Drought and the Militarization of International River Disputes

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Abstract: How does the onset of drought influence the management of international river disputes? Previous research has found that states with dry or *arid* climates are more likely to use force over river claims. However, scholars have yet to examine how short-term dry spells or *droughts* influence the use of force. I argue that droughts produce acute shortages that may substantially disrupt states' ability to use river water. In doing so, they may enhance the willingness of states involved in international disputes over the proper use of river water to coerce their opponents into complying with their demands. I test this argument using data on river claims from the Issue Correlates of War project. My analysis produces three main findings. First, countries experiencing below average rainfall in a given year are more likely to use force over a river claim. Second, drought has a stronger effect on the probability of conflict in states with arid climates. Third, the probability of conflict decreases the longer a state remains in a period of drought, which suggests that states adapt to new levels of water availability over time.

INTRODUCTION

Does drought influence the militarization of interstate river disputes? Although a sizable literature connecting water scarcity to the management of international river disputes exists (e.g. Toset, Gleditsch, and Hegre, 2000; Furlong, Gleditsch, and Hegre, 2006; Hensel, Mitchell, and Sowers, 2006; Brochmann and Hensel, 2011; Tir and Stinnett, 2011), previous research focuses primarily on the effects of a country's climate on the probability of conflict and cooperation. Compared to other countries, states with dry or *arid* climates have low *average* levels of precipitation and therefore have less water to utilize for various purposes. While climate is clearly an important determinant of how water sources are managed, short-term dry-spells or *droughts* can also have substantial effects on the amount of water available to a state. By hindering the replenishment of river water, droughts have the potential to substantially disrupt the normal flow of water within a given river. Even droughts that do not directly affect a given river system may increase the extent to which states rely on that river by reducing the availability of water from other sources. In doing so, they may create severe water shortages that inhibit normal use of the river for a wide range of activities including consumption, navigation, and fishing.

Given the potential for severe disruptions to the supply of water available to states in a river system, it is surprising that the academic literature on river disputes has devoted relatively little attention to the effects of drought on river disputes. Although several studies have argued that drought should inhibit cooperation over river disputes (Kilgour and Dinar, 2001; Tir and Stinnett, 2011; De Stefano et al., 2012), few attempts have been made to test this argument systematically (Brochmann and Hensel, 2011 is an exception). Moreover, none have yet to examine the influence of drought on the militarization of international river disputes. I argue that droughts may encourage the use of force over river disputes. By inhibiting the flow of river water to downstream states, droughts can exacerbate political disputes over the allocation and proper use of river water. Acute water shortages can produce high human and economic costs, especially for arid states. By increasing the costs of water shortages, drought may increase the willingness of states to use force to resolve disputes with their neighbors.

I test my argument using data on river claims from the Issue Correlates of War (ICOW) project. My analysis produces three main findings. First, below-average rainfall in either claimant is associated with an increased probability of initiating a militarized interstate dispute over a given river claim. Second, the effect of droughts on militarized dispute onset is conditional on the challenger's climate. In particular, the effects of drought are stronger in arid states than they are in non-arid states, suggesting that arid states have a particularly tough time adjusting to below average levels of rainfall. Third, the probability of the use of force decreases the longer a state remains in a period of drought. This suggests that the effects of drought become less severe over time as states adjust to reduced levels of water supplies and implement policies designed to adapt to conditions of scarcity.

Theoretically, my argument makes a number of contributions to the literature on international river disputes. First, compared to previous studies, I argue that we need to reframe how we think about water scarcity. Although previous research has emphasized the importance of water scarcity, these studies have generally treated scarcity as a function of a state's climate, both conceptually and empirically. Instead, my theory and findings suggest that short term shocks are a more significant determinant of international conflict, although climate does increase the extent to which states are susceptible to those shocks. Second, my theory helps explain *when* conflicts occur between states. Because a given country's climate tends to change slowly over time and significant shifts in average rainfall are relatively rare, climate cannot explain variations in the probability of initiating a dispute over time.

Third, my theory suggests that steps can be taken to enable states to adapt to these shocks and mitigate their effects. If this is true, exploring the conditions that facilitate successful adaption is an important avenue for future research. Finally, understanding the relationship between water scarcity and conflict will become increasingly important for policymakers over the coming century. In the face of rapid economic development and expanding population levels, water resources across the globe will come under increasing pressure. At the same time, climate change is expected to alter both the overall climate and variability in weather patterns of many countries. As such, understanding whether and in what conditions water scarcity promote the use of force is of vital importance for both scholars and practitioners concerned with preventing international conflict. I discuss these implications further in the conclusion.

WATER SCARCITY AND INTERNATIONAL CONFLICT

Freshwater resources are essential to human life and livelihoods. In addition to its obvious implications for human survival, water is a vital input for a diverse array of economic activities including agriculture, industry, fishing, hydroelectric power generation, mining, sanitation, and commercial navigation. Although most of the planet's surface is composed of water, only 2.5% of Earth's water is freshwater. River water represents the vast majority of water available for human consumption and use (Shiklomanov, 1993). Of the Earth's freshwater resources, only about 1.2% is directly accessible as surface water, about half of which is found in rivers. Transboundary water resources represent a particularly important source of water supplies. Approximately 40% of the world's population lives in freshwater basins that are shared by at least two countries (UNWTTW, 2008).

