Conflict on the urban fringe: Urbanization, environmental stress, and urban unrest in Africa

Theodora-Ismene Gizelis (corresponding author)
University of Essex
Wivenhoe Park, Colchester, CO4 3SQ
tig@essex@ac.uk

Steve Pickering
Brunel University London
steve.pickering@brunel.ac.uk

Henrik Urdal
Peace Research Institute Oslo (PRIO)
urdal@prio.org

1.0 Introduction

Columnist Thomas Friedman (2012) attributed the onset of the Arab Spring unrest in no small part to population and environmental stress. International security debates within academia as well as policy domains have highlighted major demographic shifts, like rapid urbanization exacerbated by push factors such as environmental shocks, as emerging drivers of violent conflict with the potential to become major threats to peace and stability in the future (e.g. Buhaug et al. 2014; Hsiang et al. 2013; Gleditsch 2012; Meierding 2013; von Uexkull et al. 2016).[1] Goldstone (1991, 2002) argues that rapid migration to cities has historically increased the risks of violent urban protests, with environmental stressors being one of the mechansisms triggering migration into the urban outskirts. Yet, there is limited evidence solidly linking urban population growth with urban social unrest. The number of studies in this domain remains low and of variable quality (Demarest 2015). In this article, we examine whether rapid growth in the urban population increases levels of urban unrest, separating the most highly urbanized centers from the peri-urban[2] areas surrounding the city.

The concern over the potentially destabilizing effects of rapid urbanization is strongly related to a major emerging security concern that global climate change may increases violence in the world (e.g. Buhaug et al. 2014; Gleditsch 2012; Hsiang et al. 2013). A simplified narrative suggests that climate change affects rural, agrarian societies through erratic precipitation and weather patterns and protracted droughts, pushing rural inhabitants towards cities where

[1] Research on resource scarcity and conflict has focused on the interaction between growing population pressures, scarcity, and degradation of renewable resources like arable land, forests, and freshwater, and the distribution of resources (for pioneering contributions, see Homer-Dixon 1991, 1994; Gleditsch et al. 1997; Kahl 1998). The literature on the security implications of climate change concentrate on weather patterns, especially precipitation patterns, temperature variation, and droughts (e.g. Hsiang et al. 2013).

[2] "Peri-urban" describes areas displaying both rural and urban characteristics and are proximate to, and often surrounding, urban areas. These are areas that typically see gradual transformation of arable lands into housing and development potentially resulting in conflicts over land use and land ownership; less developed institutional contexts and lower levels of public services provision than the primary urban areas; mixed economic zones between agricultural and modern sector economic activities; high levels of poverty and inequality; and high levels of ethnically mixed in-migration. See Griffiths (2010) and Iaquinta & Drescher (2000) for discussions about the peri-urban concept. Goldstone (1991) describes similar patterns of peri-urban pressures in 17th century London, leading to radicalization of migrants falling outside exicsting institutions of social control.

population mixing, competition for resources, poor governance and limited public service provision create tensions that could spill over into violent conflict and social unrest.

Recent reviews of the climate change and conflict literature cast doubt on, at least, any direct and broad link between climate change and organized violent conflict (Buhaug et al. 2014; Bernauer et al. 2012; Koubi 2019; Theisen et al. 2013; Scheffran et al. 2012; Witmer et al. 2017). Yet most of the literature on the drought-conflict link does not draw a clear distinction between the effects in urban and rural communities.[3] While rural societies and communities may be affected more directly by variations in rainfall and droughts, secondary effects can arguably be felt in the cities due to a high migration pressure.[4]

In this article, the primary aim is to explore the link between urban population pressure and urban unrest using disaggregated demographic and social conflict data for all African urban areas for the time period 1997 to 2010.[5] While the approach is to assess the impact of population growth on urban unrest directly, regardless of which factors that drive population growth, we also specifically set out to test whether adverse environmental conditions, operationalized as droughts, in rural areas close to urban centers may partly account for any effect of population growth on unrest. We use the geocoded Social Conflict in Africa Database (SCAD) (Salehyan et al. 2012) that includes event data such as riots, demonstrations, and protests, distinguishing such events from organized armed conflict. The case for such distinction is strong. Not only are the processes that drive protests and riots different from the

---

[3]Civil conflict here refers to the definition employed by the Uppsala Conflict Data Program (UCDP) (Pettersson & Eck 2018, http://www.pcr.uu.se/research/ucdp/definitions/). In a special issue of the *Journal of Peace Research* on climate change and conflict, none of the 16 articles examined urban violence (Gleditsch 2012: 5).

[4] While not addressed empiricallty in the current analysis, another key mechanism potentially linking drought to riots in urban spaces is volatility in food prices. Wischnath & Buhaug (2014) find that, across India, harvest loss is robustly associated with increased levels of riots and other forms of political violence.

[5] We define drought as an extreme weather pattern where a region or country experiences below normal levels of precipitation. Yet, drought is a multi-scalar phenomenon where the time scale of the assumulation over time of water deficits from diverse sources, including rainfall and ground water among others, becomes very important.

causes driving violent armed conflict such as civil wars, but also, they are geographically distinct phenomena of social unrest.[6]

The African continent is by far the least urbanized, with 40 per cent of the population currently living in cities. But it is also the continent with the highest growth in urban populations, at 3.6 per cent annually (UN 2014). The population that lives in African cities is expected to increase by more than 150 per cent between 2020 and 2050 according to UN population forecasts, massively outpacing rural population growth estimated at 35 per cent. Hence, the African continent is a prime scene for investigating the urbanization-political unrest nexus. The implications of any patterns of instability emerging in urban areas following changes in environmental conditions could have considerable impact for future urban adaptation and conflict prevention strategies in other continents as well.

This study breaks new ground in several ways. While recent important scholarship of obvious relevance for understanding urban social unrest emphasizes the role of increasing food prices (e.g. Abbs 2019; Hendrix & Haggard 2015; Smith 2014; Wischnath & Buhaug 2014), we focus specifically on urban population growth which is a neglected factor in the population-environment-conflict nexus. We further link this to debates over the potential security implications of climate change by specifically attempting to identify whether environmental "push" factors, in the form of nearby drought may explain some of the potential co-variation between population growth and urban unrest.[7] Finally, by separating between different urban locations, we are able to distinguish between different security scenarios associated with urban population growth.

---

[6]We define as urban social unrest phenomena of civil disorder such as riots and demonstrations that occur in the urban and peri-urban areas without making a distinction between different levels of intensity (violence). We are interested in separating urban social unrest from organized armed violent conflict, a phenomenon more common in rural areas (Buhaug 2006).

[7] Proximity to a drought is difficult to define, as there needs to be an arbitrary cut-off point. The threshold we eventually settled on was 200km (or four of our grid cells), as this coincides with the distance over which isohyets have moved in the drought-affected Sahel region in the twentieth century (see Nyong & Fiki 2005; Lebel et al. 1997; l'Hôte et al. 2002). When constructing the variable we do not take into account national borders.

In line with our expectations, we find that high urban population growth rates have a net positive effect on urban unrest. Importantly, peri-urban areas, the urban outskirts, are particularly susceptible to urban unrest, suggesting that demographic changes on the urban fringe pose particular challenges to political control in the form of an increased risk of political instability. We do not find, however, that this effect is conditioned on environmental push factors, as near-urban droughts do not seem to affect the relationship between urban population growyh and unrest in peri-urban areas. Furthermore, droughts hitting urban areas directly seem to depress social unrest.

2.0 **The impact of population and environmental stress on urban social conflict**

Large-scale migration to cities may arguably translate the problem of high rural population pressure on natural resources into an urban setting, potentially causing a security challenge (Cincotta et al. 2003; Homer-Dixon & Blitt 1998; Gizewski & Homer-Dixon 1995; Goldstone 1991; Kahl 2006; Kaplan 1994; Liotta & Miskel 2012). Gizewski & Homer-Dixon (1995) point to three broad risk factors. First, rural–urban migrants are likely to experience economic marginalization and relative deprivation, increasing their awareness of their own situation and, hence, the potential for political radicalization, a mechanism empirically corroborated by Østby (2016). Second, traditional authorities of social control such as schools, established churches, and government policing are less likely to be well established in peri-urban areas with high turn over of population. The space created by the absence of such social institutions is filled by alternative forms of authority and social control such as gangs, clans from the region of origin, unorthodox religious groups, where migrants turn to in search for resources and social networks. Goldstone (1991) discusses that migrants in the urban fringe areas in 17th century London were more likely to be radical because of the low absorption into existing institutions of social control. Similar patterns have been observed in developing countries as well (Goldstone 2002). Third, the urban environment facilitates high levels of social communication, including greater opportunities for collective political action.

Rapid urban population growth can constrain governments' ability to provide basic services, including employment, housing, electricity, water, sanitation, enforcement of law and order, and development of social capital, thus greatly affecting the quality of life of the citizens. According to Goldstone (2002), the combination of over-urbanization and underdevelopment produces a situation where the job market and the economy cannot keep up with urban population growth, which could lead to urban violence and instability. Similarly, the mixing of ethnicities and shifting demographic composition of urban centers are cited as central destabilizing factors in urban environments, though Toft (2003) argues that ethnicity tends to work differently in urban than rural settings since urban ethnic groups often lack a strong attachment to the city as their "homeland". Population growth is likely to add to these existing challenges. We further speculate that population growth may be more likely to cause urban unrest in more peripheral, 'peri-urban' areas, as these areas are likely to be prime locations for land use transformations as well as underservice of basic infrastructure.

