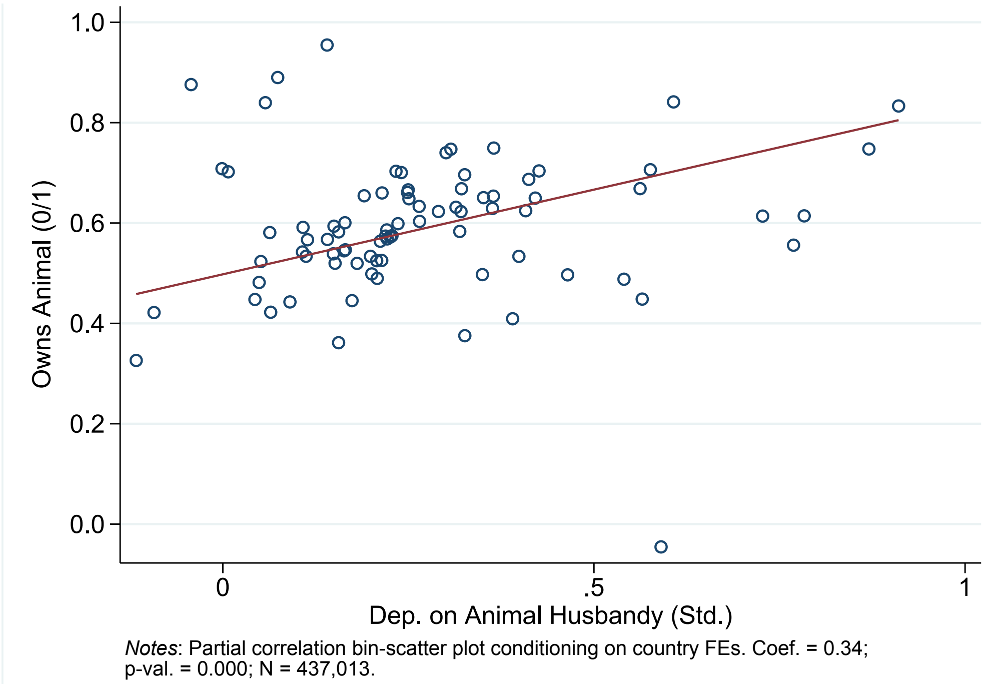
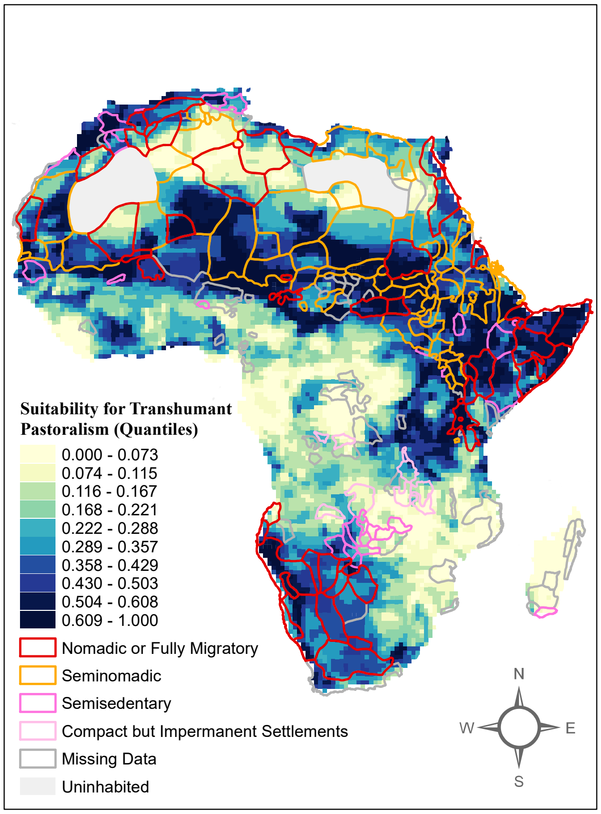
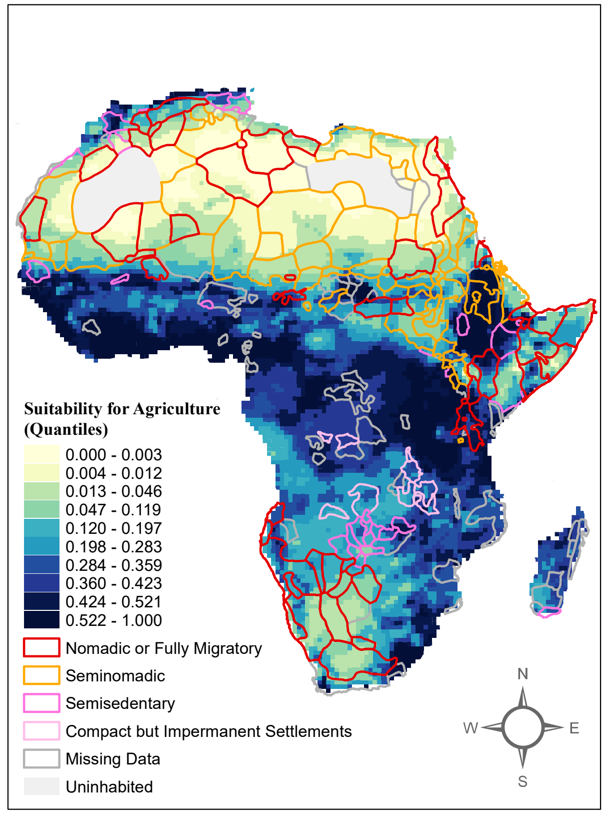


Figure A1: Binscatter partial correlation plot showing the relationship between current pastoralism (in the DHS) and our constructed measure of traditional transhumant pastoralism of the respondents ethnic group using data from Bahrami-Rad et al. (2021) and conditional on country fixed effects.



(a) Suitability for transhumant pastoralism



(b) Suitability for sedentary agriculture

Figure A2: Ecological conditions and transhumant pastoralism

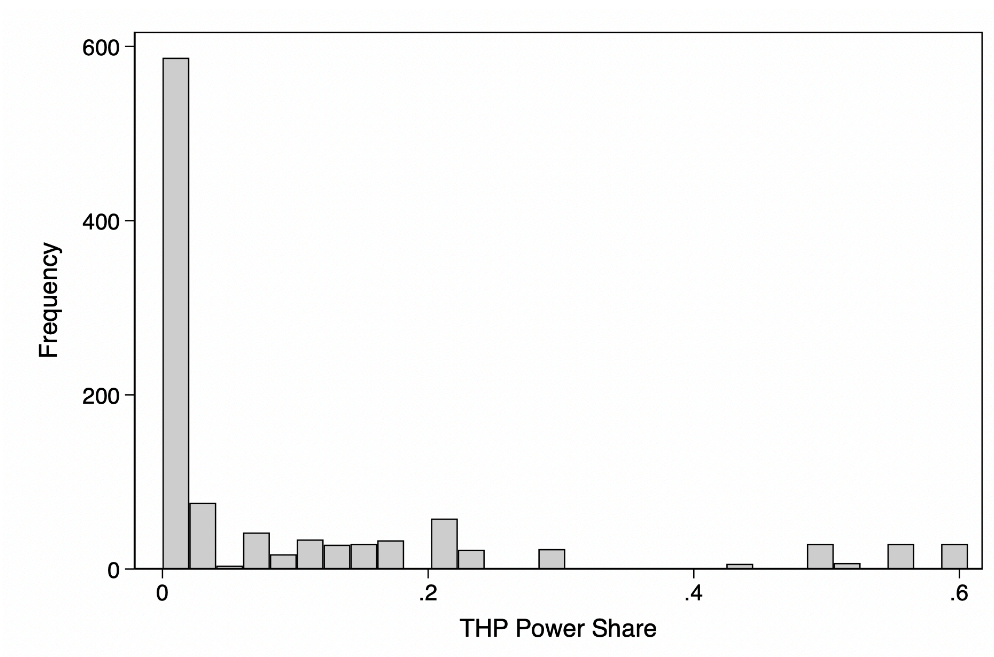


Figure A3: Histogram of power held by transhumant pastoral groups across countries and years

Appendix Tables

Table A1: Summary of Existing Information on Transhumant Pastoral Routes in Africa.

