Floods and armed conflict

April 16 2015

Ramesh Ghimire
University of Georgia

Susana Ferreira (corresponding author)
University of Georgia
Department of Agricultural and Applied Economics
313 Conner Hall, Athens, GA 30602, USA
Ph: +1 706-542-0086; Fax: +1 706-542-0739
Email: sferreir@uga.edu

Abstract

We estimate the impact of large, catastrophic floods on internal armed conflict using global data on large floods between 1985 and 2009. The results suggest that while large floods did not ignite new conflict, they fueled existing armed conflicts. Floods and armed conflict are endogenously determined, and we show that empirically addressing this endogeneity is important. The estimated effects of floods on conflict prevalence are substantially larger in specifications that control for the endogeneity of floods, suggesting that treating natural disasters as exogenous phenomena may underestimate their impacts on socio-political outcomes.

Keywords: Armed conflict; climate change; endogeneity; floods; natural disasters

Floods and armed conflict

1. Introduction

The relationship between climate change and armed conflict has gained increasing attention from academics and policy makers alike in recent years (see e.g. Barnett and Adger, 2007; United Nations, 2007; Burke *et al.*, 2009; Hsiang *et al.*, 2013), especially after the publication of the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007). French President Nicolas Sarkozy (2008) warned that “climate change is already having considerable impacts on security [...] and the Darfur crisis will be only one crisis among dozens.” President Obama in his Nobel Peace Prize acceptance speech warned that climate change “[w]ill fuel more conflict for decades” (White House, 2009). Similarly, the recently released Strategic Sustainability Performance Plan by the U.S. Department of Defense (DOD, 2014) predicts that, in addition to direct effects on military infrastructure, climate change will have indirect effects on regional stability, particularly on those areas of the world already prone to conflict.

Among its wide range of impacts, climate change is expected to increase the frequency and severity of natural hazards such as floods, droughts, heat waves, storms and tropical cyclones. These hazards can become natural disasters with profound environmental, political, and social consequences (Nel and Righarts, 2008). In this paper, we empirically examine the impact of floods on the onset and prevalence of internal armed conflict in a large sample of countries and years. We focus on large, catastrophic flood events; those causing significant damage to structures or agriculture, with long reported intervals (decades) since the last similar event, and/or fatalities (Brakenridge, 2011). Floods are a potentially "dangerous" consequence of climate change. Having a rapid onset compared to changes in mean conditions (such as temperature, sea-level, or annual precipitation), they allow for less time to adapt (Falk, 1971, Barnett, 2003).

Floods are already the most frequent natural disaster, accounting for 40 percent of all natural disasters reported over the last 25 years (CRED/OFDA, 2011), and the reported frequency and damages of floods show a positive trend (Figure 1) that is expected to continue (IPCC 2007, 2012). It is estimated that by 2020, climate change will have exposed 6 million more people living in coastal areas to flooding (39% more than would otherwise be the case) (Warren *et al.*, 2006). Although moderate floods can be beneficial in the medium to long term (Fomby *et al.*, 2011, Cunado and Ferreira, 2014), extreme weather events can be highly disruptive. In 2010, hydrological disasters caused about US$ 46.9 billion in economic damages worldwide (Guha-Sapir *et al.*, 2011), were responsible for over 8,100 deaths, and displaced over 179 million people (CRED/OFDA, 2011). Despite their huge policy relevance, the political consequences of large floods remain understudied. Only a few studies (e.g., Nel and Righarts, 2008; Bergholt and Lujala, 2012) have empirically analyzed the impact of natural disasters on armed conflict, and only one (Ghimire *et al.*, 2015) has investigated the role of the displacement caused by floods on armed conflict.

[Figure 1 here]

Our study differs from previous empirical work on natural disasters and armed conflict in several important ways. First and foremost, most previous studies treat natural disasters as phenomena whose incidence is exogenous. However, because the very definition of a natural disaster is linked to society's response capacity, state and social structures weakened by conflicts are less likely to effectively respond to the impacts of a natural hazard, making it more likely that a natural disaster will result (Barnett and Adger, 2007; Ferris, 2010).[1] Disasters are often

[1] For example, as a result of a long-standing conflict, the Somali government is extremely weak and thus unable to respond to the drought and floods that periodically ravage the country. Were there no conflict in Somalia, it is more likely that both state and local institutions would be better able to cope with natural hazards, perhaps avoiding disasters entirely (Ferris, 2010).

described as a result of the combination of exposure to a hazard, preexisting conditions of vulnerability, and insufficient capacity to reduce or cope with the potential negative consequences. More generally, environmental change does not undermine human security in isolation from a broader range of social factors that include poverty, access to opportunities, social cohesion, and institutional effectiveness (Barnet and Adger, 2007). For example, countries with higher income and better institutions are less vulnerable to and better able to cope with natural hazards (Kahn, 2005; Ferreira and Ghimire, 2012; Ferreira *et al.*, 2013). On the other hand, the incidence of natural disasters is increasing because of economic growth and growing exposure of population and infrastructures in disaster-prone areas, floodplains in particular (Raschky, 2008; IPCC, 2012). In summary, conflicts and disasters are endogenously determined (Changnon *et al.*, 2000; Oh and Reuveny, 2010), and, in our paper, we model them accordingly.

Second, unlike previous studies that group different types of natural disasters indistinctly, we focus on flood disasters. Because different disasters have potentially distinct effects on the risk of armed conflict, grouping them together may mask potentially opposing impacts. Previous studies have found that wetter years are associated with more violence (Hendrix and Salehyan, 2012; Theisen, 2012), and we hypothesize that this increase in violence could be due to the damaging effects of floods associated with abnormally large precipitation during those years.

Third, unlike most previous studies that use natural disaster data from the Centre for Research on the Epidemiology of Disasters (CRED) (www.emdat.be), our dataset, specific to floods, comes from the Dartmouth Flood Observatory (DFO) (Brakenridge, 2011). The DFO Archive is used more often than the CRED archive by flood researchers, as it provides more detailed information on flood events, including physical characteristics such as severity, magnitude, and duration, and has a reputation for strong quality control (Ferreira *et al.*, 2013).

Finally, unlike most previous studies, we consider alternative definitions of conflict. We consider non-state conflict (in which none of the warring parties is a government), in addition to the commonly used state-based (or simply armed-) conflict indicator, in which one of the battling sides is the government of a state. The rest of the paper proceeds as follows. Section 2 explores the possible links between floods and security that can result in conflict. Section 3 describes the data. Section 4 describes the methods that we employ to address the endogeneity between armed conflict and large floods. Section 5 presents the results, and the last section concludes.

2. Floods and security: Theoretical connections

According to the environmental security view of conflict, degradation in natural environments creates scarcity that when combined with population growth, skewed resource distribution, and weak institutions can lead to violent conflict.[2] This conflict is more likely to occur at a sub-national level rather than between states, to be persistent and diffuse, and to affect poor societies that are less able to buffer themselves from environmental degradation and the social crises they cause (Homer-Dixon, 1994, 1998; Homer-Dixon and Blitt, 1998).

The literature on environmental security suggests different, complementary mechanisms through which extreme flood events might lead to social unrest. First, flood events can result in anger and frustration among groups losing material benefits that they once enjoyed (Grofman and Muller, 1973; Miller *et al.*, 1977). Relative deprivation theories stress rapid changes in people's conditions such as those arising from rapid-onset floods. Floods can quickly destroy crops, cropland, forests, pastures, freshwater, and fish, leading to food shortages and spikes in

[2] Homer-Dixon (1999) used the term environmental scarcity to explain the links between environmental degradation and conflict. Supply-induced scarcity is one of the components of environmental scarcity. Environmental scarcity may also be caused by increased demand for resources caused by population growth or increased per capita resource consumption, or by the unequal social distribution of resources. Structural scarcity occurs when a resource is controlled by a small percentage of population (usually the elite), while the majority faces acute shortages of resources (Homer-Dixon and Blitt, 1998).

market prices.[3] Catastrophic flooding can knock down power lines, contaminate oil supplies, and destroy other infrastructure needed to deliver energy supplies resulting in energy scarcities. With rapid onset disasters, little time is available for adaptive changes, which increases the likelihood and intensity of violent conflict (Falk, 1971).

Scarcities in the aftermath of extreme floods do not generally affect all groups equally, and individuals commonly blame the government for natural disasters regardless of its responsibility and response, leading to hostility towards their government (Achen and Bartels, 2004). This may result in groups seizing government offices and police stations blamed for inadequately providing basic resources to victims. Although disasters can attract humanitarian aid, such as food and medicines, this aid might be appropriated by rebel groups and diverted to sustain their troops.

Extreme foods, by destroying dwellings and livelihoods in affected areas may force mass migration of people from affected areas. A sudden influx of migrants can disrupt internal migration patterns, lead to unplanned urbanization, and increase competition for jobs, housing, and other resources in the receiving areas (Kaya, 1994; Hugo, 1996). This situation can create distrust between migrants and locals and intensify ethnic tensions if they belong to different ethnic groups (Suhrke, 1997; Reuveny, 2007). In addition to much anecdotal evidence,[4] findings in Ghimire *et al.* (2015) support this transmission channel.

[3] Food prices dramatically increased in Pakistan in the aftermath of the 2010 massive inundation and these spikes in market prices increased the hostility towards the government (Kronstadt *et al.*, 2010). Likewise, transnational weather shocks leading to food price increases were an important factor leading to the 2011 Arab spring (Zurayk, 2011; The Economist, 2012).

[4] In Bangladesh, over 600,000 people migrated from rural and coastal areas to the Chittagong Hill Tracts in response to droughts, water scarcity, floods, storms, erosion and desertification between 1970 and 2000. This migration led to ethnic strife between migrants and local residents resulting in a high intensity civil conflict (Hafiz and Islam 1993; Lee 2001). Likewise, because of droughts, famines, and forest fires, approximately 600,000 Ethiopians migrated from the central and northern areas of the country to the southwest and west between 1984 and 1985. This migration created a conflict over land between nomads and farmers that initiated a medium level conflict (Otunnu, 1992; Ezra and Kiros, 2001).

Because of immediate damage to capital and agriculture, extreme events can have large negative short-run macroeconomic impacts. For instance, the 2010 floods in Pakistan damaged 3.3 million Ha. of standing crops, more than 5,000 miles of primary and secondary roads, 400 bridges, 400 miles of railways, 11,000 schools, and 200 health facilities, and reduced Pakistan's GDP growth in that year by 2 percentage points (UNITR, 2010; Looney, 2012). In Thailand, floods in 2011 resulted in US$ 45 billion damages (almost 14% of Thailand's GDP) and lowered GDP growth by one percentage point (Xinhua, 2011). Displacement, loss of lives, and damages to infrastructure, agriculture and crops can hurt overall economic productivity and result in an economic slowdown (Hendrix and Salehyan, 2012). During an economic slowdown, the opportunity costs to engage in violence are lower, while the benefits from looting and engaging in violence may become attractive (DiPasquale and Glaeser, 1998). In addition, an economic slowdown may increase competition among ethnic groups to control local resources (Olzak, 1992; Brass, 2003), and may negatively affect electoral competition and/or the electoral incentives of politicians (Horowitz, 1985; Wilkinson, 2006). This is consistent with the greed and grievance view of conflict pioneered by the influential work of Collier and Hoeffler (2004).

