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The cases of Lake Nasser, Lake Volta and Indo-Gangetic Basin reservoir

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The present document draws upon three individual desk-based reviews that cover the Indo-Gangetic Basin reservoirs, Lake Nasser and Lake Volta. These individual reviews were prepared by the partners of the project, with major contributions from E.K. Abban, H. Adam, K. Agboga, H.R. Dankwa, O. Habib, P. Katiha, I. Omar, M. Sherata, H.A.R. Soliman, K.K. Vass and M. Zaki.

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Abstract

Freshwaters contribute 15 percent of the world's reported fish catch, or about 10.1 million tonnes in 2006, most of which comes from tropical systems. The true contribution of tropical inland fisheries is likely to be higher, as less than half of the inland capture production is actually reported. While reservoir fisheries are already an essential component of this production, the potential of most of them may even exceed their current catch levels. Opportunities exist to increase productivity, provided that environmentally and socially sustainable management systems can be adopted. To realize this untapped potential, it is necessary to improve understanding of the processes influencing reservoir productivity in such a way as to involve both biological principles and stakeholder participation, as each reservoir has different properties and different research and management institutions.

Seen in isolation, catch and productivity data of individual reservoirs may be difficult to interpret. The present technical paper attempts to address this issue by reviewing the knowledge accumulated in reservoirs in some very different tropical river basins: the Indus and Ganges/Brahmaputra Basin in India, the Nile River Basin in Eastern Africa and the Volta River Basin in West Africa. In particular, it focuses on many of the reservoirs of northern India and Pakistan in the Indus and Ganges systems, Lake Nasser in the Nile River and Lake Volta in the Volta River.

Information collated from grey and published literature on the three basins is synthesized and standardized with reference to wider knowledge and up-to-date information on tropical reservoir fisheries. A considerable quantity of data and information were collected on many aspects of the systems of the three reservoirs, including hydrological, biophysical and limnological features, primary production, and fish and fisheries data. This information was condensed and synthesized with the aim of providing a baseline against which the ecological changes that have taken place since impoundment can be described and analysed. Efforts are made to explain changes in fish catch in relation to climatic variations, ecological succession and fishing effort. The review shows that biological data and information are generally available.

However, as is also common elsewhere, all three cases suffer from the general tendency to isolate and compartmentalize research into separate disciplines. Usually, there is very limited cross-disciplinary flow of information or recognition of how results of various disciplines can contribute to a more comprehensive understanding of the behaviour of fish populations, human communities and ecosystems and the productive activities that depend on them. This uniform tendency severely hampered the identification of relevant management actions.

A more pragmatic and holistic understanding of reservoir ecosystems is needed in order to guide the choice of indicators and the development of monitoring systems that can inform management of changes in reservoir productivity and, hence, the potential catch. The next step would be to devise a hierarchy of indicators describing the different ecological and economic processes influencing fisheries catches and to organize monitoring systems around those indicators. Only by combining information across sectoral disciplines will it be possible to reach a better understanding of the processes that drive fish stocks, fisheries and reservoir productivity.

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Abbreviations and acronyms

BOD	biochemical oxygen demand
C	carbon
$CaCO_3$	calcium carbonate
CIFRI	Central Inland Fisheries Research Institute
cm	centimetre
COD	chemical oxygen demand
CPUE	catch per unit effort
CV	coefficient of variation
DO	dissolved oxygen
FFDA	Fish Farmers Development Agency
FiB	fishing in balance (index)
g	gram
ha	hectare
IDAF	Integrated Development of Artisanal Fisheries (Project)
IGB	Indo-Gangetic Basin
IMC	Indian major carps
K	potassium
kg	kilogram
km	kilometre
LNDA	Lake Nasser Development Authority
m	metre
masl	metres above sea level
MEI	morpho-edaphic index
mg	milligram
mm	millimetre
MSY	maximum sustainable yield
N	nitrogen
NIOF	National Institute of Oceanography and Fisheries
P	phosphorus
pH	the negative logarithm (base 10) of the molar concentration of dissolved hydronium ions (used to indicate acidity or alkalinity)
ppm	parts per million
RLLF	relative lake-level fluctuation
STEPRI	Science and Technology Policy Research Institute
TDS	total dissolved solids
TL	trophic level
UNDP	United Nations Development Programme
VLRDP	Volta Lake Basin Research and Development Project
VRA	Volta River Authority
WRI	Water Research Institute
µg	microgram
µS	microsiemens

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1. General introduction

Tropical freshwaters contribute 15 percent of the world's reported capture fishery production from only 0.2 percent of the global aquatic surface area. The relative contribution may be even higher, as less than half of the inland capture production is officially reported (Kolding and van Zwieten, 2006). Most of the small-scale fishers in the world work in inland fisheries (BNP, 2009). Reservoirs are an essential component of most irrigation systems worldwide and, together with those built for flood control and power generation, retain large volumes of water. The total global reservoir area is unknown, but in 2000 the World Commission on Dams counted about 48 000 large dams, 46 percent of them in China, 19 percent in the rest of Asia, 3 percent in Africa (60 percent of which are in South Africa and Zimbabwe), and 2 percent in South America. The 60 000 largest reservoirs in the world – those with a volume of 10 million m^3 or more – are estimated to cover a surface area of 400 000 km^2 and together hold 6 500 km^3 of water (Kolding and van Zwieten, 2006). In addition to their roles in power generation and provision of water for agriculture, industry and homes, most of these reservoirs also play an important role in fish production and contribute significantly to the livelihoods of the communities along their shores. There is increasing recognition that the potential of most reservoir fisheries may greatly exceed current use. Considerable opportunities exist for increasing productivity, provided that environmentally and socially acceptable and sustainable management systems can be adopted.