Reference for Study	Countries Studied	Method of Measurement	Number of Routes	Directions of Routes	Distance From Origin to Destination (km)	Avg Daily Distance (km)	Total Distance Covered (km)	Duration of Route (weeks)	Months of Transhumance Season
Dongmo, Vall, Diallo, Dugue, Njoya & Lossouarn (2012)	Cameroon (North)	Interview	2 (major-transhumance), 2 (minor-transhumance)	Major: 1 west, 1 south Minor: 1 north, 1 east	Major: 75-100 Minor: 40-75			10	Major: July to September Minor: February to April
Ayantunde, Asse, Said & Fall (2014)	Gambia, Guinea, Mali and Senegal (subhumid zone of West Africa)	Interview	7	South (main pattern)	Approx. 200			12-32	Dry season, 3-8 months (not specified in paper, but should be October to May)
Reeves (2014)	Camerron (Tubah Uplands)	GPS and interviews	4	1 north, 2 soutwest, 1 southeast				22	November-Mach
Turner, McPeak, Gillin, Kitchell, Kimambo (2016)	Senegal (East)	GPS and meetings with local leaders	4 (corridors instead of routes)	South (with several branches)	20-30		827-1,762 (length of each corridor)	28-32	October-May
Feldt & Schlecht (2016)	Madagascar (Southwest)	GPS	13	West	45	17.8		12-14	December to mid-April
Sulieman & Ahmed (2017)	Sudan (East)	Focus groups and GPS	3	Noth	66-290			12	Late July to October
Motta, Porphyre, Hamman, Morgan, Ngwa, Tanya, Raizman, Handel & Bronsvoort (2018)	Cameroon (central)	GPS	6	4 southwest, 1 south east, 1 north east	53-170	3.23 - 4.14 (median)	633-763	26-32	October-May
Houessou, Dossa, Assogba, Diogo, Vanvanhossou & Schecht (2020)	Benin	Secondary data (Topographic MAP IGN, 1992; Wezel, 1999)	5	2 southwest, 2 east, 1 southeast				28-32	November-June
Zannou, Ouedraogo, Biguezoton, Lempereur, Yao, Abatih, Zoungrana, Lenaert, Toe, Fraougou & Saegerman (2020)	Benin (North)	GPS	4	3 south, 1 shoutwest				28	October-April
Feldt, Karg, Kadaoure, Besser & Schlecht (2020)	Cameroon (highlands)	GPS and map-based interviews	6	To lower altitude zones	18.4	9.2		12-16	Mid-December to mid-March/April

Notes: The table summarizes information from studies that measure transhumant pastoral routes in Africa.

Table A2: Descriptive Statistics

	Mean	SD	Count	Min	Median	Max
	Cell-Year Level Variables, 1989-2018					
UCDP: I(Any Conflict), 0/1	0.03	0.18	290,730	0.00	0.00	1.00
UCDP: I(State Conflict), 0/1	0.02	0.15	290,730	0.00	0.00	1.00
UCDP: I(Nonstate Conflict), 0/1	0.02	0.12	290,730	0.00	0.00	1.00
ACLED: I(Any Conflict), 0/1	0.08	0.27	213,202	0.00	0.00	1.00
ACLED: I(State Conflict), 0/1	0.05	0.22	213,202	0.00	0.00	1.00
ACLED: I(Nonstate Conflict), 0/1	0.08	0.27	213,202	0.00	0.00	1.00
Precipitation, cm/month	5.65	5.14	290,730	0.00	4.38	49.28
Phytomass, kg/ha/day	30.69	30.35	193,820	0.01	23.44	141.11
Temperature, $^{\circ}C$	24.50	3.95	251,922	7.51	24.75	39.53
Nearest Neighbor Precipitation, cm/month	5.89	5.06	282,690	0.00	4.83	34.96
Nearest Neighbor Phytomass, kg/ha/day	31.90	29.77	188,460	0.18	25.77	130.71
Nearest Neighbor Temperature, $^{\circ}C$	24.44	3.79	244,998	12.20	24.65	37.12
Nighttime Lights, 0-1	0.04	0.03	203,511	0.00	0.03	0.96
	Cell Level Variables					
Nearest Neighbor Transhumant Pastoralism (Narrow Definition), 0-1	0.19	0.30	8,487	0.00	0.00	0.92
Nearest Neighbor Transhumant Pastoralism (Broad Definition), 0-1	0.21	0.30	8,487	0.00	0.00	0.92
B-S: Land Suitability for Transhumant Pastoralism, 0-1	0.32	0.20	9,421	0.00	0.29	0.90
B-S: Land Suitability for Agriculture, 0-1	0.24	0.20	9,421	0.00	0.22	0.88
ln(Population) in 1990	9.31	2.11	9,659	-0.69	9.61	16.01
	Ethnic-Group-Year Level Variables, 1989-2018					
Precipitation, cm/month	8.54	5.20	23,400	0.00	8.27	34.96
Phytomass, kg/ha/day	44.31	28.53	15,600	0.18	43.59	130.71
Temperature, $^{\circ}C$	24.78	3.47	20,280	12.20	25.28	37.12
EPR: Political Power, 0-5	2.13	1.16	12,500	0.00	2.00	5.00
	Ethnic Group Level Variables					
Transhumant Pastoralism (Narrow Definition), 0-1	0.08	0.22	712	0.00	0.00	0.92
Transhumant Pastoralism (Broad Definition), 0-1	0.09	0.23	712	0.00	0.00	0.92
EA: Agriculture, 0-1	0.55	0.18	745	0.03	0.61	0.92
EA: Jurisdictional Hierarchy, 0-4	1.29	0.97	687	0.00	1.00	4.00
EA: Belief in High Gods, 0/1	0.45	0.50	488	0.00	0.00	1.00
Share Muslim, 0-1	0.29	0.38	689	0.00	0.05	1.00
Share Christian, 0-1	0.46	0.35	689	0.00	0.46	1.00
Segmentary Lineage, 0-1	0.50	0.25	722	0.02	0.48	0.98

