

Drought, Local Public Goods, and Inter-communal Conflicts: Testing the Mediating Effects of Public Service Provisions.

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ABSTRACT: Water charities and the UN development goals consider access to clean water and sanitation as transformative: improving personal dignity, quality of life and economic opportunities for individuals and the economic resilience of communities to climate stress. Can the provision of services also mitigate the conflict potential arising from climate change? If so, how broad must access be to become effective? We test how household access to improved water, sanitation, and electricity affects the probability of local conflict in nine drought-prone African countries. We use annual PRIO-GRID cells as the unit of analysis and model the probability of a grid-cell experiencing fatal armed conflict during local or proximate drought conditions. DHS data are used to calculate the percentage of households with access to specific services. We show that even relatively modest investments in reliable sanitation and water infrastructures enhance communities' ability to avoid getting drawn into violent conflict in response to rainfall shocks.

INTRODUCTION

In recent years violent conflicts between sedentary farmers and nomadic herders in the Sahel region have escalated and spread ever further south. Due to the rise of Jihadist groups in the region the “deadliest conflict you have never heard of” is often framed as ethnic or religious tension but competition over diminishing land and water resources is often cited as its root cause (Foreign Affairs 2019, BBC 2019, Reuters 2018). Scholars across academic disciplines still debate whether resource degradation associated with climate change contributes to political instability and violent conflict (Benjaminsen et al. 2012; Hsiang et al. 2013; Mach et al. 2019). Large-N disaggregated studies as well as ethnographic case studies find mixed evidence for a relationship between drought, scarcity, and the probability of violent conflict. Clearly, the implications of resource scarcity are not the same across all communities. One understudied question is what local factors can mitigate the effects of drought on the risk of conflict. Our analysis focuses on how droughts affect the risk of local conflicts while considering the mitigating effect of access to public services such as improved sanitation, water access, and electricity.¹

The existing literature has attributed the lack of a clear relationship between resource stress and violent armed conflict to factors such as adaptive local responses including migration and emergency relief (Buhaug et al. 2010; Martin 2013). In this article we focus on policy outcome variables such as access to public services that enable local communities to better handle resource scarcity under drought conditions. We posit that access to services such

¹ Most studies that seek to consider the effects of climate change are confined to studying the effects of historical variations in the weather (Gleditsch 2012). The relevance for understanding future challenges associated with a changing climate rests on the assumption that variations in weather will increase because of climate change (Hsiang et al. 2013).

as wells or piped drinking water, improved sanitation and electricity may reduce vulnerabilities to drought and mitigate the risk of violent armed conflict. More specifically, these local public services can mitigate the conflict effect of drought by improving economic conditions and public health of the local population. We are primarily interested in the distribution of access, measured by the proportion of people within a community that have access to certain services. We are not concerned about who provides the services (the state, NGO's, private providers) or why (political expediency, humanitarian goals or support of co-ethnics), but rather the effect on conflict if the service provision is relatively inclusive or limited to a privileged few.²

We test our hypothesis using fine-grained spatial data. We assess how the probability of a grid-cell experiencing incidents of fatal armed conflict correlates with household survey data on the provision of three types of local public services – electricity access, improved sanitation, and improved water access. We expand previous research on water and road infrastructure (Detges 2016) by using PRIO-GRID data and modelling improved water access as a continuous variable rather than a binary one, as well as adding improved sanitation and electricity access as further potential mitigating factors.

We examine nine African countries – Burkina Faso, Cameroon, Central African Republic, Ethiopia, Kenya, Mali, Niger, Nigeria, and Senegal – that are covered by the Demographic and Health Surveys (DHS) and are extremely vulnerable to droughts.³ All nine countries face the most adverse conditions of resource stress. The Sahel is a region where droughts are frequent, prolonged and often linked to famine (Ahmadalipour and Moradkhani

² We do empirically control for the endogenous provision of local public goods in the robustness section and online Appendix E.

³ Droughts accounted for 8% of natural disasters globally but for 25% of natural disasters in Africa between 1960-2006 (Gautum 2006).

2018; Hansen et al. 2004; Naumann et al. 2014). Together, these countries present ideal conditions for testing the hypothesized mitigating effect of public access to services on violent armed conflict (Levy 2008). If the hypothesized mechanism holds in these Sahel countries, then further research can expand the scope conditions of this study. We find evidence that conflict is affected by local droughts as well as droughts in neighboring areas. Moreover, we find that improved sanitation, and to a lesser extent, improved water access, can mitigate the risk of conflict from droughts, although we do not find a mitigating effect of electricity access.

THEORIES OF SCARCITY, CLIMATE CHANGE, AND CONFLICT

The literature identifies different mechanisms inducing conflict. The first concerns the effects of scarcities on local social and economic vulnerabilities and state legitimacy. Scarcity increases demands on governments and prospects for rebel recruitment improve (Kahl 2006). Yet, reduced agricultural production undermines the capacity of states to respond to crises and to provide services to offset the impact of degradation (Theisen et al. 2011/2012). A second mechanism is exclusionary policies and resulting grievances. In a process that Kahl labels ‘resource exploitation’, political elites restrict access to political institutions to specific groups. More recently, the literature also brings in migration exacerbated by droughts as an additional mechanism as prolonged changes in temperature and precipitation reducing agricultural production can contribute to migration leading to resource competition in other areas (Buhaug et al. 2010; Martin 2013; Reuveny 2007).⁴ Furthermore, climate change leading to severe droughts, combined with scarcity of resources, such as access to clean water, creates proximal

⁴ Koubi et al. (2018) found that migrants that have experienced gradual environmental degradation in their region of origin perceived conflict and challenges in the location of origin to a greater degree than migrants having experienced sudden-onset changes.

and distal pathways impacting the well-being of communities. Diseases and poor infrastructure increase food insecurities especially in marginalized communities. The changes in food security may have an independent effect on violent armed conflict among communities because of higher levels of displacement and mobility (Caruso et al. 2015; Koren and Bagozzi 2016; Levy 2019; Morris et al. 2017; Rukundo et al 2019).

The literature on climate changes and violent armed conflict has reached widely divergent empirical results though. Some cross-national studies that link precipitation, temperature anomalies and global weather phenomena to conventional armed conflict have been criticized for selective use of conflict data, unconventional empirical strategies, and a lack of plausible mechanisms that explain the results (Buhaug 2010). Many large-N analyses as well as ethnographic case studies find limited support for simplistic and deterministic claims that conflict results from resource scarcity and droughts (Bell and Keys 2018; Buhaug et al. 2010; Detges 2017; Keels 2019; Raleigh et al. 2014; Scheffran et al. 2012; Theisen et al. 2013).⁵

Recently, the growing availability of geographically disaggregated environmental, social, and conflict data has facilitated a local analysis approach of the resource-conflict nexus. Several grid-based studies of Sub-Saharan Africa have found no or only negligible effects of water scarcity or drought (Buhaug and Rød 2006; Raleigh and Urdal 2007; Theisen et al. 2011/2012; van Weezel 2019). Grid-based studies of East Africa have produced somewhat different results, though none provide strong support for the resource scarcity perspective (O'Loughlin et al. 2012; Raleigh and Kniveton 2012; Theisen 2012).

⁵ Using a country-level analysis, Wischnath and Buhaug (2014) find similar non-result for Asia.

Given the mixed empirical findings linking droughts to conflicts, more recent studies have focused on the scope conditions where the drought-conflict link might be observed. For instance, areas dependent on agriculture and in combination on low levels of economic development and political marginalization are particularly prone to conflict (Koubi 2019). The location of conflict incidents, thus, depends on a combination of ecological constraints, especially access to clean water, strategic choices of groups, and social and economic structures. Socio-economic structures and institutions both at the local and country levels can mitigate environmental shocks (Gizelis and Wooden 2010; Linke et al. 2017; Omelicheva 2011).

Often any evidence linking rainfall shortages or variability in droughts of communal conflicts is conditional on political exclusivity and marginalization of groups (Couttenier and Soubeyran 2013; Fjelde and von Uexkull 2012). In one of the first studies examining the role of local infrastructures on mitigating communal violence under conditions of drought, Detges (2016) found that regions with higher proportions of households with access to an improved water source are associated with moderate conflict risks. Yet not all key infrastructures have the same effect in mitigating the impact of droughts on different types of conflict, namely civil war incidents and communal violence (Detges 2016: 705).

