Policy Brief 2020/2

Sustainably managing fisheries in water reservoirs: A case from Northern Ghana

SUMMARY

Northern Ghana endows numerous freshwater bodies and therewith an enormous potential for inland fisheries development, which still remains largely untapped. This potential contribution is high if reservoirs are technically and purposefully designed to provide significant and sustainable fish production. However, fish production in these reservoirs is often insignificant due to failures in reservoir designs, unsustainable fishing practices, inadequate planning and policy, limited research and development. Addressing these issues requires an adequate assessment of the reservoir fisheries resources, accompanied by the implementation of better policies and management strategies. As reservoirs in the region are mainly constructed for irrigational farming, there is a need for better integration and assessment of fisheries in irrigation development and management.

This policy brief is based on a study of the three reservoirs Tono, Bontanga and Golinga in northern Ghana. We provide a complete description and analysis of the food web dynamics and fisheries productivity in our publications (see References). Moreover, we developed an empirical model to estimate the harvest potential of reservoirs in West Africa. Here, we present the main findings and derive recommendations on how to facilitate the sustainable management of the reservoirs' fisheries.

This policy brief is intended to inform stakeholders that implement and support activities that protect the aquatic environment and provide the food and nutritional needs of the rural communities. We offer our recommendations to decision-makers from Ministries (Fisheries, Agriculture), the Fisheries Commission, the Ghana Irrigation Development Authority, NGOs, project managers, donors, and interested fishers, farmers and researchers.

KEY RESULTS

- The 3 lakes Tono, Bontanga, and Golinga differ in physical features (shape, mean depth, overall size, water holding capacity and water throughflow) which relates to differences in food web structures and resource productivities.
- We can estimate the harvest potential of the reservoirs based on the known lake size: Catch (tonnes/year) = $17.3 \times \text{Area (km2)}^{0.8626}$.
- Fisheries productivity is inversely related to lake size: The smallest and shallow lake Golinga is the most productive on a per unit area basis.
- Fish species diversity is beneficial to the health of a lake and increases yields.
- The harvest levels of targeted fish resources of the three reservoirs differ from under- to overexploited.

RECOMMENDATIONS

- Form inter-sectoral working groups to promote sustainable use of the reservoirs for both agriculture and fisheries production.
- Integrate fisheries into irrigation schemes development (e.g. in development plans).
- Include an ecosystem-based fisheries perspective when planning new reservoirs.
- Protect and control the environment of reservoirs for fish production.
- Optimise sustainable exploitation of reservoirs through targeted stocking.
- Expand knowledge and research on man-made reservoirs
- Improve fisheries assessment and update statistical models.

THE CONTEXT

Figure 1. A fisher landing his catch at Tono reservoir (July 2017)

Northern Ghana is covered in Savannah and has a seasonal rainfall cycle that is subject to great interannual variations. Under drought conditions, crop and animal production can be strongly reduced. To mitigate these challenges, reservoirs were constructed for domestic uses, livestock watering, fish farming, and irrigated agriculture. With time, many of these "constructed lakes" have grown into significant inland fishing grounds. Ghana's fisheries sector provides livelihoods for over 2.4 million people and contributes significantly to the food and nutritional needs of the people, accounting for 60% of animal protein consumption. The sector adds 4.5% to the Gross Domestic Product (GDP) and contributes to poverty alleviation and the foreign exchange of the country[1].

The inland fisheries of Ghana are poorly appreciated and are given low priority relative to other competing uses of water. As a consequence, inland fish stocks are not comprehensively monitored or assessed[2]. Many inland water bodies in Ghana lack management that can adequately enforce the sustainable use of resources. Where management arrangements exist, compliance and enforcement are often minimal or nonexistent[2]. Lake ecosystem functioning and thus fish productivity are controlled by many factors such as natural predation, nutrient fluxes, abundance and composition of introduced species and fishing practices and intensity. Understanding the dynamics and the impacts of these factors is therefore crucial for successful ecosystem-based fisheries management.

A major constraint to science-based fish stock management in West Africa is the lack of reliable data on target stocks. This especially holds true for inland fisheries, such as those that operate in reservoirs. Due to the low availability of resources and population data, and the limited number of fisheries experts in the region, state institutions and investigators rely heavily on simple catch statistics and empirical models for their estimations of fish production and potential yields.

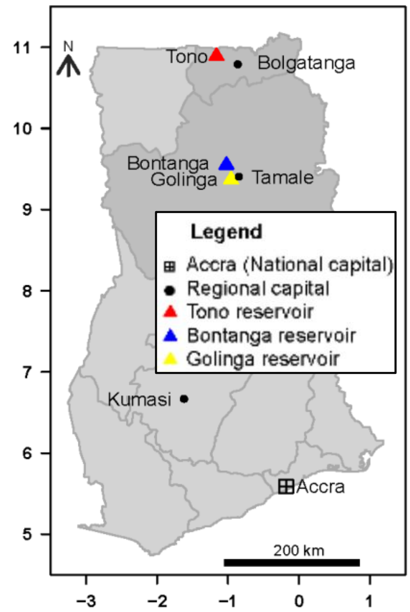

Figure 2. Map of Ghana indicating the location of national and regional capital cities, as well as the three reservoirs studied.

