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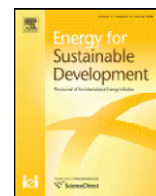
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## Charcoal supply chains from Mabalane to Maputo: Who benefits?



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### ABSTRACT

In urban centres of Mozambique, charcoal is the major energy source for cooking. Growing demand drives high wood extraction rates over increasing areas of miombo and mopane woodlands. Charcoal production can lead to changes in ecosystem service provision and woodland degradation while also significantly contributing to rural income and, possibly, poverty alleviation. As such, understanding charcoal production and trade has important implications for rural areas and for the sustainable development of woodland resources. Here, we investigate charcoal production and trade through empirical research conducted in Gaza Province, the main charcoal supply area for Maputo, Mozambique.

We analyse the present structure of the main charcoal supply chains from Gaza province to Maputo and the profit distribution along them. Seven villages in the Mabalane district, Gaza, at different stages of engagement with the charcoal industry, were selected for investigation. We conducted household surveys and semi-structured interviews with key informants (village leaders, charcoal producers, licence holders, wholesalers, transporters and forest technicians), from May to October 2014.

Our results highlight two main charcoal supply chains comprising four main actor groups a) Local small-scale operators producing charcoal on a small-scale with household labour, who sell to wholesalers b) Large-scale operators producing and commercialising large volumes of charcoal using migrant labour, who sell their own production to wholesalers. While charcoal production constitutes an important income source for rural households in Mabalane, under supply chain a) more than 90% of the monetary benefits do not reach local communities and remain with external agents. Two of the main factors impeding the generation of greater revenues at community level are: 1) bureaucratic burdens in obtaining charcoal commercialisation rights in the form of licences; and 2) weak institutional capacities for woodland resource governance.

We conclude that access to markets and control over woodlands is key if local communities are to generate greater benefits from charcoal production while aiming at sustainable charcoal production. Strong local institutions for obtaining commercialisation rights and managing woodland resources have to be developed, while the restructuring of the licensing system in favour of small-scale producers and more rigorous control of the regulations could support this process.

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### Introduction

Charcoal is one of the major sources of energy in most African countries; about 90% of urban households depend on charcoal for cooking and heating (Schure et al., 2013; Zulu and Richardson, 2013; World Bank, 2011). Growing demand for charcoal, due to population growth and urbanisation, has led to increased wood extraction rates, particularly around urban centres (Ahrends et al., 2010) and contributes to expanding wood extraction in the woodland areas inhabited by rural

populations. Where this exceeds regrowth rates, forest or woodland degradation occurs (Cuvilas et al., 2010).

Currently, millions of rural and urban people worldwide derive part of their livelihood from the charcoal value chain (Zulu and Richardson, 2013; Macqueen and Korhaliller, 2011; World Bank, 2011). Quasi open access to woodland resources, low investment requirements and low labour opportunity costs due to a lack of alternative income-generating activities and low agricultural productivity make charcoal production a profitable activity for the rural population (Zulu and Richardson, 2013; NL Agency, 2010; Kambewa et al., 2007; SEI, 2002; Luoga et al., 2000). Managed sustainably as a renewable resource, charcoal production could serve as a long-term income source for the poor

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(Ghilardi et al., 2013; Falcão, 2008), alleviate poverty during the agricultural off-season and improve well-being (Schure et al., 2014b; Zulu and Richardson, 2013; Arnold et al., 2006; Angelsen and Wunder, 2003).

Several studies have investigated charcoal supply chains and their political economies (Minten et al., 2013; van Beukering et al., 2007; Kambewa et al., 2007; Brouwer and Magane, 1999; Ribot, 1998) showing highly informal institutional arrangements. Typically, and especially in larger urban areas (Zulu and Richardson, 2013), a small number of vertically integrated operators (i.e., participating in several levels of the value chain) capture most of the profits. Low competition due to high barriers of entry, collection of profit margins at more than one level and high turnover rates lead to high profit accumulation for these integrated actors (Shively et al., 2010; Zulu, 2010; Puna, 2008; Boberg, 1993). In contrast, local community producers are seldom organised into groupings such as associations, have little bargaining power and are usually not integrated beyond the production level (Zulu and Richardson, 2013; Shively et al., 2010; Puna, 2008; van Beukering et al., 2007).