THE CONDITIONAL EFFECT OF LOCAL PUBLIC SERVICE PROVISIONS

Services such as water, sanitation, and electricity have the potential to affect economic opportunities and health conditions for people challenged by droughts. We argue that investments in local public services can mitigate the conflict effect of drought by improving 1) economic conditions and 2) public health of the local population. Of course, local economic development and public health are not independent outcomes as they clearly affect each other. For instance, better public health can increase worker productivity while faster

economic development facilitates investments in health facilities such as hospitals and clinics. Improved water access, improved sanitation, and electricity access all contribute to better outcomes in the local economy and public health, though the degrees of their impact might vary. Electricity access is more likely to have a direct effect on local economic conditions while its effect on local public health often is more of an indirect nature, that is, via its effect on local economic development. At the same time, for improved sanitation and water access, we expect a more direct effect on public health conditions (e.g., by reducing water-related diseases) while their impacts on economic development can be both direct (e.g., more clean water for irrigation and livestock) and indirect (e.g., via the aforementioned health-productivity channel).

As we discussed in the previous section, numerous causal pathways have been proposed to connect climate change to conflict. For instance, climate change might disrupt existing supply and distribution of resources. However, one of the most dominant and popular views links climate change to conflicts through the mechanism of resource scarcity. This school of thought can be traced back to the study of environmental degradation and conflicts. Most famously, Homer-Dixon's work has been particularly associated with this neo-Malthusian tradition of thought that scarcity in resources is likely to trigger conflicts as different groups are pressured to fight for limited resources, especially in less developed countries (Homer-Dixon 1991). More recently, Theisen et al. (2011) argue that in agriculture-based societies, deviation from normal precipitation reduces agricultural output. This first reduces state income through taxation and exports and therefore lower state counterinsurgent capacity and its ability to deliver public goods to appease dissident population. Second, at the individual level, reduced available income for citizens lower their opportunity costs of becoming a rebel soldier.

Local public service provisions have the potential to mitigate the negative impacts of droughts on local economic conditions, therefore lowering the chances of conflict. Evidence from rural communities indicates that access to electrical grids contribute to local development (Das 2007; Kirubi et al. 2009; Kooijman-van Dijk and Clancy 2010). Access to electricity is a form of economic infrastructure and can boost employment by creating a night-time economy with additional jobs in services such as shops, restaurants, and hospitality business, and enhanced production through shiftwork.⁶ Electricity also directly affects vulnerability to droughts through allowing pumping water for irrigation.

In addition to electricity access, improved sanitation and water access help mitigate the effects of drought on local economy. Indeed, UNDP human development reports highlight the link between clean water and sanitation to inequalities, basic human rights, and loss of life, while recent studies in India show that improved sanitation has significant progressive economic benefits (Adger et al. 2014; Nandi et al. 2017; UNDP 2006: 27). Beyond safeguarding human rights, clean water access and sanitation have economic benefits as they help local communities to counter the negative effects of climate change pressures

⁶ Even when access to services does not directly create jobs, it creates opportunities for people to establish enterprises to supplement or replace traditional income streams as these become less viable (McCubbin, Smit, and Pearce 2015). If a large proportion of the local population is engaged in activities directly impacted by droughts without alternative jobs, people are more likely to engage in conflicts with neighbors or migrants, including looting, cattle-rustling, or violent protests against the government.

such as droughts (Adger et al. 2014).⁷ These services create space and time for local communities to engage in more dynamic economic activities by reducing working time lost in sickness, nursing sick relatives, and generating different types of employment less sensitive to drought (Hutton et al. 2007).⁸ Improved water access and sanitation also increase the amount of clean water available for irrigation and livestock, which directly helps local economy facing severe water shortage.

Other than drought's impacts on local economic activities, which often result in resource scarcity, another channel by which climate change can affect conflicts is via its effect on local public health. Decreased water availability is a defining feature of droughts. Reduced water quantity often leads to worsened water quality (Moran et al. 1997). This is because as water levels become low as a function of drought, the dilution capacity is reduced, resulting in poorer water quality. Both water quantity and water quality are necessary for good health. With droughts reducing both water quantity and quality, a community is expected to experience higher incidences of water-related diseases. For instance, Shehane et al. (2005) show that reduced water quantity during drought increases the risk of remaining water sources being contaminated by feces or urine. The more users there are for the limited water sources such as river/boreholes, the more likely an outbreak of infectious disease.

Depending on factors such as local climate conditions and demographic patterns, droughts may increase the chances of many infectious diseases (Kilpatrick and Randolph

⁷ In fact, access to clean and safe water, along with electricity, are multi-sectoral catalysts of development and governance that improve the adaptability of communities to adverse ecological conditions.

⁸ Moreover, clean water infrastructures reduce time spent procuring water, thus giving people - usually women - more time to engage in productive economic activities.

2012; Altizer et al. 2013).⁹ Recent literature has shown that infectious disease can precipitate conflict and instability by changing the balance of power between the state and rebel groups, creating disputes over how to manage infectious disease outbreaks, and weakening local governance capacity (Peterson 2002; Bagozzi 2016). Indeed, studies such as Beldomenico and Begon (2010) and Letendre et al. (2010) suggest a vicious cycle in which climate change such as drought weakens state governance and local health system capacity, increasing the risk of disease outbreaks, which in turn results in conflicts that further weakens state capacity, increasing the risks of future outbreaks.

All three types of local public services matter greatly for local public health, though the effect of electricity access is more likely to be an indirect one, that is, through its effects on local development and resources. Improved sanitation and water access, on the other hand, have a much more direct impact on local public health. A closer look at the global statistics reveals how the lack of sanitation is a prevalent problem in many developing countries. Sanitation affects water quality that can be used for consumption and agriculture. Improving access of disadvantaged communities to sustainable sources of clean water boosts safe reuse of limited water resources, thus, for instance, mitigating the effects of farmer-pastoralist conflicts in conditions of scarcity (Cooper and Price 2019; Faeth and Weinthal 2012). Clean water access and sanitation for families fundamentally improve health by reducing the incidence of diarrheal disease (particularly for children). When droughts reduce the available water, polluted water has a big impact on people's daily consumption of water, their health, agricultural production, and ultimately food security. For instance, a survey of farmers and

⁹ In general, the health effects of droughts vary significantly depending on their severity, the vulnerability of populations, and socio-economic conditions, as well as the available infrastructure (Stanke et al. 2013).

herders in Nigeria identified shared open water sources as direct flashpoints for conflict. The pollution of water sources by cattle (and the resultant disease burden for local farmers) and sexual harassment of women fetching water were highlighted as a ‘major cause’ of intercommunity conflict (Ofuoko and Isife 2018).

Finally, it is worth highlighting the fact that the provision of local public services such as water, sanitation, and electricity access is a function of many factors such as state capacity and the quality of national and local institutions. Probably more relevant in a developing country context, access to public services can be associated with the political weight of a local community as past studies reveal that politicians use the distribution of public goods and services for electoral gains and personal wealth (Lee 2018). As we have discussed in the introduction, our theoretical and empirical focus is not the politics of local public goods provisions, but rather the mitigating effect on conflict of service provisions. We do, however, in our robustness checks section, control for the endogenous process of local public goods provision by including measures of local population’s economic marginalization and political status, following recent studies such as von Uexkull et al. (2016).

In sum, our theory posits that local public services such as improved water access and sanitation and electricity access can mitigate the conflict-inducing effect of drought by improving local economic conditions and public health:

Hypothesis: Access to local public services in the form of water, sanitation, and electricity mitigates the chances of local conflicts arising from climate stress.

EMPIRICAL ANALYSIS

Sample of Countries and the Unit of Analysis: To test our hypotheses, we use disaggregated data on conflicts, droughts, and the provision of public services in nine African countries. We use the grid-cell based PRIO-GRID (Tollefsen et al. 2012) as the level of analysis. This grid-cell

approach is not without criticism because grids do not reflect natural boundaries or political borders; different studies use cells of varying sizes. However, this approach does have advantages compared to using administrative areas as the unit of analysis. The stationary nature of the grid structure allows units of observation that are identical in shape and size and exogenous to the feature of interest: the grid-cell structure is fixed in space and time, insensitive to changes in political boundaries and development – this is important because border adjustments and changes in administrative areas can in themselves ignite conflict. Moreover, some administrative divisions are so large that aggregating to this level often hides important within-unit variation: for example, the Turkana district in Kenya is roughly the same size as Ireland or Georgia.

We include nine African countries in our empirical analysis: Burkina Faso, Cameroon, Central African Republic, Ethiopia, Kenya, Mali, Niger, Nigeria, and Senegal. These countries experience geographic and temporal variation in climate and varying levels of local armed conflict. All nine countries have significant pastoral and agro-pastoral areas that are extremely vulnerable to droughts. Many people live in areas where livelihoods strongly depend on rainfalls. One reason why we suspect that climate change pressures such as droughts can diffuse between neighboring regions is because of the movement of people away from areas with droughts, bringing pressures into the receiving communities.

