Identifying Impacts of Climate Change on Social Conflicts

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Abstract

Does climate variability indirectly affect rates of social conflict via its impact on natural resources? Does the strength of this relationship change as a function of interaction between local climatic and geographical conditions? Does the interaction between local climate and its environment further shape the capacity and power relationship among local groups in a way that increases rates of social conflict? This topic is situated in the growing literature on the climate-conflict link, which has arrived at contradictory conclusions concerning these issues. Part of the problem is the insufficient modeling of the spatiotemporal effects of climate on conflict. This research tests the joint effects of climate, geographic conditions, natural resources, and power relationships among groups on rates of social conflict. It utilizes a global data set combining country-level aggregate data with high-resolution data which has been plotted on a grid, as they relate to local climatic and geographic conditions. Then, a three-level mixed-effect negative binomial model is employed to examine the connection between climate and rates of social conflict. Data from various resources will be used, including NOAA, SPEI, and UCDP. Preliminary analysis shows that both drought and temperature variations are significantly associated with rates of conflict. In particular, proximity to drought zones as well as connectivity to urban areas each serves as key factors that link climate variability to conflicts. Notably, although drought level does have an impact on conflicts, conflicts tend not to occur in drought areas. Instead, conflicts more often befall locations situated close to urban centers, as well as in non-drought areas because populaces need to source what their basics from the nearest closest urban center or non-drought area.

Introduction

This paper deals with a puzzling relationship among weather variation, economic income, grievance, and conflicts. Grievances exist everywhere within a country, yet conflicts tend to be concentrated within specific locations. Grievances are neither necessary nor sufficient conditions for conflict. Recent studies that use paleo- climatic data suggest that adverse long-term climatic changes and subsequent loss of agricultural output historically have been a significant cause of population decline, wars, and civilizational collapse (Tol and Wagner 2010; Zhang et al. 2007; Zhang et al. 2011; Hsiang et al. 2013). The general conclusion drawn from these studies is ambiguous as to whether past, or even current trends of a region's climate do indeed impact future securities because trade, technological innovation, and other facets of development mitigate a social system's vulnerability to changes in climatic and environmental conditions.

Therefore, this research focuses specifically on the following questions: 1) Does climate variability indirectly affect rates of intergroup conflict via its impact on natural resources and local environmental conditions? 2) Does the strength of relationship among climatic conditions, local environmental conditions, and intergroup conflicts change as a function of the interaction between availability of nature resources and the distances to the nearest urban centers? 3) Does the interaction between local climatic conditions and nature resources further shape the capacity and power relationship among ethnic groups in a way that increases rates of social conflict?

Climate-conflict nexus

This topic contributes to the growing literature surrounding the climate-conflict link (Hendrix and Salehyan 2012; Hsiang, Meng, and Cane 2011; Burke et al. 2009; Miguel, Satyanath, and Sergenti 2004). There are two major schools of thought: one stresses the role of economic factors (Burke, Hsiang, and Miguel 2013; 2015; 2017); another highlights the scarcity of natural resources (Homer-Dixon 1999; 2001). The economic perspective of climate-conflict linkage presumes a damage function of climate change on societies (Burke, Hsiang, and Miguel 2015; Hsiang, Oliva, Walker 2017). The central focus is whether climate variability is indirectly associated with conflicts through its impact on country-level aggregate agricultural productivity, energy use, and economic growth (Lopez et al. 2014; Busby et al. 2014; Detraz and Betsill 2009; Dell 2012; Blattman and Miguel 2010), as well as geographic aspects (O'Loughlin et al. 2012; O'Loughlin et al. 2014) as the key explanatory variables. Yet, results drawn from these studies have arrived at contradictory conclusions (Detraz 2011; De Soysa 2002; Furlong and Gleditsch 2003; Gleditsch, Owen, Furlong, and Lacina 2004; Hensel, Mitchell, and Sowers II 2004; Homer-Dixon 1999).[1] For example, while some studies find that conflict risk increases with higher rainfall (e.g., Hendrix and Salehyan 2012; Theisen 2012), drought (e.g., Bohlken and Sergenti 2010; Hendrix and Glaser 2007), and higher temperatures (e.g., Burke et al. 2009; O'Loughlin et al. 2012), others report no mechanistic climate effect (e.g., Buhaug 2010; Koubi et al. 2012) on different types of conflicts.

Methodologically, economic-based explanations rely mainly on country-level aggregate data and implicitly assume that a given climatic effect has the same impact on each and every society at all times. These empirical studies commonly treat adverse effects of climate as external shocks and ignore both plausible intermediate and contextual effects that might be of significance to the climate-conflict linkage. For example, it is likely that some macro-level conditions (e.g., weaker states' capacities and instable political institutions) may serve as a catalyst in translating the effect of climate variability on political and socioeconomic development, thereby increasing risks of conflict. It is also likely that gaps between rural and

[1] There is also some literature that takes an opposite position and argues that it is resource abundance, rather than resource scarcity, that contributes to conflict.

urban areas and the lack of local infrastructure (Buhang et al. 2010; Raleigh et al. 2014) exacerbate the impact of climate variability on some societies. Thus, some countries are conflict-prone regardless of climatic effects, whereas others are not.

To reconcile the inconsistency among empirical results, Hsiang, Burke, and Miguel (2013) conducted a meta-analysis to reexamine the association between climatic variation and the likelihood of interpersonal conflicts, intergroup discord, institutional breakdown, and population collapse. They found that although the distribution of intergroup conflict is broader and covers values that are larger in magnitude than other types of conflicts,[2] there is a significant association between climatological changes and conflict across ranges of geography, different time periods, and that of spatial scales, as well as across climatic events of different duration (Hsiang and Burke 2013a; 2013b).[3] However, their analysis mainly tested the direct effect of climate on conflict, and thus it is still unclear whether this effect still exists once political and socioeconomic factors are taken into account.

Literature on climate-induced environmental and resource scarcity[4] (Homer-Dixon 1999; 2001), on the other hand, emphasizes that changes in climatic conditions are likely to exacerbate conflicts in places where people are dependent on accessibility to natural resources for their incomes (Hendrix and Glaser 2007; Salehyan and Hendrix 2014; Homer-Dixon 2001).[5] For

[2] For the meta-analysis, HBM assume that given effects across studies are heterogeneity, e.g. different types of intergroup conflict in different regions responses to different climate variables differently.

