

Introduction

The Debate on Climate Change and Water Security

It is still important that the popular myth of water wars somehow be dispelled once and for all. This will not only stop unsettling and incorrect predictions of international conflict over water. It will also discourage a certain public resignation that climate change will bring war, and focus attention instead on what politicians can do to avoid it. . . . And it would help to convince water engineers and managers . . . that the solutions to water scarcity and security lie outside the water sector in the water/food/trade/economic development nexus.

Wendy Barnaby, "Do Nations Go to War over Water?" (2009, 283)

Much has been written about freshwater conditions around the world with implications for national and international security. The scientific and environmental literature tells us that water will become less available (and its supply more volatile and variable) in the future due to population growth, improved standards of living, increased pollution, and climate change. The economics literature claims that existing institutions and policy interventions are not keeping pace with increased scarcity and that water-supply and water-demand technological advancements are much less affordable to the developing world. Adopting these arguments, the popular press prophesies a less stable world, plagued by water wars that will result from competition over increasingly scarce water.

Despite these gloomy contentions and predictions, there are cases where, in spite of water scarcity (and variability) and the political and economic challenges that follow, cooperation and coordination are evidenced. Interestingly, the large majority of the works that document such cases focus on one particular river basin or a comparative analysis across a small number of basins and thus may be of lesser utility for general conclusions. More recently, scholars have attempted to more generally investigate the concepts of scarcity and variability, utilizing the corpus of international water treaties as well as other forms of large datasets and their corresponding empirical methodologies.

The main research question we attempt to address in this book is whether increased scarcity and/or variability of water resources leads parties (states) that share international water bodies to engage in violent conflict or even war, or whether there are mechanisms that help them mitigate such situations. To answer this question, this book develops an interdisciplinary approach for considering international water management under increased scarcity and variability. Our approach applies a theory rooted in international relations and economics to the analysis of scarcity, variability, and cooperation. It demonstrates the utility of the theory, utilizing the global set of transboundary water bodies. It provides a framework that allows scholars and policymakers to reflect on various future scenarios and assess the impact of policy interventions on the regional and global level.

The book begins with this introduction, which presents the “water wars” argument and considers aspects of cooperation, setting the groundwork for chapter 2 and for the rest of the empirical chapters that support our thesis in the book. Chapter 2 introduces the general scarcity-cooperation contention/theory by considering the relationship between scarcity and variability and the emergence of treaties. Chapter 3 empirically investigates that contention using econometric and statistical methods. Building on this empirical investigation, chapter 4 explores the way treaties (and the mechanisms they codify) assuage conflict and promote cooperation. Chapters 5 and 6 build on the empir-

ical results of chapter 4, which demonstrate that certain institutional mechanisms promote sustained cooperation and coordination. Chapters 5 and 6 focus on case studies that demonstrate the utility of such mechanisms. The book's concluding chapter summarizes the main arguments and results of the book with policy implications, in addition to assessing some of the shortcomings of our argument, and providing suggestions for future research. A detailed description of the book's outline and organization is provided later in the chapter.

CLIMATE AND HYDROLOGY

Climatic conditions have a direct impact on the hydrology of river basins. Climatic change will most likely affect the variability of river flows and have a variety of additional impacts on the hydrologic cycle (Jury and Vaux 2005; Miller and Yates 2006). The change in flow variability will affect populations, who will be less able to plan based on water availability and supply trends (Milly et al. 2008). Changes will not be consistent, and regions will experience either increases or decreases in river discharge compared with present observations (Palmer et al. 2008).

The Fourth and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC 2007, 2013) reiterate the trend in global surface temperature for the end of the twenty-first century. Warming will continue to exhibit interannual-to-decadal variability (IPCC 2007, 1–10). The Fifth Assessment Report further suggests that “changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions” (IPCC 2013, 18). The Fourth Assessment Report confirms the findings from the Third Assessment Report, stating that “one major implication of climate change for agreements between competing users (within a region or upstream versus downstream) is that allocating rights in absolute terms may lead to

further disputes in years to come when the total absolute amount of water available may be different” (IPCC 2001, § 4.7.3).