Another reason to focus on these countries is that they have DHS data that we can use to measure local public goods provisions. Countries such as Chad, Eritrea, and Sudan (and South Sudan) are also in the same region. However, the DHS surveys do not cover them. Even for countries with DHS, surveys were conducted only every few years: Table 1 shows the countries and years included in the empirical analysis as well as the number of grid-year observations contributed by each country. Note that our empirical analysis only covers years in which a DHS survey was conducted: as a function of this, we do not have high temporal variations in variables included in the analysis. Finally, we want to highlight the fact that the countries selected here are

in the Sahel belt and East Africa where the concentration of UCDP-GED events is among the highest and where droughts are quite frequent. To increase the external validity of our results, future analysis should include other countries such as those in Southern Africa.

Table 1: Countries and years included in the study.

Country	Years Included	N. obs. Included
Mali	1995, 2001, 2006	605
Senegal	1992, 1997, 2005	221
Niger	1992, 1998	255
Burkina Faso	1993, 1998, 2003	261
Cameroon	1991, 2004	280
Nigeria	2003, 2008	600
Central African Republic	1994	156
Kenya	2003, 2008	347
Ethiopia	2000, 2005	571

Dependent Variable: We use the Uppsala Conflict Data Program’s Geo-referenced Event Dataset (UCDP-GED), which provides geo-coded violent events in Africa, 1989-2010. An event is defined as “an incidence of the use of armed force by an organized actor against another organized actor, or against civilians, resulting in at least 1 direct death in either the best, low or high estimate categories at a specific location and for a specific temporal duration” (Sundberg et. al 2010). We create our dependent variables based on conflict locations in the UCDP-GED: this is a binary variable that takes the value of 1 in cases where one or more conflict events were registered by the UCDP-GED in a grid-cell-year; and 0 otherwise.¹⁰

Chances of experiencing at least one violent event for a grid-cell in the country-years covered by our study are relatively low. For instance, in the 3,287 grid-cell-years in the empirical analysis when we use improved water access as a measure for public service

¹⁰ While there are grid cells that experienced multiple violent events, multiple counts within each grid-cell year sometimes are likely to be realizations of the same conflict process (Pierskalla and Hollenbach 2013).

provisions, there are 140 grid-cell-years in which at least one violent event occurred, i.e., 4.26% of the total observations.

Measuring Droughts In and Outside of a Grid-cell: We are mostly interested in the effects of droughts on violent events conditional on the level of local public service provisions. An inherent challenge with grid-based analyses is to determine what the appropriate geographical focus should be. Specifically, how far can the effect of inclement weather or environmental shocks extend? As a first step, we operationalized such neighborhood by considering grid-cells within a certain order of geographical proximity. We measure drought levels in those neighborhoods to test local diffusion of climate change pressures.

For drought, we use the Standardized Precipitation Index (SPI6) variable that indicates within-year deviations in precipitation based on monthly data. For each month, the SPI6 index measures deviation from long-term normal rainfall during the six preceding months. The values are standardized where deviation estimates less than 1 standard deviation indicate near normal rainfall; 1 to 1.49 standard deviations from mean indicate moderately dry conditions; 1.5 to 1.99 indicate severely dry conditions; and values in excess of 2 standard deviations indicate extremely dry conditions. The monthly data are aggregated to a yearly format and categorized to indicate anomalous years. The final SPI6 variable used, the annualized SPI6, is coded 1 if there were at least three consecutive months with $SPI6 \geq 1$ in the given grid cell during the year (moderate drought); $SPI6 = 1.5$ if $SPI6$ was ≥ 1.5 for at least two consecutive months (severe drought); and $SPI6 = 2.5$ if both of the above criteria are met (extreme drought). A SPI6 value of 0 indicates that no drought event occurred during that year.

Based on the SPI6 data, we also calculate series of variables that capture the climate conditions of neighboring grid cells. This differs from most previous studies on climate and conflicts that treat grid-cells as independent observations and study whether there is an effect

of climate conditions within a particular grid-cell on conflict events within the same unit. However, given the size of the normal grid-cells studied (e.g. 55×55 km at the equator), it is very likely that violent events would be affected by conditions outside that particular spatial unit.¹¹ Following Harari and La Ferrara (2018), we create series of spatial lags of the SPI6 variable: by spatial lags of a variable, we mean the average level of this variable in adjacent/neighboring units. More specifically, $SPI6_{lag:1}$ measures the mean SPI6 level among adjacent grid-cells; $SPI6_{lag:3}$ measures the mean SPI6 level among grid-cells that are within three orders of proximity in the grid-cell structure; $SPI6_{lag:5}$ is the mean SPI6 level among grid-cells that are within five orders of proximity in a given year.¹² Incidentally, traditional grazing ranges are reported as several hundred kilometers in length. Sometimes the geographic range of the grazing grounds is close to 325 km (Pragya 2012: 6), equivalent of a spatial lag of 5 order of geographical proximity.¹³

¹¹ There are a few recent studies that consider the neighborhood effect of drought. Theisen (2012) uses a measure that gives the distance in kilometers to the nearest drought to control for whether violence occurs near droughts but not exactly where droughts occurred. Harari and La Ferrara (2018) model conflicts in one grid-cell as a function of lagged conflict in the cell itself, contemporaneous conflict in the neighboring cells, covariates in the cell itself, and covariates in the neighboring cells which include climate condition variables. However, they find that most neighborhood characteristics are statistically insignificant, suggesting in general that the impact of the climate characteristics is a strictly local one.

¹² Section F, online appendix, further illustrates how we created the three spatial lag variables.

¹³ Hendrix and Salehyan (2012) study how conflicts are affected by rainfall variability including both more and less rainfall compared to normal years. We are particularly

Measuring Local Public Services Provisions Using DHS: We follow Hegre et al. (2009) and use DHS data, focusing on questions that cover the provision of basic public services of electricity access, improved sanitation, and improved water access.¹⁴ Recent waves of the Demographic and Health Surveys (DHS) often come with GPS files that gives the longitudes and latitudes of survey clusters so that we can locate these clusters to specific grid-cells. This enables us to calculate, for grid-cells that have DHS clusters, the percentages of households that have electricity access, improved sanitation, and improved water access respectively. If there is more than one DHS cluster in a grid-cell, we take the mean of each cluster, then the mean of all the cluster means. The average number of clusters within a grid in our data is around 4, and the average number of households within a grid in our data is 106. While the number of data points is relatively high given that they cover a relatively small area – a grid-cell of 55×55 km size, we recognize that the method used to create sub-national estimates carries considerable uncertainties, and these data should thus not be seen as representative at the grid-cell level. That is a clear limitation of our study.

interested in the effects of drought since drier years are the likely future trends for the countries covered by this study. Empirically, we are comparing drought-affected grid-cell-years with no-drought grid-cell-years, with the latter including both normal and wet-spell grid-cell-years.

¹⁴ We are not making an argument that only these three types of public goods matter in the context of drought nor are they more important than other types (please refer to Detges 2016).

About a third of the grid-cells for the nine countries included have no DHS survey clusters.¹⁵ For these grid-cells, we spatially interpolate their values based on neighboring grid-cells' available information. We calculate the weighted average value (of electricity access, improved sanitation, and water access respectively) of those neighboring grid-cells that have DHS survey information, using inverse distance as the weights. In the main text, we only show results using interpolated DHS data up to one order of proximity of a grid-cell, that is, using information from contiguous grid-cells that have DHS surveys.¹⁶ For electricity access, we use DHS household questionnaire question no. 111: "Does your household have: Electricity?" This is a simple yes or no answer. We calculate the percentage of households that have electricity within a grid-cell as the measure for electricity access.

For improved water access and improved sanitation, we use DHS household questionnaire questions no. 101 and 108 respectively. The former asks the question: "What is the main source of drinking water for members of your household?" There are thirteen potential answers on the questionnaire describing various sorts of water access facilities ranging from piped water into dwelling to bottled water. The latter asks: "What kind of toilet facility do members of your household usually use?" Twelve different potential types are on the questionnaire ranging from flush to piped sewer system to no facility/bush/field. We followed World Health Organization (WHO) and United Nations Children's Fund (UNICEF)'s *core questions on drinking-water and sanitation for household surveys* to define 'improved'

¹⁵ One cause for this missing data is the DHS's tendency to survey more peaceful areas (e.g. southern Mali), which means that we might have an incomplete sample as some of the most war-torn areas are not covered by DHS.