Due to the importance of transboundary water resources, disputes over the use of shared rivers has often been the subject of contention between states. States may initiate river claims for a number reasons. Disputes frequently emerge over water quantity when overconsumption by one state prevents others from receiving adequate water flows to meet their needs. Excess consumption by upstream states may prevent downstream states from receiving a sufficient amount of water to meet these needs. Attempts by upstream states to control river flows by constructing dams or diverting water away from the river may also prevent downstream states from receiving adequate supplies.

River claims may also arise over the quality of the water that reaches downstream states.

Water use by one state can produce negative externalities that diminish the availability of high quality water for other riparians. Activities that lead to increased sediment, salinity, and waste from agricultural, human, and industrial sources can seriously degrade the quality of water available for downstream states. Disputes over the allocation of river water have plagued a number of states and occasionally produced militarized disputes between claimants. For example, plans to divert water from the Jordan River led to disagreements between Israel, Syria, and Jordan in the 1950s and 1960s and resulted in conflict. Similar disputes have emerged between Turkey, Iraq, and Syria over the Tigris-Euphrates river system as well as Bolivia and Chile over the Lauca River (Hensel, Mitchell, and Sowers, 2006).

Disputes over rivers may arise for a number of other reasons. States may dispute each other's right to use rivers for activities such as fishing and navigation. Rivers may also form the border between neighboring states and are often the subject of border disputes. Historically, disputes over navigation have been particularly contentious. Most notably, disagreements over navigation rights on the Shatt al-Arab produced a number of militarized disputes between Iran and Iraq culminating in the Iran-Iraq war. Militarized disputes over navigation have also occurred between Nicaragua and Costa Rica as well as Argentina and Uruguay (Hensel, Mitchell, and Sowers, 2006).

Unsurprisingly, the issue of water scarcity has been central to research on river disputes. The theoretical arguments concerning the relationship between water scarcity and the management of river disputes can be summarized by two perspectives drawn from the broader literature on resource scarcity and international conflict.[1] On the one hand, *neo-malthusians* or *resource pessimists* expect resource shortages to produce increased competition between states. As resources become increasingly scarce, neo-malthusians expect states to assign higher value to them and regard them as zero-sum goods. As a result, states with a dire need for water resources may be more willing to bear the human, economic, and diplomatic costs associated with coercing other states to meet their demands (Gleick, 1993). Scarcity

[1] For an overview, see Gleditsch (2003) and Koubi, Spilker, et al. (2014).

may also reduce the viability of settling a dispute through cooperative means. By effectively increasing the value of shared water resources, scarcity effectively narrows the range of acceptable agreements and may make states loathe to relinquish control of those resources by acceding the demands of other states. Likewise, scarcity may make states more likely to defect from previously signed agreements by using more than their allocated share (Brochmann, 2012).

By contrast, *cornucopians* or *resource optimists* argue that resource shortages can be managed by cooperative means. For water scarce states, the prospect of successful cooperation carries the potential for significant benefits. Establishing an agreement governing the use of water resources may be beneficial in providing a stable and predictable allocation of river water for water scarce states (Barkin and Shambaugh, 1999; Tir and Ackerman, 2009; Dinar, Dinar, and Kurukulasuriya, 2011). Moreover, cooperation involves significant transaction costs, and as a result, states are unlikely to negotiate agreements unless they have a common interest that can only be solved by coordination (Keohane, 2005). States that have an abundance of water generally do not have an urgent need to settle outstanding river disputes, and are therefore unwilling to restrict their future ability to develop these resources unnecessarily. Others have argued that the link between water scarcity and treaty formation exhibits a curvilinear relationship, wherein the probability of successfully negotiating an agreement increases as scarcity increases but decreases once it reaches extreme levels (Dinar, Dinar, and Kurukulasuriya, 2011).

Empirical research on river disputes supports elements of both of these perspectives. With respect to the use of force, scholars have generally found that water scarcity increases the probability of militarized disputes over shared rivers (Gleick, 1993; Hauge and Ellingsen, 1998; Toset, Gleditsch, and Hegre, 2000; Furlong, Gleditsch, and Hegre, 2006; Hensel, Mitchell, and Sowers, 2006; Hensel and Brochmann, 2007).[2] However, the use of force over river disputes is a rare phenomenon; states are far more likely to cooperate than they are to

[2]Gleditsch et al. (2006) and Yoffe, Wolf, and Giordano (2003) do not find evidence that scarcity increases the probability of militarized conflict.

fight. Moreover, scarcity increases the probability of cooperation as well as violent conflict. Water scarce states engage in more peaceful settlement attempts and sign more agreements governing the use of rivers (Hensel, Mitchell, and Sowers, 2006; Tir and Ackerman, 2009; Brochmann and Hensel, 2009; Brochmann and Hensel, 2011; Zawahri and Mitchell, 2011). These states also tend to design stronger agreements that include provisions for monitoring, conflict resolution, and enforcement mechanisms (Tir and Stinnett, 2011).