Note: This table presents basic descriptive statistics. The first panel presents variables that vary at the level of a cell-year. *UCDP: I(Any Conflict)* and *ACLED: I(Any Conflict)* measure conflict incidence for all conflicts. *Precipitation* is measured in average cm per month. *Phytomass* is the average monthly growth of dry vegetation measured in kg/ha/day. This is computed using the 'Dry Matter Productivity' variable from the *Copernicus* remote sensing program. *Temperature* is from Fan and van den Dool (2008). Variables beginning with "*Nearest Neighbor*" measure, for each cell, statistics at the level of the nearest ethnic group that is contiguous to the ethnic group in which the cell lies. *Nighttime Lights* is based on data collected by US Air Force Weather Agency and processed by NOAA's National Geophysical Data Center. The second panel presents cross-sectional variables that vary at the level of a cell. *Nearest Neighbor Transhumant Pastoralism* measures the transhumant pastoralism index score of a cell's nearest neighboring group. The narrow measure includes only groups that are classified in the *Ethnographic Atlas* as 'nomadic or fully migratory' or as 'seminomadic.' The broad measure additionally includes groups that are 'semisedentary' or that have 'compact but impermanent settlements.' The *Land Suitability* variables are based on data from Beck and Sieber (2010). *Population* is measured in persons and is taken from CIESIN and CIAT (2005). The third panel presents variables that vary at the level of an ethnic-group-year. *EPR: Political Power* is the score assigned to each ethnic group in the *Ethnic Power Relations* dataset, where 0 indicates that the group is either discriminated against or completely excluded from national politics, while a score of 5 indicates that the group has a monopoly on national political power. In cases where an ethnic group shares power in multiple countries, we compute the average score. In this panel, we also present precipitation, phytomass, and temperature aggregated to the level of an ethnic-group-year. The fourth panel presents cross-sectional variables that vary at the level of an ethnic group. *Transhumant Pastoralism* is described in the main text. *Avg. Neighbor Transhumant Pastoralism* measures the average transhumant pastoralism index score across an ethnic group's contiguous neighbors. The variable *EA: Agriculture* measures an ethnic group's historical dependence on agriculture for subsistence; the variable *EA: Jurisdictional Hierarchy* measures the number of jurisdictional layers beyond the local community within an ethnic group; *EA: Belief in High Gods* is an indicator equal to one if an ethnic group believed in a moralizing god before contact with European colonizers; all three of these variables are from the *Ethnographic Atlas*. The variables *Share Muslim* and *Share Christian* measure the estimated share of people in each ethnic group that are today Muslims or Christians respectively. This data comes from the *World Religion Database*, which we match to our *Ethnographic Atlas* data using *Ethnologue* identifiers. The variables *Temperature*, *Nighttime Lights* and *Population* are available in the PRIO-GRID v.2.0 dataset (Tollefsen, Strand and Buhaug, 2012).

Table A3: Balance Table, Sub-Samples by THP Classification

Variable	(1) THP > 0	(2) THP = 0	(3) Difference
	Cell-Year Level, 1989-2018		
UCDP: I(Any Conflict), 0/1	0.024	0.041	-0.017***
	(0.152)	(0.198)	(0.002)
UCDP: I(State Conflict), 0/1	0.017	0.029	-0.012***
	(0.130)	(0.168)	(0.002)
UCDP: I(Nonstate Conflict), 0/1	0.009	0.020	-0.011***
	(0.095)	(0.140)	(0.001)
ACLED: I(Any Conflict), 0/1	0.051	0.098	-0.047***
	(0.221)	(0.297)	(0.003)
ACLED: I(State Conflict), 0/1	0.034	0.063	-0.030***
	(0.180)	(0.243)	(0.002)
ACLED: I(Nonstate Conflict), 0/1	0.051	0.098	-0.047***
	(0.220)	(0.297)	(0.003)
Precipitation, cm/month	2.066	8.513	-6.447***
	(2.715)	(4.857)	(0.078)
Phytomass, kg/ha/day	9.214	47.835	-38.621***
	(17.333)	(27.446)	(0.475)
Temperature, $^\circ C$	25.323	23.859	1.465***
	(4.115)	(3.688)	(0.083)
Nearest Neighbor Precipitation, cm/month	2.400	8.531	-6.131***
	(2.843)	(4.768)	(0.080)
Nearest Neighbor Phytomass, kg/ha/day	11.216	47.620	-36.404***
	(17.965)	(27.075)	(0.484)
Nearest Neighbor Temperature, $^\circ C$	25.213	23.879	1.334***
	(3.939)	(3.542)	(0.081)
Nighttime Lights, 0-1	0.037	0.042	-0.006***
	(0.021)	(0.043)	(0.001)
Observations	115,650	148,740	290,730
	Cell Level		
Nearest Neighbor Transhumant Pastoralism (Narrow Definition), 0-1	0.357	0.070	0.287***
	(0.333)	(0.204)	(0.006)
Nearest Neighbor Transhumant Pastoralism (Broad Definition), 0-1	0.378	0.085	0.294***
	(0.323)	(0.214)	(0.006)
B-S: Land Suitability for Transhumant Pastoralism, 0-1	0.390	0.266	0.124***
	(0.196)	(0.186)	(0.004)
B-S: Land Suitability for Agriculture, 0-1	0.099	0.354	-0.255***
	(0.132)	(0.182)	(0.004)
ln(Population) in 1990	8.093	10.230	-2.137***
	(1.977)	(1.729)	(0.040)
Observations	3,855	4,958	9,691
	Ethnic-Group-Year Level, 1989-2018		
Precipitation, cm/month	3.840	9.745	-5.905***
	(3.342)	(4.885)	(0.349)
Phytomass, kg/ha/day	19.923	50.563	-30.640***
	(23.412)	(26.176)	(2.339)
Temperature, $^\circ C$	25.171	24.756	0.415
	(4.014)	(3.330)	(0.377)
EPR: Political Power, 0-5	1.894	2.169	-0.274**
	(1.237)	(1.093)	(0.135)
Observations	3,750	17,610	23,400
	Ethnic Group Level		
EA: Agriculture, 0-1	0.338	0.593	-0.255***
	(0.208)	(0.133)	(0.015)
EA: Jurisdictional Hierarchy, 0-4	1.555	1.240	0.315***
	(0.852)	(0.980)	(0.100)
EA: Belief in High Gods, 0/1	0.779	0.355	0.424***
	(0.417)	(0.479)	(0.050)
Share Muslim, 0-1	0.565	0.246	0.319***
	(0.478)	(0.337)	(0.039)
Share Christian, 0-1	0.278	0.484	-0.205***
	(0.361)	(0.339)	(0.037)
Segmentary Lineage, 0-1	0.476	0.509	-0.033
	(0.191)	(0.257)	(0.025)
Observations	125	587	780

Note: This table presents balance tests. Column 1 shows averages across groups where our measure of *Transhumant Pastoralism* (THP) is greater than zero. Column 2 shows averages across groups where this measure is equal to zero. We use the broader definition of THP that includes all pastoral groups without fully permanent settlements. Standard errors are clustered by ethnic group. See Table A2 for variable descriptions.