¹⁶ We calculate up to 3 orders of proximity of grid-cells in unreported robustness checks and the main results do not change.

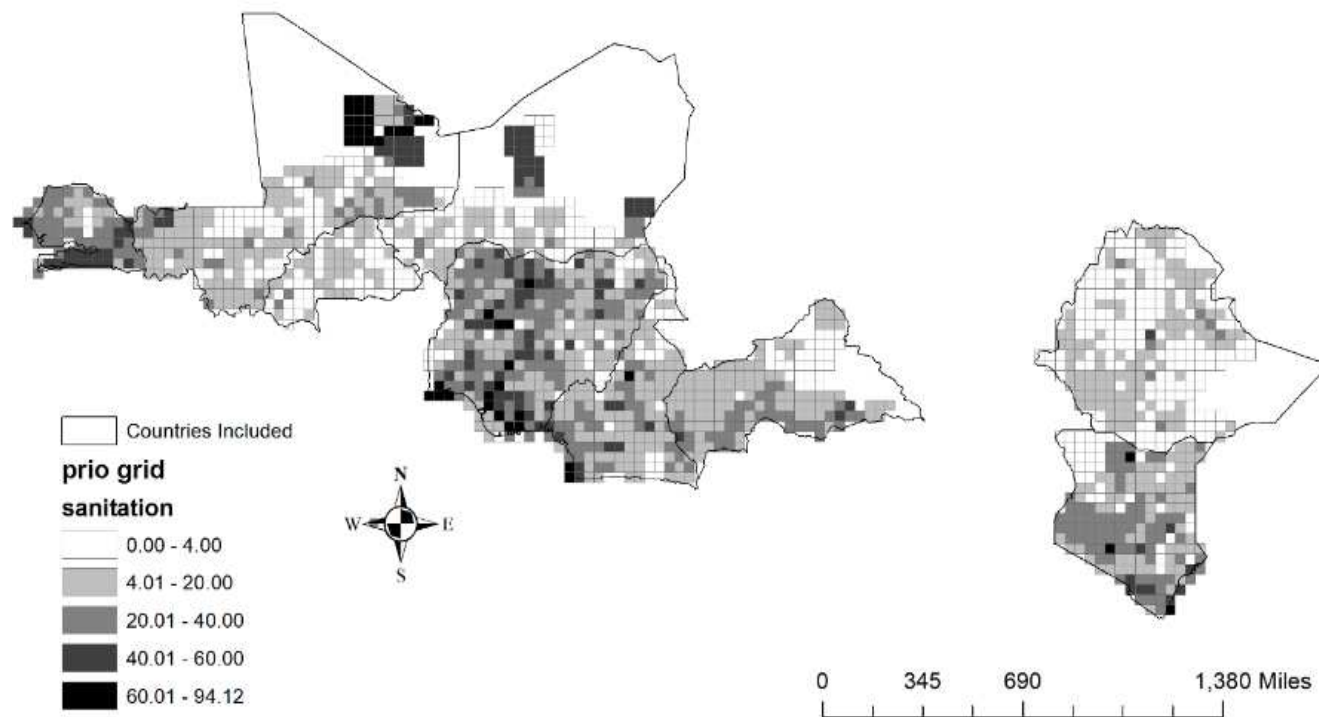
(drinking) water and sanitation facilities.¹⁷ We calculate, at the grid-cell level, the percentage of households that have improved water access and the percentage of households with improved sanitation facilities.

Figure 1 shows 3 maps of the spatial variations in the three local public goods variables in the nine countries included. Other than the Central African Republic, all other countries have multiple waves/years of DHS (Table 1); because of space limit, we only present the grid-cell level mean values (averaged over available years) of local public goods variables in the maps. For example, Mali has DHS data for 1995, 2001, and 2006; in Figure 1(a), we only show the grid-cell level improved sanitation (%) levels averaged over 1995, 2001, and 2006 for Mali.

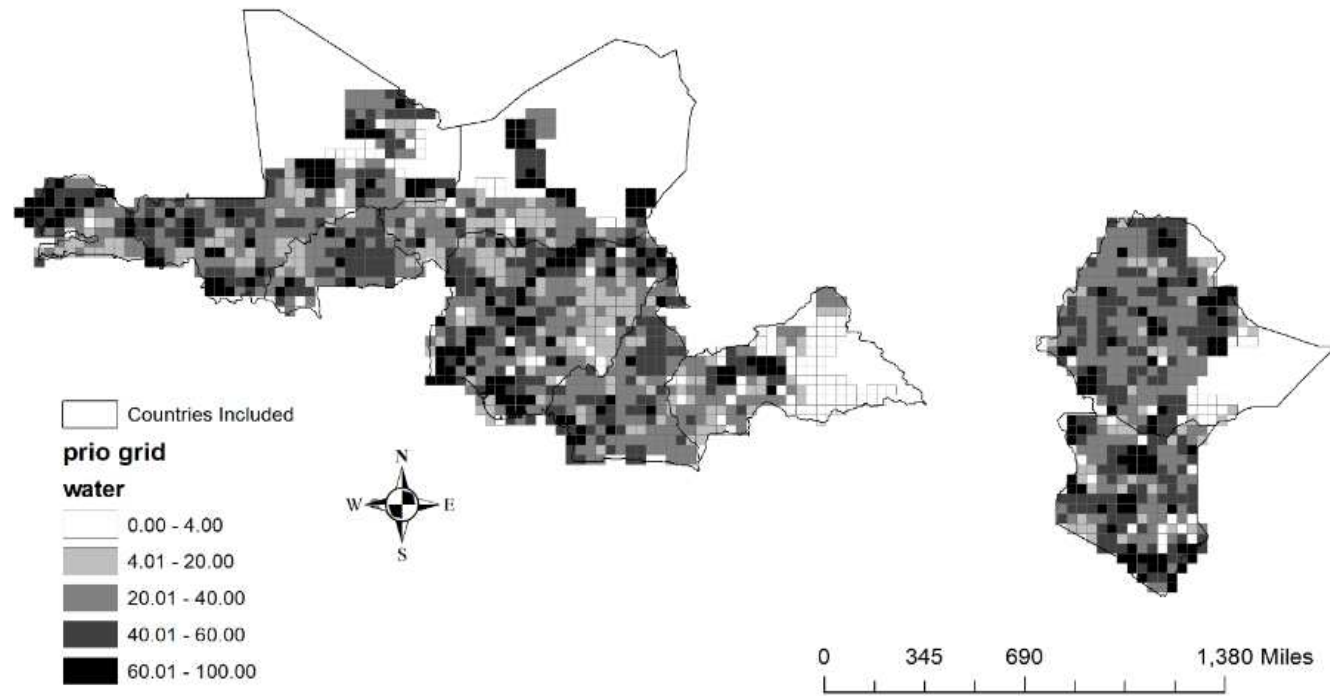
Moreover, we only display the grid-cells that have non-missing values of the local public goods variables. Even after spatial interpolation, there are still grid-cells – for example those in Eastern Ethiopia and Northern Mali and Niger – that have no information on local public goods; they therefore do not enter the regression analysis. Figure 1 shows that there is enough within-country, grid-cell level variation in all three types local public goods. Moreover, it seems that there is a higher level of improved water access in most of the countries compared to the case of improved sanitation and that of electricity access.

¹⁷ In the DHS household recode data, there are more types of facilities than those covered by the WHO/UNICEF classification. We provide a table in online Appendix A with detailed classification of water access and sanitation.