Extreme floods can lead to violent conflict through the destruction of infrastructures (e.g. roads and communication networks), making it more costly for government troops to suppress rebel groups (Miguel *et al.*, 2004; Hendrix and Salehyan, 2012). This situation may weaken political institutions and government responses to natural disasters, further increasing the vulnerability to armed conflict (Keefer, 2009; Hendrix and Salehyan, 2012). As police and military forces needed to enforce law and order engage in relief and recovery efforts, maintaining the rule of law may be challenging in the aftermath of extreme events. Following the 2010 floods in Pakistan, with the government troops concentrated in rescue and relief works in a few urban areas, Pakistani Taliban exploiting the ‘political space’ created by the floods, intensified their activities in several parts of the country (CBS News, 2010).

Finally, extreme events can strain government budgets through a simultaneous reduction of the tax base and increased demand for services and assistance by those hardest hit. Reduced state revenue hinders delivery of public goods, such as relief and rescue activities, which in turn reduces the political legitimacy of the government, and may give rise to political challengers. For instance, the weak response of the Algerian government in the aftermath of large flooding in 2001, 2002, and 2008, resulted in violent protests and riots (Hendrix and Salehyan, 2012).

Although, in principle the theoretical mechanisms described above can apply to many forms of social unrest, from peaceful protests and demonstrations, strikes and riots, all the way to armed conflict, we focus on the latter, armed conflict. One reason is of a practical nature; as described below, our data comes from the UCDP/PRIO dataset which is one of the most accurate and well-used data sources on global armed conflict. Its definition of armed conflict (as state-based conflict) is becoming a standard in how conflicts are systematically defined and studied. More importantly, state-based conflicts are much more costly and deadly than other forms of conflict. According to the Human Security Report (2012), reported battle-deaths per year from the average non-state conflict between 1989 and 2009 (approximately the time frame covered by our analysis) were about 16 percent of the battle death toll from the average state-based conflict during the same period. Because of their broader spatial coverage and longer duration, state-based conflicts have greater socio-economic and political impacts than non-state conflicts.

3. Data

We compiled annual data on conflict, large floods, and a range of socioeconomic and institutional characteristics for 126 countries between 1985 and 2009 (these are all the countries for which data were available). For robustness, we also report results for the sample of developing countries, and for the sample of countries that experienced at least one episode of armed conflict over the sample period (we denote these as “conflict prone” countries). Appendix Table A1 lists the countries included in the different sample definitions.

3.1 Conflict data

The main indicator of conflict, “armed conflict” comes from the UCDP/PRIO dataset (Gleditsch *et al.*, 2002; Themnér and Wallensteen, 2012). Armed conflict is defined as "a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which one is the government of the state, results in at least 25 battle-related deaths." This definition of armed conflict (as state-based conflict) is becoming a standard in how conflicts are systematically defined and studied. It refers to only politically motivated violence; excluding conflicts among groups without political motives, such as drug cartels. The unit of observation in our analysis is the country-year.

Similar to previous studies (e.g. Fearon and Laitin, 2003; Bergholt and Lujala, 2012), we create a variable ‘armed conflict onset’ coded one when a new conflict emerges, there has been a total change in the opposite side or when a conflict that has been inactive for more than two calendar years becomes active again, and zero otherwise. In the data, there are 86 armed conflict onset events (3.2% of the country-year observations for the sample of all countries – Table 1 panel a).[5] Like Miguel *et al.* (2004), we also measure armed conflict prevalence with an 'armed conflict incidence' variable that takes the value of one in a given country and year if there is any type of armed conflict (new or existing). The dataset has a total of 468 armed conflict incidence events or 17% of the observations for the sample of all countries. The proportions for developing and conflict-prone countries are 23% and 40%, respectively.

[5] The proportions for developing and conflict-prone countries are 4.2 and 7.4%, respectively (Table 1 panels b, c).

In addition to armed conflict, we analyze the impact of large floods on the onset and incidence of an alternative type of conflict in the UCDP: non-state conflict (Sundberg *et al.*, 2012). Unlike state-based conflicts, neither of the battling sides is the government of a state. However, the death threshold for inclusion in the database (25 battle-related deaths in a year) is the same. Table 1, showing a larger proportion of non-state conflict onsets than state-based conflict onsets in the full sample, suggests that the former are more easily triggered. The comparison of the conflict incidence proportions, however, suggests that the latter last longer.

[Table 1 here]

3.2 Flood data

Flood data come from the Dartmouth Flood Observatory (DFO). DFO records only large events, i.e. those with significant damage to structures or agriculture, long reported intervals (decades) since the last similar event, and/or fatalities (Brakenridge, 2011).[6] We code flood frequency as zero if there are no floods reported in a country-year. Otherwise, flood frequency equals the sum of reported events in a country-year; it ranges from zero to 32 with an average of 1.14 flood events per country-year in the whole sample, while the frequency averages 1.20 for developing countries and 1.35 for conflict-prone countries (Table 1). In addition to the number of floods, DFO reports the magnitude of each flood event as the log of the product of duration (in days) times severity, times affected area (in km^2.)[7]. Similar to flood frequency, magnitude equals zero if no floods were reported in a country-year. Otherwise, it is the sum of the reported events'

[6] DFO uses a wide range of flood detection tools, including MODIS (Moderate Resolution Imaging Spectroradiometer, http://modis.gsfc.nasa.gov), optical and passive microwave remote sensing (AMSR-E and TRMM sensors monitoring around 10,000 areas; http://old.gdacs.org/flooddetection/) which provide frequent updates of water conditions worldwide to detect and locate flooding. DFO also uses a wide variety of news and governmental sources to complement these data.

[7] Flood severity is divided into 3 classes. Class 1: large floods with significant damage to structures or agriculture, fatalities, and/or 1-2 decades interval since the last similar event; class 1.5: very large events with 20-100 years recurrence interval; class 2: extreme events with an estimated recurrence interval greater than 100 years.

magnitude during the year. Magnitude averages 5.96 in the full sample, 6.40 in the sample of developing countries, and 7.05 in the sample of conflict-prone countries (Table 1).

3.3 Other controls

There is general agreement that there are links between environmental change and violent conflict. However, typically environmental factors are not the only source of conflict (Barnett, 2003). The literature on armed conflict has identified a number of relevant socio-economic controls that we include in the regressions. We control for GDP growth and GDP per capita to account for the opportunity cost of rebels to engage in armed conflict, with data from the World Development Indicators (WDI, 2010). We also control for population and population density. According to the greed and grievance view of armed conflict, a larger population means a smaller proportion of resources per capita (Collier and Hoeffler, 2004). Additionally, a larger population may mean a greater probability of disaster events getting reported. Large youth cohorts (youth bulges) may increase both opportunities and motives for armed conflict (Urdal, 2005; Nel and Righarts, 2008). We control for 'youth-bulges' (15-24 year-old population), with data from the WDI (2010) and United Nations (2010).

Other factors affecting the vulnerability to armed conflict are ethnic tensions (Collier and Hoeffler 2004; Blimes 2006), democracy scores (Ellingsen and Gleditsch, 1997; Hegre *et al.*, 2001), and economic inequality (Nel and Righarts, 2008). An 'ethnic tensions' variable measures the degree of tensions within a country attributable to racial, nationality or language divisions. Data come from Political Risk Services (2011), with higher scores denoting an improvement (reduction) in ethnic tensions. To control for democracy scores, we use the Polity2 regime indicator from the Polity IV dataset (Marshall and Jaggers, 2011), ranging from +10 (strongly democratic) to -10 (strongly autocratic). We use both Polity2 in levels and squared to account for a potential nonlinear relationship between democracy scores and the risk of armed conflict (Ellingsen and Gleditsch, 1997; Hegre *et al.*, 2001). Nel and Righarts (2008) argue that the infant mortality index not only serves as a proxy for overall economic development, but is also a good proxy for economic inequality. Because of the limited coverage and numerous missing values in the Gini coefficient (e.g. Deininger and Squire, 1996) we use infant mortality rate (fraction of live-born children who die before their first birthday) from WDI (2010).

We control for time-invariant country characteristics, such as terrain ruggedness (from Nunn and Puga, 2012), country area (from WDI 2010), and an oil wealth dummy equal to one if a country is an oil exporter, with data from World Bank (2010). It has been argued that it is the competition for the control of resources rather than their scarcity that drives conflict. (Time-invariant variables, however, drop out from the specifications that include fixed effects.) Finally, since countries in proximity to countries experiencing conflict are more likely to become involved in armed conflict (Alcock, 1972; Most and Starr, 1980), we control for this spatial dependency with a 'conflict in neighboring country' variable equaling one if there is conflict in a neighboring country-year and zero otherwise, with data from UCDP/PRIO.

We do not control for other types of disasters. While there are popular disaster databases, notably EM-DAT (www.emdat.be), that record other types of disasters, their classification criteria for floods are not comparable to that in the DFO. DFO records floods independently of them being caused by another disaster (e.g. by a storm, or by an earthquake breaking a dam or triggering a tsunami). EMDAT, however, does not report whether storms or earthquakes (if these are the primary disasters) resulted in floods. This could be problematic especially for storms, as some of them can be highly destructive but not cause flooding (e.g. windstorms) while some of them do. Combining both datasets might thus result in measurement error in the number of other disasters, for example by double counting some floods.

We are confident that the omission of other disasters does not bias our estimates of the impacts of floods. Such bias might arise from a correlation between floods and other types of disasters. However, as we mention above, DFO records floods resulting from any other disaster, such as tropical storms, cyclones, hurricanes, typhoons, volcanic eruptions, and earthquakes, which means that the effect of these other disasters is partially accounted for by the floods variable. More generally, floods could be correlated with other disasters because certain countries (those poorer and with weaker institutions) are more prone to experiencing any kind of disaster. As we explain in the next section, we minimize this concern with a three-pronged strategy. First, the regressions include a large number of socioeconomic, political, and institutional variables that may be correlated with both floods and other types of disasters. Second, all the regressions include country and year fixed effects. Third, to correct for the endogeneity of large floods we instrument floods using rainfall variability (captured by the standard deviation of monthly precipitation) with data from the Tyndall Centre for Climate Change Research (2011). Summary statistics of all the variables are provided in Table 1.