So far, however, the evidence for a link between urban population growth and social conflict is limited. Urdal found high urban population growth to be associated with a *lower* risk of conventional armed conflict both cross-nationally (2005) and across Indian states (2008), while Fox & Bell (2016) found a negative association between urban population growth and African state-level protest rates across all income levels. Buhaug & Urdal (2013) and subsequently Østby (2016) found no correlation between high urban population growth and "urban social disorder" events in 55 major cities across Asia and Sub-Saharan Africa. However, the geographical resolution of earlier studies, even those addressing the city level, has been low, not allowing for a separate treatment of different urban environments. Earlier studies have also not attempted to empirically consider the potential role of rural environmental conditions in the population growth-unrest nexus .

In contrast to conventional armed violent conflict, riots and demonstrations are more common in urban areas (Tarrow 1998; Wilkinson 2004) and are less likely to be driven by the same environmental risk factors as conflicts in rural areas in the periphery of a country. Therefore, the causal mechanisms that lead to urban unrest might differ compared to rural areas. Hendrix & Salehyan (2012) identify some mechanisms that can explain variation in unrest in urban settings. We develop these mechanisms further and also explore the impact of droughts on urban unrest, by focusing on urban and peri-urban population growth in the context of low development.

Existing theoretical frameworks link certain forms and constellations of demographic and environmental pressures, such as droughts, to increased risks of armed conflict and political instability (e.g. Goldstone 1991; 2002; Homer-Dixon 1991; Kahl 2006). A key assumption for the climate change and conflict literature is the expectation that precipitation patterns will significantly alter as a result of climate change, with rainfall levels generally increasing in temperate zones and decreasing in subtropical areas, including in many parts of Africa. Changing rainfall patterns are likely to trigger slow processes of soil degradation rather than abrupt changes (Buhaug et al. 2010). The literature further suggests that low-income countries are particularly susceptible to resource conflicts. Butler & Gates (2012: 24) argue that water availability most directly affect pastoral conflicts as rural communities are directly dependent on renewable resources threatening subsistence agriculture, while any effects on urban groups are arguably more indirect and complex according to Hendrix & Salehyan (2012). In Sub-Saharan Africa, where only five percent of arable land is irrigated, large parts of the agrarian population are vulnerable to extensive periods of drought. Moreover, low capacity states often have weak resource management institutions, unclear property rights, inefficient markets, and low financial and human capital. Such states are arguably less likely to be able to prevent serious environmental change from happening in the first place, and more likely to fail in adapting to actual changes (Gizelis & Wooden 2010; Raleigh et al. 2015).

Yet, the evidence of eco-conflicts at the sub-state level is relatively weak. Studies of the reactions to income shocks suggest that extreme weather conditions, particularly droughts, lead to more cooperation rather than conflict. While resources might be at the center of conflict, it is political exclusion and corruption that cause conflict as evidence from Mali, Somalia, and Sudan suggests (Benjaminsen 2008; Verhoeven 2005). Large-N studies have also expanded the range of types of conflicts that are attributed to environmental stress. The anticipation that demographic and environmental factors may be more relevant to spontaneous, small-intensity, and inter-group forms of violence, rather than civil wars, has led to an increasing sophistication in the models applied and a greater diversity on the operationalization of the dependent variable (e.g. Fjelde & von Uexkull 2012; Hendrix & Salehyan 2012; Theisen 2012). The use of high-resolution geographical units as the basis for analysis rather than country averages, has allowed for more detailed studies of interactions between demographic, environmental, economic, political and social interactions (Koubi 2019; Raleigh & Kniveton 2012; Raleigh & Urdal 2007).

Environmental factors determining resource supply or social demand factors -- arising locally because of migration or unequal access to services--, are likely to affect the probability of violent unrest and conflict in overstretched communities in states with low capacity to adapt (e.g. Barnett & Adger 2007; Bell et al. 2011; Homer-Dixon & Blitt 1998; Kahl 2006; Raleigh et al. 2015; Reuveny 2007). Prolonged periods of drought driven by erratic changes in temperature and precipitation levels affect agricultural production, prompting migration into other vulnerable areas depending on the existing contextual factors and the duration of the drought (Buhaug et al. 2008; Lilleør & Van den Broeck 2011; Reuveny 2007; Suhrke 1997).

Chronic droughts primarily lead to labor migration, while acute and sudden disasters contribute to distress migration. While household vulnerabilities shape the behavior of migrants, “environmental migrants” have higher levels of return than other types of forced migrants. Environmental migrants also tend to be internally displaced while the duration of migration is an average of short length reducing the probability of unrest and violent conflict. The patterns of the environmental migrants’ settlement, whether migrants are self-settled or established in larger, organized hamlets such as camps, influence the interactions between the migrants and the host communities. Droughts and scarcity create the underlying conditions for unequal distribution of resources and political corruption leading to violent conflict (Kahl 2006). A recent study by Detges (2017) of African data suggests that the propensity to violent responses to drought is amplified by group political exclusion.

In this article we specifically explore whether droughts, which are expected to increase in frequency and severity as a result of climate change, could affect urban unrest through spurringrural-to-urban migration.[8] While the concern over “climate refugees” has received considerable attention, much of the migration related to changing weather patterns is likely to contribute to the relatively slow, yet substantially massive, population transfer from rural to urban areas worldwide. The case of Syria is often cited as a recent example of migratory movements leading to protests in areas less affected by the historic drought (Ash and Obradovich 2019; Fratkin 2001; Galvin 2009; UN 2014). These patterns have also been recorded in East Africa. Historically, pastoralist communities used to migrate between rural areas in search for available pastures for their livestock. Droughts in areas of Somalia, Kenya, and Tanzania have led pastoral communities to increasingly migrate to urban centers in search for employment opportunities and better access to health and services (Fratkin 2001; McCabe 2004; Omolo 2010). While in cities and urban areas, rural migrants are facing different challenges that are often linked to governance and the ability of governments to accommodate their needs and demands.

We hypothesize that migration into urban areas will trigger an increase in unrest in the cities, and that this dynamic may in part be explained by rural-urban migration triggered by droughts in the surrounding rural areas:

---

[8] We are also briefly empirically addressing the role of food prices, another intermediary mechanism between drought and urban unrest, in the Online Appendix. Wischnath & Buhaug (2014) find that, across India, harvest loss is robustly associated with increased levels of riots and other forms of political violence. Because of the mediation of politics and markets, any effect of adverse environmental conditions on urban unrest through changes in food prices is likely to be temporally lagged and more contingent on the political and economic climate, compared to the more immediate effects expected in rural areas (Abbs 2019; Demarest 2015; Jones et al. 2017; Natalini et al. 2019).

H1: High urban population growth is associated with increased levels of urban social unrest. This effect is likely to be more pronounced in peri-urban areas than urban cores.

H2: Droughts in nearby rural areas contribute to explain any effect of high urban population growth on urban social unrest.

3.0 **Model and data**

To credibly study these relationships, one must go below these coarse units of observation to capture local dynamics and the variation within states and urban areas (see Buhaug & Rød 2006, Cedermann et al. 2011 and Theisen et al. 2011 for earlier, influential GIS-based approaches). To test our empirical hypotheses, we look at low intensity unrest events, such as riots and protests, in Africa for the period 1997-2010. Our unit of analysis is the grid-cell-year. Each grid is 0.46x0.46 decimal degrees, corresponding to areas of approximately 50x50 km at the equator. Across 14 years it yields 164,542 observations, or 11,753 per year. The data for our dependent variable are based on events data on riots, protests, and other forms of social unrest from the Social Conflict in Africa Database (SCAD) (Salehyan et al. 2012).[9] SCAD records riots and protests independently from civil wars within a country for a given year. The dataset includes all African countries with populations greater than 1 million and the main sources of information are Associated Press and Agence France Presse newswires (Salehyan & Hendrix 2012).

SCAD uses 10 categories of events to code social violence. Categories 1-6 include organized and spontaneous riots and demonstrations, as well as general and limited strikes. These categories are distinct from categories of armed conflict between state actors and organized opposition groups. Since we are interested in separating between areas that have

[9] SCAD includes more low-intensity unrest events than two other prominent event datasets, the Armed Conflict Location & Event Dataset (ACLED) (Raleigh et al. 2010) and the Uppsala Conflict Project (UCDP) Georeferenced Event Data (Sundberg & Melander 2013). UCDP includes events defined as part of organized violence only. While ACLED includes riots and demonstrations, the orientation of the dataset is towards incidents that are associated with ongoing civil wars.

experienced major unrest and those that have not we create a dummy variable (0-1) to capture urban social unrest, scoring 1 of there is at least one event within a calendar year.

We specifically separate urban social unrest from armed violent conflict, the latter being a phenomenon more common in the rural areas of a country. Using our restricting criteria gives us a total of 4,230 events from 1997 until 2010.[10] While demonstrations and riots may conceptually be thought of as distinct phenomena, with the latter being associated with largely uncoordinated, violent rampaging and the former with peaceful and coordinated action, they may also be considered as events along a continuous scale ranging from "peaceful" to "violent". Both are typically mass events and can be both spontaneous and organized (see e.g. Brass 2003 and Wilkinson 2004 on the organization of Indian riots). The main distinguishing criterion between demonstrations and riots is the level of violence where demonstrations are "largely peaceful" and riots "violent". SCAD also includes an "escalation variable" that notes whether the nature (event type) of an event has changed over the course of its duration. "Largely peaceful" is somewhat subjective, with different researchers using different criteria to define "peaceful". The variation in the intensity of rioting tends to be large, though most cases are recorded at a low intensity level.[11]

Based on the theoretical discussion and the derived empirical hypotheses we formulate the following base model that we empirically estimate:

OccurenceOfUnrest = GridPopulationGrowth + GridPopulation + UrbanCore + DistanceToDroughtArea + Drought + GridYear + DensityOfInfrastructure + GridDistanceToCapital + LogGridEconomicDevelopmentPerCapita + SpatialLag

[10]The breakdown of the events per category is as follows: 19% Type 1: Organized demonstration (795); 31% Type 2: Spontaneous demonstration (1,292); 4% Type 3: Organized violent riot (172); 25% Type 4: Spontaneous Violent riot (1053); 2% Type 5: General strike (99); 18% Type 6: Limited strike (755). The number of grid cell years with at least one event is 1,932, a little over 1% of the total.

