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Case Studies on Water Security: Analysis of System Complexity and the Role of Institutions

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Abstract: Water security is a challenge faced within many transboundary river basins. Identifying the resilient factors within a system may reduce water security concerns and enhance cooperation. In this paper, we are examining the dimensions of resilience as influenced by the rate of change and institutional capacity within river basins. Three case studies are analyzed for their water security capacity, including resilience and vulnerability, as well as institutional capacity.

Keywords: *Water security, system resilience, vulnerability*

Water security is the availability of freshwater in the right quantity and quality, at the right times, for dependent systems. This is a prerequisite for human and environmental security, as well as economic growth. Global freshwater resources are vital not only for individual consumption and the natural environment, but also for the agricultural, energy, industrial, and transportation sectors. As a limited resource, water is influenced by a nexus of geophysical conditions, geopolitical agendas, and socio-cultural dynamics on several scales. The relationship between changes to the physical environment and political and social instability has been postulated by numerous scholars, with shifts in freshwater resource access, quality, and quantity often noted as being a key change and influence on societal and political stability (Brown et al. 2007; Eckstein 2010; Swart 1996). Changes in water resources can alter the relative wealth of countries and cause shifts in relative power. In many ways, water is one of the most important components holding societies together. When the rate of change to a water system exceeds its capacity to adapt, the myriad connections to overall security and stability soon become evident.

Global freshwater is increasingly under pressure due to direct human use and alteration, and also due to environmental issues, such as global climate change. Several studies have examined how already-stressed systems that are vulnerable could be driven past a tipping point by shifts in climate (Barnett 2003; Dabelko 2008; Mabey 2007). More than one billion people already lack access to safe drinking water (Gleick 1999; Loftus 2009) and more than 2.4 billion lack access to sanitation worldwide (World Health Organization 2000). Globally, water-related illness and accidents are one of the leading causes of death each year, especially from diarrheal diseases.

International interests, through the creation of agreements, such as the United Nations Millennium Development Goals (MDGs), seek to reduce this number through international development and aid. Discussion of security and stability at different scales and for different sectors is especially useful in the context of freshwater resources and climate change (Buzan 2000; 2001). The impact of freshwater stress is of concern for all sectors of society, sometimes indirectly, with consequences that are largely unpredictable (Allan 2001).

Water interacts with broader national security concerns and can contribute to state instability and social disruptions. Three levels of scale can be employed to describe and understand interactions concerning freshwater resources: the individual,

intranational, and international systems (Buzan and Waever 2009). For individuals, water security can be considered a factor of "life, health, status, wealth, and freedom" (Stone 2009). States have larger, more complicated considerations that include a shifting hierarchy of requirements in often overlapping political, military, economic, societal, and environmental sectors (Buzan 2000; 2001). Each sector impacts security, but these individual sectors are also linked to one another, making a discussion of individual sectors inadequate to address impacts on security (Stone 2009). Due to the complexity at the state level, international systems are even more complicated, attempting to mesh multiple ever-fluctuating state water security aims and goals. This paper will examine the key role that state institutions take at the international level in regard to water security.

Institutional Capacity

Examining the roots of water resources conflicts suggests a relationship between change, institutions, and scale. These types of conflicts tend to occur where the rate of change within a basin exceeds its institutional capacity to absorb that change. Institutional capacity goes beyond the formal water management institutions to include all facets that contribute to water governance, including economy, military, and infrastructure. Evaluating past conflicts also suggests that sudden changes within a basin, either physical (e.g., high rate of population growth, dams) or institutional (e.g., new political boundaries, new governments, economic growth), are more hazardous to a basin's stability than "creeping changes" (e.g., water quality decline, certain aspects of climatic change excluding more severe droughts or floods). When changes occur in the absence of mitigating institutions, there exists the greatest potential for political tensions.

Hydropolitical Resilience and Vulnerability

The concepts of "resilience" and "vulnerability" as related to water resources are often assessed within the framework of "sustainability" and relate to the ability of biophysical systems to adapt to change (Gunderson and Pritchard 2002). As the discourse on sustainability has broadened to include human systems, research has also shifted towards the identification of resilience and vulnerability indicators within this context (Bolte et al. 2004; Lonergan et al. 2000; Turner et al. 2003).

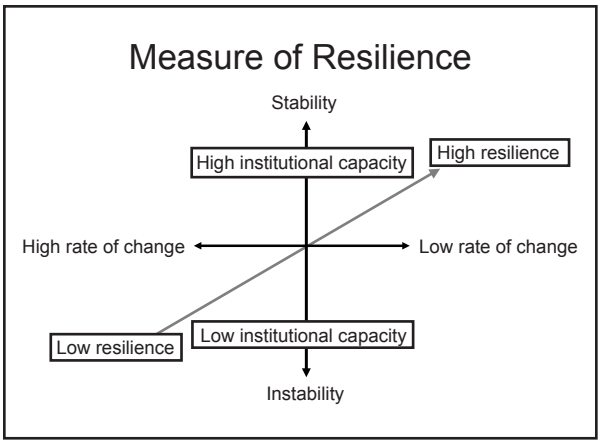

Figure 1. Measuring the resilience of a system. Systems with high institutional capacity and a low rate of change are likely to be highly resilient.