4. Estimation strategy and econometric methods

Floods are natural *hazards* that occur when water inundates land that is normally dry. One could imagine instances in which one battling side in a war ruptures a dam or levee, but generally floods are initiated by exogenous factors such as excessive rain, rapid ice melting, or large storms or tsunamis resulting in inland sea surges. As previously discussed, however, the large flood *disasters* considered in this paper are endogenous (that is, determined simultaneously with the occurrence of armed conflict) because the presence of armed conflict reduces a country's ability to effectively provide public services related to floodplain management and flood emergency management, thereby increasing the probability and severity of damaging flood events. Other plausible sources of endogeneity are measurement error in the construction of the flood variable and omitted relevant variables. As explicitly mentioned in the DFO archive, "the statistics presented in the DFO Global Archive of Large Flood Events are derived from a wide variety of news and governmental sources. The quality and quantity of information available about a particular flood is not always in proportion to its actual magnitude, and the intensity of news coverage varies from nation to nation."

We used a two-pronged approach to correct for endogeneity. First, we employed an instrumental-variable (IV), two-step, estimation procedure: two stage least squares. In the first stage (equation 1), we estimated a reduced form equation for the flood variable. In the second stage, we estimated an equation for armed conflict (equation 2) with the fitted values from (1).

$$Flood_{it} = f(\mathbf{X_{it-1}}, Z_{it}, \alpha_i, \delta_t) \tag{1}$$

$$Conflict_{it} = g(Fl\hat{o}od_{it-1}, \mathbf{X_{it-1}}, \alpha_i, \delta_t) \tag{2}$$

In equation (1) we use variability (the standard deviation) in monthly rainfall as an instrument for floods, Z. Rainfall variability is a natural choice for instrumenting floods. Because of standard coping strategies, average rainfall is expected to have a lesser impact on flooding than variations in rainfall patterns (Reardon and Taylor, 1996).

Previous studies have used rainfall growth (Miguel *et al.*, 2004; Miguel and Satyanath, 2011) or levels (Ciccone, 2011) as an instrument for economic growth in conflict regressions. Sarsons (2011) argues that rainfall is not a good instrument for *income* because dams and irrigation smooth the impact of weather shocks. We note, however, that this criticism does *not* affect our study since we instrument *floods*, not income or economic growth. Moreover, we tested that the instrument satisfies the exclusion restriction; rainfall variation affects armed conflict only through floods. We regressed the conflict variables (conflict onset or conflict incidence) on rainfall variation with and without controls and found that rainfall variation was not a statistically significant predictor of armed conflict in either case (appendix Table A2).

Second, to minimize the risk of omitted-variable bias, the regressions include the vector of controls **X** (GDP growth, GDP per capita, ethnic tensions, total population, population density, youth population, polity2 in levels and squared, infant mortality rate, conflict in neighboring country, country area, terrain ruggedness, and oil wealth).[8] In addition, we exploit the panel structure of our data set, and use country and time fixed effects (FE) to control for unobserved time- and country- invariant factors that may affect the occurrence of and reporting of flood events and/or armed conflict. Country FE (α_i) control for unobserved confounding factors that vary across countries but do not change overtime (this might include geographic characteristics, and slowly changing national cultural attitudes or climate characteristics that may affect both floods and armed conflict). Likewise, year FE (δ_t) control for unobserved confounding factors constant across countries but evolving over time (e.g. weaponry technical developments, satellite improvements in flood detection, or common global shocks).[9]

To accommodate lagged effects between flood disasters and armed conflict (Drury and Olson, 1998), we lagged the flood variable by one period in equation (2). We analyzed the robustness of the results to using longer lags and to using a 3-year moving average in flood frequency. Additionally, in both reduced form and structural equations, all explanatory variables are lagged one period to mitigate potential endogeneity bias.[10] Finally, since the dependent variables in equation (2) (conflict onset or conflict incidence) are binary, in addition to estimating (2) using least squares, we present alternative estimates from a logit model.[11]

5. Results

We report estimates for the reduced form equation for floods (equation (1)) in the first column of Table 2. Rainfall variability is positive and statistically significant (at a 1% level) to explain

[8] We checked for multicollinearity (which if present would make the estimates imprecise) using the variance inflation factor (VIF). The VIF for all the explanatory variables was smaller than 5, suggesting that we do not have a multicollinearity problem (Kennedy, 2009, p.199).
[9] As mentioned, time invariant characteristics (ruggedness, country area, oil wealth) drop out from FE models.
[10] We also tested for serial autocorrelation using Wooldridge's (2002) test for serial correlation in panel data and failed to reject the null hypothesis of no first-order autocorrelation [F=0.123 (p-value = 0.7259)].
[11] The use of a logit model ensures that estimated probabilities range between zero and one. We note, however, that the use of FE in non-linear models can give rise to the 'incidental parameters problem (Neyman and Scott, 1948). Thus, logit models are estimated using random effects. The results remain robust to the use of country and year FE, with and without IV procedures.

flood frequency. The F-test of excluded instrument is 18.116, satisfying the instrument relevance condition for a valid instrument (Baum *et al.*, 2007).[12]

[Table 2 here]

5.1 Floods and armed conflict

Table 2 also shows the results of the estimation of equation (2). Results for armed conflict onset are presented in the left half of the table and for armed conflict incidence in the right half of the table. Results are presented for both, least-squares and logit specifications. In order to gauge the importance of instrumenting for floods, the IV estimates are contrasted with estimates in which floods are not instrumented ("No IV").

In columns 2-5 in Table 2, we estimate the impact of large floods on armed conflict onset (i.e. on the emergence of new armed conflict). Flood frequency is not statistically significant in any of the specifications and it has the "wrong" sign in columns 3 and 4.[13] Columns 6-9 show the estimates for armed conflict incidence. Unlike the results for conflict onset, flood frequency appears to be a statistically significant determinant of armed conflict incidence. The 2SLS-IV results in column 6 show that, on average, one additional extreme flood is associated with a 5.7 percentage-point increase in the predicted probability of conflict incidence in a given country-year (at a 10% significance level). The results remain robust in column 8 showing the logit model coefficients; the estimated marginal effect (not shown here) is 4.7, implying that one additional large flood event is associated with a 4.7 percentage-point increase in the predicted

[12] Because we have one endogenous variable and only one instrument (i.e. our model is exactly identified), we cannot formally test for the instrument exogeneity condition (Stock and Watson, 2011), but results in Table A2 strongly suggest that rainfall variability is exogenous and uncorrelated with armed conflict onset and incidence.
[13] The results are robust to the inclusion of a conflict in previous year variable (=1).

probability of armed conflict incidence.[14] In columns 7 and 9 where flood frequency is not instrumented, the results are not statistically significant.

The large difference between the IV and No-IV estimates in both specifications for armed conflict incidence suggests that it is important to correct for the endogeneity in the occurrence of natural disasters. Treating natural disasters as exogenous phenomena may underestimate their impact on broad sociopolitical outcomes. Measurement error and omitted variables can be sources of endogeneity. However, we do not believe that this is what the results in Table 2 are showing. First, the variable measuring flood occurrence – the count of large flood events - is quite parsimonious. It does not require detailed information on the exact number of people dead or displaced, or on the economic damages of the particular flood being reported. Second, the regressions control for a large number of variables and include country and time FE. The most plausible cause of endogeneity in our study is reverse causality between conflict and floods as described in previous sections, that we address with an IV approach.

Regarding other controls, the results robustly show that an increase in ethnic tensions does not statistically increase the risk of conflict onset but that it does increase the risk of conflict incidence. A one unit improvement in ethnic tensions is associated with about a 3-4 percentage-point reduction in the predicted probability of conflict incidence (columns 6-7). (The marginal effect in the logit models of columns 8-9, not shown here, is also about 2-3 percentage points).[15] We find a nonlinear relationship between democracy scores (polity2) and the risk of armed conflict incidence. As the democracy score improves, the predicted risk of armed conflict

[14] In non-linear models such as the logit, the effect of a change in an independent variable depends on its starting value. Thus, the estimated coefficients do not correspond to marginal effects. Marginal were calculated at the means of the independent variables.
[15] The ethnic tensions variable is measured on a scale of zero to 6, with a higher score denoting lower tensions.

incidence decreases at an increasing rate.[16] Infant mortality is statistically significant (at a 1% level) in columns 4-7 and 9 with an intuitive positive sign. We also find that conflict in neighboring countries is a statistically significant predictor of conflict onset in columns 2 and 4.

5.2 Robustness to alternative flood indicators

We analyzed the robustness of the results to alternative indicators of flood occurrence. Table 3 presents the results for the FE 2SLS models. (Results for the logit models were similar and are reported in Table A3.) We first considered the total magnitude of the floods (as described in Section 3) during a given year. As with flood frequency, we lagged flood magnitude and used monthly variability in rainfall as an instrument. Flood magnitude is statistically insignificant to explain armed conflict onsets (columns 1-2), but it is positive and statistically significant to explain armed conflict incidence at a 10% level or better (columns 3-4). Also, the difference in magnitude between the IV and No-IV estimates is large. On average, a unit increase in flood magnitude is associated with about a one percentage-point increase in the predicted probability of armed conflict incidence in column 3 (IV estimate), which is an effect fifteen times larger than that estimated in column 4 (No-IV).

[Table 3 here]

In columns 5-8 of Table 3, we took the previous 3 years moving average in flood frequency to investigate the average effect of an additional large flood when additional years of flooding are considered. We instrumented the flood variable using monthly variability in rainfall (now for the previous 3 years). Again, floods are statistically significant to explain armed

[16] In columns 6-9, while polity2 is not significant, its overall marginal effect is significant at a 5% level. We also decomposed polity2 into three groups: high score (6 to 10) corresponding to democracies, intermediate score (-5,+5) corresponding to a mix of democracy and autocracy (anocracies), and low score (-10,-6) for autocracies, per Fearon and Laitin (2003). From this decomposition, we created separate dummies for democracy and anocracy, and re-estimated (1) and (2). The results hold; floods increase the probability of conflict incidence but not of conflict onset, and countries with higher democracy scores are less vulnerable to the incidence of armed conflict.

conflict incidence, but not armed conflict onset, and the point estimates are substantially larger in magnitude when they are instrumented. Finally, the results were also robust to longer lags (two and three years) of flood frequency (results not shown here, but available upon request).

5.3 Robustness to the sample definition

We analyzed the robustness of the results to changing the composition of the sample. From 126 countries in the benchmark specification, we changed the sample to cover only developing countries and conflict-prone countries (that experienced at least one conflict episode over 1985-2009). (Table A1 lists the countries included in each sample.) Table 4 shows the results for the FE 2SLS estimation. (Results for the logit models were similar and are presented in Table A4.) Consistent with previous results, flood frequency is not a statistically significant determinant of armed conflict onset (columns 1-2 for developing countries and 5-6 for conflict-prone countries). It is, however, a statistically significant determinant of armed conflict incidence. For developing countries, on average, one additional large flood is associated with an 8 percentage-point increase in the predicted probability of armed conflict incidence (column 3), while the flood frequency is not significant when it is not instrumented (column 4). For conflict-prone countries, the effects are larger in magnitude and statistically stronger. This is what we would expect because this sample includes countries that have experienced at least one conflict episode between 1985 and 2009. On average, one additional large flood is associated with about a 15.6 percentage-point increase in the predicted probability of conflict incidence. Flood frequency is also statistically significant (at a 10% level) when floods are not instrumented (column 8).

