

# **Water Resources, Institutions, & Intrastate Conflict<sup>i</sup>**

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Abstract:

Although linkages between water scarcity and conflict have received a great deal of attention, both in qualitative case studies as well as quantitative studies, the relationship remains unclear since the literature has generally not considered the effectiveness of governance. We distinguish between direct effects and indirect effects linking water resource scarcity and conflict by systematically examining how intervening factors, such as political institutions, might influence the impact of water scarcity on the probability of conflict. We find support for our hypotheses postulating both direct and indirect relationships between water scarcity, governance, and conflict.

## INTRODUCTION

Reg: All right, but apart from the sanitation, medicine, education, wine, public order, irrigation, roads, the freshwater system and public health, what have the Romans ever done for us?

Attendee: Brought peace?

(Monty Python's *Life of Brian*)

Existing literature on environmental scarcity and conflict has led to mixed conclusions about whether scarce water resources are likely to generate violent conflict (Hauge and Ellingsen, 1998; Tose, Gleditsch, and Hegre, 2000; de Soysa, 2002; Hensel, Mitchell, and Sowers II, 2004; Furlong and Gleditsch, 2003; Gleditsch et al., 2004; Homer-Dixon et al., 1991, 1994, 1999; Gleick 1993, Lowi, 1995; Wolf, 1995). Most studies have focused on proving or disproving that a direct, deterministic relationship exists between scarcity and conflict. Likewise, non-conflict studies scholars studying these issues often do not recognize important patterns in conflict onset and do not differentiate between conflicts of interest that might arise in conditions of environmental scarcity and the actual environmentally-driven onset of a violent conflict. We argue that political institutions and democratic governance can mitigate disputes and alleviate grievances. Thus, our article focuses on how political and institutional responses can mediate between resource scarcity and the risk of intrastate conflict.

We posit that the ability of governments to manage environmental grievances, and specifically water scarcity, is an important determinant of whether violent intrastate conflict will arise. For this analysis, we focus on water resource scarcity, although there are important distinctions between types of scarcity, or as Gleditsch (1998), notes, between

simple scarcity and degradation. Likewise, sub-national level variation in scarcity and degradation and the specific decision-making influences at those levels are important, but beyond the scope of this analysis.

Effective governance can address problems of water supply, for example by improving storage, preservation, and water quality. Governance can also help ensure a fair and equitable distribution of water resource, as well as limiting total demand through efforts to promote better conservation and more efficient use. These factors all suggest that governance can play a crucial role in whether water scarcity is likely to give rise to violent conflict. Responsive governments may be better able to deal with problems like water scarcity, and thus avert discontent and civil strife caused by environmental factors.

The next section discusses the link between water scarcity and the probability of intrastate conflict. We present our argument and contribution in section three. In section four we discuss our methodology and data, and in section five we discuss our empirical findings from the pooled data analysis of 98 countries from 1980 to 2001. The paper concludes in section six.

## WATER SCARCITY AND CONFLICT POTENTIAL

In the late 1980s, neo-Malthusian scholars began exploring environmental scarcity and conflict relationships, most arguing that natural resource scarcities, together with social inequalities, independently and directly increase the probability of conflict. Although Homer-Dixon (1999) and others (Schwartz, Deligiannis, and Homer-Dixon, 1991, 1994, 2000) discuss social variables such as ingenuity and adaptability as possible conflict-mitigating factors, they also emphasize the physical limits of such social variables. That is, most neo-Malthusian scholars circle back to deterministic links between environmental scarcity and conflict.

Gleditsch (1998) and others argue that neo-Malthusian studies are overly complex and deterministic and highlight the absence of important political and economic variables in these analyses. Neo-Malthusian theorists have responded to critiques of determinism and complexity by pointing out the exogenous factor of environmental scarcity and thus the “automatic” response of conflict to such scarcity. While the neo-Malthusians make an important point in highlighting the complexity of ecosystems and human interactions (Matthew, 2000), a common neo-Malthusian assumption that conflict arises automatically out of scarcity is problematic. This automatism argument is problematic because it assumes that institutions are either irrelevant or minimally important, that adaptation possibilities are limited and determined at base by environmental context, and that politics does not matter as much as other factors. Some of these deterministic and pessimistic neo-Malthusian claims are not supported by recent micro-level studies (Turner, 2004; Horowitz, 2009).

Resource optimists or cornucopianists—exemplified by Simon (1996) and Lomborg (2001a and 2001b)—claim that scarcity is not the condition that actually applies to most natural resources (Urdal, 2005). Humans automatically adapt to resource scarcities, either by using market mechanisms which respond to scarcities or through purposeful technological innovation which drives adequate responses (Boserup and Schultz, 1990, Urdal, 2005).

The argument that innovation drives environmental improvement is also important in the literature on environmental Kuznets curves. Scholars argue that environmental degradation will display an inverted u-shaped relationship with economic development. Although economic growth in very poor countries at the outset will lead to greater environmental problems, such as water pollution, higher economic development beyond some threshold will yield decreasing degradation either through industrial and technological shifts, increasing concerns over environmental degradation once core material needs are satisfied, or more income to expend on anti-pollution efforts (Shafik and Bandopadhyay,

1992 & Grossman and Krueger, 1994). Work focusing on water resource availability and Kuznets curves has considered outcomes such as water consumption (Goklany 2002; Rock, 1998), improved irrigation efficiency (Bhattarai, 2004), and water withdrawals and virtual water (Katz, 1998). However, contrary to the cornucopianist expectations, this line of research does not consistently find support for the hypothesized inverted u- shape relationship between income and water resource outcomes. For example, while Katz (1998) finds that water withdrawals exhibit a Kuznets curve – decreasing with increasing income after some level – he also shows that total water use does not confirm this relationship. Katz demonstrates that water footprints, which incorporate virtual water through imported goods and therefore all water consumption, do not exhibit Kuznets curves. The fact that there is not a one to one relationship between income and effective governance may account for some of these findings. The fact that there is not a one to one relationship between income and effective governance may account for some of these findings.

In addition to cornucopianist arguments about income and resource scarcity and the tests of these hypotheses, the resource abundance hypothesis posits that a plethora rather than the scarcity of natural resources increases the risk of violent conflict, although the resource abundance literature does not address water resources (Collier and Hoeffler, 1998; Collier, 2000, Le Billon, 2001, de Soysa, 2002; and Urdal, 2005).

Conflict studies scholars have moved to a more systematic examination of the competing arguments about the impact of decreasing water resource availability primarily on the probability of interstate conflict (Gleditsch, 1998; Gleditsch and Urdal, 2002; Collier and Hoeffler, 1998; Tir and Diehl, 2001; Vasquez, 1993; Hensel, Mitchell and Sowers, 2004). These studies have sought to identify whether or not patterns of relationships between nations sharing water resources exhibit the hypothesized neo-Malthusian relationship between

conflict and increasing scarcity (Ackerman and Tir, 2003, Furlong and Gleditsch, 2003, Gleditsch et al., 2004, Hensel, Mitchell, and Sowers II, 2004).

Hauge and Ellingsen (2001) find a positive and significant impact of freshwater availability on both intra- and interstate conflict, with more significant impacts on intrastate conflicts. However, their findings have not yet been replicated. Toset, Gleditsch and Hegre (2000) find that countries with shared rivers have a slightly higher frequency of armed conflicts than those that do not share river basins. Hensel, Mitchell, and Sowers (2004) argue that regional conflict management institutions develop more often and are more effective in resource abundant regions. Basing their work on the hypotheses of the neo-Malthusian approach by Critchley and Terriff (1993) and “Lateral Pressure Theory” proposed by Choucri and North (1975), Hensel, Mitchell and Sowers II (2004) offer a hypothesized “indirect” relationship between water scarcity and peace through regional institutions and democracy, rather than just the direct relationship postulated by most other studies. Their results indicate that international institutions dealing with water scarcity can account for variation in interstate conflict and can reduce the probability of such conflict.

