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Transboundary Threats in the Mekong Basin: Protecting a Crucial Fishery

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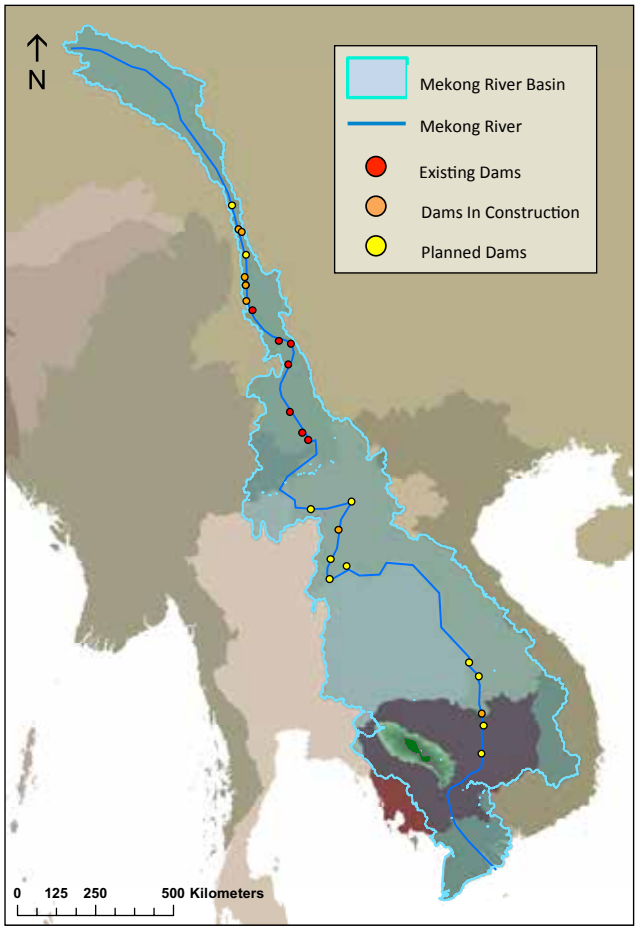
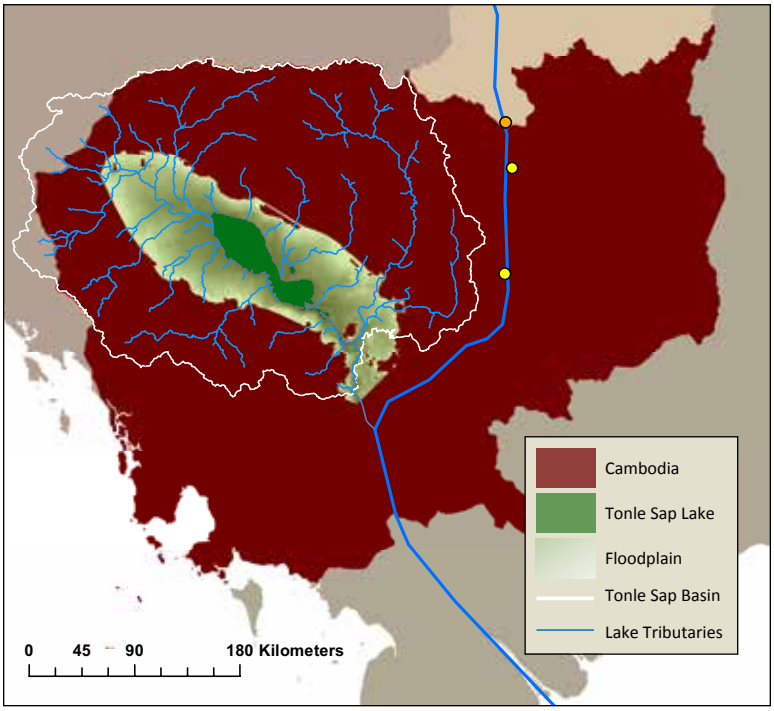
The Mekong River is a source of fresh water, food, energy, biodiversity, and cultural heritage to more than 70 million people living throughout its basin. Flowing from its headwaters in southern China to the Viet Nam Delta, the river's watershed extends nearly 800,000 km^2 across five countries of mainland Southeast Asia: Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam. About two-thirds of the basin's people live in rural conditions with high reliance on natural resources supplied by the free-flowing river, especially its fisheries, which produce an annual harvest of approximately 2.6 million tons and valued over US$7 billion (MRC 2010). Despite its importance, the river — and fish and other natural resources associated with it — is threatened by hydroelectric dams and other water diversion projects, collectively referred to as "water development." Since 1995, a total of seven dams have been built along the northern Chinese portion of the Mekong (Yunnan Province) with 16 more planned or in construction along the mainstream (Figure 1). In addition, more than 70 dams are in operation, construction, or planning stages in tributaries throughout the watershed.