[Table 4 here]

Regarding other controls, as in the baseline specification ethnic tensions, democratic scores and infant mortality are robust determinants of armed conflict incidence (but not conflict onset). Conflict in neighboring country is significant to explain armed conflict onset.

5.4 Floods and non-state conflict

We also analyze the impact of large floods on non-state conflicts. In particular, we estimate onset and incidence of non-state conflicts by using the same estimation methods (IV 2SLS) and set of controls as in the baseline specification.

[Table 5 here]

Results in Table 5 suggest that there is no relationship between large floods and non-state conflict (conflict onset and/or conflict incidence) or that if there is one, it is not captured with the number of deaths threshold used in the definition of non-state conflict. This finding supports our choice of armed conflict (state-related conflict) as the dependent variable. Incidentally, the results also show the importance of instrumenting the flood variable. In the conflict onset equation, flood frequency has the "wrong" sign in columns (2) and (4), the "No-IV" columns. These are the specifications that do not account for the endogeneity of large, damaging floods.

6. Conclusion

Climate change is increasingly viewed as a security threat. Many officials and analysts have argued that climate change will increase political and social instability and result in a proliferation of armed conflict, especially in poor countries or countries with already weak governments. Some of the impacts of climate change on social-ecological systems will be experienced through changes in mean conditions (such as temperature, sea level, and annual precipitation) over long time scales. Empirically testing the impact of these long-term changes on security using historical data is challenging due to data limitations, especially in multi-country analyses. However, some impacts of climate change will be experienced through an increase in the intensity and frequency of floods, droughts, and other high-impact events for which historical data are readily available. Only between 1985 and 2009 there were over 3,500 large flood events across the world (Brakenridge, 2011). Assuming that the past can tell us something about the future, we can use historical data on floods and conflict to shed light on how a future with more and larger floods may look like.

We statistically analyze the impact of extreme flood events on the risk of armed conflict and non-state conflict using data for over 100 countries between 1985 and 2009. We find that large floods increase the predicted probability of continuation of existing armed conflicts, rather than contributing to the emergence of new armed conflicts. This suggests that, on average, floods do not act as a catalyst for opposing factions being united by the common adversity, but that the opposite happens. Looking at both armed conflict onset and armed conflict prevalence allows us to interpret the flood-conflict link from a more nuanced perspective – the factors contributing to the emergence of a conflict are not necessarily identical to those associated with the continuation of an existing conflict. We show that this is the case for large floods. Continuation of an existing conflict depends on factors such as how the conflict is handled by actors, income to support insurgency, propensity of actors to negotiate, difficulties in counterinsurgency, and international support (Uvin, 1999; Bleaney and Dimico, 2011). While we do not have the data to test the role of these channels in our study, our results suggest that in the aftermath of large floods governments are unable to cease ongoing conflicts. This might be because governments are distracted by relief efforts, which could provide opportunities for the rebels to strengthen their presence and fuel their insurgencies against the government. The post disaster period demands higher government expenses. However, disaster events are a strain on government revenues by reducing tax receipts. Consequently, people's aspirations for relief and reconstruction may remain unsatisfied, leading to growing hostility towards their government and sympathy for rebel groups that enable the continuation of the conflict. Because of the weak government presence, foreign aid might be captured by rebel groups and used to finance their insurgency.

Not surprisingly, the estimated effects of floods are larger in conflict-prone countries; on average, one additional large flood is associated with a 16 percentage-point increase in the predicted probability of armed conflict incidence for this sample of countries, while the average increase in predicted probability is 8 percentage points for the sample of developing countries, and 6 percentage points for the sample of all countries. Conflict prone and developing countries are characterized by lower levels of economic development and weaker political institutions, which makes them more vulnerable to disaster shocks and armed conflict.

Our finding that extreme flood events magnify the risk of prevalence of armed conflict is consistent with anecdotal evidence. Following the 2010 catastrophic flooding in Pakistan, with the security forces concentrating on rescue and relief efforts, Pakistani President Asif Ali Zardari worried that insurgents would exploit the situation to garner support and bolster their ranks with new recruits (Righarts, 2010). Indeed, the Pakistani Taliban, began a large recruitment campaign, attempting to enlist 50,000 new fighters in return for food and medicine (IANS, 2010). Further, militants exploiting the chaos ensuing the flooding intensified their attacks to the state apparatus in the Northwest, the area most affected by flooding and the epicenter of Pakistan's fight against al Qaeda and the Taliban (CBS News, 2010). Another recent example comes from Somalia, a country ravaged by the confluence of hydro-metrological disasters and armed conflict for decades. The increased intensity of flooding, combined with weak governance has increased the risk of civil unrest in the country (Shongwe *et al.*, 2008). The inadequate government's response to the 2009 floods that hit most of the rural areas in the country is blamed for granting opportunities to the rebels to expand their activities (Ferris, 2010).

Our findings are also consistent with results in previous studies that wetter years are associated with more conflict. Our study suggests that the increased violence in wetter years may be partly due to the damaging effects of floods. Global climate models predict that changes in patterns and distribution of precipitation are inevitable consequences of climate change (IPCC, 2007, 2012). If the historical relationship between extreme flood events and internal armed conflict continues, our results suggest that the future is likely to see more conflict, in the absence of adaptation and mitigation efforts.

Since floods are endogenous, it is imperative to understand the human-flood interactions while formulating floodplain management and flood emergency management. From an econometric standpoint, the estimated impacts of floods on armed conflict prevalence are substantially larger in the specifications that control for the endogeneity of floods, suggesting that previous studies that treat natural disasters as exogenous phenomena may have underestimated their impacts on societal peace.

We end on a note of caution. A limitation of econometric analyses at the country level such as ours is that they assess the strength of the relationships between variables for the "average" country. They are not suitable for identifying the specific causal mechanisms at play in a particular country, so there is a danger of oversimplification when extrapolating the results of such analyses without paying attention to the peculiarities of the case study at hand.

References

Achen C.H. and L.M. Bartels (2004), 'Myopic retrospection and party realignment in the great depression', Unpublished manuscript, NJ: Princeton University.

Alcock N.Z. (1972), *The War Disease,* Oakville: CPRI Press.

Bleaney M. and A. Dimico (2011), 'How different are the correlates of onset and continuation of civil wars?', *Journal of Peace Research* **48** (2):145-155.

Barnett J. (2003), 'Security and climate change', *Global Environmental Change* **13** (1):7-17.

Barnett J. and W.N. Adger (2007), 'Climate change, human security and violent conflict', *Political Geography* **26**(6): 639-655.

Baum C.F., M.E. Schaffer and S. Stillman (2007), 'Enhanced routines for instrumental variables/GMM estimation and testing', *The Stata Journal* **7**(4):465-506.

Bergholt D. and P. Lujala (2012), 'Climate-related natural disasters, economic growth, and armed civil conflict', *Journal of Peace Research* **2012** (49):147-162.

Blimes R.J. (2006), 'The indirect effect of ethnic heterogeneity on the likelihood of civil war onset', *Journal of Conflict Resolution* **50** (4):536-547.

Brakenridge G.R. (2011), 'Global active archive of large flood events' [Available at] http://floodobservatory.colorado.edu/Archives/index.html.

Burke M.B., E. Miguel, S. Satyanath, J.A. Dykema, and D.B. Lobell (2009), 'Warming increases the risk of civil war in Africa', *PNAS* **106**(49): 20670-74.

Brass P. (2003), *The Production f Hindu-Muslim ViolenceiIn Contemporary India,* Seattle, WA: University of Washington Press.

CBSNews (2010), 'Insurgents, police clash amid Pakistan flooding', *CBSNews*, Aug. 18.

Changnon S.A., R.A. Pielke, D. Changnon, R.T. Sylves, and R.S. Pulwarty (2000), 'Human factors explain the increased losses from weather and climate extremes', *Bulletin-American Meteorological Society* **81** (3):437-442.

Ciccone A. (2011), 'Economic shocks and civil conflict: a comment,' *American Economic Journal: Applied Economics* **3** (4):215-227.

Collier P. and A. Hoeffler (2004), 'Greed and grievance in civil war', *Oxford Economic Papers* **56** (4):563-595.

CRED/OFDA (Center for Research of the Epidemiology of Disasters/Office of Foreign Disaster Assistance) (2011), 'International disaster database' [Available at] http://www.emdat.be.

Cuñado J. and S. Ferreira (2014), 'The macroeconomic impacts of natural disasters: the case of floods', *Land Economics* **90** (1).

Deininger K. and L. Squire (1996), 'A new data set measuring income inequality', *The World Bank Economic Review* **10** (3):565-591.

DOD (Department of Defense) (2014), *Strategic Sustainability Preformance Plan*, Washington, DC: US Department of Defense.

DiPasquale D. and E.L. Glaeser (1998), 'The Los Angeles riot and the economics of urban unrest', *Journal of Urban Economics* **43** (1):52-78.

Drury A.C. and R.S. Olson (1998), 'Disasters and political unrest: an empirical investigation', *Journal of Contingencies and Crisis Management* **6** (3):153-161.

Ellingsen T. and N.P. Gleditsch (1997), 'Democracy and armed conflict in the third world', in K. Volden and D. Smith (eds.), *Causes of Conflict in Third World Ccountries*, Oslo: North South Coalition and International Peace Research Institution, pp. 69-81.

Ezra M. and G.E. Kiros (2001), 'Rural out-migration in the drought prone areas of Ethiopia: a multilevel analysis', *International Migration Review* **35** (3):749-771.

Falk, R. (1971), *This Endangered Planet: Prospected and Proposals for Human Survival*, NY: Random House.

Fearon J.D. and D.D. Laitin (2003), 'Ethnicity, insurgency, and civil war', *American Political Science Review* **97** (1):75-90.

Ferreira S. and R. Ghimire (2012), 'Forest cover, socioeconomics, and reported flood frequency in developing countries', *Water Resources Research* **48** (8):W08529.

Ferreira S., K. Hamilton, and J.R. Vincent (2013), 'Does development reduce fatalities from natural disasters? New evidence from floods', *Environment and Development Economics* **18** (6).

Ferris E. (2010) 'Natural disasters, conflict, and human rights: tracing the connections' [Available at] http://www.brookings.edu/research/speeches/2010/03/03-natural-disasters-ferris.

Fomby T., Y. Ikeda, and N.V. Loayza (2011), 'The growth aftermath of natural disasters', *Journal of Applied Econometrics* **28**(3): 412-434.

Ghimire R., S. Ferreira, and J. H. Dorfman (2015), 'Flood-induced displacement and civil conflict', *World Development* **66**(Feb.): 614-628.