Most existing research on water scarcity and rivers has focused on states with arid climates, i.e., those that have perennially low supplies of water. For example, Hensel, Mitchell, and Sowers (2006) examine regional variations in river institutions as well as the influence of average levels of water on conflict management attempts. Likewise, Dinar (2009) and Dinar, Dinar, and Kurukulasuriya (2011) argue that long-term scarcity is the primary driver behind cooperation over rivers. Although a state's climate is clearly an important factor in the amount of water they have available, water allocations also vary considerably from year to year as a function of weather. In particular, prolonged periods of below-average precipitation or *droughts* have the potential to substantially disrupt the normal flow of water within a river. According to the American Meteorological Society, drought refers to "a period of abnormally dry weather sufficiently long enough to cause a serious hydrological imbalance."[3] Droughts may persist for months or even years, making it possible for states to face extended shortages that considerably alter the supply of natural water available to them. Since drought is defined relative to a state's average levels of rainfall, both arid and non-arid states can experience droughts, although the effects of drought are likely to be stronger in arid states (see below).

Regardless of the average amount of water available to a state, drought may lead to significant negative shocks to the amount of water available to a state. In doing so, it may influence the way in which states manage river disputes. Despite this, scholars have paid relatively little attention to the effects of drought on the management of international river

[3]This definition comes from the American Meteorological Society's online glossary, available at `http://glossary.ametsoc.org/wiki/Main_Page`, accessed July 2016.

disputes. These studies have examined the effects of drought on cooperation. Brochmann and Hensel (2011) find that droughts do not have an influence on whether states sign agreements over rivers. Kilgour and Dinar (2001) and Tir and Stinnett (2011) argue that droughts can lead to violations of existing water sharing agreements. De Stefano et al. (2012) analyze whether river management institutions contain provisions to cope with water variability and find that these provisions are the least common globally. However, to my knowledge, no previous studies have examined the influence of droughts on the militarization of river disputes.

DROUGHT AND THE MILITARIZATION OF RIVER DISPUTES

Droughts have the potential to substantially disrupt the normal functioning of a river system by simultaneously decreasing the supply of river water available and increasing the extent to which states rely on rivers for consumption. In terms of supply, droughts directly reduce river flow by decreasing the amount of runoff available to replenish surface water. Precipitation also has an essential role in recharging groundwater reserves that in turn feed into rivers, particularly in arid regions (Thomas, Behrangi, and Famiglietti, 2016). Annual variations in precipitation can reduce river flows by as much as 25%, while long-term droughts can reduce mean annual flow by up to 70% (IRLI, 1993). Droughts can also influence the rate at which states consume river water by diminishing the supply of water available from other resources. The depletion of lakes, aquifers, and other rivers may lead states to rely more heavily on a given river to meet their needs. This may lead states to engage in projects to divert river water away from the main body of the river by constructing dams, barrages, canals, and levees. For example, rainfall deficits may lead a state to channel water away from the river to use for irrigation, reducing the amount of water that flows downstream.

If these effects disrupt the normal functioning of transboundary rivers, drought has the potential to aggravate existing disputes between states by exacerbating the underlying cause of the claim. Droughts occurring anywhere along a river system may potentially complicate relations between the riparian states by reducing the supply of water available to disputants. The effects of drought should be felt most acutely in downstream states whose supply of water is dependent on the amount that upstream states allow to flow downstream. However, droughts in upstream states may have similar effects if these shortages propagate downstream.

In the context of preexisting disputes over water allocation, states may become even more dissatisfied with the status quo and may be willing to take drastic actions to remedy perceived inequities. Even if states have previously signed water allocation agreements, droughts may hinder states' ability to deliver on the terms of the agreement. For example, in 1999 a drought led Israel to violate the terms of a water-sharing agreement with Jordan signed in 1994 (Kilgour and Dinar, 2001). If the shortages induced by droughts are particularly acute, this can potentially increase the willingness of states to take costly military actions against their neighbors to compel them to adjust their consumption patterns. States may rely on direct threats of violence to compel the other state to comply with their demands. For example, Egypt has a history of issuing threats towards upstream states on the Nile River as a means of guaranteeing its water supplies (Deng, 2007). Alternatively, states may utilize indirect means to coerce other states into complying with their demands which bring with them their own risk of escalating into conflict. For example, following a series of droughts in the late 1980s, Syria ramped up its support for Turkish separatists. In doing so, they explicitly linked their support to the issue of Turkish development projects on the Tigris-Euphrates river system that threatened Syrian water supplies. These events culminated with a series of cross-border skirmishes between the two states in the mid-1990s (Bulloch and Darwish, 1993; Magdalena, 2016).

Decreases in the supply of river water may exacerbate claims over issues other than water quantity. Decreases in river flow are likely to aggravate concerns over water quality by increasing the concentration of pollutants in the water that flows to downstream states. Likewise, diminished river flow can impede the ability of states to use the river for other purposes such as navigation and fishing. For example, in the 1960s, India constructed of a barrage to divert water away from the Ganges River. As a result, the ability of downstream Bangladesh to use the river for fishing and navigational purposes was compromised (Wolf, 2007). In addition, the displacement of people due to water shortages in Bangladesh led to a surge of migrants into India, creating another potential source of tension between the two states.