Table A4: Effect of Rain Shock in Nearest Neighboring THP Territory on Conflict in a Cell: Broad Definition of Transhumance

	Indicator for the presence of conflict					
	UCDP			ACLED		
	(1) I(Any)	(2) I(State)	(3) I(Nonstate)	(4) I(Any)	(5) I(State)	(6) I(Nonstate)
Nearest Neighboring Ethnic Group						
Rain [γ_0^s]	-0.0005	0.0002	-0.0006	-0.0005	0.0005	-0.0007
	(0.0006)	(0.0006)	(0.0005)	(0.0011)	(0.0009)	(0.0011)
Rain × Transhumant Pastoral [γ_1^s]	-0.0082***	-0.0105***	0.0008	-0.0093**	-0.0081**	-0.0094**
	(0.0031)	(0.0028)	(0.0019)	(0.0037)	(0.0036)	(0.0037)
Own Ethnic Group						
Rain [γ_2^s]	0.0003	0.0016*	-0.0001	0.0008	0.0015	0.0006
	(0.0010)	(0.0009)	(0.0007)	(0.0014)	(0.0011)	(0.0014)
Rain × Transhumant Pastoral [γ_3^s]	-0.0050	-0.0065	-0.0009	-0.0028	-0.0080	-0.0013
	(0.0042)	(0.0042)	(0.0035)	(0.0062)	(0.0057)	(0.0062)
Own Cell						
Rain [γ_4^s]	-0.0004	-0.0006	-0.0002	-0.0005	-0.0008	-0.0003
	(0.0007)	(0.0006)	(0.0005)	(0.0010)	(0.0009)	(0.0010)
Rain × Transhumant Pastoral [γ_5^s]	0.0049	0.0062**	0.0001	0.0054	0.0056	0.0041
	(0.0033)	(0.0030)	(0.0024)	(0.0048)	(0.0039)	(0.0048)
Nearest Neighboring Ethnic Group: Additional Calculations						
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:						
Rain	-1.82	1.03	-4.13	-0.77	1.01	-0.95
p-value	[0.41]	[0.70]	[0.29]	[0.61]	[0.61]	[0.54]
Rain × Transhumant Pastoral	-27.95	-49.97	6.15	-13.27	-17.70	-13.36
p-value	[0.01]	[0.00]	[0.67]	[0.01]	[0.02]	[0.01]
Rain + Rain × Transhumant Pastoral	-29.77	-48.95	2.01	-14.04	-16.69	-14.31
p-value	[0.00]	[0.00]	[0.89]	[0.01]	[0.03]	[0.01]
Dep. Var. Mean	0.035	0.025	0.016	0.085	0.055	0.084
Cell FE	Yes	Yes	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	420	322	322	322
Cell Clusters	7,722	7,722	7,722	7,722	7,722	7,722
Observations	231,660	231,660	231,660	177,606	177,606	177,606

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* refers to the ethnic territory that contains cell i. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A5: The Determinants of Phytomass Growth

	Phytomass		
	(1)	(2)	(3)
Rain	0.4151***		0.4092***
	(0.0357)		(0.0350)
Temp		-0.2223***	-0.2018***
		(0.0400)	(0.0383)
Share of RSS explained by weather variable(s) (in %)	3.63	0.61	4.13
F statistic	135.55	30.84	75.07
Effect of 1 Std. Dev. Shock as % of Dep. Var. Mean:			
Rain	1.63		1.61
p-value	[0.00]		[0.00]
Temp		-0.58	-0.53
p-value		[0.00]	[0.00]
Dep. Var. Mean	30.57	30.57	30.57
Cell FE	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes
Climate-Zone-Years	224	224	224
Cells	9,691	9,691	9,691
Observations	155,032	155,032	155,032

Note: This table presents phytomass (in kg/ha/day) as a function of rainfall (in cm/month) and temperature (in °C), conditional on cell fixed effects and country-by-year fixed effects. *RSS* refers to the residual sum of squares after partialling out the cell fixed effects and country-by-year fixed effects. Standard errors (in parentheses) are adjusted for serial correlation at the level of a cell and spatial correlation at the level of a climate zone. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A6: Robustness to Additional Controls for Ethnicity-Level Characteristics

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain	-0.0025	-0.0010	-0.0025	-0.0026
	(0.0015)	(0.0013)	(0.0023)	(0.0023)
Rain $\times$ Transhumant Pastoral	-0.0117***	-0.0123***	-0.0094**	-0.0097**
	(0.0036)	(0.0031)	(0.0038)	(0.0038)
Rain $\times$ Jurisdictional Hierarchy	0.0004	-0.0000	-0.0002	-0.0002
	(0.0006)	(0.0005)	(0.0008)	(0.0008)
Rain $\times$ Segmentary Lineage	0.0028	0.0022	0.0030	0.0029
	(0.0019)	(0.0015)	(0.0029)	(0.0030)
Rain $\times$ High Gods: Active, Not Supportive	0.0013	0.0015	0.0030	0.0031
	(0.0023)	(0.0016)	(0.0036)	(0.0036)
Rain $\times$ High Gods: Active, Supportive	0.0014	0.0017*	-0.0010	-0.0009
	(0.0013)	(0.0011)	(0.0022)	(0.0022)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain	-8.52	-4.86	-3.41	-3.61
p-value	[0.10]	[0.43]	[0.28]	[0.26]
Rain $\times$ Transhumant Pastoral	-39.42	-59.20	-13.00	-13.44
p-value	[0.00]	[0.00]	[0.01]	[0.01]
Rain + Rain $\times$ Transhumant Pastoral	-47.93	-64.06	-16.42	-17.05
p-value	[0.00]	[0.00]	[0.01]	[0.00]
Dep. Var. Mean	0.0357	0.0249	0.0869	0.0865
Cell FE	Yes	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	6,603	6,603	6,603	6,603
Observations	198,090	198,090	151,869	151,869

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A7: Robustness to Additional Controls for Ethnicity-Level Average Rainfall

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain	-0.0000	-0.0004	-0.0004	-0.0004
	(0.0014)	(0.0013)	(0.0021)	(0.0021)
Rain × Transhumant Pastoral	-0.0111***	-0.0116***	-0.0100**	-0.0100**
	(0.0034)	(0.0031)	(0.0040)	(0.0039)
Rain × Average Rain (0-1)	-0.0012	0.0012	-0.0008	-0.0009
	(0.0028)	(0.0028)	(0.0042)	(0.0042)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain	-0.10	-1.80	-0.52	-0.62
p-value	[0.98]	[0.78]	[0.86]	[0.84]
Rain × Transhumant Pastoral	-37.91	-55.18	-14.26	-14.30
p-value	[0.00]	[0.00]	[0.01]	[0.01]
Rain + Rain × Transhumant Pastoral	-38.01	-56.97	-14.78	-14.92
p-value	[0.00]	[0.00]	[0.01]	[0.01]
Dep. Var. Mean	0.0351	0.0253	0.0845	0.0842
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Years	420	420	322	322
Cells	7,722	7,722	7,722	7,722
Observations	231,660	231,660	177,606	177,606

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: Robustness to Additional Controls for Time-Varying Characteristics

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain	-0.0006	0.0001	-0.0007	-0.0009
	(0.0006)	(0.0006)	(0.0011)	(0.0011)
Rain $\times$ Transhumant Pastoral	-0.0114***	-0.0126***	-0.0095***	-0.0094***
	(0.0034)	(0.0031)	(0.0036)	(0.0036)
Year $\times$ Transhumant Pastoral	-0.0005	-0.0003	-0.0064***	-0.0064***
	(0.0006)	(0.0006)	(0.0018)	(0.0017)
Price Index: Energy $\times$ Transhumant Pastoral	0.0006***	0.0004**	0.0005**	0.0005**
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Price Index: Metals and Minerals $\times$ Transhumant Pastoral	0.0001	0.0003	-0.0004	-0.0004
	(0.0002)	(0.0002)	(0.0003)	(0.0003)
Price Index: Precious Metals $\times$ Transhumant Pastoral	-0.0004	-0.0005*	0.0005	0.0005
	(0.0003)	(0.0002)	(0.0005)	(0.0005)
Price Index: Agriculture $\times$ Transhumant Pastoral	-0.0001	0.0001	0.0006	0.0006
	(0.0005)	(0.0004)	(0.0007)	(0.0007)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain	-1.90	0.61	-1.04	-1.22
p-value	[0.39]	[0.82]	[0.49]	[0.42]
Rain $\times$ Transhumant Pastoral	-39.14	-59.85	-13.46	-13.45
p-value	[0.00]	[0.00]	[0.01]	[0.01]
Rain + Rain $\times$ Transhumant Pastoral	-41.04	-59.25	-14.50	-14.67
p-value	[0.00]	[0.00]	[0.00]	[0.00]
Dep. Var. Mean	0.0351	0.0253	0.0845	0.0842
Cell FE	Yes	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	7,722	7,722	7,722	7,722
Observations	231,660	231,660	177,606	177,606

