

# 2015 Snapshot of Water Security in the Nile, Mekong, and Amazon River Basins

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Challenges for policy makers and water managers working on river basins are on the rise as ambitious water infrastructure projects, coupled with the uncertainty of global climate change, alter rivers worldwide. Water security implications of new water infrastructure are particularly complex for transboundary river basins, rivers shared by multiple countries. Three transboundary basins—the Amazon, Mekong, and Nile—demonstrate how similar water security challenges manifest risks and possible solutions differently. Common challenges in the Amazon, Mekong, and Nile basins include dam development, extensive land-use changes, conservation for biodiversity, indigenous and traditional communities' reliance on river resources, and systemic sensitivity to global climate change. Water security as a theory and a tool allows for researchers to take an interdisciplinary approach toward finding solutions and areas of collaboration for addressing management challenges of water infrastructure. Research scientists have the opportunity to serve as a bridge between the data and analysis using water security tools and the policy and decision makers planning development and management strategies. Though there is a lack of consistent monitoring and baseline data collected on many of the world's transboundary rivers in transition, coordinated contribution from scientists to local and national partners can fill the capacity gap.



**Fig. 1.** Hydropower Dam in upper Amazon Basin, Ecuador © 2009 Elizabeth Anderson.

**“Global climate change, rapid infrastructure development, and widespread reliance on river resources by diverse human and ecological communities are common challenges in the Amazon, Mekong, and Nile river basins.”**

## Introduction

Policy makers and water managers working on river basins in much of the world face increasing challenges as ambitious water infrastructure projects, coupled with the uncertainty of global climate change, alter rivers. The water security implications of new water infrastructure are particularly complex for transboundary river basins, shared by multiple countries—and often multiple states within those countries—with vastly different political, economic, and social landscapes.

Generally, water security refers to the “availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies” (Grey and Sadoff 2007). Natural changes to water resources—like river channel shifts or deviations from historic flow regimes—can result from inherent hydrologic variability, extreme events, and climate change, and have implications for water security. Manmade changes to water resources—like engineering projects for irrigation, diversion, drainage, or hydropower—can also have implications for water security. Water security as a theory and a tool allows for researchers to take an interdisciplinary approach toward finding solutions and areas of collaboration for addressing management challenges of water infrastructure. As a tool, it helps to identify systemic assets and risks in the dependent aspects of the relationship between humans and their environment, and the nature of those relationships in the system complexity inherent in water.

Three transboundary river basins explored in this article—the Amazon, Mekong, and Nile—demonstrate how similar water security challenges can manifest different risks and different possible solutions, depending on the context. These are but three river basins in more than 300 transboundary water basins in the world, shared by billions of people and species, facing similar challenges due to uncertainty and change (TFDD 2015). Common challenges in the Amazon, Mekong, and Nile river basins include contemporary dam development, extensive land-use changes, conservation for biodiversity, indigenous and traditional communities’ reliance on altering rivers resources, and systemic sensitivity to global climate change, particularly shifts in temperature or precipitation regimes. These

rapid changes have led to many questions about these basins and their iconic rivers, and those that depend on them. Who and what will be able to use and access water once the dams are completed? Does one water use, such as a dam project, eliminate other water uses? Who benefits? How long before those benefits are felt? Who loses and why? Analysis through the lens of water security may help to answer some of these questions.

The Amazon Basin, while the most biodiverse river system in the world, is currently sited for some of the most extensive dam development in the world. Amazonian dams will disrupt upstream-downstream and channel-floodplain connections that are essential to the survival of Amazonian species, impacting fisheries the human populations in the Amazon depend on for food and income. The Mekong Basin is host to natural resource-intensive economic development that includes dams, diversions, and land-use changes. Demand for irrigation water in China and Thailand, electricity demand for industry in Thailand and Vietnam, and poverty alleviation needs in Laos and Cambodia are driving economic reforms and major physical alterations throughout the basin. The Nile River Basin is poised for shifting political dynamics where traditional water rights to Egypt and Sudan are challenged by the development of the Ethiopian Government’s Grand Ethiopian Renaissance Dam. International dialogue has focused on political diplomacy and national economics, while environmental impacts and sociocultural changes to dependent local river communities is missing from assessments and discussion.

