Tempisque Basin Water Management and Sustainability

Project prospectus

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Executive Summary

Current water use in the Pacific Mesoamerican region is unsustainable and will become worse as global and regional climate models forecast a warmer and dryer future. This generates management challenges in both natural and human systems, already strained beyond their limit of economic and biological sustainability. The 5404 km^2 Tempisque basin in NW Costa Rica is the focal site for our proposed work and a good biophysical proxy for Pacific Mesoamerica because it contains many of the land and water challenges found across the region (including a wetland recognized worldwide as a Ramsar site). This site is also ideal for this project because it contains a strong institutional framework, necessary to support a complex project that will allow our work to be effective and have significant impacts. The **long-term goals** of this effort are to: (1) Conduct an in-depth quantitative analysis of the sustainability of water supply and demand in the Rio Tempisque/Bebedero basin in NW Costa Rica. (2) Explore, through empirical data, stakeholder input integration and model-based scenarios analysis, how climate change may affect ecosystem services through changes in water availability, land use and biodiversity. (3) Use the basin as a representative site of Pacific Mesoamerica to investigate what actions may be taken, from policy to practice, to help maintain or improve water availability and ecosystem services in future years.

Project goals

Water availability is one of the biggest collective concerns the 21st century. Northwestern Costa Rica and, more specifically, the Tempisque River Basin are no exceptions to this challenge. The Tempisque Basin is home to close to 200,000 people, and in the last 1.5 centuries it has been dramatically converted from dry forest and natural savannas to cattle ranching, and more recently to intensive agriculture and fish farming, thanks to a large scale irrigation project. In less than 6% of the country, the

Tempisque Basin generates 45% of the country´s rice, 50% of its sugar cane, and 100 of its melon production. This region also holds the largest tilapia fisheries plant in the world. All these productive activities require water, and there is additional demand from neighboring areas where tourism is increasing. Yet, current water management policies are inadequate, and the results are already manifesting in multiple and negative ways for both humans and natural systems (see site description and major issues section below). The Tempisque River Basin represents a compelling site for developing and implementing new models of water management and policy, based on solid science and stakeholder participation.

A collective of US and Costa Rican organizations has started a project entitled Tempisque Basin Water Management and Sustainability. Its **goal** is to identify the mechanisms that will ensure water sustainability in this region both for human and natural systems, more specifically, to:

- understand the causes and consequences of current water availability and use in NW Costa Rica;
- forecast how water allocations will change as temperature rises, rainfall diminishes and land use changes; and
- propose what adaptive governance measures may be taken to ensure regional sustainability while protecting endangered ecological sites of international importance.

This project is conceived as a two-pronged approach: (a) an integrated assessment of the social, political, economic and ecological factors that affect water availability, demand and use, and of the consequences of current water use and allocation to both human and natural systems, both under current conditions and under forecasted climate change scenarios (the science dimension), that will be conducted by an integrated group of researchers from at least five Costa Rican and US academic institutions and (b) active and direct stakeholder involvement throughout all the phases of this project, from design to implementation, through consultations and hands-on guided analysis of alternative scenarios and policy directives (the policy dimension). These parallel but intertwined elements will ensure the identification of realistic policy recommendations based on sound science and active stakeholder participation.

This is an international, inter-institutional and inter-disciplinary project, led and catalyzed by the Organization of Tropical Studies (OTS) and University of Florida. The project builds upon OTS´s long-term presence in the area and involvement in search for solutions to some of the most visible threats to biodiversity in the region, and UF´s strong trajectory on hydrological, social, ecological, and policy issues in Costa Rica and elsewhere.

Background information: Site description and broad issues.

The 5404-km2 Costa Rican Tempisque Basin extends from the Tilarán and Guanacaste Mountains to the Gulf of Nicoya, essentially from summit to sea (Fig. 1). On the west side, the Basin ends in the Serranía de Nicoya, which separates it hydrologically from the Nicoya Coastal watershed. The Tempisque and its principal tributaries, the Bebedero, Cañas and Liberia rivers, flow into the northern Gulf of Nicoya,

Pacific Ocean. The lower end of the basin forms the Palo Verde marsh, an internationally recognized Ramsar site, protected by the Palo Verde National Park and the International Convention on Wetlands (Ramsar, Iran, 1971, http://ramsar.org). The area is considered a dry zone, where water is by definition a limiting factor for both native biodiversity and human activities.