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A9: Sample Statistics by the Agricultural Intensity Indicator

Variable	(1) Agricultural Groups	(2) Non-Agricultural Groups	(3) Difference
	Cell-Year Level, 1989-2018		
UCDP: I(Any Conflict), 0/1	0.038	0.023	0.016***
	(0.191)	(0.149)	(0.002)
UCDP: I(State Conflict), 0/1	0.027	0.017	0.010***
	(0.163)	(0.129)	(0.001)
UCDP: I(Nonstate Conflict), 0/1	0.018	0.008	0.010***
	(0.134)	(0.092)	(0.001)
ACLED: I(Any Conflict), 0/1	0.090	0.048	0.042***
	(0.286)	(0.214)	(0.003)
ACLED: I(State Conflict), 0/1	0.059	0.031	0.028***
	(0.235)	(0.173)	(0.002)
ACLED: I(Nonstate Conflict), 0/1	0.090	0.048	0.042***
	(0.286)	(0.214)	(0.003)
Precipitation, cm/month	7.532	1.822	5.710***
	(5.152)	(2.398)	(0.076)
Phytomass, kg/ha/day	42.125	7.506	34.619***
	(30.080)	(14.455)	(0.460)
Temperature, $^\circ C$	24.359	25.001	-0.642***
	(3.606)	(4.588)	(0.095)
Nearest Neighbor Precipitation, cm/month	7.662	2.186	5.476***
	(5.034)	(2.643)	(0.079)
Nearest Neighbor Phytomass, kg/ha/day	42.440	10.204	32.236***
	(29.403)	(16.630)	(0.487)
Nearest Neighbor Temperature, $^\circ C$	24.375	24.740	-0.365***
	(3.474)	(4.314)	(0.092)
Nighttime Lights, 0-1	0.041	0.037	0.004***
	(0.039)	(0.024)	(0.001)
Observations	190,770	85,470	290,730
	Cell Level		
Nearest Neighbor Transhumant Pastoralism (Narrow Definition), 0-1	0.104	0.395	-0.292***
	(0.227)	(0.351)	(0.007)
Nearest Neighbor Transhumant Pastoralism (Broad Definition), 0-1	0.122	0.409	-0.287***
	(0.235)	(0.344)	(0.007)
B-S: Land Suitability for Transhumant Pastoralism, 0-1	0.286	0.389	-0.103***
	(0.200)	(0.184)	(0.004)
B-S: Land Suitability for Agriculture, 0-1	0.310	0.093	0.217***
	(0.199)	(0.123)	(0.004)
ln(Population)	10.515	8.820	1.695***
	(1.713)	(1.398)	(0.037)
Observations	6,359	2,849	9,691
	Ethnic-Group-Year Level, 1989-2018		
Precipitation, cm/month	9.412	3.659	5.753***
	(4.924)	(4.164)	(0.485)
Phytomass	49.165	17.181	31.984***
	(26.730)	(24.276)	(2.842)
Temperature, $^\circ C$	24.799	24.828	-0.029
	(3.346)	(4.294)	(0.481)
EPR: Political Power, 0-5	2.130	1.927	0.203
	(1.076)	(1.375)	(0.182)
Observations	19,860	2,490	23,400
	Ethnic Group Level		
Transhumant Pastoralism (Narrow Definition), 0-1	0.019	0.534	-0.515***
	(0.090)	(0.354)	(0.017)
Transhumant Pastoralism (Broad Definition), 0-1	0.032	0.564	-0.532***
	(0.109)	(0.334)	(0.018)
EA: Jurisdictional Hierarchy, 0-4	1.289	1.308	-0.019
	(0.981)	(0.872)	(0.117)
EA: Belief in High Gods, 0/1	0.396	0.797	-0.401***
	(0.490)	(0.405)	(0.062)
Share Muslim, 0-1	0.252	0.636	-0.383***
	(0.346)	(0.468)	(0.046)
Share Christian, 0-1	0.482	0.233	0.249***
	(0.342)	(0.358)	(0.044)
Segmentary Lineage, 0-1	0.507	0.469	0.038
	(0.249)	(0.229)	(0.031)
Observations	662	83	780

Note: See Table A2 for variable descriptions.

Table A10: Robustness to Various Inference Procedures

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(State)
	Panel A: Clustering by country			
Nearest Neighboring Ethnic Group				
Rain [γ_0^s]	-0.0005	0.0001	-0.0007	0.0004
	(0.0006)	(0.0006)	(0.0011)	(0.0009)
Rain × Transhumant Pastoral [γ_1^s]	-0.0110**	-0.0121***	-0.0096***	-0.0092***
	(0.0044)	(0.0038)	(0.0022)	(0.0026)
Country Clusters	49	49	49	49
	Panel B: Clustering by country and climate-zone			
Nearest Neighboring Ethnic Group				
Rain [γ_0^s]	-0.0005	0.0001	-0.0007	-0.0008
	(0.0006)	(0.0005)	(0.0010)	(0.0010)
Rain × Transhumant Pastoral [γ_1^s]	-0.0110***	-0.0121***	-0.0096***	-0.0096***
	(0.0033)	(0.0028)	(0.0014)	(0.0015)
Country Clusters	49	49	49	49
Climate-Zone Clusters	14	14	14	14
	Panel C: Spatial HAC within 1000km			
Nearest Neighboring Ethnic Group				
Rain [γ_0^s]	-0.0005	0.0001	-0.0007	-0.0008
	(0.0007)	(0.0006)	(0.0010)	(0.0010)
Rain × Transhumant Pastoral [γ_1^s]	-0.0110***	-0.0121***	-0.0096**	-0.0096**
	(0.0040)	(0.0035)	(0.0043)	(0.0043)
Dep. Var. Mean	0.035	0.025	0.085	0.055
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Observations	231,660	231,660	177,606	177,606

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. *Own Ethnic Group* refers to the ethnic territory that contains cell i. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a country. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A11: Phytomass Suitability Index (Predicted by Rain)

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Phytomass Suitability Index	-0.0001	0.0000	-0.0001	-0.0002
	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Phytomass Suitability Index $\times$ Transhumant Pastoral	-0.0021***	-0.0023***	-0.0018**	-0.0018**
	(0.0006)	(0.0006)	(0.0007)	(0.0007)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Phytomass Suitability Index Shock as % of Dep. Var. Mean:				
Phytomass Suitability Index	-1.88	0.57	-0.95	-1.13
p-value	[0.40]	[0.83]	[0.53]	[0.46]
Phytomass Suitability Index $\times$ Transhumant Pastoral	-37.51	-57.26	-13.60	-13.64
p-value	[0.00]	[0.00]	[0.01]	[0.01]
Phytomass Suitability Index + Phytomass Suitability Index $\times$ Transhumant Pastoral	-39.39	-56.68	-14.55	-14.76
p-value	[0.00]	[0.00]	[0.01]	[0.00]
Dep. Var. Mean	0.035	0.025	0.085	0.084
Cell FE	Yes	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	7,722	7,722	7,722	7,722
Observations	231,660	231,660	177,606	177,606

