Water resources of the Upper Tempisque River Watershed, Costa Rica (Technical note)

Recursos hídricos de la Cuenca Alta del Río Tempisque, Costa Rica (Nota técnica)

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Palabras clave

Río Tempisque, Planificación de recursos hídricos, Guanacaste, Costa Rica.

Resumen

El estudio aborda la situación de los recursos hídricos de la Cuenca Alta del Tempisque ubicada en la Provincia de Guanacaste, Costa Rica.

Se proporciona una breve descripción biofísica del área de estudio, así como el cálculo detallado de la disponibilidad y uso de los recursos hídricos. Se encontró que antes del 2005, las concesiones de agua, además de los requisitos recomendados de caudal ambiental para el río superó la disponibilidad de los flujos naturales durante la estación seca.

Se da una serie de recomendaciones con el fin de mantener los caudales ecológicos, evitar los conflictos sociales y satisfacer las demandas de agua de las comunidades, inversionistas agrícolas, el turismo y desarrollos inmobiliarios.

Key words

Tempisque River, water resources planning, Guanacaste, Costa Rica.

Abstract

The study addresses the state of water resources of the upper Tempisque Watershed located in the Province of Guanacaste, Costa Rica.

A brief biophysical description of the study area as well as detailed accounting of availability and use of water resources is provided. It was found that before 2005, water concessions plus the recommended environmental flow requirements for this river exceeded the availability of natural flows during the dry season.

A series of recommendations are given in order to maintain environmental flows, avoid social conflicts and meet the water demands of communities, agricultural investors, tourism and real estate developments.

Introduction

The state of planning and management of water resources in Costa Rica is no different from other developing countries. Water demand has increased steadily over the last decades and trends indicate that the growing demand will generate social conflicts and environmental problems (Calvo-Alvarado, 1989, Reynolds et al., 1997, Segura et al., 2004).

Despite the available legal framework to regulate and monitor the use and management of this resource, both national and watershed-scale visions of integrated management are lacking. In this study, we analyze the Upper Tempisque River Watershed, which has faced high water demand from various users over the past decades. The main objective of this study is to contribute to water resource planning of the dry Pacific Slope of Mesoamerica by addressing the state of water resources in the Tempisque Watershed as a case study.

Methodology

Description of the study area

The study focuses on the Upper Tempisque Watershed located in the Guanacaste Province, Costa Rica. The study area also includes the section of river located between the Guardia Bridge and the community of La Guinea. This 28 km-long section is included because no tributaries flow into it, therefore, most of its flow depends exclusively on the upper watershed stream flows (figure 1).

The selected watershed has an area of 166,000 ha and encompasses almost 50% of the Greater Tempisque River Watershed. The maximum elevation is 1894 meters above sea level (m.a.s.l.) and the lowest point is the Guardia Bridge, at 21 m.a.s.l. The watershed encompasses stratigraphic units that correspond to the Tertiary and Quaternary periods with predominantly volcanic rocks from the Quaternary (Bergoeing, 1998).

Overlaying this geologic material, approximately 12 soil subgroups have developed, most of which belong to two taxonomic orders according to the USA soil taxonomy: Entisols (34% of the area) and Inceptisols (56% of the area). The channel section between Guardia and La Guinea crosses a plain dominated by two soil orders, Mollisols and Vertisols that are heavily cultivate for sugar cane, rice and watermelon (SEPSA 1984, González et al., 2001).

As the study area is located in the North Pacific region of Costa Rica, it consequently has a dry tropical climate regime, characterized by warm temperatures and a well defined dry season. The Inter-tropical Convergence Zone and the trade winds from the northeast and southwest determine the marked seasonality of this region. Both rain and temperature distributions are affected by elevation, higher areas are wetter and cooler, and lower areas are warmer and drier (Maldonado et al., 1995, Calvo-Alvarado et al., 2008).