As the potential for conflict and violence regarding international waters has become identified, the term "hydropolitics" has emerged as a descriptor of the ability of geopolitical institutions in their management of shared water resources in a manner that is politically sustainable, meaning without tensions or conflict between political entities. "Hydropolitical resilience," then, is defined as the complex human-environmental system's ability to adapt to permutations and change within these systems, while "hydropolitical vulnerability" is defined by the risk of political dispute over shared water systems (Figure 1). Wolf et al. (2003) suggested the following relationship between change, institutions, and hydropolitical vulnerability: "The likelihood of conflict rises as the rate of change within the basin exceeds the institutional capacity to absorb that change."

Factors Influencing Hydropolitical Resilience and Vulnerability

The general assumption of the relationship between hydropolitical resilience and vulnerability is that rapid change is a stress that can expose or accentuate vulnerability while institutional capacity tends to indicate resilience, and that the

Figure 2. The Columbia River Basin.

two sides need to be assessed in conjunction with each other to gage hydropolitical sustainability more accurately.

The characteristics of a basin that would tend to enhance resilience to change include:

- International agreements and institutions, Such as River Basin Organizations,
- A history of collaborative projects,
- Generally positive political relations,
- Higher levels of economic development,

In contrast, facets that tend towards vulnerability would include,

- Rapid environmental change,
- Increased hydrologic variability,
- Rapid population growth or asymmetric economic growth,
- Major unilateral development projects,
- The absence of institutional capacity,
- The potential for "internationalization" of a basin, and
- Generally hostile relations.

When examining all characteristics in combination, it becomes clear that major water projects, such as dams, diversions, or development schemes in the absence of agreements or collaborative organizations that can mitigate for the transboundary impacts of these projects, are the most likely settings for conflict.

Case Studies

Columbia River Basin

The Columbia River Basin (Figure 2) has had a long history of warm cooperation regarding water management, starting with the Boundary

Waters Treaty of 1903. The Columbia River Treaty has been in effect since 1964. The basin has many characteristics that tend to enhance resilience to change, and therefore promote stability.

Columbia River Treaty

During the 1950's, the need for electricity in the United States increased considerably. Canada was also considering its increasing power demands and economic growth (LeMarquand 1977). Flood control was also cited as a primary concern for both countries along the Columbia mainstem, as communities in both nations suffered heavy damages in the 1948 Columbia River flood.

Canada was initially reluctant to proceed with any collaborative flood control projects unless it was assured of receiving some compensation for the unrealized benefits for in the United States (Barrett 1994; Giordano and Wolf 2003a). The United States believed that Canada would want to develop the Columbia River on its side of the border regardless of what the United States wanted, and so felt that it needed to compensate Canada for constructing the project (Dinar 2009) When Canada threatened to construct an alternate project for hydropower on a different river, which would provide the United States with no benefits, the United States heeded the threat as credible. Canada was therefore able to secure a more attractive deal (Barrett 1994).

Future Issues

One of the facets of the Columbia River Treaty is that either party may terminate it in 2024 at the earliest. However, at least ten years notice must be provided (Columbia River Treaty 1964). Because of this, entities in each nation are undertaking studies to elaborate upon options to be explored by 2014 (U.S. Army Corps of Engineers; and Bonneville Power Administration 2009). Some of the changes that are likely to be considered include: the change in empowerment in local communities and Native American and First Nation governments, the change in the viability of populations of anadromous fish that spawn within the Columbia River system, the change in energy demand, and climate change (Cosens 2010).

Analysis of Basin Resilience and Vulnerability

While climate change and the change in the anadromous fish population are facets towards vulnerability of the system, the Columbia River Basin has all of the facets towards resilience in place, as it has generally positive political relations, strong international agreements, a history of collaborative projects and strong economies in both nations. It is important to note, though, that this does not mean that the Columbia River Basin is a completely resilient system. Changes to the ecosystem over time, changes in public participation and changes for the Native American and First Nation governments, to include political empowerment, will all shape future decisions made for the basin.

Zambezi River Basin

The Zambezi River Basin (Figure 3) has fewer characteristics for basin resilience than the Columbia River Basin. With eight riparian states, all of which have developing economies, cooperation is perhaps more difficult to achieve than in the Columbia River Basin.