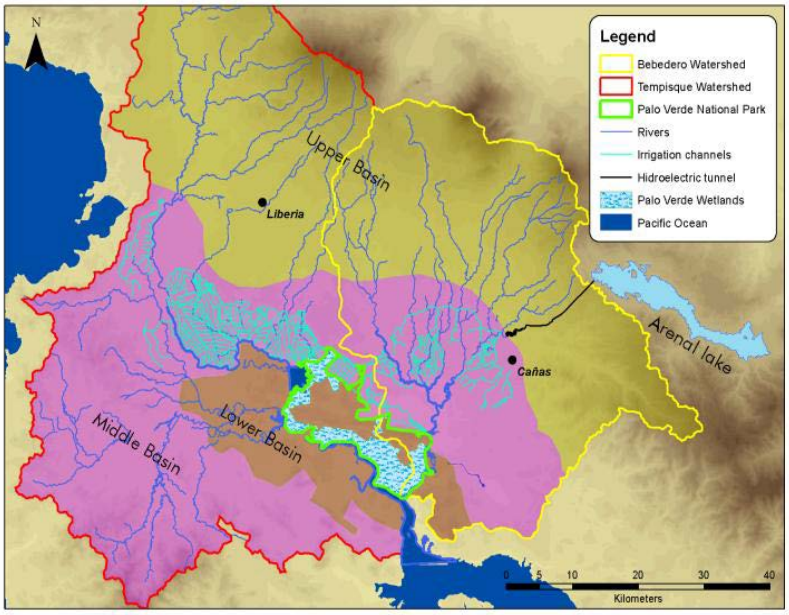

Figure 1.Map with upper/mid/lower Tempisque Basin

In the 1970s, a pivotal hydrological change occurred when the government, with funding from the InterAmerican Development Bank, created a large-scale irrigation district in an effort to provide agricultural land to low-income Costa Ricans. This irrigation infrastructure transfers 30-65 m3/s of water from the Caribbean versant (collected at Lake Arenal) into the Tempisque´s mid and lower basin. This additional water first generates electricity as it passes through three turbine stations located in the upper Basin, and once it reaches the town of Cañas, it enters a network of channels that spread through the middle Tempisque Basin irrigating 44,000 hectares.

In spite of a significant addition of water from the Caribbean side, the Tempisque is not exempt from the risk of waters scarcity. This additional water is dedicated exclusively to agriculture, while human needs and natural ecosystem needs are met from local sources, i.e., the Tempisque and Bebedero rivers and their tributaries and from underground water. The rivers also serve irrigation channels on the west side of the Basin. Contrary to its original intention, however, this large-scale irrigation project (Fig. 1) currently benefits mostly owners of extensive rice and sugarcane fields, and large-scale tilapia fish farms. In addition it is causing an unintended but significant degradation of the natural ecosystems that abut the productive lands.

The irrigation channels collect, as they pass through the agricultural plots and fish farms, pesticides, excess nutrients, hormones, antibiotics, parasites and feces, later delivering them into rivers and wetlands (fig 2). While the extent of water contamination and its impact on human health are unknown, some manifestations are already visible in the protected wetlands in the lower basin. Because of its location within the watershed, the Palo Verde marsh is suffering from severe habitat modification, manifested by severe invasion of dense cattail (*Typha dominguensis*) stands, which are thought to be responding to hydro-period modification and excess phosphorus loading from upstream agriculture. The result is the ongoing loss of the waterfowl that earned the wetland its Ramsar status, and could eventually become an international embarrassment for this country recognized internationally for its conservation success.

The water eventually reaches the Gulf of Nicoya, where further impacts occur. The Gulf of Nicoya harbors 75% of the artisanal of the fisheries of the country, representing 25% of the country´s fish landing. The most affected area is the estuary and upper part of the gulf that holds the nurseries for most of the important fish populations of the gulf. Four thousand artisanal fishermen families depend on this resource. Water pollution is already affecting the fish populations of 140 species.

In addition to water contamination, unmanaged water demand and mismanagement are affecting water availability and sustainable use. This mostly agrarian basin benefits little from the significant international tourism industry that characterizes Costa Rica, because the tourism developments are concentrated on the beaches on the other side of the Coastal range. Yet, rather than contribute to the local economy, tourism poses an additional strain due to their high water demand.