The systematic studies of water resource conflict have been important for shedding light on the role of institutions at the international level. The wide consensus in the literature is that water scarcity does not induce violent international conflicts; however, the literature pays little attention to the impact of water scarcity on the most common type of violent conflict, namely intrastate wars. While much of the systematic literature in search of general patterns uses the Homer-Dixon group’s work as a starting point for proving that this relationship is not automatic, to our knowledge no quantitative work approaches the level of complexity of most neo-Malthusian arguments and models. Thus, much of the quantitative literature does not adequately reflect the complex relationships identified by the case study literature. As most conflicts tend to be at the intrastate level, we argue that the analysis of

water resource conflict potential should be at the sub-state level, where environmental factors interact with domestic institutional structures.

### THE MEDIATING ROLE OF DOMESTIC INSTITUTIONS

In order to better understand when and how conflicts over water resources occur, we look at the institutional capacity of states to adapt to environmental constraints and public dissatisfaction with increasing environmental constraints. Our argument that intrastate water resource conflicts are institutionally driven is based on a set of assumptions: regime type influences conflict potential, resource distribution, and perception of resource availability; intrastate conflict has an impact on institutional effectiveness; international spillover effects are possible in regionally resource-dependent countries; and conflict, political institutions and natural resources interrelate both directly and indirectly in an endogenous system.

Structural scarcity – the unequal distribution of resources – matters for the emergence of environmental conflict, as neo-Malthusians argue, because it puts pressure both on natural ecosystems and social structures (e.g., Burton, 1990a, 1990b; Galtung, 1996; Lederer and Galtung, 1980). Nevertheless, since we assume that institutions affect distribution and access, conflict will not always occur in water scarce nations, and in fact, the modal tendency may be for it not to occur. What matters is how governments respond to the pressure of natural and structural scarcity. Case studies and in-depth analysis of herder-farmer conflicts in Africa also support the argument that these conflicts are often driven by social tensions that primarily reflect institutional failures and mismanagement at the local and community level. Environmental degradation is the outcome rather than the cause of institutional breakdown which leads to social conflict (Turner, 2004: 883). In the context of these social conflicts, environmental factors interact with political decisions.

Government policies and their effectiveness are not only a function of state strength, but also influenced by the formal and informal relationships between political leaders and their constituents. In democracies, political elites need to accommodate and satisfy a larger part of the electorate to ensure political survival (Bueno de Mesquita and Root, 2000; Bueno de Mesquita et al., 1999). The degree of a political regime's democracy is not always synonymous with good governance; very autocratic regimes often have high levels of institutional capacity, and may be able to distribute public goods more efficiently than weak democratic political systems (e.g. Singapore and China). However, even though there are cases of highly effective autocratic regimes, it is generally the case that democracies tend to have better and more responsive governance systems, especially at meeting the basic needs of the electorate.

Regime type matters for environmental conflict not because democratic rulers are more "enlightened" to environmental issues, but because democracies are better at alleviating public concerns and developing trust in government responsiveness. Democracies pay greater attention to local actors' needs and concerns, or have formal mechanisms that are likely to hold governments accountable when such needs are not met or rights protected. Conflicts of interest are likely to be present in scarce resource distribution situations. However, disputes can be addressed in the early stages before escalating into violence or intrastate war. Domestic institutional structures can mitigate the social polarization that environmental scarcities may give rise to. Research has demonstrated that democratic institutions tend to have a mitigating impact on the probability of intrastate conflict more so than autocratic regimes all things equal (Benson and Kugler, 1998; Ellingsen, 2000; Hegre et al., 2001).

Overall, democracies are less likely to experience violent intrastate conflict, since they can provide a political outlet to the expression of grievances (Muller and Weede, 1990;

Hegre and Nome, 2009), including demands over distribution of resources and environmental scarcity. These distribution and scarcity issues will not necessarily be addressed or resolved to anyone's satisfaction, but the existence of an outlet to express dissatisfaction will reduce violent conflict potential regardless of actual government responsiveness. Thus, democracies may or may not be more effective or efficient at dealing with water resources, but they are better at dealing with internal conflict.<sup>ii</sup> It is the ability to effectively alleviate grievances and adapt to change that matters.

Democracies tend to develop these pressure-valve mechanisms and are better at distributing public goods, such as health, compared to autocratic political systems (Lake and Baum, 2001). Although freshwater is not a pure public good, it is a common good, which is necessary for the survival of communities, and we anticipate that democracies will be more responsive to demands for the provision of adequate water resources to the majority of the population (Hauge and Ellingsen, 2001; Gleditsch, 1998, and Urdal, 2005; Gleditsch and Sverdrup, 2002).

Colorado River flow disputes in the Western US demonstrate the importance of political institutions in water disputes. Urbanization strained natural resource per capita availability and reprioritized distribution from one sector – agricultural to municipal – and region in the Colorado basin to another. This environmental conflict has been contained in intensity and scope partly because of the presence of well-established institutional structures that allow for litigation and mediation of competing demands between urban and rural communities and between states, even as water rights systems have not changed to reflect new realities. This type of interdependent, tense relationship between US states over the Colorado River is magnified for regionally resource-dependent countries without established mediating institutions and a higher governing body to manage the disputes.

International water politics in Central Asia exemplify the water resource dependency and institutional issue for internal and internationalized disputes. Two of the downstream nations in the Amu Darya and Syr Darya basins—Uzbekistan and Turkmenistan—are not categorized as water-scarce or water-stressed nations. But these semi-arid and arid countries are highly dependent on their upstream neighbours—Kyrgyzstan and Tajikistan—for water resources due to the downstream countries' important agricultural sectors. Internally and in relations with their neighbours, Uzbekistan and Turkmenistan frame themselves as water scarce nations because of their dependency.

#### The Nexus between Water Scarcity, Domestic Institutions, and Conflict

Domestic institutions are the mitigating factors between environmental scarcity and conflict. However, violent intrastate conflict has also a direct and measurable impact on the formation and capacity of domestic institutions. Countries with weak and unstable political institutions and low economic development (Fearon and Laitin, 2003; Collier et al., 2003) are of higher risk to experience intrastate conflict, all things equal. If countries fail to rebuild their domestic structures and improve economic development, more often than not, they enter the vicious circle of conflict and underdevelopment that is identified as the conflict trap (Collier et al., 2003). Thus, domestic institutions and intrastate conflict are two potentially endogenous outcomes, and the role of conflict and institutions must be considered in a simultaneous framework.

One question that is raised by the Malthusian literature and understudied in quantitative analyses is whether there exists an ecological trap – analogous to the conflict trap – linking environmental scarcities with conflicts and institutions directly in a feedback cycle. Bio-geographic endowments have been found to have a deep influence on economic development (Sachs, 2005; Hibbs and Olsson, 2005), and ecological factors at initial stages

of development plus state formation influence the type of political institutions that emerge, particularly a country's prospects for democracy (Crenshaw 1995, Midlarsky, 1998). As we have argued, effective institutions can address environmental and structural scarcity through policies such as conservation or redistribution. Yet, will countries with unfavorable initial endowments be stuck in a trap where bad institutions exacerbate rather than alleviate scarcity and scarcity in turn undermines prospects for political reform? Stated differently, can undemocratic institutions create policies that lead to greater scarcity – such as through unchecked population growth placing pressure on water resources – or alternatively increasing perceptions of scarcity?

Conflict can clearly lead to the deterioration of existing water resources or inability to distribute them adequately through the destruction of infrastructure or the lack of control over key regions. Countries where water resource infrastructure has been undermined by internal conflict include Sudan, Afghanistan, Iraq, the Democratic Republic of Congo, the former Yugoslavia, Columbia, Tajikistan and Nepal. The decline of institutional capacity could make it more difficult for states to address environmental stress, which then in return reduces the ability of institutions to mitigate the link between resources and conflict. Therefore, these questions about the direct links – and potential endogeneity – between political institutions and water resource scarcity are important to consider, in addition to our arguments about the indirect relationship between these factors.