The watershed has eight Life Zones according to the Holdridge Life Zones classification system (Holdridge 1967, Bolaños & Watson, 1993), of which the most important are: Premontane Moist Forest (45.7% area), Tropical Moist Forest (12.5%) and Tropical Dry Forest (24.2%). The biota of this watershed and the Guanacaste Province in general is very different from the rest of the country, given that this region is the southern limit of the dry Pacific slope that extends from Mexico to Costa Rica (Vaughan

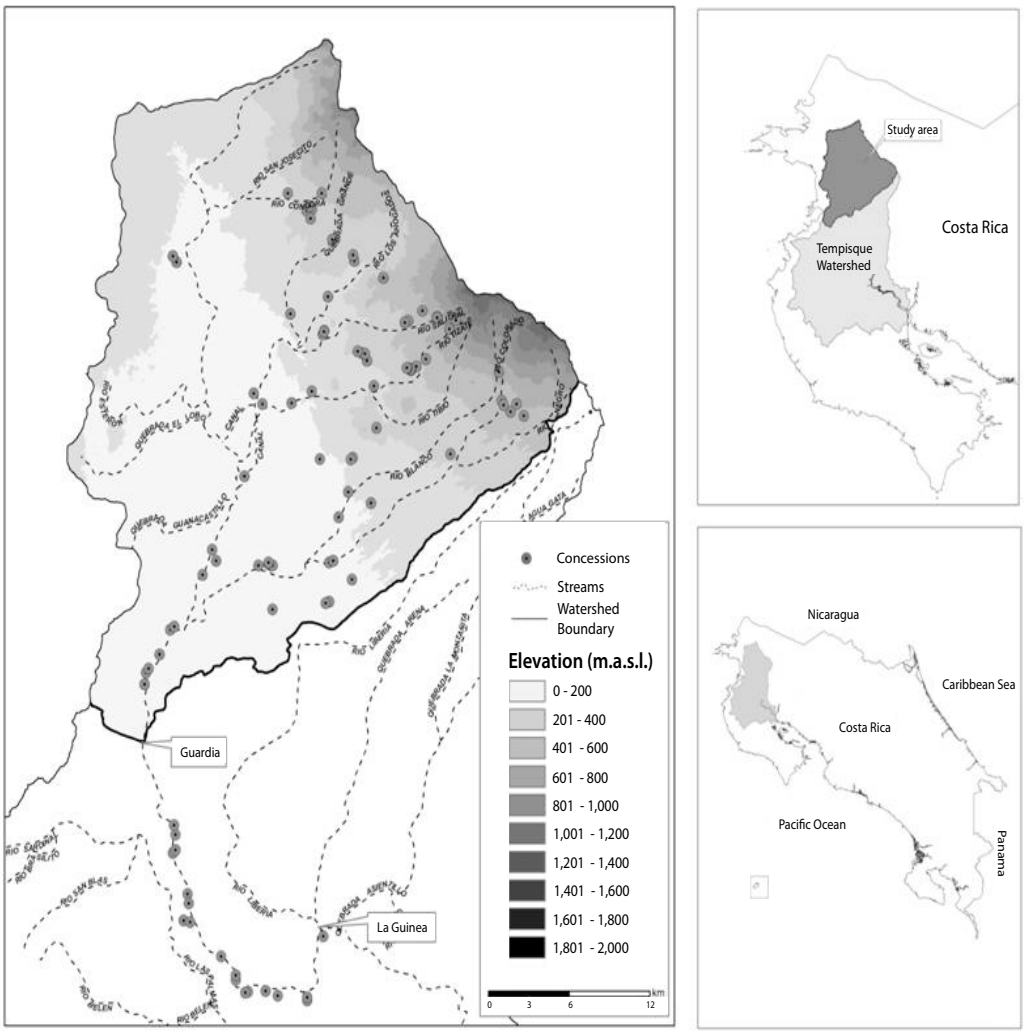

Figure 1. Geographical location of upper Tempisque watershed, Guanacaste, Costa Rica.

et al., 1996). Three national parks are found within the watershed, covering 22.4% of the total area: Santa Rosa (2.1%), Guanacaste (14.6%) and Rincón de la Vieja (5.7%).