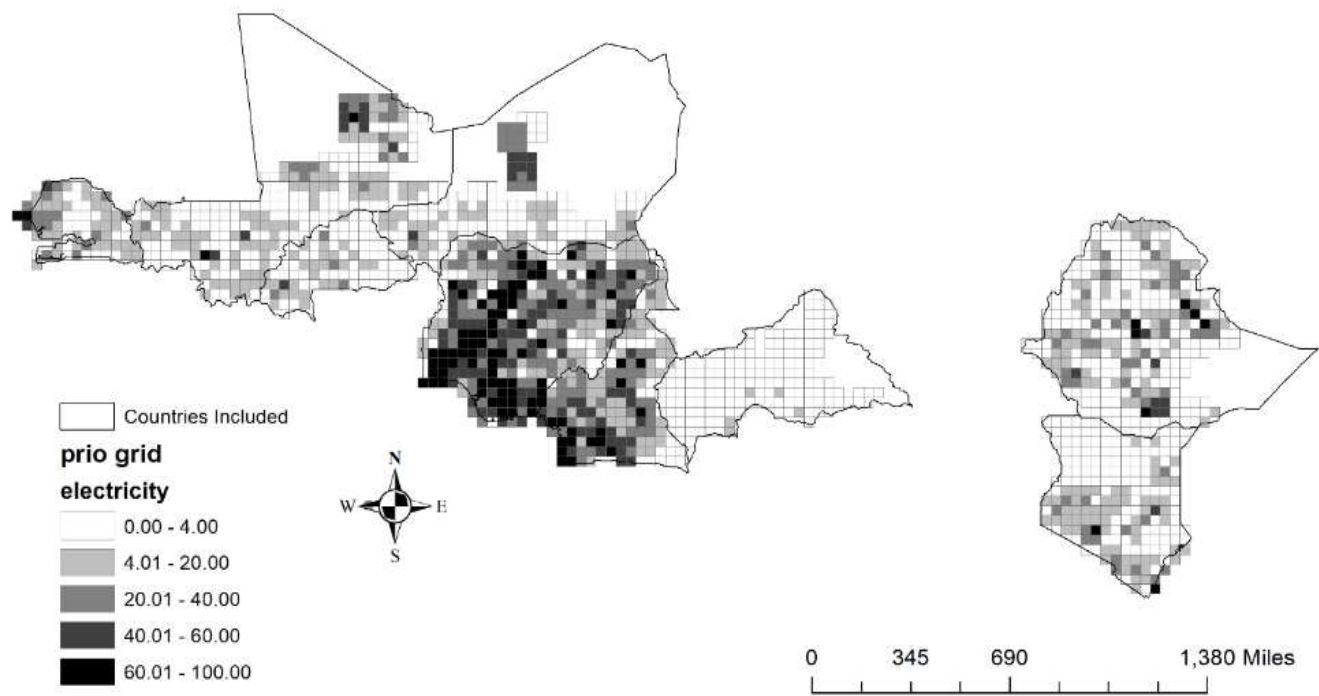
Figure 1: Spatial variation in improved sanitation, water access, and electricity access.



(a): improved sanitation



(b): improved water access



(c): electricity access

Control Variables: we control for the population size for each grid (Gridded Population of the World, version 3, CIESIN 2005). Population estimates are available for 1990, 1995, 2000, and 2005. We linearly interpolate the data for years without data.¹⁸ We take log transformation for population size. The logged GDP per capita variable is from the G-Econ data set (Nordhaus 2006), which is calculated by multiplying the GDP value with one billion divided by the population of the G-Econ 1 × 1 decimal degree cell. The results are GDP per capita for 1990, 1995, 2000, and 2005. Similarly, we linearly interpolate the data.

We also control for time-invariant and slow-moving variables. Distance to border is the distance (in kilometer, logged) from the cell centroid to the border of the nearest neighboring country. Distance to capital is the distance (in kilometer, logged) from the cell centroid to the national capital city in the corresponding country. Population, GDP per capita, mountain area, distance to border, and distance to capital are all provided by the PRIO-GRID.

We control for urbanization, the number of mineral extraction facilities, and strength of pre-colonial institutions. Urban areas are often subject to higher chances of violence. We calculate the percentage of urban area within a grid cell using the Urban Extents Grid, v1 (1995) data from the Global Rural-Urban Mapping Project (GRUMP).¹⁹ We further create a variable that captures the number of mineral facilities within a grid cell.²⁰ Recent studies have shown that mineral deposits affect conflicts (Berman et al. 2017). Moreover, mineral

¹⁸ For 2006-2008, we use the 2005 data.

¹⁹ <http://sedac.ciesin.columbia.edu/data/set/grump-v1-urban-extents>, accessed July 2014. This variable is based on 1995 data. While dated it is the only source that provide data at grid-cell level.

²⁰ Data are from the US Geological Survey: <http://pubs.usgs.gov/of/2006/1135/>, accessed July 2014.

extractions might affect local public goods: for example, Paredes and Rivera (2017) find that mineral tax increases the provision of certain types of public goods in communities in Chile.

We include a measure for the strength of pre-colonial institutions. Recent studies suggest that the remnant of centralized ‘state-like’ institutions before colonization affects present day likelihood of conflict (Wig 2016). We use a digitized version of George Peter Murdock’s ‘jurisdictional hierarchy’ data (Nunn and Wantchekon 2011).²¹ This atlas (Murdock 1967) is intended to capture the degree to which an ethnic group exhibited a high level of political centralization prior to colonization, ranging from 0 for stateless societies, through 1 or 2 for petty and larger paramount chiefdoms or their equivalent, to 3 or 4 for large states.²²

A violent event in one grid-cell is likely to increase the probability of a violent event in a neighboring cell. A standard approach to model spatial dependence often involves the inclusion of a spatial lag of the dependent variable. The use of spatial lags for binary dependent variables has been employed in the analysis of conflict (Ward and Gleditsch 2002), but this is often computational challenging. For large data sets such as ours, computation becomes difficult. We follow a more practical approach and use a temporally lagged spatial lag, Spatial lag_{t-1} : this is the average level of violent events in adjacent grid-cells of the previous year.²³ This avoids spatial simultaneity.

We also control for temporal dependence. We follow Theisen et al. (2011/2012) and create a conflict history variable using the decay function of time since last event, $2^{-(t/\alpha)}$: t is the time (number of years) since last violent event; we let $\alpha=5$, assuming that the risk of violent

²¹ <http://scholar.harvard.edu/nunn/pages/data-0>, accessed July 2014.

²² If there is more than one ethnic group within a grid cell, we use the measure for the dominant group.

²³ We use eight adjacent cells.

events decreases by half every 5 years.²⁴ Correlation and summary statistics of these variables are in Table B-1/2 from the online appendices.

Empirical Results: We link the dependent variable to observed covariates via a standard logit link function to the linear predictor, $p(y_{i,t} = 1 | \theta_{i,t}) = \frac{e^{\theta_{i,t}}}{1+e^{\theta_{i,t}}}$. The linear predictor is in turn is a function of climate change and other explanatory variables:

$$\theta_{i,t} = \beta_0 + \beta'x_{i,t} + \rho w_i y_{t-1} + 2^{-(t/\alpha)} + T_t + C_i + \epsilon_{i,t}$$

β_0 is the population intercept, $\beta'x_{i,t}$ are the effects of grid-specific characteristics including SPI6 and its spatial lags. $\rho w_i y_{t-1}$ represents the temporarily lagged spatial lag term. $2^{-(t/\alpha)}$ is the decay function of time since last violent event. We also include year (T_t) and country (C_i) fixed effects in our analysis.

The results without the interactive effects between droughts and public services are in Tables 2. We have four droughts variables: SPI6 captures droughts within a grid-cell itself; SPI6_{lag:1} measures droughts from the immediate adjacent grid-cells (i.e., one order of proximity); SPI6_{lag:3} and SPI6_{lag:5} also measure the diffusion effect of droughts, that is, average drought level of the neighboring units up to 3 and 5 orders of proximity respectively. In all analysis reported in the paper, we exclude grid-cells that have annual precipitation lower than 100 millimeters: these are uninhabited desert areas. Our results hold when we include these grid-cells: the difference between excluding and including these grid-cells with annual precipitation lower than 100 millimeters is about 40 observations.

We find evidence that conflict erupts not only as a function of droughts in one's own grid-cell, but also as a function of droughts in immediate neighboring areas (approximately within a distance of 55 kilometers). Specifically, Table 2 shows that the coefficient estimates of

²⁴ We experiment with other values for α such as 2, 3, 4, and 6; the main results do not change.

the SPI6 and SPI6_{lag:1} variables are both consistently statistically significant and their substantive effects are important. To get a sense of the substantive effect of drought on local conflicts, we conducted a simulation exercise based on the first model specification of Table 2: holding all other variables as their mean levels and using 2008 as the baseline year, we first calculate the probability of a violent event when SPI6 is at its mean level; we then increase SPI6 from its mean by one standard deviation and calculate the probability again; finally, we calculate the difference in these two probabilities, that is, what is the change in probability of conflict when SPI6 increases from its mean by one standard deviation? The mean change in probability is 0.015, with a 95% confidence interval of (0.002, 0.033). Considering that the mean value of the dependent variable is around 0.043, this is a quite substantively important effect.

However, average drought levels beyond adjacent grid-cells are unrelated to local violence. We find that the SPI6_{lag:3} and SPI6_{lag:5} variables, which measure the average drought level of the neighboring units up to 3 and 5 orders of proximity, are unrelated to local violence in a given grid-cell. 3 and 5 orders of proximity are approximately buffer zones within 165 and 275 kilometers respectively. This suggests that the diffusion effect of droughts seems to be unable to travel too far as indicated as the lack of effect of the SPI6_{lag:3} and SPI6_{lag:5} variables.