Gleditsch N.P., P. Wallensteen, M. Eriksson, M. Sollenberg, and H. Strand (2002), 'Armed conflict 1946-2001: a new dataset', *Journal of Peace Research* **39** (5).

Grofman B.N. and E.N. Muller (1973), 'The strange case of relative gratification and potential for political violence: the V-curve hypothesis', *American Polit. Science Review* **67**(2):514-39.

Guha-Sapir D., F. Vos, R. Below, and S. Ponserre (2011), *Annual Disaster Statistical Review 2010*, Belgium: Centre for Research on the Epidemiology of Disasters.

Hafiz A. and N. Islam (1993), *Environmental Degradation and Intra/Interstate Conflicts in Bangladesh*, ETH-Zentrum: Swiss Federal Institute of Technology.

Hegre H., T. Ellingsen, S. Gates, N.P. Gleditsch (2001), 'Toward a democratic civil peace? Democracy, political change, and civil war, 1816-1992', *American Pol. Sci. Review* **95**(1):33-48.

Hendrix C.S. and I. Salehyan (2012), 'Climate change, rainfall, and social conflict in Africa', *Journal of Peace Research* **49** (1):35-50.

Homer-Dixon T.F. (1994), 'Environmental scarcities and violent conflict: evidence from cases', *International Security* **19** (1):5-40.

Homer-Dixon T.F. (1999), *Environment, Scarcity, and Violence*. NJ: Princeton University Press.

Homer-Dixon T.F. and J. Blitt (1998), *Ecoviolence: Links Among Environment, Population and Security*, MD: Rowman & Littlefield Pub Inc.

Horowitz D.L. (1985), *Ethnic Groups in Conflict*, Berkeley: University of California Press.

Hsiang S.M., B. Marshall, and M. Edward (2013), 'Quantifying the influence of climate on human conflict', *Science* **341**(6151): 1235367.

Hugo G. (1996), 'Environmental concerns and international migration', *International Migration Review* **30** (1):105-131.

Human Security Report (2012), *Non-State Armed Conflict*, Vancouver: Human Security Research Group, Simon Fraser University.

IANS (Indo-Asian News Service) (2010), 'Taliban tap Pakistan flood misery to enlist 50,000 men', *Indo-Asian News Service*, August 31.

IPCC (Intergovernmental Panel for Climate Change) (2007), *Impacts, Adaptation and Vulnerability*, Cambridge, UK: Cambridge University Press.

------(2012), 'Managing the risks of extreme events and disasters to advance climate change adaptation', in C.B. Field, V. Barros, and T.F.Stocker (eds.) *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*, UK: Cambridge University Press.

Kahn M.E. (2005), 'The death toll from natural disasters: the role of income, geography, and institutions', *Review of Economics and Statistics* **87** (2):271-284.

Kaya L. (1994), 'The reckoning', *Far Eastern Economic Review* **27**:24-30.

Keefer P. (2009), 'Conflict and disaster', Washington DC: The World Bank.

Kennedy, P. (2009), *A Guide to Econometrics*, Blackwell Publishing.

Kronstadt K.A., P.A. Sheikh, and B. Vaughn (2010), *Flooding in Pakistan: Overview and Issues for Congress*, Washington, DC: Congressional Research Service.

Lee S.W. (2001), *Environmental Matters: Conflict Refugees and International Relations*, Tokyo: World Human Development Institute Press.

Looney R. (2012), 'Economic impacts of the floods in Pakistan', *Contemporary South Asia* **20**(2):225-241.

Marshall M.G. and K. Jaggers (2011), 'Polity IV project: political regime characteristics and transitions, 1800-2010' [Available at] http://www.systemicpeace.org/polity/polity4.htm.

Miguel E. and S. Satyanath (2011), 'Re-examining economic shocks and civil conflict', *American Economic Journal: Applied Economics* **3** (4):228-232.

Miguel E., S. Satyanath, and E. Sergenti (2004), 'Economic shocks and civil conflict: an instrumental variables approach', *Journal of Political Economy* **12**(4):725-753.

Miller A.H., L.H. Bolce, and M. Halligan (1977), 'The J-curve theory and the black urban riots: an empirical test of progressive relative deprivation theory', *The American Political Science Review* **71** (3):964-982.

Most B.A. and H. Starr (1980), 'Diffusion, reinforcement, geopolitics, and the spread of war', *The American Political Science Review* **74** (4): 932-946.

Nel P. and M. Righarts (2008), 'Natural disasters and the risk of violent civil conflict', *International Studies Quarterly* **52** (1):159-185.

Neyman J. and E.L. Scott (1948), 'Consistent estimates based on partially consistent observations', *Econometrica* **16**:1-32.

Nunn N. and D. Puga (2012), 'Ruggedness: the blessing of bad geography in Africa', *The Review of Economics and Statistics* **94** (1).

Olzak S. (1992), *The Dynamics of Ethnic Competition and Conflict*, CA: Stanford Univ. Press.

Oh C.H. and R. Reuveny (2010), 'Climatic natural disasters, political risk, and international trade', *Global Environmental Change* **20** (2): 243-254.

Otunnu O. (1992), 'Environmental refugees in sub-Saharan Africa: causes and effects', *Refuge* **12** (1):11-14.

Political Risk Services (2011), 'International country risk guide' [Available at] https://www.prsgroup.com/prsgroup_shoppingcart/cdwizard5.aspx.

Raschky P.A. (2008), 'Institutions and the losses from natural disasters', *Natural Hazards and Earth System Sciences* **8** (4):627-634.

Reardon T. and J.E.Taylor (1996), 'Agroclimatic shock, income inequality, and poverty: evidence from Burkina Faso', *World Development* **24** (5):901-914.

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

Righarts M. (2010), 'Pakistan's floods: a window of opportunity for insurgents?', *ABC News*, Sept. 8.

Sarkozy N. (2008), 'Climate change driving Darfur crisis', *Agence France-Presse*, April 18.

Sarsons H. (2011), 'Rainfall, rupees, and riots: testing rainfall as an instrumental variable' [Available at] http://sarso.files.wordpress.com/2011/08/sarsons_aug_draft1.pdf.

Shongwe M., G.J.V. Oldenborgh, B.D. Boer, B.V.D. Hurk, and M.V. Aalst (2008), 'Changes in extreme weather in Africa under global warming, [Available at] http://www.knmi.nl/africa_scenarios/brochure_Afrika.pdf.

Stock J.H. and M.W. Watson (2011), *Introduction to Econometrics*, Pearson Education.

Suhrke A. (1997), 'Environmental degradation, migration, and the potential for violent conflict', in Gleditsch N.P. (ed.) *Conflict and the Environment*, Dordrech: Kluwer Academic, pp 255-272.

Sundberg R., K. Eck, and J. Kreutz (2012), 'Introducing the UCDP non-state conflict dataset', *Journal of Peace Research* **49**:351-362.

The Economist (2012), 'Food and the Arab spring', *The Economist*, March 17.

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

Themnér L and P. Wallensteen (2012), 'Armed conflicts, 1946-2011', *Journal of Peace Research* **49** (4): 565-75.

Tyndall Centre for Climate Change Research (2011), 'Climate data' [Available at] http://www.cru.uea.ac.uk/cru/data/hrg/timm/cty/obs/TYN_CY_1_1.html.

United Nations (2007), 'Security council holds first-ever debate on impact of climate change' [Available at] http://www.un.org/News/Press/docs/2007/sc9000.doc.htm.

------ (2010), 'Population aged 15-24' [Available at] http://esa.un.org/unpd/wpp/unpp/panel_indicators.htm.

UNITR (United National Institute for Training and Research) (2010), 'The Pakistan floods of 2010' [Available at] http://www.unitar.org/unosat/node/44/1506.

Urdal H. (2005), 'People vs. Malthus: population pressure, environmental degradation, and armed conflict revisited', *Journal of Peace Research* **42** (4):417.

Uvin P. (1999), *The Influence of Aid in Situations of Violent Conflict,* Paris: OECD.

Warren R., N. Arnell, R. Nicholls, P. Levy, and J. Price (2006), 'Understanding the regional impacts of climate change', Tyndall Center for Climate Change Research WP 90.

WDI (World Development Indicators) (2010), 'World development indicator (WDI) & global development finance (GDF)' [Available at] http://databank.worldbank.org/ddp/home.do.

White House (2009), 'Remarks by the President at the acceptance of the Nobel Peace Prize' [Available at] http://www.whitehouse.gov/the-press-office/remarks-president-acceptance-nobel-peace-prize.

Wilkinson S.I. (2006), 'Votes and violence: electoral competition and ethnic riots in India', Cambridge: Cambridge University Press.

Wooldridge J. (2002) *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

World Bank (2010), 'Adjusted net saving – a proxy for sustainability' [Available at] http://siteresources.worldbank.org/EXTEEI/Resources/oil_and_gas_rents.xls.

Xinhua (2011), 'Floods could reduce Thailand's economic growth by 1 percentage point' [Available at] http://news.xinhuanet.com/english2010/world/2011-11/22/c_131263134.htm.

Zurayk R. (2011), 'Use your loaf: why food prices were crucial in the Arab spring', *The Guardian*, July 16.