In sum, we argue that political institutions and external dependence matter and that these institutions, together with conflict and water resource availability, are interrelated and must be considered in an endogenous system. Based on these and our previously outlined assumptions, we derive and test the following direct and indirect relationships among political institutions, conflict and water scarcity:

H1: Water resource scarcity increases the probability of intrastate conflict.

H2: Democratic institutions reduce the probability of intrastate conflict.

H3: Water resource scarcity contributes to the emergence of autocratic regimes.

### A MODEL OF ENVIRONMENTAL SCARCITY, GOVERNANCE, AND CONFLICT

We assess our three hypotheses using data for 98 countries for the time period 1981-2000. The timeframe of our data was determined by the availability of most indicators on the countries included in the sample. Similarly, missing data on many countries limit the sample to 98 countries. Despite this limitation, our sample includes a very diverse set of countries which guarantees significant variation in terms of both the dependent and the independent variables. Since we argue that reciprocal causation exists, we need to consider a system of simultaneous equations to take into account the potential endogeneity of scarcity, governance, and conflict. For example, treating institutions as pre-determined or fixed when estimating their effects on conflict would be inappropriate here given our hypothesized relationships between water scarcity, institutional capacity, and the probability of conflict. Simultaneous equations methods are therefore appropriate in our analysis to take into account the potential endogeneity suggested by our theoretical argument. We use a two-equation model to evaluate our central argument that regime type impacts conflict potential in water scarce conditions. In this model, we treat water scarcity as an exogenous variable. More specifically, we estimate the following system of equations:

$$\begin{aligned} C &= \gamma_C IRFWR + \xi_C G + \beta_C X_C + \varepsilon_C \\ G &= \gamma_G IRFWR + \xi_G C + \beta_G X_G + \varepsilon_G \end{aligned} \quad (1)$$

Where:

C= intrastate and internationalized intrastate conflict,

G= State Capacity/Governance,

$X_C$  = water scarcity (IRFWR), previous conflict, total population, log of GDP per capita, agricultural productivity, lag of urbanization, lag of rural population density, interactive term between democracy and IRFWR

$X_G$  = log of GDP per capita, lag of urbanization, urbanization square, and number of peace years

$\varepsilon$  = error terms.

### Operationalization

We now detail the specific measures used for our key variables. Our variable selection is based on generally accepted practice and precedents in the literature reviewed and extended by our assumptions and theoretical framework. Included also are factors that are likely to influence both the dependent and independent variables of interest.

### Water availability variable

One difficulty faced by scholars is reliably measuring socially and politically constrained natural resource availability at the national level. As we are interested in scarcity (rather than sanitation, infrastructure, or distribution) to properly test the arguments made in the literature, we utilize a measure that is widely used by environmental and conflict scholars (Hauge and Ellingsen, 2001; Furlong and Gleditsch, 2003; Toset et al., 2000, Midlarsky, 2001; Hensel, Mitchell and Sowers II, 2004). This measurement is to a limited extent a proxy for the human-impacted side of natural availability, specifically in terms of population growth (and thus per capita distribution). Thus, we measure water availability as internally renewable freshwater resources per capita (IRFWR). This includes the average annual flow of rivers and the recharge of groundwater (aquifers) generated from precipitation occurring within a country's borders. While this is the most widely used measure of water resource

scarcity, there are other possible measures to capture scarcity, such as access to freshwater or available drinking water (Molle and Mollinga, 2003). The measure used in this study has the most comprehensive coverage in terms of countries and time periods. We expand the available data by extrapolation using linear regression. Extrapolating data – in particular water availability which can be stochastic – is somewhat problematic, but the benefits of increasing the number of observations outweigh the potential problems of extrapolation in this setting. The data are from FAO Aquastat (2001), provided for intervals of five years (FAO 2001). We extrapolated the in-between years to obtain annual data and take the natural log of the variable for the presented models. While it may be useful to measure trends in scarcity, thus considering moving averages of water scarcity levels, we are limited by gaps in the data in conducting such an analysis.

Differentiation between totally available freshwater resources and internally derived resources is made by FAO and in the World Development Indicators to incorporate political and economic realities along with ecological ones. Internal water resources reflect population changes that affect natural availability. Likewise, this measure does not reflect purely natural availability given the inexact match between national boundaries and watersheds. “Internally available” water resources constrains our measurement to non-shared water sources or those not originating internationally, as well as reflecting population changes impacted by government policies, economic growth, and social welfare. This water resource measure therefore is a partly politically and socially contrived one, rather than purely natural. Moreover, we use an interactive term of democracy and freshwater resources per capita to capture the combined effect of political institutions and water scarcity on the probability of civil conflict.

#### Endogenous variables

Conflict:<sup>iii</sup> Although conflict in terms of incompatibilities may not always give rise to violence, we here focus on violent conflict where armed force is used. For our measurement we use the Uppsala Conflict Data Programme (UCDP) (Uppsala Conflict Data Programme, 2008) which uses as threshold 25 battle-related deaths per year. This is the lowest possible threshold available cross-nationally for armed conflicts. Thus, UCDP's threshold allows us to capture a larger number of violent intrastate and internationalized intrastate conflicts than alternative measures of intrastate conflict such as the COW dataset. We do not include interstate conflicts, since our focus is on intrastate conflict and the sample is for the period 1981-2000, where very few interstate wars occurred (on the data see Eriksson and Wallensteen, 2004; Gleditsch et. al, 2002). Based on the Uppsala dataset we create a dichotomous variable for conflict, which takes the value of 1 if we have either a type 3 (intrastate) or type 4 (internationalized intrastate) conflict breaking out in a particular year. Internationalized intrastate conflicts are defined as civil wars where external actors are involved. We also exclude from our analysis cases where the location of the incompatibility or conflict is different from the geographical location of the fighting (for more on location see UCDP, 2008).

Governance: Measuring governance effectiveness remains challenging, and most available suggested measures such as GDP per capita (Fearon and Laitin, 2003) and tax extraction rate of governments (Arbetman and Kugler, 1997) are considered controversial as they may reflect a host of factors other than governance or the ability of the state to enact responsive policies (Jackman, 1993). Moreover, the World Bank indicators on governance have limited coverage starting from 1996 (Kaufmann et al., 2007). Therefore, we use democracy or type of political regime as a proxy for better governance, as argued. To measure the type of political system we use the Polity "institutionalized democracy" measure from Polity IV (on the data see Jagers and Gurr, 1995), which takes on values ranging from

-10 for the most autocratic regime to 10 for the most democratic political systems.<sup>iv</sup>

Although high Polity scores indicate democratic regimes and very low scores indicate autocracies, it is possible there is not always a linear relationship in the index, making the interpretation difficult (Przeworski et al., 2000). Thus, we created a dummy variable for democracy (if Polity score is above 7 then the dummy variable gets a value of 1, otherwise it gets a value of 0).

We also used Vanhanen's (2000) index of democracy as an alternative measurement for political institutions. Vanhanen's index of democracy and the institutionalized democracy measure from Polity are positively correlated ( $r= 0.66$ ). We replicated all the models presented in this article by using Vanhanen's index instead of Polity. Including the Vanhanen's index indicates a decrease in the probability of conflict and an increase in freshwater resources per capita. All the other coefficients remained the same. The replication data are available upon request.

### Exogenous variables

In a system of simultaneous equations the search for the proper instruments as well as parsimony is always challenging. We choose exogenous variables based on plausible specifications for each of the endogenous variables and the need to consider relevant control variables. In this context, we use as instruments variables that explain the variance of all three endogenous variables (conflict, water resource scarcity, and regime type) and their hypothesized relationships. We run separate OLS regressions with each one of the endogenous variables to examine if the applied instruments are adequate to explain variation. Each one of the OLS regressions has adjusted R-squares between 0.49 (for the total internal renewable resources) and 0.28 (for the conflict equation). The exogenous variables can be divided into two categories: environmental and structural.