> "Extensive development pressure combined with the governance failure is creating an unprecedented threat to poor people and those living downstream in the Mekong Basin."

Dams directly impact fisheries by obstructing passage of migratory species and by changing the nature and timing of water flows. Indirect threats include food web changes and loss of critical habitat. In the Mekong, investors, construction companies, hydropower operators, and state-owned enterprises stand to profit considerably from dam projects, with the rural poor bearing the costs of this development via physical displacement, loss of dependent resources (especially fisheries), and diminished livelihood





Maps created by the author using publicly available resources.

Figure 1. Dams along the Mekong River (left). Cambodia's Great Lake, Tonle Sap (right).

opportunities (Kuenzer et al. 2012). Impacts will also affect people living along the upstream-downstream gradient of the Mekong in different ways. Upstream users are often at an advantage over downstream ones in their ability to access and utilize high quality fresh water and avoid the negative impacts including loss of water flows, reduced fisheries resources, pollution, and more.

Exacerbating the unequal distribution of costs and benefits (e.g. tradeoffs) of water development is the failure of transboundary governance in the region. The Mekong River Commission (MRC) is the institution responsible for coordinating sustainable management of water resources for its member countries' mutual benefit. Despite being a formal presence in the region for over two decades, the MRC operates without a rule-based, criteria-driven decision framework, is hindered by long-standing geopolitical and economic tensions among member countries, and lacks enforcement authority (Ha 2011). Recently, the MRC has been further weakened by extensive reductions in funding from donor agencies that are its main financial backers, causing a downsizing in operations and reassessment of the organization's current mission (Hunt 2016).

Extensive development pressure combined with the governance failure is creating an unprecedented threat to poor people and those living downstream in the Mekong Basin. This is the situation in Cambodia's Tonle Sap, the largest freshwater lake in the region which is fed by the Mekong river. The lake system is a microcosm of the tensions and disparities regarding water development playing out on the regional stage. This *Issues in Brief* outlines the case study of Tonle Sap and describes how hydropower development will impact resource dependent people here. Despite the challenges, ecological and political features of the lake system can be the focus of planning efforts to buffer against the impacts and enhance resilience of this ecosystem.

Tonle Sap Fishery: The Foundation of Food Security and Livelihoods of Cambodia's Rural Poor

Located in central Cambodia, Tonle Sap means "Great Lake" in the national language of Khmer. The name is fitting. As the largest freshwater lake in Southeast Asia, the Tonle Sap is critical to the food security and livelihood of Cambodian people as well as others in the region. Fish catch from the system is estimated at 300,000-400,000 tons annually (Baran 2005), which is equivalent to approximately 15 percent of the total catch for the entire Mekong Basin (some experts suggest the figure could be much higher). Given their abundance, accessibility, and high nutritional quality, the lake's fish are essential to the food security of Cambodians. Fish contribute about 18 percent of daily intake, as much as 80 percent of people's dietary protein, and are an important source of micronutrients, especially iron, in Cambodia (IFReDI 2013).

Access to abundant, high quality food is especially important in Cambodia because it is one of the poorest countries in Southeast Asia. Twenty percent of the population live below the national poverty line and per capita GDP is by far the lowest in the region; over 500 percent below that of Thailand which is the wealthiest country in the region (The World Bank, 2015). In addition, 80 percent of Cambodia's population live in rural settings and are highly dependent on natural resources to generate food, income, and livelihood opportunities. The fishery historically has also been an important economic sector in Cambodia valued at $233 million annually and contributing 10–12 percent of the country's GDP (Baran 2005, MRC 2010).