The studies underlying this policy brief were carried out at 3 reservoirs: Tono, Bontanga, and Golinga (Figure 2). Tono is the largest reservoir in the Upper East Region of Ghana and has a surface area of 1,860 ha. Bontanga with a surface area of 670 ha is the largest reservoir in the Northern Region of Ghana, while Golinga is the smallest with an area of 62 ha. They vary in shape, surface area, mean depth, water level fluctuation, total water volume and intensity of resource use. The number of households that depend on the reservoirs for their livelihoods also varies in relation to the reservoir size - with 16250 (Tono), 4950 (Bontanga) and 900 (Golinga) residents. The number of households is an indicator of pressure on resources such as water and fish.

RESEARCH RESULTS

Target fisheries resources of reservoirs in northern Ghana

Fisheries resources at the lakes were studied from July 2016 to June 2017. The exploitation of the resources differ, with total catch per unit of area being highest for the small (17.11 t km^{-2} yr^{-1} in Golinga), lowest in the largest (10.07 t km^{-2} yr^{-1} in Tono) and intermediate in the medium-sized lake (15.51 t km^{-2} yr^{-1} in Bontanga; Fig. 3). The highest species catch of 5.54 and 7.30 t km^{-2} in Tono and Bontanga, respectively were from *S. galilaeus* (Mango Tilapia), while *O. niloticus* (Nile Tilapia) catches (6.9 t km^{-2}) were the highest in the smallest reservoir (Golinga).

The results from our analysis of three species (Nile Tilapia, Mango Tilapia, and Redbelly Tilapia)[4] suggest that they are heavily exploited in all three reservoirs, but with no alarming signs of overexploitation. The fishing effort at Golinga is comparatively low as a result of insignificant fishing during the agriculture season.

The giraffe catfish (*Auchenoglanis occidentalis)* was found only in Tono and Bontanga reservoirs. In Bontanga, the catfish stock is fully exploited. Since in Tono, the giraffe catfish is underexploited, the current exploitation rate could be doubled to increase yield[5]. Further monitoring of these fisheries will be needed for the improvement of assessments and thus, management advice.

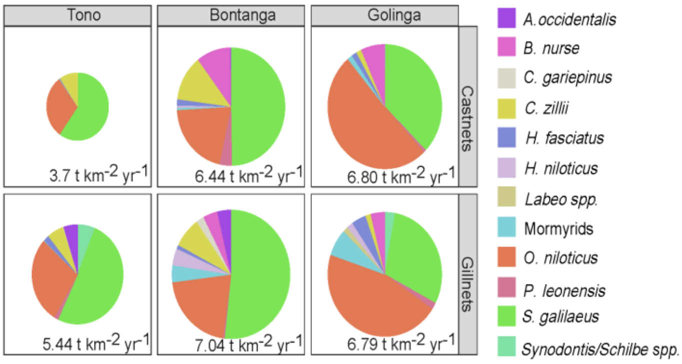

Figure 3. Total annual catch (t km^{-2} yr^{-1}) per fishing gear (castnets, gillnets, hooks and traps) targeting the fish groups in the three reservoirs (Tono, Bontanga and Golinga).

Catch-area relationship of West African reservoirs

In our paper[3], we reviewed data from the FAO, and published articles and reports on 30 West African reservoirs and primary data on our three focus reservoirs. We found that fisheries productivity is inversely correlated with both mean depth and surface area, but there is no significant correlation found with reservoir age. The predicted fish catch of a reservoir with a known area can be observed from Figure 4, with 95% confidence in the blue-shaded area. This confirms what some studies suggest, that fish productivity (per unit area) is comparatively lower and fish less abundant in larger water bodies. This is likely due to decreased rates of nutrient recycling within these larger lakes.

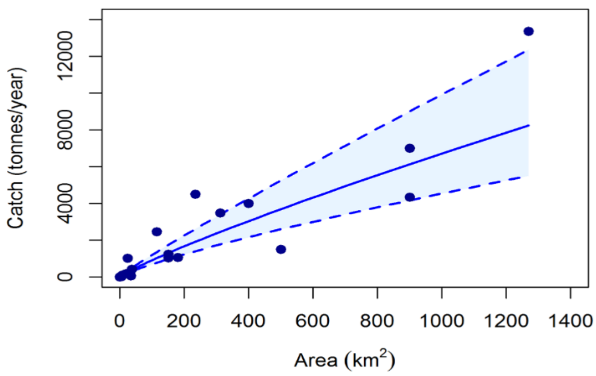

Figure 4. Modelled catch-area data: Predicted catches for a known area are found within the blue shaded area

Productivity, food web dynamics and human use

We analysed the food web structures and fisheries characteristics of the three lakes. We identified biological groups, their biomass, and their feeding interactions. Food web models for Tono, Bontanga and Golinga reservoirs were constructed to illustrate the trophic interactions in each reservoir and human activities in the catchment areas.