[3] Their result show that with an interquartile range of 6 to 14% per 1sigma and the 5th to 95th percentiles spanning –5 to 32% per 1 sigma. They maintain that these variations might be meaningful since different types of climate variables have different impacts, or that social, political, economic, or geographic conditions mediate the effect of climate change. It might also because measurement error, mis-specified model, and difference on the definition of conflicts.

[4] Honer-Dixon (1999) theorized three types of resource scarcities: 1) demand-induced scarcity, which is resulted from resource degradation or depletion, population growth and increased demand, and unequal distribution of resource; 2) supply-induced scarcity occurs when there is a sever degradation of renewable resources or environment simultaneously no powerful institutions to guarantee a sustainable use of resources; 3) structural-induced scarcity, which typically refers to the effect of institutions, such as institutions or laws of property right. Consequently, scarcity might contribute to ethnic clashes, rebellion, insurgency, or military coups.

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example, in many rain-fed agricultural countries where most of the population's income relies mainly on natural capital or employment in the primary sectors, such as Kenya and Uganda, researchers have found that conflicts during drought periods are significantly higher than normal periods (Nordas and Gleditsch 2007; Barnett and Adger 2007).

Given this theoretical perspective, there are three types of scarcity: supply-induced scarcity, demand-induced scarcity, and structural scarcity (Homer-Dixon 1999). Supply-induced scarcity[6] refers to the situation where the availability of renewable resources is reduced due to consumption and degradation that develop faster than regeneration processes (Homer-Dixon 1994; 1999). Demand-induced scarcity[7] is defined as a situation where the growth in population and agricultural productivity leads to increased pressure on local renewable resources, such as available water for irrigation (Gizelis and Wooden 2010). Structural scarcity is caused by an unequal access to natural resources, and this unequal access interacts with and reinforces demand and supply induced-scarcity, shaping the pathway toward resource capture[8] and ecological marginalization[9] (Homer-Dixon 1994; 1999).

The resource scarcity literature places special emphasis on already-fragile states where people have low coping capacity to the adverse effects of climate variability on natural resources.

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effect of institutions, such as institutions or laws of property right. Consequently, scarcity might contribute to ethnic clashes, rebellion, insurgency, or military coups.

[6] For example, in some regions, the supply of water is determined by climatic factors. Climatic conditions affect evapotranspiration and snow cover, which in some regions acts as a natural reservoir of freshwater that eventually becomes available downstream during the summer months (Parry et al., 2007). Yet, in practice, water supply is more than a simple function of deviations in rainfall and temperature patterns. Water storage capacities in the form of reservoirs or dams, river flows across water basins, and general water dependency are likely to matter as well.

[7] Some scholars stress that even in the absence of significant population pressure, the demand for freshwater in low- and middle-income countries is likely to increase with economic development and related processes, such as industrialization, energy production, health and sanitation developments, or changing food habits, including the expansion of irrigation systems in arid regions (Hoekstra and Chapagain 2006; Gleick 2011). Only in wealthy and technologically advanced societies is the net effect of additional development likely to lower the mean water consumption per capita (i.e., increasing efficiency and substitution strategies outweigh increasing demand from changing consumption habits).

[8] When a resource is declining, if powerful elites attempt to secure resources that may become scarce in the future, they are likely to manipulate polices in their own favors, which could result in even greater scarcity for weak groups or governmental failure in response to social grievances. Either case can exacerbate existing social tensions among groups of population or increase the likelihood of new conflict onset.

[9] Ecological marginalization takes place when group of people faced with scarcity of resources migrate into an area where are already a fragile eco-system, in turn creating greater scarcities in that area and deprivation conflicts between natives and newcomers.

In these states, in the face of resource dearth, powerful, more influential groups may be able to gain further access to resources by affecting various governments' decision-making and resource redistribution faculties. Those being deprived would have little choice but to engage in collective conflict in order to fight for their needs, thereby causing even more skirmishes. With decreasing access to livelihood needs, economic incomes, or renewable resources, frustrations and grievances against the state are likely to be amplified in ways that increase the opportunity for instigating an insurrection (Homer-Dixon 1999). For example, one of the pathways that has been found is that higher temperatures or low precipitation levels can cause scarcities of water, food, and arable land (Fjelde and von Uexkull 2012; Raleigh and Kniveton 2012; Gizelis and Wooden 2010; Raleigh and Urdal 2007).

Homer-Dixon's theoretical work has elucidated the understanding of how relative deprivation and grievance might result in conflict (see also Gurr 1970). However, there are two major drawbacks regarding the scarcity-based explanation. Theoretically, the paradox is that the fear of environmental change as dramatic and all-encompassing can overshadow social processes that are important in bringing about large-scale conflict. Besides, the feasibility of a rebellion should be lower if there is a severe scarcity that does not affect powerful players in national politics (Goldstone 2001). Resource scarcities not only weaken an organized group's capacity but also undermine the capability of a state (e.g. failing to deal with scarcity can stimulate mass resentment and cause a state to lose its legitimacy). When a state's capacity declines, the opportunity costs for social actors engaging in a rebel group might decrease simultaneously. In the absence of political struggles that set elites in opposition to the state, large-scale conflict is unlikely; in the presence of sever scarcity, an effective mass mobilized conflict potential vis-à-vis the state is likely to be unsuccessful even though public motivation is present (Suhrke 1997; Klare 2001). The climate-conflict link is counter-intuitive since the cost of mobilizing groups of people engage in collective violent (or non-violent) conflict could indeed be high and immediate, whereas climatic risks are often hidden and their impacts are long-term phenomena (spanning at least a decade). As a result, conflicts may or may not occur.

Moreover, the link between climate-induced conflicts is not readily apparent due to the mismatch between the time horizon of climate change and outbreaks of conflict. More specifically, there is a potential mismatch between the circumstances under which groups of individuals are motivated to fight for their livelihood in the short-term, with that of the perception of climate encompassing a set of uncertain factors for surviving in the long-term. Climate change, by definition, refers to changes in average weather conditions at a given location over the epoch of at least a decade. It may ensue smoothly or transpire in a punctuated pattern (Alley et al. 2003). In other words, climate is not a day-to-day phenomenon but a long-term average of the weather in a given place.[10] Conflict onset, on the other hand, often requires at least two organized parties and incompatible demands involving the same set of limited resources. It is an accumulation of day-to-day life dissatisfactions and rivalry which may take place in dramatic fashion, varying in their respective types and degrees, often times contingent upon political and socioeconomic factors.

