ABSTRACT

Title of Document: WATER RESOURCES, INSTITUTIONAL CAPACITY AND CIVIL CONFLICT IN SUB-SAHARAN AFRICA

Wanda J. Haxton, PhD, 2009

Directed By: Professor, George Quester, Department of Government and Politics

Case studies where both scarcity and conflict are present have dominated research on the nexus between environmental scarcity and conflict. This dissertation offers a quantitative analysis of the effect changes in water resources have on domestic conflict in 42 Sub-Saharan African nations which differ across the dependent variable, domestic conflict, and which vary across the explanatory environmental variables. This research advances the discussion of the causal effects of environmental scarcity and degradation on domestic conflict in four ways. It grounds the domestic conflict-environmental degradation discussion in the civil and social conflict literature; research on environmental security concludes that environmental change is most likely to play a role in domestic conflicts but research on domestic conflict typically does not include environmental variables. This quantitative study addresses a methodological

shortcoming of earlier research, limited variation across the variable measuring water resource availability, by testing an alternative means of operationalizing water resources using annual precipitation data weighted by land area and population and weighted by land area and gross national product. This study introduces additional variation on the dependent variable and compares the results of a dichotomous variable with the results of a dependent variable with categorical coding based on the States in Armed Conflict Database. This research extends the scope of explanatory variables to include indicators for political institutions and their capacity to manage the water resources within their national boundaries.

The findings support and extend previous conclusions that water resources contribute to civil conflict and demonstrate that the use of precipitation data weighted by land area and population, a variable with variation, is a correlate for water resource availability, a static variable; and thereby providing results that are more reliable. This correlate advances the environment-conflict discourse by more directly linking the data that describes the natural world to the social changes to which those natural phenomenon are purported to relate. This study also finds that institutional capacity to manage water resources creates opportunities for rent-seeking but that open political institutions mediate between water resources and conflict.

WATER RESOURCES, INSTITUTIONAL CAPACITY AND CIVIL CONFLICT IN SUB-SAHARAN AFRICA

By

Wanda Jeanne Haxton

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Advisory Committee:
Professor George Quester, Chair
Soo Yeon Kim, Co-Chair
Ken Conca
Virginia Haufler
Steve Fetter

Dedication

for the women who have inspired and nurtured
an independent spirit
a thirst for knowledge
passion for Africa
compassion for the disaffected
and unrelenting determination to endure
when the only way around is through
Oleava Haxton
Martha Kay Robinson
Elissa Barmack
Mary Vanderlaan
Lynn Ellen Dickey

and for
providing support and encouragement
while running this marathon
and pursuing faint fuzzies, celestial and statistical
Carl Koch

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Chapter 1: The Research Question and Why It Is Important

Introduction

African nations lack generally accepted institutional norms for either the distribution of state goods and services or executive transfer. Sub-Saharan Africa consistently ranks at or near the bottom in comparisons with other world regions and Sub-Saharan African nations frequently occupy the bottom-most places in many measures of social well-being. Regardless of the measure of human development, Sub-Saharan African nations occupy those positions representing the lowest end of the measurement scale. Each of these factors, institutional norms for the distribution of state goods and services and for or executive transfer, measures of social well-being, and measure of human development, is associated with increased likelihood of civil conflict.

Many African nations are among the least developed nations in the world; none is an industrialized nation, and development in Sub-Saharan Africa, whether measured by changes in social conditions, economic performance or political conditions, consistently lags behind other geopolitical regions. Civil conflicts have occurred with remarkable frequency in Sub-Saharan Africa. Case studies where both scarcity and conflict are present have dominated research on the nexus between environmental scarcity and conflict, yet scholars of conflict have produced very few longitudinal, large-N studies of intrastate conflict focusing on regional differences and even fewer have looked specifically at Africa. Those that have considered Africa did not include the range of political, economic, and social variables that prior studies have shown to be effective predictors of conflict and have not considered environmental variables at all.

This dissertation offers a quantitative analysis of the effect changes in water resources have on domestic conflict in 42 Sub-Saharan African nations which differ across the dependent variable, domestic conflict, and which vary across the explanatory environmental variables. This research advances the discussion of the causal effects of environmental scarcity and degradation on domestic conflict in four ways. It grounds the domestic conflict-environmental degradation discussion in the civil and social conflict literature; research on environmental security concludes that environmental change is most likely to play a role in domestic conflicts but research on domestic conflict typically does not include environmental variables. This quantitative study addresses a methodological shortcoming of earlier research, limited variation across the variable measuring water resource availability, by testing an alternative means of operationalizing water resources using annual precipitation data weighted by land area and population. This study introduces additional variation on the dependent variable and compares the results of a dichotomous variable with the results of a dependent variable with categorical coding based on the States in Armed Conflict Database. This research extends the scope of explanatory variables to include indicators for political institutions and their capacity to manage the water resources within their national boundaries.

Depravation and grievance were the basis for the first quantitative studies on environmental resources and conflict; these works began with *a priori* assumptions that the independent variable of interest was resource scarcity. Studies since then have challenged these findings and put forth an alternate claim that the variable of interest is not scarce natural resources but an abundance of natural resources. However, the two groups of researchers have operationalized the environment in significantly different

ways. The grievance work is based on a conception of environment taken from the environmental community, one in which natural resources are communal and not easily exploitable. The greed work conceives of the environment as an economic good or a marketable product, items extracted from the earth that have value in the marketplace such as diamonds, oil, and timber. This study will attempt to reconcile those differences by asking three broad questions: Do environmental variables enhance our understanding of civil conflict in Sub-Saharan Africa? Under what circumstances? And, by what means?

The evidence of a connection between the environment and conflict is not well-established; hence the first question is necessary to confirm that the alleged causal relationship is present in the assembled data for Sub-Saharan Africa. The initial piece to the puzzle is to ascertain whether the addition of any of the measures of environmental change produce a better-fitting model and then to refine that piece by exploring whether the connection between environment and conflict in Sub-Saharan Africa exists for scarcity alone, abundance alone, or both together. Having established that environmental change matters in Sub-Saharan African civil conflicts, the study next turns to solve the puzzle by questioning the circumstances under which these changes matter, looking specifically at levels of conflict, thresholds of scarcity and a difference between Cold War and the Post Cold War periods. Finally, this study will take a closer look at the manner in which political systems and ecosystems interact to cause domestic conflict in Sub-Saharan Africa through a close examination of institutional actors that mediate between environmental change and civil conflict in Sub-Saharan Africa.

Water resource availability has a discernable causal effect on civil conflict in Sub-Saharan Africa but the direction of the relationship was counter to expectations; increased water availability is associated with increased conflict, not less as expected. These findings are counterintuitive because they support a mobilization-based conflict theory rather than supporting a grievance-based theory of conflict. Increased water resource availability reduces opportunity costs of the would-be rebel to participating in violence against the state by creating conditions of a surplus labor force in search of a source of income.

This study found that water resources affecting the incidence of higher-level conflics by looking at a 35-year time span we learn that it is sufficient or abundant water resource availability, rather than scarce resources that affects the likelihood of conflict and that environmental change, and specifically changes in per capita water resource availability have only a very small explanatory power on low-level conflict over the longer time frame. The results of this study cannot confirm the hypothesis that scarcity must reach a threshold before increasing the probability of conflict but do find that abundance reduces the likelihood of conflict. While natural and physical scientists have concluded that humans are fundamentally altering the earth's biological and geophysical systems beyond the thresholds within which these systems can readily adapt, this study concludes that water resources have not yet reached a level of scarcity across enough of the continent sufficient to be detected above the existing long-term variation.

This study concludes that institutional capacity alone, be it the capacity to manage water resources or maintaining a political system that is open to the participation of all of society, has a strong influence on the likelihood of conflict. While a political system that

allows for the chief executive to be selected openly and from a wide section of society reduces the likelihood of conflict, the capacity to manage irrigated cropland indicates an increased likelihood of conflict as the benefits of this more productive land are directed to a narrow segment of society.

The indirect mechanisms explored as mediators between the environment and conflict also provided weak evidence to suggest that institutions mediate between water resources and conflict. There was no evidence that environmental stressors such as drought or floods exacerbate existing political weaknesses, Nor was there evidence that the extent to which individuals in society are able to express options without fear of interference by the government has any effect on the relationship between water resources and conflict or that open political institutions mediate the effect of precipitation by increasing the opportunity cost of engaging in violent action against the state. The contradictory findings between the effect of irrigated agriculture on the one hand and civil liberties and executive recruitment on the other provide evidence that the relationship between water resources, and the environment more generally, institutional capacity and civil conflict are complex.

Studies of the environment conflict interrelationship have not succeeded in specifying well the manner in which the environment matters to civil conflict in Sub-Saharan Africa. The findings of this study provide additional insights into the mechanisms by which environmental change, and water resources in particular, affects the likelihood of conflict. It has concluded that water resource availability has a discernable causal effect on civil conflict in Sub-Saharan Africa and that increasing amounts of precipitation are associated with an increased likelihood of conflict

preferencing a mobilization-based theory of conflict over a grievance-based theory of conflict. Finally, these results indicate that nations that are able to establish, implement, and enforce political and economic policies such as those to control or direct economic growth, reduce poverty, and adapt to changing water resource availability are less likely to experience conflict.

The Puzzle

African nations lack generally accepted institutional norms for either the distribution of state goods and services or executive transfer. Sub-Saharan Africa consistently ranks at or near the bottom in comparisons with other world regions and Sub-Saharan African nations frequently occupy the bottom-most places in many measures of social well-being. Regardless of the measure of human development, Sub-Saharan African nations occupy those positions representing the lowest end of the measurement scale. Each of these factors, institutional norms for the distribution of state goods and services and for or executive transfer, measures of social well-being, and measure of human development, is associated with increased likelihood of civil conflict and will be examined in more detail below. Furthermore, this detailed exposition will reveal the need for a closer examination of the factors of conflict specific to Sub-Saharan Africa.

Many African nations are among the least developed nations in the world; none is an industrialized nation, and development in Sub-Saharan Africa, whether measured by changes in social conditions, economic performance or political conditions, consistently lags behind other geopolitical regions. Civil conflicts have occurred with remarkable frequency in Sub-Saharan Africa, yet scholars of conflict have produced very few

longitudinal, large-N studies of intrastate conflict focusing on regional differences and even fewer have looked specifically at Africa. Those that have considered Africa did not include the range of political, economic, and social variables that prior studies have shown to be effective predictors of conflict and have not considered environmental variables at all.

Natural and physical scientists have concluded that humans are fundamentally altering the earth's biological and geophysical systems beyond the thresholds within which these systems can readily adapt (Turner et al. 1990, Intergovernmental Panel on Climate Change 2007b, National Academy of Science 2001). Social scientists suggest that these changes have the potential to lead to economic decline, social instability, and conflict (Gleditsch 1998, Homer-Dixon 1994, Intergovernmental Panel on Climate Change 1998). The prevalence of intrastate conflict world-wide rose throughout the Cold War then declined during the Post-Cold War years. Intrastate conflict in Africa has mirrored the global pattern however, it has declined much more slowly in Sub-Saharan Africa than across the balance of the globe. Conflict on the continent accounted for approximately one third of all intrastate conflicts in 1990, by 2000 Africa was the location of approximately half of global intrastate conflicts, and by 2005 approximately two thirds of global intrastate conflicts occurred on the African continent (Marshall and Gurr 2005).

Choucri and North (1975) and Timberlake and Tinker (1985), the earliest researchers to consider environmental change as a cause of conflict, suggested a causal trail leading from the destruction of environmental resources disrupting economic and social systems to political unrest, environmental refugees, internal migration to urban

centers, fighting between nomads and farmers, guerrilla movements, and revolutions. The cumulative evidence suggests that the link between domestic conflict and ecological scarcity is detectable but weak (Hauge and Ellingsen 1998, Homer-Dixon 1999, Ross 2004, Kahl 2006). Researchers have provided little evidence beyond educated speculation that environmental changes could lead to more conflict in the future. Combined, these provide both a sufficient basis as well as a compelling need for additional research on the complex nature of the interrelationship between environmental change and domestic conflict.

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This study is organized as follows. The remainder of Chapter 1 sets forth the case for focusing the research on Sub-Saharan Africa. Chapter 2 presents a review of the existing discourses on civil conflict, and environment and conflict; it concludes with an assessment of gaps in knowledge and the questions that this study will raise to fill those gaps. Chapter 3 lays out methodology, including variables and tests, that will employed to answer the raised questions. Chapter 4 presents the results of the statistical models and discusses the implications of the results and the extent to which those findings confirm or fail to confirm the stated hypotheses. Chapter 5 draws conclusions based on the findings and discussion thereof as well as notes opportunities for further research.

Why Sub-Saharan Africa?

Civil conflicts have occurred and continue to occur throughout the world. Some may be more violent, civil wars in El Salvador between 1979 and 1990 and in the Balkans between 1991 and 2001 can be characterized by their brutality. There are conflicts that have endured longer than some African nations have existed as independent states; Northern Ireland is one example. Many African nations are among the least developed nations in the world and none is an industrialized nation. Development in Sub-Saharan Africa, whether measured by changes in social conditions, economic performance or political conditions, consistently lags behind other geopolitical regions. This development policy can be partly attributed to past conflicts, which have hindered states from developing as leaders have used state funds for security rather than social needs such as education, medical clinics, or agricultural development (Ayittey 1999, Henderson 2000).

Sub-Saharan Africa comprises the 42 nations located south of the Sahara Desert on the continental land mass and seven island nations. While frequently referred to as a group, implying homogeneity, each nation has a unique political system, a unique economy, and very different natural resource endowments. The Democratic Republic of Congo (Zaire) harbored one of the world's notorious kleptocrats yet Botswana has been a strongly democratic nation since its independence in 1966. Ghana has embraced structural adjustment policies with a great deal of success yet the same types of externally imposed policies failed in Zambia. Nonetheless, African nations share important commonalities.

Civil conflicts have occurred with remarkable frequency in Sub-Saharan Africa, yet scholars of conflict have produced very few longitudinal, large-N studies of intrastate conflict focusing on regional differences (Henderson 2000, Hegre et al. 1997, Henderson and Singer 2000) and even fewer have looked specifically at Africa. Those that have considered Africa (Collier and Hoeffler 1998) did not include a full complement of political, economic, and social variables, let alone environmental variables.

African nations lack generally accepted institutional norms for either the distribution of state goods and services or executive transfer. The SIPRI Yearbook in 1999 identified Africa as the only region in the world where armed conflict is on the rise (cited in Collier and Hoeffler, 2002). While Collier and Hoeffler found no difference in the incidence of conflict between Africa and the rest of the world over the entire period of their study, 1965-1999, the patterns among the independent variables for African nations were substantially different from the rest of the world. Average per capita income and average annual growth in GDP were significantly lower in African nations than in non-African nations; African nations are more heterogeneous than non-African nations. These differences helped to explain why, during the Post-Cold War era, the incidence of conflict within African states has been greater than intrastate conflict in the rest of the world (Marshall and Gurr 2005).

Conflict since Independence

Those looking at Sub-Saharan African nations from the outside perceive them to be subject to frequent internal conflicts. This perception has been a part of the western world's impression of the continent since its first encounters with altercations between historical kingdoms and continued through resistance to colonial rule; struggles,

occasionally armed and occasionally protracted, for independence; frequent coups and civil conflict (Reader 1997, Thomson 2000).

A burial ground in Sudan is the location of one of the earliest sites with evidence of conflict in the world and dates to 14,000 to 12,000 years ago. The location of flints, the direction of the arrowheads, and size of skeletal remains substantiate conclusions that the deaths were violent and without regard for sex or age (Reader 1997). Several West African empires thrived during the medieval period in Europe, including the Ghana Empire, the Mali Empire and the Songhai Empire. These great African empires rose by conquering neighboring tribes and controlling trade in resources such as gold and salt, each subsequently fell when others, in turn, conquered them to control the flow of trade and the wealth that could thereby be gained (Jackson 1993).

African tribes continued their opposition to and defiance of external rule throughout the colonial period. To illustrate: Khosians mounted armed resistance to early Dutch settlers in the last quarter of the Eighteenth Century and Xhosa rebelled against British settlers in the early Nineteenth Century. The Maji-Maji rebellion erupted in German East Africa in 1905 when African laborers received only a fraction of promised wages for laboring in cotton fields (Tordoff 2002).

Several African nations also engaged in protracted and violent conflict to gain independence. Three Portuguese colonies, Angola, Guinea-Bissau and Mozambique, all mounted armed rebellions against the Salazar regime beginning in 1961, 1963 and 1964, respectively; the struggles for independence continued through 1974 in Angola and Guinea-Bissau and continued through 1975 in Mozambique. Independence in Angola and Mozambique was quickly followed by protracted civil wars among Marxist-leaning

and non-Marxist oriented factions that had fought for independence with each group supported by the respective superpower.

Since 1980, three quarters of the continent's nations have experienced armed conflict. In 2000, two thirds of the people worldwide who died as a direct result of armed conflict were in Africa. Between 1960 and 2006 African nations experienced 85 coups d'état, 129 attempted but failed coups and 102 reported coup plots. These have been widely experienced; thirty states have had at least one successful coup and eighteen have experienced more than one. Only nine states have seen no attempted or successful episodes of military intervention and three of those have achieved independence only since 1990. Frequently cited causes include perceived inequities among societal groups as a result of state-building and economic development activities (Henderson 1998) and the prospect of engaging in rent seeking behavior (Bayart in McGowan 2003).

Cultural difference is a common causal variable in numerous studies of African conflict. It is grounded in common values and behaviors, often rooted in the religion, customs, or ideology that a group shares as part of its collective identity. In Africa, that collective identity is typically linked to ethnicity or tribal origin.[1] These cultural factors

[1] Nomenclature for African identity groups is problematic in a context where the nation-state is the standard reference point. "Tribe" is a term based in colonialism and carries with it the negative connotation of a backward, traditional, and rural society. Ethnicity has become more widely used in the post-colonial period and, although initially associated with modern and urban identities, has come to refer to collective identity relationships more broadly. Connotations notwithstanding, both terms refer to the same concept: the culture as a whole, including a shared language, history, geography, and demography. In the Western context, the terms nation and state generally, although not universally, connote that meaning well; the same does not hold true on a continent where states are artificially imposed constructs with little or no relation to groupings of people who share a common language, history, territory or identity.

interact with other social, political and economic factors in myriad ways to contribute to conflicts (Henderson 1998 and Mkandawire 2002).

Resources have been a factor in conflicts from time immemorial; they are no less important to African conflicts in the late twentieth century and their influence on these conflicts takes many different forms (Gleick 1993b and 2003). European nations colonized the African continent in a quest to control access to its many natural resources, which fueled industrial expansion in both Europe and the Americas. African natural resources have played an important part in the tremendous industrialization and growth in the western world since then, including timber from the rainforests of western Africa, metals and ores from central and southern African nations, and more recently oil from Nigeria. These resources have also contributed to conflicts that have arisen within nations both as conflicts over control of the resources themselves and as conflicts that have arisen because the revenues from the sale of those resources have been unevenly redistributed within the nation. Prominent examples of the former include Sierra Leone, Liberia, Nigeria, and Democratic Republic of the Congo while Nigeria is the preeminent example of the latter. Access to water is increasingly a common source of tension among groups in African societies, particularly between nomadic herders and farmers. In a recent incident, farmers and herders in Kenya fought over access to water during a period of drought when farmers allegedly diverted water for irrigation, reducing the quantity available for nomadic herds (BBC News, 2005; The East African Standard, 2005; UN Integrated Regional Information Networks, 2005).

Regardless of the causal path, conflict in Africa is about control of governmental power and finances, which are used to support an extensive patronage system (Adedeji

1999). Africans have a deeply rooted cultural norm of relying upon the extended family in times of need and providing aid in times of surplus. This norm may work adequately in a local setting, but it dies not well to an increasingly urbanized and diverse environment of national and more recently international political realms.[2] The subsistence societies of Sub-Saharan Africa commonly practice mutual assistance: I help my brother's family today because tomorrow my crop may fail and I will be in need of help myself. When this expectation of mutual assistance is taken to the extreme, however, a member of the family who has great success in an urban center also finds that the extended rural family continues to grow and with it continued expectations to support even more family members.

This model of family relations carries over to the political sphere in the form of patronage. Governments, through licensing, contracts, and, in states where industries were nationalized, parastatal organizations, controlled access to these economic inputs necessary for entrepreneurial development by dispensing them to loyal supporters.[3] Patronage systems evolved, often along ethnic lines, as the means by which those in control of government resources disburse them. Because patronage systems are, by nature, inequitable, the disenfranchised may resort to violence to demand a more equitable redistribution of government resources.

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[2] The effect is not unlike that of a mega-jackpot lottery winner. Once a winner's identity becomes public, family and friends, known intimately or only distantly, appear with requests for assistance based on the assumption that the most fortunate of the family have an obligation to share their wealth with their kinsman.

[3] Loyal supporters, loosely defined, may include those in a recognized patron-client relationship; they may also include those who present a government official with an acceptable additional payment for the desired service, essentially a bribe.

The African colonial experience was not a model in democratic norms that, once independent, political leaders could emulate, and, as a result, African states had no experience in an orderly and peaceful change in governments. Military coups or civil strife rather than democratic elections were the dominant means of political succession for much of the period under study. While the fractionalization in African societies generally occurs along ethnopolitical lines, the root causes are not generally based in ethnic differences, rather, ethnic identity is a common bond around which organizers are able to mobilize groups to demand redress of grievances. By better understanding the nature of conflict on the continent scholars will provide policy-makers with better tools to prevent or resolve African conflicts. The following discussion provides details on a wide range of indicators, both as background and to set the context for focusing on Sub-Saharan Africa. As will be discussed in later chapters, many of these same indicators have been shown to be indicators of civil conflict.

Social Indicators

Sub-Saharan Africa, as a region, consistently ranks at or near the bottom in comparisons with other world regions on indicators of social well-being and human development. Furthermore, Sub-Saharan African nations frequently occupy the bottom-most places in comparison with other nations on these same measures of social well-being and human development. The discussion here highlights indicators for food production, health, demography and education.

Food Production

Despite crop, food, and cereal production index increases consistent with world increases, African agricultural productivity decreased from $419 (1979-1981) to $360

(2000-2002), measured as value added per worker in 1995 $US. Food production has increased since 1960 but not as rapidly as other regions of the world. Between 1980 and 2000, per capita food production grew by 2.3% annually in Asia and 0.9% in Latin America. During the same time period food production in Sub-Saharan Africa declined by 0.01% per year. Despite increasing volume in food production, African nations are failing to keep up with population pressures and, as a result per capita food production is declining. (United Nations Development Program 2006)

Disease

Sub-Saharan Africa is home to approximately 10% of the world's population but over two thirds of the world's people living with HIV reside here. Approximately 26 million Africans are infected with HIV/Aids, 7.2% of the adult population (UNAIDS 2007). Even the success stories of Kenya, Côte d'Ivoire, and Zimbabwe, where adult prevalence is declining, fail to provide much to celebrate. While prevalence is declining, these nations still have significant proportions of the population infected and Zimbabwe's infection levels are among the highest in the world. South Africa has more people living with HIV than any other in the world and only about 15% of the 5.5 million affected receive antiretroviral drugs.

Malaria is endemic to 46 countries on the African continent, only Lesotho is malaria-free. Approximately 60% of the world's malaria cases and over 90% of the deaths attributable to malaria occur in Africa, virtually all in Sub-Saharan Africa. Children under 5 years of age account for three-quarters of those deaths and malaria was the principle cause of nearly 20% of all deaths in children under 5 years of age (World Health Organization 2006). Malaria is estimated to cost Sub-Saharan African businesses

0.6 percent of gross domestic product according to a 2006 survey by the World Health Forum (US Department of State 2006).

Demography

Sub-Saharan Africa has the highest infant mortality rate in the world at 103 deaths per live 1000 births and has reduced infant mortality the least between 1970 and 2004. Other regions have succeeded in reducing this important measure of well-being by half or more whereas the Sub-Saharan African decline is less than 30 percent. Some nations, including Burkina Faso, Mozambique, Guinea, Malawi, Gambia, and Senegal, have made great strides and reduced infant mortality by 40-50 percent. Others have made very little progress; during the same nearly thirty-year period infant mortality rates fell less than 15 percent in Botswana and Angola and less than 10 percent in Zambia, Zimbabwe, and Rwanda (World Bank 2004).

Life expectancy in Sub-Saharan Africa is similarly far lower than the rest of the world. Between 1970 and 2004 life expectancy on the continent increased by approximately 4 months from 45.8 to 46.1 years. In contrast, life expectancy worldwide has increased by 7 years and other regions with a large proportion of low- and middle-income countries have each seen life expectancy increase by about 10 years. There is, however, great disparity among the individual countries. Several nations have seen life expectancy fall precipitously, 20 years in Botswana, 18 years in Zimbabwe, 17 years in Swaziland, and 13 years in Zambia, in part due to their high incidence of AIDS. Other nations have made great progress in extending life expectancy despite AIDS; the Gambia, Senegal and Guinea have all raised life expectancy by 15-17 years. In addition, the five nations with the lowest ranks on the 2004 Human Development Index, Guinea-Bissau,

Burkina Faso, Mali, Sierra Leone and Niger, all experienced modest increases in life expectancy during this period ranging from 3.5 to 10 years (United Nations Development Program 2006).

Population growth rates in Africa are among the highest in the world. While other world regions have seen their growth rates slow, Africa, as a whole, has not had the same experience. Growth rates for Sub-Saharan Africa climbed from a range around 2.5% per year continent-wide in the 1960's as most nations were gaining independence to peak at over 3.0% per year in the early 1980s. The Sub Saharan annual population growth rate for the two decades 1975-2004 was 2.7% per year and is projected to be 2.2% per year for the subsequent decade, a rate that is faster than other parts of the world and faster than the world as a whole. Only the Arab states have comparable growth rates. Both HIV and civil conflicts have contributed to a slowing of these rates more recently. Of the nations noted in the discussion above on HIV, South Africa saw an annual 2.1% growth rate between 1975 and 2004 but is expected to experience only 0.1% growth annually from 2004-2015. Côte d'Ivoire is projected to see its 3.4% growth rate cut in half to 1.7% and Zimbabwe is projected to see its population growth rate drop from 2.5% to 0.6%. Of the nations with high HIV rates, only Kenya is not projected to experience a dramatic reduction in its population growth rate, although it is projected to drop from 3.1% to 2.5%. A few nations are even projected to see negative growth rates: Botswana (-0.4%), Swaziland (-0.4%), and Lesotho (-0.3%). A few Sub-Saharan nations will see their populations grow faster than their historic rates: Burundi at 3.4 percent compared with a historic rate on 2.4 percent and Eritrea at 2.9 percent compared to a historic rate of 2.4 percent (United Nations Development Program 2006).

Education

Literacy rates have risen throughout the world, but African literacy rates have risen more slowly than other regions. Between 1990 and 2004, adult literacy has increased by 7.8 percentage points in Africa, from 55.5% in 1990 to 63.3% in 2004, while other world regions have experienced increases of 11-20 percentage points. South Asia's literacy rate of 60.9% remains lower than Sub-Saharan Africa's, but South Asia's rate of increase is about 50% greater than Sub-Saharan Africa's and is expected to soon surpass Sub-Saharan Africa, leaving Sub-Saharan Africa at the bottom of the list. As with other social indicators, there are differences within the continent. Equatorial Guinea, South Africa, Namibia, and Lesotho all have adult literacy rates of greater than 80%; at the other extreme, there are 10 nations with adult literacy rates less than 50%, the least literate being Mali at 19.0%. Sudan, Mauritania, Democratic Republic of the Congo, and the Central African Republic all experienced literacy rate gains of 15 percentage points or greater and Burundi experienced a 22.2 percentage point increase. Meanwhile Chad, Ghana and Zambia all experienced losses of -2.0, -0.6 and -0.4 percentage points, respectively (United Nations Development Program 2006).

Sanitation

As a whole, Sub-Saharan Africa made little progress between 1990 and 2004 in providing its population with access to an improved water source. Only 8% more people had access to safe drinking water at the end of that 14-year period than at the beginning. As the continent started the 21st century, a little more than half of the population had access to an improved water source. All other regions of the less developed world report providing a greater proportion of their population with safe drinking water; the next

lowest proportion is East Asia and the Pacific at 79% in 2004. Access to improved sanitation is even lower across the developing world. Sub-Saharan Africa and South Asia both stand at 37% of the population with access to improved sanitation; however, Sub-Saharan Africa made far less progress in bringing sanitation to its population. In the years between 1990 and 2004, it increased the proportion of the population with access to this necessity by only 5% while South Asia improved by 19%, more than doubling the proportion of its population with access to improved sanitation (United Nations Development Program 2006).

Some of the social indicators discussed above have been directly linked to conflict and many others interact with additional factors to contribute to civil conflict; those linkages will be addressed in detail in the next chapter. Regardless of the measure of human development, this discussion has demonstrated that Sub-Saharan African nations have the ignoble honor of occupying, indeed nearly monopolizing, those positions representing the lowest end of the measurement scale. For these reasons, a closer examination of the factors of conflict specific to Sub-Saharan Africa is warranted.

Political Stability and Capacity to Govern

Polity scores are an indicator of a nation's stability and its ability to exercise the authority inherent in its recognition as a sovereign nation. In 1980, the approximate midpoint between independence and 2000, the terminal year of this study, only three Sub-Saharan African nations scored in the top third of the 21-point Polity scale[4] whereas 30 scored in the bottom third; by 2000 only two nations scored in the top third of the

[4] All references to Polity in this document are based on the Polity IV version 2000 data. set.

scale and only two scored in the bottom third of that scale, indicating improvement from those states on the authoritarian end of the scale but also indicating some backsliding by some states on the democratic end of the scale.