While the hydrologic forecasts of the impact of climate change on future runoff of rivers are only as good as the models used for their prediction, all models suggest significant changes (Doll and Schmied 2012; Nohara et al. 2006; Gosling et al. 2011). Results of expected future changes in levels and trends of several hydrologic variables at a global scale for 2081–2100 can be found in the IPCC report (IPCC 2013, 45). Among the six variables listed in the IPCC report, the three relevant to our work demonstrate a distributional range of both increase and decrease in precipitation (−0.8 to +0.8 millimeters per day), evaporation (−1 to +0.8 millimeters per day), and runoff (−40 to +40%), suggesting wide variability across different parts of the world.

The impact of climate change will be felt most acutely through its effects on water resources and through these on the rest of society. Most evidence suggests that climate change will not change the basic nature of threats to water resources, but rather will affect the severity and timing of these threats (Doczi and Calow 2013, 35). As suggested by many recent hydrological studies (e.g. Milly et al. 2005; Milliman et al. 2008), a significant increase in river flow variability has already been observed. Furthermore, it is expected that future climate change will extend that variability beyond the range already observed (IPCC 2007, 31; Milly et al. 2008).

HYDROLOGIC VARIABILITY, INSTITUTIONS AND CONFLICT AND COOPERATION

Hydrologic variability creates a significant challenge especially for countries sharing international river basins. Unanticipated high-flow or low-flow events may lead to flooding, severe drought, destruction of infrastructure and human lives, and water resource disputes. These events may, in turn, give rise to economic shocks and political tensions and in some cases even armed conflict (Drury and Olson 1998; Nel and

Righarts 2008; Hendrix and Salehyan 2012). In the context of interstate relations, political tensions and other types of conflict-ridden water-related events may unfold not just in basins devoid of institutional capacity (such as water treaties) but also in basins where water treaties have been negotiated. In other words, climate change could increase the probability of flow below treaty specifications and expectations, leading to noncompliance and consequent hostilities between riparians (Ansink and Ruijs, 2008; Dinar, Dinar, and Kurukulasuriya 2011; Dinar et al. 2015). Interestingly, some scholars have argued that water supply variability (as a function of climate change) may actually be an impetus for cooperation whereby riparian states negotiate water agreements or revise an existing treaty (Brochmann and Hensel 2009; Dinar et al. 2010b).

While the existence of a treaty may be an important factor in assuaging conflict wrought by water scarcity and variability, treaty design may be equally important. De Stefano et al. (2012) distinguish between flexible and non-flexible treaty mechanisms to deal with water variability. They identify four major mechanisms, namely (1) water allocation, (2) water variability management, (3) conflict resolution, and (4) river basin organization. They claim that having one or a subset of these mechanisms enhances treaty resilience in dealing with water variability.

Additional features that may help in dealing with water variability and reduce conflict include *issue linkage* (Pham Do, Dinar, and McKinney 2012), *compensation mechanisms* or *side payments* (Dinar 2008), and *water borrowing mechanisms* to allow water-stressed riparians emergency access to water in a bad year with the understanding of repayment in the future. For example, the treaty between Mexico and the United States on the Rio Grande (Rio Bravo), which was renegotiated in 2014, reflects a much higher level of cooperation. The treaty allows for reservoir storage capacity in the United States in abundant years, for use by Mexico in dry years, up to Mexico's allocated share. Finally, the concept of *strategic alliance* also serves to deal with water variability and assuage conflict (A. Dinar 2009). The strategy entails expanding the pie

of negotiation possibilities by allowing for out-of-basin water transfers (Carter et al. 2015).

Consequently, when designing water agreements or appending an outdated one, water negotiators need to forecast the distribution of water flow, in order to design an effective treaty. Having high-quality flow data will also determine the appropriate treaty stipulations and institutional mechanisms that can deal with future challenges (Dinar et al. 2015). Real-time data can also provide policymakers and researchers with the ability to predict extreme weather events, and address their economic impact on an existing treaty or shared river basin.

In the next section we further investigate whether increased water scarcity and variability affect the relations between riparian states. We largely review the academic literature (international relations and economics), rather than the popular press, which more commonly prophesies sensationalist wars over water.