Current land use corresponds to mature forest (30%), secondary forest (20%), a combination of pasture and scrub (30%) and pure pasture (11%). The remaining land (9%) is dedicated to crops or other uses. Calvo-Alvarado et al. (2009) showed that forest restoration processes in this watershed have increased significantly due to three basic reasons: a) a fall in the price of exported meat since the 1980's that caused pasture land to be abandoned, b) the creation of national parks which expropriated large ranches in the upper watershed and c) the promotion of tourism which diversified employment opportunities in the region, reducing the demand for agricultural jobs.

Collection of data and information

As indicated in previous studies (Jiménez et al., 2005), the 1951-1971 streamflow record is the best dataset to describe the natural water supply of this sub-watershed, since during that period there were no water concessions or water withdrawals. Average monthly rainfall data corresponding to the same period was obtained from Calvo-Alvarado et al. (2008) and Jiménez et al. (2005).

Information on surface water use, granted water concessions and their geographical location were obtained from the Ministry of Environment, Energy and Telecommunications (MINAET). Description of the legal and institutional framework that regulates water use within the watershed was obtained by consulting published national diagnostic studies (e.g., MINAET, 2005, 2008, Aguilar et al, 2004).

Results and discussion

Temporal availability of water

A generalized annual water balance was estimated using mean annual runoff and precipitation (Table 1) and by assuming that the average annual change of water storage is zero. Average annual rainfall in the study area is 1819 mm, annual evapotranspiration is 1294 mm (71.1%) and annual runoff is 525 mm (28.9%). It is further estimated that 31.4% of the annual runoff corresponds to base flow (165 mm according to Reynolds 1997).

Table 1 shows the monthly rainfall, mean stream runoff and discharge for the 1951-1971 record. A considerable decrease in runoff takes place during the dry season (December to April), with greatest reductions occurring in April, which has an average flow discharge of 8,96 m^3/s.

Resource use and concessions

In 2005, water concessions allocated in the study watershed totaled 12 m^3/s, corresponding to 164 granted concessions. Declared use for this water withdrawal correspond to: irrigation (70.4%), agro-industry (28.6%), municipal and other human consumption systems (1.1%).

Aside from the water allocated in concessions in 2005, the environmental flow requirements of this river must be taken into account. It had been estimated that for April (the most critical month) 3,2 m^3/s of streamflow must be left as environmental flow (Jiménez et al., 2005, Calvo-Alvarado et al., 2008).

Considering the environmental flow requirement and the average stream flow for April (8,96 m^3/s), no more than 4,9 m^3/s of water flow could be allocated for all water concessions. By applying the environmental flow requirement, a water deficit of

Table 1. Tempisque upper watershed monthly rainfall, mean stream runoff and discharge for the record 1951-1971. Guanacaste, Costa Rica.

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Agu	Sep	Oct	Nov	Dec	Year
Mean rainfall in mm	21.1	23.2	2.5	49.5	198.2	253.0	197.1	177.6	345.2	380.3	135.7	35.7	1819.4
Mean runoff in mm	29.9	20.0	16.9	14.0	23.7	55.0	39.1	40.7	67.0	101.9	77.0	39.9	524.9
Mean daily stream flow in m^3/s	18.5	13.7	10.5	8.96	14.7	35.2	24.2	25.2	42.9	63.1	49.3	24.7	27.6

5,1 m^3/s was created when the total allocated water concessions (12 m^3/s) were considered.

The conflict over water use was such that even disregarding the environmental flow requirements and considering only the concessions already granted, the water demand for March and April could not be met, creating a conflict between water users during average or drier years.

Moreover, if environmental flows were considered, the conflict would have increased by enhancing the deficit from February through May, given that during these months the stream flow would fail to meet water demand for all water concessions plus environmental flow (Table 1).

Because of this, the Water Department conducted a revision of water concession allocations after 2005 so that at least an environmental flow of 3 m^3/s was reserved.