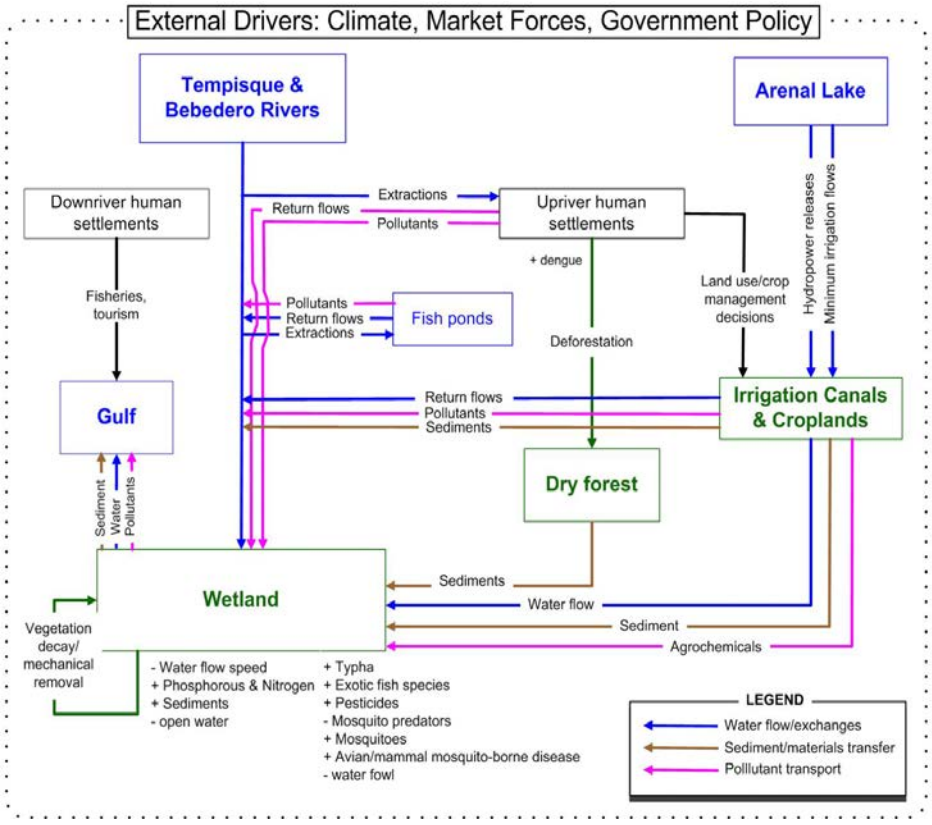

Figure 2. Conceptual model of flows and interactions among central elements in the Tempisque basin

While the current situation already yields many environmental, socio-economic and institutional problems, these conditions are likely to be exacerbated by climatic variability and change, especially the anticipated drier and hotter conditions. The 2007 Intergovernmental Panel on Climate Change (IPCC) report indicates strong consensus among climate models for increasing temperature and decreasing precipitation for much of Pacific Central America. Unless greenhouse gas trends change, average temperatures are expected to increase 2- 6 °C in the region, possibly with more extreme hydro-climatological events. Wet season precipitation is expected to decrease as much as 27% with associated drier soils and loss of water storage for irrigation, hydropower production and protected wetlands. Dry season river flow is also expected to decrease due to reduced cloud cover on the mountain ridges. These changes may unfold in as little as two decades, with a trend towards increasing aridity already evident in NW Costa Rica. Recent and regional scale weather patterns therefore appear to be consistent with long-term and global climate scenarios, and portend severe impacts on agriculture, biodiversity, and land use.

Landowners and government ministries are aware of the climate predictions, and are already working on strategies to adapt. Many of the former intend to replace rice with sugarcane and pineapple that require less water, while the latter recently announced plans to build more irrigation channels to respond to a growing demand from agriculture and the burgeoning tourism industry. These initiatives are designed to address individual challenges, but do not adopt an integrated view of all the issues, and are therefore likely to produce unintended consequences and be ineffective for the sustainability of the basin. For example, the government's plan to provide more water for irrigation may discourage landowners from adopting more water-conserving crops and in turn increase pollutant load inputs into the endangered wetland ecosystems.

Another potentially exacerbating factor is the growth of the tourism industry in the adjacent Nicoya Coastal watershed that demands waters beyond its own watershed yield, placing strong pressure to draw water from the Tempisque and the Arenal towards the coast. In 2008, the first conflict over water was sparked when Cocowater, a private company hired to provide water to the beach town of Coco, tapped into the groundwater of Sardinal. The situation was resolved and the issue settled, yet, the future water allocation and use is likely to continue to be a contentious issue in the whole watershed. For example, at this time, SENARA (see list of institutions below) plans to build a new dam (Rio Piedras) to divert water from the Tempisque Basin to the coast that will affect a protected area (Lomas Barbudal) and remove water from the Tempisque River. If implemented, this project will reduce area under conservation and is likely to speed the rate of sea level rise in the Tempisque delta, affecting riverine and estuarine ecosystems, as well as cause salinization of agricultural lands near the River´s mouth.

The gradual destruction of the Palo Verde wetland, the Sardinal conflict, and the proposed Rio Piedras Dam and its unintended consequences illustrate how individualistic actions to acquire water are unsustainable. They emphasize the urgency of conducting an integrative analysis of the situation and take measures to reach a consensual agreement on new policy that considers simultaneously all stakeholders interests and represents the solution that best serves all involved.

Broader Impacts.

Increasing demand for water along with possible diminishing supplies due to climate change creates several vulnerabilities within Pacific Mesoamerica, such as declining agricultural productivity, biodiversity losses, and limits to economic growth. A general decline in economic growth could have important implications for trade. For example, in 2006, the U.S. exported $19.6 billion worth of goods to Central America and imported nearly $19 billion worth of products, mostly agricultural, from the region. Erosion of labor-intensive agriculture could contribute to increases in labor migration and a major impact on Costa Rica's economy. Declining biodiversity would erode the region's rich natural heritage and declines in Neotropical migrant birds would significantly affect avian biodiversity in the U.S. As these vulnerabilities emerge as realities, the region will need to invest in adaptive responses and new intellectual capital. The interdisciplinary nature of this project will facilitate these investments and improve their effectiveness.