[11]We used both the ACLED and SCAD data to calculate the Kernel Distribution Function (KDF) of high and low intensity conflict events in urban and rural areas. There were more riots and protests in urban than rural areas without any substantial differences between the ACLED and SCAD data.

Identifying Urban and Peri-urban Areas

We are interested in addressing the presumed different dynamics between urban and peri-urban areas, the latter capturing transition zones between urban and rural zones and landscapes. We hypothesize that peri-urban areas are more vulnerable to environmental stress and in-migration, thus, experiencing more incidents of social unrest.

We started with the data on urban and rural populations, updated through 2010, provided by the Global Rural-Urban Mapping Project (GRUMP) (CIESIN et al. 2004; Balk et al. 2006). The gridded version of the GRUMP data has a resolution of 30" (43,200 x 16,800). This was a higher resolution than we could use, so we initially down sampled by a factor of 8, horizontally and vertically (giving us a data set with a resolution of 5400 x 2100, or approximately 0.067 degrees per grid cell). We then later downsampled to the resolution of our grid.[12] The African areas defined as urban by GRUMP[13] are presented in Figure A1 (see Online Appendix).

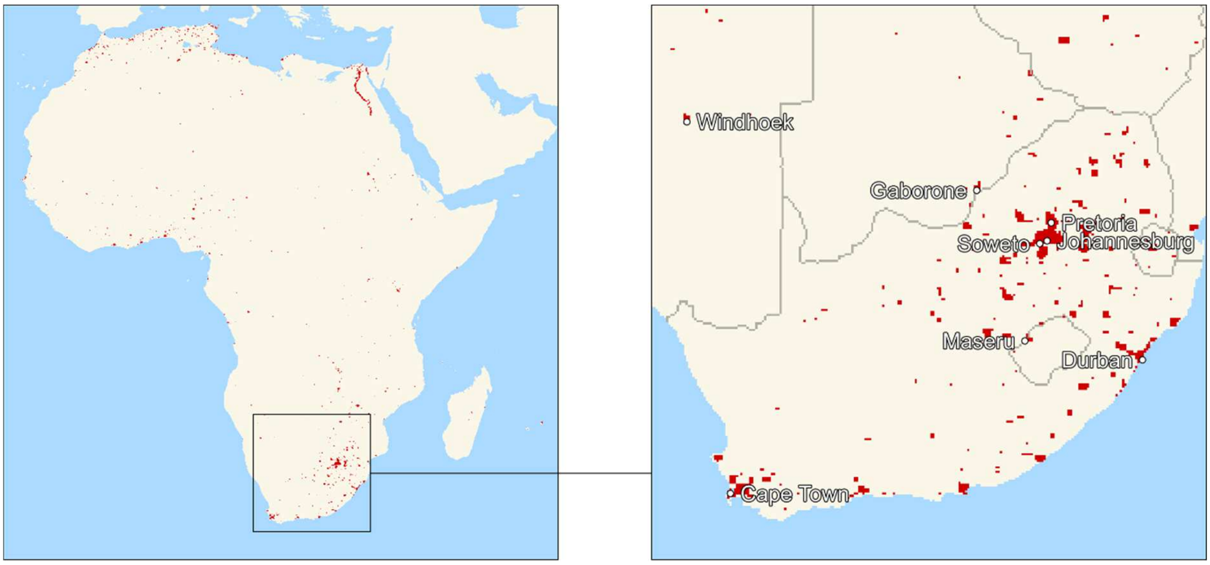

Figure 1: Urban areas in Africa, with southern Africa expanded for detail.

---

[12] The advantage of this two-stage downsampling is that it allowed us to retain a relatively large number of urban areas in the first wave, from which we were able to construct a new variable, as is discussed below.

[13] GRUMP uses a combination of population data, settlement points and nightlight data to determine which parts of the world are urban and which are rural. Urban areas are defined as those "where contiguous lighted cells from the Nighttime Lights or approximated urban extents based on buffered settlement points for which the total population is greater than 5,000 persons" (CIESIN, accessed 24 August 2018).

Very little of the territory of Africa is urban; see the red areas in Figure 1. Indeed, once these data were applied to our lower resolution grid, which is composed of 11,753 cells per grid year, only 67 cells were defined as primarily, or 'core' urban, the other 11,686 being by default 'rural', thus excluding many smaller urban areas. To mitigate this strict inclusion criterion, we expanded the radius of each urban area by approximately 30 kilometres.[14] This is presented in Figure 2. Once applied to our grid, this gives us 929 grid cells in the wider urban area.

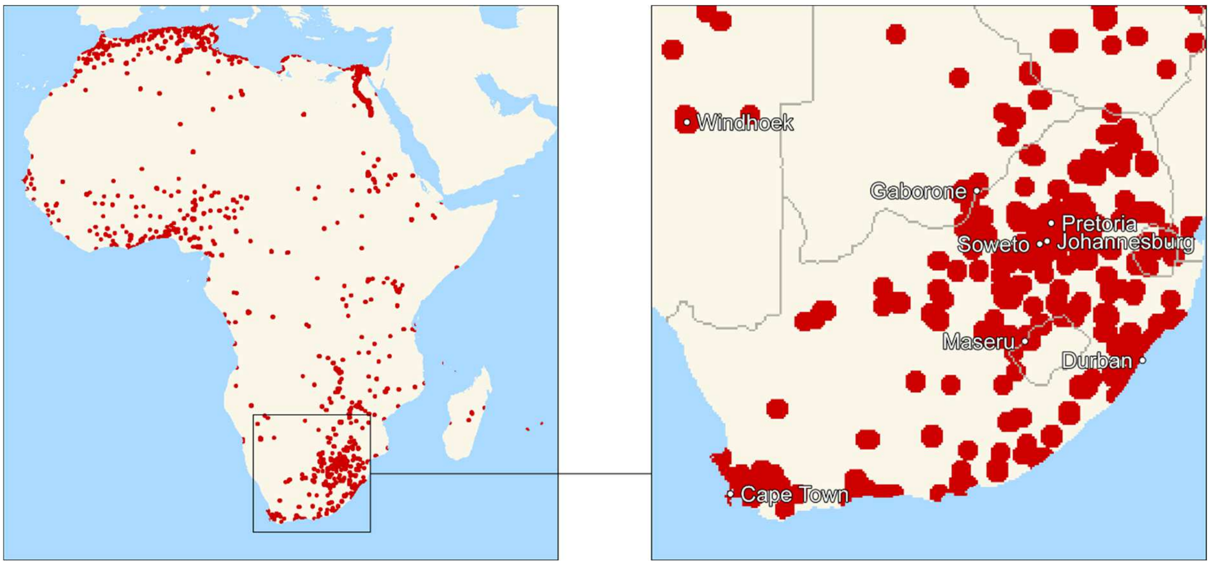

Figure 2: Urban areas in Africa, expanded by a radius of approximately 30 kilometres.

We were then able to construct a 'peri-urban' dummy variable to capture the areas which are neither the very heart of the urban area, nor the more remote rural areas. Figure 3 illustrates this. By subtracting the central urban areas (represented in yellow) from the wider urban areas, we create peri-urban areas, shown in red. These can be conceptualized as being shaped like

[14] The radius of each urban area was expanded by 0.2667 degrees which is approximately 30 kilometres at the equator.

the ring of a doughnut, with the peri-urban area surrounding the urban core. We conceptualize, therefore, that there are three main types of territory: urban core, peri-urban and rural.

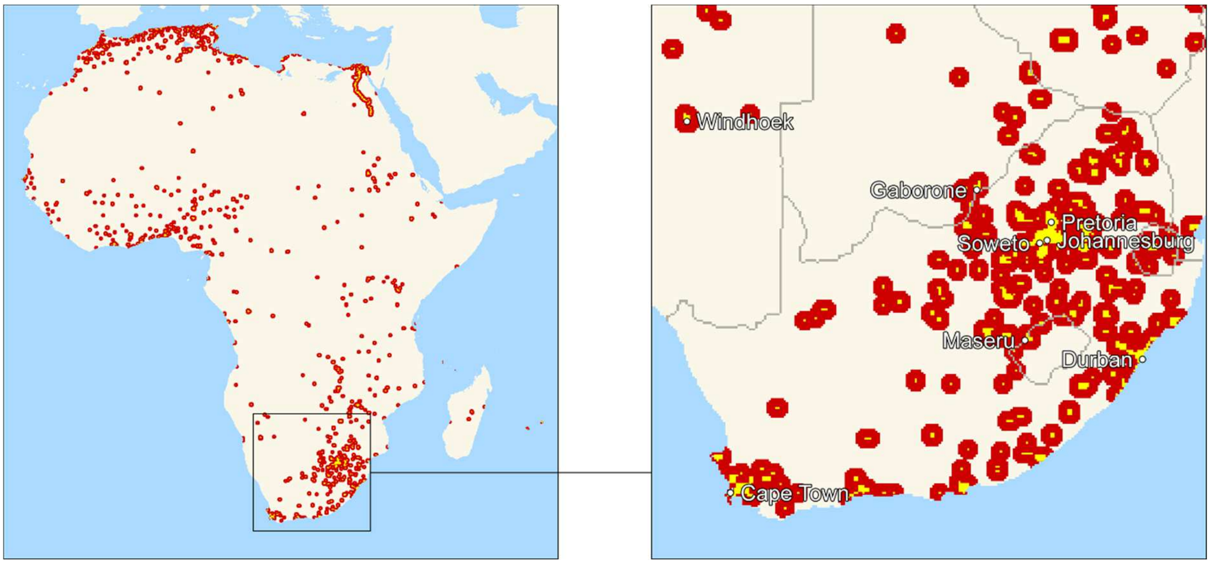

Figure 3: Urban (yellow) and peri-urban (red) areas in Africa.