Table 1: Descriptive statistics

a. Sample of all countries (countries=126, observation=2586)	Mean	Std. dev.	Min	Max
Armed conflict onset	0.0316	0.1752	0	1
Armed conflict incidence	0.1725	0.3778	0	1
Non-state conflict onset	0.0675	0.2509	0	1
Non-state conflict incidence	0.0824	0.2751	0	1
Floods frequency	1.1369	2.5739	0	32
Flood magnitude	5.9636	13.6576	0	159.9693
GDP growth	3.6394	5.5092	-51.0308	106.2798
GDP/capita	6.68E+03	9.51E+03	57.7849	4.19E+04
Ethnic tensions	3.9727	1.4182	0	6
Total population	4.76E+07	1.51E+08	430845	1.33E+09
Polity2	3.2851	6.7743	-10	10
Youth population	18.0921	2.9434	0.1913	26.1056
Population density	148.0273	536.2377	1.3126	7125.143
Infant mortality	41.1892	36.9736	2.1	167.2
Conflict in neighboring country (=1)	0.4324	0.4954	0	1
Terrain ruggedness (100 m.)	1.1221	0.9043	0.016	4.761
Country area (km^2)	989570	2186710	670	1.64E+07
Oil-wealth (=1)	0.1691	0.3749	0	1
Monthly variation (standard deviation) in rainfall, mm	60.4032	48.7193	0.8628	391.1516
b. Sample of developing countries (countries=88, observations= 1825				
Armed conflict onset (=1)	0.0418	0.2002	0	1
Armed conflict incidence (=1)	0.2257	0.4182	0	1
Flood frequency	1.2027	2.3996	0	25
Flood magnitude	6.3986	12.8855	0	152.6216
GDP growth	3.8385	6.1138	-51.030	106.2798
GDP/capita	1640.574	1692.972	57.784	9935.834
Ethnic tensions	3.7137	1.4114	0	6
Total population	5.61E+07	1.76E+08	723448	1.33E+09
Polity2	1.8572	6.2442	-10	10
Youth population	19.4859	1.8096	12.5734	26.1057
Population density	82.6306	124.8423	1.3126	1129.5240
Infant mortality	54.8326	35.8552	4.5	167.2
Conflict in neighboring country (=1)	0.5555	0.4972	0	1
Terrain ruggedness (100 m.)	1.0674	0.7962	0.147	4.287
Country area (km^2)	989250	2068944	10000	1.64E+07
Oil-wealth (=1)	0.1672	0.3732	0	1
Monthly variation (standard deviation) in rainfall, mm	71.1500	51.7433	0.8629	391.1516
c. Sample of countries with armed conflict between 1985-2009 (countries = 52, observations = 1058)				
Armed conflict onset (=1)	0.0742	0.2623	0	1
Armed conflict incidence (=1)	0.4041	0.4909	0	1
Flood frequency	1.3531	2.2644	0	20
Flood magnitude	7.0478	11.8084	0	98.2241
GDP growth	1.6760	6.3209	-50.2904	92.5859
GDP/capita	2485.845	4519.442	57.78493	29627.91
Ethnic tensions	3.2995	1.4137	0	6
Total population	5.74E+07	1.46E+08	957688	1.21E+09
Polity2	2.4221	6.0267	-10	10
Youth population	19.3170	1.9275	10.5438	26.1056
Population density	108.3488	154.8962	5.4736	1129.524
Infant mortality	60.8348	39.5203	3.7	167.2
Conflict in neighboring country (=1)	0.5794	0.4939	0	1
Terrain ruggedness (100 m.)	1.06218	0.7383	0.148	4.198
Country area (km^2)	955072.1	2023401	5130	1.64e+07
Oil-wealth (=1)	0.2220	0.4158	0	1
Monthly variation (standard deviation) in rainfall, mm	74.2328	54.9658	0.8628	292.9158

Note: Conflict data came from UCDP; flood data from Brakenridge (2011); GDP growth, GDP/Capita, total population, population density, infant mortality, and country area from WDI (2010); youth population from United Nations (2010) and WDI (2010); oil-wealth from World Bank (2010); ethnic tensions from Political Risk Service (2011); polity2 from Marshall and Jagers (2011); terrain ruggedness from Nunn and Puga (2010); and rainfall variability from TCCCR (2011).

Table 2: Floods and armed conflict (1985-2009)

VARIABLES	Flood frequency (1st stage)	Armed conflict onset (2nd stage)				Armed conflict incidence (2nd stage)			
	Least squares	Least squares		Logit		Least squares		Logit	
		IV	No IV	IV	No IV	IV	No IV	IV	No IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Flood frequency		**0.0190**	**-0.0001**	**-0.175**	**0.0120**	**0.0574***	**0.0032**	**1.082***	**0.0486**
		(0.0363)	**(0.0021)**	**(0.375)**	**(0.0556)**	**(0.0362)**	**(0.0029)**	**(0.607)**	**(0.0560)**
GDP growth	0.0021	0.0003	0.0001	0.0130	0.0116	0.0003	-9.45e-05	0.0253	0.0183
	(0.0043)	(0.0009)	(0.0007)	(0.0221)	(0.0179)	(0.0019)	(0.0009)	(0.0360)	(0.0166)
Ln(GDP/capita)	0.365	0.0094	0.0138	0.00530	-0.0665	0.0519	0.0386	0.00977	0.0838
	(0.335)	(0.0392)	(0.0243)	(0.243)	(0.250)	(0.0632)	(0.0327)	(0.545)	(0.351)
Ethnic tensions	-0.0607	0.0049	0.0040	-0.172	-0.148	-0.0348***	-0.0403***	-0.550**	-0.638***
	(0.0577)	(0.0060)	(0.0049)	(0.203)	(0.127)	(0.0093)	(0.0066)	(0.218)	(0.125)
Ln(total population)	-1.396	-0.293	-0.317	2.064	1.655	-1.101	-1.092***	-36.69	-37.60***
	(2.643)	(0.195)	(0.280)	(16.29)	(10.46)	(0.855)	(0.377)	(42.42)	(11.39)
Polity2	0.0216	-0.0015	-0.0010	0.0177	0.0126	-0.0038	-0.0025	-0.0337	-0.0136
	(0.0230)	(0.0023)	(0.0012)	(0.0408)	(0.0279)	(0.0031)	(0.0016)	(0.0451)	(0.0268)
Polity2 x Polity2	0.0004	8.28e-06	5.38e-05	-0.0065	-0.0064	-0.0019***	-0.0019***	-0.0220**	-0.0214***
	(0.0019)	(0.0002)	(0.0002)	(0.0065)	(0.0063)	(0.0007)	(0.0003)	(0.0102)	(0.0053)
Youth population (%)	-0.0554*	-0.0043	-0.0050	-0.0259	-0.0359	0.0061	0.0044	0.213	0.188**
	(0.0310)	(0.0032)	(0.0031)	(0.0921)	(0.0844)	(0.0090)	(0.0042)	(0.267)	(0.0926)
Ln(population density)	2.094	0.367*	0.403	-1.551	-1.313	1.225	1.248***	37.23	39.05***
	(2.839)	(0.194)	(0.286)	(16.24)	(10.44)	(0.851)	(0.385)	(42.49)	(11.37)
Infant mortality rate	0.0089	0.0003	8.24e-05	0.0214**	0.0192**	0.0045***	0.0044***	0.0336	0.0342***
	(0.0086)	(0.0006)	(0.0006)	(0.0088)	(0.008)	(0.0017)	(0.0008)	(0.0219)	(0.0120)
Conflict in neighboring country (=1)	-0.237*	0.0205*	0.0191	0.457*	0.452	-0.0123	-0.0133	-0.0866	-0.108
	(0.124)	(0.0110)	(0.0119)	(0.261)	(0.346)	(0.0260)	(0.0160)	(0.468)	(0.288)
Oil wealth (=1)				0.947*	0.828*			0.255	0.486
				(0.511)	(0.497)			(1.026)	(0.565)
Ln(terrain ruggedness)				-1.566	-1.307			36.83	38.68***
				(16.31)	(10.45)			(42.54)	(11.39)
Ln(country area)				0.113	0.0713			0.541	0.5806
				(0.244)	(0.2349)			(0.637)	(0.4713)
Rainfall variability	**0.527*** **								
	(0.124)								
F-test of excluded instrument	*18.116*								
Prob > F	*(0.000)*								
Country fixed effects	Yes	Yes	Yes	No	No	Yes	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2586	2586	2586	2586	2586	2586	2586	2586	2586
Number of id	126	126	126	126	126	126	126	126	126

Note: Estimates as indicated by column headings. Standard errors (clustered at the country level) in parentheses. Standard errors in logit models are bootstrapped using 400 replications. *** p<0.01, ** p<0.05, * p<0.1. The variables oil wealth, terrain ruggedness, and country area are time invariant and dropout from estimates with country fixed effects.

Table 3: Floods and armed conflict (1985-2009) second stage results – alternative indicators for floods

VARIABLES	Flood magnitude (coefficients)				3-year moving average in flood frequency (coefficients)			
	Armed conflict onset		Armed conflict incidence		Armed conflict onset		Armed conflict incidence	
	IV	No IV	IV	No IV	IV	No IV	IV	No IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Floods	**0.0058**	**0.0001**	**0.0121***	**0.0008***	**0.0837**	**0.0001**	**0.1430****	**0.0104****
	(0.006)	**(0.0004)**	**(0.0069)**	**(0.0005)**	**(0.0609)**	**(0.0033)**	**(0.0657)**	**(0.0045)**
GDP growth	0.0003	0.0001	0.0004	-9.33e-05	0.0007	0.0003	0.0009	4.57e-05
	(0.0009)	(0.0007)	(0.0018)	(0.0009)	(0.0009)	(0.0007)	(0.0018)	(0.0009)
Ln(GDP/capita)	0.0053	0.0131	0.0451	0.0379	-0.0254	0.0128	-0.0014	0.0214
	(0.0404)	(0.0243)	(0.0663)	(0.0327)	(0.0485)	(0.0256)	(0.0708)	(0.0343)
Ethnic tensions	0.0050	0.0041	-0.0352***	-0.0403***	0.0075	0.0043	-0.0317***	-0.0379***
	(0.0059)	(0.0049)	(0.0095)	(0.0066)	(0.0063)	(0.0050)	(0.0092)	(0.0067)
Ln(total population)	-0.224	-0.312	-0.932	-1.084***	-0.0816	-0.3430	-0.7320	-1.173***
	(0.183)	(0.280)	(0.930)	(0.377)	(0.203)	(0.3020)	(0.9290)	(0.404)
Polity2	-0.0017	-0.0010	-0.0044	-0.0025	-0.0031	-0.0010	-0.0065**	-0.0027
	(0.0025)	(0.0012)	(0.0031)	(0.0016)	(0.0026)	(0.0012)	(0.0032)	(0.0017)
Polity2 x Polity2	2.14e-06	5.36e-05	-0.0019***	-0.0019***	2.99e-05	4.94e-05	-0.0018***	-0.0018***
	(0.0002)	(0.0002)	(0.0007)	(0.0003)	(0.0002)	(0.0002)	(0.0007)	(0.0003)
Youth population (%)	-0.0035	-0.0049	0.0076	0.0044	-0.0005	-0.0061*	0.0118	0.0040
	(0.0031)	(0.0031)	(0.0092)	(0.0042)	(0.0038)	(0.0033)	(0.0097)	(0.0045)
Ln(population density)	0.296	0.398	1.062	1.239***	0.140	0.4350	0.848	1.316***
	(0.183)	(0.286)	(0.920)	(0.385)	(0.210)	(0.3050)	(0.922)	(0.409)
Infant mortality rate	0.0002	7.59e-05	0.0042**	0.00447***	-0.0001	9.37e-05	0.0036*	0.0047***
	(0.0006)	(0.0006)	(0.0019)	(0.0008)	(0.0007)	(0.0006)	(0.0018)	(0.0008)
Conflict in neighboring country (=1)	0.0207**	0.0192	-0.0135	-0.0134	0.0251**	0.0172	-0.0078	-0.0155
	(0.0098)	(0.0119)	(0.0274)	(0.0160)	(0.0107)	(0.0122)	(0.025)	(0.0163)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,586	2,586	2,586	2,586	2,586	2,586	2,586	2,586
Number of id	126	126	126	126	126	126	126	126

Note: Least-square estimates. Standard errors (clustered at the country level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Floods and armed conflict (1985-2009) second stage results– alternative sample definitions