### What is water security and how can it help face these challenges?

Water security, as a term and theory, is flexible to incorporate multiple scales and multiple disciplines and means different things to different people. Water security can mean different things in different contexts, to different stakeholders, at different scales, and at different times. Specific definitions range from a focus on timely access to safe water resources to international cooperation over water sharing to sufficient quality and quantity of water for environmental needs. The United Nations defines water security as a safety issue as, “the

capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.” Water resources scholars often discuss water security as related to interstate conflict (Gleick 1993; Gleick 2013). Water science and management literature identifies water security as stakeholder based with the right quality, in the right quantity, at the right time (Veilleux 2014). Stakeholders are understood as water users, including humans and ecosystems.

The strength of this flexibility in the understanding of water security is that it allows us to describe complex systems that include human and ecological components, examine the relationships between actors and/or systems, and consider different geographic- and time-scales and seemingly divorced areas of interest. Water security is a concern for national-level politics, environments, culture, and economics; it also can be applied to understand these factors and their relation to water resources at local (e.g., village, county) or regional (e.g., districts, states) scales. Water management is concerned with the present and future states of water resources for human and ecological systems. In this way, water security is the backbone of understanding water sustainability: the questions of strengths and weaknesses of access, quality, and quantity are asked from the vantage point of the “now” with a look toward the “future,” or sustainability, of that resource.

Water security is also a helpful way to consider or combine stakeholder’s needs and priorities. In any given water resources system there are many different types of stakeholders who share the resources, and all stakeholders’ water security is related. For example, the water security of a fishing village is predicated on the water security of the river’s aquatic ecosystem. Geography plays a key role in the power or control that one stakeholder has to another, such as in the case of upstream or downstream dynamics, or geopolitical or economic might. Institutional capacity, in the form of treaties or organizations, can play a role in mediating cooperation and fostering dialogue between stakeholders, but it can also mask potential coercion or hegemony which can eventually lead to more insecurity (Wolf et al. 2003; Zeitoun and Warner 2006).

Water security allows for voices of otherwise silent stakeholders to gain volume in a room of decision makers. By taking the complexity of the system into consideration, the concept of water security allows managers to understand strengths they can capitalize on and areas of weakness that should be monitored and perhaps mediated or mitigated.

### How do we assess water security?

There are many ways in which scientists and water resources managers assess water security. Table 1 provides a short list of general methods of assessment. While each one of these assessment tools can tell us something about water resources, not one, taken on their own, can really describe the water security of an entire system. Together, however, they allow for a more comprehensive analysis of water security in a given system. This interdisciplinary, qualitative, and quantitative combined approach is more of a time investment up front, but it can save time later to react or respond to potential conflicts and water security challenges.

### Applying water security: Stories from three basins

The following case studies illustrate the challenge of providing water security as it manifests in portions of three great world rivers: the Amazon, Mekong, and the Nile.

#### Fragmentation in the Amazon

The world's largest river basin, the Amazon River of South America, teems with biological and cultural diversity, much of it tightly linked to freshwater systems. Traditional visions of the basin often depict the Amazon as a vast landscape of uniform wet tropical forest, sparsely inhabited by humans. But in reality, the Amazon comprises a heterogeneous landscape of terra firme forests, palm swamps and peatlands, white sand forests, and mountainous Andean headwater regions. And the Amazon Basin's current human population is estimated at over 30 million people, including indigenous groups in remote areas and urban dwellers in cities like Iquitos, Peru, or Manaus, Brazil (Slater 2015). Rivers and other aquatic environments connect Amazonian peoples and Amazonian ecosystems, and provide habitat for numerous freshwater species. In fact, the Amazon Basin is the global



Fig. 2. Mekong fisherman upstream of Xayaburi Dam site, Laos PDR © 2013 Jennifer Veilleux.

center of species richness of freshwater fishes, harboring 2200 described species and counting, with an anticipated total above 3000 species (Reis et al. in press). Freshwater fisheries are a primary source of protein and income for many Amazonian human populations in both remote areas and urban centers.