THE WATER SCARCITY—WAR DISCOURSE

Many events taking place around the world make headlines as they impact global security. However, environmental change might have the most significant impacts. Along with extreme and frequent weather patterns, rising sea levels, and other natural hazards, global warming has negative effects on freshwater resource availability, potentially leading to serious long-term social and political impacts. Such a situation prompts policymakers, politicians, and researchers to think in terms of security risks.¹ For example, the Office of the Director of National Intelligence (2012) suggests that international water disputes, a result of increased water scarcity, will affect the security interests of not only riparian states but also the United States.

Analysts expect that climate change will intensify security concerns both within (domestic) and between (international) countries that share basins (Gleick 1993; Nordas and Gleditsch 2007). While in this book we do not address domestic issues, it has been argued (Barnett 2003) that

climate change, via direct and indirect negative impacts, will undermine institutions and jeopardize the well-being of large populations. Climate change, through its impact on resource availability and water variability, can lead to uncertainty in property rights as well as changes in land productivity, forest cover, and water availability. These differential effects on the resource base are potential triggers for conflict among basin states (Gartzke 2012).

Recent research has found causal linkages between climate change and increased levels of conflict, including civil wars, mainly in developing countries (Barnett and Adger 2007; Klare 2001; Hensel, Mitchell, and Sowers 2006). However, as argued by Gartzke (2012, 179), economic and industrial development, which contribute to climate change, also contribute to international peace because development reduces the inclination of states to fight. In addition, Gartzke asserts that warfare is a much more costly approach to solving conflicts among states, especially compared with bargaining alternatives (180). In a global analysis of transboundary basins, Tir and Stinnett (2012) find that water scarcity could contribute to interstate tensions and increase the risk of military conflict. However, the same study argues that to prevent conflicts from escalating, agreements with strong institutional features have to be in place. A regional study on the Aral Sea Basin (Bernauer and Siegfried 2012) identifies climate change as a likely trigger of political tensions over water allocation among the basin states. Yet, the authors conclude that a climate change–induced militarized dispute over water in the basin is unlikely.

In general, two types of studies have rejected predictions of wars over water. The first type is more theoretical in nature. Such works make qualitative arguments and provide logical consequences and extrapolation, often buttressed by historical and case-specific evidence (e.g. Gleditsch 1998; Wolf 1998). The second type is more empirical and statistical, utilizing econometric tools to provide more generalizable and global results (e.g. Yoffe, Wolf, and Giordano 2003).

This book follows the line of thought that climate change–induced scarcity and water variability leads to conflict, as does any scarce

resource that is in demand by different individuals or states. The book expands on our recent work, developing a theory of conflict and cooperation under conditions of scarcity and variability with application to various contexts at the global level.

THE RELEVANCE OF THE BOOK TO THE DEBATE
ON WATER CONFLICT AND COOPERATION

This book develops and demonstrates the application and usefulness of an interdisciplinary approach for considering international water management under increased scarcity and variability. The book exhibits the usefulness of the theory, utilizing the global set of transboundary water bodies. By doing so, the book provides a framework that allows scholars and policymakers to reflect on various future scenarios and assess the impact of policy interventions on the regional and global levels with implications for conflict and cooperation. Finally, the book considers strategies and other forms of incentives that help assuage conflict and motivate cooperation despite scarcity and variability. We briefly review here the literature pertaining to the main variables that are related to conflict and cooperation in the context of international water. An expanded literature review will be provided in a separate chapter.

Countries cooperate over water bodies they share for several reasons. The economics and international relations literature suggests that they do so because they face challenges they cannot overcome themselves; because they anticipate externalities in dealing with pollution, flood control, or hydropower; or for reasons of economies of scale, where parties anticipate being better off cooperating when facing certain water scarcity situations (Just and Netanyahu 1998; S. Dinar 2009). Countries also cooperate so as to formalize historical uses of water; to establish fairness and equity considerations in water allocation procedures; and to provide simple recognition of rights to shared water (Wolf 1999; Wolf and Hamner 2000).

The economics and international relations literature that applies statistical tools and analysis to international water datasets (Brochmann and Hensel 2009; Espey and Towfique 2004; Gleditsch et al. 2006; Hensel, Mitchell, and Sowers 2006; Song and Whittington 2004; Tir and Ackerman 2009; Tøset, Gleditsch, and Hegre 2000; S. Dinar 2009; Dinar, Dinar, and Kurukulasuriya 2011) has gone a long way already in developing a theory that explains various aspects of cooperation over shared water. We adopt a number of these variables in our study.

