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Estimation of the economic value of the ecosystem services provided by the Blue Nile Basin in Ethiopia

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A B S T R A C T

This paper aims to quantify and economically value the main ecosystem services provided by the Blue Nile basin in Ethiopia. It is the first study in its kind to do so in a consistent and comprehensive manner using the same valuation approach. Water flows are linked to corresponding economic market values using the residual value method. Values for provisioning and regulating services related to the hydro-morphological and hydro-ecological functioning of the Blue Nile's water resources are derived based on four main water-dependent activities in the basin: irrigated agriculture, hydropower production, commercial navigation and fisheries. Data are collected from existing official and other secondary sources and are supplemented with information obtained from stakeholders and experts. The estimated annual contribution of the provisioning and regulating services of the freshwater ecosystem to the national economy was ETB 883 million (US$ 52 million) in 2011. This is very low compared to current GDP (< 1%), partly due to the malfunctioning and underdevelopment of the current infrastructure to fully exploit the potential of the Blue Nile water resources. An integrated water resources management policy and improved institutional-economic setup aimed at maximization of continued provision of these services is expected to generate substantially higher economic values.

1. Introduction

Ecosystems are a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit (MA, 2005). They have the capacity through their natural processes and components to provide goods and services that satisfy human needs (De Groot, 1992; Costanza et al., 1997; MA, 2005; Fisher and Turner, 2008). Despite the high value of ecosystem services, a growing body of evidence suggests that these services are undervalued in policy and decision-making due to a variety of reasons, including market and environmental policy failures (e.g., Salzman, 2005; MA, 2005; Lant et al., 2008; Locatelli et al., 2011; TEEB, 2013). Since the value of many ecosystem services are not fully captured in commercial markets or adequately quantified in terms comparable with economic goods and services and manufactured capital, they are often given insufficient weight in investment and policy decisions (Costanza et al., 1997; Chan et al., 2006). In this study we aim to quantify the main water-based ecosystem services provided by the Blue Nile river basin in Ethiopia, i.e. the provisioning and regulating services related to the hydro-morphological and hydro-ecological functioning of the Blue Nile, and derive their economic value from the main economic activities which they so crucially underpin using a market based valuation approach. The novelty of the study is found in the fact that it is the first study of its kind to value these water services in a consistent and comprehensive manner using the same valuation approach. Based on a systematic review of the available data and information needed for the valuation of the water services, we identify key methodological and data challenges in this particular developing country context.

The Blue Nile basin is the largest river basin in Ethiopia in terms of discharge volume and second largest in terms of area size (Conway, 2000). As in many other developing countries, the livelihood of people living in the Blue Nile basin is highly dependent on the provision and quality level of the available ecosystem services (Van Beukering et al., 2013). Fresh water from the basin supports agriculture, which is the main economic activity in the country as a whole and in the basin, and hydropower production, which accounts for 95 percent of the total energy generated in the country (MoFED, 2006; McCartney et al., 2010). Given the fact that large dams are prominent instruments for a country's economic growth (Richter et al., 2010), Ethiopia's irrigation and hydropower dams are at the core of its future development plans (McCartney et al., 2010). Among the many projects under construction and

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planned to be undertaken in the near future, the country's most ambitious project to date is the Grand Ethiopian Renaissance Dam, Africa's largest hydroelectric power plant. When this dam is completed in 2016, it will supply about 5,250 megawatts of electricity to domestic Ethiopian households and neighboring countries. It will also create the country's largest artificial lake, with a capacity of 63 billion cubic meters of water (Kahsay et al., 2015). In view of the importance of the freshwater resources for the country as a whole, it is essential to secure a continued sustainable provision of the associated water services to meet the country's growing demand for food and energy (Nellemann et al., 2009). Economic valuation of the water related ecosystem services provided by the basin is expected to contribute significantly to better informed decision-making to sustainably use and manage the water resources providing these services. Based on a screening of the available data and information, we focus here on the main regulating and provisioning services underpinning hydropower, irrigation, commercial navigation and fisheries. The basin's regulating services such as water flows for irrigation and hydropower generation includes storing surplus water during wet periods and releasing it later (Guo et al., 2000). Adequate flow levels, including lake water levels, play an important role also to sustain commercial navigation activities. Fish catch is the main provisioning service considered here. We exclude drinking water supply in this study because more than 70 percent of domestic drinking water use originates from the abundant groundwater wells, which is estimated to range between 2.6 and 6.5 billion m^3 per year (MoWE, 2010).