### Environmental variables

The most commonly used control variable of renewable freshwater resources is the amount of annual precipitation, a proxy for the natural factors in the complicated hydrological cycle which provides an alternative test of an exogenous impact of freshwater resources on political outcomes. FAO Aquastat provides average values of precipitation for every 5 years, measured as  $Km^3$ . Annual precipitation has little variance across years for the time period and countries evaluated here; thus, we cannot make any inferences. Due to limited observations, we extrapolated the data using linear regression.

The second environmental control variable we are using is the dependency ratio capturing water resources that originate from neighbouring countries. Countries that are dependent derive a large portion of their total available water resources externally, i.e. they are located downstream in a river basin, share a river border, water used is delivered from another nation. The dependency ratio variable reflects a government's "controllability" of resources and external pressures, and is important for evaluating the perception of scarcity as well as the internationalized component of intrastate conflicts (in other words, when external factors influence domestic politics or when domestic conflicts spill over national borders). Theoretically the ratio varies from 0 to 100. The ratio is estimated as follows: Dependency ratio =  $IRWR/(IRWR+IWR) \times 100$  percent, where IRWR stands for internal renewable water resources and IWR stands for total volume of incoming water resources from neighbouring countries (FAO, 2001).

### Structural variables

Urbanization, economic development, agricultural productivity and density of the rural population put consumption pressure on water resources and lead to additional

asymmetry in distribution (beyond geographically-based maldistribution). Moreover, due to political choices these processes and sectors (e.g. urban-rural, agricultural and municipal uses) are often competing, creating the underlying conditions for intrastate conflict. Thus, changes in these structural variables reflect the interaction between domestic institutions and environmental pressures, and how these processes are linked to intrastate conflict (Matthew, 2001).

Agricultural productivity is the ratio of crop production index (CPI) over the percentage of irrigated land (CPI/%irrigated land). The data are from the FAO reported by the World Bank Development Indicators. This measure captures demand side water use and indicates how productive a country's agriculture (worldwide the most water intensive sector) is relative to the amount of land being irrigated – thus how efficiently a country uses its water resources when precipitation is not enough at the right time.

For urbanization, which is defined as the percentage of the total population that lives in urban centres, we also use data from the World Bank Development Indicators. Urbanization is lagged by one year to avoid problems of endogeneity. In the institution equation we also include the square of urbanization, per the literature on democratization that finds a curvilinear relationship with urbanization continuing without increases in economic growth (Barro, 1999; Fay and Opal, 1999). Urbanization is also squared to capture the rapid urbanization effects in developing countries and the drag it can play on social and political institutions (Barro, 1999).

As a measure of population distribution, urbanization is distinct from and has a different impact on water resources than rural population density, which is also used in our analysis. Also, rural and urban groups tend to engage in distinct manifestations of political actions. The data for rural population density are also from the World Bank Social Indicators and we use the one year lag of this variable.

The natural log of GDP per capita is included to capture overall levels of development, which is widely held to be associated with better prospects for democracy and lower levels of intrastate conflict (Fearon and Laitin, 2003). The data for GDP per capita come from the World Bank Development Indicators.<sup>v</sup>

Although urbanization and GDP per capita are mildly correlated (-.55), the Variance Inflation Factor (VIF) does not indicate that multicollinearity is a problem in our analysis. The conventional wisdom is that countries with higher income are also more urbanized; yet, some of the large and developed countries included in this sample (e.g. US and Canada) have much lower levels of urbanizations than the average. All of these variables are estimated at the national level; thus, they cannot explain regional variation within countries.

Regarding intrastate conflict we use two key control variables as these are identified by the literature on intrastate conflict to control for alternative explanations to the environmental scarcity argument. We include total population and the occurrence of conflict in previous years (Fearon and Laitin, 2003; Hegre and Sambanis, 2006). Since our sample is from 1981 to 2000, we estimate the presence of conflict in previous years by averaging the years from 1970 to 1980 and create a dummy variable that takes the value of 1 if a country has experienced conflict during this time period and takes the value of 0 if a country has not experienced any intrastate conflict for the same time period.

This is not an exhaustive list of all the factors that might contribute to intrastate conflict independently from environmental pressures and concerns. Nevertheless, we are confident that conflict in previous years, together with GDP per capita as an indicator of social and economic development, captures many of the structural factors that are usually associated with the onset and recurrence of intrastate conflict (Collier *et al.*, 2003; Lacina, 2006; Ellingsen, 2000).

Finally, in the institutions' equations we include as an additional control variable the number of consecutive peace years since the beginning of our sample. Existing studies suggest that democracy does not break down in the presence of conflict, but there is evidence suggesting that democracy is less likely to emerge in conflict prone regions (Thompson, 1996). Therefore we also include a count of the number of consecutive years of peace to assess potential long run consequences of conflict on domestic institutions. For a list of all the variables included in the analysis, see Appendix III.

## **EMPIRICAL ANALYSIS**

The first step in our analysis is a preliminary view of the data to identify if water scarcity indeed is more prevalent in countries that have experienced internal conflict and have democratic regimes. Since internal renewable water resources ("water availability") is a continuous variable we look in Table 1 at how the median values vary conditional to the other main explanatory variables of interest.

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Table 1 about here

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We observe in Table 1 that the median value of the water availability variable is higher among the countries that are democratic than non-democracies and higher for countries that do not experience intrastate conflict than among countries that do. These descriptive statistics are clearly consistent with our hypotheses. However, democracy, conflict, and freshwater could also be influenced by other features that may be correlated with the other independent variables of interest, and these descriptive statistics do not take into account the potential endogeneity between the variables. Hence, we move to the next step, which is the estimation of the simultaneous equations model and the hypothesized

causal links among water scarcity, democracy, and intrastate conflict while taking into account the relevant control variables.

### Simultaneous Equation Models

We argue that institutional structures are the intervening mechanisms influencing the significance and direction of the water scarcity and intrastate conflict relationship. It is important to distinguish between short term and net effects in order to evaluate our results. We make this distinction throughout our empirical analysis discussion. We present first the results for our baseline model, which does not include the interactive term between democracy and water availability. Then we turn to presenting the results for our interactive term model. Finally, we introduce preliminary results of a three-equation model where water availability is included as an endogenous variable.

### Baseline model

As previously discussed, the literature on water scarcity and conflict almost entirely focuses on direct effects between these variables. Earlier in this paper, we hypothesize that water scarcity adversely affects the prospects of democracy to emerge. These hypothesized short-term effects of water availability on regime type are supported by our empirical analysis. In the political regime equation, the coefficient for water resources is positive and statistically significant at the 1% level. These results indicate that countries that are water scarce are less likely to have democratic institutions, all else being equal. Similarly, countries that experience civil conflict are less likely to be democratic; the coefficient for civil conflict is statistically significant at the 1% level. Thus, intrastate conflict increases the likelihood of autocracy. Regarding the control variables, economic development increases the likelihood

that a country will be democratic, as is anticipated by the literature on democracy and development (Lipset, 1960).

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Table 2 about here

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When it comes to the results for the conflict equation, hypothesis one – i.e., that water resource scarcity increases the probability of intrastate conflict – is not supported. The coefficient is positive but insignificant. Hypothesis 2 – democratic institutions reduce the probability of intrastate conflict – is also not supported in our baseline model. Regime type does not have a significant effect on the probability of conflict when controlling for water availability. This finding at first does not seem to fit well with most of the literature on intrastate conflicts (Buhaug, 2006; Hegre *et al.*, 2001). Thus, further exploration is required. Since water scarcity has an impact on the type of political regime, we are also interested in exploring how water availability conditional on political institutions affects the probability of conflict. We thus introduce an interactive term of these two variables to our baseline model.

#### Interactive term model

The effect of the interactive term between democracy and water availability on the probability of conflict in Table 3 is significant at the 1 per cent level and negative. When a multiplicative interaction term between the two variables is included in a regression model, the individual terms for these variables cannot be interpreted independently and the net effect of a marginal change in one variable will depend on the value of the other (Braumoeller, 2004). In other words, the estimated coefficients from the model with interaction between type of political institutions and water availability imply that in democratic regimes water availability decreases the probability of conflict.