Two major dams along the mainstream of the Zambezi River have been constructed with international cooperation as a goal: the Kariba Dam (located between Zambia and Zimbabwe) and the Cahora Bassa Dam (located in Mozambique). Zimbabwe and Zambia's agreement (The Agreement between Zambia and Zimbabwe Concerning the Utilization of the Zambezi River), while focusing primarily on the management of the Kariba Dam, has flexibility by including in its scope the possibility of merging future developments on the river in terms of water and other resources (Giordano and Wolf 2003b). The Cahora Bassa Dam was constructed in the early 1970's, during which Mozambique was a colony of Portugal. Colonial authorities built the dam with the anticipated benefits of expanding irrigated farming, stimulating European settlement, increasing mineral output, facilitating communication and transportation throughout the strategic Zambezi Valley, reducing floods, and providing electric power to South Africa (Isaacman and Sneddon 2000).

However, basin-wide cooperation has remained elusive. Attempts at basin-wide cooperation have been made since 1949, where the European

Figure 3. The Zambezi River Basin.

colonies of Northern and Southern Rhodesia, Nyasaland, Portuguese East and West Africa, and the nation of South Africa held the Conference on the Use and Control of the Zambezi River. The establishment of a Zambezi River Authority (which would involve all basin states) was discussed, but was never established. South Africa was against this, fearing that it would influence similar developments in the Limpopo Basin (Chenje 2003).

In 1987, the Southern Africa Development Community developed the "Action Plan for the Environmentally Sound Management of the Common Zambezi River System" and launched the Zambezi River Action Plan (ZACPLAN) to promote joint management of the water resources of the Zambezi River (World Bank 2010). The first detailed negotiations among riparian countries took place in 1998, but negotiations were terminated in the same year (World Bank 2010). The ZACPLAN process, including negotiations on the establishment of the Zambezi River Commission (ZAMCOM), was initiated again in October 2001. An updated version of the ZAMCOM agreement was signed by seven of eight riparian countries in July 2004. The agreement will come into force when six countries ratify the agreement; however, only five have ratified to date (Zambia is awaiting conclusion of the policy reform process and

institutional alignments) (World Bank 2010). In July 2009, in the absence of a ratified agreement, riparian ministers responsible for water adopted an Interim ZAMCOM Governance Structure (World Bank 2010).

Analysis of Basin Resilience and Vulnerability

The Zambezi River Basin has a number of prevailing constraints that limit basin-wide cooperation. The basin has rapid population growth (averaging 2.9 percent annually); widespread poverty; weak legal and institutional frameworks (including monitoring and enforcement); centralized management systems, including fragmented water management approaches and institutions; and pollution (Chenje 2003). One of the weakest areas of management across the basin is within an environmental context. Most basin countries have many environmental standards and regulations to monitor human impacts and to help enforce environmental laws. However, the enforcement of said laws and regulations is hampered by a lack of resources and poor coordination, among other factors (Chenje 2003).

Amu Darya Basin

The Amu Darya river basin covers portions of Tajikistan, Afghanistan, Turkmenistan, Uzbekistan, and Kyrgyzstan. The river originates in Tajikistan and forms the borders of Tajikistan and Afghanistan, Uzbekistan and Afghanistan, and part of the border between Turkmenistan and Uzbekistan. Historically, the river has been used for regional irrigation. Along with the Syr Darya River, it emptied into the Aral Sea (Figure 4). In many years, due to human alteration for intensive cotton agriculture, the Amu Darya does not reach the Aral Sea. The river basin is considered a water crisis region (Martius et al. 2009) and has high water stress, making it at risk for water security concerns.

Given the regional political and economic instability of the former Soviet States, and the current problems within Afghanistan, practical application of a multi-state water resource management plan for the Amu Darya has been weak. An international agreement and body has been established to manage the Aral Sea Basin, called the Interstate Commission for Water Coordination and was signed in 1992 (Martius et al. 2009; Interstate Commission for Water Coordination in Central Asia 2010). Included within this framework is a body that handles the Amu Darya development and management, though it is not clear to what extent the body is efficient.

Tajikistan is the main source of headwaters to the Amu Darya. It is also the poorest Former Soviet country and harnessing the hydroelectric potential of water resources for domestic and international markets offers a way to address economic and energy concerns (Humber and Khrennikov 2010). Tajikistan has signed a trade agreement, the Central Asia-South Asia (CASA-1000) regional electricity project, whereby Tajikistan and Kyrgyzstan will supply electricity to Afghanistan and Pakistan (Central Asian Economy Newswire 2011). Regional partners can benefit from Tajikistan's economic development (Mahmood 2011). Stability in Tajikistan can help