The distinction between urban and peri-urban is important. Figure 4 zooms in further on southern Africa. The image on the top shows urban and peri-urban areas at the resolution of our initial GRUMP rendering; the image on the bottom shows the same data reduced to the resolution of our grid. As can be seen in both cases, Pretoria, Soweto and Johannesburg are identified as urban, while the surrounding areas are identified as peri-urban. These are not the urban centres where we might expect to find mass-congregation protests; they are the urban sprawl areas, which exhibit different characteristics and which we would not expect to serve as a locus for protests.

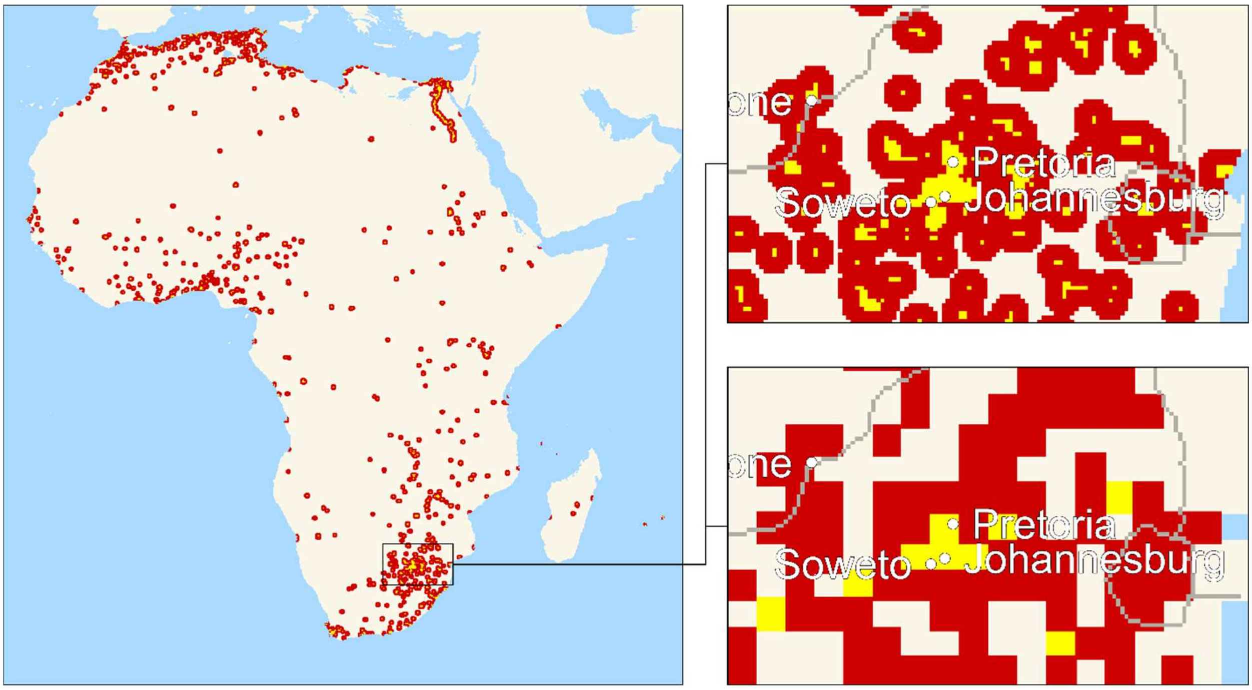

Figure 4: Urban (yellow) and peri-urban (red) areas at GRUMP resolution (top right) and grid resolution (bottom right).

We are especially interested in peri-urban areas as, at least in absolute terms, this is where most instances of unrest are to be found, as is shown in Table 1.

Table 1: African grid cells experiencing unrest in core urban, peri-urban and rural areas.

Cell type	**Cell count (all years)**	**Cell years experiencing unrest**	**Percentage of cell years experiencing unrest**	**Total unrest events in cells**	**Percentage of all unrest events**
All types	164,542	1,918	1.2	4,166	100
Core urban	938	210	22.4	823	19.8
Peri-urban	12,068	836	6.9	1,954	46.9
Rural	151,536	872	0.6	1,389	33.3

This is in part a function of the fact that there are more peri-urban cells than urban ones; in relative terms, we see that there is a greater likelihood of unrest events in urban areas than in peri-urban areas. Yet in simple absolute terms, there are more instances of unrest in peri-urban areas than in core urban areas. The case of Algeria, presented in Figure 5, provides a useful (and quite representative) example here. This is the case for most African states: the individual grid cell with the greatest number of incidences of unrest is a peri-urban cell, not an urban core cell. In 41 of the 50 African states we analyse, the cell with the greatest frequency of unrest is a peri-urban cell (for more on this, please see Figure A2 in the Online Appendix).

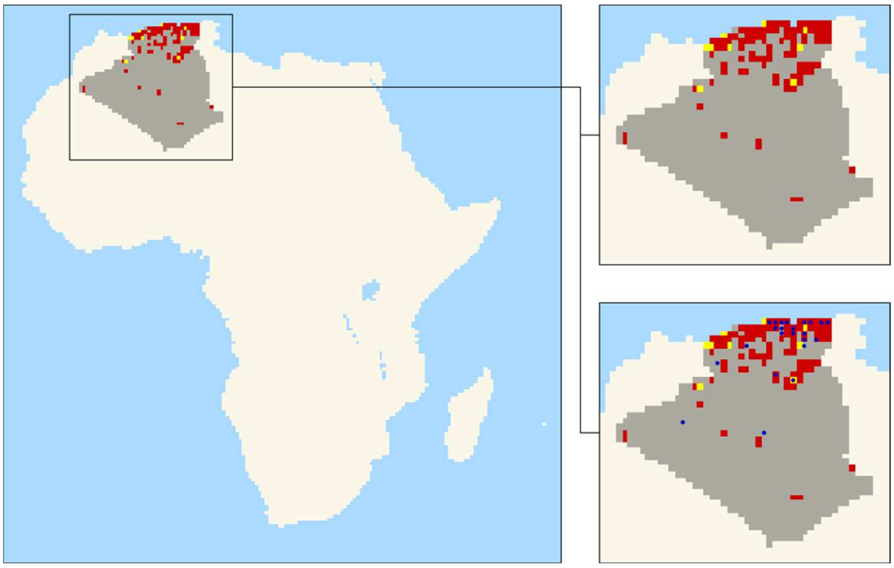

Figure 5: Urban (yellow) and peri-urban (red) areas with focus on Algeria, rendered at the resolution of our grid. Blue dots in the bottom right image indicate cells experiencing unrest.

Accordingly, there have been enough unrest events in peri-urban regions to warrant inclusion in our analysis. However, we feel that peri-urban areas are different enough from either urban core or rural areas that they constitute a separate category. Table A1 in the online appendix includes information on differences between the categories in relation to infant mortality rate, infrastructure, population, night light and disaggregated GDP.

Main Independent Variables

Grid Population Size and Growth

We argue that demographic changes, and in particular high population pressure on urban areas, can lead to urban riots and social unrest. The expectation is that these effects are particularly strong in peri-urban areas. We include in our analysis not only the population size of the grid, but we also calculate the population growth of each grid for every year included in our sample. Large positive changes in population growth are assumed to capture larger migratory patterns into the grid cell. We cannot, however, empirically distinguish between urban population growth that is attributed to migration from natural population growth (stemming from the balance between fertility and mortality). It is important to underscore, however, that the by far most significant driver of African urban population growth is migration, and not natural growth, as evidenced by the fact that urban population growth rates on the continent are close to five times as high as rural population growth rates. Neither can we distinguish between migration that is caused by economic attractiveness in the urban areas ("pull factors") or caused by adverse environmental conditions in the rural regions ("push factors"). We attempt to minimize this problem by separating between urban and peri-urban areas, assuming that environmental and other push factors are more likely to lead migrants to more marginal, peri-urban areas. We have also considered the interaction of urban population growth and level of economic development (which admidttedly is a coarse measure in such a high-resolution model) to capture variation in economic attractiveness.

The population data (*gridPop*) data are derived from Gridded Population of the World (GPW) Version 3 (CIESIN & CIAT, 2005), providing data up until 2010. As the GPW compiles data on a five-yearly basis, the final variable, *gridPop*, chooses the nearest of the previous four variables to the year in question for that grid-cell-year. Despite concerns regarding the modifiable areal unit problem (MAUP) described by Openshaw (1984), we believe that these data are superior to country aggregates. To estimate changes in the population patterns of each grid and calculate the population growth, we use linear interpolation to calculate the grid population for each year. Then, we calculate the population growth for each year.

Drought

We measure *drought* using data from the Global Standardized Precipitation-Evapotranspiration Index (SPEI). The SPEI index is based on monthly precipitation and potential evapotranspiration data and offers near real-time information about drought conditions at the global scale. SPEI is a multi-scalar index of drought based on the Standardized Precipitation Index (SPI), but also incorporates temperature data because temperature variations have a significant impact in drought conditions (for more information on the construction of the index and its differences from other indices see http://sac.csic.es/spei/home.html). The index provides SPEI time-scales between 1 and 48 months. One advantage of SPEI that explains the popularity of the index is its comparability in time and space (Hayes et al 1999). Currently it covers the period between January 1901 and December 2015; for our purposes, we restricted this set to 1997 – 2010, using the 12-month version of the variable.[15] In this restricted set, SPEI values are between -8.32 and 7.47 globally. For Africa, the range is from -3.46 to 3.05. We develop two drought variables for our empirical analysis: one for "drought in the grid cell" and one dummy for "drought within the proximity of 200 km of the cell". Using "0" as a theoretical median of all our grid cells we create a drought binary to capture whether a rural environment is more or less hospitable to local populations. Locations where the SPEI variable is lower than 0 are defined as less hospitable areas that have experienced drought, while in areas where the SPEI variable is higher than 0 are more hospitable and do not experience drought.