Water Scarcity and Variability

Overall scarcity (or water availability) is an important explanatory variable in various statistical studies. In particular, S. Dinar (2009; see also the literature he cites) hypothesizes an inverted-U-shaped curve between levels of treaty cooperation and water scarcity. He finds a lower need to cooperate when riparians boast a sufficient level of water. As scarcity levels increase, the impetus for cooperation increases. When water becomes extremely scarce, there is very little of the resource to cooperate over, and thus formalized coordination becomes less likely. A similar curvilinear relationship was suggested in relation to water variability, which also measures water scarcity (Dinar et al. 2010b). Cooperation in the aforementioned studies is measured by the signing of (a) new treaties in cases where they did not exist before, (b) additional treaties to amend the initial set of agreements, or (c) new treaties introducing more issues (such as water quantity, hydropower, and flood control) into the overall cooperative framework (Dinar, Dinar, and Kurukulasuriya 2011).

Democracy and Governance

Past studies have concluded that dyads² made up of democratic countries, relative to dyads with at least one non-democratic country, are more likely to demonstrate higher international environmental commitment in

general and to sign international agreements in particular (Neumayer 2002b; Tir and Ackerman 2009).

Domestic (political, legal, and economic) institutions may play a major role in either facilitating or inhibiting international cooperation. They reflect the state's ability to enter into, and honor, an agreement, which may require financial investments and costs (Congleton 1992, 412–413). More institutionally advanced countries may in turn have little interest in cooperative ventures with countries having weaker and unstable institutions. Similarly, investments are not secure and property rights are poorly defined in unstable countries characterized by political turmoil (Deacon 1994). Past studies have also examined how political, legal, and economic institutions perform under conditions of increased water scarcity and affect intrastate conflict in the form of civil wars and other forms of domestic violent conflict (Hauge and Ellingsen 1998, 311; Raleigh and Urdal 2007, 684). Hauge and Ellingsen (1998), for example, find that a non-democracy and, particularly, a partial democracy (also known as a semi-democracy) are more prone to domestic violent conflict in comparison to a democracy. Raleigh and Urdal (2007) find a similar result whereby countries that are becoming less democratic over time (labeled “movement to autarchy” by the authors) are more conflict-prone.

Trade and Overall Country Relations

The literature also considers trade and the extent of diplomatic ties among states when explaining the emergence or failure of treaty signature and sustained cooperation. By some accounts, the more countries trade, the greater their interdependence and the higher the likelihood of treaty formation (Polachek 1980, 1997). In fact, Janmatt and Ruijs (2007) argue that there is little scope for capturing the gains from basin-level management if economic integration does not extend beyond water issues. A history of diplomatic ties and good relations are also expected to increase the likelihood of treaty signing (Yoffe, Wolf, and Giordano 2003).

Power Asymmetries

Some studies in the international relations literature have claimed that power asymmetry facilitates cooperation, specifically when the downstream country is more powerful (Lowi 1995). Similarly, Zeitoun and Warner (2006) claim that power asymmetries in a given basin are conducive to “hydro-hegemony,” whereby the more powerful country can dictate the basin’s affairs, in the form of either coercion and resource capture or cooperation and treaty signature.

Other works have argued that power asymmetry is not a prerequisite for cooperation, although if asymmetry does exist the hegemon often plays a benign role by facilitating interstate coordination through incentives (Young 1994; Barrett 2003). Consequently, while brute power may be less relevant for analyzing interstate conflict and cooperation in the case of hydro-politics (Wolf 1998, 258–261), the different abilities of countries to provide such incentives as financial transfers or side payments may be important.