African states are qualitatively different from the Westphalian assumptions about what constitutes a modern, sovereign state (Jackson 1990); they lack the internal legitimacy and the institutions necessary to exercise their claimed authority to regulate the use of natural resources within their territory. African states, in general, are not truly sovereign according to Jackson's argument, yet "…modern states claim sovereignty over land and natural resources within their territorial boundaries and thus sole authority to regulate their use" (Neumann 2005, 121).

Their legitimacy is conferred by external others, including states and international organizations such as the UN, rather than derived internally from the capacity to exercise fundamental state privileges such as exercising control over territory and defending the state against aggression. New states admitted into the international order as quasi-states ultimately "…would have to make good on their claims to sovereignty, through the development of effective domestic economies and political institutionalism or else the inadequacies of their statehood would be revealed" (Clapham 1998, 146). Sub-Saharan African nations and their leaders generally emerged at independence with popular support internally and expectations, both internally and externally, that they would translate their status as quasi-states into fully sovereign nations and members of the international political system. That initial, popular support quickly eroded when leaders took paths of political development that included favoritism, corruption, and dictatorship. Challenges to the state resulted from unfulfilled expectations for unfettered political

participation among or between interest groups or ethnic groups hitherto repressed or favored by colonial rulers, each expecting to advance or protect its sectional claims and concerns (Davidson 1978). When that happened, other groups from within and outside the state challenged the externally conferred authority to exercise sovereignty and, in some cases, established the required institutions, including those necessary to manage the resources within that portion of the nation's territory over which they lay a claim of sovereignty.

Because of Sub-Saharan African insurgent and rebel movements' success in controlling territory, providing services, and establishing institutions commonly associated with a state, the quasi-state moniker can also be applied to these groups. These groups often controlled a significant percentage of the territory outside the capital and with it the economic benefits of the resources contained therein. The Eritrean People's Liberation Front controlled the territory that would eventually become Eritrea to such a degree that Ethiopian forces control was limited to Asmara and effectively governed the majority of the population. UNITA in Angola and the NFPL in Liberia both controlled sizeable portions of their respective countries, set up governing institutions, and traded commodities such as iron ore, diamonds, rubber, and timber on the international markets to finance their operations, both insurgent and governmental (Clapham 1998).

In the Post Cold War years, this blurring of the lines between the internationally recognized state that exerts little power outside of the capital and the insurgent and illegal state that provides protection and defense, as well as exerts control over the economic commodities has caused the international community to perceive all groups who have

exercised state-like functions as equivalent to a state and to offer both recognized governments and rebel groups aspiring to be governments the privileges afforded to states: a seat at the negotiation table, a role to play in the post-conflict government, as well as access to humanitarian and international aid. In some cases, the states themselves have conducted their business in such a way that they appear to the international system to be no different from an insurgency; Clapham (1998) presents these cases, using Idi Amin and Jean-Bédal Bokassa as examples, as privatized states whereas William Reno (1995) likens similar cases to shadow states. For both authors the distinguishing characteristics are the use of public resources for personal gain and the conducting of the state's affairs as though the sovereign nation were the leader's personal property.

Understanding who controls the state and access to its resources is important to understanding who is likely to participate in or be disinterested in and disillusioned by political processes. Throughout the post-independence years, those in Sub-Saharan Africa who have controlled the state have often used it as a personal fiefdom to reward loyalists, typically comprised of those with family or tribal connections to the ruler, and have intentionally designed state institutions to entrench their power and enhance the state's extractive capacities. Those with access to the state and its institutions maintain sole authority to regulate their use. In Sub-Saharan Africa that regulation has taken the extreme form of corruption to an extent that the state has devolved to a point where it is often a mere shadow of a state, in some cases collapsed, or near collapse, in some cases managed as though it were a privately held empire.

Patronage and clientelism was the basis for political and social relationships in traditional African societies. For example, chiefs doled out offices, political or

administrative, in exchange for trust and loyalty in a relationship based in the relative power of the two roles. Alternatively, superiors provided subordinates with protection, economic security, or social position in exchange for loyalty, obedience, and service. Similar relationships exist between merchants, artisans, and customers; and between religious leaders and their followers. Power in each of these relationships is based in the ability of the patron to confer on the client a political, economic, or social good or service in the form of administrative positions, social position (upward mobility) or wealth on the client and the client's reciprocal act of loyalty, obedience, or provision of the good to be purchased. Both the pattern of the patron-client relationship and the relative positions of the occupants of the roles transferred to post-independence political institutions.

Lemarchand (1972) observed that a political system whose structural basis is clientelism will ultimately find that clientelism will "…impose serious harm on the system's capacity to innovate" (p. 89). Some thirty-five years later evidence has proven this assertion to be valid. Sub-Saharan African political systems based in clientelism have become dysfunctional. The political regimes of postcolonial Sub-Saharan African are characterized by an individual who is identified with the state, who dominates the state, and who perceives himself to be above the law; relationships of loyalty and dependence; and bureaucrats who perceive their office as a means to acquire wealth and status with little regard for the public good. Within this system both state elites and bureaucratic functionaries use the resources of the state to maintain patronage networks, use their official positions to collect illegal rents, and often perceive these actions as rightful entitlements of their office. Such practices are not unique to the African continent; they are commonplace throughout the developing world. What is unique to

Sub-Saharan Africa is their role as the dominant feature of Sub-Saharan African politics and the foundation of Sub-Saharan African political institutions. It is the systematic use of clientalism and the rents gained from state resources to ensure political support that differentiates Sub-Saharan Africa from other parts of the world where similar corporatist and patrimonial behavior is also found.

The process used to privatize state enterprises in Uganda serves to illustrate this point. Cronyism, in combination with the use of considerable personal discretion to favor those with whom government officials have close political or kinship connections (Tangri and Mwenda 2001), occurs at all levels of government from the cabinet minister down to the civil servant who processes routine paperwork, for a small fee. Privatization was intended to counter this long-standing means of conducting business. However, there were few mechanisms in place to ensure accountability or transparency in decision-making and many parastatals, including the Uganda Grain Milling Corporation, the ground handling operations at Entebbe International Airport, Uganda Commercial Bank, and the Uganda Sheraton, were sold to foreign investors for far less than they were worth. The state manipulated privatization so that enterprises were divested into the hands of loyal clients and not opponents. While the state did lose the parastatals as direct tools of patronage, it ensured itself a continued measure of control by selling the enterprises to loyal clients and thereby used the forced divestiture as means to consolidate political power. Parastatals in private hands, if economically viable, meant revenue and the state wanted to retain as much control, albeit indirectly, over that revenue as possible.

Failure to demonstrate adequate progress as measured by the Polity scale, a persistent inability to convincingly exert sovereign authority, and perpetration of

dysfunctional structural relationships all support continued investigation into the causes of conflict in Sub-Saharan Africa.

Economic Conditions

In 2001, Sub-Saharan Africa was the only region of the developing world with a higher proportion of its population in poverty, defined as per capita GDP of less than $2 per day, and in extreme poverty, defined as per capita GDP of less than $1 per day, than in 1981. In 1997, approximately one-half of African nations had a per capita GDP of $1 per day or less and less than one quarter of African nations had a per capita GDP of $1000 or more (World Bank 2004). Between 1981 and 2001, Sub-Saharan African per capita GDP decreased by 14%; during the same time period poverty increased from 41% to 46% and 140 million more people were in extreme poverty at the end of those two decades than at the beginning. Between 1990 and 2001, the number of people living on $1 per day or less declined by 25% in South Asia and 50% in East Asia but grew by 4% in Sub-Saharan Africa. Even Latin America and the Caribbean, where the numbers in poverty and extreme poverty have risen but the proportion in poverty and extreme poverty has remained fairly steady over the 20-year period, at 10% and 25% respectively, can claim success over Sub-Saharan Africa where both poverty and extreme poverty have risen.

Foreign direct investment has become an increasingly important source of revenue in Sub-Saharan Africa, especially since the end of the Cold War. African foreign direct investment, both in terms of millions of dollars and as a percent of GDP, grew considerably from 1990 to 2002; although foreign investments in Africa never approached the levels of the Latin American or East Asian regions during these years, it

did surpass the Middle East and South Asian regions. These trends suggest that some Sub-Saharan African nations, in the decade after the end of the Cold War, successfully demonstrated themselves as viable locations for investment.

In the realm of official, government-to-government assistance, Sub-Saharan Africa still eclipses other regions in terms of dollars and as a percent of national income. The $19.4 million in official assistance is more than 2.5 times that of the $7.3 million sent to East Asia and the Pacific region, the next largest recipient. Nor does the $7.8 million in direct investment come close to the $19.4 million in official assistance. The volume of official development assistance, however, suggests that Sub-Saharan Africa still relies far more on government-to-government assistance than on direct investment.

Primary commodities other than agriculture play an important part in the economies of many African nations. Oil is one of the most important. Nigeria, whose proven reserves have grown from 17.4 billion barrels in 1980 to 36.2 billion barrels in 2008, is the only Sub-Saharan African nation in the world's top 20 known reserves, which represent 95% of known reserves. A small number of Sub-Saharan African nations have reserves greater than one billion barrels and about as many have known reserves less than 1 billion barrels.

Table 1: Oil Reserves
(Billion Barrels)

Country	Current Reserves
Nigeria	36.2
Angola	9
Sudan	5
Chad	1.5
Congo Brazzaville	1.6
Equatorial Guinea	1.1
Gabon	2.0

Table 2: Countries with Fewer than 1 Billion Barrels in Reserves	
Benin	Ethiopia
Cameroon	Ghana
Côte d'Ivoire	Mauritania
Congo Kinshasa	South Africa

At no time have Sub-Saharan African reserves been more than the 4.3% of world reserves they represent in 2008 and, for most of the time between 1980 and 2008, they ranged between 2.5% and 3.5% of known world reserves.

Other natural resources that comprise a large share of Sub-Saharan African nation's economies are the primary commodities copper, iron ore, bauxite, and diamonds. Nations who rely too heavily on these minerals are held hostage to the vagaries of the international commodity markets and their price fluctuations. Zambia has relied heavily on copper. Its production however dropped from more than 675,000 metric tons in 1975 to 445,000 metric tons in 1990 and held 12 million metric tons of reserves in 1990 (World Resources Institute 1992). By 2000 Zambian production had dropped to 250,000 metric tons (US Geological Survey 2007). Zaire held 26 million metric tons of reserves in 1990 and saw its production decline from more than 460,000 metric tons in 1974 to 370,000 metric tons by 1990 and to 21,000 metric tons by 2000. Iron ore has been important to the economies of South Africa, Liberia, and Mauritania. In 1990, South Africa had 2,500 million metric tons of iron ore reserves (World Resources Institute 1992) and in 2000 was producing more than 33 million metric tons of ore (US Geological Survey 2007). Liberia had 500 million metric tons of reserves in 1990 and produced 4,050,000 metric tons that year but because of conflict in the country was not producing any ore in 2000 (World Resources Institute 1992 and US Geological Survey 2007).

Bauxite is important to the Ghanaian economy; in 1990, the nation produced 381,000 metric tons and in 2000 production was over 500,000 metric tons (World Resources Institute 1992 and US Geological Survey 2007). Diamonds, both industrial and gemstone, have been found in several Sub-Saharan African nations and are now an important commodity, both legal and smuggled, to Angola, Botswana, Central African Republic, Côte d'Ivoire, Gabon, Ghana, Guinea, Namibia, Sierra Leone, South Africa, Tanzania, Congo Kinshasa, Zimbabwe, and Liberia (US Geological Survey 2007 and World Resources Institute 1992).

Forestry and forest resources play an important part in the economic vitality of many communities and of the nations in eastern, central, and western Africa. The forests account for approximately 6% of GDP in Africa, the highest in the world; that figure skyrockets to more than 60% of GDP in western Africa, where timber exports are a vital economic resource. In addition to the export revenue, forest resources provide fuel for cooking, particularly among rural households; as well as numerous non-timber products such as raw materials for the craft industry, ecotourism destinations, gums and resins, honey and beeswax, and medicinal plants. Export trade in medicinal plants brought a combined $65 million annually in the early years of the century to South Africa, Zambia and Cameroon.

Environmental Conditions

These social, political, and economic conditions exist in a natural environment of either highly variable water resources or very limited water resources. Over 70% of the earth's surface is covered with water, either in liquid form in oceans, lakes and rivers or in solid form in polar ice. Two images of the planet taken from space illustrate the point.

The first, with the earth in full phase, is a hemispheric shot with the African continent and the expanses of South Atlantic, Indian, and Antarctic Oceans. Note that the proportion of land is considerably smaller than the water. The second image has the pale blue dot of earth visible through the rings of Saturn. The sunlight reflected off the expanse of water causes the planet to appear blue from space.

Figure 1: Earth from space, taken by Apollo 17 crew. Source: http://apod.nasa.gov/apod/ap050102.html

Figure 2: Earth from Saturn, taken by Cassini Spacecraft Source: http://antwrp.gsfc.nasa.gov/apod/ap060927.html

The continuous exchange of water from the oceans and land surfaces comprises the hydrologic cycle. But, as omnipresent as the compound is, its distribution across land

surfaces is uneven as is its distribution across the temporal sphere; in the same location, it can fall in massive quantities at one time and be completely absent at other times. This vast resource also does not frequently exist in a form that is usable to human societies (or to most ecosystems). Only approximately 2.5% of the total volume of 1.4 billion cubic kilometers is fresh water, the balance is saline and unusable. Two thirds of that 2.5% is permanently (presumably) frozen as polar icecaps and about 30% is in underground aquifers. The usable portion, about 200,000 cubic kilometers, is less than 1% of the total volume. The minimum water requirements for an individual are 20-50 liters (approximately 5-13 gallons per day). However, the water required to produce the food an individual eats each day is about 70 times as much; one kilogram (2.2 lbs.) of a staple grain, such as rice or wheat, requires 500 to 4000 liters (100 to 1100 gallons) (Rijsberman, Manning, and de Silva 2006).

Water insecurity encompasses more than mere physical availability. That which is characterized as insecurity or scarcity is often a function of policy decisions and water management that preference some users over others; often agricultural uses take precedence over the needs of ecosystems or industry. Security is also a function of risk and vulnerability. A civilization's or a community's success in harnessing the potential of its water resources is always a determining factor of the extent to which it can succeed or thrive (United Nations Development Program 2006, 133-134). Water insecurity is also defined by variability. In some respects, drought-prone areas are less insecure because drought is a part of the area's variability; therefore, it can be planned for and adapted to. In effect, drought remains a serious problem in some Sub-Saharan African regions precisely because its governments have not effectively planned for and adapted to that

variability. Drought's impact on a society has been likened to a slow, debilitating disease that takes some time to manifest itself; in contrast, floods are acute and devastating. The floods of 2000 in Mozambique illustrate a flood's ability to undo the accomplishments of many years hard work in a short time (United Nations Development Program 2006, 157).

The distribution of water resources across Sub-Saharan Africa is not well-matched to the distribution of population across the continent. The availability of water across Sub-Saharan Africa varies widely from nation to nation, across seasons and across years. Furthermore, water resources, unlike food or fuel, other factors that are essential for a community or civilization to survive and thrive, are not easily moved over long distances. These realities in combination help to explain why Sub-Saharan Africa as whole has sufficient water for its population but many individual nations face water scarcity and water stress. Several examples serve to illustrate this point: the Democratic Republic of the Congo has more than 20,000 cubic meters per person while Kenya, Malawi and South Africa fall below the water stress threshold.

While Africa does have more water available on a per capita basis than other regions of the world, including Europe and Australia, 5720 cubic meters per person per year compared with 4230 cubic meters per person per year in Europe and 3920 cubic meters per person per year in Australia, its variability in timing and distribution combined with the large number of countries experiencing water stress (less than 1667 cubic meters of renewable water resources per person per year) or water scarcity (less than 1000 cubic meters of renewable water resources per person per year) in 1990 leave Sub-Saharan Africa more vulnerable to that variability than other parts of the world. Sub-Saharan Africa has the largest number of water-stressed countries of any world region; in 2006,

approximately one quarter of the population lived in a water-stressed country and that proportion is projected to rise to 85% by 2025 (United Nations Development Program 2006, 135-136).

Annual precipitation patterns vary greatly across Sub-Saharan Africa. The Sahelian region is among the driest: Mauritania received less than 100 mm of precipitation annually[5], on average during the 20th century, Mali 280 mm and Chad 320 mm. In the east, Eritrea saw an average of 390 mm and Kenya 670 mm annually; in the south Botswana, averaged 400 mm annually during the 20th century but Equatorial Guinea saw an average of 2150 mm. Tropical west Africa was the wettest area on the continent where Liberia received an average of 2380 mm annually and Sierra Leone saw an average of 2580 mm annually (Mitchell et al. 2004). These annual averages disguise regional variation within nations and are subject to the placement of rain gauges, which may or may not be representative of the climatic variations within each nation.

Available water resources come not only from precipitation but also from international rivers. Africa stands out as having more international river basins than any other continent, at 60 and has six basins shared by five or more states, more than any other region. Most nations have access to only a single river basin and all of the major river basins are shared among three to ten nations. Most African river basins are characterized by an annual climatic cycle that alternates seasons of rainfall with seasons of drought. African societies have succeeded by adapting to such large variations in water supply. Nevertheless, these natural variations make African nations vulnerable to

[5] 25.4 mm = 1 inch

the effects of extreme drought, and more recently, flooding as agricultural areas traditionally reserved for recession agriculture are converted to irrigated crop land.

The agricultural sector typically consumes more water than any other sector and throughout Sub-Saharan Africa, agriculture is the largest sector of the economy, however that sector is predominately subsistence agriculture. In the late 1980s Sub-Saharan Africa utilized 640 cubic meters of water per person per year to produce the average diet, two thirds that of Latin America and the Middle East (including North Africa) and only one third that of North America or Europe (Gleick 2000).

Even with the rise in irrigated agriculture, Sub-Saharan African farmers rely almost exclusively on seasonal rains to sustain their farms. Irrigated agriculture has remained a very small proportion of agricultural land. Between 1961 and 1999, irrigated land was never more than 4.5% of Sub-Saharan African cropland (World Bank 2001).

Forests and wooded areas covered nearly 22% of the African continent in 2005 (United Nations Environment Program 2006) and these regions represent more than 16% of the world's forested areas. In fact, the Congo basin holds the world's second largest continuous block of tropical rain forest. Deforestation is a significant concern to some nations. Liberia lost 22% of its forest cover between 1990 and 2000 as timber was sold to finance the decade-long civil war. Côte d'Ivoire and Gambia are unique among West African nations for increasing the proportion of their land covered in forests; for the former the 2% increase during the last decade of the Twentieth Century was part of a concerted effort to establish industrial tree plantations, for the latter its 7% increase during the same time period was a matter of necessity to slow the encroachment of the desert. Sub-Saharan African forests provide many key ecosystem services for its water

resources; they protect catchment areas, purify water, regulate river flows, and prevent soil erosion. The forests of Sub-Saharan Africa are also an important component of its hydrologic cycle; the process of transpiration adds water vapor to the atmosphere, which in turn contributes to cloud formation and precipitation. Thus, significant changes in quality and quantity forest cover can have an effect on the timing, intensity, and frequency of precipitation and therefore water resource availability.

Because they are essential for life, water resources stand out as a probable source of societal tension. Africa stands out among the world's water-scarce regions because it currently has the world's largest percentages of people without safe drinking water, because the hydrological cycle in Africa is highly variable (Adams 1992), because 18 of 48 nations will be water stressed by 2025 from population growth alone (Sharma et al. 1996), because the continent is home to a large number of the world's poorest nations, and because the governments are generally undemocratic and unstable. The impacts of climate change are expected to become an additional stressor in societies beset by a plethora of social, economic, and political stresses.

Summary of Research Agenda

Research on the role of environmental factors in the outbreak of conflict has typically been grounded in the international security literature, which concludes that environmental degradation is most likely to contribute to the outbreak of domestic conflict yet the domestic conflict literature rarely includes environmental factors among its explanatory variables. The dynamics of conflict are very different for each and the more plausible relationship is between the environment and conflict within a nation. More recently, studies looking at domestic conflict through a political economy lens have

provided evidence that abundant resources, especially in forms that generate income, contribute to the outbreak of conflict (Collier and Hoeffler 1998, le Billon 2001, Peluso and Watts 2001, de Soysa 2002). Those who acknowledge the theoretical literature on civil conflict either make a direct claim of deprivation, or imply that the connection exists. Auvinen (1997), as one example, asserts "(t)he regime's inability to provide economic and political goods is seen as a source of relative deprivation within a population." However, the civil conflict literature concluded that deprivation and grievance alone were insufficient to produce conflict. The foundation for environmental scarcity arguments will be strengthened by clearly grounding them within the broader theoretical framework of civil conflict literature; this will be accomplished by including in one model both the variables typically included in quantitative studies of civil conflict and the variables used in the quantitative environmental security studies.

Methodological concerns are found throughout this young area of research. The Homer-Dixon case studies have been criticized for choosing cases with both conflict and environmental scarcity (Levy 1995). Hauge and Ellingsen (1998) addressed the case study critics with a quantitative study based in the Homer-Dixon hypotheses. One shortcoming of the Hauge and Ellingsen study is the lack of variation across two of their three environmental variables; data for each was available for one year during the period under study but not the same year for each nation. Their solution was to replicate the values they had over the years of missing data, thus reducing the reliability of their results. This analysis will expand on the number of years covered by extending the date range back to 1965 and improve on the variation in the water resources variable by using meteorological data on total annual precipitation to provide a more robust data point.

This study will demonstrate that water resource availability has a discernable causal effect on civil conflict in Sub-Saharan Africa. Furthermore, this study supports and extends Hauge and Ellingsen's (1998) findings that water resources contribute to civil conflict by demonstrating that a variable measure of water resource availability based on annual precipitation can be used successfully in lieu of the water resource availability estimates. This noteworthy finding makes a valuable contribution to the study of environment and conflict by adding a new indicator to the correlates of civil conflict that is both variable and updated and that can be used in place of an estimator that is neither variable nor frequently updated.

Both the temporal and spatial scopes of quantitative conflict studies have also been limited by the ranges of existing data sets. As a result, developing nations in general and African nations in particular are under represented. This study will cover all post-colonial years for each African nation. It will also include separate analyses for two temporal subsets, the Cold War and post-Cold War periods; there is reason to suspect different causal dynamics at work during each period. African nations were the site of proxy wars during the Cold War. In the absence of a superpower rivalry African nations lost their patrons and foreign aid dollars were redirected to nations of the former Soviet Union and Eastern Europe. Opposition groups in Africa have adapted, becoming more entrepreneurial and relying on natural resources to fund their arms purchases.

This study has utilized two differing methods to quantify the concept of civil conflict, the widely-used 0/1 coding to denote the presence of any form of civil conflict in a given year and an infrequently-used categorical variable that denotes increasing levels of violence defined by duration and deaths. The expectation is that the more finely-

grained categorization will offer a more detailed picture of how environmental change contributes to conflict in Sub-Saharan Africa.

Chapter 2: Environmental Security: Evolution of a Concept

This chapter traces the evolution of studies at the intersection of conflict and environmental change. The discussion starts with an exploration of civil conflict and the factors, both generally applicable and specific to the nations of Africa, which that body of work has identified as useful predictors. The discussion then turns to explore the relatively recent literature on environmental security, a discussion which takes place almost exclusively within the realm of international relations theorists despite the conclusion that conflicts whose causal factors include changes in the environment are far more likely be intranational than international. The chapter concludes by summarizing what is known on the question of environmental change as a causal factor of conflict, identifying gaps in that knowledge and setting forth the hypotheses that are the basis for the subsequent analysis.

Civil Conflict

The study of conflict within a nation has become a fractured body of literature that encompasses a wide range of inter-societal relations. A field that once focused nearly exclusively on the "great revolutions" now spans a continuum along which lie events as diverse as failed states, civil war, social revolutions, state repression, democratic transitions, coups d'état, guerilla warfare, protest, and rebellion. Between the extremes of stability and revolution lie varying combinations of expressed dissension and state responses that can manifest themselves as conflict at any time. The methods have similarly expanded from single case studies to comparative case studies to quantitative regression analyses and rational choice analyses. A recent overview article (Goldstone

2001) contained nearly 40 different terms for intrastate conflict and identified a similar number of causal variables, highlighting theoretical, definitional, and operational dilemmas. Each study adopts a unique definition for the dependent variable; for empirical studies, it is often predicated on the pre-existing data set used in the analysis.

One lens through which to view politics is as a competition among groups within society to control the distribution of state-controlled goods and services. This view presumes that the society has established norms to regulate the distribution of said goods and services as well as intergroup competition. A common element in the notion of intrastate conflict is that it occurs outside the set of rules governing executive transfer. Most African nations however, lack generally accepted institutional norms for either the distribution of state goods and services or executive transfer. This shortcoming is a direct result of the significant obstacles African nations faced at independence. They were expected simultaneously and instantaneously (or nearly so) to build the institutional components of a state; construct a national identity from disparate ethnic groups, some of whom had histories (colonial or pre colonial) of conflict; and to ensure the economic development and welfare of their citizens. These are processes that the developed world accomplished successively and over periods ranging from decades to centuries (Ayoob 1984, 1995; Cohen et al. 1981; Henderson 1998, 2000; Jackson 2001; Jackson 1990; Snow 1996). It is the absence of norms for distributing state goods and services and for transferring executive power that is the basis of many conflicts in Sub-Saharan Africa. Pressures for democratization came late to Sub-Saharan Africa; while Huntington (1991) has marked a third wave of democratization globally beginning in 1974, Sub-Saharan Africa experienced little change until the 1990s (Bratton and van de Waal 1997). As

noted in the first chapter, Sub-Saharan African leaders tolerated little competition from rivals and ensured loyalty through patronage networks. Consenting to competition among elites meant that political rivals would be given brief tenures in government with a salary and access to resources to support what could become a patronage network capable of challenging the leader. Including opposition members in a cabinet also meant that they became disaffected when they were replaced. Removal from office excluded the ousted, whether rival or follower, from the network of power and created a class of aggrieved elites who were capable of creating independent and competing patronage networks and bases of power with which thereby lowering the opportunity cost for elites to support rebel movements (Bratton and van de Waal 1997).

Early African leaders also recognized that the creation of legitimate political and economic institutions meant allowing the existence of an opposition and accepting challenges to their power. Most chose instead to imitate the methods of their colonizers; they created weak, economically marginalized, autocratic and heavily militarized states and limited access to political and economic goods to an elite few (Henderson 2000, Holsti 1996, Suliman 1998). As a result, many post-colonial African states failed to garner the legitimacy of their subjects and the norm for executive transfer devolved into a series of coups, the dominant means of executive transfer until roughly the end of the Cold War, or rigged elections, held to provide a façade of democratization. Regardless of regime type, coups d'état have been the primary means of regime change in Africa (McGowan and Johnson 1984).

Civil conflict theory posits an inverted-U curvilinear relationship between regime type and conflict (McGowan and Johnson 1984, Muller and Weede 1990, Auvinen 1997,

Collier and Hoeffler 1998, Elbadowi and Sambanis 2000, Henderson and Singer 2000). Democratic regimes have a lower propensity for violence because their resources are distributed according to compromise and consensus. A democratic regime by definition provides opportunities to express grievances and to negotiate compromises over their redress. An autocratic regime also has a low propensity for violence because the public expression of grievance is neither tolerated nor negotiable. A group will challenge the existing regime only if it perceives that its opportunity for success is high, or at least greater than the costs. Semi-democracies, also termed transitional democracies, provide ideal conditions for civil violence and African democracies, to the extent that they exist, are transitional or semi-democracies. They lack the routine, institutionalized, and widely accepted processes for negotiating compromises. In addition, the transitional democracies have yet to address the backlog of grievances.

Grievance

The socio-psychological tradition in conflict studies, also known as relative deprivation, has its origin in the works of Mosca (1939), Pareto (1935), and Durkheim (1933). The contemporary version generally grounds itself in Gurr (1970) who considers the motivations behind individual participation in rebellion and how those motivations generate episodes of political violence and revolution. Its main premise centers on deprivation, the perceived difference between what one has and what one believes one is entitled to. The larger this differential the more reason one has to hold a grievance against the state and therefore the more likely one is to engage in collective violence against the state.

Rising expectations, the difference between what society expects and what it receives, are one source of grievance. Rapid social change can take many forms: socioeconomic (Olsen 1963), industrialization (Feierabend et al. 1969), urbanization (Hibbs 1973), political modernization (Huntington 1968), increased exposure to mass media and education (Parvin 1973), and democratization (Huntington 1991). The arguments presented in the previous chapter provide a plethora of evidence to, at least intuitively, find the grievance argument compelling in Sub-Saharan Africa. Rapid social change exacerbates grievances when neither state nor society has developed the institutional capability to provide the expected goods and when individual expectations change faster than the state's resources and institutions can supply the required economic and political goods.

These changes lead to changes in expectations, frustration about the difference between expectations and outcomes; politicized anger emanates from these frustrations and is expressed through participation in movements and protests. A number of cross-national studies (Gurr 1970; Gurr and Duvall 1973; Gurr and Lichbach 1979, 1986) provided evidence that short-term economic stress and long-term strains increase conflict intensity. Other studies (Feierabend and Feierabend 1966; Huntington 1968) look at strains of modernization (increased mobilization and slow economic growth) and argue for a curvilinear relationship between economic development and conflict. They (and others: Hardy 1979, Weede 1981) found instead a negative linear relationship.