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Table 3 about here  
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For the control variables, we find that a higher GDP per capita not only decreases the probability of conflict (negative and significant at the 5% level in the conflict equation), as the literature overwhelmingly suggests, but also it is positively related to the presence of democratic institutions (significant at the 1% level in the regime equation). The remaining control variables, both structural and environmental, have significant coefficients in the anticipated directions, albeit some of the structural variables such as agricultural productivity and population have coefficients that imply a very limited effect on the probability of intrastate conflict, where the marginal impact almost approaches zero. A particularly interesting finding in light of our arguments is the significant convex relationship of urbanization and democratic institutions in the interactive model in Table 3. The mediating effect of institutions on how water scarcity influences the risk of conflict raises the question of whether water scarcity itself may be endogenous to governance and conflict (Miguel et al., 2004). That is, democratic governments may address water scarcity through better governance, while conflict may undermine governance of water resources. Unfortunately, our water availability variable is not constructed in a manner that allows us to fully capture the socially exploitable component of water scarcity and primarily captures initial endowment and geographic factors. However, the results from a three-equation model where water availability is treated as an endogenous variable, reported in Appendix I, still show support for our claims regarding the role of governance in mediating the link between scarcity and conflict. As such, our findings here cannot be dismissed as an artefact failing to take into account the full three-way reciprocal causation between political regime, civil conflict, and water availability.

## DISCUSSION

Despite the complexity of our arguments, there is a clear theme in our empirical results: institutions influence the ability of states to adapt to their freshwater needs by mitigating possible conflicts of interest that could potentially escalate to intrastate wars. Similarly, the availability of water resources can affect the nature and effectiveness of domestic institutions. Environmental conditions tend to be linked to and interact with the development of political and economic institutions (Diamond, 1997; Wittfogel, 1957). In fact, the ecological trap hypothesis is granted support in this analysis, as anticipated (Midlarsky, 1998; Crenshaw, 1995).

The neo-Malthusian arguments about direct and largely unavoidable linkages between resource scarcity and conflict are not supported by the current analysis. In fact, in the two-equation models presented in this article, the level of water resources does not have a significant impact on the probability of conflict, an empirical finding that suggests that the actual distribution, rather than the available stock, of resources might be more relevant to the onset of conflict. The convex relationship found between urbanization and democratic institutions renders further support to our argument about the complex interaction between population dynamics, environmental structures, and institutions. Micro and meso-level studies of the links between urbanization, population distribution and environmental issues, such as White et al.'s (2009) analysis of environmental degradation in coastal Ghana, demonstrate that urban growth is not deterministically linked to environmental degradation, even in developing countries. Including domestic institutions in our analysis we gain a more

nuanced understanding of the mechanism through which water scarcity might be linked to intrastate conflict.

Water scarcity undermines governance and the establishment of democratic institutions within a country, all things equal. Thus, countries that experience water scarcity might enter a vicious cycle of scarcity-autocracy-conflict. The implication of this finding can also be linked to climate change, which can threaten not only the availability of water resources, but also undermine the overall capacity of states to respond to increasing demands and the deterioration of fresh water resources (Barnett and Adger, 2007). However, the impact of climate change on political institutions will vary in different areas (Hendrix and Glaser, 2007), and there is a great deal of uncertainty over what future changes may look like and the specific response required. Regardless, it seems that domestic institutions become the key to the solution of this puzzle.

Our results are at the level of nation-states. This is generally an appropriate level of analysis for studying governance's influence on water resource distribution and internal conflicts. However, given the widely recognized fact of sub-national and regional variations in water resource availability (see Feitelson and Fischhendler, 2009), future studies should incorporate the degrees of variation across a nation in the range of water resource availability as well as links to other states. In fact, case studies at the community level support our main argument and suggest that the environmental conflict literature needs to further explore and understand the role of institutions in shaping the pathways to violent conflict in the context of environmental disputes (Turner, 2004; Bogale and Kurf, 2009). Thus, greater attention to variations within countries would also highlight the role of the quality of governance, as a well-governed state would be more capable to deal with these differences and the conflict-generating possibilities. The presence of democratic institutions by itself might not be enough to mitigate environmentally-related conflict; the quality of governance can be

important, in particular at the local level. Evidence from the resource-related conflict in New Caledonia suggest that conflicts that are often considered to be related to environmental factors might also be related to political factors, such as legitimacy and responsiveness to the needs of local communities (Horowitz, 2009).

We expect that our results here are conservative estimates given the national aggregate nature of the data used for water resources and other factors. Likewise, we utilize the commonly accepted available measure of water resources availability per capita, but one that reflects mostly physical scarcity rather than human-induced scarcity. Hence, the fact that we are able to identify both direct and indirect links among our main dependent variables at the national level leads us to believe that these relationships may well be even stronger at the sub-national level and with improved measures of water resource availability.

## CONCLUSIONS

Our main argument focuses on the role of political and institutional factors – primarily, governance – and the ability of governments to mitigate or exacerbate water scarcity and its impact on conflict. Overall, we find evidence that supports a nuanced resource abundance argument. But this is only part of the story, as the net effect of water availability on the probability of conflict through the interaction between democracy and water resources suggests that institutions mediate the impact of environmental factors on the onset of conflict. Democratic state institutions reduce the likelihood of intrastate conflict; democratic institutions are also more likely present in countries with greater availability of freshwater resources per capita. Thus, regime type does make a difference when it comes to addressing environmental concerns.

Even though deriving strong policy implications seems premature, our analysis does underline the benefits of examining the arguments in the neo-Malthusian literature through

systematic large-N studies. Although the results do not support as strong and direct a relationship (posited by neo-Malthusian scholars) between political institutions and conflict in water scarcity contexts, our results nevertheless demonstrate that there is an effect and that it is worth further study. Clearly the literature has to work in that direction, to evaluate indirect as well as direct relationships, pay greater attention to resource scarcity and political variations within countries and more fully test the arguments of how institutions, water, and conflict interact. Future research would do well to pay attention to the possibilities of the interaction between these factors and their relative importance.

## References

- Ackerman, J. and J. Tir. (2003). To Share or Not to Share: Conditions Affecting Signing of River-Managing Treaties Between Riparian States. Presented at the Annual Meeting of International Studies Association, Portland, Oregon.
- Arbetman, M. and J. Kugler, eds. (1997). *Political Capacity and Economic Behaviour*. Boulder: Westview Press.
- Barnett, J. and W. N. Adger. (2007). Climate change, human security and violent conflict. *Political Geography*, 26 (6), 639-655.
- Barro, R. J. (1999). Determinants of Democracy. *Journal of Political Economy*, 107 (S6), S158-S183.
- Benson, M. and J. Kugler. (1998). Power Parity, Democracy, and the Severity of Internal Violence. *Journal of Conflict Resolution*, 42(2), 196 - 209.
- Bhattarai, M. (2004). *Irrigation Kuznets Curve, governance and dynamics of irrigation development: A global cross-country panel analysis from 1972 to 1991*. Research Report 78. Colombo, Sri Lanka: International Water Management Institute.
- Bogale, A. and B. Korf. (2009). To share or Not to Share? (Non-)violence, Scarcity and Resource Access in Somali Region, Ethiopia. *Development Studies*, 43 (4), 743 – 765.
- Boserup, E. & T. P. Schultz, eds. (1990). *Economic and Demographic Relationships in Development*. Baltimore: Johns Hopkins University Press.
- Braumoeller, B. F., (2004). Hypothesis Testing and Multiplicative Interaction Terms. *International Organization*, 58(4), 807–820.
- Bueno de Mesquita, B. and H. L. Root. (2000). When Bad Economics Is Good Politics. In *Governing for Prosperity* ed., B. Bueno de Mesquita and H. L. Root, pp. 1-16. New Haven: Yale University Press.
- Bueno de Mesquita, B., J. D. Morrow, R. M. Siverson, A. Smith. (1999). Policy Failure and Political Survival: The Contribution of Political Institutions. *Journal of Conflict Resolution*, 43 (2), 147-161.
- Buhaug, H. (2006). Relative Capability and Rebel Objective in Civil War. *Journal of Peace Research*, 43(6), 691-708.
- Burton, J. (1990a). *Conflict: Resolution and Prevention*. New York: St. Martins Press.
- Burton, J. (1990b). *Conflict: Basic Human Needs*. New York: St. Martins Press.
- Chatrchyan, A. M. and A. Wooden. (2005). Linking Rule of Law and Environmental Policy Reform in Armenia and Georgia. In *The State of Law in the South Caucasus* ed., C. P.M. Waters, pp. 144-78. London: Palgrave Macmillan.