Ecological Drivers of Tonle Sap Fisheries

Two related factors drive the extensive fish production in Tonle Sap. First, the lake is annually plenished with an immense input of water as 53 percent of the lake's total water content (Kummu et al. 2013) and roughly 72 percent of its sediments (a key source of food web nutrients) come from the Mekong River (Kummu et al. 2008). In addition, many of the lake's fish species are migratory and spend part of their lives in the mainstream. The second factor is related to an annual pattern of flooding and drying that occurs. The dynamic, known as a "flood pulse," is caused by seasonal monsoons which occur from November to April. During this period, heavy rains swell the Mekong River and increase water flow to the lake leading to extensive flooding (the lake expands five-fold across the floodplain, Fig. 1). The flood pulse supports important fish habitats like gallery forests, which are dominated by freshwater mangroves *(Barrintonia acutangula)* and other flood-tolerant plants. Flooding also results in areas of diminished oxygen around the lake's margin, yet many fish species are adapted to tolerate these extreme environmental conditions. (For example, the walking catfish *[Clarias batrachus]* has specialized air breathing organs.) The diversity of species and their ability to live in different environments may support the lake's impressive fish production. For example, Holtgreive et al. (2013) suggest the lake's fisheries may benefit from incorporating a variety of food sources present in the system (e.g. anaerobic and aerobic bacteria, terrestrial organic matter) — some of which are only found in extreme or marginal environments.

Impacts of Water Development on Tonle Sap Fisheries

Water development will have direct impacts on migratory species as dams will limit or fully obstruct their passage between upstream spawning and downstream feeding habitats. In one modeling study, mainstream dams were projected to reduce the annual Mekong catch

between 122,000 and 328,000 tons — roughly the annual yield identified for all of Tonle Sap (Ziv et al. 2012). In Cambodia, as much as one-third of the approximately 300 species of freshwater fish could be impacted by mainstream blockage, with estimated loss to this group in the Tonle Sap between 6 to 34 percent (IFReDI 2013, the broad range reflects uncertainty about fish migration pathways). Dams will also increase the extinction risk to at least the five of the lake's migratory fish species already listed as "threatened" (Halls 2009) including iconic and culturally important species like the Mekong giant catfish and the Mekong stingray.

Indirect impacts from water development are also a major concern. Dam operations upstream will restrict water flows in the wet season and release stored water in the dry season, thereby diminishing the amplitude of the lake's flood pulse. The effect on the Tonle Sap will be to reduce the floodplain and at the same time increase the area of the permanent lake. Some key fish habitats are expected to decline, including areas of gallery forest, which may be reduced by more than 80 percent (Arias 2012). This impact is especially concerning because gallery forest is a biodiverse and structurally complex habitat that provides unique feeding and refuge opportunities for fish and other aquatic animals. Dams along the Mekong will also trap sediments and therefore limit the nutrient replenishment coming into the lake with critical consequences to the base of the food web (i.e. phytoplankton and other plants that feed the fish). Resulting losses to the base of the food web could be extensive, especially in locations that are far away from other tributaries that provide a secondary source of sediments and water flow. Preliminary modeling results show that some Lake areas will exhibit losses of 50 percent in primary production as a result of dam development (Koponen 2010). Initial estimates of fish loss due to sediment trapping dams could be at least 20 to 30 percent and probably higher (Halls 2009).

Given mounting threats from water development and limited effectiveness of transboundary governance in the region, Cambodia's Tonle Sap fish and fishery dependent people are facing an existential crisis. Efforts to reform the institutions and the process of regional decision making must take place, but such efforts are sure to move slowly and without guaranteed success. In the meantime, alternative response strategies are needed to enhance system resilience and support adaptation in the system right now. Some of those alternative strategies include:

Prioritize National-Scale Actions to Enhance Resilience of Tonle Sap Ecosystem

Upstream processes strongly influence the Tonle Sap, yet the majority of the lake's watershed basin (greater than 90 percent) is contained within Cambodia's national borders (Fig.1). This geographical feature can be leveraged to guide national-scale responses that aggressively protect ecosystem processes and support resource dependent people in Cambodia.