The Amazon Basin also comprises one of the Earth's most rapidly changing landscapes, in large part as a result of new infrastructure projects—such as hydropower dams—that now tend to be larger in size and number than in previous times. The drivers of this development are varied; some development is motivated by increasing need for electricity, while much is motivated by increased investment from China and Brazil. There is little to no coordination of the Amazonian dam development, which means that most projects are evaluated on an individual basis and without

good understanding of cumulative impacts or tradeoffs between hydropower and other uses of rivers. Exact numbers of existing and proposed hydropower projects are difficult to find, given the number of countries with Amazonian territory, the limited availability of information on dams, and plans for development that often quickly change. As of 2015, according to available estimates, the Amazon Basin counts about 100 large and an unknown number of small dams in operation, and an additional >300 projects in various stages of construction, advanced planning, or proposal (see [www.dams-info.org](http://www.dams-info.org)). Present hydropower development targets two major regions of the Amazon: the Andean-Amazon headwater regions, with about 50 existing and 150 proposed dam projects, heavily concentrated in Ecuador and Peru (Finer and Jenkins 2012), and the Brazilian Amazon in

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Fig. 3. Panning for gold in the Blue Nile River, Ethiopia © 2012 Jennifer Veilleux.

particular the Madeira, Tocantins, Tapajos, and Xingu River Basins.

The case of Amazonian fisheries illustrates the potential for hydropower development to affect water security in the Amazon Basin in numerous ways and at various scales. Hydropower projects fragment riverine corridors by introducing barriers (dams) and disrupting hydrologic connectivity—the water-mediated transfer of energy, matter, and organisms between elements of the hydrologic cycle

(Pringle 2003). Many Amazonian freshwater fishes are migratory, covering distances that range from 10s to 1000s of kilometers as they move between the Amazonian lowlands and Andean piedmont or between river channels and floodplain forests for feeding or spawning. Through these migrations, these fishes connect distant aquatic habitats and influence ecosystem dynamics throughout the Amazon. Migratory fishes are also among the most important species for artisanal and

commercial fish landings. Data from the Loreto region, Peruvian Amazon, indicate that *Prochilodus nigricans*, a migratory Characin, accounted for 40% (average) of commercial fish landings over the period 1984–2006 (Garcia et al. 2009). Recent studies suggest that Amazonian dams have terminally interrupted movements to some headwater regions by large-bodied migratory catfish (*Brachyplatystoma* spp.; Sa-Oliveira et al. 2015). Pre-impoundment studies have predicted declines of migratory fishes as a consequence of recently constructed dams on the Madeira River, a major tributary that drains the southwestern Amazon region and that historically has supported intensive commercial fisheries, dominated by migratory species that spawn in headwater regions now upstream from the Jirau and Santo Antonio dams (Sant’anna et al. 2014; Cella-Ribeiro et al. 2015). Simply by restricting movement of migratory fishes, hydropower dams in the Amazon challenge preservation of ecosystems, and affect human food security and livelihoods and therefore human well-being and socioeconomic development; all are components of water security in the Amazon Basin.

#### Development in the Mekong

The 795,000 km<sup>2</sup> Mekong River basin is home to 260 million people in six countries that include China and Myanmar in the upper basin, and Laos, Thailand, Cambodia, and Vietnam in the lower basin (Veilleux 2014). This total includes an estimated 75% to 80% subsistence fishers of the 70 million person population of Lower Mekong River Basin countries (MRC 2003; Dore et al 2012; Orr et al. 2012; Ziv et al 2012; Gleason and Hamdan 2015). Eighty percent of Cambodians living on the Mekong fish and about half of the 6 million people in Laos fish in the Mekong or its tributaries (Dugan et al. 2010). Fish catch in the Mekong can constitute between 2 and 10 million tons of freshwater fish in a year (Baran 2013). The 94,000 km<sup>2</sup> Mekong River Delta in Vietnam is host to 20 million farmers that are dependent on deposition of nutrient-rich sediment (Kondolf et al. 2015). Lives and livelihoods of many people on the Mekong are predicated on a delicately balanced cyclical river system driven by a monsoon pulse.