Urban areas are less likely to be in regions where the most severe droughts historically occur in Africa, partly because of the dependence on large and regular water supplies for urban areas. We calculate our distance from the drought variable by using the Great-Circle distance formula, the geographical distance of urban areas from regions that are coded as having experienced drought. This is a dummy variable indicating if there is major deviation from the average levels of precipitation in a cell within the 200 km in the buffer zone relative to each observation. Once we construct the dummy variable then we take the lag to indicate the distance from an area that had experienced drought in the previous year.

---

[15] We also use 48 months as a robustness check.

Control Variables

To control for the effect of government capacity, we use the Geographically Based Economic Data (G-Econ). We use the current data set (GEcon 4.0, available at gecon.yale.edu; Nordhaus et al. 2006) that covers “gross cell product” for all regions for 1990, 1995, 2000, and 2005. The basic metric is the regional equivalent of gross domestic product. Gross cell product (GCP) is measured at a 1-degree longitude by 1-degree latitude resolution at a global scale. Because the G-Econ data are of a lower spatial resolution that our grid (four times lower), we mapped each one of our cells to the geographically nearest cell to G-Econ. We also used the G-Econ year of 1995 to calculate our years of 1997-1999; the G-Econ year of 2000 for our data years 2001-2004; and the G-Econ year of 2005 to ours 2006-2010.

One of the controls that we use at the grid level is the density of infrastructure as an experimental variable that analyzes the complexity of map images from http://maps.google.com. For some time, there has been an expectation that roads and other infrastructure will be related to increases in the opportunities for various types of conflict (roads permit troops or protestors to move more easily; buildings give troops and rebels places to hide in civil war). The significance of road networks in facilitating conflict is primarily relevant in large rural areas rather than urban areas. Here we are interested not only in the primary urban centers, but also in the peri-urban areas that combine urban and rural landscapes. The infrastructure variable is used as a proxy for the ability of demonstrators and protestors to spread and mobilize. See the Online Appendix for a discussion on the construction of the infrastructure variable.

We assume that urban areas closer to the capital experience more riots and demonstrations than more peripheral urban and peri-urban areas, since governments tend to locate in the capital city. Thus, we create the variable Grid Distance from the capital and calculate the distance of each grid from the capital in kilometers. We expect that there is more urban disturbance in the most densely population areas, simply reflecting a per capita effect. In our analysis, we include the variable urban core dummy to capture the most central and densely populated urban areas. We also control for possible time trends using the variable *GridYear*.

We also control for the possibility that riots and demonstrations are clustering in space. We construct the spatial lag of social urban unrest by analyzing the eight pixels surrounding each grid cell (known as the Queen's Move, see Figure 6).[16] If one or more SCAD events occurred in each of the eight cells, that cell was given the value 1; otherwise, it was assigned the value of 0. The eight values are then added up and divided by eight. The spatial lag value for the pixel at the center of Figure 6, therefore, is 0.25.

1	1	0
0		0
0	0	0

Figure 6: Creation of Spatial SCAD Lag, using Queen´s Move.

Finally, we tested for possible multicollinearity without any evidence that any of the variables included in the analysis are collinear.

4.0. Results and discussion

[16] The Queen’s move is a long-established means of controlling for spatial lag. See Cliff & Ord 1972, 1973; Oden 1984; Anselin et al. 1996; Fingleton 2008; Getis & Ord 2010; LeSage & Page 2010; Rey & Anselin 2010.

Table *2* presents the empirical estimation of our theoretical model.[17] The first model (Model 1) is the base model that includes urban population growth. Model 2 adds the drought variables to allow us to test whether environmental push factors could be driving the population growth-unrest relationship. Model 3 includes only the peri-urban areas in our sample, isolating the effect of population growth in the urban outskirts, while Model 4 focuses strictly on the primary urban core areas.

In Model 1 we present the core model including our main explanatory variable, the urban population growth in a given grid. Consistent with our first hypothesis, grid population growth has a significant and positive effect on urban unrest, linking high urban population growth to higher likelihood of urban social unrest. An important qualification is that we cannot empirically separate between urban population growth that is due to migration driven by “pull” factors, such as higher economic growth and opportunities, from migration caused by “push” factors such as environmental adversity.

As expected, grid cells that are defined as primary urban areas and are close to the capital and hence likely targets for general political attention including unrest, and cells with higher population size all experience a greater likelihood of urban social unrest, the latter capturing a per capita effect. The density of infrastructure appears to be highly associated with urban violence, possibly suggesting that improved infrastructure creates better opportunities for mobilization. The level of development in the area, measured by the GDP per capita in the grid, is associated with lower levels of urban unrest, as expected, while the positive and clearly significant spatial lag captures a clustering effect.

In Model 2 we assess the effect on our initial model of introcucing a measure of distance from drought are in the preceding 12-month period. The expectation is that drought in surrounding rural areas may spur rural-urban migration that could feed urban unrest. There is no evidence, however, that drought in nearby rural areas increase urban social unrest through pushing rural residents towards the cities. The population growth variable is unaffected by the

---

[17] For descriptive statistics please refer to Online Appendix.

introduction of the Distance to drought variable that we expected (H2) to tap into the effect of the population growth variable, rejecting H2.[18]. Furthermore, the measure for recent droughts hitting urban areas directly is negatively associated with unrest, and statistically significant. This runs counter to a conventional resource scarcity scenario assuming increasing competition for renewable resources is a source to increased social tensions, and is particularly interesting as the geographical selection includes extensive peri-urban areas that are often already experiencing complex processes of land use pressure and change.[19] Arguably, this result is supportive of case study evidence suggesting that social conflict can be more prevalent in times of plenty, than during periods of shortage (e.g. Wario Roba et al. 2012).

As is emphasized in much of the environmental security literature, contextual factors are likely to significantly affect the role of demographic and environmental factors in explaining social unrest. Not least do we expect to see variations in drivers of unrest between primary urban centers and the urban outskirts. We assume that separating the sample between urban and peri-urban areas is a coarse, yet promising, way to distinguish between more affluent migrants moving to the urban core and poorer migrants settling at the urban fringes, partly capturing also "pull" and "push" factors respectively. While the primary urban centers are typically economic hubs that provide economic opportunities, attracting more resourceful and skilled individuals who enjoy generally better housing conditions and public services provision, migrants who go to the urban outskirts are those who cannot afford to move to the primary urban centers, but have to settle into less expensive, informal settlements without adequate provision of public goods, often dominated by mixed ethnic settlements, unclear property rights, and hybrid land use where households living off the land employing traditional modes of agricultural production compete for space with migrants and development projects.

Model 3 includes only the peri-urban areas in our sample, while Model 4 includes only the primary urban core centers. As anticipated in H1, high population growth rates are strongly

---

[18] Similar results are found when including distance from drought in Models 3 and 4, not shown here.
[19] We have also tested whether multiple demographic-environmental stressors, in the form of an interaction between population growth and drought, affects urban unrest, however this interaction effect is statistically insignificant and negative (see Table A5 in the Online appendix).

associated with more unrest in the peri-urban areas, while in the primary urban centers the grid population growth rate is negatively associated with unrest. This provides the first quantitative evidence, we believe, that urban population growth in the most vulnerable and least developed urban outskirts increases the risk of urban unrest, and that the lack of distinction between types of urban areas may explain why earlier attempts to study links between urbanization and conflict have failed to detect such relationship, which has long been emphasized in the qualitative literature.

Table 2: Environmental and Demographic Stress on Urban Unrest

	Dependent variable:			
	scad1.6 > 0			
	(1)	(2)	(3)	(4)
Grid pop growth	0.088***	0.093***	0.113***	-0.139*
	(0.024)	(0.025)	(0.026)	(0.073)
Grid population	0.00003***	0.00003***	0.00003***	0.00001***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Urban core	0.746***	0.763***		
	(0.111)	(0.115)		
Distance from drought area (lag) (past 12 months)		-0.075		
		(0.081)		
Drought (past 12 months)		-0.222***		
		(0.077)		
Grid year	-0.021**	-0.021*	-0.024**	-0.012
	(0.010)	(0.011)	(0.011)	(0.028)
Density of infrastructure	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00002)	(0.00002)	(0.00002)	(0.00003)
Grid distance to capital (km)	-0.002***	-0.002***	-0.001***	-0.004***
	(0.0002)	(0.0002)	(0.0002)	(0.001)
Log GDP grid per capita	-1.569**	-1.413*	-1.146*	-17.493*
	(0.731)	(0.724)	(0.688)	(9.953)
SCAD (lag)	2.572***	2.618***	2.537***	1.308
	(0.395)	(0.405)	(0.429)	(1.156)
Constant	40.310**	38.965*	46.340**	24.204
	(20.192)	(23.005)	(21.816)	(55.985)
Observations	10,738	9,912	9,958	780
Log Likelihood	-2,715.101	-2,520.988	-2,381.695	-303.944
Akaike Inf. Crit.	5,448.203	5,063.977	4,779.390	623.888
Note:				*p<0.1; **p<0.05; ***p<0.01

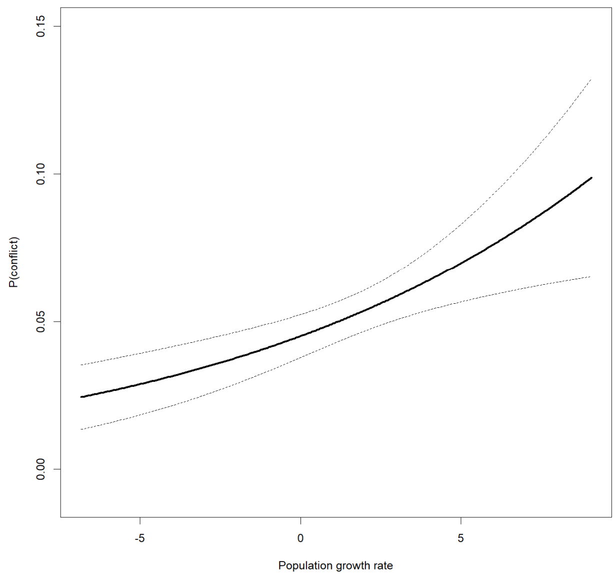

Figure 7 summarizes our key findings, and is based on Model 2 in

Table *2*, plotting the probability of urban social unrest in the y-axis conditional on population growth of the cell. The solid line depicts the probability of urban social unrest and the dotted lines represent the confidence intervals. The effects are sizeable in that the probability of social unrest is 64% greater in areas of 5% annual population growth, compared with areas with no population growth.