While the deprivation or grievance argument makes intuitive sense, under scrutiny it has a number of serious flaws and has been supplanted by other explanations for the cause of civil war including the capacity of social movements to mobilize

resources and the rationality of strategic choices in achieving their objectives. The concept is grounded in the motivations and actions of individuals; empirical studies either test the assumptions at the macro level with nations as the unit of analysis, which presumes the existence of a relationship between the macro-level conditions measured by aggregate indicators and micro-level motivations behind individual choices, or utilize indirect and imprecise tests to measure individual motivation indirectly and after the fact (Brush 1996; Gurney and Tierney 1982; Muller, Dietz and Finkel 1991). A second criticism notes that relative deprivation fails to explain how feelings of deprivation are channeled in collective action because the focus is on macro issues rather than the working of organizations; it therefore fails to explain how participants coalesce and how movements spread. Each instance is an independent event; the episodes are not related to one another (Brush 1996; Muller, Dietz and Finkel 1991). Thirdly, relative deprivation critics note that the theory is unable to explain cases of rapid change that are not accompanied by protest (Gurney and Tierney 1982; Muller, Dietz and Finkel 1991).

Resource Mobilization

Groups engage in collective action typical of social movements (demonstrations, boycotts, strikes, violence, riots, sit-ins) because they are excluded from the polity, i.e., they lack routine, low-cost access to the resources controlled by the government. They cannot realize their interests by legitimate means because the government responds only to interests of polity members and the polity in Sub-Saharan Africa, as noted earlier, has typically been intentionally circumscribed in a manner that ensures its loyalty to the government. Ethnic identity provides one basis from which to mobilize (Gurr 1994, Tilly 1978). Exclusion from access to government or the distribution of scarce economic or

political resources based on ethnic identity provides the grievances upon which civil violence may be based (Gurr and Harff 1994, Gurr 1994). Collective action is the result of struggle for power between polity members and challengers. The social movement model looks at social structures and processes that allow challengers to pursue power through collective action.

Causal Relationships

While the outward manifestation of violence has changed considerably over time, the underlying motives have changed much less. The variables most often suggested as correlates of civil wars include regime type (Auvinen 1997, Hegre et al. 2001, Henderson 2000, Henderson and Singer 2000), level of economic development (Barbier and Homer-Dixon 1999; Collier and Hoeffler 1998, Elbadawi and Sambanis 2000, Henderson 2000, Henderson and Singer 2000), ethnicity (Auvinen 1997, Collier and Hoeffler 1998, Elbadawi and Sambanis 2000, Henderson 2000, Mousseau 2001), and social mobilization (Henderson 1998, Jackman 1978, Jenkins and Kpsowa 1990, Kpsowa and Jenkins 1993, and Lunde 1991). Few in this literature consider the impact of environmental factors on the outbreak of intrastate conflict; when environmental variables are included in their analysis, it is in the context of dependence upon the income earned from the extraction of resources such as oil or minerals.

The debate on the relationship between regime type and conflict has settled around the acceptance of an inverted U: the more democratic or the more dictatorial a regime is the less likely the nation is to experience civil conflict (Auvinen 1997, de Soysa 2002, Henderson 1998, Henderson and Singer 2000, Mousseau 2001, Scarritt and McMillan 1995). Research on economic development has found it to be a double-edged

sword; in the short term economic development can be destabilizing but is necessary for long-term stability (Auvinen 1997, Collier and Hoeffler 1998, Elbadowi and Sambanis 2000, Henderson and Singer 2000, McGowan and Johnson 1984, Muller and Weede 1990). Henderson (2002), one of only a few scholars to consider the factors of conflict that are specific to Africa, did not find democracy significant in multivariate regressions of African conflict. On closer examination, however, Henderson found democracy to be significant when comparing the distribution of regime types and the onset of conflict; semi-democracies, or transitional democracies, were more prone to civil conflict than democracies or autocracies.

The economy, in one form or another, is a component of most models of domestic conflict. In earlier studies it took the form of dependence, export dependence or foreign aid dependence (Collier 2000; Jenkins and Kposowa 1990, 1992; Kposowa and Jenkins 1993; Muller 1985; Muller and Seligson 1987; O'Kane 1981). More recently it appears as income or income growth rates (Auvinen 1997; Collier and Hoeffler 1998, 2002; de Soysa 2002; Elbadawi and Sambanis 2000; Sørli 2002). In all cases authors found that improvements in the economic variables, i.e. increased growth or reduced reliance on foreign aid, reduced the odds of conflict but there are important differences among the findings. Henderson (2000) and in collaboration with Singer (2000) looked at measures of both development and economic growth. They found that economic development reduced the probability of conflict more than did economic growth. Auvinen (1997) found poor economic performance to be a reliable predictor of protest but not of rebellion.

The ethnic diversity of populations has long been included as a variable in conflict studies. Earlier studies were unable to come to a consensus and found ethnic heterogeneity to both increase (Jenkins and Kpsowa 1990, Kpsowa and Jenkins 1993) and decrease (Elbadawi and Sambanis 2000, Jackman 1978) the probability of conflict. More recently a consensus has emerged acknowledging ethnicity's complex role. Nations with two or three similarly sized groups (or dominant groups) tend to be more stable than nations with many groups or one overwhelmingly dominant group (Collier and Hoeffler 1998, Henderson 2000, Kahl 1998, Mousseau 2001).

Researchers at two different points in time included social mobilization as a component of their models. In 1978 Jackman, studying the incidence of coups (the then dominant form of civil conflict in Africa), measured social mobilization as the percent of the labor force in agriculture and the literacy rate and found that greater social mobilization increased the probability of coups. Jenkins and Kposowa (1993), reexamining the issue 15 years later, expanded Jackman's conceptualization of social mobilization to include a component measuring political awareness, defined as literacy rate plus secondary school enrollment as a percent of the population, and a component measuring the capacity to act, defined as the percent of the population that is urban plus the percent of the population in the industrial workforce. The Jenkins and Kposowa model revealed that political awareness reduced the probability of coups while structural capacity increased the probability of coup attempts.

The civil conflict literature rarely includes independent variables outside the relatively narrow realm of social causes. Yet, the societies under consideration exist within the confines of a physical environment; they have an effect on their environment

and they are affected by that environment. This fact raises two issues. First can and should social factors be explained by natural facts? Second, (assuming the first was answered in the affirmative) is how to ensure that the interrelationship is reflected in the model. "Social facts, such as conflict, cannot be explained by natural facts, such as the environment, but only by other social facts. The question is really whether people living in environmentally degraded areas can come to perceive such degradation as a threat to their way of life . . . or to their very survival . . . ." (Molvær 1991 p. 175)

What does the quantity or quality of water resources or the acreage of trees or of agricultural land in the nation have to do with how well a political system functions? At first glance they seem entirely incongruous. Scratch below the surface and the connection is quite clear. While water and forests and land will exist with or without political systems, the converse does not hold true. A political system is a human construct and as such exists only in the presence of a human civilization. Human survival requires sufficient food and water, which are available from rivers, forests and land suitable to grow crops or graze animals. Therefore, changes in environmental conditions that are so extreme as to prohibit the continued existence of human societies might explain the outbreak of conflict. Molvær is referring to changes in environmental conditions that are not as extreme but which cross a threshold - either the ecosystem fails to provide the services which society requires of it or the cost of adapting to the change is greater than society's willingness to pay for that adaptation. That threshold represents the point at which society can no longer live the life to which it has become accustomed; when that threshold is crossed, degradation becomes a grievance.

Environment and Conflict

Environmental Security

Choucri and North (1975) and Timberlake and Tinker (1985) are among the earliest researchers to consider environmental factors as a cause of conflict. The International Union for the Conservation of Nature and Natural Resources and the Bruntland Report (World Commission on Environment and Development 1987) raised environmental awareness, which subsequently led to the consideration of environmental problems as part of the security debate. Timberlake and Tinker (1985) were among the earliest to suggest what the causal chain between environmental degradation and the outbreak of conflict might be, postulating that the destruction of environmental resources disrupts economic and social systems, which in turn results in political unrest, environmental refugees, internal migration to urban centers, fighting between nomads and farmers, guerrilla movements, and revolutions. The discourse which developed around environmental security includes several sub-discussions on topics including broadening or redefining security (Gleick 1990 and 1991, Homer-Dixon and Levy 1995, Levy 1995, Matthews 1989, Ullman 1983, and Westing 1989), the definition of environmental security (Allenby 2000, Dabelko and Dabelko 1995, Deudney 1990, Dryer 2001 and Græger 1996), environmental degradation as a cause and as a consequence of violent conflict (Choucri and North 1975, Gleditsch 1998, Litfin 1997, Timberlake and Tinker 1985, and Urdal 2005), securitizing the environment (Deudeny 1990 and Barnett 2000), and human security (Benedict 2000, Dalby 2002, Deudeny 1990, Levy 2005, and Paris 2001).

The earliest work linking the environment with conflict merely theorized that competition over scarce resources could lead nations to fight over them (Choucri and North 1975, Matthews 1989, Myers 1993, Timberlake and Tinker 1980, Ullman 1983). During the 1990s several scholars added specificity by suggesting a basic causal chain in the environmental conflict thesis: population growth and high per capita resource consumption lead to a degraded environment which leads to increasing scarcity which in turn leads to a more intense competition for resources which further leads to greater risk of conflict (Gleick 1990, Hauge and Ellingsen 1998, Homer-Dixon and Blitt 1998, Renner 1996). Population growth rates and population density had been found to be important to the outbreak of domestic conflict, but in those studies political, economic, and cultural variables tend to be ignored (Ford 1995, Henderson 1993). Traditionally conflict studies sought to understand the state's behavior through systemic attributes, a research design that typically does not include environmental variables.

There is much literature examining whether environmental degradation leads to conflict. This debate occurs within the well-established security sub-field of international relations theory. However, that same literature concludes that environmental factors are more likely to contribute to the outbreak of conflict within nations, not between them (Bächler 1998, Barnett 2000, Gleditsch 1998, Gleick 1993a, Hauge and Ellingsen 1998, Homer-Dixon 1994, Renner 1996, Spillman 1995). As elucidating a discussion as this is, it neglects to address the role of the environment in civil conflict.

Before delving into the environmental resource and conflict literature, it is important to distinguish between the scarcity of environmental resources as studied by Homer-Dixon and his research team, Hauge and Ellingsen, the State Failure Task Force,

and Baechler and his research team, and the abundance of environmental resources studied by Collier and le Billon and others. The former group of researchers conceptualized the environment as renewable resources such as air, water or biodiversity, which have intrinsic value as an environmental good. These resources are vital to the continued functioning of a healthy ecosystem; society borrows them, and to one extent or another despoils them, to serve its needs but the resource is renewable if appropriately managed. The "scarcity" is the result of use at rate faster than the resource can renew the supply. The latter conceptualized the environment as non-renewable resources such as diamonds, gold and oil, which are exploitable, extractable and have monetary value in the global marketplace. The resource curse or greed-based explanation for the resource-conflict connection is grounded in the assumption that the nation is economically dependent on the revenue derived from the resource. Water, for example, is an important variable in the former group of studies. However, water resources are outside of the market economy in Sub-Saharan Africa and therefore not a variable of concern to the latter.[6] There is little overlap between the environmental variables used by these two groups of researchers. Furthermore, the way in which environmental change contributes to conflict may be different for the different conceptions of environmental resources.

Thomas Homer-Dixon (1991) made an early attempt to lay the foundation for including environmental change in studies of conflict; however, he failed in his theoretical model and in his later work to ground his work adequately in the vast body of civil conflict literature. His work, based in case studies, examined civil conflict through

[6] Water resources have been captured by the market in many places, foremost among them, the American West, where rights to use water are established by law and frequently contested, albeit in a, usually non-violent, courtroom.

the causal lens of environmental degradation and identified three types of scarcity: demand-induced (from population growth), supply-induced (environmental degradation), and structural (inequality). His work posits that economic scarcity increases deprivation and disrupts social institutions but finds little existing research on the effect of scarcity on social institutions. After an examination of five cases (Mexico, Gaza, South Africa, Pakistan and Rwanda), Homer-Dixon concluded that severe environmental scarcities contribute to major civil violence because the poor are highly dependent on renewable resources for their livelihood and because they are less able to adapt to environmental scarcity. This explanation can be extended to states as well as individuals. Poor states tend to lack well-developed markets and capable institutions to facilitate society's adaptation to scarcity; poor individuals rely on subsistence agriculture, often cultivated on marginal land, conditions that offer no choice of adaptation other than migrating to another piece of marginal land.

Poverty and maldistribution of resources, easily a source of deprivation or grievance, have a deleterious effect on the environment and this relationship is well documented (Auvinen 1997, Hauge and Ellingsen 1998, Homer-Dixon 1994, and Lanz 1996). However, until recently the vast majority of the literature asserting environment-conflict interactions has been primarily concerned with international conflicts. Hauge and Ellingsen (1998) examine a series of hypotheses on the relationship between Homer-Dixon's three types of scarcity (supply-induced, demand-induced and structural) and domestic armed conflict. In addition, they considered more traditional political and social conflict-generating variables. They concluded that while environmental scarcity may be a cause of conflict, it is not necessarily also a catalyst. Economic and political

factors in this study were more important in determining incidences of civil conflict than were environmental factors. Raleigh and Urdal (2007) confirmed this in an updated study on micro-level population pressures.

More recently, a group of researchers has emerged who have considered the economic drivers of civil conflict (Auty 2004; Berdal and Malone 2000; Collier and Hoeffler 1998, 2000, 2002; de Soysa 2002a, 2002b; Humphries 2005; le Billon 2001). In Third World nations generally, and in Africa in particular, they have found that abundant resources, marketable in the global economy, have contributed to the continuation of existing conflicts and the institutionalization of violence. This literature, which is grounded in the resource curse argument, has tended to consider resources in one of three ways: as abundance, as exploitable and as lootable. While all three refer to a quantity greater than the local community or nation can use, there are differences in meaning and ultimately the universe of cases to which the generalizations may be applied. Abundance implies more than is required for local use. In fact, any resource that is marketable is so because there are repositories of the resource in a limited number of locations and a use for the resource in locations other than its origin. Exploitable resources implies a differentiation between resources for which society has found a use and created a market, and other objects for which there is neither a use nor a market. Lootable resources are those which may be placed in commerce by clandestine means thereby circumventing state controls designed to generate revenue. The earliest efforts to explore this research avenue did not differentiate but labeled all primary commodities as abundant resources (Collier and Hoeffler 1998, 2000, and 2002; De Soysa, 2002a, 2002b; Le Billon 2001; Sorli 2002). As the research area has matured, the investigators have nuanced their

questions and narrowed their findings to more completely specify the linkages between resources and conflict (Auty 2004, Humphreys 2005, Ross 2004 and 2006).

The conditions under which abundant resources contribute to conflict have frequently been tied back to inequities or vulnerabilities in the nation's economic or political system. In the realm of economic linkages many authors start from the resource mobilization argument that the availability of primary commodities increases the likelihood of conflict and that conflict is more likely when a rebel stands to gain more from fighting than he or she would earn as subsistence farmer (Collier and Hoeffler 2001). Other authors lean towards a grievance explanation, noting variously: that abundant resources contribute to conflict when the wealth derived from the resource is inequitably redistributed among the citizenry or that economic decline (or a lack of growth), poverty and unemployment are positively related to conflict (Hendrix and Glaser 2007). The accumulated research also points to a nation's dependence on a single resource for much of its revenue rendering it vulnerable to the volatilities of international markets and thereby susceptible to the effects of grievance against the state when the revenues derived from the resource are insufficient to meet the demands for previously available revenue.

The political conditions under which resource abundance has been found to contribute to conflict are most often related to weak states and weak bureaucratic institutions in tandem with a resource-dependent economy. In these instances either an untaxed polity diminishes the state's incentive to create strong bureaucratic institutions or the lack of a dependence on tax revenue creates less demand by the polity for state accountability and therefore creates fewer incentives for the polity to withdraw its

support for the government (Hendrix and Glaser 2007). Evidence on African cases suggests that conflicts which involve lootable resources have their genesis in other political and economic factors that lend credence to a grievance explanation, particularly the decades of corrupt political governance compounded by ineffective economic and institutional governance (Ballentine 2003).

Looking at the environment conflict question through a political ecology lens provides yet another perspective on the conditions under which abundant primary commodity resources contribute to conflict. In this view, natural resources are socially constructed to fill human desires, needs and practices; the resource's value is a function of its relationship with the global economy (leBillon 2001).

At this point that it is imperative to pause and further consider the differences in perspective on natural resources. The discussion earlier established that scarcity–based or Malthusian explanation for the environment conflict connection differs from a greed or resource curse-based explanation. To recapitulate, environmental resources in the scarcity models provide a service to the ecosystem; they are renewable when appropriately managed. The resource curse or greed-based explanation for the resource-conflict connection is grounded in the assumption that the nation is economically dependent on the revenue derived from the environmental resource. Political ecologists take this a step further to suggest that without a human and economic framework, a resource has no value. This may hold for a commodity based resource, but the position is untenable for a natural resource. The latter include water, air, fertile land, biodiversity (although some individual species can be considered "socially constructed" to meet human needs). A natural resource such as water is not socially constructed, it is

necessary for life and for ecosystem survival. The decision where to build a city, plant a field, or build a dam may be a social choice but, regardless of the human choice as to location, water and fertile land have to be available somewhere within the reach of the distribution chain to support life (that distribution chain can range from the maximum distance an individual can walk to a watering hole to the range required to support a hunter gatherer to the reach of a refrigerated cargo vessel).

In all cases, the mechanisms by which abundant resources contribute to conflict emanate from the resources' ability to be sold, legally or not, in the international marketplace to finance the rebellion. Some have explored whether the rebellion began because the resource was available to finance it or whether the rebellion began for other reasons and the resource was later used to support its continuation (Hendrix and Glasser 2007). Others have examined the role that state strength played in affecting rebel opportunity structure, finding that weak states decrease opportunity costs to rebels in increase the likelihood of conflict, whereas strong states increase them the costs to rebels and thereby deter conflict (Ballentine 2003). Authors have looked for a relationship between the length of the conflict and the availability of abundant resources. Others have suggested that the connection occurs only when the state is dependent on the resources for its revenue.

Institutions mediate between the environment and its effect on human society. The preceding discussion on abundant resources has established the link between certain types of resources and economic institutions. In Sub-Saharan Africa the colonial experience shaped post-independence institutions (Easterly and Levine 2003, Kahl 2006, and Suliman 1998). One means that colonial powers used to maintain control over

colonies was to limit the extent to which markets were introduced into African economies (Suliman 1998). In many fledgling African nations, ethnic identity established the boundaries around which and within which political participation was defined; that action had a cascading effect as new leaders imitated their "mentors" when guiding political development in their new nations. Kahl (2006) has identified two paths by which that mediation occurs: groupness and institutional inclusivity. The former is an institutional representation of the society and the extent to which aggregations of individuals rely on few or many overlapping collective identities for economic and physical security. Kahl, in keeping with the findings on ethno-political conflict, asserts that nations with many interconnecting group identities or a single group identity, which represents a large proportion of the population, are less likely to experience conflict. Correspondingly, nations with multiple but discrete identity groups have a higher likelihood of conflict. Kahl's second pathway between environmental degradation and conflict represents the institutions of the state and the extent to which they empower and provide the means for societal groups to participate in and influence the decision-making process, particularly of state elites and state executives. Kahl posits that nations with inclusive institutions, those that allow for participation and influence, will have a lower likelihood of conflict and those with exclusive institutions will have a higher likelihood of conflict. Raleigh and Urdal (2007) extend Kahl's case study work by finding in a 14-year study (1990-2004) that indicators of low state capability are significant predictors of conflict and thereby supporting Kahl's assertion that state failure is a pathway to conflict.

Environmental Change

Environmental change happens. Ecosystems are not static systems; they undergo continuous natural and anthropogenic perturbations as a normal and ongoing process, regardless of the ecosystem's health. Seasons are a natural and annual cycle of variations within known ranges in temperature and precipitation to which all species adapt by incorporating this change into their behavior. Healthy ecosystems can weather occasional perturbations at the extremes of the known variability but extended or frequent perturbations at these extremes can result in degradation, scarcity, and conflict. The effects of these perturbations are analogous to the physical-chemical properties hot spot, flashpoint, and firepoint respectively (Glantz 2002).[7] A hot spot is an area characterized by a high concentration of the article of concern. A flashpoint is the lowest temperature at which a liquid will give off vapors to ignite momentarily on application of a flame. A firepoint is the lowest temperature at which a volatile liquid, after its vapors have been ignited, will give off vapors at a rate sufficient to sustain combustion.

Thresholds, the transition areas, are the points or ranges at which the state changes from one condition to another, for example from hot spot to flashpoint and flash point to fire point; they are the points at which stimuli are of sufficient intensity to begin to produce an effect. This concept from the natural and physical sciences can assist in illuminating the relationship between changes in the natural environment and the socio-political environment. Homer-Dixon (1991) offers the concept of a threshold of

[7] Glantz suggests that it is important distinguish between the three because policy options differ at each level and because problems of conflict emanating from environmental causes differ. Inherent in understanding the different degrees of effect to environment is knowing the human actions triggering them and the policy options available to either mitigate or adapt. This is an area where the ideas developed in this work can be applied in the policy arena.

irreversibility: when environmental degradation reaches the point at which it cannot be reversed, it will continue to be a burden on society.

Thresholds are important ecological concepts; relationships among environmental variables are not necessarily linear. There may be a range of conditions within which the relationship is nonexistent or linear. Once a threshold is reached, the relationship may change dramatically. For example, a wetland may be adapted for a range of rainfall amounts. If daily or annual extremes frequently exceed or fail to reach that range, then the wetland may cease to provide its ecological services. The communities that depend on those services may not have sufficient quantities of grasses and grains, fish, and pollutant filtration. These ecological changes will force governments and societies to adapt to them whenever and wherever they occur.

When changes to an ecosystem, whether due to anthropogenic or natural forces, exceed the tolerances to which the ecosystem has become accustomed, i.e. cross a threshold, they affect the ecosystem and subsequently the social and political systems which are located within the ecosystems and which depend on the ecosystems' products and services. While the survival of post-modern man is no longer limited by that which nature provides, neither have societies completely eliminated the influence of nature (Kristof 1960). The negative effects of these changes attract the greatest attention, but positive impacts also occur.

The social and political institutions often perceive these changes as negative because they require a change to the distribution of power. There are winners and losers. A negative change is perceived as such because it reduces the advantage of those in power (i.e. creates losers) and transfers it to groups not in power (i.e. creates winners).

This imbalance creates the potential for conflict within a nation as the relative advantage of societal groups changes. In a mature democracy, where the society is accustomed to changes in the relative power of groups, this rebalancing of power is not expected to result in open conflict; in less stable democracies or non-democratic nations, conflict can be expected. At the other extreme, strong dictatorships where the state exercises complete (or nearly so) control over society, little challenge is expected to its action of seizing control of the winner and therefore little violence is expected.[8] An example of a positive change would be increased rainfall in the Sahel, which supports additional agricultural production and grazing which in turn provides opportunities for rent-seeking or manipulation of the political and/or economic power structure.

A degrading ecosystem experiences stresses that reduce its usefulness to either the ecosystem itself or the society which relies on it and that either endanger the ecosystem's survival or induce a major ecological shift. The human species can, and usually does, adapt to these changes, although at a cost of increased prices for those environmental products and services incorporated into the market or of reduced services from those not in the market. Scarcity occurs when human activities, environmental processes, and processes that involve human-environment interactions are disrupted because the quantity or quality of the ecosystem, its products, or its services, are less than that demanded of it; the ecosystem has irreversibly changed. Both use of the ecosystem and adaptation continue but at the price of reduced efficiency and increased cost. A degraded environment and scarce resources contribute to the outbreak of conflict when adaptation

[8] This follows the inverted U hypothesis of Muller and Weede (1990); Auvinen (1997); Hegre et al. (1999); Henderson and Singer (2000) which was discussed in greater detail in the section on civil conflict.

is no longer feasible; the ecological change becomes irreversible and subsequently disrupts human activities.

A January 2005, low-level, violent exchange between nomadic herders and farmers over water resources illustrates these points. Scarce rains had created drought conditions in an area where farmers and herders share a common water source, River Ewaso Kedong. The region had received less than 20% of normal precipitation over a shorter period than normal. Herders, located downstream from farming communities and in a more arid region, began to travel upstream to find sufficient rangeland, where they also encountered an insufficient supply of water for their cattle, and asserted that upstream farmers were diverting the resource to irrigate their crops. The violence, perpetrated by both herding and farming communities, took several forms including vandalizing irrigation pipes, severing electrical connections to a political leaders' home, burning houses, stealing and injuring livestock, and murder. The violence displaced about 2000 villagers and disrupted traffic to the Maasai Mara Game Reserve, a popular tourist destination.

In this example, scarcity of the resource, water, created a degraded environment to which the human communities adapted. Insufficient rainfall created drought conditions and, as a result, grasslands failed to produce sufficient fodder to support cattle, watering holes dried up, and soil moisture was inadequate to support crop growth. Each user of the resource adapted to the scarce water and degraded environment: herders expanded the range over which they fed and watered their cattle and farmers drew additional water to irrigate crops. Each community's actions to adapt to the changed environment affected the other community's use of the shared resources: herders grazed

cattle on land farmers perceived belonging to them and farmers used water for irrigation that herders expected to be available for cattle.

I suggest that environmental degradation must reach a threshold before it becomes important in causing conflict. Following the work of Homer-Dixon, that threshold is extreme scarcity, or following the work of Collier and Hoeffler, that threshold is extreme abundance. That which constitutes extreme scarcity or extreme abundance is relative, depending on normal conditions for that region. Rainfall totals that would be considered a drought in the tropical rainforests of the Democratic Republic of Congo (Zaire) would be an overabundance in the Sahel or Sahara.

Received Knowledge and Information Gaps

The accumulated body of knowledge on the environment and conflict has concluded that environmental change is a contributor to conflict. However, the work to date has systematically failed to include the natural environment either as a measure of change or as a measure of scarcity. This has occurred in part because of the compartmentalized nature of the discipline and has resulted in the proverbial right hand not knowing what the left hand is doing. International relations scholars concluded that the causal variable of interest to this study, environmental change, could not effectively explain interstate conflict but suggested that a causal relationship was more likely with intrastate conflict. For many years, however, scholars of intrastate conflict failed to consider the environment as a causal variable. While the recent studies of the resource curse have brought marketable commodities into the discussion and begun to develop a greater understanding of how they matter, the study of scarcity has been neglected, not advancing beyond a ten-year old finding that the environment matters, in part because of

Homer-Dixon's methodological shortcomings, Hauge and Ellingen's lack of variation on independent variables, and literary space devoted to discussion over methods rather than advancing findings. This research advances the discussion of the causal effects of environmental scarcity and degradation on domestic conflict by using an alternative means of operationalizing water resources, annual precipitation data weighted by land area and population to addressing the methodological shortcoming of earlier research, the lack of variation across the variable measuring water resource availability.

Research on the abundance - conflict connections have begun to understand the circumstances under which and the conditions whereby that connection occurs. This study will pursue a similar course for scarce resources by introducing additional variation on the dependent variable and comparing the results of the more widely used dichotomous variable with the results of a dependent variable with categorical coding to determine whether the resource-conflict connection is more prevalent at one level of conflict or another, i.e. low-level conflicts, intermediate level conflicts, or war. This research considers the conditions under which resources and conflict connect by extends the scope of explanatory variables to include indicators for political institutions and their capacity to manage the water resources within their national boundaries.

Hypotheses

The first quantitative studies to find support for claims of a causal relationship between environmental resources and conflict (Hauge and Ellingsen 1998 and State Failure Task Force 1999) were based in a depravation and grievance model and worked from *a priori* assumptions that the independent variable of interest was resource scarcity. Studies since then have called these findings into question and put forth an alternate

claim that the variable of interest is not scarce natural resources but an abundance of natural resources (Collier and Hoeffler 1998, 2000; le Billon 2001). However, the critics operationalize the environment in ways that have important differences from the earlier studies. The grievance work is based on a conception of environment taken from the environmental community, one in which natural resources are communal and not easily exploitable. They take forms such as air, water, soil, and biodiversity. The greed work conceives of the environment as an economic good or a marketable product, items extracted from the earth that have value in the marketplace such as diamonds, oil, and timber. This study will attempt to reconcile those differences by asking three very simple questions: Do environmental variables enhance our understanding of civil conflict in Su-Saharan Africa? Under what circumstances? And, by what means?

Does the Environment Matter in Sub-Saharan African Civil Conflict?

The preceding literature has established that the evidence of a connection between the environment and conflict is tenuous; this study will first confirm that the connection is evident in the assembled data for Sub-Saharan Africa during the period in question, 1965-2000.

H1: Models of civil conflict that include environmental variables are better predictors of that conflict than models without environmental variables.

Water is critical to the life of both individuals and communities and the availability of adequate supplies can be expected to have some cascading effects on societies therefore the "Does the environment matter?" question is next narrowed to focus specifically on water resources. The hypothesis is next framed following the two

competing theories of scarcity and abundance. While water resources in Sub-Saharan Africa are not a marketable resource, they are a resource whose abundance can be as degrading and potentially as destabilizing as its scarcity. Hence, a third variation of the environmental change causes conflict hypothesis will be tested which suggests that, for water resources, the relationship is not unidirectional but exists for both a paucity and a surfeit of the resource.