Based on the argument above, droughts should lead to an increased propensity for states to use force. Although the challenger (i.e., the state dissatisfied with the status quo) is most likely to initiate any military action, drought in either state may have an effect on the probability of military disputes since the effects of drought may propagate downstream. As such, I test the following hypothesis:

> **Hypothesis 1:** *States are more likely to initiate militarized interstate disputes over a river claim when one or both disputants are experiencing a drought.*

In addition, I test two additional hypotheses about how drought influences the propensity for states to use force over river disputes. First, although I expect droughts to increase the probability of international conflict, this effect should not be equally strong in all states. In particular, droughts should have a stronger effect in those states that have lower average levels of water supplies than those with an abundance of water. States that have high levels of average rainfall are less likely to experience droughts that severely disrupt the functioning of a given river system. These states should also have larger supplies of surface and ground water reserves that they can draw on to address shortfalls. As a result, the costs associated with droughts in these states will be lower and are unlikely to be large enough to justify the use of force.

> **Hypothesis 2:** *Droughts have a stronger positive effect on the probability of militarized interstate disputes in arid states.*

Second, although drought is a temporary phenomenon by definition, countries may experience extended periods of below-average precipitation lasting several years or more. While conflict may occur at any point during a drought, the risk should be highest early on before states have time to adopt policies that may help them adjust to water shortages. Over time, states should be able to adapt to water shortages by constructing desalination and purification facilities to increase water access, constructing dams and reservoirs to better control existing resources, and implementing economic carrots and sticks to encourage decreased consumption (Homer-Dixon, 1999). Since these measures take time to construct, they cannot be implemented at the beginning of a period of drought. Given the time to implement these measures, however, they have the potential to alleviate the problems associated with water shortages. In doing so, states should become less willing to resort to the use of force should decrease as the costs of drought diminish.

Hypothesis 3: *The effect of droughts on the probability of militarized interstate disputes decreases the longer a state remains in a period of drought.*

RESEARCH DESIGN

To test my argument, I use data on river claims from the Issue Correlates of War (ICOW) project (Hensel, Mitchell, and Sowers, 2006). The current version of the ICOW dataset (version 1.10) covers river claims in the Western Hemisphere, Western Europe, and the Middle East between 1900 and 2001. ICOW codes claims for all interstate disputes over the use of a river, including disagreements over water quality, water quantity, and navigation rights. Disputes in which the use of a river or its resources are not the primary focus of the claim are not included (e.g. disputes over the location of a border that involve a river). ICOW claims are directed, with the state initiating the claim coded as the challenger and the other state coded as the target.[4] For disputes over the quantity or quality of water, the downstream state is almost always coded as the challenger.

[4]Disputes involving multiple states are broken into multiple dyadic claims. Two states may have multiple ongoing claims at once over different rivers.

The unit of analysis for all models is the claim-year, which provides one observation for each dyadic river claim for each year it is ongoing. The dependent variable for all models is a binary indicator of whether two claimants became involved in a militarized interstate dispute (MID) over a particular river claim in a given year. This dataset represents the universe of cases that could experience militarized disputes within the temporal and geographic scope of the study.

Primary Independent Variables

To measure variations in precipitation over time I utilize country-level data on total annual precipitation (measured in millimeters per year) from the Climatic Research Unit (CRU) at the University of East Anglia (Harris et al., 2014).[5] Because my theory concerns variation in precipitation from a country's average level, I follow Hendrix and Salehyan (2012) in using standardized annual deviations from the country's mean level of precipitation. This variable is constructed by dividing the annual deviation from a country's mean precipitation by the standard deviation of precipitation for that country. This provides a standardized, continuous measure of precipitation variability that is comparable across states regardless of their normal climatic conditions.

For theoretical reasons, I lag the rainfall deviations variable by one year. Although there is little concern of simultaneity bias (i.e. human activity does not affect rainfall levels on an immediate time scale), the effects of drought on hydrological systems often are not felt immediately (Van Loon, 2015). Although individuals can continue to consume available water resources until they are depleted, drought hinders the replenishment of these resources reducing the water supplies available down the road. Hypothesis 1 posits that drought in either the challenger or target state may have an effect on the militarization of river disputes. Since droughts are likely to occur simultaneously within both countries due to their close

[5] This data is available beginning in 1901 onwards. Data come from version 3.23 of the CRU country-year dataset, which aggregates monthly precipitation data from 0.5° by 0.5° grid cells at the country level. The data are available at `https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_3.23/crucy.1506241137.v3.23/countries/pre/`.

proximity, these measures are highly correlated ($r = 0.5235$, $p < 0.01$). As such, I run separate models examining the effect of precipitation deviations in both the challenger and target state.

In addition to variability in precipitation levels, a country's average precipitation level (i.e. climate) may influence the management of international river disputes. As such, I include each country's average yearly precipitation level as a control variable in all models. In addition, Hypothesis 2 states that the effects of drought are conditional on the climate of a given state. To test this, I introduce an interaction term between precipitation deviations and average precipitation.