Recent development of the controversial Xayaburi Dam project in Laos highlights the rapid changes that the Mekong River Basin

is currently undergoing. Over 130 dams are planned for the basin, which may affect close to 100% of sediment transport and have unknown impacts on migratory fish (Kondolf et al. 2015). The Mekong is thought to be the second most biodiverse river, after the Amazon, in the world (Ziv et al. 2012). The dams will eradicate the current river cyclical fluctuations based on the monsoon pulse. While changes to regional economics are enabling dam projects, diversions, and irrigation expansions throughout the region, these larger scale projects compromise local natural resources-based economies. Global climate change, combined with extensive forest removal, has altered precipitation and temperatures, and locals report that the river fluctuations are no longer predictable (Veilleux 2014). Climate change has further rendered subsistence livelihoods increasingly problematic, with many people reportedly migrating or finding different ways to make a living (Ziv et al 2012).

Dam development along the Mekong, a river with a significant human population closely dependent on river resources, raises water security concerns. Plans to develop the Mekong are not new, but are newly engaged by local and regional interests with available investment dollars, and are largely uncoordinated. Thailand and Malaysia are partnering with Laos, PDR, to build two of the first Lower Mekong River dams, following the construction of five storage dams in China commissioned in the last decade. Plans for the dams went through the legal processes of the Mekong River Commission, demonstrating how more comprehensive institutional capacity is needed. The dams mark a turning point for the region, one that has been building for the last 10 years in the construction of upper tributary dams, upstream dams in China, and land-use. River development not only threatens to displace communities in the immediate vicinity of the projects but also further downstream.

### Nile River Basin and the Grand Ethiopian Renaissance Dam

Often considered the world's longest river, the Nile snakes its way north over 6800 km from the Great Lakes of East Africa through the Sahara desert to the Mediterranean Sea. There are 280 million people living in the basin and 9 of the 11 Nile Basin countries are some of the world's poorest and least developed

**Table 1.** Selected methods for assessing different aspects of water security.

Method	Description	Area captured
Feasibility study	Brief assessment, usually by outside consultants, of resources and potential known impacts, usually based on existing material	Local (when available) National • Economics • Environment
Household surveys	Qualitative method of gathering primary data on local water users	Local • Socio-culture • Economics • Environment
Environmental impact assessment	Short-term primary and secondary data collection about environmental systems and potential impact	Local National • Environment • Socio-cultural
Political economic assessment	Qualitative and quantitative analysis of political and economic motivations and impact	National-level • Politics • Economics
Human development index	UN-generated global assessment of national-level economies, education, and life expectancies	National-level • Socio-culture • Economics
Costs and benefits analysis	Economic analysis of a project that weighs the costs and benefits in economic terms, and considers things such as externalities.	National International • Economics • Environment
Resiliency assessment	Identifies systemic strengths and weaknesses and offers alternative scenarios	Local National International • Politics • Socio-culture • Economics • Environment

(Veilleux 2014). Economic and political changes, as well as population pressures and presence of the donor and international aid communities, has rapidly changed the landscape over the last 30 years, and many countries are now looking to the Nile water resources for further development (Cascao 2009). The basin's current events debate involves colonial hangover policies, developing economies, and the future of regional African stability and diplomacy. The Nile water resources are considered key for development plans in Ethiopia, and other countries upstream, as they have been for Egypt and Sudan's agricultural and economic development to date, but according to the Nile Treaty, Egypt and Sudan have 100% water rights to the Nile. The Blue Nile basin accounts for more than 50% of all water resources in Ethiopia and has been relatively undeveloped to date. Ethiopia's population has surpassed 90 million people, and water and energy needs are widespread throughout the country. The water security situation is intensified by the burgeoning populations,

limited water resources, and lack of historic diplomatic water agreements.