H2: Water resources exhibit a U-shaped relationship with respect to conflict: extremes of both scarcity and abundance increase the probability of conflict.

Under What Circumstances?

Having established whether environmental change matters in Sub-Saharan African civil conflicts, the study next turns to question the circumstances under which these changes matter. As noted earlier, conflict is a continuum and it is reasonable to question whether different combinations of factors contribute to conflicts at different points along that continuum. Drawing on Hague and Ellingsen (1998), the next hypothesis will test whether a degraded environment is more likely to contribute to low-level conflict than to intermediate conflict.

H3: Water resource scarcity is more likely to contribute to low-level conflict than to intermediate-level conflict or war.

Another way of looking at the environment-conflict relationship is to turn Hauge and Ellingsen's (1998) conclusion that political and economic conditions are more important than the environment in increasing the probability of conflict on its head and ask what would it take in order for the environment to become a more direct cause of

conflict? Homer-Dixon (1991) suggests that ecological thresholds have consequences for human communities. These thresholds of vulnerability, as he terms them, are those ecological conditions beyond which repair or regeneration is not possible. "Even if enlightened social change removes the original political, economic, and cultural causes of the degradation, it will be a continuing burden on society. Once irreversible, in other words, environmental degradation becomes an exogenous variable" (Homer-Dixon 1994, 35-36). Societies are capable of adapting to a wide range of conditions. Homer-Dixon suggests, however, that there are points at which environmental changes are irreversible. This in turn would place a great burden on society to adapt. The scientific concept of thresholds will be applied to the basic question to explore whether ecological thresholds can provide some insights into answering that question, specifically whether ecosystem changes must cross a threshold before they interact with extant social, economic, or political cleavages to increase the probability of conflict. While Homer-Dixon was concerned exclusively with scarce water resources, an excess of water, in the form of floods can also contribute to conditions of economic or social stress and thereby contribute to conflict. Hence, this hypothesis will be tested for both threshold effects.

H4: Changes in water resources must reach a threshold of abundance or a threshold of scarcity before they increase the probability of conflict.

The international system experienced a dramatic shift with the end of the Cold War which altered the relationships between Sub-Saharan African nations and both powerful states and primary donor states. This reshuffling in the international system affected domestic power calculations in those Sub-Saharan African nations who lost or

gained political backing and economic support. These changes are expected to have an effect on the opportunity costs of opposition movements and thereby alter the likelihood that opposition movements will engage in civil conflict. They are also expected to affect the ability of governments to provide services, thereby affecting the potential for groups within societies to either experience new grievances or see existing grievances alleviated. Coincidentally, states and the international environmental community came to agreement on a climate change treaty that established baselines against which progress and climate-related environmental effects would be measured. This convergence presents an opportunity to add a corollary to the cold war hypothesis specific to water resources.

H5a: Civil conflict is more likely during post Cold War years than during Cold War years.

H5b: Changes in water resource availability is more likely to contribute to conflict during post Cold War years than during Cold War years.

By What Means?

There is no evidence to suggest that environmental degradation and scarcity alone are sufficient to cause domestic conflict; their effect on conflict becomes evident when they occur in conjunction with other social, economic, or political stresses. The next set of hypotheses will test the manner in which political systems and ecosystems interact and will conclude with a question about the future asking a "What if" question about hypothetical scenarios based on potential changes to the water regime across the African continent.

Within the foundation that has been laid marking the pathway between environmental change and conflict is the assertion that environmental stressors will

exacerbate existing weaknesses in the capabilities of political, social, or economic systems to respond to the crises that scarcity (or abundance) will create. The first area where the environment and human societies are hypothesized to interact is in the realm of political capability. Nations with stable political systems, accepted norms for changes in leadership, and whose legitimacy is derived from within the nation rather than decreed by exogenous interests can be expected to more effectively respond to the changes that environmental degradation or scarcity would bring. The literature has demonstrated that political systems in transition have a higher probability of conflict and that Sub-Saharan African nations fall into this range. Hence, the next hypothesis is built on the interaction between political stability and environmental changes.

H6: Environmental degradation in combination with political instability increases the probability of conflict.

The review of the literature has also established that institutions mediate between the environment and its effect on human society. That intervention may occur through a variety of mechanisms; this study looks at three: the capacity of offices within the bureaucracy responsible for managing water resources, group cohesiveness, and institutional inclusivity. Exclusion from government is one potential source of grievance. In addition, functioning governmental institutions provide a nation with the capacity to adapt to changes, including those emanating from the ecosystem. The interactions and the mechanism have been explored via case studies (Kahl 2006) and are the basis for the following hypotheses that environmental scarcity can affect a state's ability to exercise its power, authority, and administrative capacity. The hypotheses will test the assertion that

institutional capacity, groupness, and institutional inclusivity mediate between the environment and conflict.

H7: Nations that exhibit greater institutional capacity to manage water resources have a lower probability of conflict.

H8: Nations with more open political institutions will have a lower probability of conflict. Furthermore, this will hold true even in the presence of environmental change or environmental scarcity.

H9: Nations with more interconnected societies will have a lower probability of conflict.

Chapter 3: Research Design

Methodological Overview

Methodological concerns permeate this young area of research. One shortcoming of the Hauge and Ellingsen (1998) study is the lack of variation across two of their three environmental variables. Data for land degradation was available for only one year during the period under study, 1990. Hague and Ellingsen describe human–induced soil degradation as being divided into four categories: none, low, medium and high, based on a visual inspection of a 1990 map showing the geographical extent of four types: water, wind, chemical and physical soil degradation. Hauge and Ellingsen do not indicate how the four types have been aggregated into a single measurement. Data for per capita water resource availability was available for one year during the period under study but not the same year for each nation. Their solution in both of these instances was to replicate the single-year values they had over the years of missing data, thus reducing the reliability of their results. Thus, each nation's land degradation value for 1990 was used for every other year. The water resource availability data was available for different years between 1970 to 1997 with about half of the data from 1987. Again, Hague and Ellingsen replicated the single value across all years in their dataset.

The Homer-Dixon case studies have been criticized for choosing cases with both conflict and environmental scarcity (Levy 1995). Much of this criticism of Homer-Dixon's work is another episode in the perennial discussion over the merits of quantitative analysis over case studies; this discussion is neither new nor unique to the

question of environmental change and conflict yet it has generated a great deal of verbiage (Homer-Dixon 1994, Levy 1995; Homer-Dixon and Levy 1995; Gledditsch 1998; and Schwartz, Deligiannis and Homer-Dixon 2001). Case studies can be valuable to theory building and works by Graham Allison (1971) and Arend Lijphart (1975) are examples of such. Statistical and quasi-experimental designs are well suited to explain causal effects, to assess what seems to be happening. By aggregating data, large-N statistical studies lose the unique and valuable details of each individual observation. A statistical study can assess the health of the forest but is incapable of assessing the health of individual trees. Case studies are better suited to explore causal mechanisms - how it is happening. They lose sight of the big picture and their narrow focus limits the ability to generalize from their findings. Case studies are effective at assessing the health of individual trees but are ineffective at understanding the forest. Both analytical methods are required to show causality; the issue is not which method is better but whether the researcher has chosen the method appropriate to answer the questions raised.[9]

This analysis addresses the criticisms of the Homer-Dixon work by moving beyond case studies to conduct a quantitative analysis over a group of nations and a series of years that include varying levels of conflict and varying degrees of scarcity. This analysis addresses the shortcomings of Hauge and Ellingsen by extending the number of years covered back to 1965 or independence and forward to 2000. It will also introduce variation in the water resources variable by using meteorological data on total annual precipitation to provide a more robust data point.

[9] Robert Putnam effectively employs both in *Making Democracy Work*.

The ranges of existing data sets have also limited both the temporal and spatial scopes of quantitative conflict studies. As a result, they under represent developing nations in general, and African nations in particular. This study will cover all post-colonial years for each African nation beginning with 1965. It will also assess whether there are differences between the Cold War and post-Cold War periods; there is reason to suspect different causal dynamics at work during each period. African nations were the site of proxy wars during the Cold War. In the absence of a superpower rivalry, African leaders lost their patrons and foreign aid dollars which had flowed to Sub-Saharan Africa were redirected to nations of the former Soviet Union and Eastern Europe. Opposition groups in Africa have adapted, becoming more entrepreneurial and relying on natural resources to fund their arms purchases.

Both Timberlake and Tinker (1985) and Homer-Dixon (1995) cautioned that the complex interactions among polity, economy, society, and environment would make it difficult to clearly specify the relationships among them. Because of these interconnections among the variables, some multicollinearity will likely exist among the variables. This complexity also suggests that interaction among variables may be important. Likely candidates are interactions between population growth and precipitation and, between infant mortality and precipitation, and between GDP and precipitation.

The dependent variable in the case study literature is typically the particular conflict(s) in the nation(s) of interest. Large-N studies use a dichotomous dependent variable representing a battlefield death threshold or the ability of the state to exercise authority and political order. Conflict within a society exists not as a nominal level

variable, something that is present or absent; rather it encompasses a wide range of conditions from societal tension to armed conflict by insurgents against the state (revolution) or by the state against segments of its polity (genocide). Not all issues that will create tension within the society will provoke violence; yet most quantitative studies use a dichotomous dependent variable for conflict and each data set uses a different definition of conflict.

A more precisely defined dependent variable offers the possibility of discerning more specific conditions under which environmental change contributes to civil disorder. Operationalizing domestic conflict into mutually exclusive categories finer than the presence or absence of conflict is difficult because the definitions for different levels of conflict overlap. Environmental degradation may contribute to the outbreak of some levels of conflict but not others; alternatively, the manner in which the environment matters may differ across levels of conflict. Hauge and Ellingsen (1998) found a difference in the effect of environmental variables between low-level conflict and major conflict. This suggests that there may be differences across other levels of conflict.

One option for classifying each observation is by categories that differentiate among differing intensities of societal tension and conflict. Conceptually a continuous measure of the intensity or extensiveness of conflict makes sense. In practice it is very difficult, if not impossible, to objectively measure the quantity or the contentiousness of conflict hence the reliance on a dichotomous variable. A compromise could be to categorize according to type, but this solution is also fraught with difficulty. It is impossible to identify a fully inclusive set of mutually exclusive categories other than the presence and absence of conflict. States may experience more than one conflict type at

the same time (or during the same time period). Furthermore, if the objective is to construct a variable that reflects the continuum, a categorization scheme based only on type does do not qualify as interval, let alone ratio, level data. For these reasons, categories according to type must be rejected.

While falling short of the ideal more continuous variable, a categorization scheme based on level of conflict can provide more information than the single dichotomous variable and, therefore, this study will employ a dependent variable categorized according to level of conflict in addition to a dichotomous one.

The categorization by characteristics suggested by Wallensteen and Sollenberg (1997) is a second model for disaggregating the dichotomous dependent variable. Previous studies have provided no compelling reason to suggest that any one method of operationalizing conflict will be superior. Each has strengths and weaknesses. There may be value in contrasting the results of comparable analyses across different codings of the dependent variable. This study will contain a separate analysis using two different classification schemes for the dependent variable: 1) nominal yes-no categories used in the majority of quantitative studies on civil conflict and 2) categorization by level of conflict.

Before testing any hypothesis, the baseline model is compared model against the expectations set forth in the existing literature to confirm that the work is beginning from similar baselines. This will imitate studies by Henderson (2000), de Soysa (2002), and Collier and Hoeffler (2002) who find that the probability of conflict is a function of economic variables, political variables, social variables, and ethnic variables. Among the findings that this should confirm is the inverted U between regime type and conflict.

Dependent Variables

As noted above, a more finely parsed dependent variable offers the possibility of discerning more precisely defined conditions under which environmental change contributes to the outbreak of civil disorder. There are some options for the dependent variable data, both for the dichotomous dependent variable and for the categorical dependent variable. In quantitative research on civil war, the dependent variable is typically measured by one of a small number of data sets and, therefore, defined by the rules used to code the data. Most data sets begin with a definition of civil conflict that includes violence, interactions between insurgents and military forces of the state, and a threshold number of deaths in a year and/or over the course of the conflict that may or may not include civilians as well as combatants.

Singer and Small's Correlates of War Project is frequently used for studies with a dichotomous dependent variable. Wallensteen and Sollenberg's Armed Conflict data set and the State Failure Task Force are two of the more widely used sources for studies based on a categorical dependent variable. Civil war for Singer and Small requires a threshold of 1000 combined military and civilian deaths per year. Wallensteen and Sollenberg use three categories to classify intra-state conflict: minor armed conflict, intermediate armed conflict and war. Minor armed conflict requires a minimum of 25 battle-related deaths and no more than 1000 such deaths during the course of the conflict. Intermediate armed conflicts have fewer than 1000 battle-related deaths in any given year but break the 1000-death threshold for the conflict's duration. Conflicts are classified as war when they cross the 1000-death threshold in any given year. The State Failure Task Force (1999) work offers a second option for disaggregating conflict; they specified four

categories of severe political conflict and regime crises: revolutionary wars, ethnic wars, adverse or disruptive regime transition, and politicide/genocide.

While widely used and well regarded, these data sets fall short for a number of reasons. Two of the data sets fail to cover the years of interest in this study, 1965-2000. Singer and Small cover the years 1816-1992 while Wallensteen and Sollenberg's data cover the years 1989-2003. The State Failure Task Force data set begins with a definition of conflict that is limited to the end of the continuum that represents catastrophe; this limitation impedes the ability to apply the findings to a broader universe; it also precludes examining the effect of the independent variables across a broad range of conflict. An additional complication with this data is that any given conflict may be plausibly assigned to more than one category necessitating the use of a series of dichotomous variables for each type. Finally, Hauge and Ellingsen's findings that the environment is more important in low-level conflicts may indicate that the State Failure Task Force typology will not be a useful means to disaggregate the dependent variable in this study.

Monty Marshall's Major Episodes of Political Violence (MEPV) and Uppsala University's States in Armed Conflict Database (SACD) version 2.1 are two alternatives to Singer and Small, Wallensteen and Sollenberg, and the State Failure Task Force that cover the years of interest in this study and that have been coded across the full continuum of conflict. Marshall's Major Episodes of Political Violence is a list of 324 episodes of armed conflict for the period 1946-2006. The listing is a compilation from 16 sources, including Singer and Small's Correlates of War project and Wallenstein and Sollenberg's armed conflict data. Marshall does not attempt to mediate among the different data sets' definitions of conflict; if any data set classifies a case as being in

conflict, the Major Episodes of Political Violence data set codes thd case as being in conflict. For the purposes of this study, a nation year is coded as 1 for conflict if it is included in Marshall's list as being active during any of the years of interest and if the type is not listed as international. All years not coded 1 are coded 0 to indicate the absence of civil conflict.

The Uppsala University database, States in Armed Conflict Database, begins from the following definition of conflict: "An armed conflict is a contested incompatibility that concerns government and /or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths." Those cases classified as conflict are subdivided into categories following Wallenstein and Sollenberg, which was described above.

This research will examine cases of civil war in Sub-Saharan Africa from 1965 to 2000. The initial year, was chosen as a point in time when most Sub-Saharan African nations had gained independence and therefore had meaningful data available for inclusion in the analysis. The terminal year was dictated by the availability of precipitation data, a key independent variable. The latest year included in the Hague and Ellingsen analysis was 1992. This study seeks to extend that analysis to both cover a longer range of time and to test whether there are differences in conflicts during the Cold War and during the post-Cold War period. The unit of analysis is the nation-year, an annual observation for each of the 42 states in the data set. There are a total of 1512 nation-years with data and this comprises the universe. This study will use two different measures for the dependent variable. The first is a dichotomous variable, compiled from Monty G. Marshall's Major Episodes of Political Violence. It is coded 0 for the absence

of civil war and 1 for the presence of civil war for each nation year. The second dependent variable is multivariate and measures levels of conflict. It was compiled and coded by staff at PRIO in collaboration with the Department of Peace and Conflict Research at Uppsala University. It is coded 0 for the absence of civil conflict, 1 for cases of minor civil conflict, 2 for cases of intermediate civil conflict, and 3 for cases of civil war.

Independent Variables

Studies of civil conflict have found that variables such as regime type, a measure of economic development, the degree of ethnic homogeneity, per capita GDP, and export dependence are significant predictors of conflict in Sub-Saharan Africa. The studies on environment and conflict included measures for per capita GNP, regime type, income inequality, political instability, population density, deforestation rates, extent of land degradation, per capita fresh water resources, infant mortality, and the human development index. This analysis draws on the findings of both civil conflict and environmental conflict into a single model designed to reflect the complexity suggested by the literature; it includes a wide range of the social, economic, political, and environmental independent variables that these prior studies have found to be important predictors of conflict in Sub-Saharan Africa. The complete list is also compiled in Appendix B. All variables have been transformed as needed to conform to the requirements of a linear model.

Political Environments

The political variables measure the type of political regime; the duration of the regime; and the extent to which changes from one leader to another are regular and institutionalized, the election of the executive is competitive and open to non-elites, and the presence and openness of institutions for political participation. These variables will be taken from the Polity IV data. Regime stability (*p4durable*) is measured by the number of years the government has been in power and is expected to reduce the odds of conflict. The regime type variable (*p4polity*) is based on Polity IV indices for institutionalized democracy and autocracy. The regime type index will be obtained by subtracting the score for autocracy from the score for democracy, yielding a variable with a range of 10 (most democratic) to -10 (most autocratic). Following the consensus in the literature, this result has been squared (*politysq*) and is expected to vary inversely with conflict.

The effect of time on this analysis is accounted for in two ways. First, autocorrelation is a concern when country-year is the unit of analysis and the dependent variable measures the incidence of conflict. Nations in conflict have a high probability of being in conflict in the subsequent year; the same relationship holds true for years at peace as well. To reduce the effect this endogeneity has on the model and following the work of Hauge and Ellingsen (1998), the dependent variables will be lagged one year (*lagMEPV* and *lagSACD*). In accordance with existing theory, each lagged dependent variable is expected to vary positively with the dependent variable.

Second, there is reason to hypothesize that the major changes which occurred in the international system with the end of the Cold War affect the outbreak of African

conflicts. While the Hauge and Ellingsen study (1998) did not find a difference between Cold War and post-Cold War years, their data set ended in 1992, which may not have included enough post-Cold War years to detect discernable patterns. Hence this study will include a control variable coded 1 for each Cold War year (those years up to and including 1988) and 0 for each post Cold War year (all years 1989 and after). Further, this study will posit that Cold War (*coldwar*) will vary in opposition with conflict, i.e. conflict is more likely in post-Cold War years than in Cold War years.

The relationship between environment and conflict is mediated by institutions. Institution is not a concept that is easily quantifiable for two reasons. First, an institution is an abstract concept that can be measured only indirectly. Second, there are many aspects to the intangible constructs that could contribute to its effect. This study operationalized institutions in three different ways. The concepts of groupness and institutional inclusivity are discussed here; the capability to manage water resources is expanded upon below in a discussion specific to water variables.

Groupness is a construct which includes the fact that the individuals in a society have many identities, the extent to which those identities overlap, and the extent to which individuals depend on those identities for security; a variable has to be able to capture all of those meanings. Inclusivity represents the extent to which groups are empowered to participate in political decision-making as well as the extent to which the institutions enable groups to influence decisions. In addition, inclusivity can be directed at multiple levels of political institutions - local, provincial and national – as well as at the layers within those institutions that that work at other levels, for example the representative of a

national institution operating in a provincial or local field office. The variable that represents this construct must be able to incorporate all of those different nuances.

Were this study looking only at a time period proximate to the era of independence, a variable to indicate the colonial power might be an adequate cognate for an institutional variable because institutions at that time closely mirrored those of the colonial power. Since this analysis is looking at a much longer period that extends well beyond independence, institutional variables must be able to represent the dynamics of institutions over the entire course of the study. The indicators must also be able to capture as many aspects of the groupness and inclusivity concepts as possible. Inclusivity is the political aspect of the institutional factor and will be discussed here. Groupness, more representative of societal institutions, will be addressed in the section on the social environment below. There is some quantitative data on governance that would capture aspects of inclusivity at both national and lower governmental levels; unfortunately, these measures do not extend back much earlier than the mid-1980s and they do not fully cover the universe of Sub-Saharan African nations.

The Polity dataset includes a composite variable on executive recruitment that measures the competitiveness, the openness, and the regularity of the process by which political elites come to occupy their positions and is based on structural components that measure the transfer of executive power. Those structural components are (1) the regularity of the manner in which the chief executive is selected: unregulated seizure of power by force, the designation by the political elite in the absence of competition, or a regulated process governed by rules of hereditary succession or through competitive elections, (2) the extent to which the selection process affords non-elites an opportunity

to compete to join the political elite: an uncontested selection process or a competitive election with two or more parties or candidates, and (3) the extent to which the selection process, at least in principle, is open to all members of the polity: in nations with a single chief executive: closed to all but those with successions rights through hereditary descent or open to all; in nations with dual executives, one position closed to those with hereditary succession rights and the other selected by political elites, or one position closed to those with hereditary succession rights and the other selected through an election process.

Regular, open, and competitive elections are a means of empowering citizens to participate actively in political decision-making and choice of the chief executive is one means by which polity members are able to participate in and influence the political decision-making process; as noted earlier, the variable for institutional inclusivity must be able to measure societal groups' ability to participate in and to influence the political decision-making process.

Executive recruitment is a component of regime type and is highly correlated with it (0.51) but they are distinct variables. Polity is a scalar variable that weights the categorical component concepts differently. Thus, while the executive recruitment components are included in the polity measure, they are not included equally, either in proportion to one another or in proportion to the other component concepts. Furthermore, polity includes elements that are unrelated to inclusivity, such as the extent to which executive decisions are effectively constrained by a constitution, a legislature or a judicial system. Because of their high correlation, however, when executive recruitment is used to measure institutional inclusivity, regime type and regime type

squared will be dropped. This variable (*p4exrec*) is expected to vary inversely with conflict.

Executive recruitment fails to adequately represent the extent to which the empowerment and participation extend to local and provincial levels of government. This aspect of inclusivity will be captured through an index of civil liberties as reported by Freedom House. The Freedom House annual Freedom in the World survey measures freedom as experienced by individuals. They define freedom as the opportunity to act spontaneously in a variety of fields outside the control of the government and other centers of potential domination and their coding is derived from civil liberty as it is referenced in Universal Declaration of Human Rights. Civil liberty allows for the freedoms of expression and belief, associational and organizational rights, rule of law, and personal autonomy without interference from the state; the ratings generally reflect the interplay of a variety of actors, both governmental and nongovernmental and are therefore well-matched with the objectives of this study. Where executive recruitment represents the actions of political elites and decision-makers and the actions they take that provide for empowerment, civil liberties represents the actions of individuals and the extent to which they are able to take actions to participate in and to influence the actions taken by the political elite. Civil liberties is coded with 1 representing a high degree of civil liberties and 7 representing the absence of civil liberties, hence this variable (*civil_liberties*) is expected to increase the likelihood of conflict.

Patronage and clientelism, discussed earlier, are captured indirectly through the variables for regime type, minorities at risk, civil liberties, and executive recruitment. Political systems that rely more heavily on patronage networks are less likely to score in

the democracy range of the regime type variable or the open end of the executive recruitment scale. Similarly, a political system that is based on patronage networks is more likely to create conditions that will systematically disadvantage minority groups or that will limit the opportunities for individuals to freely express beliefs or to freely organize with others on behalf of those beliefs. While patronage might more easily be associated with the distribution of rents from marketable resources, it may also be an important factor in the state's decisions about the distribution of resources to relieve hardships caused by natural events related to water resources such as droughts or floods.

Economic Environments

The economic variables will indicate the opportunity for challenger groups to both organize and finance their ventures. Greater openness to trade increases the opportunity cost of civil war sufficiently to deter the most intense of civil conflicts but the increased trade that occurs with increased openness breaks down the internal ties among and between the groups in a society thus reducing the opportunity cost of lower level civil wars. Trade openness also represents the institutional capacity of a government to develop policies that will advance a regime's objectives, such as economic growth, poverty alleviation, or adaptation to environmental change, all of which could be expected to reduce the likelihood of conflict (Bussmann et al. 2005, Easterly and Levine 2003; Martin et al.2007). The trade openness variable (*tradeopen*) is calculated from the World Development Indicators data as the ratio of exports plus imports to GDP (World Bank 2001) and is expected to vary inversely with conflict.

Ford (1995) found the Mathusian assumption of a direct link between population pressure and environmental disaster to be false at the macro level. De Syosa (2002) used

population density in his work and found a direct positive effect on conflict. Goldstone (2001) disputes the direct causal effect and suggests that population's effect is context-specific, citing as examples rapid urbanization in combination with slow economic growth or an insufficient job supply in conjunction with an increase in the number of highly educated job seekers. Urdal (2005), looking specifically at the different aspects of population pressure espoused by Homer-Dixon and others, does not find that high population growth rates, high urbanization rates, or large refugee populations are associated with increased conflict.

The literature provides no consensus on population's effect and this study will follow the example set by Goldstone. The environment-conflict question is a sophisticated one that, thus far, has not lent itself to parsimony or direct effects. The data available for Sub-Saharan Africa over the 1965-2000 period is not robust enough to use urbanization or employment, therefore this study will include variables for both population and per capita GDP to approximate Goldstone's suggested contexts and will test Goldstone's assertion of an interaction effect. The model includes per capita GDP, taken from World Bank data (World Bank 2001), and population density, from UN Population Division data (United Nations Population Division 1999), as indicators of demand-induced scarcity. Economic growth, measured as per capita GDP (*gdpperca*) is expected to vary inversely with conflict; whereas population density (*popdense*) is expected to vary positively with conflict.

Social Environments

Ethnic identity is an important component of African societal structure, is an underlying factor in some African conflicts, is often a key to understanding how and why

political and economic goods are distributed as they are, and can approximate how social divisions in Sub-Saharan Africa operationalize the societal aspect of institutions. There are several options for using ethnicity to represent groupness in this model. One is the number of ethnolinguistic groups in the country. However a simple count of the ethnolinguistic groups cannot reflect vital information such as the relative size of the groups. Many researchers use a measure that captures the presence or absence of dominant groups, defined as the percentage of the population in the largest linguistic groups, but such a measure represents group size which is only one aspect of groupness in a society. Another option is to use the presence of minorities coded as being at risk by the Minorities at Risk project. Both an ethnolinguistic factionalization and minorities at risk variable would be coded 0/1 and be constant or nearly so for each nation across the years. Hence, from a methodological perspective, there is no advantage in using one variable over the other; neither introduces additional variation across the measurement of the construct. Most of the cited literature which includes a variable for ethnicity uses ethnolinguistic factionalization (Jenkins and Kpsowa 1990, Jenkins and Kpsowa 1992, Kpsowa and Jenkins 1993, Auvinen 1997, Henderson 1998, Elbadawi and Sambanis 2000, Henderson 2000, Henderson and Singer 2000, Collier and Hoeffler 2002, deSoysa 2002, Elbadawi and Sambanis 2002, Murdoch and Sandler 2002, Elbadawi and Sambanis 2003, Fearon 2005, Humphries 2005, Regan and Norton 2005). This study will employ the minorities at risk coding; it more accurately operationalizes the manner in which ethnicity represents groupness and thereby contributes to conflict. The presence or absence of multiple identities, in itself, would be neither necessary nor sufficient to contribute to conflict. Thus, ethnolinguistic factionalization, a measure that captures the

presence of a dominant group, is not the best choice for this variable. It is the systematic inclusion of groups in or exclusion of groups from government based on ethnic identity that creates the necessary preconditions for conflict. The Minorities at Risk Dataset defines a minority group as an "at-risk group" if the group collectively experiences discriminatory treatment and the group engages in political mobilization and collective action in defense or promotion of its self-defined interests. Minorities at risk (*MAR*) reflects the systematic exclusion of groups and is, therefore, a more appropriate choice for this variable; it is expected to vary with conflict. The Minorities at Risk Dataset could be used to code a variable to indicate the presence or absence of an at-risk minority group or to indicate the number of at-risk groups in the nation. Both codings were tested using correlation against all other variables in the baseline theoretical model and in the statistical models and yielded similar results. This study will use the dummy variable coding because its correlation coefficients were typically two to three percentage points lower than the categorical coding, indicating a somewhat smaller probability of a linear association with other variables.

The government's inability to provide for the basic needs of the population can be one source of grievance among the citizens that can contribute to the outbreak of conflict. Thus, this study includes a social variable that represents the government's ability to ensure the health and well-being of its people. There are many highly correlated indicators for basic health and education available to choose from including the numbers of doctors, nurses or clinics per capita; literacy rate; female literacy rate; and infant mortality. The human development index would also be a potential choice; however, it is not available for the full date range covered by this study. For this study, I use infant

mortality rate (*infmort*) because data, taken from UN Population Division, are available across the range of years and nations being studied and because the State Failure Task Force found it to be a strong indicator of a country's overall quality of life (State Failure Task Force 1999); it is expected to vary with conflict.

Natural Environments

The water-related hypotheses raise questions about the effect that changes in water resources and their interannual variability and that institutional capabilities to manage those resources have on conflict. The environment is represented in this model in three ways, as a measure of availability, which reflects scarcity; as a measure of environmental change, which when combined with availability indicates scarcity; and as a measure of the institutional capacity to manage water resources. Environmental change is represented in this model by two variables derived from total annual precipitation in the Tyndall Center's climate data, per capita precipitation and deviations from the 100-year mean.