Hypothesis 3 posits that extended droughts should have a stronger effect early on than they do later on. To measure this, I construct a count of the number of consecutive years that each state has been in a period of drought. I include this variable as a linear trend of drought duration to examine how the probability of MID initiation varies as a function of time.

Control Variables

Because rainfall is exogenous to human activity on any immediate time scale, there should be little concern about omitted variable bias affecting the primary results. Nonetheless, I include a number of control variables to facilitate comparisons to previous research. In order to isolate the effects of variations in water availability on the behavior of states, it is necessary to control for consumption levels. Following previous research, I include two separate proxies for water demand. Because human consumption plays a large role in determining demand for water, I include the logged population of each state in their respective models. Economic development also plays a large role in determining how much water a society uses since more developed countries tend to require more water for agriculture, manufacturing, power generation, etc. However, highly developed states also tend to be able to adapt to water shortages more easily (Homer-Dixon, 1999); As a result, (Gleditsch et al., 2006) argue that the relationship may take the form of an inverted parabolic relationship. Thus, conflict may be most likely among states that have developed to the point of straining their resources but have not yet begun to implement water-saving technologies. To control for this, I include the log of each state's GDP per capita as well as its squared term in all models.[6]

In addition, I control for the nature of the river claim and previous interactions between disputants. States are unlikely to pursue costly settlement options over rivers that do not constitute an important source of water for them (Hensel, 2001; Hensel, Mitchell, and Sowers, 2006; Hensel, Mitchell, Sowers, and Thyne, 2008). The ICOW dataset provides a measure of salience based on six factors: whether it serves highly populated areas, whether it is located in a state's homeland, and whether it is used for navigation, resource extraction, hydroelectric power generation, and irrigation. Each factor contributes one point to the index for each state, which is summed to create an ordinal measure that ranges from zero to twelve for each claim.

States that have previously signed agreements governing the use of river water are generally less likely to become involved in MIDs (Hensel, Mitchell, and Sowers, 2006; Tir and Stinnett, 2012; Mitchell and Zawahri, 2015). To control for this, I include a count of the number of river treaties previously signed by both disputants in a given year. Data on river treaties come from the Transboundary Freshwater Dispute Database (Wolf, 1998). Recent interactions between two disputants over river claims may also influence contemporaneous attempts to settle that claim. Recent MIDs and recent failed attempts to peacefully settle a dispute are associated with an increased probability of MID initiation (Hensel, 2001; Hensel, Mitchell, and Sowers, 2006; Hensel, Mitchell, Sowers, and Thyne, 2008). To capture these effects, I include a count of the number of MIDs fought over a given river claim and a count of the number of failed attempts to settle the claim in the previous five years.

Finally, I control for the nature of the dyadic relationship between disputants.[7] First,

[6] Data come from Angus Maddison's historical GDP per capita data, available from The Maddison-Project, `http://www.ggdc.net/maddison/maddison-project/home.htm`.

[7] Dyadic control variables were constructed using EUGene version 3.204 (Bennett and Stam, 2000).

the distribution of power between two disputants may influence the use of force in river disputes (Homer-Dixon, 1999; Hensel, Mitchell, and Sowers, 2006). To control for these effects, I utilize the ratio of the challenger's Composite Index of National Capability (CINC) score to the target's CINC score.[8] Second, because dyads in which both disputants are democracies are less prone to violent conflict (e.g. Russett and Oneal, 2001), I include an indicator variable for whether both states have a Polity score greater than five (Marshall and Jaggers, 2013). To avoid simultaneity bias, most time-varying covariates are lagged by one year.[9] Descriptive statistics for all variables are presented in the appendix.

RESULTS

I begin by discussing the results with respect to the challenger state, presented in Table 1. Model 1 examines the effects of the challenger's water scarcity on the probability of MID initiation. The estimated coefficient for the challenger's precipitation deviations is negative and significant, indicating that higher rainfall relative to a state's average is associated with a lower probability of MID initiation. This suggests that shocks to the challenger's water supply due to droughts significantly increase the probability of MID initiation, consistent with Hypothesis 1. Moving from one standard deviation below a country's mean level of rainfall to one standard deviation above the mean reduces the probability of MID onset from 0.0367 to 0.0123.[10] This constitutes a 67 percent reduction in the risk of militarized conflict.

Hypothesis 2 states that droughts will have a stronger effect on the probability of international conflict in states that have lower average levels of water availability. To test this, Model 2 introduces an interaction term between the challenger's rainfall deviations and its average level of rainfall. Although the coefficient on the multiplicative interaction term is not statistically significant, this does not necessarily indicate that there is not a significant

[8] Data come from the National Military Capabilities dataset version 4.0 (Singer, 1987).

[9] Recent MIDs and Recent Settlement Attempts are not lagged since they are measured with respect to previous years.

[10] All predicted probabilities are calculated with control variables held at their observed values.