Reservoirs are created by human activity and therefore host semi-natural ecosystems that can be manipulated in various ways. The productivity of reservoir fisheries can be increased by using a number of approaches that combine better harvesting strategies, fertilization, carefully adapted stock enhancement and aquaculture (Petr, 1994, 1998; Kolding and van Zwieten, 2006). An improved understanding of both biological principles and stakeholder participation is necessary to realize this untapped potential. The natural biophysical constraints of reservoirs define their ecological production processes, and their socio-economic settings shape the possibilities for human enhancement of production. By synthesizing these mechanisms into general principles and predictive indicators, it should be possible to provide various options and scenarios for improved productivity that can be adapted to local cultural and institutional settings.

Different reservoirs have different properties and separate institutions conducting research and management. Seen in isolation, these differences mean that the productivity data of each of these reservoirs may be difficult to interpret and difficult to place in a global context. It may be possible to reveal cross-regional information that otherwise would not be seen – such as where one river basin is fundamentally different from others – by examining the various attributes using a standardized approach. From a comparative angle, it may even be possible to understand why reservoirs from the same area may have different productivity levels.

The present review examines three very different river basins and was undertaken as part of the Improved Fisheries Productivity and Management in Tropical Reservoirs project funded by the CGIAR Challenge Program on Water and Food (www.waterandfood.org). The project focuses on reservoirs in the benchmark basins of the Indus and Ganges Rivers in India and the Nile and Volta Rivers in Africa. In the latter two basins, the project worked essentially on Lake Nasser and Lake Volta. The general objective of the project was to explore and test opportunities for increasing the productivity of these reservoirs with a combination of improved understanding of reservoir environment, introducing better harvesting strategies and adopting carefully selected stock enhancement strategies and/or aquaculture approaches.

Three individual desk reviews were initially prepared covering the Indo-Gangetic Basin (IGB) reservoirs (CIFRI, 2006), Lake Nasser (NIOF-LNDA, 2005) and Lake Volta (WRI, 2006). Each review included in-depth inventories of the history, resources and environments and information on: the geographical, physical, hydrological and chemical features of the basin; limnological characteristics; past, present and potential fishery production; and the socio-economic setting. They also identify gaps in information and provide recommendations for future work.

The primary intention of the present document is to synthesize and standardize the information collated in the three desk reviews with the objective of evaluating the information and summarizing it with reference to general literature and up-to-date knowledge on tropical reservoir fisheries in developing countries (Petr, 1978, 1994; Sugunan, 1995; Kolding, Musando and Songore, 2003; Kolding and van Zwieten, 2006). The three case studies represent quite different scenarios of reservoir fisheries in terms of management and fishing operations, and these differences are analysed and discussed to draw conclusions of general value.

Data and information were collected through individual desk reviews on many aspects of the ecosystems. This information has been condensed in this technical paper with the objective of providing a baseline information framework to assist in describing and analysing the ecological changes that took place after the impoundment of the rivers. The ultimate objective is to explain changes in fish productivity from both bottom-up and top-down processes, i.e. in relation to variations in climate, ecological succession and fishing effort. The information generated by the various sections in the background reviews has been integrated into a consistent framework, which may be useful for management purposes and to assist in adaptive learning. The general principle driving this framework is that: (i) data and information need to be made available in a historical context; and (ii) data from different studies and disciplines need to be organized in time series and preferably visualized in graphical form.

All three reviews show that, while biological data and information are generally available, there has not been sufficient emphasis on synthesizing this information and making it meaningful for management purposes. As a result, large amounts of research data and information have been collected from different sources but have rarely been integrated for systemic understanding. Outputs have only been translated into proposed management actions to a limited degree. The three reviews suffered from the general tendency to isolate and compartmentalize research into separate disciplines, with very limited cross-disciplinary flow of information or recognition as to how the results of various disciplines can be combined into a more comprehensive understanding of the behaviour of populations, communities and ecosystems and the productive activities that depend on them. This tendency severely hampered the analysis presented in this review.

A pragmatic and holistic understanding of reservoir ecosystems is needed in order to guide the choice of indicators and the development of monitoring systems that can inform management. This technical paper presents a basic description and analysis of the main processes taking place in different reservoir environments. The next step would be to devise a hierarchy of indicators describing the different processes taking place. Only when these are seen in combination across sectoral disciplines will it be possible to reach a better understanding of the processes that drive fish stocks, fisheries and reservoir productivity.

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