Legal and institutional framework

According to Comité Nacional de Hidrología y Meteorología (2002), the current legal and institutional framework governing the management of water resources in Costa Rica is the following:

- The National Constitution of 1949, which established the sovereignty of water resources over the national territory and declared them a public asset.
- Water Law No. 276 of 1942 and its amendments, which regulate all matters relating to water ownership and use.
- Mining Code Law No. 6797 of 1982, which established that groundwater and surface waters are public and that the State has the ownership and administration rights over them.
- Environmental Law No 7554 of 1995, which states that water is of public domain, and that its conservation and use if for the public interest. The law defined water as a public utility and that its use for human consumption has priority over any other use.
- Forestry Law No. 7575 of 1996, which regulates activities instead and private forests that may affect water resources. This law established the protection of riparian forest as well as the State's obligation to ensure the protection of watersheds.

The laws listed above regulate water use, including water given in concessions for public supply, development of hydraulic power, irrigation, navigation, and fisheries, legal and natural easements, among other specific uses. According to Zeledón (2005), the current water law is insufficient for meeting the needs of the national water sector due to increased demand, poor management, increasing social conflicts and problems of access to water in terms of quantity and quality.

Due to this, in November 2001 a draft Law on Water Resources was submitted to the National Legislative Assembly. However, this law proposal (file 14585) is currently frozen in the National Legislative Assembly and its rapid adoption is highly unlikely.

Water administration and management is the responsibility of MINAET, and although water administration is defined, in practice it has not functioned well. Due to the lack of clear laws and strong institutions, management and administration is carried out by sectors with strong participation of water users.

The institutional framework has been characterized as fragmented and dispersed, with poorly defined roles and functions, and with overlapping responsibilities. The most important institutions governing water administration and management are:

SENARA (Servicio Nacional de Aguas Subterráneas, Riego y Avenamientos): the National Irrigation and Drainage Service. SENARA was created by Law 6877 on 18 July 1983, and has the authority and responsibility to develope infrastructure and administer and operate irrigation and drainage water systems. Additionally, it conducts research on the preservation of aquifers so that optimal and efficient water resource management practices are maintained.

AyA (Instituto Costarricense de Acueductos y Alcantarillados): the Costa Rica Institute for Aqueducts and Sewer Systems.

ARESEP (Autoridad Reguladora de los Servicios Públicos): the authority for public services in Costa Rica that approves consumers' water and sewer charges.

One of the main drawbacks with the current institutional framework is that no single institution is responsible for water resource management with

full authority. This dilutes both technical and administrative responsibility, resulting in gaps and overlapping responsibilities in planning and research.

For example, information on water use is scattered, there is poor control over water used by concessionaires, and there is extensive illegal water withdrawal. Another major problem is that no adequate physical assessment exists of the availability and seasonality of water resources, let alone the determination and conservation of environmental flows in the country's major rivers (Segura et al., 2004, Jiménez et al., 2005).

Due to this, MINAET has been working on a National Water Resources Planning Strategy. The main are objectives to: a) approve a new water resources law, b) generate information about the water balances of the 15 most important watersheds, c) reformulate the water policies for cannons and rates and d) lead an institutional reform for better coordination of water resource management (Aguilar et al., 2004). The major obstacle so far has been the lack of support to approve the new law.

To conserve and properly manage water resources of the Tempisque Watershed, the approval of the new water law is of paramount importance, particularly since this law incorporates a more comprehensive concept of environmental flows as well as new ways to charge monetarily for the water resource.

Conflict due to the demand for water resources

Increased development in the watershed and the interest of investors in activities such as tourism and real estate development have resulted in water demand that is not matched by existing hydraulic infrastructure. Consequently, there have been conflicts over access to water between communities threatened by these developments. These conflicts are further magnified by the inability and limitations of MINAET to solve the problems (MINAET et al., 2008) and the lack of investment in new potable water infrastructure to satisfy community demands.