Reconsider plans for Cambodian mainstream dams: Proposed dams along the Cambodia mainstream should receive intense scrutiny, and cancellation of these projects should be considered when costs are sure to outweigh benefits to local communities. The example of the Sambor dam is illustrative. The dam is the lowest proposed on the Mekong mainstream and the largest planned in Cambodia. The project is expected to displace over 10,000 people directly, and the fisheries impacts could be devastating. Projected loss of migratory fish from the dam is between 108,000–200,000 tons, equivalent to 16 to 31 percent of Cambodia's current annual freshwater catch (IFReDI 2013). Furthermore, the majority of the hydroelectric power produced by the project is destined for Viet Nam and Lao PDR. The benefits from the dam, therefore, will be accrued mostly by the wealthy developers and people in neighboring

countries with the costs being absorbed by the rural poor in Cambodia. Other mainstream hydropower projects in Cambodia elicit similar concerns (e.g. the Strung Treng dam).

Protect and restore Tonle Sap tributaries: Cambodian decision makers should aggressively protect the water flows and habits associated with 11 main tributaries of Tonle Sap, which together contribute 30 percent of the annual water flows to the lake (Kummu et al. 2013). The vast majority of tributary sub-watersheds are fully located within Cambodia national borders, thus decision making falls squarely within the country's jurisdiction here. Ensuring tributaries are allowed unobstructed flow (i.e. restricting dams here) will help maintain the water balance of the lake, despite the impacts coming from water development upstream. Protecting riverine habitats, including in riparian and submerged zones, will also benefit fish known to use these areas (Thach et al. 2006) and restoration could even enhance the current role of tributaries in fish production.

Restore gallery forest: Gallery forest grows within a narrow elevation band around the lake and provides a structurally complex and food-rich area for fish growth and spawning. This habitat is severely threatened by water development projects but is also impacted as a result of encroachment by human settlements, conversion to rice fields, and overharvesting of timber and other natural resources (Arias et al. 2012). Efforts to protect existing flood forests and restore impacted areas can be strengthened by engaging local communities, and through education and outreach that emphasizes the ecological link between these habitats and fish production. Identifying potential expansion areas and directing efforts for regrowth can be an important component of national-scale sustainability efforts around the lake.

RESPONSE STRATEGIES AND RECOMMENDATIONS

Prioritize National-Scale Actions to Enhance Resilience
Reconsider plans for Cambodian mainstream dams
Protect and restore Tonle Sap tributaries
Restore gallery forest

Reform Fisheries Management
Adopt a local rights-based fisheries management approach
Reduce fishing pressure and develop higher value markets
Implement fisheries independent surveys to support management

Develop Technological and Knowledge-based Solutions
Explore dam operation alternatives
Support sustainable farming and aquaculture

Figure 2. Strategies (bold) and key recommendations to enhance resilience of Tonle Sap fisheries and human populations under threat from water development.

Reform Fisheries Management

Dams are expected to reduce fish production in the Tonle Sap Lake via three pathways: 1) obstruction of migratory fish movement, 2) trapping of sediments and thus a reduction in algae and other aquatic plants that are the base of the lake food web and, 3) reduction of fish diversity, compromising food web ecology and resilience of fish communities. To compensate for expected losses, management of fisheries resource must be strengthened using the best available science and allowing for adaptation.

Adopt a local rights-based fisheries management approach: Approaches that strengthen the link between fisher activities and the health of their target resource are known to promote sustainable outcomes (Beddington et al. 2007). Fisheries management in the lake should emphasize a local rights-based approach that links responsible fishing practices and community enforced conservation zones to harvest opportunities at the local scale. Research is currently underway to better understand how the spatial extent and configuration of conservation zones interact with relevant social factors (i.e. enforcement and cooperation) to affect fish populations. Fisheries managers in Cambodia are working to put elements of this reform into practice.

Reduce fishing pressure and develop higher value markets: Water development is expected to substantially decrease fish production in Tonle Sap. In order to prevent stock collapse, the annual fish catch should be lowered. A strategy that ensures subsistence level harvests and leverages regional and global markets to increase the price of commercial landings will support the development of a sustainable fishery here. Promoting the commercial value of Tonle Sap fish requires identifying where value can be enhanced along the market chain. Such analyses have been used in many systems and are a well-recognized tool of sustainable fisheries.