Furthermore, resource scarcity scholars theorize a disaggregate linkage between climate and resource scarcity, but the use of national aggregate data is problematic because the linkage between climate, resource, and conflict is not readily apparent due to the large spatial variations on climatic conditions and conflicts within a country. For cases where competition over resource is an important dimension, conflicts are likely to be spatially concentrated toward the distribution and accessibility of resource (e.g., O'Loughlin et al. 2012; O'Loughlin et al. 2014). Using aggregate data and country as the unit of analysis can mask huge variations in conflict and

[10] According to EPA, climate is defined "not only by average temperature and precipitation but also by the type, frequency, duration, and intensity of weather events such as heat waves, cold spells, storms, floods, and droughts." http://www.epa.gov/climate/climatechange/science/indicators/weather-climate/index.html

environmental conditions within countries. This calls into question of using country-level panel data to analyze the actual impact of climate on conflicts.

In sum, it remains ambiguous whether there are important intervening factors interacting with one another in ways which jointly impact conflicts (Milder et al. 2011, 159-160). My study takes a step back and rethinks how climate variability might link to conflicts. Instead of simply focusing on resource scarcities, I examine how the relationship among climate variability, resource scarcity, and power relationships among groups at local levels is moderated by its connectivity to urban areas, and then tests their joint effects on risks of conflict. This paper hypothesizes that connectivity of a locale to the nearest urban center can determine whether or not groups of people engage in conflict. Because urban centers can provide members of a group with their household needs, there is no incentive for them to fight for resources when they live close to metropolitan areas or can travel to municipalities to obtain provisions.

Research Design

This paper attempts to identify spatiotemporal effects of climate on social conflicts, with a focus on effects of resource scarcity and inter-group power relationships. More concretely, I explore the spatial association between climate variability and resource scarcity, and test how the rates of social conflict change as a function of the interaction among climatic conditions, local natural resource conditions, and power relationships among groups across countries over time. Existing literature have arrived at contradictory conclusions concerning the relationship between climate variability and social conflicts (e.g., Dell, Jones, and Olken 2014; Hendrix and Salehyan 2012; Theisen 2012; Bohlken and Sergenti 2010; Hendrix and Glaser 2007; Burke et al. 2009; O'Loughlin et al. 2012; Buhaug 2010; Koubi et al. 2012). These contradictory conclusions are, in part, a result of insufficient modeling of the spatiotemporal effects of climate on conflict given the large-scale spatial variations.

Country-level aggregate data, such as conflict events counts, average annual temperature, and precipitation, have been dominantly used by existing empirical studies. Yet, using country-level aggregate data can mask huge climate variability within a nation, thus undermining whether or not variations in regional climate can necessarily be associated with conflict in specific regions. It may also be that temperature and precipitation time series are correlated differently across regions, and drought indices might be spatially correlated (Hsiang, Meng, and Cane 2011; Auffhammer et al. 2013). As a result, some research may inappropriately measure the influence of an omitted climate variable by proxy (Auffhammer et al. 2013; Hsiang, Burke, Miguel 2013). Since advanced tools now ensure climatic data at fine scale, my study attempts to improve the estimation of differential impacts of climate variability on resource scarcity across spaces over time by compiling disaggregate spatial data.

The dependent variable in this study is data on social conflicts, measured by conflicts where armed force was used by two parties, of which an organized actor against another organized actor and a government was also engaged in the conflicts. I use data from UCDP conflict data. Climate variability is the independent variable, measured by the factors of: change in grid-cell level annual average temperature, annual rainfall, and annual drought index.[11] Temperatures, precipitations, and the drought index are from NOAA and the SPEI Global Drought Monitor. I also use distance to drought areas (quantified in km) as a proximal measurement for drought levels. This study examines the mediating effect of availability of natural/renewable sources on conflicts, including areas of forest, irrigation, and connectivity of an area to its nearest urban center. Connectivity to urban areas is measured by travel time to the nearest urban center (average minutes/per km). Connectivity of an area to its nearest urban center is the important missing linkage, in that even if it is true that drought might exaggerate conflicts via its impacts on

[11] Measurement: levels of total annual precipitation (1,000 mm) and mean temperature (°C); drought index (SPI) is based on a transformation of the accumulated precipitation into a standard normal variable with zero mean and variance equal to one. In this paper, I use SPI6, which is a standard deviation from the 6-month mean precipitation.

available natural resources, groups of people can resolve this problem by traveling to the nearest urban areas. In some instances, groups of people could also migrate if their current living environment becomes uninhabitable. And if people are able to travel to a nearest urban area, conflict rates in the urban areas are likely to increase, whereas decline in areas where resources are not abundant.

Examining the effects of climate variability on conflicts at a subnational level matters since conflicts may be concentrated in specific subnational locations. This study generates a global data, which spatially join climatic variables, conflict event count, and natural resource variables. The output is a high-resolution global gridded data set (i.e., a 0.5 x 0.5 decimal degree cell resolution). Each grid is roughly 55 x 55 kilometers at the equator (3025 square kilometers area). The size of a grid area decreases at higher latitudes due to the curvature of the earth. The period covers from 1952 to 2005 because climate, by definition, refers to the average weather condition over a 30-year period. This disaggregate data set has a multilevel structure, in which the spatial structure is constituted by country-level and grid cells, and the time structure is years.

I further test the moderating effect of power relationships among groups on the resource scarcity-conflict nexus. Groups' power relationships include four categories: power-sharing, dominance, autonomy, and powerless. Of these four types, power sharing is the reference type in the analysis. All groups have their own unique group code and grid cell code.

Identifying the underlying mechanisms becomes more challenging if many socioeconomic and political variables are endogenous with one another, or if different mechanisms dominate in different contexts (Hsiang, Burke, and Miguel 2013). As such, climate variables affect many of the socioeconomic factors commonly included as control variables. This leads to the outcome that: 1) the effect of the climate variable is inappropriately absorbed by the control variable, which in turn leads to underestimating the role of the climate factor on conflict; and 2) the estimation is biased since the population differs in unobserved ways (e.g., culture) and these factors are either omitted or correlated with climate factors.