Table 1: Binomial Logit of Militarized Interstate Dispute Initiation over River Claims Based on Challenger Characteristics

	(1)	(2)
Water Availability		
Precipitation Deviations	-0.546*	-0.778
	(0.107)	(1.174)
Average Precipitation	-0.252	-0.232
	(0.533)	(0.501)
Precipitation Deviations ×		0.040
Average Precipitation		(0.201)
Drought Duration	-0.284*	-0.282*
	(0.106)	(0.106)
Water Demands		
Population	-0.321	-0.321
	(0.349)	(0.348)
GDP per Capita	8.492	8.574
	(7.582)	(7.568)
GDP per Capita Squared	-0.492	-0.496
	(0.459)	(0.457)
River Controls		
ICOW Salience Index	0.144	0.145
	(0.162)	(0.163)
River Treaties	-0.171	-0.172
	(0.240)	(0.239)
Recent Militarized Disputes	0.572	0.573
	(0.592)	(0.591)
Recent Failed Settlement Attempts	-0.302	-0.302
	(0.232)	(0.230)
Dyadic Controls		
Capabilities Ratio	-0.009	-0.009
	(0.031)	(0.031)
Joint Democracy	-0.843	-0.834
	(1.029)	(1.050)
Constant	-36.024	-36.496
	(32.087)	(32.049)
Observations	726	726
Log-likelihood	-71.46431	-71.45771

Note: Entries are binomial logistic regression coefficients. Standard errors clustered by dyad are presented in parentheses. * $p < 0.01$ in a two-tailed test.

interaction in a nonlinear model. Instead, examining the marginal effect of one independent variable on the predicted probability of an event at different values of the other independent variable is necessary to ascertain whether there is a significant conditional effect (Berry, DeMeritt, and Esarey, 2010).

Table 2 presents the marginal effects of the rainfall deviations variable and their associated standard errors at representative values of average rainfall. This table demonstrates that there is a modest conditional effect for rainfall variability depending on the average level of the challenger state. The marginal effect of rainfall deviations is lowest at the 25th percentile of average rainfall, indicating that higher levels of rainfall have the strongest negative effect on the probability of conflict in states with dry climates. At the median level of average rainfall, the marginal effect of rainfall deviations remains negative and statistically significant, but the magnitude of the marginal effect is lower (i.e. the marginal effect is closer to zero). Moving up to the 75th percentile of average rainfall (i.e. a relatively humid climate), the marginal effect of rainfall deviations becomes even smaller and is no longer significant at the 0.05 significance level. This indicates that rainfall deviations do not have a substantial effect on the probability of conflict in relatively wet climates. Overall, the marginal effect of the yearly rainfall deviations variable is strongest at low levels of average rainfall and moves steadily towards zero as the level of average rainfall within a state increases. This trend is consistent with Hypothesis 2.

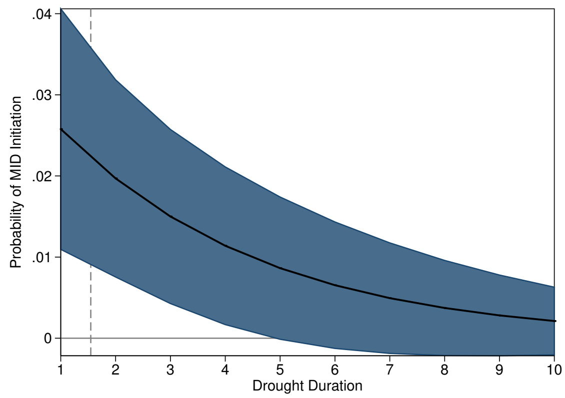
Table 2: Marginal Effects of Rainfall Deviations on the Predicted Probability of MID Initiations at Representative Values of Average Rainfall (Challenger State)

Average Rainfall	Marginal Effect	Standard Error
25th percentile	$-.0128^{**}$	.0058
50th percentile	$-.0111^{**}$	.0042
75th percentile	$-.0099^{*}$	.0052

** $p < 0.05$, * $p < 0.10$

Hypothesis 3 posits that the influence of drought on the probability of international conflict will decay the longer a drought goes on as states adapt to lower levels of rainfall.

Figure 1: Predicted Probability of MID Onset According to Duration of Challenger Drought



Predicted probabilities with 95% confidence intervals. Predicted probabilities are calculated with all other variables held at their observed values. The dashed line represents the mean of drought duration.

The coefficient on drought duration is negative and significant, indicating that the probability of MID initiation decreases the longer the challenger remains in a period of drought. Figure 1 plots the predicted probability of MID initiation (on the y-axis) as a function of time (on the x-axis) for the first ten years after the beginning of a drought. As expected, the predicted probability of MID onset is highest during the first year of a drought and declines steadily thereafter. After five years the probability of drought becomes statistically indistinguishable from zero. This illustrates that the effects of drought on the probability of MID onset diminishes with time, suggesting that states are able to adapt to water shortages given a sufficiently long time period.