Besides the drought variables, we find that the effect of conflict history is always statistically significant. It seems that violent events show consistent patterns of temporal dependence. The coefficient of the spatial lag of conflict is also positive and statistically significant, which lend support for the spatial diffusion of conflicts often found in conflicts studies. Among the control variables, we find that GDP per capita, population, and distance to capital predict higher chances of local violence. On the other hand, strong pre-colonial institutions seem to reduce violence.

Table 2: Logistic regressions testing marginal effects of drought variables.

	<i>Dependent variable: UCDP-GED</i>			
	(1)	(2)	(3)	(4)
SPI6	0.308** (0.150)			
SPI6 _{lag:1}		0.496** (0.215)		
SPI6 _{lag:3}			0.546 (0.335)	
SPI6 _{lag:5}				0.695 (0.471)
GDP per capita	0.388* (0.234)	0.396* (0.234)	0.386* (0.232)	0.384* (0.232)
Population	0.186** (0.076)	0.186** (0.076)	0.185** (0.076)	0.188** (0.076)
Distance to border	0.116 (0.101)	0.108 (0.101)	0.106 (0.101)	0.109 (0.100)
Distance to capital	0.383* (0.199)	0.390** (0.198)	0.387* (0.198)	0.395** (0.198)
Urbanization	0.045 (0.028)	0.045 (0.028)	0.046* (0.028)	0.046* (0.028)
Gas/oil	0.596 (0.398)	0.577 (0.394)	0.598 (0.394)	0.609 (0.395)
Mineral facilities	0.050 (0.163)	0.057 (0.163)	0.058 (0.163)	0.066 (0.162)
Pre-colonial inst	-0.247** (0.115)	-0.247** (0.114)	-0.233** (0.114)	-0.228** (0.114)
Conflict history	3.015*** (0.323)	3.014*** (0.323)	3.004*** (0.323)	3.004*** (0.323)
Spatial lag	2.787*** (0.664)	2.770*** (0.664)	2.723*** (0.662)	2.697*** (0.662)
Constant	-15.151 (2,657.227)	-15.501 (2,659.276)	-15.353 (1,615.735)	-15.481 (1,615.826)
Year-fixed effects	yes	yes	yes	yes
Country-fixed effects	yes	yes	yes	yes
Observations	4,108	4,111	4,111	4,111
Log Likelihood	-520.545	-520.018	-521.337	-521.592
Akaike Inf. Crit.	1,103.091	1,102.037	1,104.674	1,105.183

Note:

* p<0.1; ** p<0.05; *** p<0.01

We include both country and year fixed in model specifications presented in Table 2. These results are not shown due to space considerations; however, none of the country fixed effects is statistically significant, suggesting that after controlling for grid-cell level characteristics included in the analysis, local violence is not a function of unobserved country-specific factors. Few year fixed effects are statistically significant at the same time.

Table 3 shows the test results once we add interactive effects between the droughts variables and the three types of public services. The estimates of control variables change slightly: the variable *distance to capital city* loses its statistical significance. This makes sense because distance to capital city might well correlate with local public goods provisions (Campante and Do 2014). Table 3 shows different model specifications: they are estimated both with and without country fixed effects to show the robustness of the results.²⁵

In Table 3, for electricity, the standard errors of the interactive terms are very large compared to the mean coefficient estimates (model 9-12), indicating the lack of interactive effect between electricity access and drought conditions. One potential explanation for the lack of a mediating effect by electricity is that the electricity access variable is correlated with local GDP per capita and urbanization at relatively high levels. Table B-2 of the online appendix shows that its correlations with GDP per capita and urbanization are 0.40 and 0.42, respectively.²⁶

²⁵ Like Table 2, none of the country fixed effects is statistically significant.

²⁶ The other two public goods variables – improved sanitation and water access – are also positively correlated with GDP per capita and urbanization, but at lower levels. For example, the correlations between improved water access and GDP per capita and urbanization are 0.10 and 0.21.

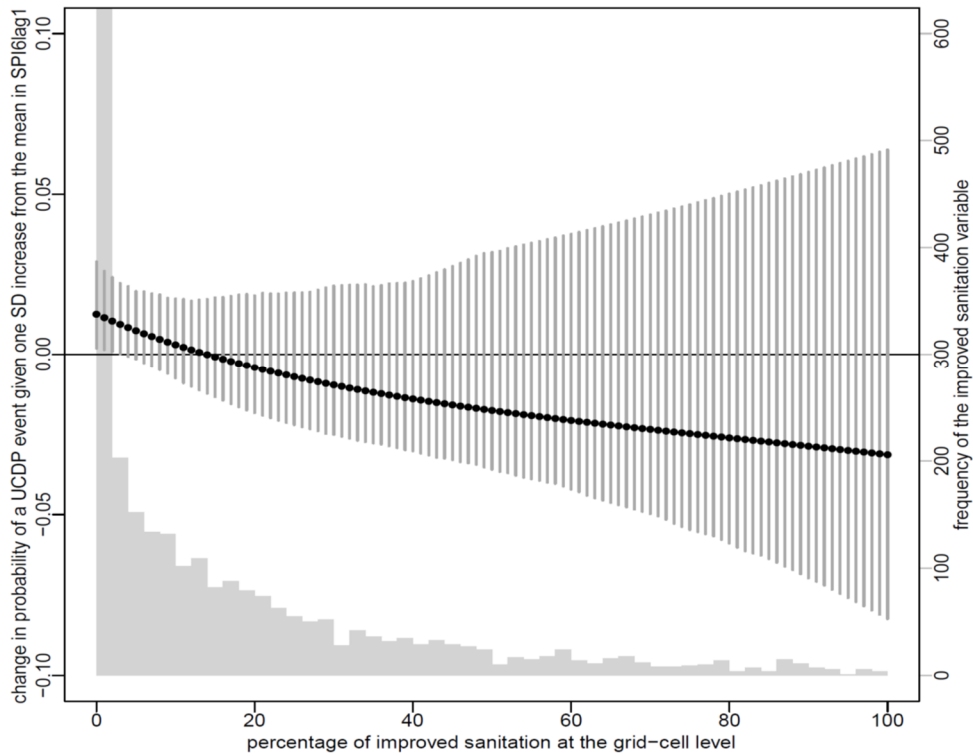
Table 3: Testing the mitigating effects of local public goods, using UCDP-GED as dependent variable.

	Improved sanitation				Improved water access				Electricity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GDP per capita	0.140 (0.256)	0.575** (0.251)	0.162 (0.255)	0.592** (0.248)	0.175 (0.255)	0.569** (0.248)	0.177 (0.255)	0.576** (0.247)	0.121 (0.255)	0.650*** (0.243)	0.127 (0.255)	0.660*** (0.242)
Population	0.195** (0.087)	0.250*** (0.089)	0.199** (0.087)	0.254*** (0.088)	0.206** (0.087)	0.262*** (0.088)	0.208** (0.087)	0.264*** (0.088)	0.186** (0.088)	0.262*** (0.088)	0.191** (0.089)	0.265*** (0.088)
Distance to border	0.106 (0.111)	0.105 (0.122)	0.090 (0.111)	0.093 (0.122)	0.114 (0.112)	0.106 (0.121)	0.107 (0.112)	0.096 (0.121)	0.091 (0.112)	0.089 (0.121)	0.088 (0.112)	0.081 (0.121)
Distance to capital	0.055 (0.183)	0.204 (0.210)	0.054 (0.181)	0.210 (0.210)	0.102 (0.184)	0.234 (0.209)	0.112 (0.182)	0.237 (0.207)	0.053 (0.184)	0.259 (0.207)	0.069 (0.182)	0.266 (0.205)
Urbanization	0.007 (0.029)	0.006 (0.031)	0.005 (0.029)	0.004 (0.031)	0.020 (0.029)	0.020 (0.031)	0.020 (0.029)	0.020 (0.031)	0.009 (0.030)	-0.006 (0.031)	0.010 (0.030)	-0.007 (0.031)
Gas/oil	0.377 (0.422)	0.276 (0.432)	0.328 (0.418)	0.242 (0.429)	0.383 (0.423)	0.298 (0.429)	0.355 (0.419)	0.275 (0.425)	0.354 (0.412)	0.162 (0.426)	0.313 (0.407)	0.130 (0.421)
Mineral facilities	0.133 (0.172)	0.133 (0.175)	0.126 (0.170)	0.128 (0.174)	0.097 (0.172)	0.090 (0.174)	0.095 (0.170)	0.087 (0.173)	0.090 (0.172)	0.096 (0.176)	0.098 (0.170)	0.100 (0.175)
Pre-colonial inst	-0.246** (0.121)	-0.221* (0.128)	-0.237** (0.121)	-0.203 (0.128)	-0.258** (0.121)	-0.237* (0.126)	-0.253** (0.121)	-0.235* (0.126)	-0.245** (0.121)	-0.237* (0.127)	-0.242** (0.121)	-0.235* (0.127)
SPI6	0.531** (0.207)	0.537*** (0.208)			0.497** (0.221)	0.496** (0.223)			0.354* (0.196)	0.373* (0.199)		
SPI6 _{lag:1}			0.770*** (0.298)	0.774*** (0.297)			0.712** (0.312)	0.714** (0.317)			0.556** (0.279)	0.586** (0.286)
Improved sanitation (%)	0.013** (0.005)	0.014*** (0.005)	0.013*** (0.005)	0.015*** (0.005)								
Improved water (%)					0.005 (0.004)	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)				
Electricity (%)									0.008* (0.004)	0.014*** (0.005)	0.007* (0.004)	0.014*** (0.005)
Improved sanitation (%) × SPI6	-0.041 ^a (0.026)	-0.044 ^b (0.027)										
Improved sanitation (%) × SPI6 _{lag:1}			-0.061* (0.036)	-0.080** (0.040)								
Improved water (%) × SPI6					-0.006 (0.005)	-0.006 (0.005)						
Improved water (%) × SPI6 _{lag:1}							-0.007	-0.007				

