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Analysis

Environmental Conservation and Social Benefits of Charcoal Production in Mozambique

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ABSTRACT

Charcoal is an important source of energy and income for millions of people in Africa. Its production often drives forest degradation and deforestation which have impacts on the local people that remain poorly understood. We present a novel methodology for analysing the contribution of woodland ecosystem services (ES) to rural well-being and poverty alleviation, which takes into account access mechanisms to ES, trade-offs between ES, and human response options. Using a participatory approach, a set of land use change scenarios were translated into a probabilistic model that integrates biophysical and social data. Our findings suggest that in highly forested areas woodland degradation does not have a critical impact on the local use of the three ES studied: charcoal, firewood and grass. Social factors show the largest impact on the quantity of charcoal produced, e.g. female-headed households experience the greatest barriers to access charcoal production. Participating in forest associations and diversifying income activities lead to greater charcoal production. Results show that charcoal production increases some aspects of well-being (e.g. household assets), but does not decrease acute multi-dimensional poverty. Great efforts are required to reach a charcoal production system that alleviates poverty, improves environmental sustainability, and provides a reliable charcoal supply.

1. Introduction

Charcoal production and trade provides work for millions of people in Africa (IEA, 2014; Openshaw, 2010; Ryan et al., 2016), is the main cooking fuel in many African urban centres (IEA, 2014) and its demand is increasing because of population growth and migration from rural to urban areas (IEA, 2014, Peter and Sander, 2009, Openshaw, 2010, Tomaselli, 2007). In rural areas of Sub-Saharan African countries (where 80% of residential energy demand is for cooking) more than 90% of the population uses firewood for cooking and less than 5% use charcoal; in urban areas the figures change to 25% relying on firewood and nearly 50% on charcoal (IEA, 2014). Charcoal is a provisioning ecosystem service, and increasing evidence suggests ecosystem services (ES), i.e. the benefits people obtain from ecosystems (MEA, 2005a), contribute to the well-being of the rural population in Africa, e.g. provisioning services (firewood, charcoal, grass, fruits, water), regulating services (erosion control, water purification) and cultural services (sacred places, recreation) (Cavendish, 2000; Dewees et al., 2010; Fisher, 2004; Kamanga et al., 2009; Shackleton et al., 2007). As such, charcoal can be an important woodland based provisioning ES for African rural populations, but at the same time can be a driver of deforestation and forest degradation through intensive and selective wood extraction (Chidumayo and Gumbo, 2013; Hosonuma et al., 2012; Luoga et al., 2002; Ryan et al., 2014). Therefore, the land use and land cover change (LULCC) produced by charcoal production is a major driver affecting future provisioning of ES and consequently can have important consequences for human well-being. Despite growing socio-ecological systems understanding (Fischer et al., 2015), the resulting complexities of charcoal production and trade for sustainable land management and local livelihoods remain poorly understood. For

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example, not only ecosystem services (ES) supply is key for the well-being of local populations, but also the way the services are used and distributed (Daw et al., 2011; Fisher et al., 2014; Kalaba, 2014; Suich et al., 2015).

In Mozambique, 15% of the population participates in the charcoal market (Cuvilas et al., 2010), which is estimated to have an annual value of 250 million USD (EUEI/GIZ, 2012). Around 70–80% of the urban population uses charcoal as primary energy source and demand is rising with rapid urban population growth (Brouwer and Falcão, 2004; IEA, 2014; Peter and Sander, 2009). Consequent woodland depletion results in a shifting charcoal production frontier that rapidly extends into more remote areas (Luz et al., 2015; SEI, 2002). Charcoal production in Mozambique is affected by a range of factors that apply to most sub-Saharan countries. Policy effectiveness suffers from limited institutional cooperation, integration and coordination between related sectors (Kwaschik, 2008; Zulu and Richardson, 2013). At the same time, the government lacks capacity for effective legislation implementation and enforcement (Kwaschik, 2008, Zulu and Richardson, 2013). Concerning the distribution of benefits from the charcoal value chain, large part of charcoal derived income goes to non-local individuals (Baumert et al., 2016; Kwaschik, 2008) due to communities' lack of technical, institutional, and financial capacity, limiting the success of community-managed projects in Mozambique (Kasparek, 2008; Puná, 2008; Sitoe et al., 2014).

In this paper we analyse the consequences of charcoal production on local well-being in Mabalane District (Southern Mozambique). Specifically, we analyse and evaluate the influence of LULCC on how the villagers use three woodland based provisioning ES (charcoal, firewood and grass) and on local well-being, and identify and evaluate policy interventions that could contribute towards a charcoal production system that alleviates poverty, improves environmental sustainability, and provides a reliable charcoal supply. We also evaluate social factors that can act as access mechanisms to ES (barriers like gender or opportunities like education) (Daw et al., 2011; Fisher et al., 2014). We chose Mozambique as a case study because despite high degradation (0.2–1.7%/yr, Marzoli, 2007) and deforestation rates (2–3%/yr, Ryan et al., 2014), there is still abundant woodland (70% of the land cover; 55 M ha, Marzoli, 2007), and a progressive land use policy, so Mozambique can still make a choice about its future before it is too late (before it is very highly deforested). The method presented allows the use of a social-ecological perspective to develop an integrated analysis of both biophysical and social consequences of charcoal production and its associated LULCC. It allows at the same time the evaluation of potential interventions aimed to improve the studied situation.