Consider, for example, income as a control variable. The main finding is that although rainfall is positively associated with per-capita income growth in African countries (Miguel and Satyanath 2011; Bruckner and Ciccone 2011; Burke and Leigh 2010), both climate–related factors and political influences have an effect on conflict and income and thus, revenue variables absorb the effect of climate and political factors, resulting in the small coefficient of each of the latter two considerations (Hsiang et al. 2013). Therefore, the inclusion of certain control variables might be problematic because many socioeconomic control variables, by themselves, are affected by climate factors. In this study, pre-existing unsolved conflicts and spatial lag of conflict in each neighborhood grid-cell are controlled. Below is the statistical model:

$$Social\ Conflict_{ijt} = \sum_{x1=1}^{4} \beta_{x1} (climatic\ variables_{ij,t} - \overline{climatic\ variables_{j,t}}) + \sum_{x2=1}^{3} \beta_{x2} (local\ natural\ resources_{ijt} - \overline{local\ natural\ resources_{jt}}) + \beta_{x3} (inter-group\ power\ relationships) + \beta_{me} (local\ natural\ resources \times climatic\ variables) + \beta_{mo} (intergroup\ power\ relationships \times local\ natural\ resources) + \sum_{z=1}^{2} Z_{ijt} + u_{i00} + u_{jo} + \varepsilon_{ijt})$$

Where ***i*** is country-level; ***j*** is grid-cell level; ***t*** is year; β_{x1} is the coefficient for 4 centered climatic variables (x1=1,2,3,4), climatic variables are measured at grid cell level; β_{x2} is the coefficients for 2 centered local natural resource variables; β_{x3} is the coefficient for the inter-group power relationships (4 types of inter-group power relationships), and this variables is defined as a moderator. β_{me} is the coefficient for the mediating effect; β_{mo} is the coefficient for the moderating effect. ***Z*** represents the two control variables, previous conflicts and spatial lag of conflict in neighborhood. All variables are grand-mean centered.

I employ a three-level mixed-effect negative binomial model in which the numbers of years are modeled at level-1, grid-cells/groups are modeled at level-2, and level-3 is countries. The advantage of this analysis is that it allows the examination of annual climate variability at a subnational level, while simultaneously allowing for the country-level random effects. This study defines inter-group power relationships as a moderator, and forest resources and irrigation as mediators. Power relationship among groups captures not only the existing power structure but also climate relevant resources and environmental conditions within a location that might affect relationships between groups.

Figure1 to 4 are examples that illustrate how variables are measured at grid-cells. Figure 1 plots the spatial distribution of conflict events and urban areas. Figure 2 and Figure 3 plot maximum temperature and precipitation measured at grid cell level. Figure 4 plots inter-group power relationships.

Figure 1 Spatial Distribution of Conflict Event and Urban Areas, 1987

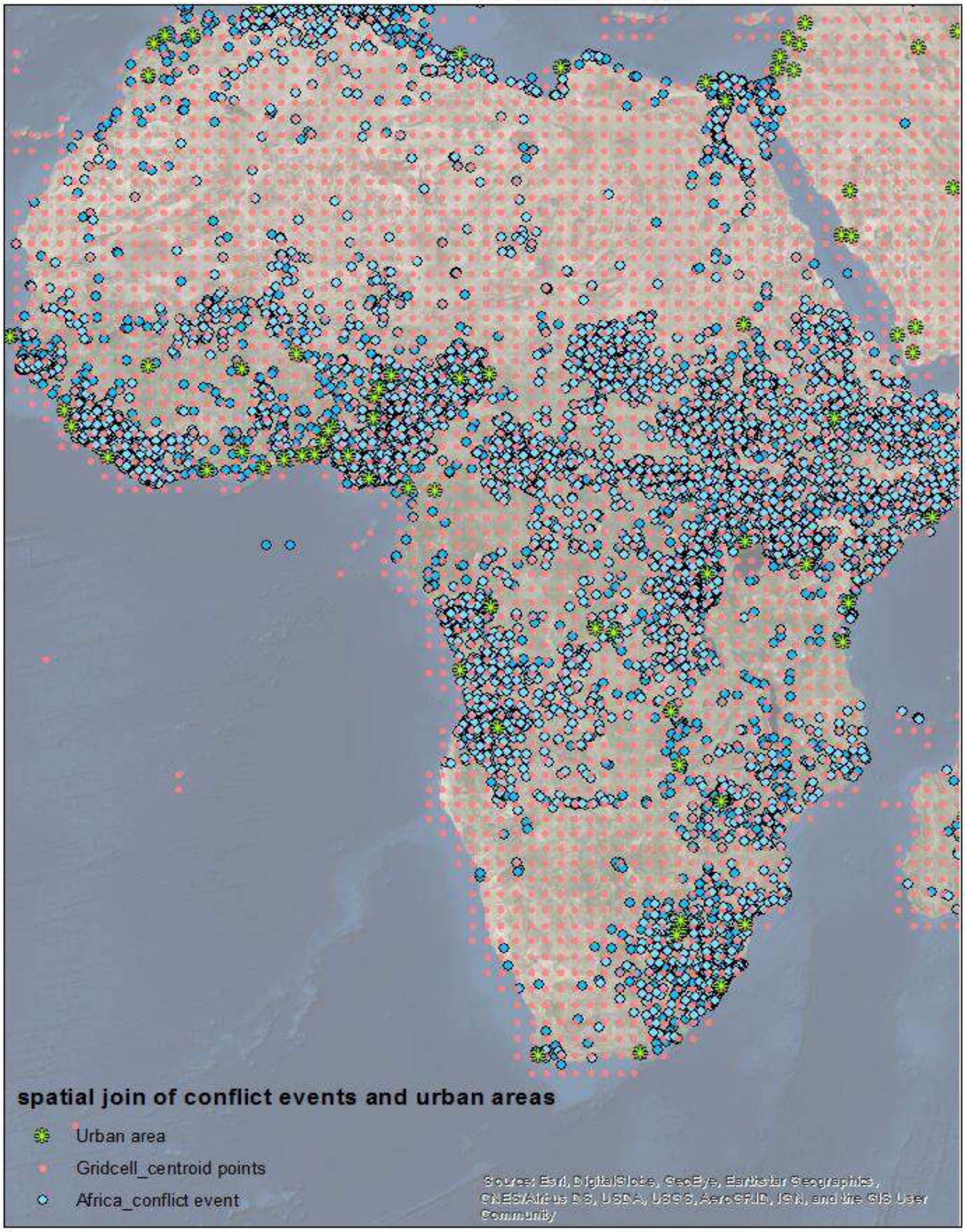


Figure 2 African Continent Maximum Temperature (measured at grid cell level), 1987