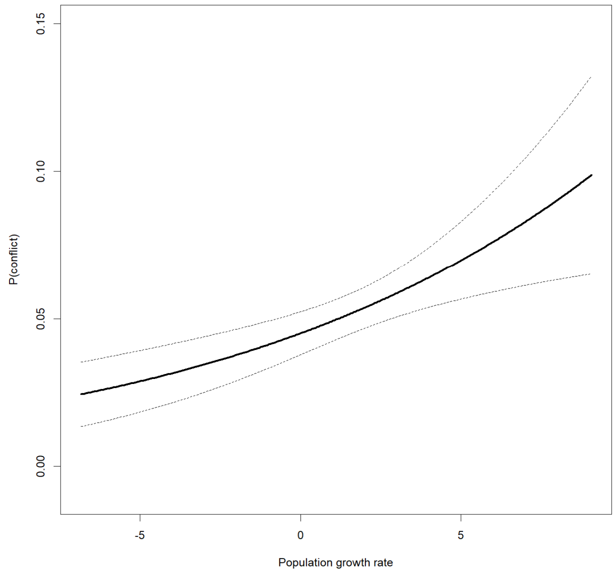

Figure 7: Probability of Urban Social Conflict (conditional on grid population growth).

In Figure 8 we plot the probability of urban social unrest in the y-axis conditional on population growth for peri-urban areas only. The solid line depicts the probability of social unrest in peri-urban areas and the dotted lines represent the confidence intervals. The conditional effect is substantial, as the probability of social unrest is 58% greater in peri-urban areas of 5% annual population growth, compared with peri-urban areas of no population growth'.

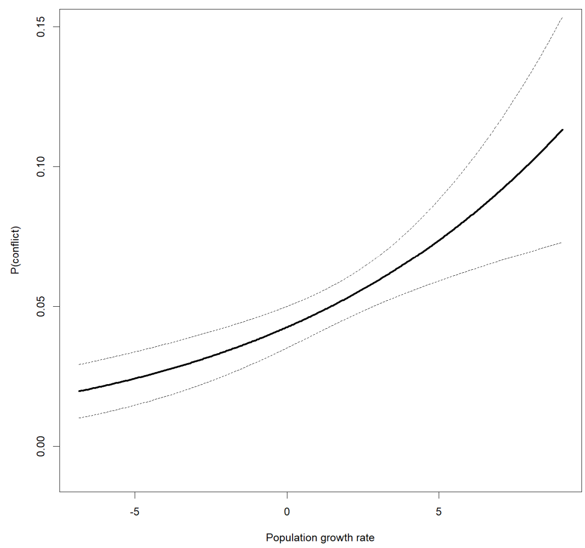

Figure 8: Probability of social conflict in peri-urban areas (conditional on grid population growth).

Robustness Checks

We test several alternative mechanisms and model specifications. Our key findings, that population growth in the grid has consistently a positive and significant effect on unrest in peri-urban areas, and the lack of any impact of droughts on this relationship, remain robust.

In Table 3, Model 2, we use a different drought variable (SPEI-48) to capture if the processes we observe in 12 months remain similar for a period of four years of drought. The key conclusions remain intact, the presence of drought in the rural surroundings does not alter the relationship between population growth and unrest, nor has it any significant impact on social unrest (the coefficient remains negative, but it is statistically insignificant). We further find that when observing drought over four years rather than a shorter period than 12 months, the previous statistically significant negative effect of drought in the city disappears. Also in Table 3, Models 3 and 4 mirror Models 3 and 4 in Table 2, but using another measure for social disturbance based on the Armed Conflict Location and Event Dataset (ACLED) (Raleigh et al. 2010). When using the protest and riot data from ACLED, we find the same statistically significant pattern as we do for SCAD, with population growth being associated with higher levels of disturbance in the peri-urban areas, and lower levels in the urban cores. When running the models with the drought variables, the results are consistent with those from the SCAD models, drought does not seem to be driving the effect of population growth on urban unrest (for more details on the construction of the ACLED measure and the results of the ACLED models, see Table A6 in the Online Appendix).

Table 3: Environmental and demographic stress on urban unrest, robustness tests (UPDATE)

	Dependent variable:			
	SCAD	SCAD	ACLED	ACLED
	(1)	(2)	(3)	(4)
Grid pop growth	0.088***	0.097***	0.113***	-0.139*
	(0.024)	(0.025)	(0.026)	(0.073)
Grid population	0.00003***	0.00003***	0.00003***	0.00001***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Urban core	0.746***	0.758***		
	(0.111)	(0.115)		
Distance from drought area (lag) (past 48 months)		0.004		
		(0.079)		
Drought (past 48 months)		-0.077		
		(0.078)		
Grid year	-0.021**	-0.018	-0.024**	-0.012
	(0.010)	(0.011)	(0.011)	(0.028)
Density of infrastructure	0.0001***	0.0001***	0.0001***	0.0001***
	(0.00002)	(0.00002)	(0.00002)	(0.00003)
Grid distance to capital (km)	-0.002***	-0.002***	-0.001***	-0.004***
	(0.0002)	(0.0002)	(0.0002)	(0.001)
Log GDP grid per capita	-1.569**	-1.439**	-1.146*	-17.493*
	(0.731)	(0.728)	(0.688)	(9.953)
SCAD/ ACLED (lag)	2.572***	2.627***	2.537***	1.308
	(0.395)	(0.405)	(0.429)	(1.156)
Constant	40.310**	32.811	46.340**	24.204
	(20.192)	(22.866)	(21.816)	(55.985)
Observations	10,738	9,912	9,958	780
Log Likelihood	-2,715.101	-2,525.038	-2,381.695	-303.944
Akaike Inf. Crit.	5,448.203	5,072.076	4,779.390	623.888
Note:				*p<0.1; **p<0.05; ***p<0.01

Next, we control for various other measures that could potentially affect social unrest as well as confound the relatiopnships of interest. Ethnicity is considered in Table A2 in the Online Appendix. As displayed in Table A2, both the count of ethnic groups (REF) and the presence of excluded ethnic groups (Wucherpfennig et al. 2011; Vogt et al. 2015) are negatively and statistically associated with unrest, however neither alter the significance of any of the key results.

We further consider levels of political stability, government effectiveness, and voice and accountability using the World Bank indicators at the country level, as well as the overall gross national income of the country per capita, Atlas method (World Bank, sourced from Index Mundi 2015). The indicators of political responsiveness dramatically mitigate the demographic variable of interest rendering population growth statistically insignificant in most models (see Table A3 in the Online Appendix). When we include the gross national income at the country level rather than the grid-specific income measure, the coefficient of population growth remains positive and statistically significant. Nevertheless, it is important to point out that here we are primarily interested in variations across urban areas rather than variations across countries. On average countries that are more accountable and wealthier should also experience less urban social unrest as they are more able to mitigate any effects of demographic and environmental stress (Gizelis & Wooden 2010). The average effect across countries neither negates nor reflects variations in urban areas within countries. We also included in the analysis the annual global food price index. While clearly acknowledging the shortcoming of this global measure for addressing local food prices dynamics, we note that its inclusion did not alter any of the key findings and had no direct effect on urban social unrest (see Table A3 in the Online Appendix).

In our analysis we use the urban core dummy to capture the more central part of urban areas as a control. We also examine how many cells included in the analysis indicate a country's capital. To construct the dummy variable for the capital we use the variable gridDistToCapKm. If the value of this variable is less than 42, then the dummy variable takes the value of 1 (0 otherwise). The threshold of 42 guarantees that all the states included in the analysis have at least one cell recognized as the capital. In some states up to four cells are recognized as the capital. A possible concern is that the Capital variable overlaps with the urban core dummy variable. This is not the case as only 11% of the urban1 cells are in the capital. As an example, Lagos, the most populous city in Nigeria, is not the capital of the country.

We also explored the possibility that African cities follow a different pattern of urbanization than cities in other parts of the world where urban centers tend to be more densely populated than peri-urban areas. We identified the geographical location of American Embassies as a proxy to capture the parts of an urban area that are politically and socially most prominent and matched it to the urban1 areas of our sample. As the map in the Online Appendix suggests, most American Embassies are in the urban areas (see Figure A5).

Finally, as an additional robustness check we employed a linear probability model fixed effects whereby "within only" information for each cell is used, i.e., using only deviation from the cell specific mean. The main variable of interest, population growth, remains significant and positive at 5% of significance level.

5.0 Conclusions

In this article we explore the links between population growth and social unrest in African urban centers in the period 1997-2010. The article contributes to the larger debate around the potential security implications of global demographic change, and the potential impact of environmental and climate change in contributing to unrest through spurring rural-urban migration. More generally it contributes to the large-N scientific inquiry that goes below the state-level to disaggregate political unrest and violence spatially as well as temporally.