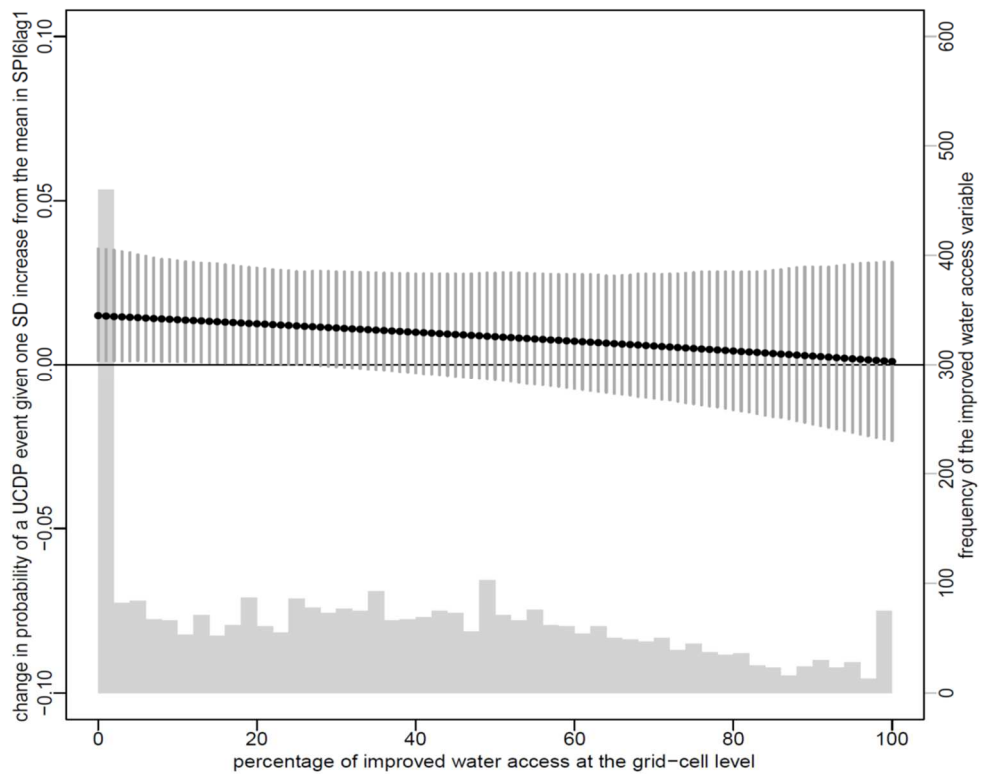
Electricity (%) × SPI6						(0.006)	(0.006)		-0.003 (0.006)	-0.005 (0.006)		
Electricity (%) × SPI6 _{lag:1}											-0.003 (0.008)	-0.006 (0.008)
Conflict history	2.947*** (0.367)	2.862*** (0.369)	2.940*** (0.366)	2.853*** (0.368)	2.931*** (0.367)	2.863*** (0.369)	2.932*** (0.366)	2.863*** (0.368)	2.930*** (0.365)	2.854*** (0.369)	2.930*** (0.365)	2.852*** (0.368)
Spatial lag	3.778*** (0.796)	3.265*** (0.804)	3.778*** (0.795)	3.226*** (0.803)	3.839*** (0.796)	3.391*** (0.804)	3.863*** (0.796)	3.411*** (0.803)	3.848*** (0.795)	3.280*** (0.803)	3.847*** (0.795)	3.276*** (0.803)
Constant	-10.875*** (2.635)	-15.521*** (3.055)	-11.034*** (2.618)	-15.686*** (3.026)	-11.710*** (2.651)	-15.949*** (3.029)	-11.809*** (2.633)	-16.030*** (3.002)	-10.693*** (2.649)	-16.736*** (3.007)	-10.901*** (2.626)	-16.887*** (2.976)
Year-fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-fixed effects	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Observations	3,296	3,296	3,299	3,299	3,284	3,284	3,287	3,287	3,296	3,296	3,299	3,299
Log Likelihood	-411.54	-404.14	-411.20	-403.15	-415.23	-408.66	-415.22	-408.62	-415.51	-406.45	-415.337	-406.21
Akaike Inf. Crit.	877.089	872.289	876.412	870.313	884.459	881.328	884.448	881.246	885.033	876.902	884.674	876.424

Note: a: p-value is 0.120; b: p-value is 0.102. *p<0.1; **p<0.05; ***p<0.01

Figure 2: Mitigating effects of improved sanitation and water access, simulations based on models without country fixed effects, using 2008 as the baseline year.



(a): mitigating effect of improved sanitation



(b): mitigating effect of improved water access

Judging by the p-values, the only statistically significant interactive effect is between the drought variable $SPI6_{lag:1}$ and improved sanitation (model specifications 3 and 4). In model specifications 1 and 2, the p-values of the interaction terms between SPI6 and improved sanitation are around 0.120 and 0.102, just failing to reach the 10% significance level. The interactive effect between the drought variables and improved water (model specification 5-8) is falling short of common p-value thresholds such as 0.05 and even 0.10. However, in a model with an interaction term, not only the marginal effect but also the associated standard errors vary with the value of the other lower-order variable in the interaction term. It has become a common practice to visualize the interactive effects using confidence intervals associated with different levels of lower-order variables. Therefore, we use simulations to further illustrate the mitigating effects of improved water access and improved sanitation on drought conditions: we only show the figures using the $SPI6_{lag:1}$ variable; those using the SPI6 variable look very similar.

In Figure 2, we simulate the conditional effect of improved sanitation/water access on drought conditions in neighboring grid-cells ($SPI6_{lag:1}$). For every value of improved sanitation/water access (x-axis), holding all other variables as their mean levels, we first calculate the probability of a violent event when $SPI6_{lag:1}$ is at its mean level; we then increase $SPI6_{lag:1}$ from the mean by one standard deviation and calculate the probability again; finally, we calculate the difference in these two probabilities, that is, what is the change in probability of conflict when $SPI6_{lag:1}$ increases from its mean by one standard deviation conditioning on a given level of improved sanitation/water access? We plot the 95% confidence intervals of such probability changes using grey vertical lines; the dark solid dots are the means of the simulated probability changes. We also display the distribution of the improved sanitation/water access variable by light gray histograms in the lower background.

Figure 2(a) shows that when grid-cell level improved sanitation percentage is very low, approximately between 0 and 4%, an increase from the mean drought level in a grid-cell's neighboring units by one standard deviation increases the probability of conflict; once improved sanitation reach more than 4%, this significance disappears as indicated by confidence intervals now including 0. The 4% threshold seems to be extremely low: within a grid-cell, only 4% of the household have access to improved sanitation. However, the distribution of this variable is very left-skewed with about 1500 grid-cell-years (out of a total of 3284 grid-cell-years entering the analysis) that have values smaller or equal to 4%.