The state of a nation's water infrastructure affects the extent to which it is vulnerable to or is prepared to adapt to changes in precipitation. Water infrastructure is physical structures, either natural or manmade, capable of storing water to deliver it during periods of low rainfall, both because of seasonal variations and because of drought. Water infrastructure is also structures, natural or manmade, capable of containing or alleviating the impact of flood waters. This infrastructure might take the form of dams, irrigation schemes, land use practices that periodically leave drought-prone lands fallow after several years of use or that leave flood-prone lands uninhabited during flood seasons. Each of these structures requires human institutions to ensure their

maintenance, and, in the case of manmade structures, also to manage their construction. Infrastructure is inversely related to risk: the higher or greater the infrastructure, the lower the risk. The presence of infrastructure represents capacity to adapt to both variability and extremes. In Sub-Saharan Africa drought is more common than flood, but the continent is vulnerable to both extremes. Sub-Saharan Africa is the more affected by drought than anywhere else in the world: in 2005 more than 20 million people were affected by drought in the Horn of Africa alone; drought is endemic to large swaths of Sub-Saharan Africa, in addition to the Horn, the Sahel, East Africa and southern Africa experience recurring drought every three to five years (United Nations Development Program, 2006, 157).

The poor are at greatest risk from weak infrastructure: they tend to work the least productive land, which will be the first to lose soil moisture during drought, or they tend to live and work in the lowest-lying and flood-prone areas, which are the first to flood, the most frequently hit, and the hardest hit by floods (United Nations Development Program, 2006, 157). As has already been discussed, Sub-Saharan Africa has a large and growing number of people in poverty and therefore, an increasing vulnerability to the debilitating effects of droughts and floods.

This study operationalizes institutional capacity to manage water resources and water resource infrastructure using measures for participation in treaties over shared water resources, World Bank lending for water projects and by the percent of irrigated cropland. Humans put water to use for irrigation more than for any other purpose. As a result, irrigation and agriculture are the largest consumers of water in a society. Furthermore, as a nation becomes more developed, the structure of water demand

changes to accommodate changes in diet, including the consuming more animal-derived protein, which requires more water to produce than grains (United Nations Development Program, 2006, 137). Previous studies have used per capita water resources as the environmental variable of interest (Hauge and Ellingsen 1998, Collier and Hoeffler 2002, and deSoysa 2002) but per capita water resources is available for only one year of the 35-year range covered in this analysis and the data for each nation is available for a different year. This study tests several alternatives that both introduce needed variation in the explanatory variable and that measure several different aspects of water's relationship to the political arena.

Building the Water Variables

Water resource availability is measured within political boundaries yet these political boundaries were arbitrarily drawn by colonial powers without regard for rivers – either their courses or their distribution across the land. Lacking a historical basis for the inclusion of a river in one nation or another and lacking a statistically supportable relationship between the number of rivers and the size of a nation, it is difficult to substantiate a claim of a relationship between the number of rivers and conflict. This study measures water resources using several different approaches, each of which captures, in a different manner, the means by which water resources are hypothesized to contribute to the presence of conflict in a nation. Not all potential approaches for measuring the various aspects of the water variable are equally robust; some have the same shortcomings as the original used by Hauge and Ellingsen: they are static and, as such, lack variation that would add to the insights we might gain from their use.

One static measure is the number of international river basins in each nation. As with the water availability variable, there is variation across nations but no variation across time; the number of river basins in any given country does not change unless the nation's borders change. A second static measure that probes the relationship between a nation and its water resources from a different perspective is the percent of the nation that lies within an international river basin. Rivers do sporadically change their course in response to floods as well as over the very long term as a result of the cumulative erosive force of the water as it travels over the material which makes up the riverbed. Softer materials will erode more rapidly than harder materials and thereby slowly alter the river's geospatial location. Changes in political boundaries may also cause a one-time change in the value of either of these otherwise unvarying variables.[10]

Both measures were calculated based on data on international river basins contained in Glecik's 2000-2001 biennial report on the world water resources. Neither of these measures was highly correlated with other possible water variables, and from that standpoint, either would thus be a good candidate for inclusion. They were tested in several models and were never found to be significant. While other variables that have been used are also never significant, these two were ultimately rejected because they lack a plausible theoretical argument to justify their inclusion in this study.

The human construct of a territorial boundary has no meaning to the geologic and geographic reality of a river basin. Nor have humans heeded river basins' drainage area when drawing boundary lines on a map; in fact, they have typically done the opposite and

[10] National borders have changed twice in Sub-Saharan Africa during the 35 years covered in this study, once with the independence of Eritrea from Ethiopia and again with the independence of Namibia from South Africa.

used the river as the boundary line thereby dividing the river basin among political entities. Hence, a variable to note the presence or absence of an international river basin in an Africa nation would have no meaning; every African nation has territory in at least one major transboundary river basin. Gleditsch et.al. (2006), in a study on international conflict and shared rivers reported that a regional variable for sub-Saharan Africa indicated less international conflict in the region than the rest of the world but noted that the finding is not as counterintuitive as it appears; most conflict in Africa is civil rather than international. If this effect spills over to the domestic arena, as African nations participate at different rates in international water treaties, they gain institutional capacity. The engagement in treaty-making is indicative of a nation's level of institutional capacity to successfully negotiate and sign international treaties while the actions necessary to fulfill the negotiated obligations are an indicator of a nation's institutional capacity to regulate the use of its water resources. Hence, the participation in treaties as well as the number of treaties to which a nation is a signatory are indicators that the nation possesses the institutional capacity to mediate among conflicting views and to address grievances without using violent force. Data on international treaties has been operationalized to represent institutional capacity: as the proportion of the cumulative number of water treaties signed to the number of international river basins. These variables have been coded using information on international treaties for water resources available from WATERLEX[11], the FAO's searchable online database of international agreements on international water sources, and the International Freshwater

[11] http://www.faolex.fao.org/waterlex/; accessed 10/22/2004

Treaties Database[12], a part of the Transboundary Freshwater Dispute Database. The variable for the number of treaties signed each year is coded as 0 for all years when no treaties were signed during the calendar year; for all other years the variables is coded with the integer which represents the number of treaties signed.[13] Those nations who were independent before 1965, the first year of the study, and who had signed international treaties governing shared water resources will have the cumulative number of water treaties signed as of 1965 as their initial value. The cumulative number of water treaties for each year is then calculated as the number of water treaties signed in that year added to the total number of water treaties signed in all prior years. It is reasonable to expect that the number of water treaties in which a nation engages is related to the number of international river basins within that nation's territory. Therefore, the variable is normalized by dividing the cumulative number of water treaties by the total number of river basins.

Another means that may be used to measure institutional capacity to manage water resources is through World Bank funding for water development projects. As with international treaties, this study asserts that a nation will have demonstrated a minimum level of institutional capacity to manage the funding and the development projects they support prior to project approval and receipt of the funds. While misuse of funds is certainly a problem across the continent, in general, those nations that proved themselves unable to manage the funds, complete the projects, and repay the debt were less likely to see additional funds for new projects.

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[12] http://ocid.cacse.org/tfdd/treaties.php; accessed 10/22/2004

[13] Most frequently, that integer is 1 but there are 26 nation years when it is a number greater than 1.

World Bank historical data on aid was the source for two variables on lending for projects that included water-related components such as dams (but not projects or amendments exclusively for electricity generation), irrigation, and sanitation. Each year that World Bank data showed a nation being awarded a water-related project, the value of the award is weighted by the average of that year's GNP and the preceding four years to control for the likelihood that larger economies are likely to receive larger loans and the fact that the funds are spent over time. Years in which no World Bank water projects are awarded are coded with a 0.

World Bank loans are typically multi-year but the data source did not consistently indicate either the duration of the funding or the start date. To simulate the effect of disbursing the funds over a period of time, a second variable is created that is a rolling average of all loans awarded in the current year plus the four preceding years. The value is then weighted by the annual GNP to account for the likelihood that larger economies are likely to receive larger loans.

As noted earlier, the measure for annual per capita water resource availability that Hauge and Ellingsen utilized was static across their study's temporal dimension and that limited the accuracy of their results. As a way to approximate the static water resources variable and introduce variation into that static variable, this study includes variables derived from total annual precipitation and the size of each nation. Total annual precipitation in millimeters is taken from the Tyndall Center's TYN CY 1.1 data set (Mitchell et al. 2002)[14] to create a measure of volume for each nation-year and is

[14] New et al. (2000) gridded total annual precipitation observations made by national meteorological agencies. The gridded data were aggregated using political boundaries by Mitchell and Hulme (2002).

multiplied by land area; it is then divided by 10 to approximate the thousand cubic liter volume and scale of Hague and Ellingsen's variable:

Total Annual Precipitation (mm) X Land Area ('000 Ha)/10

The result of this mathematical calculation is significantly larger than the rest of the dataset, therefore annual precipitation weighted by land area is log transformed to yield meaningful coefficients and effect sizes.

This variable is the foundation for the per capita precipitation variable used in the theoretical models. This measure will mirror per capita water resources used by Hague and Ellingsen and is derived by dividing annual precipitation weighted by land area by total population. The resulting variable, per capita precipitation, is expected to vary inversely with conflict. A connection between water resource availability and conflict might also be drawn through economic capacity; water is a necessary input to many, if not all manufacturing processes as an ingredient, as a coolant, or as a cleaning agent. Therefore, the per capita precipitation will be used in conjunction with an interaction term between per capita precipitation and per capita gdp..[15]

Precipitation is not constant from year to year. Ecosystems and human societies construct themselves knowing that the amount of annual precipitation tends to fall within

[15] One might expect that in economies with large agricultural sectors that precipitation, an important input in agriculture, would be highly correlated with GDP, making it difficult to discern whether the observed effect was due to precipitation of GDP. Correlations between GDP and precipitation are small and well within a range that is acceptable for inclusion as distinct variables. Bivariate correlation between annual precipitation in millimeters and gdp is -0.1403 and between the volume of precipitation per capita and gdp is -0.0975.

established bounds. Human societies decide where to build settlements and what size the settlements should be based, in part, on historical precipitation trends. Therefore, this study also includes a variable to measure the extent to which annual precipitation deviates from those historical trends. The difference between each nation-year's annual precipitation and the 100-year long-term average was calculated. The long-term average was that of the Twentieth century, 1900-2000. Deviations below the average indicate drought and deviations above the average indicate floods. Hence this variable can be expected to present a U-shaped relationship and is therefore also squared to meet the requirements of a linear model. It is expected to vary positively with conflict.

The vast majority of the African population relies on open streams or groundwater accessed via wells rather than reservoirs for their water needs therefore, annual precipitation data is a plausible substitute for the sparse water availability data. However, precipitation is not identical to per capita water availability; not all precipitation is available for consumption. Furthermore, a small number of rain gauges represent a very large area with a wide variety of precipitation patterns. Thus, it is necessary to test the viability of using a weighted precipitation variable as a proxy for water availability in African nations.

This validation was conducted using a two step process. First, total renewable water resources (Gleick 2000) was correlated against weighted precipitation (Mitchell, Hulme and New 2002). The renewable water figures are for a variety of years ranging from 1970 to 1992. In each case, the newly generated value for annual precipitation weighted by land area was included for the year to which the per capita water estimate is attributed. For example, renewable water resources for Kenya are available for 1990,

hence annual precipitation weighted by land area is taken from 1990, while renewable water resources for Ghana are available for 1970, hence annual precipitation weighted by land area is taken from 1970. Since the water resource availability figure represents the resources of the entire country, the precipitation figure, which is representative of a geographical point (or an average of multiple points) was multiplied by the total land area to provide a comparable nationwide measure.

The 0.77 correlation over 42 observations was strong enough to warrant further testing using the second step, a simple regression analysis with renewable water resources as the dependent variable and annual precipitation weighted by land area as the independent variable. Precipitation weighted by land area was significant at the 0.001 level and the R-square indicates that the weighted precipitation variable explains more than 60% of the variation in the water resource availability variable. Annual precipitation and population data are available with no missing values for all years of this study and the high correlation between the annual precipitation and water supply indicates that they are closely enough related to substitute the variable with data across the entire range of years under consideration for a variable with data for only one year of the 40-year time span.[4] The correlation table, regression results, and residual plot are reproduced in Appendix E.

[4]De Soysa (2002) used the same method to support substituting HDI for UNICEF's rate of progress and considered a correlation of 0.65 high enough to justify the replacement.

Description of Methods

This study employs Stata version 8 to analyze a series of theoretical models using regression-based statistical techniques on data gathered from international governmental organizations and academic research centers. The specific regression-based techniques are determined by the nature of the dependent variable and the extent to which the data are able to meet the underlying assumptions of the statistical tests. The objective is to ascertain whether the inclusion of variables on environmental change improves the ability to predict conflicts in Africa over models that rely primarily on economic and political variables. Many of the studies that comprise the existing literature have been conducted using a binary dependent variable and logistic regression therefore, the models are first tested using a binary dependent variable and logistic regression and are then tested using a categorical dependent variable and ordered logistic regression. These results are then compared to determine whether the data explain civil conflict better as a dependent variable with multiple categories or as a binary dependent variable. The use of multiple methods for coding the dependent variable is also used to ascertain whether environmental degradation contributes differently to the outbreak of particular levels of African conflicts. The different methods of operationalizing conflict will necessitate the use of statistical methods not typically used in studies of civil conflict.

In each case the baseline equation is:

Conflict = lagged dependent variable + tradeopen + p4polity + politysq + popdense + gdppercap + MAR + infmort + p4durable + coldwar.

The variables representing the numerous ways of operationalizing water resources are added, one at a time, to the baseline equation. The results are compared against the

baseline and against one another. The interaction variables are added, one at a time to the baseline equation and the results are compared against the baseline.

As discussed earlier, conflict is a continuum and the dependent variable drawn from the SACD dataset has to be thought of as an imperfect representation of that continuum. A model based on a continuous dependent variable cannot be tested using ordinary least squares regression; the dependent variable codings push the limits of several assumptions inherent in ordinary least squares regression, including that the range not be truncated and that the data be interval or near interval. While the zero to three range of the SACD data is considerably greater than the zero to one range of the MEPV data, it is not sufficient to effectively or reliably use ordinary least squares regression. Furthermore, the data, while certainly possessing characteristics of ordinality inherent in the scale of battlefield deaths used to determine the coding, do not reach the degree of intervalness required for ordinary least squares regression.

Therefore, this analysis is also run using ordered logistic regression rather than ordinary least squares regression. As already noted, the levels of the dependent variable are clearly ordinal and coded from least (no conflict) to greatest (war). Ordered logistic regression, like all statistical tests, has its own set of limiting assumptions. Ordered logistic regression is based on the proportional odds assumption, also referred to as the parallel odds assumption; this assumes that the coefficient for each independent variable is the same across all categories of the dependent variable.

The results of both statistical models are then examined to ascertain the extent to which the model fits the data. There are some variations in the specific tests used to judge the fit of each model; however, there is a common set of statistical tests to verify

the validity and significance of each model. First, the likelihood ratio chi squared test, tests the null hypothesis that no linear relationship exists between the dependent variable and the combined independent variables.

The second statistical test used to verify the model is one that endeavors to mimic the R-squared statistic of ordinary least squares regression, which represents the proportion of variance in the dependent variable explained by the independent variables; R-squared varies between 0 and 1. Because variance in logistic regression-based models depends on the distribution of the dependent variable, there is no analog to R-squared however, there are several alternative tests, generally called pseudo R-squared, that endeavor to approximate the R-squared and are all hampered by their inability to range from a minimum of 0 to a maximum of 1. The tables displaying results for each model include both McFadden and Nagelkerke pseudo R-squared values so that the reader may see the differences however, the discussion refers only to McFadden's pseudo R-squared.

Each logistic-based statistical model has post-estimation tests available to assess the model's ability to fit the data. Logistic regression is an attempt to predict with accuracy whether a case falls into one or the other of the two dependent variable categories. Stata's lstat command yields a two by two table illustrating how the model predicted the cases and percentages of cases that are correctly classified overall.

An underlying assumption in ordered logistic regression is that the model is comprised of multiple equations, each with the same coefficients and unique constants, known as the parallel odds or proportional odds assumption. A Brant test is run on all ordered logistic models to determine whether that assumption is true for the model.

Brant indicates the validity of the assumption for the model as a whole and for the individual independent variables.

Chapter 4: Discussion of Results

The baseline model used in this analysis drew from two related yet distinct literatures: literature on civil conflict in general as well as studies on civil conflict in Africa and literature on the environment and conflict. The intent is to demonstrate that a combination of these two approaches into a single model better reflects the complexity suggested by the literature by including a wider range of the social, economic, political, and environmental independent variables that these prior studies have found to be important predictors of conflict. This chapter will begin with a review of the baseline model to ascertain whether the variables selected follow the expectations set forth in the existing work. The discussion will then proceed to consider the evidence as presented by the data confirms the hypotheses set forth earlier; this discussion will be arranged to follow three themes "Does the Environment Matter?", "Under What Circumstances?", and "By What Means?"

This chapter will show that the environment does matter and that water resources increase the likelihood of conflict by reducing the opportunity costs of engaging in conflict for opposition movements. Rather than depending on the revenue generated from a resource, this chapter will show that increases in water resources create conditions that result in a surplus labor force in search of an income and that opposition movements promise of income thereby "employs" the surplus labor.

This chapter will further show that water resources increase the likelihood of higher-level conflicts and that changes in water resource availability have greater explanatory power on intermediate-level conflicts and war. This chapter will not find

that water resources beyond a threshold level of scarcity increase the odds of conflict but will show that surplus water resources reduce the odds of conflict. Further, this chapter will show that low-level conflict is more likely in the post-Cold War and that changes in long-term water resources are more likely to contribute to post-Cold War conflicts.

Finally, this chapter will show that institutional capacity alone has a strong influence on the likelihood of conflict and that the relationship between institutional capacity and conflict is complex, and at times, contradictory. Open political systems reduce the likelihood of conflict but the capacity to manage water resources increases that likelihood. This chapter will not find evidence that environmental stressors exacerbate existing political weaknesses or that greater civil liberties mediate the relationship between water resources and conflict, nor will this chapter will show that open political institutions mediate the effect of precipitation on conflict by increasing the opportunity cost of engaging in violence against the state.

Baseline Model

It is necessary to pause for a moment to clarify the nomenclature for the terms theoretical model and statistical model. The former term will be used to refer models which are the result of the addition of an explanatory variable to the baseline. The latter will be employed when distinguishing among the use of logistic regression, ordered logistic regression.

In general the variables in the baseline equation conform to expectations for the direction of the relationship as established by existing research (see Table 3): the lagged dependent variable, per capita gross domestic product, the presence of minorities at risk, and higher levels of infant mortality all increase the odds of a nation being in conflict and

openness to trade, regime type squared polity, population density, and Cold War reduce the odds of conflict, all as expected. The only anomaly is for political stability. While the variables in the baseline model generally follow expectations for direction of relationship with conflict, several do not meet any significance criteria. Infant mortality provides the most surprising anomaly given its role in the State Failure Force Task study as an indicator for social well-being. The other variables that fail to meet the significance test are political stability and population density. The implications of these results are discussed below. The baseline variables are reasonable initial characterization of the explanatory factors in civil conflict.

The various measures of model fit suggest that the baseline model fits the data reasonably well. Knowledge of the independent variables reduces the error beyond what would be obtained by chance by 69.7% and the model correctly classifies 94.1% of the observations.

Baseline Variables

Regime type squared generally conformed to expectations in terms of varying inversely with conflict; this confirms previous findings that the more democratic or authoritarian a government, the less likely it is to experience civil conflict. However, the variable's significance was not as strong as previous literature indicated could be expected; it was significant at some level, including the 0.10 threshold, across every statistical model and theoretical model and, in the few cases when it was not, its p-value was within thousandths of a percentage of the 0.10 threshold. In addition, its effect size is relatively small; a unit increase or decrease in the regime type score changes the odds of conflict by 1.4 percent.

One baseline variable that was surprisingly unremarkable was the length of time since the last regime change. The coefficients for political stability neither met the expectation that the indicator would vary inversely with conflict nor were they ever significant, even at the 0.10 level, across any of the theoretical models using logistic regression as the statistical test. This intriguing result will be explored in detail in the discussion of Hypothesis 6 on environmental change and regime stability.

The lagged dependent variable conformed to expectations; it was significant at greater than 0.0000 and varied positively with conflict across all statistical models and across all theoretical models. The large effect size provides strong confirmation for prior research, which asserts that a nation's state of peace or conflict in the prior year is a strong predictor of peace or conflict in the subsequent year.

Trade openness also conformed to expectations; it was significant at least 0.05, and often to 0.001, and varied inversely with conflict across all statistical models and across all theoretical models. Trade openness has a significant impact on conflict; for each percentage increase or decrease in trade openness, the odds of conflict increase or decrease by 1.7 percent. Although the statistical model for ordered logistic regression as a whole failed to meet the parallel odds assumption, the trade openness variable did meet this condition indicating that openness to trade consistently predicts conflict across the continuum represented by the categories. The results of this study confirm that openness to trade increases the opportunity cost to rebels of engaging in civil conflict.

A nation's per capita gross domestic product failed to meet the expectations set by previous studies. In the few theoretical models where per capita gross domestic product

is significant, it is always art of an interaction with other variables. Further discussion of per capita gross domestic product will occur at those points in the analysis.

Population density failed to meet the expectations set forth by the previous studies that espouse population pressures as driver of civil conflict. It was rarely significant but the sign supported the assumption that population density varied with conflict. Recall that the literature was inconclusive on the population variable and that Goldstone suggested one ought not to consider population growth and economic growth separately but in tandem; that the synergistic effects of changes in economic conditions with changes in demographic conditions was the more appropriate lens through which to search for effects. The interaction term between population density and growth in gross domestic product was not significant, and in fact was so unremarkable that the results are not included. This study supports the finding of Urdal (2005); countries experiencing population pressures are not also experiencing and increased likelihood of civil conflict.

It was noted earlier that the literature has failed to produce a consensus on the role that population pressures play in contributing to civil conflict. Previous findings ranged from a direct positive effect between population density and conflict, no significant relationship between population and conflict, and a suggestion that the relationship is contextual. This research cannot confirm either the direct positive effect or the contextual relationship between population and economic conditions. This research does support the claim that the Malthusian assumption of a link between population and environmental conflict does not hold.

The presence of at-risk minorities, an indicator of social division and ethnic tension, provided support to affirm the importance of ethnicity in Sub-Saharan African

conflicts. Although universally positive, as expected, it was not always significant at the 0.05 level but did always meet the 0.10 threshold; in the baseline theoretical modes, where there is greater confidence in the finding of significance, the presence of a minority group at risk of experiencing discriminatory action increases the odds of conflict by more than 150 percent. Further comment on at-risk minorities as an indicator of group inclusivity or exclusivity is reserved for the discussion below on Hypothesis 9.

The lack of significance of infant mortality in the baseline model and across all theoretical models and all statistical models was one of the more surprising findings. The lack of significance is particularly curious given its role as an indicator of well-being in the State Failure project. The variable always confirmed the assumption that it would vary with conflict but was never significant, not even at the 0.10 level. The differences in the findings may be attributable to the different dependent variables. Recall that this study considered using the State Failure Task Force categories as the dependent variable and rejected them because they represent only the catastrophic end of the conflict continuum. The difference in findings between this study and the State Failure Task Force study indicate that the State Failure Task Force's work is more akin to the "canary in the coal mine"; it is able to detect the "deleterious living conditions" only in the most extreme cases of conflict (State Failure Task Force 1999, 51).

The baseline model, on the whole, performed as expected, indicating that this baseline model accurately reflects current understanding about the nature of conflict in Sub-Saharan Africa. As such, it presents a valid starting point against which to judge whether and how water scarcity and institutions affect the odds of civil conflict across the continent.

Table 3: Odds of Civil Conflict in Africa, 1965-2000 Logistic Regression			
	Baseline	Precipitation per capita	Difference from long-term average
	b/se	b/se	b/se
lagged dependent variable	4.6709 *** 0.2599	4.7308 *** 0.2817	4.6991 *** 0.2632
trade openness	-0.0172 *** 0.0049	-0.0092 0.0060	-0.0170 *** 0.0049
regime type	-0.0202 0.0337	-0.0164 0.0378	-0.0216 0.0337
regime type squared	-0.0144 * 0.0064	-0.0138 * 0.0070	-0.0145 * 0.0064
population density	-0.0003 0.0028	0.0005 0.0032	0.0000 0.0028
per capita gdp	0.0000 0.0002	-0.0008 * 0.0004	0.0000 0.0002
minorities at risk	1.0639 ** 0.3937	0.7289 + 0.4155	1.0636 ** 0.3929
infant mortality	0.0060 0.0046	0.0084 0.0051	0.0060 0.0046
political stability	0.0095 0.0090	0.0099 0.0111	0.0092 0.0090
Cold War	-0.7863 * 0.3125	-0.8617 ** 0.3295	-0.8012 * 0.3125
difference from long term precipitation			-0.7206 0.6877
precipitation per capita		-0.0003 0.0002	
precipitation per capita X gdp		0.0001 ** 0.0001	
constant	-2.9114 *** 0.8072	-3.2027 *** 0.9040	-2.9970 *** 0.8138
N	1224	1119	1224
Chi squared	732.8223	685.1202	733.8636
log likelihood	-236.5357	-204.9724	-236.0151
pseudo R squared	0.6077	0.6256	0.6086
nagelkerke R squared	0.7189	0.7336	0.7196
Correctly Classified	94.12%	94.55%	94.12%
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level			

Does the Environment Matter?

H1: Models of civil conflict that include environmental variables are better predictors of that conflict than models without environmental variables.

This study employed two different variables to represent water resources: annual per capita precipitation and difference from the 100-year precipitation average (1900-2000). The first is a measure that approximates, on a per capita basis, the volume of water available for use currently in the environment and the second is a measure of environmental change. It is most plausible to assert that water resources will have an effect on the incidence of conflict as the quantity of precipitation and changes in its timing affect ongoing trends in a nation's demography or economy thus the use of a measure of precipitation available per capita and its interaction term with per capita gdp.

The following discussion will first consider how the each of the variables performed and then turn to considering whether the assembled evidence confirms or fails to confirm the stated hypothesis. Although the study has utilized different variables to represent the different manners in which changes in environmental conditions might contribute to conflict, finding evidence that the addition of any one of the these variables results in a better fitting model will be sufficient to confirm the hypothesis. All results are displayed in Table 3.

Total available precipitation per capita conforms to expectations and varies inversely with conflict but fails to meet any threshold of significance. This construction of the variable most closely resembles the measure Hague and Ellingsen used in their 1998 study and these results, which represent variation across time, cast significant doubt on their finding of a relationship between per capita water availability and conflict. The

precipitation variable based on the difference from the 100-year precipitation average was also never significant, although it always varied with conflict, as expected. The results of this study do demonstrate that precipitation during the last thirty five years of the Twentieth Century has not varied significantly enough outside of the ranges established during the course of the century to have a discernable effect, this despite the fact that during the same period, average global temperatures were setting new records.

This study provides some evidence to support an assertion that water resources are a function of economic output and are a reliable predictor of conflict in Sub-Saharan Africa. The interaction term of per capita precipitation and per capita gross domestic product is significant at the 0.01 level although the effect size is negligible. A one-unit increase in the interaction term changes the odds of conflict by less than 0.05 percent; every other variable has a larger effect on the odds of conflict than per capita precipitation and the interaction term.

Having established that water resources do contribute, albeit in a very small manner, to the incidence of civil conflict in Sub-Saharan Africa, the discussion will next turn to consider whether the weight of the evidence supports an argument that a particular conceptualization of the water resource variable is more effective than another. There are several statistical tests that can provide insight into the effectiveness of the theoretical models. The R-squared statistics discussed above are one means. These generally find that per capita precipitation produces the larger R-squared, albeit by a small amount; the difference between the largest measure and the smallest for each theoretical model was one percent.

The Bayesian information criterion is another measure of the overall fit of a model and provides a means to compare across models whether or not they are nested. The measure is known to preference more parsimonious models and thus may not be the most appropriate choice for comparisons between the baseline and other models that have more variables. It can however, be used to compare the results among the theoretical models to aid in determining which of the theoretical models for precipitation best fits the data on Sub-Saharan African conflict which have the same number of explanatory variables and differ only by the water resource variables in question. This measure preferences per capita precipitation over difference in precipitation from the long-term average by more than 50 points. Deviance reflects the error associated with the model when all of the independent variables are included: the smaller the deviance, the better the fit. Using deviance as a measure of the overall fit of a model also preferences per capita precipitation over difference in precipitation from the long-term average.

This study supports the hypothesis that water resources contribute to conflict in Sub-Saharan Africa. While the expectation was for the precipitation per capita to vary inversely with conflict and thus provide confirmatory evidence for an assertion of scarcity contributing to conflict, instead the data strongly support the opposite that abundance water resources reduce opportunity costs for rebels to recruit. Since the scarcity argument has some validity, both theoretically and in past empirical tests, perhaps the relationship between water and conflict is not limited to either extremes of scarcity or abundance, but to both. This possibility is tested in Hypothesis 2 and the results are found on Table 4.

H2: Water resources exhibit a U-shaped relationship with respect to conflict: extremes of both scarcity and abundance increase the probability of conflict.