The article diverges from previous studies in important aspects. While many studies make explicit assumptions about the different ways that demographic and environmental stress affects security, most prior large-N studies have primarily addressed rural dynamics. Furthermore, the study moves beyond the rural-urban dichotomy by separating between the urban centers, which often are hubs of economic growth and prosperity, and the peri-urban areas, or urban outskirts where conditions for social unrest are more conducive. The analysis clearly identifies the urban outskirts as the most vulnerable to demographic stress. While we find population growth to be clearly associated with increased risks of unrest, we do not find evidence that drought in neighboring rural areas is contributing to drive this relationship. Even more important as a novel observation with significant implications for policy, population growth is associated with increased risk of unrest in the urban outskirts, but not in the primary urban centers, underscoring the importance of separating between different urban environments.

The prior neglect of urban areas in the statistical study of demographic and environmental security represents a considerable and important research gap. While a very small proportion of the African landmass is categorized as urban, the population in these areas account for as much as 40 percent of the total population on the continent representing the fastest growing urban population of the world (UN, 2014). This proportion is projected to increase strongly in coming decades, underscoring the importance of studying the social and political sustainability of African urbanization. Increased urbanization is generally associated with greater economic, social and political development, and even more peace. Our results, if true, suggest that urbanization might lead to less rural armed violence, but increase urban social unrest. A major qualification is that population growth is associated with unrest in the outer, peri-urban areas, which are more likely to be under-serviced, under-governed, under-regulated, and poor, suggesting that improved political governance and provision of public services could support urban sustainability, and alleviate unrest and violence.

Increasing our knowledge about the conditions under which urban population growth represents challenges to political stability is crucial to design policies that may help governments develop strategies to facilitate a sustainable urban development. According to a survey of world governments, 78 percent of African states have implemented policies to reduce migrant flows to large cities (UN, 2008: 12). Under certain conditions, negative measures to limit urbanization could be counter-productive for political stability. Further research that links the findings reported in this article to research on urbanization and urban resilience might help exploring the role that political, social and economic conditions play in either exasperating or mitigating any effects of demographic and environmental change on urban unrest.

6.0 References

Abbs, Luke (2019) The hunger games: Food prices, ethnic cleavages and nonviolent unrest in Africa, *Journal of Peace Research* DOI https://journals.sagepub.com/doi/10.1177/0022343319866487.

Aldrich, Daniel P. (2012) *Building Resilience: Social Capital in Post-disaster Recovery*. Chicago, IL: Chicago University Press.

Anselin, Luc, Anil K. Bera, Raymond Florax, & Mann J. Yoon (1996) Simple diagnostic tests for spatial dependence. *Regional Science and Urban Economics* 26: 77-104.

Ash, Konstantin, & Nick Obradovich (2019) Climatic stress, internal migration, and Syrian civil war onset, *Journal of Conflict Resolution*: OnlineFirst.

Balk, D.L., U. Deichmann, G. Yetman, F. Pozzi, S. I. Hay, & A. Nelson (2006) Determining global population distribution: Methods, applications and data, *Advances in Parasitology* 62:119-156. http://dx.doi.org/10.1016/S0065-308X(05)62004-0.

Barnett, Jon & W. Neil Adger (2007) Climate change, human security and violent conflict, *Political Geography* 26(6): 639–655.

Bell, Curtis, Patrick Keys & Rebecca Stossmeister (2014) Food policy and civil war in Africa's drought-suffering states, in Urmilla Bob & Salomé Bronkhorst (eds) Conflict-sensitive adaptation to climate change in Africa. Berlin: BWV (177-194).

Benjaminsen, Tor Arve (2008) Does supply-induced scarcity drive violent conflicts in the African Sahel? The case of the Tuareg rebellion in Northern Mali, *Journal of Peace Research* 45(6): 819–836.

Bernauer, Thomas; Tobias Böhmelt & Vally Koubi (2012) Environmental changes and violent conflict, *Environmental Research Letters* 7: 015601. doi:10.1088/1748-9326/7/1/015601.

Brass, Paul R. (2003) *The Production of Hindu-Muslim Violence in Contemporary India*. Seattle, WA & London: University of Washington Press.

Buhaug, Halvard (2006) Relative capability and rebel objective in civil war, *Journal of Peace Research* 43(6): 691–708.

Buhaug, Halvard (2010) Dude, where's my conflict? LSG, relative strength, and the location of civil war', *Conflict Management and Peace Science* 27(2): 107–128.

Buhaug, Halvard, Nils Petter Gleditsch & Ole Magnus Theisen (2010) Implications of climate change for armed conflict, in Robin Mearns & Andy Norton (eds) *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World.* Washington, DC: World Bank (75–101).

Buhaug, Halvard et al. (2014) One effect to rule them all? A comment on climate and conflict, *Climatic Change* 127(3-4): 391-397.

Buhaug, Halvard, & Jan Ketil Rød (2006) Local determinants of African civil wars, 1970–2001, *Political Geography* 25(3): 315-335.

Buhaug Halvard & Henrik Urdal (2013) An urbanization bomb? Population growth and social disorder in cities, *Global Environmental Change* 23(1): 1–10.

Butler, Christopher K & Scott Gates (2012) African range wars: Climate, conflict, and property rights, *Journal of Peace Research* 49(1): 23–34.

Cederman, Lars-Erik; Nils B. Weidmann & Kristian Skrede Gleditsch (2011) Horizontal inequalities and ethnonationalist civil war: A global comparison, *American Political Science Review* 105(3): 478–495.

Center for International Earth Science Information Network (CIESIN) at Columbia University, International Food Policy Research Institute (IPFRI), the World Bank & Centro Internacional de Agricultura Tropical (CIAT) (2004) *Global Rural-Urban Mapping Project (GRUMP), Version 1: GPW with Urban Reallocation (GPW-UR) Population Grids*. Palisades, NY: CIESIN, Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw.

Center for International Earth Science Information Network (CIESIN) at Columbia University & Centro Internacional de Agricultura Tropical (CIAT) (2005) *Gridded Population of the World (GPW), Version 3*. Palisades, NY: CIESIN, Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw.

Cincotta, Richard P.; Robert Engelman & Daniele Anastasion (2003) *The Security Demographic: Population and Civil Conflict after the Cold War*. Washington, DC: Population Action International.

Cliff, Andrew, and J. Keith Ord (1972) Testing for spatial autocorrelation among regression residuals, *Geographical Analysis* 4(3): 267-284.

Cliff, Andrew, & J. Keith Ord (1973). *Spatial Autocorrelation*. London: Pion.

Demarest, Leila (2015) Food price rises and political instability: Problematizing a complex relationship, *European Journal of Development Research* 27(5): 650-671.

Detges, Adrien (2017) Droughts, state-citizen relations and support for political violence in Sub-Saharan Africa: A micro-level analysis, *Political Geography* 61: 88-98

Fingleton, Bernard (2008) A generalized method of moments estimator for a spatial panel model with an endogenous spatial lag and spatial moving average errors, *Spatial Economic Analysis* 3(1): 27-44.

Fjelde, Hanne & Nina von Uexkull (2012) Climate triggers: Rainfall anomalies, vulnerability and communal conflict in Sub-Saharan Africa, *Political Geography* 31(7): 444–453.

Fox, Sean & Andrew Bell (2016) Urban geography and protest mobilization in Africa, *Political Geography* 53: 54–64.

Fratkin, Elliot (2001) East African pastoralism in transition: Maasai, Boran, and Rendille Cases, *African Studies Review* 44(3): 1–25.

Galvin, Kathleen A. (2009) Transitions: Pastoralists living with change, *Annual Review of Anthropology* 38: 185-198.

Gautam, Madhur (2006) Managing drought in sub-Saharan Africa: Policy perspectives. Washington, DC: The World Bank.

Getis, Arthur, & J. Keith Ord (2010) The analysis of spatial association by use of distance statistics, In *Perspectives on Spatial Data Analysis*: 127-145. Springer, Berlin & Heidelberg.

Gizelis, Theodora-Ismene & Amanda E Wooden (2010) Water resources, institutions, and intrastate conflict, *Political Geography* 29(4): 444–453.

Gizewski, Peter & Thomas F. Homer-Dixon (1995) Urban growth and violence: Will the future resemble the past? Occasional Paper, Project on Environment, Population and Security. Washington, DC: AAAS and the University of Toronto.

Gleditsch, Nils Petter et al., eds (1997) *Conflict and the Environment*. Dordrecht: Kluwer.

Gleditsch, Nils Petter (2012) Whither the weather? Climate change and conflict, *Journal of Peace Research* 49(1): 3–9**.**

Goldstone, Jack A. (1991) *Revolution and Rebellion in the Early Modern World*. Berkely, CA: University of California Press.

Goldstone, Jack A. (2002) Population and security: How demographic change can lead to violent conflict, *Journal of International Affairs* 56(1): 3–21.

Griffiths, Michael B. (2010) Lamb Buddha's migrant workers: Self-assertion on China's urban fringe', *Journal of Current Chinese Affairs* 39(2): 3–37.

Hayes, Michael J., Mark D. Svoboda, Donald A. Wiihite, & Olga V. Vanyarkho (1999) Monitoring the 1996 drought using the standardized precipitation index, *Bulletin of the American meteorological society* 80(3): 429-438.

Hendrix, Cullen S. & Stephan Haggard (2015) Global food prices, regime type, and urban unrest in the developed world, *Journal of Peace Research* 52(2): 143–157.

Hendrix, Cullen S. & Idean Salehyan (2012) Climate change, rainfall, and social conflict in Africa, *Journal of Peace Research* 49(1): 35–50**.**

Homer-Dixon, Thomas F. (1991) On the threshold: Environmental changes as causes of acute conflict, *International Security* 16(2): 76–116.

Homer-Dixon, Thomas F. & Jessica Blitt, eds (1998) *Ecoviolence: Links among Environment, Population and Security.* Lanham, MD: Rowman & Littlefield.