- Choucri, N. and R. C. North. (1975). *Nations in Conflict*. San Francisco: W.H. Freeman and Company.
- Collier, P. (2000). Doing Well Out of War: An Economic Perspective. In *Greed & Grievance: Economic Agendas in Civil Wars* ed., M. Berdal & D. M. Malone, pp. 91-111. Boulder: Lynne Rienner).
- Collier, P. and A. Hoeffler. (1998). On Economic Causes of Civil War. *Oxford Economic Papers*, 50 (4), 563-573.
- Collier, P, V.L. Elliott, H. Hegre, A.Hoeffler, M. Reynal-Querol, and N. Sambanis. (2003). *Breaking the Conflict Trap: Civil War and Development Policy*. New York: World Bank.
- Crenshaw, E. M. (1995). Democracy and Demographic Inheritance: The Influence of Modernity and Proto-Modernity on Political and Civil Rights, 1965 to 1980. *American Sociological Review*, 60 (3), 702-718.
- Critchley, W. H. and T. Terriff. (1993). Environment and Security. In *Security Studies for the 1990s* ed., R. Shultz, R. Godson, and T. Greenwood, pp. 327-352. Washington, D.C.: Brassey's.
- Diamond, J. (1997). *Guns, Germs, and Steel: The Fates of Human Societies*. New York: W.W. Norton & Co.
- De Soysa, I. (2002). Ecoviolence: Shrinking Pie or Honey Pot? *Global Environmental Politics*, 2 (4), 1-36.
- Ehrlich, P.R. (1968). *The Population Bomb*. New York: Ballantine Books.
- Ellingsen, T.(2000). Colorful Community or Ethnic Witches' Brew? Multiethnicity and Domestic Conflict During and After the Cold War. *Journal of Conflict Resolution*, 44 (2), 228-249.
- Eriksson, M. & P. Wallensteen. (2004). Patterns of Major Armed Conflicts 1990-2003. In *SIPRI Yearbook 2004 Armaments, Disarmament and International Security*, pp. 132-147. Oxford: Oxford University Press.
- Fay, M. and Opal, C. (1999). Urbanization without Growth: A Not-So-Uncommon Phenomenon. *World Bank Policy Research Working Paper No. 2412*. (SSRN: <http://ssrn.com/abstract=632483>, Accessed on 02-11-2008).
- Fearon, J. D., and D. D. Laitin. (2003). Ethnicity, Insurgency, and Civil War. *American Political Science Review*, 97 (1), 75-90.
- Feitelson, E., and I. Fischhendler. (2009). Spaces of water governance: the case of Israel and her neighbors. *Annals of the Association of American Geographers* 99 (4), 728 -745.
- Food and Agriculture Organization of the United Nations Water Resources, Development and Management Service. (2001). Statistics on Water Resources by Country in FAO's

- AQUASTAT Programme. Rome: FAO (available on-line: [www.fao.org/ag/aglw/aquastat/water\\_res/index.htm](http://www.fao.org/ag/aglw/aquastat/water_res/index.htm), Accessed on 02-11-2008).
- Food and Agriculture Organization. (2003). *Review of World Water Resources by Country*. Rome: FAO.
- Furlong, K. & N. P. Gleditsch. (2003). The Boundary Dataset: Description and Discussion. *Conflict Management and Peace Science*, 20 (1), 92-117.
- Galtung, J. (1996). *Peace by Peaceful Means: Peace, Conflict, Development and Civilization*. Thousand Oaks: Sage Publications.
- Gleditsch, N. P. (1998). Armed Conflict and the Environment: A Critique of the Literature. *Journal of Peace Research*, 35 (3), 381-400.
- Gleditsch, N. P. and H. Urdal. (2002). Ecoviolence? Links between Population-Growth, Environmental Scarcity and Violent Conflict in Thomas Homer-Dixon's Work. *Journal of International Affairs*, 56 (1), 283–302.
- Gleditsch, N. P. and B. O. Sverdrup. (2002). Democracy and the Environment. In *Human Security and the Environment*, ed., M. Redclift & E. A. Page, pp. 45–70. Cheltenham: Edward Elgar.
- 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), 615–637.
- Gleditsch, N. P., T. Owen, K. Furlong and B. A. Lacina. (2004). Conflicts over Shared Rivers: Resource Wars or Fuzzy Boundaries Presented at the 45th Annual Convention of the International Studies Association, Montreal.
- Gleick, P. H. (1993). Water and Conflict: Freshwater Resources and International Security. *International Security*, 18 (1), 79-112.
- Goklany, I. (2002). Comparing twentieth century trends in US and global agricultural water and land use. *Water International*, 27(3): 321-329.
- Grossman, G. M. and A. B. Krueger. (1994). *Economic Growth and the Environment*. Working Paper No. 4634. Cambridge: National Bureau of Economic Research.
- Hauge, W. and T. Ellingsen. (1998). Beyond Environmental Scarcity: Casual Pathways to Conflict. *Journal of Peace Research*, 35 (3), 299-317.
- Hauge, W. and T. Ellingsen. (2001). Causal Pathways to Peace. In *Environmental Conflict*, eds., P. Diehl and N. P. Gleditsch, pp. 26-57. Westview Press.
- Hegre, H. and M. Austvoll Nome. (2009). Disentangling Democracy and Development as Determinants of Armed Conflict. *Typescript*, University of Oslo.

- Hegre, H., T. Ellingsen, S. Gates, and N. P. Gleditsch. (2001). Toward A Democratic Civil Peace? Democracy, Political Change, and Civil War 1816-1992. *American Political Science Review*, 95 (1), 16-33.
- Hegre, H. and N. Sambanis. (2006). Sensitivity Analysis of the Empirical Literature on Civil War Onset. *Journal of Conflict Resolution*, 50 (4), 508–535.
- Hendrix, C. S. and S. M. Glaser. (2007) Trends and Triggers: Climate, Climate Change and Civil Conflict in Sub-Saharan Africa. *Political Geography*, 26 (6), 695-715.
- Hensel, P. R., S. McLaughlin Mitchell, and T. E. Sowers II (2004). Conflict Management of Riparian Disputes: A Regional Comparison of Dispute Resolution. Paper presented at the 2004 Annual Meeting of the International Studies Association, Montreal, Canada.
- Hettige, H., Muthikumara M., and D. Wheeler. (1997). *Industrial Pollution in Economic Development: Kuznets Revisited*. Development Research Group. Washington, DC: World Bank.
- Hibbs, D. A. and O. Olsson. (2004). Geography, Biogeography, and Why Some Countries Are Rich and Others Are Poor. *Proceedings of the National Academy of Sciences*, 101, 3715-3720.
- Homer-Dixon, T. F. (1991). On the Threshold: Environmental Changes as Causes of Acute Conflict. *International Security*, 16 (2), 76-116.
- Homer-Dixon, T. F. (1994). Environmental Scarcities and Violent Conflict: Evidence from Cases. *International Security*, 19 (1), 5-40.
- Homer-Dixon, T. (1995). The Ingenuity Gap: Can Poor Countries Adapt to Resource Scarcity? *Population and Development Review*, 21 (3), 1-26.
- Homer-Dixon, T. F. (1999). *Environment, Scarcity, and Violence*. Princeton, N.J.: Princeton University Press.
- Horowitz, L. S. (2009). Environmental Violence and Crises of Legitimacy in New Caledonia. *Political Geography*, 28, 248-258.
- Jackman, R. W. (1993). *Power without Force: The Political Capacity of Nation-States*. Ann Arbor: The University of Michigan Press.
- Jagers, K. and T. R. Gurr. (1995). Tracking Democracy's Third Wave with the Polity III Data. *Journal of Peace Research*, 32 (4), 469-482.
- Jha, R., and J. Whalley. (1999). *The Environmental Regime in Developing Countries*. Working Paper No. 7305. Cambridge: National Bureau of Economic Research.
- Kaufmann, D., A. Kraay, and M. Mastruzzi. (2007). *Governance Matters VI: Governance Indicators for 1996-2006*. World Bank Policy Research Working Paper No 4280, Washington, D.C.: World Bank.

