Valuing the Tana River water resources

Policy Brief

Wetlands International

The economic valuation of the environmental uses of water resources such as the Tana River has the potential to bring a more balanced perspective to the allocation and management of water resources. The study outlined below explains how internalizing these values shows the cost and benefits on a societal level.

Tana River Basin

The Tana River is Kenya's longest river and originates from two of Kenya's major water towers: Mt. Kenya and the Aberdares. The Tana River Basin covers 22% of the country's total land mass and is home to 18% of the country's population.

Figure 1: Map showing the Tana River Basin

Ecosystems in the Tana River Basin include forests, arid and semiarid lands, mountain vegetation, freshwaters and wetlands, marine and coastal areas and agrosystems. These systems provide a range of ecosystem goods and services vital for human wellbeing such as drinking water, hydro-electric power, fisheries, agriculture and biodiversity. They are also interrelated and partially overlapping, e.g. water reservoirs may create benefits such as power generation, irrigation, drinking-water supply, fisheries and recreation, depending on their location, design and operation. The potential to deliver ecosystem goods and services depends on the amount of water available to the ecosystems and on the hydrological regime. This may prove to be a challenge as development plans, such as those in the Kenya Vision 2030 document - which includes plans to utilize the waters of the Tana River for water supply for Nairobi City and for the proposed and on-going Lamu port/city, to produce food using irrigation and to develop hydropower - change this water availability and hydrological regime.

Analysis of development possibilities and constraints

When the use of water resources by one group of users affects the potential for other users to use water, it generates so-called externalities. Upstream uses may lead to reduced quality or quantity of water resources at downstream locations. Given the above background on the Tana River, it is essential to understand the economic values of positive and negative externalities of different water-flow regimes, both upstream and downstream in the Tana River basin, and the temporal dynamics of changes varying between short and long term effects, as well as seasonal fluctuations.

Providing information on development opportunities and constraints helps to ensure that water allocations are better tailored to actual water needs. Secondly, the information contributes to decisions that result in the efficient utilization of public resources, resulting in maximum societal utility. Thirdly it is assumed that this information encourages evidence-based assessments of distributional consequences of water decisions.

Scenarios

The study presented here is built around scenarios which represent the most important developments that have been carried out and are currently planned in the Tana River Basin:

- **Scenario 0** – No Dams: Represents the naturalized state of the Tana River, without any interventions.

- **Scenario 1** – Masinga + dams: This baseline scenario represents the current situation, including the 5 hydropower dams (Kiambere, Kindaruma, Gitaru and Kamburu) and 2 other dams on the Thika and Chania Rivers that supply water to Nairobi

- **Scenario 2a** – High Grand Falls Dam: This policy scenario represents a future situation in which the High Grand Falls Dam (HGFD) is complete and additional irrigation in Bura, Hola and in the Tana Delta is established, as well as the Nanigi – Lamu water transfer.

- **Scenario 2b** – Million Acres: This policy scenario is the same as 2a, but with the addition of one million acres

Water being released from the Masinga dam spillway

People tapping the Tana Delta's groundwater in Handaraku Village, Tana River County

(~400.000 ha) of irrigated land (located at the Galana-Kulalu Ranch in the Tana River and Kilifi) for which water is extracted from the HGFD reservoir.

Tana's ecosystems services that support development

The ecosystems in the Tana Basin as indicated above provide various services to people and their livelihood options strongly depend on them. The ecosystems in the Tana Basin thus support human and economic development. For example, the seasonal flooding of the Tana River deposits a fertile layer of silt on the plain and oxbow lakes, supporting agriculture and pastoralism. The seasonal flooding also support fish rejuvenation in the Tana. Storage and purification capacities of the river system allow people to abstract water for multiple purposes, including drinking water and water for agriculture and livestock. Especially in the upper montane parts and the Tana Delta, the ecosystems provide a habitat to diverse and rich biodiversity, creating huge eco-tourism possibilities. The Tana Delta was designated as a Ramsar site in November 2012.