The paper is structured as follows: Section 2 first introduces the methodology used to quantify the various ecosystem services in the Blue Nile river basin. This is followed by a short description of the study area in Section 3. Section 4 first identifies the location and extent of the ecosystem services provided by the basin followed by the estimation of their economic values. Finally, Section 5 concludes and provides some policy recommendations.

2. Methodology: valuation of ecosystem services

There exists a wide range of methods to value ecosystem services (Turner et al., 2010; TEEB, Kumar, 2010). An important distinction to make is between market-based and non-market based valuation techniques. In market based valuation approaches existing market behavior and market transactions are used as the basis of the valuation exercise. Non-market valuation of ecosystem services focuses on the analysis of actual human behavior in parallel markets (e.g. housing market) or hypothetical behavior in simulated (contingent) markets to derive estimates of economic value of goods and services in situations where market prices are absent or distorted (Bateman et al., 2002; Young, 2005). In this study, we rely upon the residual value method, also called residual imputation method. This is a market-based approach which estimates how much a given ecosystem service contributes to the production of another service or commodity that is traded on existing markets (Young, 2005).

The residual value method has been widely used to estimate the economic value of water in crop and hydropower production, mainly due to its simplified approach and low data requirements. Examples include the studies by Young (2005), Hussain et al. (2009), Hellegers and Davidson (2010), Davidson and Hellegers (2011), Musamba et al. (2011), Berbel et al. (2011) and Al-Karablieh et al. (2012), who applied this approach among others to estimate the economic value of irrigation water. However, there are a number of limitations to this method. For example, inputs not accounted for in the estimation process (omitted variable bias) are implicitly considered part of the input factor of interest, in this case the water ecosystem service in question. In addition, also any error in the prices and quantities of the inputs or outputs will accrue to the imputed value of the water ecosystem service (Young, 1996).

The approach is relatively simple, by subtracting the market value of the inputs required to produce a good or service from the market value of the produced goods or services. If the value of one of the inputs is unknown, this unknown value can be derived by solving the unknown as a function of the output price multiplied by the quantity of the output less the sum of the quantities of all known inputs multiplied by the average values of these known inputs, divided by the quantity of the unknown input (Hellegers and Davidson, 2010). In this study, water is an input in the production of marketed goods such as irrigated crops and hydropower production. We quantify the value of these services through existing market prices. Due to the limited availability of data and information, we are unable to estimate a full production function, linking water input to economic output flows more formally by statistically regressing yields or returns over a series of locations or years on the various associated input factors including water. Instead, we estimate the net economic value of the contribution of the Blue Nile water ecosystem services by subtracting the calculated costs of production from the calculated market revenues. For example, economic data collected from the major irrigation projects in the Blue Nile basin were used to first multiply annual crop yields in tons per ha per year with their unit market price in Ethiopian Birr (ETB)[1] per ton. Then the calculated total costs of production per hectare per year for all marketed production factors except water were subtracted from this total market value to arrive at the net economic value, which is then ascribed to the contribution of water to serve as irrigation water (in cubic meters).

Similarly, the annual economic value of hydroelectricity production was estimated by first multiplying the amount of electricity generated in KW hours (over the years and linked to the annual water flow) by the electricity market price in ETB/KWh and then subtracting the associated annual costs of electricity generation in ETB/KWh. In this way, the value of water in irrigation and hydropower production was estimated by dividing the net market value from irrigated crops and hydroelectricity by the quantity of water used for their production.

The data referred to above and required for the valuation of the ecosystem services in the basin are obtained from secondary sources, mostly from governmental organizations and private enterprises for the years 2008–2011. Where possible, additional key informant interviews were conducted with experts, enterprise and government officials in order to assess the accuracy and reliability of the secondary data. In general, there was very limited information readily available and access to the available information was challenging due to poor data monitoring and documentation. In some cases, the data collected from different institutes and the literature was inconsistent. In these cases, it was difficult if not impossible to determine which sources were reliable and which ones not so as to exclude possibly misleading information. The estimations throughout this paper are based on the 2011 data. In cases of data inconsistency, we use value ranges to account for uncertainties in water flow and economic values that might arise from the inconsistent time series and cross-section data we collected. Moreover, even though there are many small-scale irrigation schemes in the basin, this study could not estimate their economic value due to a lack of data about their location and exact size. In all cases assumptions had to be made that the estimated costs of production include all the necessary input costs (labor,

[1] In 2011, our price reference year, one US dollars (US$) is equivalent to ETB 17.5.

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