This hypothesis is tested using annual precipitation's deviation in percent from the average precipitation of the Twentieth Century. It is necessary to use percent change from a long term average and not actual change because nations have widely varying amounts of precipitation available for use and is large changes from the norm that will generate stress. To illustrate, a three-inch change in precipitation in a nation that typically receives an average of three inches of precipitation per year is a catastrophic change whereas a three-inch change in annual precipitation to a nation whose average is 100 inches per year is within the boundaries of normal variation.

The results of this analysis cannot confirm Hypothesis 2, nor, therefore provide evidence that episodes of both drought and flood contribute to destabilizing governments. Hypothesis 2 has established that there is neither a linear nor a curvilinear relationship between annual precipitation's deviation from a long-term mean. This study will later test whether there is a threshold of scarcity that must be crossed before a relationship is apparent.

Table 4: Water Resources U-Shaped Logistic Regression		
	Difference from long-term average	Squared difference from long-term average
	b/se	b/se
lagged dependent variable	4.6991 *** 0.2632	4.7045 *** 0.2640
trade openness	-0.0170 *** 0.0049	-0.0166 *** 0.0049
regime type	-0.0216 0.0337	-0.0215 0.0338
regime type squared	-0.0145 * 0.0064	-0.0143 * 0.0064
population density	0.0000 0.0028	0.0000 0.0028
per capita gdp	0.0000 0.0002	0.0000 0.0002
minorities at risk	1.0636 ** 0.3929	1.0720 ** 0.3930
infant mortality	0.0060 0.0046	0.0060 0.0046
political stability	0.0092 0.0090	0.0094 0.0089
Cold War	-0.8012 * 0.3125	-0.7957 * 0.3121
difference from long term precipitation	-0.7206 0.6877	-1.1444 0.9489
difference from long term precipitation squared		-1.0419 1.7620
constant	-2.9970 *** 0.8138	-3.0275 *** 0.8145
N	1224	1224
Chi squared	733.8636	734.3156
log likelihood	-236.0151	-235.7891
pseudo R squared	0.6086	0.6089
nagelkerke R squared	0.7196	0.7200
Correctly Classified		
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level		

Summary: Does the Environment Matter?

The environment, operationalized as water resources, matters, albeit with some new understandings. Water as a function of per capita water availability and economic output is a reliable predictor of conflict, albeit with a very small effect. Contrary to previous findings on water resources, it is abundance of water, not its scarcity, that increases the likelihood of conflict. Water's largest contribution to Sub-Saharan economic output is through agriculture and in a rain-fed economy surplus water contributes to a surplus labor force in search of an income and thereby reduces the opportunity cost participating in conflict.

Under What Circumstances?

H3: Water resource scarcity is more likely to contribute to low-level conflict than to intermediate-level conflict or war.

This hypothesis will be tested using two different methods: ordered logistic regression and a series of logistic regressions with the dependent variable coded for the absence or presence of any level of conflict, low-level conflict, intermediate-level conflict, and war. In both methods, the dependent variable is based on the conflict categories defined by the States in Armed Conflict Database.

An ordered logistic regression model requires that the dependent variable categories be rank ordered while allowing for unequal or unknown distances between the categories. This statistical model assumes that the dependent variable is by nature continuous but observable only as categories. Civil conflict, as previously described, meets this assumption. The States in Armed Conflict Database's categories can be rank ordered and are coded from lowest, no conflict, to highest, war. An inviolable assumption of ordered logistic regression is that the model comprises multiple equations with the same betas (coefficients) and different intercepts (constants); it is also referred to as a proportional odds model. Using ordered logistic regression will test the hypothesis that the effect of environmental change differs across the various levels of conflict.

The baseline theoretical model (Table 5) performs in a manner similar to the baseline model using logistic regression: the lagged dependent variable, per capita gross domestic product, the presence of minorities at risk, and higher levels of infant mortality all increase the odds of a nation being in conflict and openness to trade, regime type

squared, and Cold War reduce the odds of conflict, all as expected. Only population density and political stability do not have signs in the expected direction, while population density, per capita gross domestic product, and infant mortality are not significant at any level. The interesting anomaly in the comparison of this theoretical model with the baseline logistic regression model is that the length of time since the last regime change becomes significant in this model but the direction of the relationship remains counter to expectations. A close examination of the data reveals that over a range of zero to 89, a quarter of the nation years have a value of two or less, more than half of the nation-years have a value of less than seven, and the mean is 12.1.

As with logistic regression, the R-squared statistics are not interpretable in the same manner as ordinary least squares regression. They will have a lower bound of 0 but the upper bound is some unknown number less than 1, making it difficult to determine whether the resulting statistic constitutes a good fit between the theoretical model and the data. Nonetheless, R-squared-like statistics of 0.4792 for pseudo R-squared (McFadden), 0.4693 for adjusted McFadden R-squared, and 0.4869 for Nagelkerke R-squared do not provide convincing evidence that the ordered logistic model is a good fit for the baseline data.

Adding either of the two water variables, per capita precipitation and difference in precipitation from the long-term average, failed to confirm the hypothesis using ordered logistic regression, however, there is evidence indicating that the odds are not equal among the conflict levels. Neither variable was significant at any level and the R-squared statistics were similarly low.

Table 5: Odds of Civil Conflict in Africa, 1965-2000
Ordered Logistic Regression

	Baseline	Precipitation per capita	Difference from long-term average
	b/se	b/se	b/se
lagged dependent variable	2.2937 ***	2.3424 ***	2.2936 ***
	0.1220	0.1353	0.1220
trade openness	-0.0112 **	-0.0063	-0.0113 **
	0.0038	0.0045	0.0038
regime type	-0.0183	-0.0159	-0.0181
	0.0277	0.0319	0.0278
regime type squared	-0.0146 **	-0.0151 *	-0.0146 **
	0.0053	0.0060	0.0053
population density	-0.0019	-0.0018	-0.0020
	0.0020	0.0024	0.0020
per capita gdp	0.0000	-0.0004	0.0000
	0.0001	0.0003	0.0001
minorities at risk	1.0507 **	0.7574 *	1.0525 **
	0.3353	0.3513	0.3360
infant mortality	0.0040	0.0068 +	0.0040
	0.0035	0.0039	0.0035
political stability	0.0147 *	0.0166	0.0149 *
	0.0070	0.0102	0.0070
Cold War	-0.4642 +	-0.6012 *	-0.4642 +
	0.2464	0.2665	0.2467
precipitation per capita		-0.0003	
		0.0002	
precipitation per capita X gdp		0.0001	
		0.0000	
difference from long term			0.2394
precipitation			0.5550
constant 1	2.6723 ***	2.8097 ***	2.6415 ***
	0.6378	0.7050	0.6414
constant 2	4.4196 ***	4.6637 ***	4.3877 ***
	0.6641	0.7398	0.6678
constant 3	5.4101 ***	5.6183 ***	5.3773 ***
	0.6836	0.7608	0.6874
N	1218	1113	1218
Chi squared	812.7677	733.8998	812.9564
log likelihood	-441.6343	-370.3963	-441.5400
pseudo R squared	0.4792	0.4977	0.4793
nagelkerke R squared	0.4869	0.4828	0.4870
brant_chi2	73.4934	-148.3494	73.4900
brant_p	0.0000	1.0000	0.0000

*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level

Table 5: Odds of Civil Conflict in Africa, 1965-2000 Ordered Logistic Regression			
	Baseline Brant chi2/p	Precipitation per capita Brant chi2/p	Difference from long-term average Brant chi2/p
lagged dependent variable	13.9175 0.0010	15.1519 0.0005	14.1605 0.0008
trade openness	0.1057 0.9485	0.7731 0.6794	0.1016 0.9505
regime type	0.3383 0.8444	1.7118 0.4249	0.3589 0.8357
regime type squared	0.7958 0.6717	3.5797 0.1670	0.7929 0.6727
population density	5.6102 0.0605	5.1315 0.0769	5.8161 0.0546
per capita gdp	1.2156 0.5446	0.6596 0.7191	1.1265 0.5694
minorities at risk	5.6754 0.0586	1.8589 0.3948	5.6401 0.0596
infant mortality	0.8553 0.6521	0.5631 0.7546	0.8546 0.6523
political stability	0.9804 0.6125	0.9419 0.6244	0.9869 0.6105
Cold War	8.1254 0.0172	10.2163 0.0060	8.1046 0.0174
precipitation per capita		13.4046 0.0012	
precipitation per capita X gdp		2.6605 0.2644	
difference from long term precipitation			0.7274 0.6951

Other measures to assess the ordered logistic regression model's overall fit indicate that the model does not fit the data well. As observed in the logistic regression model, alternatives to R-squared are in the 0.48 range. Intrinsic to ordered logistic regression is the parallel (or proportional) odds assumption, which specifies that the model be a multi-equation model in which the beta coefficients are identical for each independent variable (Long and Freese, 2003). The post-estimation Brant test confirms that all theoretical models violate the parallel odds assumption. Therefore, the hypothesis will be tested with a series of dichotomous variables coded from the categories of conflict as defined by States in Armed Conflict Database.

Table 6 presents the frequencies of the four categories.

Table 6: SACD Conflict Categories

	Frequency	Percent	Cumulative percent
Any conflict	1094	77.59	77.59
Low conflict	109	7.73	85.32
Intermediate conflict	47	3.33	88.65
War	160	11.35	100.00

The distribution of cases across the categories reveals that intermediate-level conflict has too few cases to stand alone. Intermediate-level conflict could plausibly be combined with either low conflict or war. Because the coding of intermediate conflict includes a requirement that total number of deaths cross the 1000-person threshold and the coding of war requires an annual total person death threshold of 1000, intermediate level conflict will be combined with war when generating the series of dichotomous variables. Thus the four categories of conflict as defined by the States in Armed Conflict Database will be used to generate three dichotomous variables: 1) any conflict, where zero is assigned to all cases with no conflict and one is assigned to all cases at any level of conflict; 2) low

conflict, where zero is assigned to all cases that are not coded as low level conflict and one is assigned to all cases coded as low-level conflict; and 3) intermediate-level conflict combined with war, where zero is assigned to all cases coded as no conflict or low-level conflict and one is assigned to all cases coded as intermediate-level conflict or war.

The baseline variables (Table 7) reveal some differences between the models using States in Armed Conflict Database categories of conflict and the Major Episodes in Political Violence dichotomous variable. Infant mortality, which has hitherto failed to register as significant, is significant in the no conflict model, suggesting that the universe of cases has a significant effect on the results. The universe of cases in the model using Major Episodes in Political Violence is not identical to the universe in the model using the States in Armed Conflict Database categories. The former has data for all countries and all years 1965-2000; the latter covers only post-independence years for each country. Hence, cases in the Major Episodes in Political Violence model that were not yet independent by 1965 but have infant mortality data available are included in that baseline model. In contrast, those same cases, nations not yet independent, have no data in the model using the States in Armed Conflict Database categories and the nation-years without data are dropped when running the statistical tests. These results, therefore, suggest that post-independence, infant mortality is a reliable predictor of conflict.

The discussion will now turn to consider how the baseline variables perform across the three levels of conflict. The majority of the variables perform consistently whether the dependent variable is any conflict, low-level conflict, or intermediate-level conflict and war. Minorities at risk is an interesting exception; it varies considerably across the three levels of conflict; the odds of low-level conflict in a nation with a

minority at risk are twice as high as the odds of war. These results affirm that ethnicity itself has not typically been the source of conflict on the continent; rather it has been the means by which mobilizers have been able to generate support for other causes. The minorities at risk indicator was selected for this study over the more widely used ethnolinguistic factionalization variable on the basis that it better represented the systematic inclusion or exclusion of groups from the government. The results indicate that nations that exclude groups from participation in the polity based on ethnicity are more likely to experience low-level conflict than intermediate level civil conflict or war.

Having established the continued validity of the baseline model, the discussion now considers whether the evidence can support the hypothesis. The volume of per capita precipitation varied in significance and in effect size across the categories. It was significant in distinguishing between the presence and absence of conflict and in distinguishing low-level conflict, but generally, only at the 0.10 level however, the effect size is negligible for both per capita precipitation and the interaction term between per capita precipitation and gross domestic product. The single exception is for per capita precipitation in the low-level conflict model where a one-unit change in the annual volume of water available per person reduces the likelihood of conflict by 0.1 percent. As discussed above, the States in Armed Conflict Database includes only the years each nation was independent; therefore, the missing cases will be from the Cold War years. This suggests that the results are influenced by the selection of cases. These differences also suggest that there may be differences in the causes of conflict from the Cold War to the post-Cold War. This possibility will be explored further under Hypothesis 5.

The water resource variable fails to provide convincing evidence confirm that changes in water availability are more likely to contribute to low-level conflict than to intermediate level conflicts or war, while the variable is significant, its effect size is very small. These results are inconsistent with Hague and Ellingsen (1998, p. 314) who found that environmental degradation had a stronger impact on the incidence of smaller armed conflicts than on larger ones; size for Hague and Ellingsen was determined by the number of battlefield deaths proportionate to total population. An important difference between Hague and Ellingsen's study and this study might account for the different results: Hague and Ellingsen assess deaths across the four-year period 1989-1992 whereas this study's dependent variable is based on deaths across a 35 year time span. This study's findings suggest that, in Sub-Saharan Africa during the post-colonial era, precipitation is not a strong predictor of low-level conflict.

The findings with respect to infant mortality in the baseline cases raise an intriguing question in light of the decision not to use the State Failure Task Force categories as a categorical dependent variable. Recall that the State Failure Task Force data categorizes conflicts as genocide, ethnic wars, revolutions, and adverse regime changes. While the decision to reject the data as a dependent variable for the purpose of examining the effects of water resources on various levels of conflict remains valid, the results above suggest that using these categories as a dependent variable might produce useful results in identifying which types of catastrophic conflict might be influenced by variations in water resource availability and whether or not the mobilization explanation holds in those cases.

Table 7: Water Scarcity and Levels of Conflict			
	Any Conflict	Low Level Conflict	Intermediate Level Conflict and War
	b/se	b/se	b/se
lag any conflict	3.8544 ***		
	0.2210		
lag low-level conflict		2.6011 ***	
		0.2731	
lag intermediate conflict			5.9517 ***
and war			0.3794
trade openness	-0.0128 **	-0.0032	-0.0155 *
	0.0041	0.0046	0.0067
regime type	-0.0378	-0.0113	-0.0687
	0.0285	0.0327	0.0533
regime type squared	-0.0196 ***	-0.0152 *	-0.0234 *
	0.0057	0.0064	0.0096
population density	-0.0009	-0.0013	0.0017
	0.0024	0.0027	0.0036
per capita gdp	0.0002	0.0002	0.0001
	0.0002	0.0002	0.0003
minorities at risk	1.0211 **	1.3920 **	0.7842
	0.3227	0.4982	0.5237
infant mortality	0.0081 *	0.0064	0.0054
	0.0039	0.0045	0.0064
political stability	0.0107	0.0103	0.0119
	0.0073	0.0080	0.0120
Cold War	-0.6932 **	-0.7137 *	-0.4577
	0.2671	0.3036	0.4338
precipitation per capita			
precipitation per capita X gdp			
constant	-2.9680 ***	-4.0492 ***	-3.6600 ***
	0.6809	0.8758	1.0808
N	1224	1224	1224
Chi squared	612.9590	161.8974	643.0246
log likelihood	-306.2902	-240.5645	-141.5965
pseudo R squared	0.5002	0.2518	0.6942
nagelkerke R squared	0.6228	0.3032	0.7699
	*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level		

Table 7: Water Scarcity and Levels of Conflict			
	Any Conflict	Low Level Conflict	Intermediate Level Conflict and War
	b/se	b/se	b/se
lag any conflict	3.8753 ***		
	0.2444		
lag low-level conflict		2.3927 ***	
		0.3000	
lag intermediate conflict and war			6.1766 ***
			0.4429
trade openness	-0.0054	0.0013	-0.0074
	0.0050	0.0054	0.0084
regime type	-0.0457	-0.0029	-0.0804
	0.0327	0.0369	0.0708
regime type squared	-0.0220 ***	-0.0135 *	-0.0271 *
	0.0064	0.0068	0.0113
population density	-0.0002	-0.0017	0.0034
	0.0027	0.0030	0.0040
per capita gdp	-0.0004	-0.0003	-0.0001
	0.0003	0.0004	0.0005
minorities at risk	0.6584 +	1.0720 *	0.5175
	0.3397	0.5128	0.5655
infant mortality	0.0129 **	0.0078	0.0099
	0.0044	0.0051	0.0074
political stability	0.0131	0.0062	0.0163
	0.0101	0.0114	0.0153
Cold War	-0.7628 **	-0.9349 **	-0.5676
	0.2870	0.3307	0.4679
	-0.0004 +	-0.0007 +	-0.0001
precipitation per capita	0.0002	0.0004	0.0003
precipitation per capita	0.0001 *	0.0001 +	0.0000
X gdp	0.0001	0.0001	0.0001
constant	-3.4828 ***	-3.7103 ***	-4.4540 ***
	0.7773	0.9468	1.2671
N	1119	1119	1119
Chi squared	561.7700	156.8251	566.9283
log likelihood	-257.9260	-204.5551	-118.5191
pseudo R squared	0.5213	0.2771	0.7052
nagelkerke R squared	0.6384	0.3294	0.7756

*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level

These results are not consistent with those of both Homer-Dixon (1995) and Hague and Ellingsen (1998), whose works support the finding that environmental variables contribute to minor conflict more than to major conflict. The differences in approach explain the different findings. Homer-Dixon's work is case study where both conflict and environmental degradation are present, making it difficult to generalize beyond the case. Hague and Ellingsen base their conclusion on the difference in their dependent variables. However, their two variables for "major" and "minor" conflict do not share the same temporal distribution; the former spans 7 years, 1989-1996, whereas the latter spans only 4 years, 1989-1992. It is possible that the difference that Hague and Ellingsen found is due to the difference in the time periods each variable covers rather than the battle-death threshold to which they attribute the difference. This study uses similar levels of conflict to distinguish between its categories and compares those categories across identical time spans, 1965-2000. Thus, the results of this study add a nuance not seen before in studies of African conflict and environmental degradation. Specifying the dependent variable into gradations finer than the presence or absence of conflict brings new understanding to the environment-conflict debate. Environmental change, and specifically changes in water resources availability, has, at best, only nominally greater explanatory power on low-level conflict than on other categories of conflict over the longer time frame, 1965-2000.

H4: Changes in water resources must reach a threshold of abundance or a threshold of scarcity before they increase the probability of conflict.

Several authors have suggested that human communities adapt to environmental change until the environmental change crosses a threshold (Glantz 2002, Homer-Dixon 1995, 1999). Water scarcity has been defined variously as 7,300 cubic meters per person per year (UN), less than 1,000 cubic meters per person per year (Sharma), and less than 5,000 cubic meters per person per year (Hague and Ellingsen).[16] Hague and Ellingsen have also denoted a level of water abundance at 20,000 cubic meters per person per year . In order to test for the presence of a threshold effect, it is necessary to first identify the value of the precipitation variables, generated as correlates to these cubic meters per person per annum values, that corresponds to the established thresholds, This is accomplished via a multi-stage process. The first step is a series of bivariate regressions (see Table 8) using the same limited set of data employed to ascertain the validity of substituting annual volume of precipitation for annual per capita water supply. These bivariate tests establish the functional relationship between the correlate precipitation variable and annual per capita water supply to ascertain the relationship among known nation-years.

Table 8: Regress Precipitation on Water Supply		
Variable	Coefficient (beta)	Constant
precipitation per capita	7.0655	71.5420

This relationship was then used to generate thresholds of abundance and scarcity that correspond to known water availability thresholds.

[16] Sharma further defines water stress as more than 1,000 and less than 1,667 cubic meters per person per year and adequate water availability as more than 2500 cubic meters per person per year. Hague and Elllingsen also reference categories for average water availability at 5,001 to 20,000 cubic meters per person per.

Table 9: Setting Threshold Values for Abundance and Scarcity				
	Hague and Ellingsen		UN	Sharma
	abundance (20,000 cu m)	scarcity (5000 cu m)	scarcity (7300 cu m)	scarcity (2500 cu m)
precipitation per capita	212.8511	106.8693	123.1198	89.2057

Finally, the thresholds of abundance and scarcity are used to generate dichotomous variables to indicate the presence (coded 1) or absence (coded 0) of abundant precipitation, in the case of the Hague and Ellingsen-derived abundance variable, or scarce precipitation, in the case of the Hague and Ellingsen-, United Nations-, and, Sharma-derived scarcity variables.

Table 10: Frequencies of Abundance and Scarcity Threshold Variables		
	0	1
Hague and Ellingsen Scarcity	1,391	121
UN Scarcity	1,352	160
Sharma Scarcity	1,428	84
Hague and Ellingsen Abundance	438	1,074

Table 11 displays results that show that no scarcity threshold variables were significant at any level. The results of this study cannot confirm the hypothesis that scarcity must reach a threshold before increasing the probability of conflict. In light of these results, particularly in combination with the fact that no explanatory variable of change in precipitation from a long-term average reached a level of significance, this study suggests that water resources have not yet either reached the necessary threshold of scarcity or yet deviated outside of the range of adaptability in a sufficient number of cases to be distinguished from the background noise in the data.

While there is no evidence to support an assertion that scarce water resources have a measurable effect on the odds of conflict, the abundance model does support the

assertion that of a relationship with conflict. A nation with abundant per capita water resources, defined in this model as a surplus, has a 43.6 percent lower likelihood of conflict than a nation with adequate or scarce water resources. This does not confirm the hypothesis that abundance increases the likelihood of conflict.

These findings are somewhat counterintuitive. As noted at the beginning of this chapter, it is most plausible that precipitation acts to influence conflict through the economy. To understand the finding that abundant per capita water resources reduce the likelihood of conflict, consider the source of economic output in Sub-Saharan Africa. The manufacturing sector is small, small-scale, and labor-intensive; and therefore, does not require the large volumes of water of more industrialized economies. Household consumption, another large component of water demand, is similarly small throughout Sub-Saharan Africa. Few homes outside of the upscale sections of cities have running water in the home; the majority of Sub-Saharan African households carry water from communal sources to the home. In most Sub-Saharan African nations agriculture is the largest economic sector, much of that sector is small-scale or subsistence farming, and much of Sub-Saharan African agriculture is rain-fed rather than irrigation-dependent. Thus, the largest user of water resources in Sub-Saharan Africa is rain-fed agriculture and, when there is abundant water available for this sector, there is less likelihood that an aggrieved peasant population will feel compelled to take up arms against the state.

The second reason that these findings are counterintuitive is the expectation that the more precipitation that is available, i.e. the more abundant water is, the lower the likelihood of conflict. It is important to note that while these results find abundant water resources significantly reduce conflict, they do not support a resource curse theory of

conflict. As discussed earlier, water is not a lootable resource, something that can be exchanged in the marketplace. In its extreme abundant water, i.e. flooding, is as devastating to an economy as drought. However, there was no evidence to support an argument that the positive relationship between increased levels of water resource availability and conflict are due to floods; the annual difference from long term average precipitation was not significant. Nor was there evidence to support a curvilinear relationship, indicating a relationship between both drought and flood and conflict.

Rather than supporting a grievance-based theory of conflict and therefore those who assert that water scarcity will lead to conflict, these findings support a mobilization-based conflict theory. Increased water resource availability reduces opportunity costs for the would-be rebel of participation. In an agriculturally-based and labor intensive economy that is dependent on precipitation rather than irrigation for agricultural production, increased precipitation contributes to increased agricultural product, perhaps even small surpluses. When there is sufficient precipitation to reduce the need for additional labor or to generate surplus product, there remains the barrier of an ineffective market and poor roads over which to transport the product to a market combined with high transportation costs to get the product to a marketplace where there might be enough demand to buy the product. In these instances, sufficient water availability acts to free labor resources for other uses. However, if there are few alternative opportunities available, the promises of the spoils of war are appealing to the potential recruit. Instead of dependence on the revenue generated from a resource or commodity, we have evidence here of abundant water resources creating conditions of a surplus labor force in search of a source of income.

Table 11: Thresholds of Abundance and Scarcity				
	Hague and Ellingsen-based Scarcity Threshold	Sharma-based Scarcity Threshold	UN-based Scarcity Threshold	Hague and Ellingsen-based Abundance Threshold
	b/se	b/se	b/se	b/se
lagged dependent variable	4.6745 *** 0.2603	4.6713 *** 0.2599	4.6702 *** 0.2602	4.6642 *** 0.2613
trade openness	-0.0175 *** 0.0049	-0.0171 *** 0.0049	-0.0179 *** 0.0050	-0.0169 *** 0.0049
regime type	-0.0201 0.0336	-0.0201 0.0337	-0.0187 0.0335	-0.0211 0.0339
regime type squared	-0.0146 * 0.0064	-0.0143 * 0.0064	-0.0147 * 0.0064	-0.0151 * 0.0065
population density	-0.0020 0.0048	0.0005 0.0048	-0.0035 0.0046	-0.0039 0.0035
per capita gdp	0.0000 0.0002	0.0000 0.0002	0.0000 0.0002	0.0000 0.0002
minorities at risk	1.0628 ** 0.3937	1.0645 ** 0.3937	1.0675 ** 0.3929	1.0508 ** 0.3883
infant mortality	0.0057 0.0046	0.0061 0.0046	0.0060 0.0046	0.0084 + 0.0048
political stability	0.0096 0.0090	0.0095 0.0090	0.0099 0.0090	0.0105 0.0090
Cold War	-0.7996 * 0.3140	-0.7823 * 0.3132	-0.7996 * 0.3135	-0.7710 * 0.3139
Hague and Ellingsen scarcity threshold	0.3404 0.7746			
Sharma scarcity threshold		-0.1824 0.9075		
United Nations scarcity threshold			0.5781 0.6622	
Hague and Ellingsen abundance threshold				-0.6216 + 0.3758
constant	-2.8247 *** 0.8325	-2.9556 *** 0.8361	-2.8094 *** 0.8177	-2.6292 ** 0.8122
N	1224	1224	1224	1224
Chi squared	733.0128	732.8629	733.5720	735.5420
log likelihood	-236.4405	-236.5154	-236.1609	-235.1759
pseudo R squared	0.6079	0.6077	0.6083	0.6100
nagelkerke R squared	0.7190	0.7189	0.7194	0.7208
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level				

H5a: Civil conflict is more likely during post Cold War years than during Cold War years.

The end of the Cold War brought significant changes to relationships between nations of the developing world (and groups within their boundaries who are engaged in or harbor aspirations of armed resistance) and both their former colonial powers and their primary sources of economic and military aid. In Sub-Saharan Africa these changes are alleged to have contributed to an increase in the incidence of conflict. This assertion is first tested with the baseline theoretical model and then extended consistent with the theme of this study on water resource availability.

The results presented thus far provide strong evidence to support an assumption of a difference between the Cold War and the Post-Cold War time periods. In baseline theoretical models for both logistic regression and ordered logistic regression, the cold war variable is consistently significant at a 0.05 level or better and varies inversely with conflict. As expected, the Cold War years varied inversely with conflict, providing support for the assertion that the odds of a Sub-Saharan African nation being in civil conflict during the post cold war years are greater than during the cold war years. It was significant in the logistic regression models; it was also significant in the ordered logistic regression model but the Brant test indicates that Cold War violates the parallel odds assumption and therefore that for some levels of conflict there is no difference in the odds of conflict between the Cold War and post-Cold War periods. The tests for different levels of conflict (see Table 7) reveal that the Cold War variable was significant in distinguishing between the presence or absence of conflict and between low-level conflict and all other conflict categories but not between the presence or absence of intermediate-

level conflict and war. The Cold War variable was never significant for the theoretical model with the dependent variable coded for intermediate-level conflict and war. Thus, there is no difference between historical periods in the likelihood of the deadliest of civil wars. Based on the results of this research, the assertion of a difference in odds of conflict between the Cold War and post-Cold War can be qualified to assert that there is a difference in the odds of low-level conflicts, with this type being more likely in the post-Cold War years. The finding that the odds of low-level conflict are greater during post-Cold War years can explain why Hague and Ellingsen found per capita water availability significant and this study did not; their analysis includes only post-Cold War years.

H5b: Changes in water resource availability is more likely to contribute to conflict during post Cold War years than during Cold War years.

The analysis is next extended to consider whether there is an historical effect on water resources' influence on conflict. Interaction variables were generated between Cold War and the two previously-used water resource variables: volume of precipitation per capita and precipitation's deviation from the 100-year long-term precipitation average. These data do not support an assertion of a difference in the effect of per capita precipitation between the Cold War and post-Cold War periods. However, the difference from the 100-year precipitation average, which was not significant across the entire temporal range, shows some evidence of a temporal dimension to its influence on conflict. The data support a finding of a difference between the Cold War and the post-Cold War eras for changes in precipitation relative to long-term average precipitation. Both of the component variables of the interaction term, Cold War and the difference

from the 100-year precipitation average, and the interaction term are significant to at least a 0.10 level and the effect size is large. The sign is in the expected direction indicating that changes in water resource availability were more likely to contribute to conflict during the post-Cold War era than during the Cold War. For each percentage increase in precipitation over the long term average, the odds of conflict during the post-Cold Ware are more than 800 percent greater than during the Cold War.

These results confirm that the odds of civil conflict in Sub-Saharan Africa differ in the Cold War and Post Cold War eras and that changes in long-term water resources are more likely to contribute to conflict in the post-Cold War than in the Cold War. These results also indicate that in the future studies whose temporal boundaries cross these historical periods include a control for this temporal dimension.