Note: In these specifications, the Phytomass Suitability Index is phytomass predicted by rainfall. These regressions use the full sample of observations for which there is data on rainfall. The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A12: Phytomass Suitability Index (Predicted by Rain and Rain Squared)

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Phytomass Suitability Index	-0.0001	0.0000	-0.0002	-0.0002
	(0.0002)	(0.0001)	(0.0002)	(0.0002)
Phytomass Suitability Index × Transhumant Pastoral	-0.0018***	-0.0020***	-0.0014**	-0.0014**
	(0.0005)	(0.0005)	(0.0006)	(0.0006)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Phytomass Suitability Index Shock as % of Dep. Var. Mean:				
Phytomass Suitability Index	-0.94	0.25	-1.23	-1.33
p-value	[0.70]	[0.93]	[0.42]	[0.39]
Phytomass Suitability Index × Transhumant Pastoral	-28.07	-43.06	-9.20	-9.17
p-value	[0.00]	[0.00]	[0.02]	[0.02]
Phytomass Suitability Index + Phytomass Suitability Index × Transhumant Pastoral	-29.01	-42.80	-10.44	-10.50
p-value	[0.00]	[0.00]	[0.01]	[0.01]
Dep. Var. Mean	0.035	0.025	0.085	0.084
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	7,722	7,722	7,722	7,722
Observations	231,660	231,660	177,606	177,606

Note: In these specifications, the Phytomass Suitability Index is phytomass predicted by rainfall and rainfall squared. These regressions use the full sample of observations for which there is data on rainfall. The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A13: IV 2SLS Estimates: Instrumenting Phytomass with Rain

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Phytomass	-0.0035	-0.0011	-0.0050	-0.0054
	(0.0027)	(0.0021)	(0.0036)	(0.0037)
Phytomass $\times$ Transhumant Pastoral	-0.0031	-0.0076**	-0.0060	-0.0059
	(0.0038)	(0.0036)	(0.0039)	(0.0039)
Own Ethnic Group				
Phytomass	-0.0015	0.0033	0.0025	0.0012
	(0.0051)	(0.0045)	(0.0067)	(0.0067)
Phytomass $\times$ Transhumant Pastoral	0.0013	-0.0053	-0.0114	-0.0066
	(0.0114)	(0.0100)	(0.0153)	(0.0151)
Own Cell				
Phytomass	0.0030	-0.0007	0.0008	0.0024
	(0.0054)	(0.0046)	(0.0077)	(0.0077)
Phytomass $\times$ Transhumant Pastoral	0.0029	0.0090	0.0152	0.0106
	(0.0114)	(0.0101)	(0.0144)	(0.0143)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Phytomass Shock as % of Dep. Var. Mean:				
Phytomass	-30.69	-14.13	-18.98	-20.55
p-value	[0.19]	[0.59]	[0.17]	[0.14]
Phytomass $\times$ Transhumant Pastoral	-27.32	-95.01	-22.56	-22.41
p-value	[0.42]	[0.03]	[0.13]	[0.13]
Phytomass + Phytomass $\times$ Transhumant Pastoral	-58.00	-109.14	-41.54	-42.96
p-value	[0.13]	[0.03]	[0.01]	[0.01]
First Stage K-P LM Test Stat. (Underidentification)	35.83	35.83	33.66	33.66
First Stage K-P F Test Stat. (Weak Identification)	4.85	4.85	4.50	4.50
Dep. Var. Mean	0.037	0.027	0.087	0.087
Cell FE	Yes	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	280	280	294	294
Cell Clusters	7,722	7,722	7,722	7,722
Observations	154,440	154,440	162,162	162,162

Note: All phytomass variables and interactions are instrumented with their corresponding rainfall variables. The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A14: Phytomass Suitability Index (Predicted by Temperature)

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Phytomass Suitability Index	-0.0013	-0.0019**	-0.0018	-0.0017
	(0.0011)	(0.0009)	(0.0018)	(0.0018)
Phytomass Suitability Index × Transhumant Pastoral	-0.0015	-0.0032	-0.0020	-0.0020
	(0.0025)	(0.0024)	(0.0031)	(0.0030)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Phytomass Suitability Index Shock as % of Dep. Var. Mean:				
Phytomass Suitability Index	-4.70	-9.33	-3.16	-3.02
p-value	[0.24]	[0.04]	[0.32]	[0.35]
Phytomass Suitability Index × Transhumant Pastoral	-5.55	-15.89	-3.48	-3.42
p-value	[0.54]	[0.18]	[0.52]	[0.52]
Phytomass Suitability Index + Phytomass Suitability Index × Transhumant Pastoral	-10.25	-25.22	-6.64	-6.43
p-value	[0.26]	[0.04]	[0.15]	[0.16]
Dep. Var. Mean	0.032	0.024	0.068	0.068
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	364	364	252	252
Cell Clusters	7,722	7,722	7,722	7,722
Observations	200,728	200,728	138,968	138,968

Note: In these specifications, the Phytomass Suitability Index is phytomass predicted by temperature. These regressions use the full sample of observations for which there is data on temperature. The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A15: Phytomass Suitability Index (Predicted by Temperature and Temperature Squared)

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Phytomass Suitability Index	0.0002	-0.0001	-0.0014**	-0.0014**
	(0.0004)	(0.0004)	(0.0006)	(0.0007)
Phytomass Suitability Index × Transhumant Pastoral	-0.0008	-0.0013	0.0009	0.0010
	(0.0008)	(0.0008)	(0.0010)	(0.0010)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Phytomass Suitability Index Shock as % of Dep. Var. Mean:				
Phytomass Suitability Index	1.83	-0.88	-6.52	-6.50
p-value	[0.66]	[0.87]	[0.03]	[0.03]
Phytomass Suitability Index × Transhumant Pastoral	-7.38	-16.76	4.03	4.40
p-value	[0.37]	[0.11]	[0.39]	[0.34]
Phytomass Suitability Index + Phytomass Suitability Index × Transhumant Pastoral	-5.55	-17.65	-2.49	-2.10
p-value	[0.45]	[0.07]	[0.51]	[0.57]
Dep. Var. Mean	0.032	0.024	0.068	0.068
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	364	364	252	252
Cell Clusters	7,722	7,722	7,722	7,722
Observations	200,728	200,728	138,968	138,968

Note: In these specifications, the Phytomass Suitability Index is phytomass predicted by temperature and temperature squared. These regressions use the full sample of observations for which there is data on temperature. The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A16: Allowing for Rainfall and Temperature in the Same Specification