Some economic studies (Just and Netanyahu 1998, 9; Hijri and Grey 1998, 89), nonetheless, claim that power asymmetries generally impede cooperation. First, a power balance may reflect a type of inequality in the sense that trust issues are reduced. In asymmetric contexts, a weaker party may believe it will be taken advantage of by the stronger party (Rubin and Brown 1975, 213–233). Second, motivating environmental cooperation in asymmetric contexts often requires costly incentives from the more powerful/richer (and often more environmentally conscious) state to the weaker/poorer state (Compte and Jehiel 1997; Bennett, Ragland, and Yolles 1998, 63–66). Such incentives may be considered a “bribe,” and the party providing the incentive may even be branded a weak negotiator, thus deterring that party from following through on its commitment.

Geography

Certain riverine geographical configurations are said to facilitate conflict, while others are said to be more conducive to cooperation. The

literature has argued that the more asymmetric the river geography, the more difficult it is to achieve cooperation (LeMarquand 1977; Hafendorn 2000). This is notoriously most common in upstream-downstream situations. In contrast, the more symmetric the river geography (i.e. the more retaliation is internalized to the river system), the less feasible conflict becomes. In other words, the more the river straddles the international boundary, the less such a typology may be conducive to conflict (Toset, Gleditsch, and Hegre 2000) and the more favorable to cooperation.

THE ORGANIZATION OF THE BOOK

Chapter 2, “Theory of Scarcity-Variability, Conflict, and Cooperation,” develops the scarcity-cooperation contention introduced in this chapter and builds on the framework proposed by S. Dinar (2009) and Dinar et al. (2011), suggesting that cooperation between states is a function of the level of water scarcity. This theory, however, suggests that the relationship between scarcity and cooperation is hill-shaped (inverted-U-shaped), rather than linear as suggested in many previous models. That is, the level of institutionalized cooperation over the management of international water is low when the level of water scarcity is very low or very high. Since increased variability of water supply, as it relates to climate change, is argued to be associated with the concept of scarcity, the inverted-U-shaped relationship also holds for variability. The chapter will provide examples to support this relationship, and will set the stage for the various empirical analyses to follow. The chapter will likewise highlight sociopolitical, economic, and geographic attributes that facilitate or impede cooperation over water.

Chapter 3, “Emergence of Cooperation under Scarcity and Variability,” is based on the empirical analyses and findings of Dinar, Blankepoor, and Kurukulasuriya (2010a, 2010b), Dinar, Dinar, and Kurukulasuriya (2011), and other empirical studies focusing on basins shared between two or more states. Results based on the scarcity/variability–

cooperation contention are highlighted, as well as the results pertaining to the so-called control variables (e.g. sociopolitical, economic, and geographical).

Chapter 4, “Institutions and the Stability of Cooperative Arrangements under Scarcity and Variability,” investigates treaty design and considers the institutional instruments states negotiate in an effort to overcome scarcity and enhance treaty stability under conditions of variability. The chapter reviews the rich institutional literature pertaining to cooperation and environmental treaty design in general, as well as consulting the more specific water policy and politics literature. Quantitative and empirical works are examined to further shed light on the utility of specific mechanisms and stipulations.

Chapter 5, “Incentives to Cooperate: Economic and Political Instruments,” builds on the previous chapter, which considered treaty design. It reviews the ways riparian states deal with scarcity and variability in practice through different (domestic and international) policies and diplomatic instruments. Political arrangements such as issue linkage, foreign policy considerations, reciprocity, and side payments are considered. The chapter provides evidence from various water negotiation cases and international river compacts. Lessons are extrapolated for basins not yet governed by agreements.

Building on chapter 5, chapter 6, “Evidence: How do Basin Riparian Countries Cope with Scarcity and Variability?” provides evidence from actual treaties as to the ways riparian states deal with scarcity and variability and analyzes the effectiveness of treaties. Special attention is given to virtual water, second-order resources strategies, supply-side solutions, and demand-side solutions.

Chapter 7, “Conclusion and Policy Implications,” provides not only a concluding synopsis of the entire book but also discusses policy implications based on the scarcity and variability contentions introduced. The linear, but, particularly, the curvilinear relationship pertaining to scarcity, variability, and cooperation has important ramifications for international water negotiation as well as lessons for concerned governments

and international organizations. In addition, suggestions regarding particular treaty mechanisms and stipulations, as well as policies, incentives, strategies, and diplomatic instruments, are advanced for those basins in the midst of negotiations or those basins not yet governed by agreements. Future research is discussed in the context of both regional and global water agreements.