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Assessment of changes in ecosystem service monetary values in Mozambique

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ABSTRACT

Land cover change has been negatively affecting the provision of ecosystem services (ES) to satisfy the increasingly global demand of goods. ES valuation assessments may provide relevant information to policy makers about natural capital, being one potentially effective way of achieving sustainability. In this work GlobCover land cover data was utilized to identify Mozambique's biomes between 2005 and 2009. A benefit transfer approach was used to estimate the values of the services delivered by the ecosystems. It was found that the Cropland biome increased its ES value considerably between 2005 and 2009 due to the increase of food production, as agriculture is considered the key factor for reducing poverty in the country. In contrast, the Grass/Rangeland area fell substantially in order to support the increase of the Cropland and Forest biomes. Niassa and Gaza provinces contributed the most to the loss of Mozambique's ES value. Mozambique's total ES value was estimated in 5,054.4 × 10^6 US$ for the year 2009, representing a variation of −11.4% since 2005. Despite this decrease, the ES value for 2009 was still about half of the Gross Domestic Product (GDP) for the year 2009 (10,910 × 10^6 US$). This information may contribute to the development and monitoring of policy instruments that consider ES provision. Additionally, they can also be used to call for the importance of considering ES in national well-being accounting, and for going beyond GDP as a national welfare measure and policy goal.

1. Introduction

Ecosystems provide a wide range of benefits to society known as ecosystem services (ES), which are constituents of well-being (Millenium Assessment, 2003). However, changes in ecosystems in a global context of increasing demand for agricultural land, forest plantations, and industrial and urban areas are compromising their ability to support mankind (Halpern et al., 2008; Kareiva et al., 2011). By ignoring the benefits provided by nature, mankind puts itself at danger by degrading ES beyond the limits of sustainability (Millenium Assessment, 2003). One factor having an important impact on the provision of ES is land cover change (Lawler et al., 2014; MEA, 2005) and the effective management of the locations responsible for maintaining ES has been considered essential to prevent their further decline (Cabral et al., 2016; Egoh et al., 2007; Leh et al., 2013; Portela and Rademacher, 2001).

Considerable efforts have been made to draw attention to the importance of preserving natural capital, and also to providing useful information for decision making through economic valuation of ES (Jacobs et al., 2016; Kindu et al., 2016). To this end, several research works have been carried out at global (Costanza et al., 2014, 1997; de Groot et al., 2012), and/or national and/or regional levels (D'Amato et al., 2016; Joshi and Negi, 2011; Perez-Verdin et al., 2016). Some of these valuation studies also include spatially

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explicit approaches which provide information on those locations responsible for ES provision (Frélichová et al., 2014; Kremer and Hamstead, 2016; Kubiszewski et al., 2013; La Notte et al., 2012; Liu et al., 2010).

Globally, the ES value in 2011 was estimated at US $125 trillion/yr for 2007 $US (Costanza et al., 2014). According to these authors, between 1997 and 2011 the ES value fell by US $4.3–20.2 trillion/yr as a result of land changes. Losses in ES value at national and regional levels have also been reported (Crespin and Simonetti, 2016; Wang et al., 2015). For Africa there are very few studies about ES valuation as a consequence of land cover change (Dawson and Martin, 2015; Kindu et al., 2016). The main reason for such a scarcity of studies is the absence of data (Leh et al., 2013). The lack of such studies is an important problem because Africa is undergoing significant land changes with important impacts on the provision of ES (Kindu et al., 2016; Power et al., 2010). Specifically in Mozambique, previous works have analyzed single ES at local or regional levels. Wong et al. (2005) provided a preliminary review of ES threats by region in Mozambique. These authors found that Gaza, Manica, Nampula, Sofala and Tete had all the analyzed ES and well-being constituents being threatened. Fallis (2013) reported that the Chibuto district (province of Gaza in southwestern Mozambique) largely served as an agro-ecosystem with agricultural, grazing, and fiber collection. More recently, Nunes and Ghermandi (2015) carried out a study dealing with the understanding and valuation of marine ES for the Northern Mozambique Channel. These authors found that just the Northern Mozambique Channel contributes 5% of national Gross Domestic Product (GDP) in small island states. Mudaca et al. (2015) show that economic benefits, social inclusion, and forest conservation are the factors influencing household's decisions to participate in the Payments for Ecosystem Services (PES) program in a Community located in Sofala province. Niquisse et al. (2017) studied the trends of ES and biodiversity biophysical values in Mozambique as a consequence of land cover change. These authors found a moderate increase in climate regulating service between 2005 and 2009, and a decrease in projected water quality (nutrient retention) and biodiversity to the year 2025. Hence studies about ES in Mozambique are rare when compared to other locations, and to our knowledge none of them has provided a monetary valuation at national and/or province levels and/or its changes. The lack of such studies may constitute an important obstacle for maintaining ES provisioning which could be achieved through several available policy instruments in Mozambique when targeting specific or several ES (Table 1).

In line with the national TEEB (*The Economics of Ecosystems and Biodiversity*) assessments (TEEB, 2010), this study seeks to provide the first monetary assessment of ES for Mozambique. Freely available data was used to assess the ES value for Mozambique and its provinces, between years 2005 and 2009, using a spatially explicit approach. Knowing ES value and its spatial dynamics at national and province levels calls for the importance of considering ES in national well-being accounting and for going beyond GDP as a national welfare measure and policy goal.

2. Methods

2.1. Study area

Mozambique, officially the Republic of Mozambique, is located in Southeast Africa and comprises a land surface of about 800,000 km^2 (Fig. 1). Mozambique has a diverse landscape ranging from coastal plains to savanna, and woodlands to mountains. There are numerous rivers flowing from west to east into the Indian Ocean, with the Zambezi and Limpopo being the two largest. Mozambique is divided into 11 provinces and shares borders with six countries. It is separated from Madagascar by the Mozambique Channel to the east. Mozambique had about 27.22 million inhabitants in 2014 (World Bank, 2016). The capital and largest city is Maputo with 1,241,702 inhabitants (INE, 2015). This country became independent from Portugal in 1975, followed by a civil war which ended in 1992. The first democratic elections took place in 1994 and the country has enjoyed political stability since then (Brouwer and Falcão, 2004). Mozambique's GDP was 14,807 $\times$ 10^{-6} US$ in 2015 (World Bank, 2016). Mozambique ranked 180 out of 188 countries in the most recent Human Development Index (UNDP, 2015).

Table 1
Policy instruments available in Mozambique related to ES analyzed in this study.

Biome	Ecosystem service(s)	Policy instrument
Cropland Grass/Rangeland	Food	National Agriculture Investment Plan (República de Moçambique, 2013) Action Plan for Poverty Reduction (República de Moçambique, 2011)
Forest	Biodiversity protection Food Raw materials	National Strategy for the Sustainable Development of Mozambique (MICOA, 2007) National Agriculture Investment Plan (República de Moçambique, 2013) Action Plan for Poverty Reduction (República de Moçambique, 2011) National strategy for forests (RCM, 2015) Strategy for the Mangrove Protection (República de Moçambique, 2015a)
Wetlands	Food Raw material Water	National Agriculture Investment Plan (República de Moçambique, 2013) Action Plan for Poverty Reduction (República de Moçambique, 2011) National Strategy for Forests (RCM, 2015) Strategy for the Mangrove Protection (República de Moçambique, 2015a) National Strategy for Hydrological Resources Management (República de Moçambique, 2007)
Desert	Raw material	National Plan for Fighting Desertification (RCM, 2014)
Lakes / Rivers	Recreation	Strategic Plan for Tourism Development in Mozambique (República de Moçambique, 2004)