The Cold War years of this study coincide closely with the years selected by the Intergovernmental Panel on Climate Change (IPCC) as the baseline period for all studies assessing the possible impacts of a changed climate, 1960-1990. It may be tempting to use these results to advance the cause for those who assert a connection between a changing climate and conflict. That would be a grievous error. The IPCC baseline period does not represent either a peak, a valley, or a neutral point in any environmental state critical to climate change assessments; the time period represents political expediency, a consensus around a period of time prior to the beginning of the negotiations that resulted in the Framework Convention on Climate Change which would serve as the baseline against all future measurements of greenhouse gas emissions would be compared. Because there is no scientific basis for either the timing or the duration of the baseline period, there is no valid theoretical or scientific reason on which to base an

expectation of significance in a correlation between water resource availability and the time period under study, whether it is referred to as the Cold War under the nomenclature of international relations or the IPCC baseline period under the nomenclature of the IPCC.

Table 12: Conflict and the Cold War		
	Per Capita Precipitation	Change in Precipitation
	b/se	b/se
lagged dependent variable	4.7384 ***	4.7474 ***
	0.2824	0.2676
trade openness	-0.0099	-0.0163 ***
	0.0061	0.0049
regime type	-0.0174	-0.0238
	0.0376	0.0337
regime type squared	-0.0134 +	-0.0146 *
	0.0070	0.0064
population density	0.0006	-0.0001
	0.0032	0.0028
per capita gdp	-0.0008 *	0.0000
	0.0004	0.0002
minorities at risk	0.7430 +	1.0841 **
	0.4169	0.3939
infant mortality	0.0084	0.0063
	0.0051	0.0046
political stability	0.0102	0.0087
	0.0110	0.0090
Cold War	-0.7101 +	-0.6597 *
	0.3905	0.3234
precipitation per capita	-0.0001	
	0.0004	
	0.0001 **	
precipitation per capita X gdp	0.0001	
precipitation per capita X Cold War	-0.0003	
	0.0005	
difference from long term precipitation		-2.0036 *
		0.9991
long term difference X Cold War		2.2602 +
		1.4057
constant	-3.2918 ***	-3.1659 ***
	0.9133	0.8276
N	1119	1224
Chi squared	685.6675	736.4509
log likelihood	-204.6988	-234.7214
pseudo R squared	0.6261	0.6107
nagelkerke R squared	0.7340	0.7215
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level		

Summary: Under What Circumstances?

The results of this study add a nuance not seen before in studies of African conflict and environmental degradation. Specifying the dependent variable into gradations finer than the presence or absence of conflict brings new understanding to the environment-conflict debate. There are distinct differences among the levels of conflict and these differences are inconsistent with the results of Hague and Ellingsen. Hague and Ellingsen found that environmental degradation was more likely to affect the incidence of low or intermediate level conflict; this study only weakly supports a finding of water resources affecting the incidence of low-level conflicts. There does not yet appear to be a threshold effect of scarcity that is discernable above the background noise of interannual precipitation variability. None of the scarcity thresholds was significant in any statistical model nor was scarcity able to distinguish between any levels of conflict. However, the abundance model does support the assertion that of a relationship with conflict. There is also a difference between the Cold War and post-Cold War periods, both in the baseline odds of conflict and in the effect of water resources on conflict: conflict is more likely in the post-Cold War and water resources are more likely to contribute to conflict in the post-Cold War period.

By What Means?

This study now turns to explore several mechanisms by which political systems and environmental systems might interact including political stability measured as the length of time since the last regime change; institutional capacity to manage water resources measured in four different ways as annual World Bank water project lending per million dollars in gross national product, annual World Bank water project lending normalized by the 5-year rolling average gross national product, cumulative number of signed water resource treaties per international river basin, and percent of arable land purposely provided with water; the openness of political institutions measured in two ways as civil liberties and as a composite variable comprised of indicators for the degree to which procedures for the transfer of executive power are institutionalized, the extent to which elections for executive office are competitive and the opportunity for non-elites to gain elective office; and the interconnectedness of social groups measured as the presence or absence of minorities at risk.

H6: Environmental degradation in combination with political instability increases the probability of conflict.

Political instability could be operationalized in a number of different ways. First, democracies tend to be stable, thus instability could be measured using either a nation's democracy score or its polity score from the Polity IV data. However, highly authoritarian nations can also be stable; thus neither of these is an appropriate choice to measure instability in this instance. Second, following the finding that conflict is less likely among both strongly democratic and strongly authoritarian regimes, political

instability can be measured as regime type squared. Third, instability can be operationalized as the number of years since the last regime change. This study will test instability measured in both ways, as regime type squared and as the number of years since the last regime change.

Two interaction variables were created using both measures of instability, each in combination with per capita precipitation. The interaction term was not significant in either of the tests, the results of which are presented in Table 13. Hence, these results cannot support the hypothesis that environmental degradation in combination with political stability increases the odds of conflict. These findings cannot confirm the assertion that environmental stressors will exacerbate existing weaknesses in the capabilities of political systems to respond to the crises that scarcity creates. This finding casts some doubt on the existing research upon which the hypothesis is based, However, more than three fourths of the nation years have a regime type score of 0 or less and half of the nation-years have had a regime change in the past 7 years; thus, it is possible that Sub-Saharan African States exist in such a state of weakness that additional stressors such as environmental change are unlikely to have a discernable effect on them.

Table 13: Environmental Change and Political Instability		
	Regime Type and Per Capita Precipitation	Political Stability and Per Capita Precipitation
	b/se	b/se
lagged dependent variable	4.7383 ***	4.7169 ***
	0.2832	0.2818
trade openness	-0.0087	-0.0105 +
	0.0061	0.0061
regime type	-0.0152	-0.0164
	0.0378	0.0375
regime type squared	-0.0158 +	-0.0119 +
	0.0092	0.0072
population density	0.0005	-0.0002
	0.0032	0.0032
per capita gdp	-0.0007 +	-0.0009 *
	0.0004	0.0004
minorities at risk	0.7229 +	0.7428 +
	0.4158	0.4189
infant mortality	0.0087 +	0.0075
	0.0052	0.0052
political stability	0.0096	0.0258
	0.0111	0.0177
Cold War	-0.8628 **	-0.8690 **
	0.3298	0.3297
precipitation per capita	-0.0005	0.0000
	0.0006	0.0003
precipitation per capita X gdp	0.0001 *	0.0001 **
	0.0001	0.0001
regime type squared X precipitation per capita	0.0000	
	0.0000	
political stability X precipitation per capita		0.0000
		0.0000
constant	-3.1678 ***	-3.1502 ***
	0.9104	0.9020
N	1119	1119
Chi squared	685.2335	686.6345
log likelihood	-204.9157	-204.2152
pseudo R squared	0.6257	0.6270
nagelkerke R squared	0.7337	0.7348
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level		

H7: Nations that exhibit greater institutional capacity to manage water resources have a lower probability of conflict.

The question now turns to the manner in which institutions act and tests this effect in two different ways: first, which is examined in this hypothesis, is the state's ability to manage water resources through treaties, through international funding for water resource development, and through the control of water for agricultural production, typically a nation's largest water consumer; and second, as Kahl envisioned, mediating between the environment and conflict, which is examined in the next hypothesis.

The results, presented in Table 14, provide only weak evidence that institutions capable of managing water resources may matter in Sub-Saharan African civil conflicts; the proportion of a nation's land under irrigated agriculture was significant at a 0.10 level although its effect size is small, increasing the percent change in odds by 1.4 percent for each percent increase in arable land under irrigation. However, the data also indicate that as the percent of arable land under irrigation increases the likelihood of conflict also increases, not decreases as hypothesized. Rather than serving as a mechanism for the state to develop the institutional infrastructure necessary to manage water resources, this indicates instead that irrigated agricultural land might be the equivalent of a lootable resource.

Throughout much of the thirty-five-year period of this study, African governments, their leaders, and their bureaucracies were infamous for corruption, patronage, and misappropriation of government funds. These findings suggest that irrigated agricultural land (which yields more per acre than rain-fed land) was not put to uses that enhanced institutional capacity and thereby reduced the likelihood of conflict; it

was instead employed in a manner that made civil conflict more likely. Actions such as ensuring that privileged clients were granted usage rights to the most productive land in the community when repeated over time or on a large scale are not inconsistent with the findings that higher percentages of irrigated agricultural land increase the likelihood of conflict.

The addition of variables to test the hypothesis that institutions mediate between the environment and conflict, provided weak evidence to support the hypothesis. This relationship is further examined in the next hypothesis where the variables representing groupness and inclusivity are interacted with annual precipitation weighted for land area and volume of precipitation weighted per million dollars of annual gross national product, the significant water resource variables.

Table 14: Institutional Capacity to Manage Water Resources				
	Irrigated Land	Treaties per Basin	WB Lending per 5-year Average GNP	5-year Average WB Lending per capita
	b/se	b/se	b/se	b/se
lagged dependent variable	4.7206 ***	4.6677 ***	4.8315 ***	4.6960 ***
	0.2938	0.2600	0.2800	0.2626
trade openness	-0.0267 ***	-0.0178 ***	-0.0173 **	-0.0179 ***
	0.0061	0.0050	0.0054	0.0049
regime type	-0.0138	-0.0220	-0.0236	-0.0181
	0.0399	0.0340	0.0359	0.0335
regime type squared	-0.0124 +	-0.0148 *	-0.0160 *	-0.0148 *
	0.0073	0.0064	0.0066	0.0064
population density	-0.0013	-0.0006	-0.0001	-0.0003
	0.0032	0.0028	0.0029	0.0028
per capita gdp	0.0000	0.0000	0.0000	0.0000
	0.0002	0.0002	0.0002	0.0002
minorities at risk	1.1320 *	1.0851 **	0.9961 *	1.0468 **
	0.4617	0.3924	0.4063	0.3933
infant mortality	0.0043	0.0064	0.0074	0.0065
	0.0049	0.0046	0.0049	0.0046
political stability	0.0124	0.0095	0.0138	0.0096
	0.0100	0.0090	0.0108	0.0089
Cold War	-0.9909 **	-0.7439 *	-0.8411 *	-0.8137 **
	0.3413	0.3171	0.3317	0.3144
irrigated agricultural land	0.0003 +			
	0.0001			
cumulative number of treaties per river basin		0.1161		
		0.1579		
World Bank lending per 5-year average gnp			21.6539	
			14.9429	
5-year average World Bank lending per capita				0.1105
				0.0950
constant	-2.2188 *	-3.0454 ***	-3.1509 ***	-2.9423 ***
	0.9390	0.8297	0.8828	0.8085
N	1039	1224	1150	1224
Chi squared	619.2603	733.3663	702.4121	733.8518
log likelihood	-190.5745	-236.2637	-210.1190	-236.0210
pseudo R squared	0.6190	0.6082	0.6257	0.6086
nagelkerke R squared	0.7263	0.7193	0.7334	0.7196
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level				

H8: Nations with more open political institutions will have a lower probability of conflict. Furthermore, this will hold true even in the presence of environmental change or environmental scarcity.

This section operationalizes a nation's institutional capacity in two different ways: as a measure of the extent to which a population enjoys civil liberties and as openness of executive recruitment. Civil liberties, as measured by Freedom House, provides the first means to operationalize institutional capacity; it looks at institutions from the perspective of the individual in society by measuring the extent to which individuals are able to act spontaneously and without government interference. All results for this hypothesis are presented in Table 15. This measure of institutional capacity is also a strong predictor of conflict; a one-unit increase the civil liberties score, marking a reduction in civil liberties, increases the odds that a nation is in conflict by 55 percent.

Open political institutions, the second indicator of institutional capacity, measures political inclusivity and is expected to reduce the probability of conflict. To test this hypothesis the Polity IV composite variable for the openness of executive recruitment was added to the baseline model. The variable is highly correlated with the broader polity variable for regime type therefore, in these theoretical models, that broader variable and its squared term are dropped to test the effect of the narrower construct. First, the executive recruitment baseline model confirms that the narrower variable can be used in place of the composite measure of regime type. These data indicate with a high degree of confidence that in Sub-Saharan African nations with more open political institutions have a lower likelihood of conflict. A one unit change in executive recruitment score reduces the odds that nation is in conflict by 18 percent.

Trade openness also captures an aspect of openness in political institutions. Trade openness, the ratio of imports plus exports to gross domestic product is a measure of the openness of economic institutions, as well as an indicator of the political institutions' abilities to exercise some degree of control over the market. As noted earlier, the variable was significant in the logistic regression models, but when the dependent variable was disaggregated into the categories of conflict, trade openness was significant in predicting the presence or absence of conflict and in predicting intermediate-level conflict and war but not in predicting low-level of conflict, indicating that effective trade policies reduce the odds of conflict overall and reduce the odds of the most violent conflicts. The effect size, however, is small; each percent increase in openness reduces the odds of conflict by less than 2 percent.

Having established that open political institutions matter in Sub-Saharan Africa, the analysis now turns to consider whether these institutions act to mediate the effects of variations in water resource availability. The interaction between water resources and political institutions was tested by creating two interaction terms, combining the institutional variables on executive recruitment and civil liberties with per capita precipitation. Neither interaction term met a threshold of significance therefore, this study cannot confirm that open political institutions mediate the effects of environmental scarcity or change.

This study confirms that nations in which groups are empowered to participate in and have an influence on political decision-making are less likely to experience conflict. Civil liberties measures freedom as experienced by individuals and therefore captures the openness of civil and social institutions while executive recruitment measures the

openness of the highest levels of the government and captures the openness of political institutions. These findings provide strong evidence to support the assertion that inclusivity reduces the likelihood of conflict but cannot confirm that environmental stressors are currently exacerbating existing political weaknesses to give rise to conflict. These results indicate only that nations that are able to establish, implement, and enforce political and economic policies such as those to control or direct economic growth, reduce poverty are less likely to experience conflict.

Table 15: Openness of Institutions				
	Civil Liberties	Civil Liberties and Per Capita Precipitation	Executive Recruitment	Executive Recruitment and Per Capita Precipitation
	b/se	b/se	b/se	b/se
lagged dependent variable	4.4977 ***	4.6257 ***	4.6849 ***	4.7624 ***
	0.2863	0.3140	0.2614	0.2854
trade openness	-0.0152 **	-0.0071	-0.0185 ***	-0.0115 *
	0.0052	0.0065	0.0048	0.0058
regime type	0.0494	0.0477		
	0.0427	0.0481		
regime type squared	-0.0181 *	-0.0177 *		
	0.0072	0.0078		
population density	0.0006	0.0021	0.0001	0.0001
	0.0028	0.0034	0.0027	0.0031
per capita gdp	0.0001	-0.0008 +	0.0001	-0.0004
	0.0002	0.0004	0.0002	0.0004
minorities at risk	1.0617 *	0.7796 +	1.1422 **	0.8400 *
	0.4248	0.4519	0.4034	0.4271
infant mortality	0.0067	0.0082	0.0025	0.0041
	0.0053	0.0059	0.0045	0.0050
political stability	0.0008	0.0007	0.0107	0.0102
	0.0100	0.0121	0.0085	0.0105
Cold War	-0.5731 +	-0.6257 +	-0.9272 **	-0.9427 **
	0.3481	0.3660	0.2947	0.3167
civil_liberty	0.4404 **	0.3410		
	0.1661	0.2082		
precipitation per capita		-0.0003		-0.0002
		0.0011		0.0006
precipitation per capita X gdp		0.0002 *		0.0001 +
		0.0001		0.0001
precipitation per capita X civil liberties		0.0000		
		0.0002		
executive recruitment			-0.1927 *	-0.1891 +
			0.0761	0.1116
precipitation per capita X executive recruitment				0.0000
				0.0001
constant	-4.9542 ***	-4.7556 ***	-2.1686 *	-2.3519 *
	1.1312	1.3068	0.9127	1.0759
N	1036	939	1226	1120
Chi squared	664.7139	620.4856	734.3233	686.7589
log likelihood	-202.0040	-173.4336	-236.2173	-204.3663
pseudo R squared	0.6220	0.6414	0.6085	0.6269
nagelkerke R squared	0.7358	0.7520	0.7195	0.7346
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level				

H9: Nations with more interconnected societies will have a lower probability of conflict.

The theoretical background section introduced the concept of groupness, the notion that societies organize themselves around interconnections of identity and affiliation. The extent to which those identities and affiliations overlap one another contributes to the costs of and benefits (real and perceived) derived from engaging in collective action against a state. Societies with many interconnecting identities are expected to experience lower odds of conflict than societies with few interconnections. Societies with a dominant identity and several minority identities are expected to experience higher odds of conflict. In Sub-Saharan Africa, the dominant form of identity or affiliation is ethnicity and this form of identity captures the manner in which group identity is most frequently transferred to the political arena; hence the variable of interest is drawn from the Minorities at Risk dataset and coded to denote the presence or absence of a minority community at risk of discrimination. It has already been established that nations that exclude groups from participation in the polity based on ethnicity are more likely to experience low-level than intermediate level civil conflict and war thus confirming, for Sub-Saharan Africa, the evidence presented in earlier case studies.

The connection between groupness and conflict is further tested here by interacting availability of per capita precipitation with the minorities at risk variable to ascertain whether water scarcity exacerbates existing stresses as previous work has theorized. Specifically, previous work has asserted that environmental scarcity will have the greatest impact on marginalized groups, who are also more likely to be minority groups, because they tend to be poor and inhabit the poorest quality land. Neither component variable nor the interaction term was significant when added to the baseline

theoretical model. Therefore, this study cannot confirm the presence of an effect between marginalization and conflict in the face of scarce water resources when marginalization is defined as being a minority at risk of discrimination. Likewise, this study cannot confirm the presence of a causal relationship between the inclusivity or exclusivity of society, scarce water resources, and the odds of civil conflict.

The findings of this section are counter to the evidence of institutional studies (Boone, 2003 and Kahl, 2006). The lack of an interaction effect for either civil liberties or minorities at risk, despite the significance of each alone provides some insight into the means by which institutions mediate between water and conflict. Both civil liberties and minorities at risk are indicators for social institutions; executive recruitment, which is useful at mediating between water resources and conflict, is an indicator political institutions. This finding can only partially affirm Kahl's assertion that suggests that environmental scarcity pressures both society and the state thereby increasing the opportunities and incentives to engage in violence against the state. Kahl asserted that states with a high degree of groupness, sharp divisions along ethnic lines, and environmental scarcity would have a high likelihood of conflict. Kahl further asserted that states with low levels of institutional inclusivity and environmental scarcity would have a high likelihood of conflict. This research can only support a causal pathway from environmental change, in the case of this study, changes in water resources, through the political institutions of the state, to civil conflict. Political openness and inclusivity create conditions under which groups can both express and seek redress for grievances in a nonviolent fashion.

Table 16: Intersocietal Connections		
	Regime Type and Per Capita Precipitation	Minorities at Risk and Per Capita Precipitation
	b/se	b/se
	4.7383 ***	4.7349 ***
lagged dependent variable	0.2832	0.2822
trade openness	-0.0087	-0.0109 +
	0.0061	0.0063
regime type	-0.0152	-0.0208
	0.0378	0.0378
regime type squared	-0.0158 +	-0.0147 *
	0.0092	0.0070
population density	0.0005	0.0011
	0.0032	0.0033
per capita gdp	-0.0007 +	-0.0007
	0.0004	0.0004
minorities at risk	0.7229 +	0.4048
	0.4158	0.5594
infant mortality	0.0087 +	0.0081
	0.0052	0.0051
political stability	0.0096	0.0104
	0.0111	0.0111
Cold War	-0.8628 **	-0.8882 **
	0.3298	0.3309
precipitation per capita	-0.0005	-0.0006
	0.0006	0.0006
precipitation per capita X gdp	0.0001 *	0.0001 *
	0.0001	0.0001
per capita precipitation X regime type squared	0.0000	
	0.0000	
per capita precipitation X minorities at risk		0.0005
		0.0007
constant	-3.1678 ***	-2.8863 **
	0.9104	0.9810
N	1119	1119
Chi squared	685.2335	685.9595
log likelihood	-204.9157	-204.5527
pseudo R squared	0.6257	0.6264
nagelkerke R squared	0.7337	0.7342
*** = significant at 0.001 level, ** = significant at a 0.01 level, * = significant at a 0.05 level, + = significant at a 0.1 level		

Summary: By What Means?

This study hypothesized that institutional capacity would mediate between water resources and conflict. There is some evidence to confirm that nations with more capable institutions have a lower likelihood of conflict and that these institutions can act to reduce the effect that water resources have on conflict. While there was not sufficient evidence to confirm that water resources, scarcity or abundance, would exacerbate existing weaknesses, there was evidence to suggest that the capability to manage water resources was being used in manners that increased the likelihood of conflict not reduced it, i.e. that the benefits to be derived from irrigated crop land are being disbursed via a patronage system to reward loyal followers.

When the concept of institutions is narrowed to focus on the effect of political institutions, and in particular the extent to which the selection of the chief executive is an open process, the data clearly indicate that open political institutions lower the likelihood of conflict but the data do not support a finding that open political institutions mediate between water resources and conflict.

Chapter 5: Conclusion

In a focused examination of Sub-Saharan Africa this study sought to advance the discussion of the causal effects of environmental scarcity and degradation on domestic conflict in several ways: by grounding the domestic conflict-environmental degradation discussion in the civil and social conflict literature and including environmental variables in a model based in the civil conflict literature; by conducting a quantitative study in a field where few have been undertaken; by extending the scope of explanatory variables to include indicators for political institutions, and by introducing variation to the dependent variable through the use of a categorical variable. These objectives were accomplished by exploring on three questions: Does the environment matter, with environment defined as water resource availability? Under what circumstances? And by what means?

Does the Environment Matter?

Sub-Saharan Africa exhibited some remarkable differences from the findings of previous studies of conflict that included nations from across the world. The linkages between population and civil conflict across the globe are undetermined; this work finds that population pressures are not a contributor to conflict in Sub-Saharan-Africa. There are a few densely populated countries, for example, in 2000 Rwanda had 293 people per square kilometer and Burundi had 240 people per square kilometer. There are also certainly sections within urban areas are very densely populated and Lagos, Nigeria is one of the world's mega-cities. In contrast, Botswana and Namibia each have fewer than two or three people per square kilometer. As a whole, the continent is not populated densely enough for a significant trend to emerge from the data.

This study revealed a second remarkable difference from earlier work on civil conflict. Infant mortality failed to pass the test of significance; a particularly curious finding in light of its role as an indicator of well-being in the State Failure project. This work concludes that the differences in the findings are attributable to the different dependent variables. Because the State Failure Task Force categories represent only the catastrophic end of the conflict continuum, the difference in findings between this study and the State Failure Task Force study indicate that the State Failure Task Force's work can apply only on the extreme end of the conflict continuum.

This study examined several means of operationalizing the environment in an effort to ascertain whether one conceptualization of the environment was more effective at predicting conflict than another. This study provides some evidence to support an assertion that water resources are a function of economic output and are a reliable predictor of conflict in Sub-Saharan Africa. While the expectation was for the precipitation per capita to vary inversely with conflict and thus provide confirmatory evidence for an assertion of scarcity contributing to conflict, instead the data support the opposite, that abundance water resources reduce opportunity costs for rebels to recruit. Water resource availability has a discernable causal effect on civil conflict in Sub-Saharan Africa but there is no evidence to support the assertion that the relationship is curvilinear, i.e. that that extremes of both drought and flood will increase the likelihood of civil conflict.

While per capita precipitation more likely to be significant and significant at a higher level than difference in precipitation from a long-term average, other constructions of the precipitation variable, the direction of the relationship was counter to expectations;

increased water availability is associated with increased conflict, not less as expected. These findings are counterintuitive for two reasons. First, the expectation was that precipitation would act to influence conflict through the economy, hence the use of an interaction term between gross domestic product and precipitation per capita. However, this research concluded that absolute water availability has a larger effect on conflict than volume of water per unit of economic output. The pathway between water and conflict still goes through the economy, just not in the fashion envisioned. The agricultural sector is often the largest economic sector in a Sub-Saharan African nation; it is also the largest consumer of water and much of Sub-Saharan African agriculture is rain-fed rather than irrigation-dependent. Thus, it is volume of water, which directly affects agricultural production, that has the largest effect on Sub-Saharan conflicts.

Second, this study's conclusions are counterintuitive because they reveal that abundant precipitation is associated with an increased likelihood of conflict. Rather than supporting a grievance-based theory of conflict, these findings support a mobilization-based conflict theory. Increased water resource availability reduces opportunity costs of the would-be rebel to participating in violence against the state. In an agriculturally based and labor-intensive economy that is dependent on precipitation rather than irrigation for agricultural production, sufficient quantities of precipitation reduce the need for additional hands to tend crops. Typically, surplus product would require additional labor to transport and market it but, in Sub-Saharan Africa, there is the additional barrier of an ineffective market and poor roads over which to transport the product to a market. These barriers are compounded by high transportation costs to get the product to a marketplace where there might be enough demand to purchase it. In these instances,

sufficient water availability acts to free labor resources from agriculture for other uses. However, if there are few alternative employment opportunities available, also a typical scenario in Sub-Saharan Africa, the promises of the spoils of war are appealing to the potential recruit. Instead of dependence on the revenue generated from a resource or commodity, we have evidence here of abundant water resources creating conditions of a surplus labor force in search of a source of income.

This study supports and extends Hauge and Ellingsen's (1998) findings that water resources contribute to civil conflict. Per capita precipitation created from a volumetric measure of annual precipitation multiplied by land area and weighted for total population, constructed to mimic the quantity of freshwater resources available in the nation, extends Hauge and Ellingsen's findings by demonstrating that a variable measure of water resource availability based on annual precipitation can be used successfully in lieu of the water resource availability estimates. This noteworthy finding makes a valuable contribution to the study of environment and conflict by adding a new indicator to the pantheon of potential correlates of civil conflict that is both variable and updated and that can be used in place of an estimator that is neither variable nor frequently updated. This finding also means that future studies involving a larger selection of nations worldwide can incorporate a similar indicator for the static fresh water per capita resource variable. The use of precipitation data in this study also provides a valuable contribution to the environment-conflict discourse by more directly linking the data that describes the natural world to the social changes to which those natural phenomenon are purported to relate.

Gletitsch et al. (2006), in their study of international conflict and shared river basins, found that water resources can lead to conflict between states but are more likely to lead to smaller conflicts than large-scale conflicts or wars. There may be a similarity between such militarized international disputes an intermediate-level civil conflicts and civil wars as both use a 1000-death threshold and rebels involved in larger-scale civil conflict may be more likely to obtain support from neighboring countries. This support may include actions such as allowing territory to be used as a base of operations or enabling the purchase and delivery of arms. While not engaging in interstate conflict, such actions blur the lines between civil and international conflict.

There is insufficient evidence in Sub-Saharan Africa to support the assertion in assessments of climate change impacts that changes in water resource availability will contribute to conflict. While global temperatures have exhibited a discernable pattern, precipitation has not yet varied significantly enough outside of the ranges established in the recent past to have a discernable effect.

Under What Circumstances?

This research attempted to discern whether a categorical variable to represent the continuum of conflict could provide a more nuanced understanding of the relationship between the predictor variables and civil conflict. This was tested using two distinct methods: ordered logistic regression and a series of dichotomous dependent variables. The statistical model ordered logistic regression provided strong evidence that the categories are distinct but could not support the assumption that they represent a continuum of conflict; the model failed to meet the assumption of proportional odds across all categories of the dependent variable. Further testing of this hypothesis using a

series models with dichotomous dependent variables, one model for each category of conflict, produced valuable results. There are distinct differences among the levels of conflict and these differences are inconsistent with the results of Hague and Ellingsen. Hague and Ellingsen found that environmental degradation was more likely to affect the incidence of low or intermediate level conflict; this study only weakly supports a finding of water resources affecting the incidence of low-level conflicts. The results of this study add an important nuance not seen before in studies of African conflict and environmental degradation. By looking at a 35-year time span rather than the narrower 6-year time period of Hague and Ellingsen, we learn that it is sufficient or abundant water resource availability, rather than scarce resources that affects the likelihood of conflict and that environmental change, and specifically changes in water resources availability, has greater explanatory power on intermediate level conflict and war than on low-level conflict over the longer time frame. Specifying the dependent variable into gradations finer than the presence or absence of conflict brings new understanding to the environment-conflict debate by indicating when resources are an effective explanatory variable.

The results of this study cannot confirm the hypothesis that scarcity must reach a threshold before increasing the probability of conflict. None of the scarcity thresholds was significant in any statistical model nor was scarcity able to distinguish between any levels of conflict. There are two possible conclusions that might be drawn from these findings. First, it is possible to conclude that there is no single absolute threshold of scarcity that consistently distinguishes levels of conflict or that increases odds of conflict across the continent. Nations, communities, individuals all adapt to the normal range of

water resource variability. The demands that communities located in normally arid areas, such as the Sahel, the Namib Desert or the Kalahari Desert, place on water resources differ dramatically from those of communities in the tropical rain forests of west or central Africa. It is more likely that an effective measure of scarcity has to have inherent in it these variations in "normal" and the extent to which annual precipitation deviates outside of the range of normal to which communities have become accustomed. Second, it is also possible to conclude that water resources have not yet reached a level of scarcity across enough of the continent sufficient to be detected above the existing long-term variation in a large-N statistical study.