Changes in the river discharges

A GIS based rainfall-runoff model (STREAM) was set up to simulate river discharges for each of the above-mentioned scenarios. The translation from discharges to flood levels formed the link between the hydrological model and ecosystem services.

The combined effects of these interventions (Scenario 2b) impacts the amount of seasonal flood events the most, with a decline of 65% in flood events in the middle catchment area in Garissa, with 12-19% decline in the lower catchment area in Nanigi and Garsen and with 8% decline at the river outlet in Kipini. The effects reduce downstream as more tributaries discharge into the Tana River main channel.

Figure 2 illustrates the magnitude of the dampening effect of the current dams and the additional effect the HGFD may have on discharge, reducing the seasonal signal of the Tana River hydrological

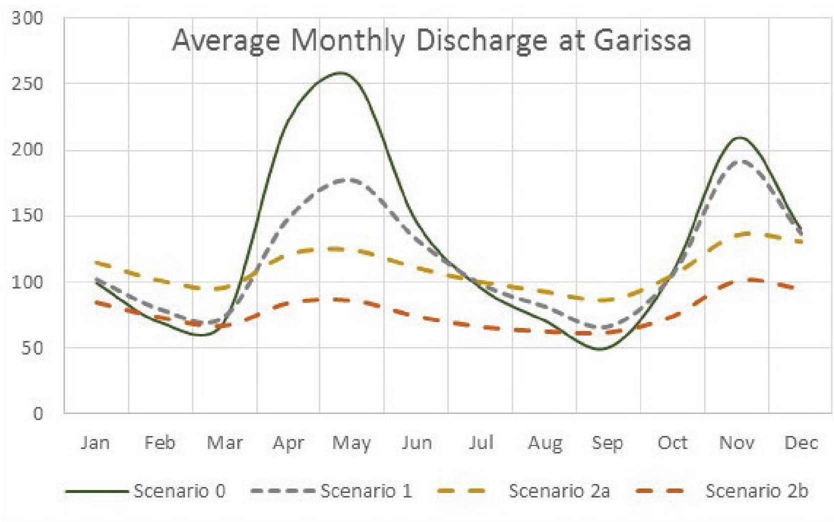


Figure 2: Changes in the seasonal regime of hydrological discharge resulting from the developments in the scenarios. Hydropower dams tend to dampen the seasonality of high and low flows while water diversions for irrigation and drinking water tend to lower discharges throughout the year

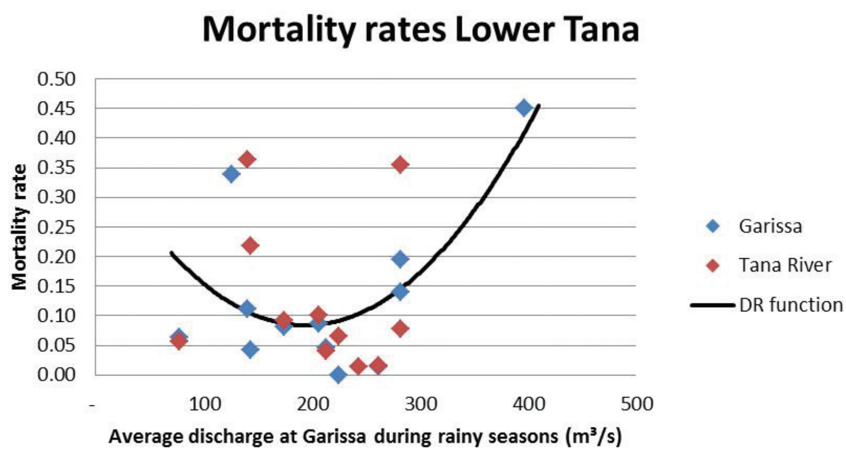


Figure 3: Statistical relationship between river discharge at Garissa and mortality showing both correlation with high flows (flood risks) and low flows (water and food insecurity)

regime considerably. From the figure it can also be deduced that with the large water extraction due to the million acres irrigation in Scenario 2b, overall water resources in the lower Tana are greatly reduced, almost to a constant level of natural minimum flow with hardly a flood peak left.