	Indicator for the presence of conflict			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain	-0.0004	0.0002	-0.0002	-0.0004
	(0.0007)	(0.0006)	(0.0011)	(0.0012)
Rain $\times$ Transhumant Pastoral	-0.0116***	-0.0125***	-0.0071**	-0.0075**
	(0.0035)	(0.0033)	(0.0036)	(0.0035)
Temperature	0.0020	0.0029**	0.0028	0.0026
	(0.0016)	(0.0013)	(0.0027)	(0.0027)
Temperature $\times$ Transhumant Pastoral	0.0017	0.0040	0.0026	0.0026
	(0.0037)	(0.0035)	(0.0045)	(0.0044)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain	-1.66	1.18	-0.41	-0.72
p-value	[0.50]	[0.68]	[0.84]	[0.72]
Rain $\times$ Transhumant Pastoral	-42.99	-63.49	-12.53	-13.18
p-value	[0.00]	[0.00]	[0.05]	[0.03]
Rain + Rain $\times$ Transhumant Pastoral	-44.65	-62.31	-12.94	-13.90
p-value	[0.00]	[0.00]	[0.03]	[0.02]
Effect of 1 Std. Dev. Temp Shock as % of Dep. Var. Mean:				
Temp	7.24	14.83	4.87	4.65
p-value	[0.23]	[0.03]	[0.30]	[0.33]
Temp $\times$ Transhumant Pastoral	6.23	20.28	4.62	4.51
p-value	[0.65]	[0.25]	[0.56]	[0.56]
Temp + Phytomass $\times$ Transhumant Pastoral	13.47	35.11	9.49	9.17
p-value	[0.32]	[0.05]	[0.17]	[0.17]
Dep. Var. Mean	0.032	0.024	0.068	0.068
Cell FE	Yes	Yes	Yes	Yes
Country $\times$ Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	364	364	252	252
Cell Clusters	7,722	7,722	7,722	7,722
Observations	200,728	200,728	138,968	138,968

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. This regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A17: Summary of Seasonal Regressions, Agricultural Cells Only

	Wet Season UCDP Conflict		Dry Season UCDP Conflict	
	(1)	(2)	(3)	(4)
	Incidence Year Equiv.	No. Events Year Equiv.	Incidence Year Equiv.	No. Events Year Equiv.
	Panel A.1. Annual Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Annual Rain	0.0005	0.0042	-0.0025	-0.0034
	(0.0024)	(0.0050)	(0.0033)	(0.0124)
Annual Rain × Transhumant Pastoral	-0.0361**	-0.0918*	-0.0029	-0.0262
	(0.0173)	(0.0472)	(0.0162)	(0.0499)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Annual Rain × Transhumant Pastoral	-49.64	-72.94	-3.56	-18.14
p-value	[0.04]	[0.05]	[0.86]	[0.60]
	Panel A.2. Seasonal Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Seasonal Rain	0.0011	0.0062	-0.0021	-0.0048
	(0.0015)	(0.0038)	(0.0023)	(0.0061)
Seasonal Rain × Transhumant Pastoral	-0.0229*	-0.0603*	-0.0067	-0.0199
	(0.0134)	(0.0359)	(0.0169)	(0.0272)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Seasonal Rain × Transhumant Pastoral	-53.30	-80.99	-10.42	-17.47
p-value	[0.09]	[0.09]	[0.69]	[0.47]
Dep. Var. Mean	0.087	0.151	0.098	0.174
Climate-Zone-Year Clusters	390	390	390	390
Cell Clusters	3,897	3,897	3,897	3,897
Observations	116,910	116,910	116,910	116,910
	Panel B.1. Annual Phytomass and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Annual Phytomass	0.0001	0.0041	0.0006	0.0033
	(0.0017)	(0.0037)	(0.0018)	(0.0039)
Annual Phytomass × Transhumant Pastoral	-0.0095*	-0.0196***	0.0041	0.0090
	(0.0053)	(0.0070)	(0.0061)	(0.0093)
Effect of 1 Std. Dev. Phytomass Shock as % of Dep. Var. Mean:				
Annual Phytomass × Transhumant Pastoral	-35.25	-41.50	13.09	16.07
p-value	[0.08]	[0.01]	[0.51]	[0.33]
	Panel B.2. Seasonal Phytomass and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Seasonal Phytomass	0.0004	0.0027	-0.0001	-0.0036
	(0.0013)	(0.0030)	(0.0014)	(0.0062)
Seasonal Phytomass × Transhumant Pastoral	-0.0061	-0.0100	-0.0017	-0.0119
	(0.0050)	(0.0062)	(0.0047)	(0.0131)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Seasonal Phytomass × Transhumant Pastoral	-33.27	-30.96	-7.10	-28.16
p-value	[0.22]	[0.11]	[0.72]	[0.37]
Dep. Var. Mean	0.089	0.156	0.103	0.185
Climate-Zone-Year Clusters	260	260	260	260
Cell Clusters	3,897	3,897	3,897	3,897
Observations	77,940	77,940	77,940	77,940
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes

Note: This table presents separate regressions for each column and panel. The unit of observation is a 0.5-degree grid-cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. Each regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A18: Summary of Seasonal Regressions, Non-Agricultural Cells Only

	Wet Season UCDP Conflict		Dry Season UCDP Conflict	
	(1)	(2)	(3)	(4)
	Incidence Year Equiv.	No. Events Year Equiv.	Incidence Year Equiv.	No. Events Year Equiv.
	Panel A.1. Annual Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Annual Rain	0.0057	0.0082	0.0039	0.0246
	(0.0117)	(0.0204)	(0.0126)	(0.0192)
Annual Rain × Transhumant Pastoral	-0.0197	-0.2018	-0.0137	-0.1432
	(0.0189)	(0.1728)	(0.0156)	(0.1288)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Annual Rain × Transhumant Pastoral	-23.01	-102.26	-16.60	-78.22
p-value	[0.30]	[0.24]	[0.38]	[0.27]
	Panel A.2. Seasonal Rainfall and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Seasonal Rain	0.0033	-0.0230	0.0075	0.0695
	(0.0092)	(0.0270)	(0.0085)	(0.0565)
Seasonal Rain × Transhumant Pastoral	-0.0045	-0.0944	-0.0039	-0.0426
	(0.0152)	(0.0996)	(0.0124)	(0.0561)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Seasonal Rain × Transhumant Pastoral	-8.78	-80.91	-6.10	-29.59
p-value	[0.77]	[0.34]	[0.75]	[0.45]
Dep. Var. Mean	0.103	0.237	0.099	0.220
Climate-Zone-Year Clusters	390	390	390	390
Cell Clusters	735	735	735	735
Observations	22,050	22,050	22,050	22,050
	Panel B.1. Annual Phytomass and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Annual Phytomass	0.0018	-0.0032	-0.0030	-0.0051
	(0.0029)	(0.0101)	(0.0025)	(0.0071)
Annual Phytomass × Transhumant Pastoral	-0.0061	-0.0565	-0.0033	-0.0414
	(0.0056)	(0.0480)	(0.0060)	(0.0385)
Effect of 1 Std. Dev. Phytomass Shock as % of Dep. Var. Mean:				
Annual Phytomass × Transhumant Pastoral	-15.57	-59.02	-9.14	-48.67
p-value	[0.28]	[0.24]	[0.58]	[0.28]
	Panel B.2. Seasonal Phytomass and Conflict by Seasons			
Nearest Neighboring Ethnic Group				
Seasonal Phytomass	-0.0010	-0.0173	0.0016	0.0132
	(0.0021)	(0.0154)	(0.0030)	(0.0119)
Seasonal Phytomass × Transhumant Pastoral	-0.0033	-0.0186	-0.0092	-0.0861
	(0.0038)	(0.0183)	(0.0079)	(0.0724)
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Seasonal Phytomass × Transhumant Pastoral	-12.41	-28.38	-33.64	-133.23
p-value	[0.39]	[0.31]	[0.24]	[0.24]
Dep. Var. Mean	0.130	0.317	0.119	0.282
Climate-Zone-Year Clusters	260	260	260	260
Cell Clusters	735	735	735	735
Observations	14,700	14,700	14,700	14,700
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes

Note: This table presents separate regressions for each column and panel. The unit of observation is a 0.5-degree grid-cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. Each regression controls for the corresponding variables at the *Own Ethnic Group* level and the *Own Cell* level. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A19: Descriptive Statistics for Country-Year Level Variables

	Country-Year Level Variables					
	Mean	SD	Count	Min	Median	Max
Total Agriculture Aid	3.87	8.56	1,421	0.00	0.97	97.40
Total Non-Agriculture Aid	52.36	121.44	1,421	0.00	11.78	1176.00
Irrigation Projects	0.41	0.81	1,421	0.00	0.11	7.67
Forestry Projects	0.88	1.75	1,421	0.00	0.25	17.00
Conservation Projects	0.50	1.14	1,421	0.00	0.10	12.33
Land Projects	0.47	1.09	1,421	0.00	0.11	13.00
Conservation Land (km^2/cell)	0.05	0.04	1,728	0.00	0.03	0.21
THP Power Share	0.10	0.17	987	0.00	0.00	0.61

Note: This table presents basic descriptive statistics for the country-year level variables used in our heterogeneity analyses.

Table A20: Heterogeneity by the Presence of International Aid Projects, Controlling for Country FE and Year FE interacted with Main Interaction of Interest

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Non-State)
	Panel A: Heterogeneity by International Agricultural Aid			
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0381***	-0.0394***	0.0026	0.0027
	(0.0118)	(0.0116)	(0.0134)	(0.0134)
Rain × Transhumant Pastoral × Total Agriculture Aid	-0.0161*	-0.0177**	-0.0031	-0.0030
	(0.0083)	(0.0080)	(0.0114)	(0.0116)
Rain × Transhumant Pastoral × Total Non-Agriculture Aid	0.0011*	0.0011*	-0.0005	-0.0005
	(0.0006)	(0.0006)	(0.0008)	(0.0008)
	Panel B: Heterogeneity by International Aid Types			
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0359***	-0.0383***	-0.0031	-0.0032
	(0.0120)	(0.0117)	(0.0137)	(0.0138)
Rain × Transhumant Pastoral × Irrigation Projects	0.0251	-0.0069	0.0342	0.0378
	(0.0367)	(0.0346)	(0.0524)	(0.0520)
Rain × Transhumant Pastoral × Forestry Projects	0.0020	-0.0132	0.1487**	0.1422**
	(0.0269)	(0.0255)	(0.0656)	(0.0651)
Rain × Transhumant Pastoral × Conservation Projects	0.0145	-0.0045	-0.0443	-0.0491
	(0.0324)	(0.0231)	(0.0405)	(0.0398)
Rain × Transhumant Pastoral × Land Projects	-0.0890	-0.0356	-0.1500*	-0.1555**
	(0.0606)	(0.0542)	(0.0786)	(0.0784)
Rain × Transhumant Pastoral × Other Agriculture Projects	-0.0157	-0.0098	-0.0159	-0.0127
	(0.0129)	(0.0128)	(0.0188)	(0.0186)
Rain × Transhumant Pastoral × Other Non-Agriculture Projects	0.0009	0.0009	0.0003	0.0003
	(0.0007)	(0.0007)	(0.0008)	(0.0008)
Dep. Var. Mean	0.032	0.024	0.068	0.068
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Rain × Transhumant Pastoral × Country FE	Yes	Yes	Yes	Yes
Rain × Transhumant Pastoral × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	364	364	252	252
Cell Clusters	7,722	7,722	7,722	7,722
Observations	200,772	200,772	138,996	138,996

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. Relevant covariates at the *Own Ethnic Group* and *Own Cell* levels are controlled for but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A21: Heterogeneity by the Presence of Conservation Lands, Controlling for Country FE and Year FE interacted with Main Interaction of Interest

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Nonstate)
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	0.0107	0.0110	0.0869***	0.0863***
	(0.0147)	(0.0138)	(0.0217)	(0.0217)
Rain × Transhumant Pastoral × Conservation Land (km^2/cell)	-0.4324***	-0.4398***	-0.7696***	-0.7622***
	(0.1301)	(0.1227)	(0.1798)	(0.1794)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain × Transhumant Pastoral when Conservation at 10th pctile	36.01	51.01	131.60	131.19
p-value	[0.50]	[0.46]	[0.00]	[0.00]
Rain × Transhumant Pastoral when Conservation at 90th pctile	-133.62	-187.20	4.01	4.30
p-value	[0.00]	[0.00]	[0.87]	[0.86]
Dep. Var. Mean	0.033	0.024	0.078	0.078
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Rain × Transhumant Pastoral × Country FE	Yes	Yes	Yes	Yes
Rain × Transhumant Pastoral × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	420	420	322	322
Cell Clusters	7,517	7,517	7,517	7,517
Observations	225,510	225,510	172,891	172,891

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. Relevant covariates at the *Own Ethnic Group* and *Own Cell* levels are controlled for but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A22: Heterogeneity by Share of Political Power Held by Transhumant Pastoral Groups, Controlling for Country FE and Year FE interacted with Main Interaction of Interest

	Conflict in All Grid Cells			
	(1)	(2)	(3)	(4)
	UCDP I(Any)	UCDP I(State)	ACLED I(Any)	ACLED I(Non-State)
Nearest Neighboring Ethnic Group				
Rain × Transhumant Pastoral	-0.0525**	-0.0481**	-0.0855**	-0.0856**
	(0.0177)	(0.0169)	(0.0293)	(0.0293)
Rain × Transhumant Pastoral × THP Power Share	0.0954**	0.0762**	0.2811***	0.2810***
	(0.0380)	(0.0348)	(0.0755)	(0.0756)
Nearest Neighboring Ethnic Group: Additional Calculations				
Effect of 1 Std. Dev. Rain Shock as % of Dep. Var. Mean:				
Rain × Transhumant Pastoral when THP Power at 10th pctile	-192.61	-235.69	-136.17	-136.81
p-value	[0.00]	[0.00]	[0.00]	[0.00]
Rain × Transhumant Pastoral when THP Power at 90th pctile	-86.52	-122.55	-0.58	-0.69
p-value	[0.05]	[0.04]	[0.98]	[0.98]
Dep. Var. Mean	0.032	0.024	0.075	0.075
Cell FE	Yes	Yes	Yes	Yes
Country × Year FE	Yes	Yes	Yes	Yes
Rain × Transhumant Pastoral × Country FE	Yes	Yes	Yes	Yes
Rain × Transhumant Pastoral × Year FE	Yes	Yes	Yes	Yes
Climate-Zone-Year Clusters	406	406	308	308
Cell Clusters	7,018	7,018	7,015	7,015
Observations	195,975	195,975	149,290	149,290

Note: The unit of observation is a 0.5-degree grid-cell and year. "I(Any)" is an indicator variable that equals one if at least one violent conflict occurs in a cell and year. "I(State)" is an indicator variable that equals one if at least one conflict event involving the state occurs in a cell and year; "I(Non-State)" is an indicator variable that equals one if at least one conflict event not involving the state occurs in a cell and year. *Nearest Neighboring Ethnic Group* refers to the nearest neighboring ethnic territory to cell i. Relevant covariates at the *Own Ethnic Group* and *Own Cell* levels are controlled for but not reported. Standard errors, which are reported in parentheses, are adjusted for clustering at the level of a grid-cell and a climate zone-year. * p < 0.1, ** p < 0.05, *** p < 0.01.