Implement fisheries independent surveys to support management: The redesign of management rules in the lake must be accompanied by regular scientific analyses to assess fish stocks and recommend catch targets. To date, these features have not been regularly adopted by fisheries managers in Cambodia (Enomoto et al. 2011). Annual assessments of fish stocks and identification of fishing targets in Tonle Sap are especially important given the high level of uncertainty regarding system productivity and production trends, impacts of water development, and the effects of climate change in the system. While a comprehensive field monitoring effort to assess fish populations does not exist in the lake, data on fish catch is gathered and could be used along with limited fisheries-independent surveys to support analyses. The key is to link data collection and analysis efforts in a timely way so that decision makers can respond to system changes as they unfold. Fish catch data and the results of scientific analyses must also be made publicly available and communicated to local communities to increase transparency and support science capacity in this system.

Develop Technological and Knowledge-Based Solutions

The construction of at least some mainstream dams is likely to proceed despite strong opposition by various environmental, political and social justice groups. The mainstream dams coming online will have strong and unavoidable impacts, yet some aspects of dam design and operations offer opportunities to lessen the magnitude of downstream changes. In addition, local knowledge should be tapped to strengthen the resilience of human communities under threat.

Explore dam operation alternatives: An assumption of most water development impact studies in the Mekong is that dam operations (e.g. the timing and volume of water held and released) will be designed with the singular goal to maximize profits. However, a more rigorous and thorough examination of the relationship between profits, hydroelectric production, and hydrological impacts is needed in which alternative dam operations that lower the environmental risk are considered. Alternatives should be examined under baseline conditions and for more extreme flooding and drought cycles that are predicted as a result of climate change. In the latter context, dam operations could be leveraged to respond to periods of extreme drought (such as that which was experienced in 2015) and extreme floods.

Support sustainable farming and aquaculture: Sustainable agriculture and aquaculture techniques that anticipate changes from water development and utilize local knowledge should be identified and promoted. Expected increases in the permanent lake zone will reduce opportunities to grow the most flood-tolerant rice species in the system (also the least labor intensive variety to farm). Unlike some other Southeast Asian countries, in Cambodia a great number of rice varieties are still actively cultivated and local knowledge can therefore be tapped to identify species best adapted to future conditions around the lake. On the other hand, habitat for some nutrition-rich plant species will expand as a result of water

development. For example, the floating legume *Sesbania javanica* is an edible plant that could be promoted as a nutrition-rich, naturally growing food source around the lake.

Limited forms of cage culture are already widely practiced in Tonle Sap (e.g. small grow-out cages used by individual households) and aquaculture expansion is being strongly promoted by the Cambodia government. While the practice can help offset losses to the wild capture fishery, environmentally sensitive and precautionary approaches that prioritize long-term health of the lake's diverse fish community must guide the way. Sustainable practices include:

1) a focus on native fish species, especially those with higher tolerance to a range of environmental conditions
2) a reliance on plant-based and terrestrial food sources to minimize impacts on the lake's aquatic food web
3) well-designed cage placement and feeding programs to avoid eutrophication, other water quality impacts, and reduce the likelihood of disease outbreaks
4) careful monitoring of fish production and impacts, and a willingness to adjust practices based on those findings.

Conclusions

The impacts bearing down on Cambodia's Tonle Sap fisheries and dependent people are extensive, yet transboundary governance in the region is severely challenged. There is a need to reform cooperative decision making across the region, but time to make progress on this front is limited. To buffer against impending impacts, Cambodia decision makers must implement actions at a national scale that mitigate threats, strengthen resilience, and promote sustainable adaptation. Actions must support an overarching goal to protect the long-term maintenance of ecological processes, respect traditional livelihoods, and identify alternative development opportunities in the region. A number of paths exist.

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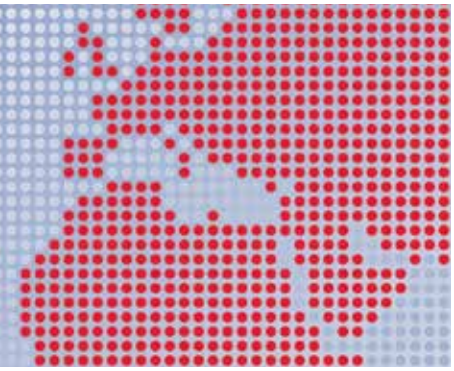

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