Relating hydrological changes to ecosystem services provision

By means of statistical analysis of time series ecosystem service outputs such as crop yields and fish catches could be related to river discharges and flooding. In literature and from stakeholder interviews it was found that the Tana River, while vital for the health of the people living in the Basin, can cause lethal floods in extremely wet years.

Clear statistical relation was established between the average discharge in Garissa during the rainy seasons and the mortality rate in the Lower Tana (Garissa and Tana River counties). Mortality rates tend to increase both when the water flow is low and when it is high. Even though regulation of extreme floods can be a positive consequence of additional dams in the Tana River Basin, further reduction of river discharge and moderate flooding can have considerable adverse effects on the benefits provided by ecosystem services downstream. It therefore seems likely that the HGFD will increase the disparity of water availability between the Upper Basin and the Middle and Lower Basin, as is the case with the dams that were built in the past.

Extended Cost Benefit Analysis

An extended cost benefit analysis (CBA) compares the costs side (financial inputs resulting from the interventions) with the benefits side (socio-economic consequences that result from these interventions as planned in the scenarios). The CBA conducted as part of the study incorporates the economic values of the ecosystem services and calculates how they change under various scenarios using statistical analyses. It also calculates the cost and benefits of irrigation schemes and hydropower. Irrigated agriculture currently has the potential to produce 64,000 tons of rice and maize per year. The current value of the electricity supplied by the dams is estimated at almost $400 million per year. HGFD is going to increase these benefits further. Yet the cost of generating hydropower is also significant. Based on worldwide experience of large-scale dam construction costs, the costs of the HGFD is assumed to be twice as high as the US$ 1.5 billion often reported in the media.

Predictions of costs and benefits were made for a period of 25 years for the three scenarios (1, 2a and 2b) relative to the baseline scenario (0). Results are shown in figure 4. The extended CBA draws a number of conclusions:

1. Construction of the existing dams has generated abundant benefits for the upstream region in terms of electricity, potable water and agricultural outputs. The downstream region lost slightly more benefits than it gained. This loss mainly resulted from reduced agricultural productivity and increased health complications. The benefits of scenario 1 for downstream counties come from an increase in power supply and flood prevention.

2. Positive change that results from the HGFD is especially the increase in electricity supply. The downstream positive and negative effects showed a similar but less pronounced pattern, as occurred with the Masinga dam addressed in Scenario 1.

3. The million acres scenario seems to create significant agricultural benefits in the downstream region (i.e. Tana River County) yet the large water demand of the irrigation schemes is likely to cause serious water shortages in this same region which will lead to substantial declines in health, potable water availability, fisheries and livestock options.