Table 3 presents the results of MID onset as a function of target state characteristics. In Model 3 the estimated coefficient for the target's precipitation deviations is negative and significant, indicating that increases in rainfall in the target state are associated with a decrease in the probability of MID initiations. Moving from one standard deviation below a country's mean level of rainfall to one standard deviation above the mean reduces the probability of MID onset from 0.0313 to 0.0149, a reduction of 53 percent. This finding is consistent with Hypothesis 1 and suggests that droughts in the target state exacerbate

Table 3: Binomial Logit of Militarized Interstate Dispute Initiation over River Claims Based on Target Characteristics

	(3)	(4)
Water Availability		
Precipitation Deviations	-0.370*	0.484
	(0.135)	(1.120)
Average Precipitation	-0.384	-0.426
	(0.445)	(0.432)
Precipitation Deviations ×		-0.143
Average Precipitation		(0.193)
Drought Duration	-0.287	-0.298
	(0.204)	(0.211)
Water Demands		
Population	-0.463	-0.447
	(0.267)	(0.266)
GDP per Capita	7.518	6.721
	(9.861)	(9.597)
GDP per Capita Squared	-0.548	-0.500
	(0.612)	(0.595)
River Controls		
ICOW Salience Index	0.241	0.237
	(0.213)	(0.213)
River Treaties	0.171	0.170
	(0.247)	(0.246)
Recent Militarized Disputes	0.523	0.513
	(0.668)	(0.646)
Recent Failed Settlement Attempts	-0.084	-0.080
	(0.218)	(0.211)
Dyadic Controls		
Capabilities Ratio	-0.178	-0.175
	(0.159)	(0.160)
Joint Democracy	-1.035	-1.124
	(0.864)	(0.791)
Constant	-22.453	-18.990
	(37.871)	(36.970)
Observations	747	747
Log-likelihood	-69.99491	-69.85976

Note: Entries are binomial logistic regression coefficients. Standard errors clustered by dyad are presented in parentheses, * $p < 0.01$ in a two-tailed test.

river claims either by reducing overall river flow or altering consumption levels. As with the challenger state, the average level of rainfall in the target state does not have a significant effect on the probability of MID initiation, which may suggest that variation in rainfall matters more than the average level of rainfall available to a state.

Model 4 tests the interactive hypothesis for the target state. None of the constitutive terms are significant individually. Table 4 presents the marginal effects of the rainfall deviations variable at various levels of the average rainfall variable. This table illustrates that the marginal effect of precipitation deviations on the predicted probability of MID initiation remains constant across the range of average precipitation. Thus, the effects of drought do not appear to be conditional on the average level of rainfall in the target state in the same way that they are for the challenger state. Given that drought should have the most direct effect on the challenger state, it is not surprising that the average level of precipitation in the target state does not influence the probability of conflict.

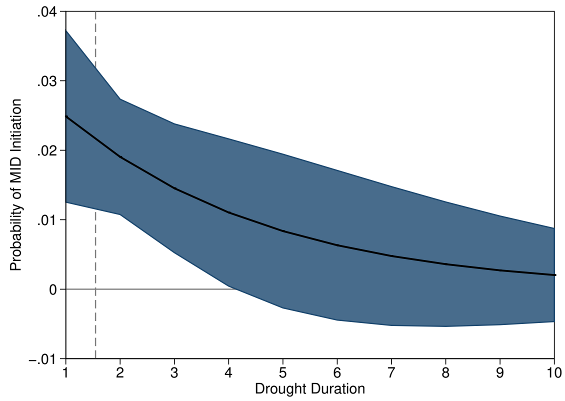
Table 4: Marginal Effects of Rainfall Deviations on the Predicted Probability of MID Initiations at Representative Values of Average Rainfall (Target State)

Average Rainfall	Marginal Effect	Standard Error
25th percentile	-.0086*	.0049
50th percentile	-.0086*	.0046
75th percentile	-.0086*	.0047

** $p < 0.05$, * $p < 0.10$

The estimated coefficient for drought duration in the target state does not achieve statistical significance at conventional levels in either model in Table 3. It is worth noting, however, that the coefficient is significant at the 0.1 level in a one-tailed test ($p < 0.16$ in Model 3 and $p < 0.156$ in Model 4). This constitutes weak evidence that the effect of drought in the target state decays over time as predicted by Hypothesis 3. Figure 2 plots the predicted probability of MID initiation with respect to drought duration. This plot demonstrates that the probability of MID initiation decays as a function of time and does so more quickly than in the challenger state, becoming insignificant after four years. Based on these

Figure 2: Predicted Probability of MID Onset According to Duration of Target Drought Duration



Predicted probabilities with 95% confidence intervals. Predicted probabilities are calculated with all other variables held at their observed values. The dashed line represents the mean of drought duration.

results, there is some reason to believe that attempts by either the challenger or target state reduce the probability of conflict over time, although this finding should be interpreted with an appropriate degree of caution.

As noted above, the average level of precipitation in a state does not have a significant influence on the probability of MID onset. In addition, neither of the control variables for water demands (GDP per capita or population) for either the challenger or the target have a discernible effect. Together, this suggests that precipitation variability may be a more important factor influencing of the use of force than average levels of supply and demand. None of the other control variables have a significant effect on the probability of MID initiation.

CONCLUSION

The connections between water scarcity and international conflict have long been of interest to scholars and practitioners alike. Although most river disputes are resolved via cooperative means, several notable conflicts have occurred over the use of joint rivers in the past. Acute precipitation shortages have the potential to severely disrupt river flows and consumption patterns which may have substantial effects on states' ability to use rivers for a wide array of activities including consumption, navigation, fishing, and power generation. In doing so, droughts may exacerbate existing international disputes over these issues and increase the willingness of states to use force to resolve their disagreements. My findings indicate that there is an association between below average precipitation levels in either the challenger or target state in a river claim and the probability of militarized disputes.