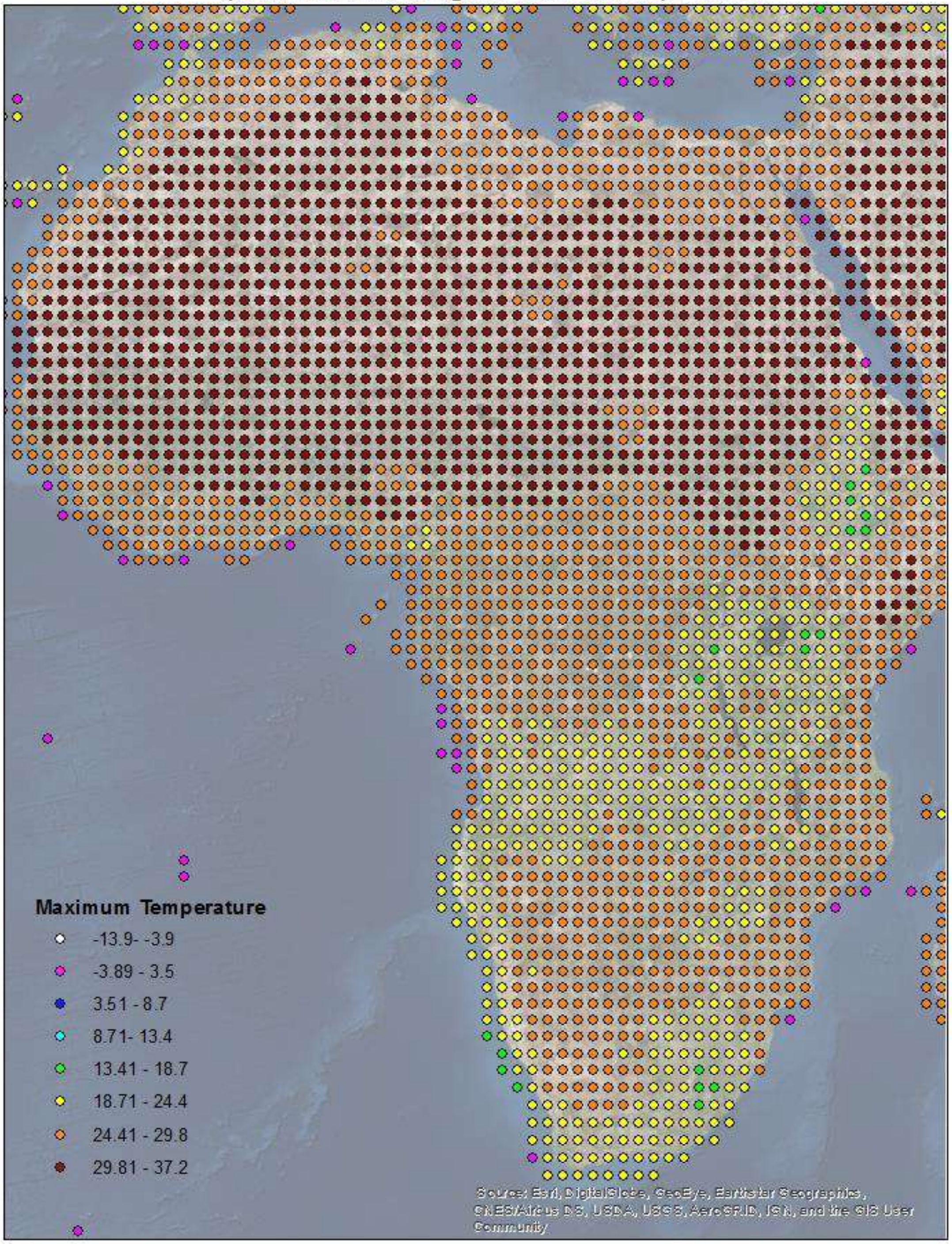


Figure 3 African Continent Maximum Precipitation (measured at grid cell level), 1987