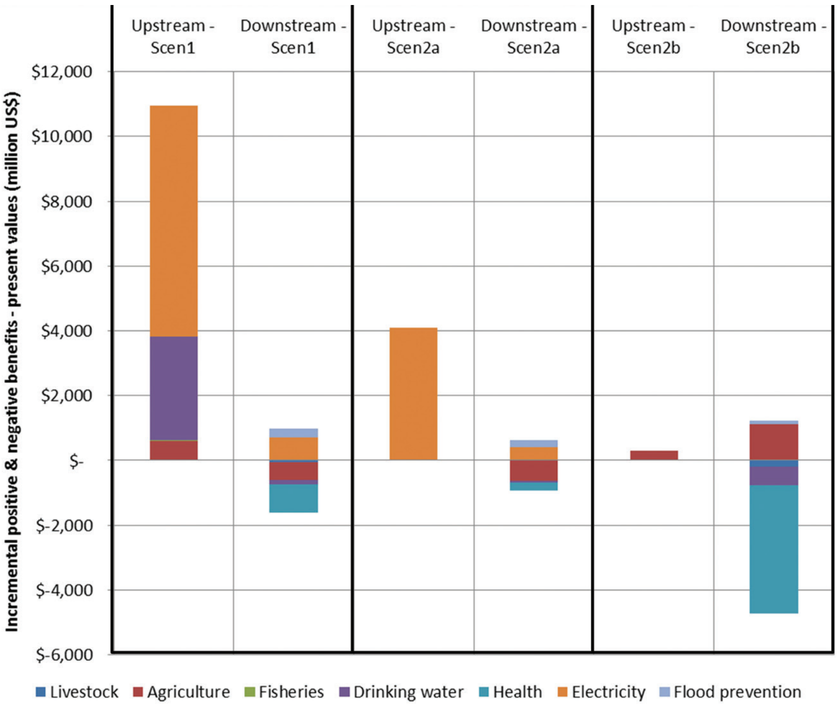


Figure 4: Present value of incremental benefits of each additional infrastructural work in the Tana River Basin, 25 years, discount rate 4%. Benefits are referred to as those effects that arise external to the direct domain of the financial decision-maker. The value of benefits can be both negative (e.g. decline of fisheries in the Delta) and positive (e.g. increase of revenues from irrigation schemes).

County-level distributional effects

When looking at the distribution of costs and benefits at the county level, the winners and losers of the three scenarios are revealed (figure 5).

Clearly, upstream counties such as Nairobi (not physically located in the basin but a clear recipient of the benefits created in the basin) and Kirinyaga benefit most from the interventions of the scenarios. For each dollar invested in the current dams, 8 dollars were returned in terms of electricity and drinking water benefits within the county. These positive effects in the upstream counties are less pronounced in scenario 2a and 2b, yet the benefits still outweigh the costs (measured proportional to the population share in the Tana Basin).

The "losers" of the current dams are the counties Kitui, Tana River and Isiolo. All downstream counties suffer from the million acres project, except for the Tana River County where most of the planned irrigation is scheduled to take place.