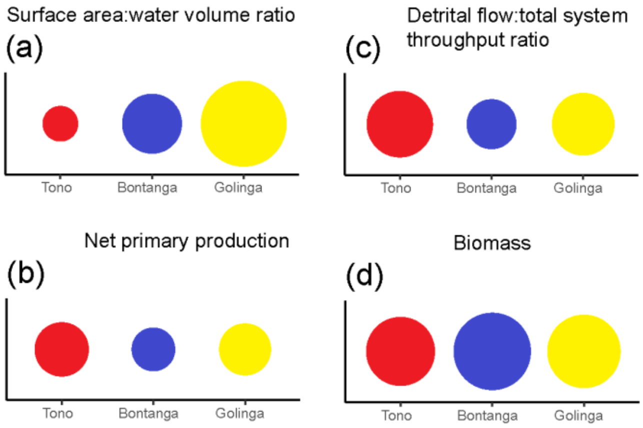

Figure 5. Comparison of system indicators of the three reservoirs (Tono in red, Bontanga in blue, Golinga in yellow). The sizes of the bubbles are comparable within each subplot.

The three reservoirs were found to differ greatly in terms of morphology, water volumes, overall surface area (Fig. 5a), seasonal changes in water level and vegetation coverage, generating lake-specific conditions for fish growth and production. Due to excessive nutrient load, plant biomass and primary production are high in Tono and Golinga (Fig. 5b). High levels of dissolved organic carbon, total dissolved nitrogen bonded, and nitrite nitrogen were found in Golinga; and Silicate and chlorophyll *a* in Tono. In Bontanga, to the contrary, less detritus is accumulated, and eutrophication (excessive growth of algae) is less severe (Fig. 5c). Bontanga, which is intermediate in size and is characterised by less farming activities in the reservoir's catchment area showed the greatest fish diversity – an indicator for water quality and ecosystem health.

Dissolved oxygen (DO) contents of the reservoirs were within the optimum range that sustain aquatic life. The DO levels together with high concentrations of nitrates-nitrogen found suggest that high photosynthetic activity occurs in the reservoirs, and confirms the observed eutrophication and algal blooms in the reservoirs. The smallest shallow (Golinga) reservoir is more significantly impacted by anthropogenic activities than the other two reservoirs as indicated by the high levels of dissolved organic carbon, total dissolved nitrogen bonded, nitrite nitrogen and turbidity in the Golinga reservoir.

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POLICY RECOMMENDATIONS

Form inter-sectoral working groups to promote sustainable use of the reservoirs for both agriculture and fisheries production: Ministries and administrative bodies responsible for fisheries and agriculture could form joint working groups for the planning, monitoring and management of reservoir systems. On the national level, ministries may formulate joint policies and regulations. Management of reservoirs would also greatly benefit from engaging fishermen and farmers in planning and decision-making (co-management).

Integrate fisheries into irrigation schemes development (e.g. in development plans): By harvesting aquatic resources and using water for agricultural products and livestock in parallel or alternatively, livelihoods of local communities can be made more resilient. Guidance on how to better link the planning of fisheries and irrigation is e.g. given by the FAO[6].

Include an ecosystem-based fisheries perspective when planning new reservoirs: When constructing new reservoirs, size and depth, as well as the number of dependent households and water use for irrigation, need to be carefully evaluated. Including a fisheries perspective supports sustainable outcomes: Though high fisheries productivity was shown in small reservoirs, the exploitation potential should not necessarily be tapped. We conclude that the use of too small reservoirs (< 2 km^2) in populated semi-arid environments for both, irrigation and fisheries production, maybe unsustainable due to risks associated with seasonal water loss, siltation and aquatic habitat degradation. When new reservoirs are planned, a minimum period of 2 years should be considered for maximum filling and system development after construction.

Protect and control the environment of reservoirs for fish production: Since reservoirs may change over time, they need to be monitored regularly to guarantee sustainable fish production. Farming, animal grazing and dumping of domestic wastes are the main sources of pollution and nutrient enrichment in the reservoirs. Critical levels for e.g. mean reservoir depth and limits to farming activities within the reservoir flood area need to be defined in effective regulation. The administration needs to be equipped to monitor effluents, changes in reservoir surface area, depth, and plant biomass.

Optimise sustainable exploitation of reservoirs through targeted stocking: Depending on the reservoir size and physical characteristics, a particular set of species should be introduced to optimise ecosystem fish production. Hereby, species of different functional groups (e.g. multispecies assemblage of omnivorous and carnivorous fish) should be selected to utilise the different niches of the reservoir to maintain a balanced ecosystem.

Expand knowledge and research on man-made reservoirs: Research institutions and universities should be motivated to study reservoir systems to contribute to the sustainable management of these systems. Ministries and administrative bodies responsible for reservoir management can communicate knowledge needs to the science community, support research activities through funding or though providing information and access to infrastructure.

Improve fishery assessment and update statistical models: Fish stocks need to be monitored and assessed to prevent resource depletion. Our here presented global reservoir yield model should be updated periodically to accommodate new information as it becomes available. This is crucial since the catch obtained may depend largely on the developmental state of the fishery and the age of the reservoir

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You can find more information about the project here.

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