Hsiang, Solomon M.; Marshall Burke & Edward Miguel (2013) Quantifying the influence of climate on human conflict, *Science* 341(6151): 1235367.

Iaquinta, David L. & Axel W. Drescher (2000) Defining periurban: Understanding rural-urban linkages and their connections to institutional contexts. University of Freiburg: mimeo. http://portal.geographie.uni-freiburg.de/forschungsprojekte/indigenoveg/Background1PeriurbanTypology.pdf

Index Mundi (2015) http://www.indexmundi.com/. Accessed 7 June 2015.

Jones, Benjamin T., Eleonora Mattiacci, & Bear F. Braumoeller (2017) Food scarcity and state vulnerability: Unpacking the link between climate variability and violent unrest, *Journal of Peace Research* 54(3): 335-350.

Kahl, Colin H. (2006) *States, Scarcity, and Civil Strife in the Developing World*, Princeton, NJ: Princeton University Press.

Kaplan, Robert D. (1994) The coming anarchy, *Atlantic Monthly* 273(2): 44–76.

Koubi, Vally (2019) Climate Change and Conflict, *Annual Review of Political Science* 22:343-360.

L'Hôte, Y., G. Mahé, Somé, B. & J. Triboulet (2002) Analysis of a Sahelian annual rainfall index from 1896 to 2000: The drought continues, *Hydrological Sciences Journal* 47: 563-572.

Lebel, Thierry , Taupin, Jean Denis & Nathalie d'Amato (1997) Rainfall monitoring during HAPEX-Sahel: 1. General rainfall conditions and climatology, *Journal of Hydrology* 188-189: 74-96.

LeSage, James P., & R. Kelley Pace (2010) Spatial econometric models. In *Handbook of Applied Spatial Analysis*, pp. 355-376. Springer, Berlin & Heidelberg.

Lilleør Helene B. & Kathleen Van den Broeck (2011) Economic drivers of migration and climate change in LDCs, *Global Environmental Change* 21(S1): S70–S81.

Linke, Andrew M., Frank DW Witmer, John O'Loughlin, J. Terrence McCabe, & Jaroslav Tir (2018) Drought, local institutional contexts, and support for violence in Kenya, *Journal of Conflict Resolution* 62(7): 1544-1578.

Liotta, Peter H. & James F. Miskel (2012) *The Real Population Bomb: Megacities, Global Security & The Map of the Future*. Dulles, VA: Potomac.

McCabe, J. Terrence (2004) *Cattle Brings us to Our Enemies: Turkana Ecology, Politics, and Raiding in a Disequilibrium System*, Ann Arbor: University of Michigan Press.

Natalini, Davide, Giangiacomo Bravo, & Aled Wynne Jones (2019) Global food security and food riots: An agent-based modelling approach, *Food Security* 11(5): 1153-1173.

Nordhaus, William; Qazi Azam, David Corderi, Kyle Hood, Nadejda Makarova Victor, Mukhtar Mohammed, Alexandra Miltner & Jyldyz Weiss (2006) *The G-Econ Database on Gridded Output: Methods and Data*. Yale University: unpublished manuscript. http://gecon.yale.edu/data-and-documentation-g-econ-project.

Nyong, Anthony, & Charles Fiki (2005) Drought-related conflicts, management and resolution in the West African Sahel. *International Workshop on Human Security and Climate Change*, Oslo.

Oden, Neal L. (1984) Assessing the significance of a spatial correlogram, *Geographical Analysis* 16(1): 1-16.

Omolo, Nancy A. (2010) Gender and climate change-induced conflict in pastoral communities: Case study of Turkana in Northwestern Kenya, *African Journal of Conflict Resolution* 10(2): 81–102.

Openshaw, Stan (1983) The Modifiable Areal Unit Problem, Catmog 38, Study Group in Quantitative Methods. Norwich: Geo Books.

Østby, Gudrun (2016) Rural–urban migration, inequality and urban social disorder: Evidence from African and Asian cities, *Conflict Management and Peace Science* 33(5): 491–515.

Pettersson, Therése & Kristine Eck (2018) Organized violence, 1989–2017, *Journal of Peace Research* 55(4): 535–547.

Raleigh, Clionadh & Dominic Kniveton (2012) Come rain or shine: An analysis of conflict and climate variability in East Africa, *Journal of Peace Research* 49(1): 51–64.

Raleigh, Clionadh, Hyun Jin Choi, & Dominic Kniveton (2015) The devil is in the details: An investigation of the relationships between conflict, food price and climate across Africa, *Global Environmental Change* 32: 187-199.

Raleigh, Clionadh, Andrew Linke, Håvard Hegre & Joackim Karlsen (2010) Introducing ACLED: An Armed Conflict Location and Event Dataset, *Journal of Peace Research* 47(5): 651–660.

Raleigh, Clionadh & Henrik Urdal (2007) Climate change, environmental degradation and armed conflict, *Political Geography* 26(6): 674–694.

Reuveny, Rafael (2007) Climate change-induced migration and conflict, *Political Geography* 26(6): 656–673.

Rey, Sergio J. & Luc Anselin (2010) PySAL: A Python library of spatial analytical methods. In *Handbook of Applied Spatial Analysis*, pp. 175-193. Berlin & Heidelberg: Springer.

Salehyan, Idean & Cullen S. Hendrix (2012) *Social Conflict in Africa Database Version 3.0: Codebook and Coding Procedures*. www.strausscenter.org/codebooks/SCAD%203.0%20Codebook.pdf.

Salehyan, Idean; Cullen S. Hendrix, Jesse Hamner, Christina Case, Christopher Linebarger, Emily Stull & Jennifer Williams (2012) Social conflict in Africa: A new database, *International Interactions* 38(4): 503–511.

Scheffran, Jürgen; Michael Brzoska, Jasmin Kominek, Michael P. Link & Janpeter Schilling (2012) Climate change and violent conflict, *Science* 336(6083): 869–871.

Smith, Todd G. (2014) Feeding unrest: Disentangling the causal relationship between food price shocks and sociopolitical conflict in urban Africa, *Journal of Peace Research* 51(6): 679–695.

Suhrke, Astri (1997) Environmental degradation, migration, and the potential for violent conflict. In Nils Petter Gleditsch et al. (eds) *Conflict and the Environment*. Dordrecht: Kluwer (255–272).

Sundberg, Ralph & Erik Melander (2013) Introducing the UCDP Georeferenced Event Dataset, *Journal of Peace Research* 50(4): 523–532.

Tarrow, Sidney (1998) Fishnets, internets, and catnets: Globalization and transnational collective action, in Michael P. Hanagan, Leslie Page Moch & Wayne Philip Te Brake (eds) *Challenging Authority: The Historical Study of Contentious Politics*. Vol. 7. U of Minnesota Press (228–244).

Theisen, Ole Magnus (2012) Climate clashes? Weather variability, land pressure, and organized violence in Kenya, 1989-2004, *Journal of Peace Research* 49(1): 81–96.

Theisen, Ole Magnus; Nils Petter Gleditsch & Halvard Buhaug (2013) Is climate change a driver of armed conflict?, *Climatic Change* 117: 613–625.

Toft, Monica Duffy (2003) *The Geography of Ethnic Violence: Identity, Interests, and the Indivisibility of Territory*. Princeton, NJ & Oxford: Princeton University Press.

UN (2008) *World Urbanization Prospects: The 2007 Revision. Highlights.* New York: United Nations.

UN (2014) *World Urbanization Prospects: The 2014 Revision.* New York: United Nations. http://esa.un.org/unpd/wup/

Urdal, Henrik (2005) People vs. Malthus: Population pressure, environmental degradation and armed conflict revisited, *Journal of Peace Research* 42(4): 417–434.

Urdal, Henrik (2008) Population, resources and violent conflict: A sub-national study of India 1956–2002, *Journal of Conflict Resolution* 52(4): 590–617.

Verhoeven, Harry (2011) Climate change, conflict and development in Sudan: Global neo-Malthusian narratives and local power struggles, *Development and Change* 42(3): 679-707.

Vogt, Manuel, Nils-Christian Bormann, Seraina Rüegger, Lars-Erik Cederman, Philipp Hunziker, and Luc Girardin. 2015. “Integrating Data on Ethnicity, Geography, and Conflict: The Ethnic Power Relations Data Set Family.” *Journal of Conflict Resolution* 59(7): 1327–42.

von Uexkull, Nina; Mihai Croicu, Hanne Fjelde & Halvard Buhaug (2016) Civil conflict sensitivity to growing season drought, *Proceedings of the National Academy of Sciences of the United States of America 113(44): 12391-12396.*

Wario Roba, Adano; Ton Dietz, Karen Witsenburg & Fred Zaal (2012) Climate change, violent conflict and local institutions in Kenya's drylands, *Journal of Peace Research* 49(1): 65–80.

Wilkinson, Steven (2004*) Votes and Violence: Electoral Competition and Ethnic Riots in India.* Cambridge: Cambridge University Press.

Wischnath, Gerdis & Halvard Buhaug (2014) Rice or riots: On food production and conflict severity across India, *Political Geography* 43: 6–15.

Witmer, Frank DW, Andrew M. Linke, John O'Loughlin, Andrew Gettelman, & Arlene Laing (2017) Subnational violent conflict forecasts for sub-Saharan Africa, 2015–65, using climate-sensitive models, *Journal of Peace Research* 54(2): 175-192.

World Bank (2015) World Wide Governance Indicators. http://info.worldbank.org/governance/wgi/index.aspx#home [Accessed on 11 May 2015]

Wucherpfennig, Julian, Nils B. Weidmann, Luc Girardin, Lars-Erik Cederman, and Andreas Wimmer. 2011. "Politically Relevant Ethnic Groups across Space and Time: Introducing the GeoEPR Dataset." *Conflict Management and Peace Science* 28(5): 423–37.