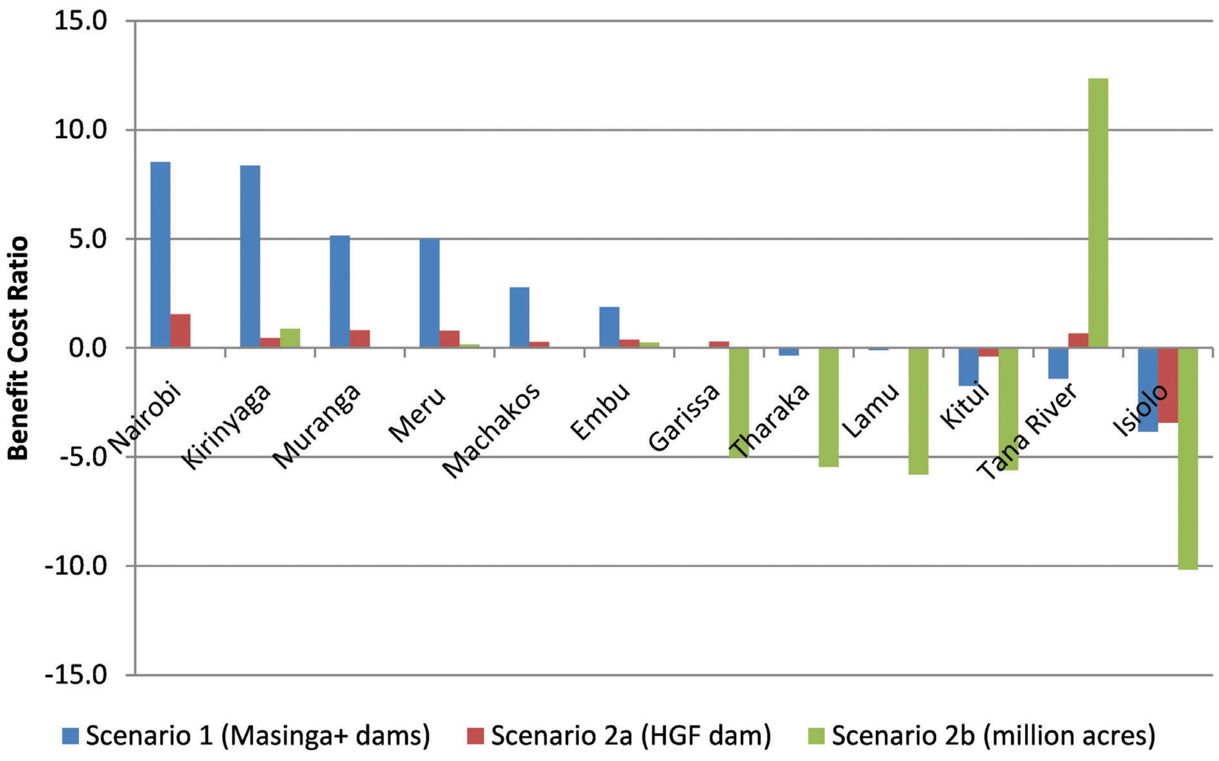
Policy relations

This study aimed at clarifying the different values of the ecosystem services of the Tana River basin and their significance to the Kenyan economy, with a view to providing evidence for development planning and water resources allocation, so as to safeguard the basin's hydrological, ecological and socio-economic benefits.

The study clearly shows that current development plans in the Tana River Basin have positive but also serious negative effects for various stakeholder groups in the basin. It is beyond the scope of this study to determine whether these negative effects can be mitigated in a cost-effective manner. Although the research boundaries of this study limit direct use of this study for policy implementation in the Tana River Basin, it helps to identify a number of critical areas that deserve further attention before the proposed development projects are implemented.

First, the study shows that the negative downstream effects of the HGFD often outweigh the positive effects of the dam upstream. This outcome does not imply that the HGF dam should not be developed, but instead calls for further investigations of the extent to which alternative dam management regimes could mitigate the negative effects of the HGFD downstream.

Second, although the study shows that several planned development projects fall short in terms of economic efficiency, it does not provide an immediate alternative for the basic economic services provided by these interventions, since this is beyond the scope of the current study.



Benefit cost ratios	Upstream counties	Downstream counties	Total Tana River Basin
Scenario 1	6.0	-1.1	4.3
Scenario 2a	1.0	-0.2	0.7
Scenario 2b	0.1	-4.0	-0.9

Figure 5: Benefit costs ratios (BCR) of incremental changes of each additional infrastructural work in the Tana River Basin, 25 years, discount rate 4%. Costs refer to direct financial effects relevant for the decision-maker who is directly responsible for the financial feasibility of the investment. An example cost in this study is the investment of constructing and maintaining dams. Several BCRs of the downstream counties have a negative sign due to the fact that instead of positive net benefits, negative effects of the interventions dominate. In other words, for the downstream regions the interventions do not only cost money in terms of capital investment, they also experience a reduction in welfare due to the dominance of negative consequences of these interventions. Knowing that an intervention is economically feasible at a BCR of 1 or more, it is clear that only the current situation (scenario 1, with a BCR of 4.3) is economically feasible for the Tana River Basin at the given assumed conditions. At the regional level, however, it is clear that downstream counties mainly lose in terms of welfare (especially in scenario 2b)

Young boy herding his goats in fields next to the Tana Delta Irrigation Project, Garsen region

Key messages

1. Ecosystems in the Tana River Basin vital for human wellbeing and economic development, such as drinking water, hydro-electric power, fisheries, agriculture and biodiversity depends on the amount of water available to the ecosystems and hence on the hydrological regime of the Tana River.

2. Water resource developments (e.g. dams, flow diversions) have dampened the "original" hydrological regime in the Tana. High flow discharges have reduced while the low flows have increased.

3. Further reductions of the river discharge and the moderate (desirable) flooding will have considerable adverse effects on the benefits provided by ecosystem services downstream.

4. The existing dams have generated abundant welfare skewed towards the upstream region in terms of electricity, potable water and agricultural outputs.

5. Positive change will occur as a result of the HGF dam, especially the increase in electricity supply and the regulation of extreme flood events. Benefits accrue mostly upstream.

6. Large water extraction due to the so-called million acres irrigation project, will reduce overall water resources in the lower Tana to an almost constant level of natural minimum flow.

7. The million acres scenario creates significant agricultural benefits in Tana River County and Kilifi County yet its large water demand is likely to cause serious water shortages in the downstream Tana river basin resulting in an economically non-feasible benefit cost ratio of minus 4.

Acknowledgements

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For the full report visit: www.wetlands.org

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