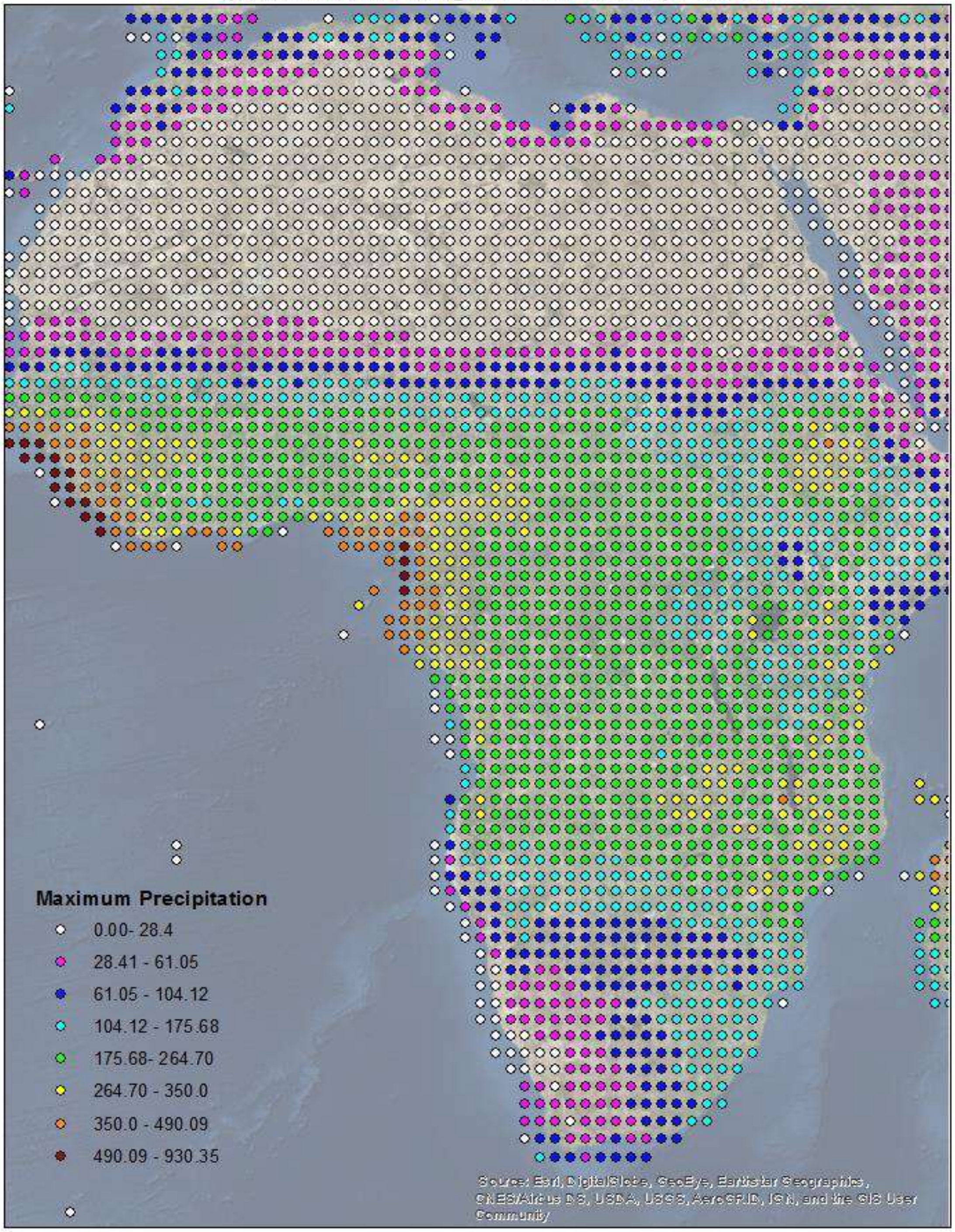
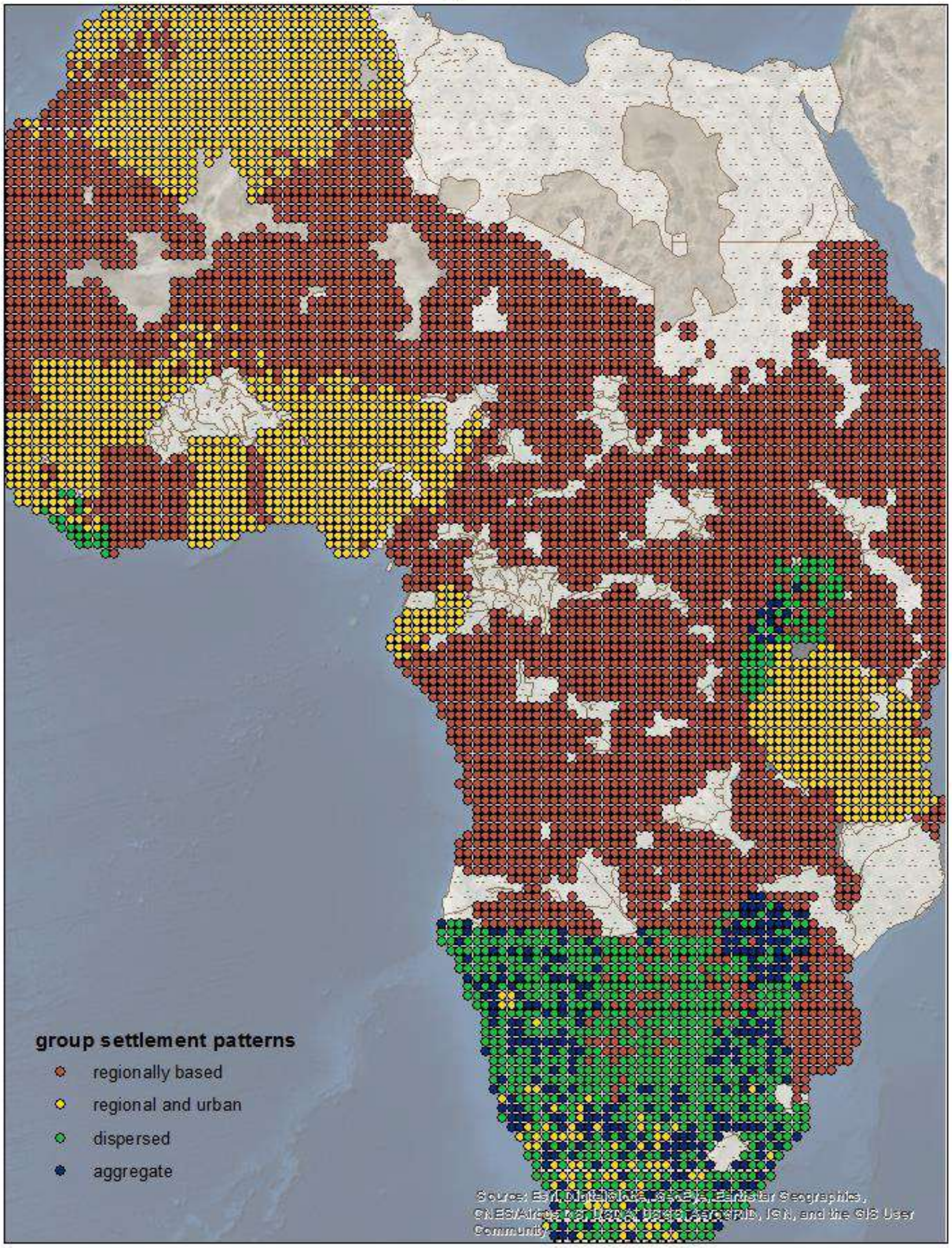


Figure 4 Group Settlement Patterns (measured at grid cell level), 1987



Models and Results

I first test whether or not a three-level multilevel model is necessary. Table 1 below shows that this three-level multilevel negative binomial model is more appropriate than that of a negative binomial model. Also, time effects (linear, quadratic, and cubic time effects) are all insignificant; thus, controls were set only for the linear time-trend.