- Katz, D. L. (1998). *Water, Economic Growth, and Conflict: Three Studies*. Ph.D. Dissertation. University Of Michigan.
- Lacina, B. (2006). Explaining the Severity of Civil Wars. *Journal of Conflict Resolution*, 50 (2), 276-289.
- Lake, D. A., and M. A. Baum. (2001). The Invisible Hand of Democracy: Political Control and the Provision of Public Services. *Comparative Political Studies*, 34 (6), 587-621.
- Le Billon, P. (2001). The Political Ecology of War: Natural Resources and Armed Conflicts. *Political Geography*, 20 (5), 561-584.
- Lederer, K. and J. G. ed. (1980). *Human Needs: A Contribution to the Current Debate*. Cambridge: Oelenschlager Press.
- Lipset, S. M. (1960). *Political Man: The Social Bases of Politics*. Garden City, NY: Anchor.
- Lomborg, B. (2001a). *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge: Cambridge University Press.
- Lomborg, B. (2001b). Resource Constraints or Abundance? In *Environmental Conflict* ed., Paul Diehl and Nils Petter Gleditsch, pp. 125-154. Boulder: Westview Press.
- Lowi, M. R. (1995). *Water and Power: The Politics of a Scarce Resource in the Jordan River Basin*. Cambridge: Cambridge University Press.
- Matthew, R. A. (2000). Environment and Security in an International Context: Critiquing a Pilot Study from NATO's Committee on the Challenges of Modern Society. *Environmental Change and Security Project Report*, Issue 6, 95-8.
- Matthew, R. A., and T. Gaulin. (2001). Conflict or Cooperation? The Social and Political Impacts of Resource Scarcity on Small Island States. *Global Environmental Politics*, 12, 48-70.
- Meadows, D.H., D. Meadows, J. Randers, and W. Behrens. (1972). *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Potomac Associates.
- Midlarsky, M. I. (1998). Democracy and the Environment: An Empirical Assessment. *Journal of Peace Research*, 35 (3), 341-361.
- Midlarsky, M. I. (2001). Democracy and the Environment. In *Environmental Conflict* eds. P. F. Diehl and N. P. Gleditsch, pp. 155-178. Boulder: Westview Press.
- Miguel, E., S. Satyanath, and E. Sergenti. (2004). Economic Shocks and Civil Conflict: An Instrumental Variables Approach. *Journal of Political Economy*, 112 (4): 725-753.

- Molle, F. and P. Mollinga. (2003). Water poverty indicators: conceptual problems and policy issues. *Water Policy*, (5) 5: 529-544.
- Muller, E. N., and E. Weede. (1990). Cross-National Variation in Political Violence: A Rational Action Approach. *Journal of Conflict Resolution*, 34(4), 624-51.
- Przeworski, A., M. E. Alvarez, J. A. Cheibub, F. Limongi. (2000). *Democracy and Development: Political Institutions and Well-Being in the World, 1950-1990*. Cambridge: Cambridge University Press.
- Rock, M. T. (1998). Freshwater Use, Freshwater Scarcity, and Socioeconomic Development. *The Journal of Environment and Development*. (7) 3: 278-301.
- Sachs, J. (2005). *The End of Poverty: Economic Possibilities for Our Time*. New York: Penguin Press.
- Schwartz, D. M., T. Deligiannis, and T. F. Homer-Dixon. (2000). The Environment and Violent Conflict: A Response to Gleditsch's Critique and Some Suggestions for Future Research. *Environmental Change and Security Project Report*, Issue 6, 77-94.
- Shafik, N. and S. Bandopadhyay. (1992). *Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence*. Background Paper for the World Development Report. Washington, DC: World Bank.
- Simon, Julian. 1996. *The Ultimate Resource*, 2<sup>nd</sup> ed. Princeton: Princeton University Press.
- Thompson, W. (1996). Democracy and Peace: Putting the Cart Before the Horse? *International Organization*, 1 (50), 141-74.
- Toset, H., P. Wollebæk; N. P. Gleditsch, and H. Hegre. (2000). Shared Rivers and Interstate Conflict, *Political Geography*, 19(8), 971-996.
- Tir, J. and P. F. Diehl. (2001). Demographic Pressure and Interstate Conflict: Linking Population Growth and Density to Militarized Disputes and Wars. In *Environmental Conflict* ed., P. F. Diehl and N.P. Gleditsch, pp. 58-83. Boulder: Westview Press.
- Turner, M. D. (2004) Political Ecology and the Moral Dimensions of 'Resource Conflicts': The Case of Farmer-Herder Conflicts in the Sahel. *Political Geography* 23, 863-889.
- Uppsala Conflict Data Program (UCDP). (2008). UCDP Database: [www.ucdp.uu.se/database](http://www.ucdp.uu.se/database), Department of Peace and Conflict Research, Uppsala University. (Accessed on 12-08-2010).
- Urdal, H. (2005). People vs. Malthus: Population Pressure, Environmental Degradation, and Armed Conflict Revisited. *Journal of Peace Research*, 42(4), 417-434.
- Vanhanen, T. (2000). A New Dataset for Measuring Democracy, 1810-1998. *Journal of Peace Research*, 37(2), 251-265.

- Vasquez, J. A. (1993). *The War Puzzle*. Cambridge: Cambridge University Press.
- Wittfogel, K.A. (1957). *Oriental Despotism, a Comparative Study of Total Power*. New Haven: Yale University Press.
- White, M., Andrzejewski, K Awusabo-Asare, A Kumi-Kyereme, SW Nixon, B Buckley, S Granger, H. Reed. (2009). Urbanization and Environmental Quality: Insights from Ghana on Sustainable Policies. In *Urban Population-Environment Dynamics in the Developing World: Case Studies and Lessons Learned*, eds. A de Sherbinin, A Rahman, A Barbieri, JC Fotso, and Y Zhu, pp. 153-180. Paris:CICRED.
- Wolf, A. T. (1995). *Hydropolitics Along the Jordan River: Scarce Water and Its Impact on the Arab-Israeli Conflict*. New York: United Nations University Press.
- Wooden, A. (2002). Silent Chernobyls': Ecological Degradation, Macroeconomic Policies and Political Institutions. Ph.D. diss. Claremont Graduate University.