The simulation exercise for the improved water access variable is in Figure 2(b). We also see a mitigating effect associated with this variable even though the effect is less salient than the case of improved sanitation. It seems that when grid-cell level improved water access percentage is low, approximately between 0 and 26-27%, an increase from the mean in drought conditions in a given grid-cell's neighboring units by one standard deviation increases the probability of conflict; once improved water increase to more than 26-27%, this significance disappears as indicated by confidence intervals now including 0.

In sum, from Table 3 and Figure 2, we find a mitigating effect for the improved sanitation variable, and to a lesser extent, for the improved water access variable, but not for the electricity access variable. Improved water access's mitigating effect is intuitive. Relying on improved water access such as public tap water rather than on rivers and streams has obvious benefits for the local population and reduce flashpoints of violence around shared open water sources, as illustrated in the case of Nigeria.

The strongest mitigating effect comes from improved sanitation. For some, this might seem a surprise. Past studies have shown that water access and economic development reduce the conflict effect of drought (e.g., Detges 2016). Sanitation, as a mitigating factor, has been largely overlooked. Yet, improvement in sanitation and in public health in general has a great

potential to mitigate the conflict effect of drought by, for instance, reducing infectious diseases that often precipitate conflict and instability (Peterson2002; Bagozzi 2016). In Ofuoko and Isife (2018), farmers blame cattle-herders for polluting drinking water and causing human disease as a major source of inter-community conflict. This and similar problems would be greatly reduced by better sanitation facilities. We have argued that improved water and sanitation have a much more direct impact on local public health while electricity access often does not. The lack of a mitigating effect by electricity and the fact that improved sanitation has the strongest mediating effect suggest that a promising way to weaken the conflict effect associated with drought is by protecting local public health.

Finally, regarding a stronger mediating effect associated with sanitation than that associated with water access, a 2008 Global Policy Forum online article suggests that while the lack of safe drinking water affects over 1 billion people worldwide, the lack of safe sanitation has a much broader impact, affecting over 2.5 billion people.²⁷ Moreover, our maps of grid-cell level improved water access and sanitation (Figure 1a and 1b) in the nine countries included in this study show that the percentages of households with improved sanitation are on average much lower than those of improved water access. Access to sanitation might therefore be a better measure of local communities' vulnerability and the lack of basic government infrastructure.

ROBUSTNESS CHECKS

More Model Specifications: To see whether the mitigating effect of the improved sanitation variable is robust to other model specifications, in online Appendix D, Table D-1, we started

²⁷ <https://www.globalpolicy.org/component/content/article/212/45362.html>, accessed on February 04, 2018.

with a reduced model specification – keeping only GDP per capita, Population, drought variables, improved sanitation – and we added in more variables step by step. The results are very similar to what we have found in model specification 1-4 in Table 3, showing that improved sanitation’s mitigating effect is not driven by specific model specifications.

Controlling for Land Types: Whether a drought affects cropland or barren land may matter to the local economy and community. In Table D-2 of the online appendices, we further control for land types at the grid-cell level, that is, the percentages of pasture area (Pasture area (%)), agricultural land (Agricultural area (%)), grass land (Grasslands (%)), barren land (Barren areas (%)) and pasture and agricultural lands combined (Pasture area (%) + Agricultural area (%)). None of these land types affects the chances of local conflicts. At the same time, like findings from Table 3, we find empirical support for the mitigating effect of improved sanitation.

Controlling for Endogenous Public Goods Provision: It is likely that local services are provided to areas politically relevant to leaders. Moreover, leaders might prevent a conflict from emerging by investing in public services in areas with a higher a priori risk of conflict onset – these are often politically and economically marginalized areas. In online Appendix E, we use the political exclusion variable *excluded* from the EPR data set to control for political status and a measure of *infant mortality* as a proxy for economic marginalization. After adding these two variables, our main findings concerning the mediating effect of improved sanitation and to a lesser extent, that of improved water access, do not change (Table E1).

Using ACLED instead of UCDP: The UCDP-GED data set is not the only geo-coded event data for conflicts. Another prominent data project is the Armed Conflict Location and Events Dataset (ACLED) (Raleigh et al. 2010). ACLED has a clear advantage over similar datasets because it also includes non-violent events, riots, and protests. However, comparing the two data sets, Eck (2012) claims that the UCDP often reports more events in rural or remote areas. We conducted analysis replacing our dependent variable with the ones using ACLED events. Detailed results are reported in online Appendix C. The general findings are first, droughts variables (SPI_6 , $SPI_{6lag:1}$, $SPI_{6lag:3}$, and $SPI_{6lag:5}$) have no effect on conflicts/violence using ACLED (Table C-1); and second, we do not find any mitigating effect associated with improved sanitation, water access, or electricity access (Table C-2).²⁸

Why such null effect for drought variables and the mitigating effect of public goods variables when using ACLED data? Theoretically, UCDP events are part of ACLED as UCDP only reports events that are part of organized armed conflicts (≥ 25 death).²⁹ ACLED include all events with or without casualty or even with no violence at all. The different findings using UCDP vs. ACLED seems to suggest that the effect of droughts in increasing conflicts is more likely to be present in the broader context of existing armed conflicts: in regions with armed conflicts, climate change pressures make things worse by for example increasing resource scarcity. It seems that the UCDP events are part of the broader conflict processes and climate change pressures increase the chances of such violent events because

²⁸ We have also run analysis using only fatal ACLED events and only non-fatal ACLED events. The results are similar to when using all ACLED events.

²⁹ See codebook: <http://ucdp.uu.se/downloads/ged/ucdp-ged-40-codebook.pdf>, “Only events linkable to a UCDP/PRIO Armed Conflict, a UCDP Non-State Conflict or a UCDP One-Sided Violence instance are included.”

grievances or other deeper causes for conflicts are already there. For the non-UCDP events that are in ACLED, climate change pressures seem to be unable to affect the chances of their occurrences. A second reason why we find null result using ACLED might be that ACLED includes all types of events. Even when only using fatal events,³⁰ there are quite a large number of different sub-types; it is likely that climate change might affect some but not other event types; when we mix event types together, the effects disappear.³¹

CONCLUSION

We have argued that the provision of local services and public goods mitigates the effect of drought, reducing the likelihood of conflict. We empirically assess our hypothesis by modeling the mitigating effects of basic public services provisions at the local level. We find evidence that the provision of improved sanitation, and to a lesser extent, improved water resources can mitigate the probability of conflict aggravated by drought in these areas. Indeed, beyond some threshold levels of improved sanitation/water access, the positive effect of droughts on violent events disappears. We find no such mitigating effect for electricity access. Although improvements in electricity have been shown to provide substantial benefits for countries of

³⁰ ACLED codebook suggests the fatal vs. non-fatal difference might not be that accurate, see http://www.acleddata.com/wp-content/uploads/2015/01/ACLED_Codebook_2015.pdf, accessed July 22, 2016.

³¹ Our online appendices have more robustness checks. E.g., section E controls for the endogenous public goods provisions process: leaders might try to prevent a conflict from emerging by investing in public services in areas with a higher a priori risk of conflict onset – these are often politically and economically marginalized areas. We therefore control for political exclusion and infant mortality at the grid cell level; our main results do not change.

higher levels of development (Ferguson et al. 2000), it seems that sanitation and access to clean water are crucial in preventing conflict in marginal and fragile environments.

This research has important policy implications. First, our empirical results suggest that investment in reliable sanitation and water infrastructures is likely to enhance communities' ability to cope with rainfall shocks. Based on our estimates, the thresholds beyond which droughts from within a locale and neighboring areas cease to increase the chances of conflicts are around 4 per cent households with improved sanitation (Figure 2(a)) and around 26-27 per cent households with improved water access (Figure 2(b)). These are not extremely high targets for national governments and international community to reach. While acknowledging the potential role of development assistance in providing public infrastructure that mitigate climate-induced conflict, particular care should be given to equitable access.³²

Moreover, in addition to our main finding regarding the mitigating effects associated with improved sanitation and to a lesser extent, improved water access, we also find evidence that conflict erupts not only as a function of droughts in one's own grid-cell, but also of droughts in neighboring areas. Droughts in immediate adjacent grid-cells, that is, approximately within fifty-five kilometers, increase chances of violent events. Average drought levels beyond adjacent grid-cells, however, are unrelated to local violence. This suggests that the effects of a drought can spread beyond the area where missing rainfalls have compromised livelihoods. We expect our findings to be applicable beyond the Sahel area. Recent studies on Syria suggest that strategies to address climate and water-related conflict risks should be multi-layered processes intersecting with social and economic policies

³² Karell and Schutte (2018) found that aid exacerbates conflict if it leads to exclusionary projects.

addressing population movements, food insecurities, and fragile economies in the context of ecological constraints (Gleick 2014).

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