Table 1 Null model and Time Effect Model

Variables	Null Model	Time Effect Model
	IRR (Std Err)	IRR (Std Err)
AIC	4549.31	4553.54
BIC	4583.75	4613.81
Wald Chi2		1.76 (not significant)
Intercept	.002	.0001
Linear		1.69 (.92)
Quadratic		0.97 (.03)
Cubic		1.00 (.0005)
Country variance (con)		8.00 (3.68)
Grid-cell group variance (con)		11.94 (4.55)
Better than signal-level Negative Binomial Regression?	Yes (LR test sign at p<.0001)	Yes (LR test sign at p<.0001)
N: 40543; Grid-cell level number of groups: 122; countries: 24 *p<.05; **p<.01; ***p<.001		

Next, I test whether there is a difference on the impact of climatic variables regarding conflicts. Table 2 includes three models: a linear climate fixed effect model, and two non-linear climate fixed models (temperature, and drought non-linear effect). The results show that the linear effect of temperature and drought are consistently significant, as well as associated with an increase in conflict rates; yet when non-linear temperature effect is modeled, conflict rates seem to be reduced and the linear temperature effect on conflicts becomes insignificant.

Additionally, although rainfall is significantly associated with a reduction in conflict rates, there is only a small reduction in such when compared with the effect of temperature and drought on conflicts. Temperature and drought seems to be stronger predictors.

Table 2 Comparing Effects of Linear & Nonlinear Climatic Variability on Conflicts[12]

Variables	Linear Fixed Effect Climate Model (+/- change in % of conflict rate per year)	Non-Linear Climate Model (Temperature) (+/- change in % of conflict rate per year)	Non-Linear Climate Model (Drought) (+/- change in % of conflict rate per year)
Temperature	(+)***	(+)	(+)***
Precipitation	(-)**	(-)	(-)*
Drought	(+)***	(+)**	(-)
Distance to drought areas (km)	(+)***	(+)*	(+)
Non-Linear Temperature		(-)***	
Non-Linear Drought			(+)

The first model examines the relationship between climate variability, inter-group power relationships, and conflict. Table 3 is a summary of the statistical results. The analysis shows that an increase in annual temperature and drought levels are significantly positive and associated with an increase in the incidence rate ratio of conflicts. An increase in the average annual temperature escalates the occurrence of conflict in a year by 19%, and the increase in one (1) unit of drought index is associated with the increase of conflict to 41%. Although the distance of a location to neighborhood drought areas is also positively related to conflict rates, if a group is dominant within a geographical area, compared with those groups which share power with others, the conflict rate decreases 1% (roughly). Moreover, an increase in annual precipitation is likely to reduce conflict in a year's time. The reason for this is likely because the

[12] See Table 2A for detail statistical result

increase in rainfall helps to reduce uncertainty regarding food stocks for many African countries, thereby resulting in fewer conflicts.

The second model introduces connectivity of a location to the nearest urban center as the moderator. Temperature and drought levels are still both significantly and positively associated with conflict. An increase in the level of drought occurrence, as well as that in temperature, is very likely to result in a reduction in agriculture productivity (e.g., crops), and therefore a reduction in economic growth or a heightened insecurity about food stocks and thus, more conflict. When a group exists in a location whereby they are far from urban centers but the area itself is either not a drought quarter or is well distanced from one, the conflict rate is still likely to increase. This indirectly indicates that conflicts may occur in non-drought areas although seasons of drought are definitely capable of impacting rates of conflict. In addition, large-scale conflicts can occur in locations situated close to urban centers, or in populous municipalities themselves as people groups typically source their sustainable needs from urban centers.

Moreover, dominant and powerless groups tend to fight more amongst themselves than do groups which share authority when they dwell far from an urban center. Yet, if a dominant group and powerless group live in locations far-removed from a drought area, or actually in a non-drought area, the conflict rate reduces (roughly 1%). From the perspective of faction empowered relationships, this result makes sense because a dominant group has the ability to prevent physical challenges from opposing parties when the areas in which they live are secure, familiar and habitable, whereas powerless groups may not have the motivation to engage in any form of conflict due to the uncertainty of their environment. Thus conflict rates decrease. This indicates that connectivity of a location to the nearest urban center is an important moderator. However, this cannot explain locations with autonomous groups.

Table 3 Climate Variability, Inter-group power relationships, Connectivity to Urban Area, and Conflicts[13]

Variables	Climate, Inter-group power relationships, and Conflict (+/- change in % of conflict rate per year)	Climate, Inter-group power relationships, Connectivity to Urban Area, and Conflict (+/- change in % of conflict rate per year)
Temperature	(+)***	(+)***
Precipitation	(-)*	No sign
Drought	(+)**	(+)**
Inter-group power relationships (reference: power showing)	No sign	Monopoly(+)*** Powerless(+)**
Distance to drought areas(square_km)	(+)*	(+)***
Connectivity to nearest urban center (avg.minutes)		(-)***
Distance to drought * Connectivity to urban		(+)***
Inter-group power relationships * distance to drought area	Monopoly(-)*	Monopoly(-)*** Powerless(-)**
Inter-group power relationships * travel time to urban area		Monopoly(+)*** Powerless(+)**
Inter-group power relationships * distance to drought area * travel time to urban area		Monopoly(-)*** Powerless(-)**

Finally, I examine the relationship between climate, forest, and irrigation, as they correlate to conflicts since forests and irrigation are crucial to local people/groups in African countries. Table 4 indicates that the percentage of irrigated areas within a location is both significantly and positively associated with conflict, whereas the percentage of forested areas is not. The effects of drought are also moderated by irrigation. When groups live in a location that is largely irrigated, conflict reduces by 1%.

[13] See Table 3A for detail statistical result

Table 4 Models of Climate, Forest Resource, Irrigation, and Conflict[14]

Variables	Climate, Forest Resource, and Conflict (+/- change in % of conflict rate per year)	Climate, Irrigated Area, and Conflict (+/- change in % of conflict rate per year)
Temperature	(-)	(+)
Drought	(+)***	(+)**
Non-linear Temperature	(-)*	(-)*
Forest resource (percentage area)	(-)	
Irrigation system (percentage area)		(+)*
Drought * forest resource	(-)	
Drought * irrigated area		(-)
Distance to drought	(+)*	(+)*

Conclusion

This study explores the conditions under which climate variability influences domestic conflicts. On the one hand, this research tests whether the effect of climate on conflict is transmitted through resource scarcity, and whether this relationship is further moderated by the power relationships among groups and the connectivity of an area to urban centers in close proximity thereof. This study contributes to existing climate-conflict study by employing a disaggregate analysis through the use of grid-cell spatial data to avoid inappropriate aggregation.