**Table 1: Median water availability by independent variables with 95% CI**

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**Median water availability, democracies**

**0.0041 (0.0038, 0.0055)**

**Median water availability, non-democracies**

**0.0031 (0.0029, 0.0034)**

**Median water availability, conflict cases**

**0.0032 (0.0029, 0.0036)**

**Median water availability, non-conflict cases**

**0.0038 (0.0036, 0.0042)**

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Table 2: Two Equation Base Model, 1981-2000

**Equations**

Probability of Civil Conflict\*

Variable	Coef.	S.E.	z	P> z
Political regime (Democr/Polity)	-0.056	0.156	-0.360	0.720
Log of (TIRFWR)**	0.300	0.268	1.120	0.262
Conflict in previous years	0.398***	0.026	15.420	0.000
Population	>-0.001	0.000	-0.970	0.333
Natural log of GDP per capita	-0.047*	0.025	-1.910	0.056
Productivity	<0.001*	0.000	1.940	0.053
Urbanization (lag)	-0.015**	0.007	-2.120	0.034
Rural population density (lag)	<0.001**	0.000	2.400	0.017
Constant	0.489***	0.107	4.550	0.000

Political Regime (Democr/Polity)

Civil Conflict*	-0.160**	0.067	-2.390	0.017
Log of (TIRFWR)**	0.860***	0.247	3.480	0.000
Natural log of GDP per capita	0.123***	0.008	15.680	0.000
Urbanization (lag)	-0.053***	0.005	-11.260	0.000
Urbanization square (lag)	-0.001***	0.000	-6.350	0.000
Peace years	0.007***	0.003	2.790	0.005
Constant	-0.350***	0.089	-3.920	0.000

Number of Observations: 1927	RMSE	chi2	P
Equation 1	0.376	674.950	0.000
Equation 2	0.374	1488.450	0.000

\* Civil Conflict includes intrastate & internationalized intrastate conflicts

\*\* Log of Total Internal Renewable Fresh Water Resources

Significance Levels: \* 0.10, \*\* 0.05, \*\*\*0.001

Table 3: Two Equation Model, Conflict and Political Regime, 1981-2000

Equations	Variable	Coef.	S.E.	z	P> z
Probability of Civil Conflict*	Political regime (Democr/Polity)	0.105	0.232	0.45	0.65
	Log of (TIRFWR)**	3.512***	1.082	3.24	0.001
	Democ*TIRFWR	-5.748***	2.082	-2.76	0.006
	Conflict in previous years	0.389***	0.028	13.98	0
	Population	<0.001*	0.000	-1.79	0.074
	Natural log of GDP per capita	-0.075**	0.037	-2.04	0.041
	Productivity	<0.001*	0.000	1.96	0.05
	Urbanization (lag)	-0.021***	0.007	-3.05	0.002
	Rural population density (lag)	<0.001***	0.000	2.85	0.004
	Constant	0.641***	0.160	4.02	0
	Political Regime (Democr/Polity)	Civil Conflict*	-0.212***	0.068	-3.11
Log of (TIRFWR)**		0.830***	0.255	3.25	0.001
Natural log of GDP per capita		0.118***	0.008	14.5	0
Urbanization (lag)		-0.053***	0.005	-10.99	0
Urbanization square (lag)		<0.001***	0.000	-5.73	0
Peace years		0.009***	0.003	3.48	0
Constant		-0.305***	0.092	-3.33	0.001
Number of Observations: 1927		RMSE	chi2	P	
Equation 1	0.38	771.38	0.000		
Equation 2	0.38	1441.97	0.000		

\* Civil Conflict includes intrastate & internationalized intrastate conflicts

\*\* Log of Total Internal Renewable Fresh Water Resources

Significance Levels: \* 0.10, \*\* 0.05, \*\*\*0.001

## APPENDIX I:

### 3SLS Renewable Fresh Water Resources, Conflict, Political Regime, 1981-2000

Variable	Coefficient	Std. Error	z	P> z
Log of Total Internal Renewable Fresh Water Resources				
Political regime	0.013***	0.002	5.280	0.000
Internationalized intrastate conflict	-0.007**	0.003	-2.190	0.029
Average precipitation	<0.001***	0.000	18.220	0.000
Productivity index	<-0.001*	0.000	-1.660	0.098
Dependency ratio	<0.001	0.000	0.380	0.706
Constant	-0.007***	0.002	-3.230	0.001
<b>Probability of Internationalized Intrastate Conflict</b>				
Political regime	-0.798***	0.195	-4.090	0.000
Log of Total Internal Renewable Fresh Water Resources	6.200***	1.071	5.790	0.000
Population	<0.001***	0.000	2.650	0.008
Conflict in previous years	0.381***	0.030	12.720	0.000
Rural population density (lag)	<0.001	0.000	1.030	0.301
Urbanization (lag)	-0.039***	0.009	-4.420	0.000
Natural log of GDP per capita	0.067**	0.031	2.160	0.031
Productivity	<0.001**	0.000	2.250	0.025
Constant	-0.110	0.156	-0.710	0.480
<b>Political regime</b>				
Internationalized intrastate conflict	0.081	0.062	1.310	0.189
Log of Total Internal Renewable Fresh Water Resources	5.29***	0.526	10.060	0.000
Natural log of GDP per capita	0.140***	0.008	18.530	0.000
Urbanization (lag)	-0.040***	0.004	-9.080	0.000
Urbanization square (lag)	-<0.001***	0.000	-3.220	0.001
Peace years	0.013***	0.002	5.980	0.000
Constant	-0.701***	0.084	-8.330	0.000
# Observations: 1907				
	RMSE	chi2	P	
Equation 1	0.033	445.420	0.000	
Equation 2	0.505	501.490	0.000	
Equation 3	0.403	1453.880	0.000	

## APPENDIX II:

### Countries Included in the Analysis

Algeria	Haiti	Philippines
Angola	Honduras	Poland
Argentina	Hungary	Portugal
Australia	India	Romania
Austria	Indonesia	Rwanda
Bahrain	Iran	Saudi Arabia
Bangladesh	Israel	Senegal
Belgium	Italy	Sierra Leone
Benin	Ivory Coast	South Africa
Bolivia	Jamaica	South Korea
Botswana	Japan	Spain
Brazil	Jordan	Sri Lanka
Burkina Faso	Kenya	Sudan
Burundi	Kuwait	Suriname
Cameroon	Madagascar	Swaziland
Canada	Malawi	Switzerland
Chad	Malaysia	Syria
Chile	Mali	Tanzania
Colombia	Malta	Thailand
Congo	Mauritius	Togo
Costa Rica	Mexico	Trinidad and Tobago
Cyprus	Morocco	Tunisia
Denmark	Myanmar	Turkey
Ecuador	Nepal	Uganda
Egypt	Netherlands	United Kingdom
El Salvador	New Zealand	United States of America
Ethiopia	Nicaragua	Uruguay
Fiji	Nigeria	Venezuela
Finland	Pakistan	Zambia
France	Panama	Zimbabwe
Gabon	Paraguay	
Gambia	Peru	
German Federal Republic		
Ghana		
Greece		
Guatemala		

### APPENDIX III:

Summary of Included Variables		
Variable:	Measurement:	Source:
Water availability	Internally renewable freshwater resources per capita (TIRFWR)	FAO, Aquastat
Political regime	Dummy Variable (0/1), based on Polity index	Jagers and Gurr, 1995
	Vanhanen Index	Vanhanen, 2000
Intrastate Conflict & Internationalized Intrastate Conflict	> 25 battle-related deaths per year	UCDP, 2008
Annual Precipitation	$Km^3$	FAO, Aquastat
Dependency ratio	$IRWR/(IRWR+IWR) \times 100 \%$	FAO, Aquastat
Urbanization	% of total population that lives in urban centers	World Bank Development Indicators
Agricultural Productivity	Ratio of crop production Index over percentage of irrigated land (CPI/%irrigated land)	World Bank Development Indicators/FAO
Development	GDP per capita	World Bank Development
Rural population density		World Bank Development
Population	Total Population	World Bank Development
Previous Conflict history	1 if a country has experienced conflict in the period 1970-1980/0 otherwise	UCDP, 2008
Peace Years	#of consecutive years since the 1980	Calculated based on UCDP, 2008

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<sup>ii</sup> Further distinction in regime types than degree of democracy can also matter, but the lack of systematic data means that these are better addressed through case studies, see Chatrchyan and Wooden (2005) on hybrid regimes, consolidated (and unconsolidated) democracies and environmental policy reform.

<sup>iii</sup> Although we use both intrastate and internationalized intrastate conflicts in our analysis, for simplification purposes we will use the terms intrastate and civil conflict instead.

<sup>iv</sup> We converted irregular polity scores (e.g. values of -77, -88, -60) to -10 for the empirical analysis.