In addition, I find that the effect of rainfall on river disputes is conditional on the average level of precipitation a state experiences, at least for the challenger state. This is to be expected, since the effects of droughts should be particularly severe in states that already have limited water supplies. In addition, I do not find evidence that average levels of rainfall have an effect on the probability of conflict independent of yearly variation in water availability. This suggests that water variability may be a more significant determinant of conflict than climate, although more research should be conducted to verify this before drawing strong conclusions.

Finally, I find that the effect of precipitation shortages decays the longer a state remains in a period of drought. The risk of engaging in the use of force is highest during the early stages of a drought and rapidly decreases to zero within five years. This suggests that states are able to gradually adapt to the effects of drought as time goes on, decreasing the risk of military conflict. Although this effect is particularly strong in the challenger state, there is some weak evidence that this is true in the target state as well.

From a scholarly perspective, these findings have implications for several areas of research. First, my argument contributes to literature on international river disputes and represents one of a handful of studies that suggest that drought influences the way in which states manage river claims. These findings suggest that scholars should pay more attention to the manner in which changes in weather patterns influence the management of river disputes and the way that weather and climate interact to produce certain outcomes. In addition, changes in water availability due to weather have the advantage of being able to explain *when* states resort to the use of conflict, compared to the constant effects of climate.

In addition to its influence on international conflict, previous research has found that droughts may affect the propensity of states to sign and comply with agreements governing the use of shared rivers (e.g. Kilgour and Dinar, 2001; Brochmann and Hensel, 2011; Tir and Stinnett, 2011). This suggests that future research on river disputes should pay more attention to short-term variations in water availability due to weather in addition to climatic conditions within particular states or regions. For example, future research might examine how drought influences other aspects of river dispute management such as the formation, design, and resilience of international institutions designed to manage river disputes. Drought may also have implications for the onset and termination of river claims.

Second, my findings speak to the debate on whether resource scarcity encourages conflict between states. To date, research on renewable resources and conflict focuses almost exclusively on water (Koubi, Spilker, et al., 2014). If the way states manage river disputes are indicative of how states manage disputes over other natural resources, the literature suggests that states tend to avoid using force and have had great success managing these resources in a cooperative manner. However, my findings indicate that acute shortages of a valuable resource may enhance the willingness of states to resort to the use of force to coerce their enemies into complying with their demands. Future research should examine whether variations in resource availability over time influence the propensity to use force over other resources as well.

Third, scholars have increasingly turned their attention to the possibility that climate change will precipitate international conflict. Although previous studies have mostly produced weak findings (see Theisen, Gleditsch, and Buhaug, 2013), my findings suggest that the increasing frequency and severity of drought due to climate change may represent a serious risk for increased interstate conflict. Combined with the effects of population growth and increasing economic development, the prospect of international conflict over water resources deserves careful consideration.

From a policy perspective, my findings suggest that members of the international community concerned with alleviating the risk of conflict over water should focus on expanding access to water and developing conflict management institutions in countries that are subject to frequent and severe droughts. This is particularly important given that provisions designed to mitigate the effects of runoff variability are the least common type of provision found in river management institutions globally. Moreover, these provisions are frequently absent in the regions at the greatest risk of experiencing increased variability such as northern and sub-Saharan Africa (De Stefano et al., 2012).

In addition, my findings also provide evidence that states can adapt to drought given sufficient time to implement policies designed to increase supplies and alter consumption patterns. This suggests that attempts to bolster the capacity of states to rapidly respond to water shortages may be an effective method of reducing the risk of conflict. Given that climate change is expected to increase the frequency and severity of droughts for many countries in the coming decades, policies designed to facilitate the peaceful management of shared rivers will be particularly important in preventing the outbreak of violent conflict.

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APPENDIX

Table 5: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
MID Initiation	763	.024	.152	0	1
Precipitation Deviations (Challenger)	757	-.088	1.054	-3.166	2.904
Precipitation Deviations (Target)	757	-.034	1.069	-3.194	3.378
Average Precipitation (Challenger)	760	6.215	.701	3.717	7.96
Average Precipitation (Target)	760	6.376	.634	3.717	7.776
Drought Duration (Challenger)	760	1.547	2.635	0	22
Drought Duration (Target)	760	1.084	1.597	0	11
Population (Challenger)	758	9.347	1.115	7.012	12.537
Population (Target)	758	9.784	1.537	6.802	12.537
GDP/Capita (Challenger)	734	8.299	.705	6.851	10.265
GDP/Capita (Target)	756	8.527	.623	6.83	10.265
ICOW Salience Index	763	5.696	2.338	2	10
River Treaties	763	1.59	2.391	0	12
Recent Militarized Disputes	763	.117	.401	0	3
Recent Failed Settlement Attempts	763	.569	1.097	0	8
Capabilities Ratio	758	2.599	6.489	.013	62.422
Joint Democracy	757	.205	.404	0	1