VARIABLES	Developing countries (coefficients)				Conflict prone countries (coefficients)			
	Armed conflict onset		Armed conflict incidence		Armed conflict onset		Armed conflict incidence	
	IV	No IV	IV	No IV	IV	No IV	IV	No IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Flood frequency	**0.0411**	**0.0008**	**0.0832***	**0.0069**	**0.0411**	**-0.0015**	**0.156****	**0.0115***
	(0.0440)	**(0.0031)**	**(0.0479)**	**(0.0042)**	**(0.0501)**	**(0.0053)**	**(0.0696)**	**(0.0068)**
GDP growth	0.0004	0.0002	0.0006	-8.92e-07	0.0009	0.0010	0.0010	0.0018
	(0.0011)	(0.0008)	(0.0020)	(0.0011)	(0.0019)	(0.0014)	(0.0037)	(0.0018)
Ln(GDP/capita)	0.0081	0.0153	0.0443	0.0311	0.0134	0.0165	0.0854	0.0685
	(0.0433)	(0.0295)	(0.0813)	(0.0400)	(0.0680)	(0.0543)	(0.111)	(0.0702)
Ethnic tensions	0.0081	0.0078	-0.0482***	-0.0520***	0.0106	0.0081	-0.0594***	-0.0641***
	(0.0075)	(0.0065)	(0.0137)	(0.0088)	(0.0121)	(0.0113)	(0.0209)	(0.0147)
Ln(total population)	-0.315	-0.342	-1.578	-1.499**	-0.612	-0.622	-2.567	-3.008***
	(0.377)	(0.442)	(1.825)	(0.599)	(0.826)	(0.887)	(4.570)	(1.149)
Polity2	-0.0017	-0.0010	-0.0051	-0.0036*	-0.0032	-0.0021	-0.0127**	-0.0083**
	(0.0024)	(0.0014)	(0.0035)	(0.0020)	(0.0041)	(0.0026)	(0.0062)	(0.0034)
Polity2 x Polity2	-4.64e-05	4.74e-05	-0.0021***	-0.0020***	0.0001	0.0001	-0.0025**	-0.0027***
	(0.0002)	(0.0002)	(0.0008)	(0.0003)	(0.0008)	(0.0004)	(0.0010)	(0.0006)
Youth population (%)	-0.0033	-0.0064	0.0073	0.0004	-0.0093	-0.0125	0.0326	0.0149
	(0.0056)	(0.0048)	(0.0162)	(0.0065)	(0.0103)	(0.0094)	(0.0328)	(0.0122)
Ln(population density)	0.417	0.484	1.512	1.497**	0.878	0.930	3.123	3.411***
	(0.348)	(0.437)	(1.770)	(0.592)	(0.803)	(0.866)	(4.446)	(1.121)
Infant mortality rate	0.0003	-9.73e-05	0.0050**	0.0048***	8.74e-06	-5.77e-05	0.0054*	0.0069***
	(0.0008)	(0.0007)	(0.0020)	(0.0010)	(0.0014)	(0.0014)	(0.0037)	(0.0018)
Conflict in neighboring country (=1)	0.0293**	0.0237	-0.0042	-0.0089	0.0463**	0.0369	-0.0239	-0.0488
	(0.0127)	(0.0151)	(0.0284)	(0.020)	(0.0230)	(0.0282)	(0.0531)	(0.0364)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1825	1825	1825	1825	1,058	1,058	1,058	1,058
Number of id	88	88	88	88	52	52	52	52

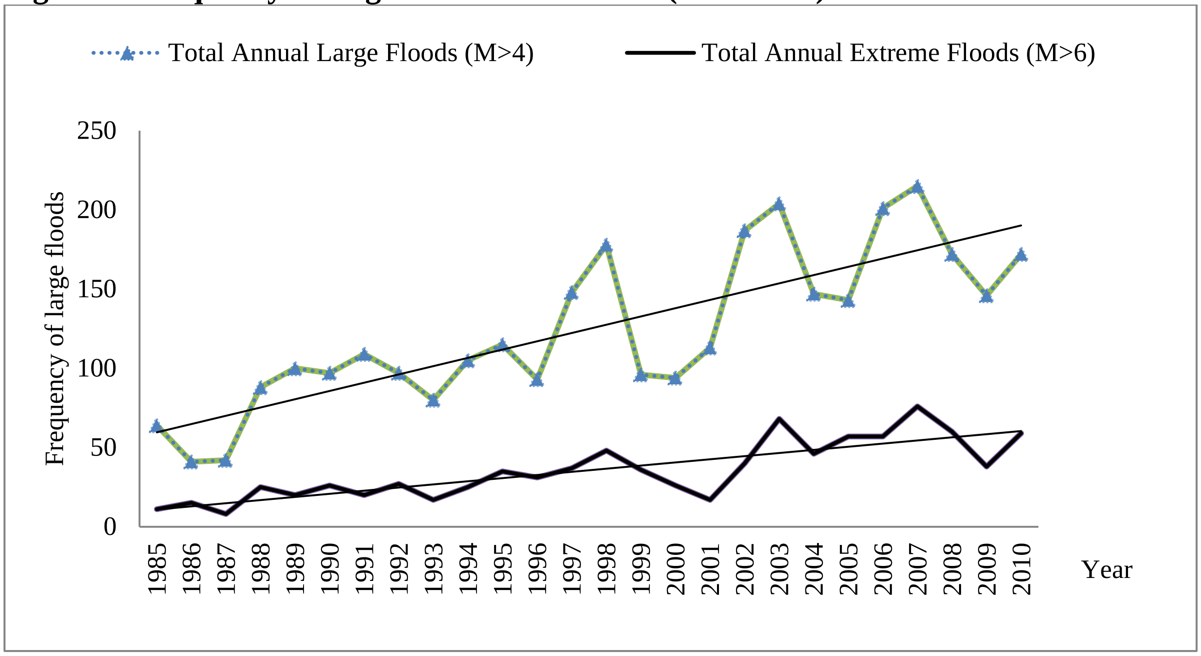
Note: Least squares estimates. Standard errors (clustered at the country level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Floods and non-state conflict (1989-2009) second stage results

VARIABLES	Non-state conflict onset				Non-state conflict incidence			
	Least squares		Logit		Least squares		Logit	
	IV	No IV	IV	No IV	IV	No IV	IV	No IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Flood frequency	**-0.0049**	**-0.0048***	**0.198**	**-0.127***	**0.0238**	**-0.0023**	**0.497**	**-0.0474**
	(0.0241)	**(0.0026)**	**(0.625)**	**(0.0687)**	**(0.0266)**	**(0.0027)**	**(0.684)**	**(0.0612)**
GDP growth	-0.0037**	-0.0042***	-0.0861***	-0.0891***	-0.0044***	-0.0050***	-0.101***	-0.102***
	(0.0016)	(0.0008)	(0.0252)	(0.0239)	(0.0015)	(0.0008)	(0.0264)	(0.0253)
Ln(GDP/capita)	0.0374	0.0348	-0.270	-0.219	0.0253	0.0384	-0.390	-0.274
	(0.0668)	(0.0318)	(0.348)	(0.326)	(0.0714)	(0.0333)	(0.382)	(0.353)
Ethnic tensions	-0.0170*	-0.0182***	-0.554***	-0.577***	-0.0215**	-0.0232***	-0.497***	-0.534***
	(0.0098)	(0.0060)	(0.138)	(0.132)	(0.0109)	(0.0063)	(0.139)	(0.132)
Ln(total population)	-1.483*	-1.507***	-97.41	-98.32	-0.723	-0.880	-8.651	-7.668
	(0.818)	(0.542)	(140.4)	(148.1)	(0.544)	(0.566)	(39.01)	(39.24)
Polity2	0.0008	0.0008	-0.0024	0.0074	0.0015	0.0019	0.0053	0.0139
	(0.0017)	(0.0016)	(0.0334)	(0.0319)	(0.0020)	(0.0017)	(0.0337)	(0.0326)
Polity2 x Polity2	-0.0006	-0.0006**	-0.0032	-0.0034	-0.0011*	-0.0011***	-0.0129*	-0.0125*
	(0.0004)	(0.0002)	(0.0064)	(0.0064)	(0.0006)	(0.0003)	(0.0066)	(0.0066)
Youth population (%)	0.0023	0.0032	0.217*	0.221**	-0.0003	-0.0007	0.102	0.0961
	(0.0045)	(0.0038)	(0.116)	(0.111)	(0.0047)	(0.0040)	(0.122)	(0.117)
Ln(population density)	1.594*	1.604***	98.30	99.52	0.786	0.941*	9.526	9.011
	(0.826)	(0.542)	(140.3)	(148.1)	(0.551)	(0.567)	(39.01)	(39.24)
Infant mortality rate	-0.0008	-0.0008	8.19e-05	0.0017	-0.0012	-0.0011	-0.0037	-0.0002
	(0.0016)	(0.0007)	(0.0116)	(0.0109)	(0.0019)	(0.0008)	(0.0127)	(0.0120)
Conflict in neighboring country (=1)	0.0138	0.0117	0.444	0.337	0.0054	0.0022	0.245	0.150
	(0.0123)	(0.014)	(0.377)	(0.368)	(0.0150)	(0.0149)	(0.377)	(0.368)
Oil wealth (=1)			-1.275**	-1.147**			-1.760***	-1.548***
			(0.569)	(0.522)			(0.648)	(0.598)
Ln(terrain ruggedness)			0.0195	0.0507			-0.0063	0.0059
			(0.353)	(0.342)			(0.397)	(0.383)
Ln(country area)			98.27	99.48			9.471	8.979
			(140.4)	(148.1)			(39.01)	(39.24)
Country fixed effects	Yes	Yes	No	No	Yes	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2392	2392	2392	2392	2392	2392	2392	2392
Number of id	126	126	126	126	126	126	126	126

Note: Estimates as indicated by column headings. Standard errors (clustered at the country level) in parentheses. Standard errors in logit models are bootstrapped using 400 replications. *** p<0.01, ** p<0.05, * p<0.1. The variables oil wealth, terrain ruggedness, and country area are time invariant and dropout from estimates with country fixed effects.

Figure 1: Frequency of large floods in the world (1985-2009)



Notes: M is magnitude of floods, computed as log(duration × severity × affected areas). Flood severity is divided into 3 classes. Class 1: large floods with significant damage to structures or agriculture, and/or 1-2 decades interval since the last similar event; class 1.5: very large events with 20-100 years recurrent interval; class 2: extreme events with an estimated recurrence interval greater than 100 years (Brakenridge 2011).