That the Nile River is dominated by Egypt and Sudan through the Nile Treaty, but its resources are included in national development plans of upstream countries, presents a water security dilemma. In 1999, Nile basin countries formed the Nile Basin Initiative to legally reform water rights in the Nile basin from domination by Egypt according to the 1929/1959 Nile Treaty (Cascao 2009). A new treaty was eventually drafted and proposed, but nothing was ever resolved due to the withdrawal of Egypt and Sudan from negotiations. So, when in 2011 the Ethiopian Government began unilateral development of a mega-project, the Grand Ethiopian Renaissance Dam, on the Blue Nile River, it caused international controversy throughout the basin (Veilleux 2013). The Renaissance Dam has changed historic control of Nile waters in the basin. The dam is a crowd-funded mega-project that has become an Ethiopian national symbol of pride and identity. The majority of populations in Egypt and Sudan live in the Nile River

**Table 2.** Amazon, Mekong, Nile River Basins characteristics.

River	Estimated human population	Name and number of countries	Unique basin characteristics
Amazon	30 million	8 countries: Venezuela, Colombia, Ecuador, Peru, Bolivia, Brazil, Suriname, and Guyana; 1 territory: French Guyana.	World's most biodiverse river system with 2200 known freshwater fish species, and an anticipated total above 3000 with future scientific discovery.
Mekong	260 million	6: China, Myanmar, Laos, Thailand, Cambodia, Vietnam	World's most productive inland fishery with an estimated 2.2 million tones of wild fish.
Nile	280 million	11: Egypt, Sudan, South Sudan, Eritrea, Ethiopia, Burundi, Rwanda, Uganda, Tanzania, Kenya, Democratic Republic of the Congo	Considered the world's longest river flows north and about 10% of the African continent is contained in the basin.

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Basin and depend on the river resources with little water resources alternatives. Since 2013, Egypt, Ethiopia, and Sudan have been in cooperative discussions about Ethiopia’s development with a recent cooperative agreement to continue development with conditions.

The Nile, while historically important for Western civilization, is one of the least researched major rivers for biodiversity, cultural diversity, and development impacts. Much remains unknown about the Nile as a natural river system, despite its superlative global status. The water security issues facing the Nile center on development and climate change as related to regional stability and diplomacy, and the Renaissance Dam highlights these issues of political and economic importance. The Renaissance Dam also highlights the lack of understanding and study of environmental and cultural security aspects of changes in the Nile River basin to the water resources.

## Conclusion

Challenges mount for policy makers and water managers in countries with ambitious water development projects, but there are tools to help identify systemic strengths and weaknesses that can be applied across political boundaries. While there is a lack of consist-

ent monitoring and baseline data collected or available on many of the world’s transboundary rivers in transition, coordinated contribution between scientists and local and national partners can fill the information gap. Using water security tools and analysis, research scientists have the opportunity bridge regional communication for basin-wide development and management strategies. Transboundary river basins pose a unique set of water security challenges given the inherent complexity in crossing political, economic, and cultural boundaries that have little in common. The three major river examples of the Amazon, Mekong, and Nile demonstrate the versatility of a water security approach, and highlight how while water security challenges can be similar across each river the differences are unique to the geography, culture, politics, economics, and natural environments. Some of these differences can be captured and compared across borders using a variety of water security assessment tools, allowing for the possibility of coordinated management decisions.

When a lack of consistent monitoring and baseline data collection exist in river basins shared by more than one country, coordinated contribution from scientists to local and national partners, can fill the capacity gap.

Applying water security assessment to our global rivers is crucial for managing current available water resources sustainably and informing policy. Development practices often use water security tools to discover the feasibility or logistics necessary to complete a project, but each tool, used in isolation, is not sufficient to describe the systemic strengths and weaknesses of the water resources. Used in combination, however, the tools describe a system across scale and sector that can be useful for policy makers and water managers when making decisions about how to respond to natural and man-made changes to rivers.

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