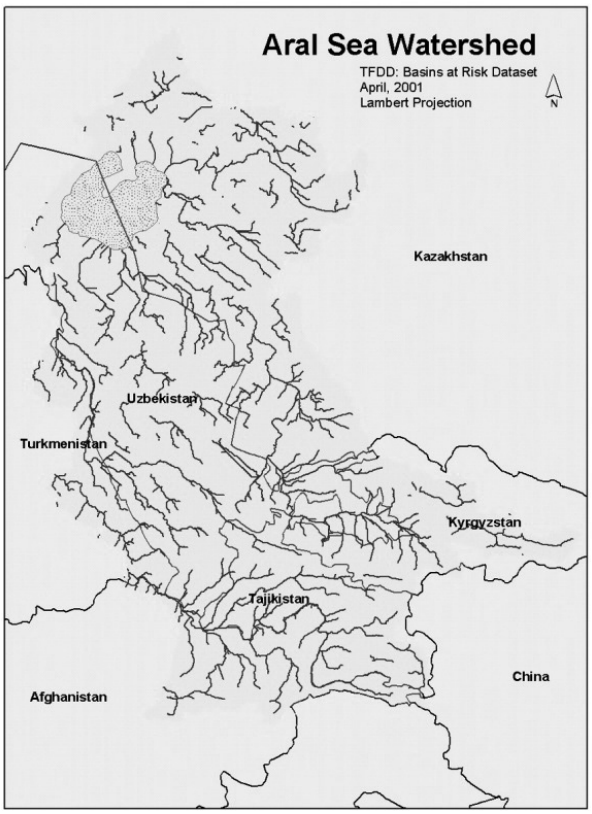

Figure 4. The Aral Sea Watershed.

create regional stability, an issue of particular interest to neighboring country leaders, as well as the United States (Cheema 2012). The Tajikistan government has plans to develop two dams on the Vakhsh River, an upper tributary of the Amu Darya mainstem (TerraDaily 2010). This action has incited public declarations of protest from the Uzbekistan government as well as a blockade of railway transit of supplies from Iran for the dams (Galpern 2009; Central Asia Newswire 2010). Though plans are moving forward with the two dams, there is no solid foreign funding commitment.

Uzbekistan and Turkmenistan are responsible for 83 percent of total river water consumption (Martius et al. 2009). Of Uzbekistan's estimated population of 16 million, 44 percent work in agriculture (CIA World Factbook 2011). Cotton is the main crop, is tightly controlled by the state, and accounts for approximately 40 percent of export earnings (Martius et al. 2009). Despite the central importance of the water to these economies, water resources are said to be managed quite unsustainably (Martius et al. 2009).

Analysis of Basin Vulnerability and Resilience

The Amu Darya Basin appears to be quite vulnerable to additional water and infrastructural changes. The risk to water security is high because of existing uncoordinated water resource management in regard to all the basin users and conflicting needs, as well as uncoordinated development plans in each country. An agreement exists between the basin countries (with the exception of Afghanistan as an observer rather than participant) to manage the Aral Sea Basin. Within this agreement, there is an international framework for the management and development of the Amu Darya. This body could be expanded to handle issues such as the one that currently exists between Tajikistan and Uzbekistan about dam development. Establishment of an outside international body for river management could help coordinate the diplomatic hurdles the countries of Central Asia are currently experiencing in their communication. Regional political and economic instability add to the complexity of shared water resource management, but water could serve as the platform upon which the countries move toward better cooperation.

Legacy culture of state-supported cotton production in Uzbekistan and Turkmenistan are based on a Soviet model of agriculture, and are still state-controlled. Continuation of this unsustainable model, dependent upon an already water-stressed system, can further elevate water security risks. Political legacy from the Soviet era has crippled the Central Asian economies, preventing full entry into the global market, and preventing sizable investment in national infrastructure. Lack of investment in an aging infrastructure creates vulnerability for the entire Basin. Afghanistan experiences regular flood damage along the floodplain, but has plans to develop the river to remove an estimated 10 percent of its flow (Martius et al. 2009). Uncoordinated efforts by the separate countries could lead to further economic and security instability.

The shared water resource itself can also be a source of resilience. The Amu Darya offers a way that these economically and politically challenged countries can develop solutions, if done collaboratively. Even though each country has its own political and economic challenges to solve, the common water resource can offer partial solution to several of the current challenges. Further collaboration and cooperation between countries is necessary to ensure future water security stability.

Conclusion

Examining each of these basins through the factors of hydropolitical resilience and vulnerability reinforces the notion that basins with nations that are more stable economically, environmentally, and politically are better suited to be more hydropolitically resilient. The Columbia River Basin is an example of one basin with a high level of water security. Meanwhile, nations in the Zambezi River Basin have taken steps to increase their water security, but still have much progress to be made. The Amu Darya Basin is politically and economically unstable, with no institutional capacity created to manage transboundary water security issues.

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