According to the Central American Water Tribunal (Tribunal Centroamericano del Agua, 2001), the lack of opportunity for civil society to participate and the lack of clarity in competition between the various entities of the State have been the main causes of serious conflicts in water resource management. Occurred conflicts show that most of the time, water concessions have come before the needs of communities and farmers.

In response to current conflicts, the government proposes the construction of hydraulic infrastructure to better distribute water resources in Guanacaste Province. This includes building a dam on the Piedras River, which would create a reservoir of 830 ha with a capacity of 83 Hm^3.

The basic function of this reservoir will be to store water surplus from the Arenal hydroelectric complex and the Piedras River. Stored water in this reservoir will be used to compensate unsatisfied growing water demands along the Guanacaste Coast, the agro-industry and irrigation sectors, so that the Tempisque River can maintain its recommended environmental flows during the dry season (Ballestero, 2009).

Conclusions

The Tempisque River is highly important for development and conservation in Costa Rica. It drains a vast area that empties into the Gulf of Nicoya, resulting in rich and diverse ecological, economic and social interactions. Surface water resources are the easiest to withdraw during the marked dry season, creating conflict caused by high water demand by a myriad of users in this watershed.

By 2005, water concessions plus the recommended environmental flows requirement for this river exceeded natural flows from February to May, particularly along the channel section between Guardia and La Guinea. As an immediate response, the Water Department of MINAET launched a strategy to reduce water use by revising the allocated flows of several concessions to guarantee at least an environmental flow of 3 m^3/s. Additionally, further solutions are being considered by the State to amend this growing water resources conflict, such as adding extra flows to the Tempisque River from the water surplus of neighboring rivers and the Arenal hydroelectric complex.

Within the legal and institutional framework, many institutions have some level of participation in the management of water resources nationally, which means that there is no single institution responsible for water management. Therefore, administrative

and technical responsibility is diluted, creating significant gaps in water resources planning and research.

The proposed new Water Resources Law is pending sanction in the legislature and is the best alternative for solving many of these problems. The lack of approval of this proposed law has been a serious setback in the planning and management of water resources in Costa Rica and in the Tempisque Watershed in particular. Nevertheless, as of March 2012 this proposed new law does not seem likely to be approved in the near future by the Legislative Assembly.

To maintain environmental flows, avoid social conflicts and meet the water demands of investors in tourism and real estate developments, proper planning of water resources with a vision towards the future is essential. This is no easy task given the prevailing legal and institutional framework, particularly if the highly dynamic nature of economic development in this area is considered. Nevertheless, the challenge must be faced and the process of resource planning and management must start as soon as possible.

Recommendations

a- It is fundamental to monitor the different variables that determine climate and their relationships to watershed flow regime and to make this information available to researches and decision-makers granting water concessions. Therefore, there should be continued support of existing hydro-meteorological stations as well as improving the network by adding more stream gauging stations.

b- MINAET should keep the maximum flow for concessions to 4,8 m^3/s so that even in the driest years, the recommended environmental flow is maintained after satisfying approved water withdrawal. To do this, new and future concessions must be renegotiated to realistic volumes based on the needs of stakeholders.

c- It is urgent to develop a model for water resource planning that allows for the regulation of how concessions are granted and the amount of water that is granted. This model must include water consumption scenarios for at least the next 20 years and involve communities, users, planners and decision-makers. The model must also consider the impact of climate and land use change on stream flows within the watershed.

d- Regarding legislation related to management of water resources, it is imperative to have congruence between the laws and regulations to ensure both the conservation of the resource as well as organizational agility. Therefore, the proposed new legislation on water resources must be approved.

e- An awareness campaign amongst stakeholders must be promoted advocating that concessions within the watershed cannot exceed the supply of the resource and that water-use technologies should be implemented for water conservation.

f- Several of the proposed technical solutions to satisfy the increasing water demand in this watershed, such as adding extra flows to the Tempisque River from water surplus from neighboring rivers and the Arenal hydroelectric complex (see MINAET, 2008), need social and environmental assessments as a component of an integrated water resources management plan for the Tempisque Watershed.

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