The results show that climatic variables, especially temperature and drought, are significantly associated with conflicts. The effects of climate variability on social conflict are transmitted through the mediator, inter-group power relationships. Thus, climate variability has

[14] See Table 4A for detail statistical result

indirect effects on conflict rates. This relationship is further tempered by the moderator, which is connectivity to those urban centers closest to the affected group. Notably, although drought levels do have an impact on conflicts, skirmishes tend not to occur in drought areas. Instead, conflicts more often befall locations situated close to urban centers, as well as in non-drought areas because populaces typically source basic provisions from the closest urban center or non-drought area.

Moreover, conflict rate ratios increase when dominant and powerless groups live in areas far from urban centers. Yet, if a dominant group and powerless group live in a non-drought location and are far-removed from drought-stricken areas, the rate of conflict is reduced. This indicates that the connectivity of a location to the nearest urban center is an important moderator. Still, this cannot explain locations with autonomous groups.

However, the result does not support the hypothesis involving resource scarcity. In this study, the percentage of forest cover within an area is not significantly associated with either an increase or decrease in conflict rates. Also, the main effect of irrigated areas appears to relate significantly to the increase in conflict rates, and can moderate the impacts of a drought. The implication drawn from this study is that climatic effects on conflicts are consistently significant, yet conditional. A disaggregate analysis can help tease out how climate variability might link to conflict, since it avoids inappropriate aggregation that might otherwise ignore the various impacts of climate variability on local dynamics.

Appendix

Table 2A Comparing Effects of Linear & Nonlinear Climatic Variability on Conflicts

Variables	Linear Fixed Effect Climate Model	Non-Linear Climate Model (Temperature)	Non-Linear Climate Model (Drought)
	IRR (Std Err)	IRR (Std Err)	IRR (Std Err)
AIC	3831.38	3776.95	3831.27
BIC	3906.80	3860.75	3915.07
Wald Chi2	39.35 (p<.0001)	55.97 (p<.0001)	40.99 (p<.0001)
Intercept	.002	.004	.002
Annual average temperature	1.18*** (.05)	1.08 (.06)	1.18*** (.05)
Annual average rainfall	.99** (.0004)	.99 (.0004)	.99* (.0004)
Annual drought	1.46*** (.16)	1.43*** (.16)	.699 (.36)
Distance to drought areas (km)	1.002** (.0007)	1.0001* (.0007)	1.001 (.0007)
Non-Linear Temperature		.93*** (.01)	
Non-Linear Drought			1.35 (.28)
Time fixed effect	.97 (.02)	.98 (.02)	.97 (.02)
Country variance (con)	8.8 (4.15)	8.18 (4.00)	8.83 (4.17)
Grid-cell group variance (con)	13.3 (5.45)	13.23 (5.47)	13.45 (5.53)
N: 32187; grid-cell level number of groups: 119; countries: 24 *p<.05; **p<.01; ***p<.001			

Table 3A Climate Variability, Inter-group power relationships, Connectivity to Urban Area, and Conflicts

Variables	Climate, Inter-group power relationships, and Conflict	Climate, Inter-group power relationships, Connectivity to Urban Area, and Conflict
	IRR (Std Err)	IRR (Std Err)
AIC	3116.58	3007.83
BIC	3240.47	3197.8
Wald Chi2	49.95 (p<.0001)	116.07 (p<.0001)
Intercept	0.0004	0.000004
Annual average temperature	1.19*** (.05)	1.27*** (.06)
Annual average rainfall	.999* (.0005)	.999 (.0005)
Annual drought	1.41** (.17)	1.38** (1.17)
Type of inter-group power relationships (reference: power showing)		
Autonomy	4.29 (7.1)	.00007 (.0009)
Dominance/ Monopoly	1.23 (1.3)	175.06*** (272.34)
Discriminated/Powerless	2.14 (1.06)	39.00** (49.31)
Travel time to the nearest urban areas (average minutes)		.99*** (.003)
Distance to drought areas (km)	1.003* (.001)	1.01*** (.003)
Interaction between distance to drought area and travel time to urban area		1.00003*** (.000007)
Interaction between inter-group power relationships and distance to drought area		
Autonomy	.999 (.003)	.97 (.06)
Dominance/ Monopoly	.996* (.002)	.99*** (.004)
Discriminated/Powerless	.998 (.002)	.99** (.003)
Interaction between inter-group power relationships and travel time to urban area		.98

Autonomy Dominance/ Monopoly Discriminated/Powerless		(.02) 1.01*** (.003) 1.01** (.003)
Interaction between inter-group power relationships, distance to drought area, and travel time to urban area (reference: power sharing) Autonomy Dominance/ Monopoly Discriminated/Powerless		.9999 (.0002) .99997*** (.000009) .99998** (.000002)
Spatial lag of conflict neighborhood	.15** (.1)	.22* (.15)
Country variance (con)	9.08 (4.88)	6.9 (4.19)
Grid-cell group variance (con)	16.8 (8.63)	15.6 (7.99)
N: 28524; Grid-cell Level number of groups: 108; countries: 22 *p<.05; **p<.01; ***p<.001		

Table 4A   Models of Climate, Forest Resource, Irrigation, and Conflict

Variables	Climate, Forest Resource, and Conflict	Climate, Irrigated Area, and Conflict
	IRR (Std Err)	IRR (Std Err)
AIC	255.6	279.77
BIC	314.9	339.39
Wald Chi2	16.44 (P<.05)	14.43 (p<.05)
Intercept	.0004	.002
Annual average temperature	.89 (.17)	1.08 (.22)
Annual drought	6.67*** (3.87)	7.81** (5.21)
Non-linear Temperature	.84* (.07)	.85* (.06)
Forest resource (percentage area)	.97 (.02)	
Irrigation system (percentage area)		2.15* (.68)
Interaction between drought and forest resource	.999 (.003)	
Interaction between drought and irrigated area		.98 (.01)
Distance to drought areas	1.01* (.006)	1.01* (.007)
Spatial lag of conflict neighborhood	2.05 (8.5)	4.2 (16.8)
Country variance (con)	7.52 (5.5)	2.8 (2.5)
Grid-cell group variance (con)	Close to zero	Close to zero
*p<.05; **p<.01; ***p<.001		

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