2. Study Area

Mabalane District, in Gaza Province, covers 8922 km^2 (Fig. 1). Its semi-arid climate, erratic rainfalls and poor soils lead to low agricultural yields, and land cover is dominated by woodlands (90% of the study area) with minor extension of other land cover classes (4% cropland, 4% wetlands and water bodies, and 2% villages, bare soil and other classes) (Mahamane et al., 2017).

In Mabalane District, 300 km from Maputo, charcoal production started to increase in early 2000 (Baumert et al., 2016), and has now become the main charcoal supply area of Maputo (Luz et al., 2015). Since 2007, large-scale commercial charcoal production has been evident in the Mopane woodlands (*Colophospermum mopane* (J. Kirk ex Benth. J. Léonard)) of Mabalane (Chavana, 2014; Luz et al., 2015). Mopane is the preferred tree species used for charcoal production in the study area, followed by *Combretum* sp., because it produces the highest quality charcoal: it burns slowly and produces low smoke and little sparks (Chavana, 2014 and own data). There are two main charcoal value chains in Mabalane: one run by local producers and one by large-scale operators. The latter is responsible for the largest amount of wood extraction for charcoal production, with only 8% of its monetary benefits remaining in the local communities (Baumert et al., 2016). Vollmer et al. (forthcoming) found unequal charcoal production patterns at the community (village) level and they could not find a direct relation between charcoal production and alleviation of acute multi-dimensional poverty. Both findings suggest that most benefits are not reaching the rural poor in Mabalane, yet the direct consequences of forest degradation are felt locally.

Our research was carried in seven villages, each with fewer than 70 households (HH), distributed along a forest degradation gradient, from high (after charcoal peak) to low degradation (pre-charcoal peak) as described in Baumert et al. (2016). Approximately 85% of the investigated sample of HH (n = 261, from a total number of 308 HH) are farmers and up to 70% also produce charcoal. A HH was defined as a unit based on members who “eat from the same pot” (Tvedten et al., 2012). Subsistence agriculture is the most predominant farming system, practiced on a small scale (mean cropland size = 1.70 ha HH^{-1} (S.D. 2.11)). Main crops are maize, cow peas, peanuts and sesame. Sixty percent of the HH keep livestock (cattle, goats, chickens, pigs) as insurance and production gains are not targeted.

3. Methods

The objective of the paper is articulated through a series of specific research questions designed to query a newly developed Bayesian Belief Network (BBN) of the charcoal production system in Mabalane (Research questions included in the Analysis section). We used a BBN to conceptualize the charcoal production in Mabalane as an integrated system to compare the consequences of policy interventions on woodland based provisioning ES supply and on the well-being of the local population. The BBN and three alternative future scenarios were developed in a participatory process involving a broad range of stakeholders and experts to increase the saliency and relevance of research. The process followed eight main steps (Fig. 2) that are described in the next paragraphs.

3.1. Stakeholder Consultation Process

BBNs have been used in participatory approaches in the environmental sector (Cain et al., 2003; Castelletti and Soncini-Sessa, 2007; Düspohl et al., 2012; Zorrilla et al., 2010) and several different guidelines have been produced (Bromley, 2005; Cain, 2001; Pollino and Henderson, 2010). We assimilated the most pertinent aspects of those guidelines for a participatory BBN construction in Mabalane, using stakeholders to help design the BBN structure.

Participatory workshops are often structured around a topic, which typically emphasises a specific theme or subject that can be explored in depth (Bryman, 2004). In our case, the focus was on the construction of a causal diagram by the participants. We asked them to link aspects of rural wellbeing, ecosystem services, land use change and possible interventions so that well-being of rural habitants and natural conservation could be improved at the same time (Table 1). We conducted five workshops at different levels: 1) one with stakeholders working in institutions at national level held in Maputo (18 participants); 2) one with stakeholders working at provincial and district levels held in Xai Xai (14 participants); and 3) three with local communities of the study area (24 participants, with a diversity in gender, age and main income activity). The objectives of the workshops were: a) to ensure that all important aspects were considered during the process of construction of the BBN structure; b) to get a local perspective of issues related to land use, ES and rural well-being; and c) to learn how these are influenced by interventions and other factors. We were also interested in the new variables that were generated from the discussion among participants, as these workshops provide an excellent means for knowledge exchange and discussion (Bromley, 2005).

The method used in the village workshops followed a similar pattern as Maputo and Xai-Xai workshops (Table 1), adapted to the local