Source: Authors, with data from Brakenridge (2011)

Table A1: List of countries

All countries (N =126 countries)
Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Cameroon, Canada, Chile, China, Colombia, Congo, Democratic Republic of Congo, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, EL Salvador, Estonia, Ethiopia, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyz Republic, Latvia, Lebanon, Liberia, Libya, Lithuania, Madagascar, Malawi, Malaysia, Mali, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Netherland, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Rumania, Russia, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syria, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, Uruguay, United States of America, Venezuela, Vietnam, Yemen, Zambia.
Developing countries (N=88 countries)
Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Cameroon, Chile, China, Colombia, Congo, Cuba, Democratic Republic of Congo, Costa Rica, Dominican Republic, Ecuador, Egypt, EL Salvador, Ethiopia, Gabon, Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Latvia, Lebanon, Liberia, Libya, Lithuania, Madagascar, Malawi, Malaysia, Mali, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rumania, Russia, Senegal, Sierra Leone, South Africa, Sri Lanka, Sudan, Syria, Tanzania, Thailand, Togo, Tunisia, Turkey, Uganda, Ukraine, Uruguay, Venezuela, Vietnam, Yemen, Zambia.
Countries experiencing armed conflict or conflict-prone countries (N=52)
Algeria, Angola, Azerbaijan, Bangladesh, Burkina Faso, Colombia, Congo, Democratic Republic of Congo, Croatia, Egypt, El Salvador, Ethiopia, Guatemala, Guinea, Guinea-Bissau, Honduras, India, Indonesia, Iran, Iraq, Israel, Lebanon, Liberia, Mali, Mexico, Morocco, Mozambique, Nicaragua, Niger, Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rumania, Russia, Senegal, Sierra-Leone, South Africa, Spain, Sri Lanka, Sudan, Thailand, Togo, Trinidad and Tobago, Turkey, Uganda, United Kingdom, Venezuela, and Yemen.

Table A2: Rainfall variability and armed conflict (exclusion restriction)

VARIABLES	Armed conflict onset		Armed conflict incidence	
	(1)	(2)	(3)	(4)
Rainfall variability	0.0008	0.0084	0.0087	0.0094
	(0.0129)	(0.0129)	(0.0268)	(0.0237)
GDP growth		0.0001		-9.85e-05
		(0.0009)		(0.0017)
Ln(GDP/capita)		0.0132		0.0404
		(0.0329)		(0.0602)
Ethnic tensions		0.0040		-0.0405***
		(0.0053)		(0.0101)
Ln(total population)		-0.311**		-1.099
		(0.155)		(0.763)
Polity2		-0.0010		-0.0024
		(0.0021)		(0.0030)
Polity2 x Polity2		5.61e-05		-0.0018***
		(0.0002)		(0.0007)
Youth population (%)		-0.0050*		0.0043
		(0.0028)		(0.0077)
Ln(population density)		0.399**		1.260
		(0.159)		(0.765)
Infant mortality rate		9.70e-05		0.0045**
		(0.0005)		(0.0018)
Conflict in neighboring country (=1)		0.0194*		-0.0134
		(0.0105)		(0.0279)
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Observations	2614	2614	2614	2614
Number of id	126	126	126	126

Note: OLS estimates. Robust standard errors (clustered at country level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3: Floods and armed conflict (1985-2009) second stage results – alternative indicator for floods with logit estimates

VARIABLES	Flood magnitude (coefficients)				3-years moving average in flood frequency (coefficients)			
	Armed conflict onset		Armed conflict incidence		Armed conflict onset		Armed conflict incidence	
	IV	No IV	IV	No IV	IV	No IV	IV	No IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Floods	-0.0432	0.0049	0.181*	0.0144	0.134	0.0336	1.662*	0.158*
	(0.0761)	(0.0102)	(0.119)	(0.0113)	(0.709)	(0.0741)	(0.942)	(0.0834)
GDP growth	0.0131	0.0113	0.0251	0.0185	0.0150	0.0133	0.0287	0.0195
	(0.0181)	(0.0179)	(0.0386)	(0.0165)	(0.0242)	(0.0177)	(0.0390)	(0.0164)
Ln(GDP/capita)	0.0079	-0.0670	0.0565	0.0644	-0.0571	-0.0713	-0.222	0.0180
	(0.208)	(0.252)	(0.475)	(0.355)	(0.298)	(0.257)	(0.590)	(0.363)
Ethnic tensions	-0.177	-0.142	-0.560**	-0.636***	-0.151	-0.147	-0.488**	-0.607***
	(0.167)	(0.127)	(0.251)	(0.125)	(0.170)	(0.129)	(0.220)	(0.127)
Ln(total population)	1.921	1.723	-36.02	-37.93***	0.862	0.479	-36.80	-38.69***
	(11.78)	(10.44)	(41.66)	(11.42)	(10.11)	(10.66)	(41.16)	(11.49)
Polity2	0.0181	0.0130	-0.0285	-0.0139	0.0085	0.0110	-0.0491	-0.0184
	(0.0362)	(0.0279)	(0.0523)	(0.0267)	(0.0430)	(0.0282)	(0.0475)	(0.0274)
Polity2 x Polity2	-0.0063	-0.0065	-0.0223**	-0.0216***	-0.0065	-0.0064	-0.0210**	-0.0208***
	(0.0074)	(0.0063)	(0.0096)	(0.0053)	(0.0075)	(0.0064)	(0.0097)	(0.0054)
Youth population (%)	-0.0274	-0.0337	0.210	0.188**	-0.0341	-0.0517	0.247	0.191**
	(0.0725)	(0.0850)	(0.248)	(0.0928)	(0.0963)	(0.0870)	(0.275)	(0.0962)
Ln(population density)	-1.361	-1.393	36.66	39.30***	-0.623	-0.178	36.89	39.97***
	(11.63)	(10.42)	(41.83)	(11.40)	(10.04)	(10.64)	(41.36)	(11.47)
Infant mortality rate	0.0215**	0.0191**	0.0351*	0.0343***	0.0186*	0.0185**	0.0258	0.0332***
	(0.0094)	(0.0081)	(0.0208)	(0.0121)	(0.0111)	(0.0082)	(0.0241)	(0.0124)
Conflict in neighboring country (=1)	0.452	0.454	-0.125	-0.109	0.535	0.487	-0.111	-0.0939
	(0.347)	(0.346)	(0.462)	(0.288)	(0.336)	(0.356)	(0.487)	(0.292)
Oil wealth (=1)	0.955**	0.850*	0.319	0.463	0.780	0.779	-0.0517	0.320
	(0.478)	(0.500)	(0.867)	(0.567)	(0.519)	(0.507)	(0.929)	(0.578)
Ln(terrain ruggedness)	0.107	0.0724	0.566	0.592	0.0995	0.0676	0.469	0.598
	(0.275)	(0.235)	(0.602)	(0.472)	(0.268)	(0.238)	(0.621)	(0.478)
Ln(country area)	-1.370	-1.399	36.25	38.92***	-0.653	-0.171	36.41	39.59***
	(11.66)	(10.43)	(41.89)	(11.43)	(10.04)	(10.65)	(41.40)	(11.50)
Country fixed effects	No	No	No	No	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,249	2,374	2,468	2,595	2,134	2,259	2,353	2,480
Number of id	126	126	126	126	126	126	126	126

Note; Logit estimates. Bootstrapped standard errors (400 replications) in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A4: Floods and armed conflict (1985-2009) second stage results – alternative sample definitions with logit estimates

VARIABLES	Developing countries (coefficients)				Conflict prone countries (coefficients)			
	Armed conflict onset		Armed conflict incidence		Armed conflict onset		Armed conflict incidence	
	IV	No IV	IV	No IV	IV	No IV	IV	No IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Flood frequency	**-0.162**	**0.0277**	**0.877[a]**	**0.0645**	**0.0238**	**0.0782**	**0.835***	**0.0924**
	(0.335)	**(0.0574)**	**(0.670)**	**(0.0598)**	**(0.331)**	**(0.0644)**	**(0.476)**	**(0.0622)**
GDP growth	0.0110	0.0091	0.0234	0.0149	0.0113	0.0108	0.0209	0.0235
	(0.0221)	(0.0192)	(0.0413)	(0.0170)	(0.0228)	(0.0181)	(0.0331)	(0.015)
Ln(GDP/capita)	0.0608	-0.0079	0.659	0.598	-0.151	-0.1242	0.482	0.300
	(0.245)	(0.311)	(0.570)	(0.418)	(0.281)	(0.2607)	(0.630)	(0.403)
Ethnic tensions	-0.0396	-0.0104	-0.574**	-0.608***	-0.0131	-0.0105	-0.533**	-0.563***
	(0.160)	(0.136)	(0.231)	(0.128)	(0.153)	(0.1150)	(0.212)	(0.126)
Ln(total population)	3.581	3.581	-32.74	-35.90***	3.623	4.7105	-36.84	-37.51***
	(13.62)	(11.28)	(49.88)	(11.66)	(13.11)	(11.36)	(34.16)	(11.49)
Polity2	0.0060	0.0022	-0.0434	-0.0228	-0.00242	-0.0038	-0.0528	-0.0305
	(0.0341)	(0.029)	(0.0497)	(0.0273)	(0.0490)	(0.0280)	(0.0479)	(0.0273)
Polity2 x Polity2	-0.0067	-0.007	-0.0235***	-0.0228***	0.0010	0.0012	-0.0199**	-0.0192***
	(0.005)	(0.006)	(0.0083)	(0.0053)	(0.0070)	(0.0061)	(0.0093)	(0.0055)
Youth population (%)	-0.122	-0.1192	0.114	0.0594	-0.148	-0.1539*	0.139	0.0895
	(0.121)	(0.1006)	(0.305)	(0.101)	(0.101)	(0.0856)	(0.285)	(0.100)
Ln(population density)	-3.058	-3.254	33.28	37.22***	-3.497	-4.638	36.79	38.23***
	(13.59)	(11.26)	(50.01)	(11.64)	(13.10)	(11.34)	(34.24)	(11.46)
Infant mortality rate	0.0223***	0.0204**	0.0474**	0.0438***	0.0065	0.0079	0.0125	0.0091
	(0.0083)	(0.0082)	(0.0221)	(0.0127)	(0.0073)	(0.0072)	(0.018)	(0.0124)
Conflict in neighboring country (=1)	0.405	0.3940	-0.0968	-0.0952	0.495	0.5371	-0.0216	-0.199
	(0.277)	(0.3668)	(0.427)	(0.292)	(0.302)	(0.3307)	(0.475)	(0.301)
Oil wealth (=1)	0.660	0.580	0.165	0.250	0.624	0.5994	-0.133	0.361
	(0.559)	(0.521)	(0.894)	(0.566)	(0.511)	(0.4521)	(1.000)	(0.580)
Ln(country area)	-2.904	-3.068	33.18	37.05***	0.0891	0.0998	0.365	0.245
	(13.69)	(11.28)	(50.01)	(11.67)	(0.298)	(0.2141)	(0.565)	(0.504)
Ln(terrain ruggedness)	0.122	0.0520	0.427	0.5814	-3.349	-3.588	37.00	38.28***
	(0.369)	(0.258)	(0.570)	(0.5263)	(13.12)	(11.34)	(34.28)	(11.49)
Country fixed effects	No	No	No	No	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1825	1825	1825	1825	1,058	1,058	1,058	1,058
Number of id	88	88	88	88	52	52		

Note: Logit estimates. Bootstrapped standard errors (400 replications) in parentheses. *** p<0.01, ** p<0.05, * p<0.1, [a] – significant at 14% level.