While there is no evidence to support an assertion that scarce water resources have a measurable effect on the odds of conflict, the abundance model does support the assertion that of a relationship with conflict. Yet, this does not confirm the hypothesis that abundance increases the likelihood of conflict. The largest user of water resources in Sub-Saharan Africa is rain-fed agriculture and, when there is abundant water available for this sector, there is less likelihood that an aggrieved peasant population will feel compelled to take up arms against the state. Rather than supporting a grievance-based theory of conflict and therefore those who assert that water scarcity will lead to conflict, these findings support a mobilization-based conflict theory. Increased water resource availability reduces opportunity costs for the would-be rebel of participation. Instead of dependence on the revenue generated from a resource or commodity, we have evidence here of abundant water resources creating conditions of a surplus labor force in search of a source of income.

The research confirmed and extended earlier findings on the differences in conflicts across the historical divide of the Cold War. This study not only found the temporal difference to be significant, but also found that there is no difference between the historical periods in the likelihood of the deadliest of civil wars and that low-level conflict is more likely in the post-Cold War. We can therefore conclude that opposition movements experience lower opportunity costs and are thereby more likely to engage in low-level civil conflicts in the post-Cold War era. Furthermore, this study concludes that changes in long-term water resources are more likely to contribute to conflict in the post-Cold War than in the Cold War. This confirms expectations that the loss of external support has affected the ability of Sub-Saharan governments to provide services, thereby affecting the potential for groups within societies to either experience new grievances or see existing grievances alleviated. These results also indicate that in the future studies whose temporal boundaries cross these historical periods include a control for this temporal dimension.

By What Means?

This study hypothesized that institutional capacity would mediate between water resources and conflict and explored several direct and indirect mechanisms by which political systems and environmental systems interact including political instability, institutional capacity to manage water resources, the openness of political institutions, and the interconnectedness of social groups. Variables representing these constructs were included in the baseline, were added to the baseline model singly and added to the baseline in interactions with variables representing water resource availability. The variable included in the baseline that represents institutional capacity more broadly

defined, that is capacity of the economic system to exert control over the market, was useful predictor of civil conflict in Sub-Saharan Africa and the greater the institutional capacity the lower the odds of conflict, but this indicator was not useful at distinguishing between level of conflict.

In testing the various hypotheses, several variables were added singly to the baseline equation to explore the direct effects of institutional capacity in reducing the odds of civil conflict in Sub-Saharan Africa. This study concludes that institutional capacity alone, be it the capacity to manage water resources or maintaining a political system that is open to the participation of all of society, has a strong influence on the likelihood of conflict. The effect, however, is not always in a direction that was expected. While a political system that allows for the chief executive to be selected openly and from a wide section of society reduces the likelihood of conflict, the capacity to manage irrigated cropland indicates an increased likelihood of conflict as the benefits of this more productive land are directed to a narrow segment of society.

This study offers some evidence to suggest that institutional capacity to manage water resources has an effect on the odds of conflict however; the data suggest an effect opposite to that hypothesized. Rather than serving as a mechanism for the state to develop the institutional infrastructure necessary to manage water resources, the measures of institutional capacity variables indicate that World Bank funding and irrigated agricultural land created opportunities for political leaders to engage in rent-seeking, misappropriate funds, and reward loyal supporters. This finding is of particular interest to policy-makers who provide aid and advice to Sub-Saharan African governments on the development of their water resources and irrigated agriculture in

particular. These findings suggest that technical projects would benefit from components to strengthen governance practices.

The indirect mechanisms explored as mediators between the environment and conflict also provided no evidence to suggest that institutions mediate between water resources and conflict. There was no evidence that environmental stressors such as drought or floods exacerbate existing political weaknesses. There was no evidence that the extent to which individuals in society are able to express options without fear of interference by the government has any effect on the relationship between water resources and conflict, nor was there evidence that open political institutions mediate the effect of precipitation by increasing the opportunity cost of engaging in violent action against the state.

Models on institutional capacity to manage water resources and on institutions as mediators between environmental change and conflict offered modest support for the hypotheses. However, the theoretical grounding on which their inclusion is based suggests that institutional capacity ought to be of even greater import in explaining the risk of conflict. The contradictory findings between the effect of irrigated agriculture on the one hand and civil liberties and executive recruitment on the other provide evidence that the relationship between water resources, and the environment more generally, institutional capacity and civil conflict are even more complex that was possible to model in this study. Nonetheless, this study contributes to further refining our understanding of the intersections between institutions and conflict and of institutional study as a whole by suggesting that some seemingly plausible indicators for institutional capacity, while modestly useful in explaining an African nation's risk for conflict, are still not as well-

specified as they might be. It is also likely that the interaction variables are affected by the same limitations of the environmental variables on which they are based. It was noted above that environmental change may not have reached the point at which it will have a detectable effect on society. Until the water resource variables are clearly distinguishable from the background noise in the data, it may not be possible to clearly discern or fully understand the manner in which institutions are mediating between environmental change and civil conflict in Sub-Saharan Africa.

Studies of the environment conflict interrelationship have not succeeded in specifying well the manner in which the environment matters to civil conflict in Sub-Saharan Africa. The findings of this study provide additional insights into the mechanisms by which environmental change, and water resources in particular, affects the likelihood of conflict. It has concluded that water resource availability has a discernable causal effect on civil conflict in Sub-Saharan Africa and that increasing amounts of precipitation are associated with an increased likelihood of conflict preferencing a mobilization-based theory of conflict over a grievance-based theory of conflict. By expanding the dependent variable beyond the mere presence or absence of conflict to include categories representative of different levels of conflict we learn that changes in water resource availability has greater explanatory power on intermediate level conflict and war than on low-level conflict. Finally, these results indicate that nations that are able to establish, implement, and enforce political and economic policies such as those to control or direct economic growth, reduce poverty, and adapt to changing water resource availability are less likely to experience conflict.

Directions for Further Research

This study has revealed several opportunities for further study. In validating the applicability of a variable based in annual precipitation data weighted by the land over which it falls, these results open up new avenues to refine that variable. The precipitation that falls goes to many different places, among them runoff, ground water recharge and evaporation. The weighted precipitation variable used here can be made to more accurately reflect the proportion of precipitation that is usable to and used by society by further adjusting it to account for the other ecosystem uses to which that precipitation is put. Incorporating additional precision, such as that described, into this key variable will then add additional precision and accuracy to the results of these models.

A second opportunity for further research is to expand this analysis to cover other geographic regions as well as the globe as a whole. Each continental land mass experiences differing precipitation patterns, different balances between precipitation, runoff, recharge, and evaporation, which interact to provide different climatic norms for water resource availability, to which societies have adapted. One would expect that the interactions between these varying natural worlds and the varying political, economic and social worlds that have been constructed within those natural worlds will differ. The question to ask is what those geographic differences are, whether they are significant or whether Sub-Saharan Africa is unique, and finally whether there are discernable patterns world-wide. A first step in this expansion would be to extend to all countries the initial correlation of existing per capita water resource availability with the variable constructed for this study.

A third opportunity for additional study, which this work has shed light on, is institutions and the role they play in the web of interconnections between resources and conflict. This work has used a rudimentary method to quantify the institutional capacity to manage water resources, none of which was strongly significant and thereby successful. The choice of a rudimentary method for quantifying institutions was deliberate in order to maintain the temporal range of 1965 to 2000. There are a number of datasets with a more widely accepted method for transforming the abstract concepts of capacity and governance into numerical scales that reliably represent the relationship between the concept and the scale in which it is measured. The body of theoretical work supporting the assumption that intuitional capacity is important warrants further research to better explore that relationship within the temporal bounds the available data imposes.

The relationship between groups and institutions examined in this study can go both ways; this study has posited the presence of a unidirectional causal relationship between the existence of a group with a particular characteristic and the odds of conflict in a state. The causal relationship might also flow in the opposite direction: while the existence of a group makes it easier for contenders to organize and influence individuals to participate in collective action against the state, they also make it easier for the state (democratic or authoritarian) to target group members for retaliation or punishment. Thus, this relationship might be further explored with a dependent variable that distinguishes between violence perpetrated by citizens against the state and violence perpetrated by the state against its citizens.

A fourth area for additional research is in the linkages between indicators and effects of climate change ant the propensity for conflict. The international policy

community has asserted such a linkage but there has been little rigorous work to affirm or negate that assertion. Average global temperatures are increasing as are concentrations of greenhouse gases. Temperatures have risen 1.1°F in the past century, a rate that exceeds that of the past 1000 years, and current temperatures are rising three times as fast as those of the early 20th Century. Concentrations of carbon dioxide, the most prevalent greenhouse gas, have increased from 280 ppm to 370 ppm since the preindustrial era and concentrations of this magnitude have not been seen in the last 420,000 years and perhaps as long as 20 million years. This warming is having a discernable impact on the habits or range of many species and ecosystems. Signs of this impact include thawing of the arctic permafrost, earlier songbird migration and nesting, and the melting of glaciers, including on Mount Kilimanjaro and Mount Kenya. The glaciers on Mount Kilimanjaro have decreased in size by 80% in the Twentieth Century. Some of these changes, including those in the arctic, are forcing human communities to adapt.

Climate change is expected to have an impact on Africa by exacerbate existing threats and vulnerabilities. African nations are the most vulnerable to the impacts of climate change because they are least able to adapt (Hernes et al. 1995). Many nations are currently vulnerable to drought, have high population growth rates, are highly dependent on agricultural production for export earnings, have low rates of foreign direct investment, and have large populations living in poverty (Benson and Clay 1998). Changes to precipitation and temperature will have a cascading effect first on agricultural production, transportation systems, and water available for personal, agricultural, and industrial consumption. These initial impacts will subsequently affect food security, human health, and economic growth; the first and last are causal factors in civil conflict.

Climate models suggest that temperatures will, on average, increase by 0.02°C per decade across the continent. The current rainfall patterns exhibit much variability and modelers do not foresee any reductions in that variability. Climate models project that dry areas will become drier and that wet areas will become wetter. Specific changes modeled include a reduction of 30% or more from 1961-1990 baseline in water run-off in current drought-prone areas of southern Africa, including Angola, Malawi, Zambia and Zimbabwe, as well as Senegal and Mauritanian Sahel regions.

Based on these temperature and precipitation projections Africa will experience many impacts. Reductions in volume and area of snow cover on glacial mountaintops can be expected to lead to less stream runoff and potentially fewer tourist visits. Not all of the impacts are projected to be negative: models project that the Horn of Africa will experience an increase in water-run-off of 20% or more, but these modeled changes do not reflect the additional impact of changes in temperature and timing of water flows. Many African rivers are highly sensitive to climate change because they have a low runoff efficiency and a high dryness index; increases in precipitation are not expected to be greater than the increased evaporation that will occur because of higher temperatures. When these other effects are accounted for, some areas in Sub-Saharan Africa have been modeled to experience more run-off but less total water availability because of the additional effects of increased evaporation due to higher temperatures.

These countervailing forces are expected to occur in the Sahel and East Africa. Climate scientists strongly caution against drawing definitive causal arrows between runoff and a human security problematic, but several links between the natural causes and social implications can be reliably asserted. Sub-Saharan Africa is heavily reliant on

rainfed-agriculture. This, in tandem with its high rates of poverty, means that its families, communities, and polities are highly vulnerable to changes in precipitation and that their vulnerability is expected to increase as water variability increases. Increased variability is expected to reduce crop yields, as a result of either flood or drought, and to have the greatest impact on the poor because they have the least capacity to adapt. Adaptation requires financial resources to move into irrigated agriculture or to purchase improved seeds (which not only cost more but also require fertilizer). Hence, the impact on crop yields is an important indicator for Sub-Saharan Africa. While projected crop production models are only speculation or best guesses, they could be taken as an early indicator of probable trouble spots: areas projected to see dramatic decreases in cereal productivity (declines of 25% or more) correspond to those areas currently known to experience frequent, recurring droughts, i.e. the Sahel, the Horn, portions of Kenya and Tanzania in East Africa, and Zimbabwe, Mozambique and South Africa in southern Africa (United Nations Development Program 2006, 162).

Social scientists have begun to look at the linkage between climate change and conflict. In general, they begin from a premise similar to that outlined above: as existing resources essential to daily living, such as arable land and water, come under increasing pressure from changes in temperature and precipitation, conflict will arise over access and distribution to arable land or reliable sources of water for humans and livestock. Some initial work, using precipitation data similar to that in this study, has confirmed the connection between changing water resources and conflict (Hendrix and Glasser, 2007; Raleigh and Urdal, 2007). Because changes in water resources will interact with and

exacerbate existing scarcities, I suggest that climate change is a potential causal factor in the outbreak of conflict that should continue to be explored further.

Ultimately, one must ask whether these findings are significant or whether they constitute averted imagination.[17] On the whole, the evidence is still not overwhelming. Just as the astronomer, secure in the knowledge that the object exists, will reconfirm an uncertain observation under better conditions, social scientists currently have adequate evidence to continue their pursuit of a more complete understanding of the means by which environmental change is a contributing factor to civil conflict, in Sub-Saharan Africa, the region on which this study focused, and across the world.

[17] Averted imagination is a phenomenon commonly referred to among amateur astronomers when they are uncertain whether they have observed a faint object. It derives from a technique, averted vision, whereby the observer looks just to the side of the object in question. In so doing, a previously invisible object becomes visible. Averted imagination, then, occurs when the observer is certain that the sought after object is located in the field of view but is uncertain, because of the object's faintness or the suboptimal observing conditions, whether the brain is indeed registering an image of the object or merely tricking the eye into thinking that it has glimpsed the sought-after object. The technique is analogous to the social scientist using quantitative data to represent an abstract and not directly measurable concept. The quantification of the concept is the analog to averted vision; the running of statistical tests and declaring the findings to be of significance is the analog to averted imagination.

Appendix A: African Nations

Sub Saharan African Nations Included in this Study

Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Central African Republic
Chad
Congo
Djibouti
Equatorial Guinea
Ethiopia
Gabon
The Gambia
Ghana
Guinea
Guinea Bissau
Ivory Coast
Kenya
Lesotho
Liberia
Malawi
Mali
Mauritania
Mozambique
Namibia
Niger
Nigeria
Rwanda
Senegal
Sierra Leone
Somalia
South Africa
Sudan
Swaziland
Tanzania
Togo
Uganda
Zaire
Zambia
Zimbabwe

Nations Excluded

North Africa
Algeria
Egypt
Libya
Morocco
Tunisia

Islands
Cape Verde
Comoros Islands
Madagascar
Mauritius
Reunion
Sao Tome and Principe
Seychelles

Appendix B: Variables

Dependent Variables

Descriptive Name (*variable name*)	Measurement	Source
Conflict (*MEPVconfl*)	0 no conflict 1 conflict	Major Episodes of Political Violence compiled by Monty G. Marshall
Categorical Conflict (*SACDconfl*)	0 no conflict 1 low level conflict 2 intermediate level conflict 3 war	Armed Conflict Database version 2.1, 11 March 2004 (Eriksson et al. 2003)
Any Conflict (*noSACDconfl*)	0 SACDconfl equals 0 1 SACDconfl greater than 0	Armed Conflict Database version 2.1, 11 March 2004 (Eriksson et al. 2003)
Low-level Conflict (*lowconfl*)	0 SACDconfl not equal to 1 (low level conflict) 1 SACDconfl equal to 1 (low level conflict)	Armed Conflict Database version 2.1, 11 March 2004 (Eriksson et al. 2003)
Intermediate-Level Conflict and War (*midNwar*)	0 SACDconfl equals 0 or 1 1 SACDconfl equals 2 or 3	Armed Conflict Database version 2.1, 11 March 2004 (Eriksson et al. 2003)

Independent Variables

Descriptive Name (*variable name*)	Measurement	Source
Lagged dependent variable (*lagMEPV*)	dummy dependent variable MEPVconfl lagged by 1 year	Marshall 2003
Lagged categorical dependent variable (*lagSACD*)	categorical dependent variable SACDconfl lagged by 1 year	Eriksson et al. 2003
Lagged Any Conflict (*lagnoSACDconfl*)	dummy dependent variable for any SACD conflict lagged by 1 year	Eriksson et al. 2003
Lagged Low-level Conflict (*laglowconfl*)	dummy dependent variable for low-level SACD conflict lagged by 1 year	Eriksson et al. 2003
Lagged Intermediate-Level Conflict And War (*lagmidNwar*)	dummy dependent variable for intermediate-level SACD conflict and war lagged by 1 year	Eriksson et al. 2003
Openness To Trade (*tradeopen*)	total trade as a percentage of GDP 100*(imports + exports)/GDP	World Bank 2001
Regime Type (*p4polity*)	institutionalized democracy index score minus institutionalized autocracy index score index from low (-10) to high (10)	Marshall and Jaggers 2000
Regime Type Squared (*politysq*)	regime type squared p4polity ^2	Marshall and Jaggers 2000
Population Density (*popdense*)	population density in people per square kilometer 100*(landarea/total_pop)	World Bank 2001

Descriptive Name (*variable name*)	Measurement	Source
per capita GDP (*gdppercap*)	per capita gross domestic product in constant 1995 dollars	World Bank 2001
Presence Of A Minority At Risk (*MAR*)	dummy variable coded as 1 if nation has any group classified as a minority at risk, otherwise coded as 0	Gurr et al. 2002
Infant Mortality Rate (*infmort*)	number of infants dying before reaching age one, per 1,000 live births in a given year	World Bank 2001
Political Stability (*p4durable*)	number of years since last regime transition or since 1900, whichever is more recent	Marshall and Jaggers 2000
Cold War era (*coldwar*)	dummy variable coded as 0 for years 1989 through 2000 and 1 for years 1965 through 1988	
Per Capita Precipitation (*precipcap*)	cubic meters per person 1000*(precip_volume / total_pop)	Mitchell et al. 2004 and World Bank 2001
Difference from Long Term Average Precipitation (*ann100yr*)	percent difference from 100-year precipitation average (1900-2000) 100 * (annprecip - ave100yr) / ave100yr	Mitchell et al. 2004
Squared Difference from Long Term Average Precipitation (*ann100yrsq*)	squared percent difference from 100-year precipitation average (1900-2000) ann100yr ^2	Mitchell et al. 2004
Average Per Capita World Bank Lending (*wb5yrh2ocap*)	average per capita World Bank lending in million 1995 dollars for water resource projects over the last 5 years 0.001 * ave5yrwblend / total_pop	World Bank 2001
5-year Average World Bank Lending as a Percent of GNP (*wbh2oper5yrgnp*)	average World Bank water project lending as a percent of GNP over the last five years 100 * ave5yrwblend / gnpave5yr	World Bank 2001

Descriptive Name (*variable name*)	Measurement	Source
Cumulative Number Of Treaties Per River Basin (*treatyperbasin*)	cumulative number of signed international water resource treaties per river basin cumtreaty / intlrivr	WATERLEX, International Freshwater Treaties Database, and Gleick 2000
Percent Of Arable Land Purposely Irrigated (*irrigland*)	percent of arable land purposely provided with water, including land irrigated by controlled flooding 100 * irrigarea / arabland	World Bank 2001
Hague and Ellingsen-based Abundance Threshold (*abundHEcap*)	dummy variable for threshold of abundance coded as 1 if precipcap is greater than 213 cubic meters of precipitation per capita, otherwise coded as 0	Mitchell et al. 2004 and Hague and Ellingsen 1998
Hague and Ellingsen-based Scarcity Threshold (*scHEcap*)	dummy variable for threshold of scarcity coded as 1 if precipcap is less than 107 cubic meters of precipitation per capita, otherwise coded as 0	Mitchell et al. 2004 and Hague and Ellingsen 1998
Sharma-based Scarcity Threshold (*scSHcap*)	dummy variable for threshold of scarcity coded as 1 if precipcap is less than 89 cubic meters of precipitation per capita, otherwise coded as 0	Mitchell et al. 2004 and Sharma et al. 1996
UN-based Scarcity Threshold (*scUNcap*)	dummy variable for threshold of scarcity coded as 1 if precipcap is less than 123 cubic meters of precipitation per capita, otherwise coded as 0	Mitchell et al. 2004 and Gleick 2000
Civil Liberties (*civil_liberty*)	Freedom House Civil Liberties Index 1 (high) to 7 (low)	Freedom House 2002
Executive Recruitment (*p4exrec*)	Polity IV composite index measuring the extent to which the process for selecting a nation's political leader is institutionalized, open and competitive index from low (10) to high (8)	Marshall and Jaggers 2000

Source Data for Independent Variables

Descriptive Name (*variable name*)	Measurement	Source
Difference from Long Term Average Precipitation (*ann100yr*)	percent difference from 100-year precipitation average (1900-2000) 100*(annprecip - ave100yr) / ave100yr	Mitchell et al. 2004
Annual Precipitation (*annprecip*)	total annual precipitation in millimeters	Mitchell et al. 2004
Arable Land (*arabland*)	thousand hectares of arable crop land	World Bank 2001
Long Term Average Precipitation (*ave100yr*)	millimeters of annual precipitation averaged over the years 1900-2000, inclusive	Mitchell et al. 2004
Five-Year Average Gross National Product (*ave5yrgnp*)	five-year rolling average gnp average of gnp over the five-year period ending in the current year, in million constant 1995 US dollars	World Bank 2001
Five-Year Rolling Average World Bank Water Project Lending (*ave5yrwblend*)	average annual World Bank water project lending over the last five years average of wbh2olend over the five year period ending in the current year, in million constant 1995 dollars	World Bank 2001
Cumulative Number of International Water Resource Treaties (*cumtreaty*)	cumulative number of international treaties over water resources	WATERLEX and International Freshwater Treaties Database accessed October 2004
Exports (*exports*)	value of all goods and other market services provided to the rest of the world, in constant 1995 US dollars	World Bank 2001

Descriptive Name (*variable name*)	Measurement	Source
Per Capita Freshwater Resources (*h2o_supply*)	thousand cubic meters of freshwater resources per person per year	Gleick 2000
Imports (*imports*)	value of all goods and other market services received from the rest of the world, in constant 1995 US dollars	World Bank 2001
Number of International River Basins (*intlrivr*)	the number of times each nation is listed as a riparian member of an international river basin	Gleick 2000
Arable Crop Land Under Irrigation (*irrigarea*)	thousand hectares of arable crop land under irrigation	World Bank 2001
Land Area (*landarea*)	total land area of country in thousand hectares	World Bank 2001
Number Of International Treaties Signed Annually (*numtreaty*)	number of international treaties over water resources signed during the calendar year	WATERLEX and International Freshwater Treaties Database
Regime Type (*p4polity*)	institutionalized democracy index score minus institutionalized autocracy index score index from low (-10) to high (10)	Marshall and Jaggers 2000
Volume of Precipitation (*precip_volume*)	volume of annual precipitation equivalent to cubic meters per year landarea * annprecip / 10000	Mitchell et al. 2004 and World Bank 2001
Total Population (*total_pop*)	total mid-year population in thousands	World Bank 2001
Total Trade (*total trade*)	value of all goods and other market services exchanged with the rest of the world, in constant 1995 US dollars imports plus exports	World Bank 2001

Descriptive Name (*variable name*)	Measurement	Source
Annual World Bank Water Project Lending (*wbh2olend*)	amount of World Bank lending for water-related projects during the year in million constant 1995 dollars	World Bank 2001

Appendix C: Summary Statistics

variable	N	mean	standard deviation	minimum	maximum	variance
MEPV conflict	1512	0.24	0.42	0	1	0.18
lagged MEPV conflict	1512	0.24	0.42	0	1	0.18
SACD conflict	1410	0.48	1.00	0	3	1.00
lagged SACD conflict	1398	0.47	0.99	0	3	0.98
trade openness	1283	66.29	35.53	0	237.96	1,262.30
regime type	1405	-4.00	5.36	-10	9	28.77
regime type squared	1403	44.72	24.47	0	100	598.74
population density	1512	32.27	41.53	0.85	293.61	1,724.62
per capita gdp	1285	704.36	1,020.85	84.72	8,508.24	1,042,124
minorities at risk	1512	0.74	0.44	0	1	0.19
infant mortality	1512	119.53	34.80	50	208.4	1,211.37
political stability	1512	12.11	15.14	0	89	229.14
Cold War	1512	0.67	0.47	0	1	0.22
executive recruitment	1406	4.26	1.96	0	8	3.86
per capita precipitation	1512	876.48	1,307.19	27.80	10,639.11	1,708,738.00
difference from long-term precipitation squared	1512	0.05	0.14	2.18E-08	2.50	0.02
Hague and Ellingsen abundance threshold	1512	0.71	0.45	0	1	0.21
Hague and Ellingsen scarcity threshold	1512	0.08	0.27	0	1	0.07
Sharma scarcity threshold	1512	0.06	0.23	0	1	0.06
United Nations scarcity threshold	1512	0.11	0.31	0	1	0.09
5-year average World Bank lending per capita	1512	0.53	1.58	0	17.36	2.48
World Bank lending per 5-year average gnp	1189	0.00	0.01	0	0.14	0.00
cumulative number of treaties per river basin	1512	0.65	0.84	0	5	0.71
percent of irrigated agricultural land	1231	3.84	6.78	0	44.11765	45.97
civil liberties	1167	5.26	1.28	2	7	1.63
total population	1512	9,665.22	14,157.45	108	111,506.10	200,000,000.00
annual precipitation	1512	993.98	595.39	45.5	3,107.30	354,485.50
lag any conflict	1512	0.28	0.45	0	1	0.20

variable	N	mean	standard deviation	minimum	maximum	variance
lag low conflict	1512	0.07	0.26	0	1	0.07
lag intermediate conflict and war	1512	0.13	0.34	0	1	0.11

Appendix D: Hypotheses

Does the Environment Matter in Sub-Saharan African Civil Conflict?

H1: Models of civil conflict that include environmental variables are better predictors of that conflict than models without environmental variables.

H2: Water resources exhibit a U-shaped relationship with respect to conflict: extremes of both scarcity and abundance increase the probability of conflict.

Under What Circumstances?

H3: Water resource scarcity is more likely to contribute to low-level conflict than to intermediate-level conflict or war.

H4: Changes in water resources must reach a threshold of abundance or a threshold of scarcity before they increase the probability of conflict.

H5a: Civil conflict is more likely during post Cold War years than during Cold War years.
H5b: Changes in water resource availability is more likely to contribute to conflict during post Cold War years than during Cold War years.

By What Means?

H6: Environmental degradation in combination with political instability increases the probability of conflict.

H7: Nations that exhibit greater institutional capacity to manage water resources have lower probability of conflict.

H8: Nations with more open political institutions will have a lower probability of conflict. Furthermore, this will hold true even in the presence of environmental change or environmental scarcity.

H9: Nations with more interconnected societies will have a lower probability of conflict.

Appendix E: Per Capita Water Resources and Precipitation

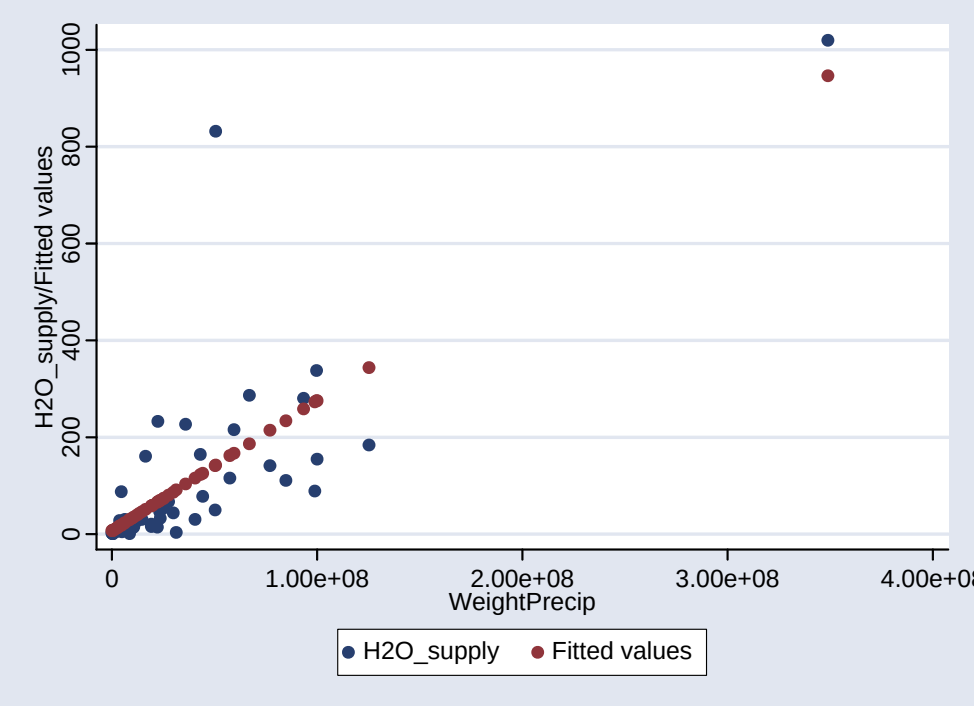
Correlation Water Resources and Precipitation

	H2O_supply	WeightPrecip
H2O_supply	1.0000	
WeightPrecip	0.7812	1.0000

Ordinary Least Squares Regression

Source	SS	df	MS	Number of obs	51
				F(1,49)	76.73
Model	1088890.38	1	1088890.38	Prob > F	0.0000
Residual	695341.168	49	14190.6361	R-squared	0.6103
				Adj R-squared	0.6023
Total	1784231.55	50	35684.6309	Root MSE	119.12

H2O_supply	Coef	Std. Err	t	P>|t|	[95% Conf. Interval]
WeightPrecip	2.69e-06	3.07e-07	8.76	0.000	2.07e-06 3.31e-06
_cons	6.191536	20.21669	0.31	0.761	-34.43542 46.81849



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