Water Resources and Economics 8 (2014) 16–31

Contents lists available at ScienceDirect

Water Resources and Economics

journal homepage: www.elsevier.com/locate/wre

Hydro-economic risk assessment in the eastern Nile River basin

Diane Arjoon [a,*], Yasir Mohamed [b,c], Quentin Goor [d], Amaury Tilmant [a]

[a] Department of Civil and Water Engineering, Université Laval, Québec, Canada
[b] UNESCO-IHE, Department of Integrated Water Systems and Governance, Delft, The Netherlands
[c] HRC-Sudan, Wad Medani, Sudan
[d] SHER Ingénieurs-Conseils s.a., Namur, Belgium

ARTICLE INFO

Article history:
Received 24 September 2013
Received in revised form
7 October 2014
Accepted 16 October 2014

Keywords:
Eastern Nile River basin
Hydro-economic optimisation
Risk assessment
Hydropower generation
Irrigated agriculture

ABSTRACT

In 2011, the Ethiopian government announced plans for the construction of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile, east of its border with Sudan, at a cost of almost 5 billion USD. The project is expected to generate over 5 TWh of electricity per year and will include a reservoir of more than 60 km^3 capacity. This project is part of a larger development scheme, by the Ethiopian government to expand its hydropower capacity; however, the scheme faces strong concerns, mainly from Egypt who are highly dependent on Nile River flows originating in Ethiopia. The Ethiopian government argues that the dam would supply electricity for Ethiopians and neighbouring countries and would generate positive externalities downstream by reducing floods and providing more constant and predictable flows. This study provides an independent analysis of the hydrologic and economic risks faced by downstream countries when the GERD will be online. To achieve this, an integrated, stochastic hydro-economic model of the entire Eastern Nile River basin is used to analyse various development and management scenarios. Results indicate that if riparian countries agree to cooperative management of the basin, and its major infrastructure, the GERD would significantly increase basin-wide benefits, especially in Ethiopia and in Sudan, and would generate positive externalities in Sudan and Egypt during dry years.

* Corresponding author at: Department of Civil and Water Engineering, Université Laval, Av de la Médecine 1065, Québec, Canada G1V0A6.
E-mail address: diane.arjoon.1@ulaval.ca (D. Arjoon).

http://dx.doi.org/10.1016/j.wre.2014.10.004
2212-4284/

1. Introduction

The Blue Nile River is shared between Ethiopia and Sudan and is an extremely important resource for Egypt as it is the main source of water flowing into the Main Nile River. No formal mechanisms to cooperatively develop and manage the river are currently in place, although the three riparian countries have agreed to collaborate, in principal, through the Nile Basin Initiative (NBI) [1]. Significant potential benefits of cooperation exist; however, all three countries continue to develop unilateral projects to harness the potential of the river [2].

In 2011, the Ethiopian government announced plans for the construction of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile, east of its border with Sudan, at a cost of almost 5 billion USD. The project is expected to generate over 5 TWh of electricity per year and will include a reservoir of more than 60 km^3 in capacity. This project is part of a larger development scheme, by the government, to expand its hydropower capacity.

Ethiopia has abundant water resources and massive hydropower potential but, as of 2001, only 3% of this hydropower potential had been developed [3]. As well, only 5% of the irrigable land in the Blue Nile basin had been developed for food production [4] while only 17% of the population had access to electricity, with 94% relying on fuel wood for cooking and heating [5]. The Ethiopian government argues that the GERD will supply electricity for the country as well as generate surplus cheap energy for export to neighbouring countries. It has been suggested that a strong link exists between energy and development, and that access to electricity, including access in rural areas, is one of the keys to reducing poverty [6]. It is also expected that the huge reservoir would generate positive externalities downstream by reducing flooding and sediment loads and by providing more constant and predictable flows.

Since the announcement of the project, Egypt, primarily, has expressed its concern. Egypt's main argument against the project is that other Nile basin countries have alternative water sources, but the Nile is the only source of water in Egypt. Egypt insists that its historic rights to the water of the Nile (rights of 55.5 billion m^3 per year from the 1959 bilateral agreement between Egypt and Sudan), be respected, and there is a concern that the GERD will decrease the amount of water that Egypt will ultimately receive.

Prior to the GERD, Ethiopia had plans to build four dams on the Ethiopian stretch of the Blue Nile: Karadobi, Beko-Abo, Mandaya and Border (which has been replaced by the GERD). A number of studies have been carried out on the hydrologic and economic effect of these dams on the downstream riparians. Both Goor et al. [9] and McCartney et al. [11] find that the installation of these four dams would result in peak flows in the Blue Nile being decreased while low flows are augmented, reducing the risk of floods and droughts. Whittington et al. [7] show an increase in benefits of between 2.76 billion USD and 3.63 billion USD with full Blue Nile basin development (all proposed dams in Ethiopia are built). This increase is mainly due to the economic benefits from additional hydropower production and to savings from storing water upstream in Ethiopia rather than downstream in Egypt. Jeuland and Whittington [25] look at a real options approach to planning the new infrastructures in Ethiopia and conclude that the results provide strong support for the decision to move forward with the construction of an initial dam in the Blue Nile cascade. Dinar and Nigatu [26] examine water trade as a means to enable cooperation among Blue Nile countries sharing the resource, and study the distribution of the additional gains due to cooperation using game theory.

In this study, we assess the hydrologic and economic risks faced by the hydropower and agricultural sectors in Sudan and Egypt when the GERD will be online. A basin-wide, integrated hydro-economic model has been developed which links hydrologic, economic and institutional components of the river basin to identify optimal allocation decisions in order to maximise the aggregated basin-wide net benefits. This model is solved using stochastic dual dynamic programming (SDDP) which has been successfully employed to solve multipurpose, multi-reservoir operation problems with stochastic inflows. Tilmant et al. [22] used SDDP to determine the economic value of storage in the Euphrates River basin, Tilmant and Kinzelbach [23] looked at the cost of non-cooperation in the Zambezi River basin and Marques and Tilmant [24] assessed the economic value of coordination in large-scale multireservoir systems in the Parana River.