In Mozambique a few studies analysed the benefit distribution along the Maputo charcoal supply chain and showed substantial benefit generation at the local level. Chavana (2014) concluded that charcoal producing community members can create highest benefits among all groups involved in the value chain due to their low production costs. Also van der Plas et al. (2012) calculated that 53% of total charcoal income goes to producers (and 9% to transporters, 17% wholesalers and 21% to retailers) and concluded that a considerable share of the charcoal benefits remain in rural areas. Likewise, Brouwer and Magane (1999) estimated that considerable revenues benefit rural areas. However, none of the studies distinguished variability between producers e.g., between local village producers and migrant full-time workers who are contracted by large-scale urban operators and are not members of the local community, a common phenomenon in Southern Mozambique (Atanassov and Mahumane, 2012; Puna, 2008). Communities may not in fact receive any benefit either due to unlicensed wood harvesting by the urban operators or due to weak enforcement of benefit sharing mechanisms (i.e., payment of 20% licence fee to communities). In this case, research suggests that most money generated does not benefit the rural population but remains with a few external actors (World Bank, 2009; Puna, 2008; Boberg, 1993). In Mozambique it remains unclear how much of the total value generated through charcoal production is retained at the community level. Moreover, inconsistent use of calculation methods, data sources and terminology (e.g. margin, profit, revenue, mark-up) makes it difficult to compare different studies and come to sound conclusions.

We propose that there are at least three major reasons why policy-makers might want to intervene in this commodity chain to promote the interests of community-level producers. The first reason is for rural poverty reduction. The government of Mozambique is attempting to reduce poverty through the new five year plan (PQG 2014–2019) (GoM, 2015), which places emphasis on community governance of natural resources to reduce poverty (Priority V of the PQG). This is linked to the second rationale, which is about the government attempting to foster inclusive growth. A shift towards a charcoal commodity chain more in the interests of community-level producers would promote more local employment opportunities (Priority III of the PQG), and expand the local economy. The third reason for governance of the charcoal commodity chain in the interests of community-level producers is as part of efforts to promote environmental sustainability, and to ride on the coat tails of current areas of international policy concern such as land use emissions of greenhouse gases (Schure et al., 2014a).

We first present an overview of the legal framework in Mozambique and elaborate the approaches and methods used in our research. The result section starts by describing the charcoal production trends in the observed villages. Then a vertical analysis examines the structure of the charcoal value chain from rural production to urban marketing and the role that the different actors play within it. This enables us to understand who participates at what stage and how. Next, an analysis

of how the legal framework operates in the study area provides insights on its consequences on villagers and on the alternatives they have in the future. Last, we present the profits obtained by each group and its distribution along the value chain. This helps in differentiating between groups and their ability to derive benefits from the woodland.

In our discussion, we interpret our results through the lens of the access approach of Ribot (1998), and examine how the different actors are gaining, controlling and maintaining their access (Ribot and Peluso, 2003) to the value chain. This is critical, as it enables an understanding of how governance can be shaped in favour of communities. In light of our results, we then examine the operationalisation of the Forest and Wildlife law (GoM, 1999) on the ground. Our work is particularly timely, as it can inform the implementation of the 2013 Strategy for Conservation and Sustainable Use of Biomass Energy (GoM, 2013) aiming at joint interventions with the government agencies responsible for renewable energy, forests and rural development.

#### *Policy and legal framework in Mozambique for charcoal production*

Forests and woodlands in Mozambique fall under the responsibility of the Ministry of Land, Environment and Rural Development (MITADER). The Forest and Wildlife Law (GoM, 1999) sets the legal basis for sustainable use of forest and wildlife resources. Forest resources are the property of the state, with local communities being allowed to exploit forest resources for their own consumption. Any commercial exploitation needs authorization through a licence which is available to national operators and local communities (GoM, 1999). To apply for 'simple licences', a forest management plan (*plano de manejo*) must be prepared, which documents the species abundance and the quantity and duration of resource extraction in a defined area. If the applicant is a non-resident of the community where charcoal production is planned, he/she must conduct local consultations (GoM, 2002, Decree no. 12/2002): Exploitation of the community woodlands or forest resources and a contribution to the respective village has to be negotiated between the community resource management committee and the applicant. Following consensus, the record of consultation (*acta da consulta*) has to be read out loudly and signed by at least 10 people representing the committee (GoM, 2002, Decree no. 12/2002). Eventually, the decision needs to be approved by the district administrator. Following this, an area of maximum 500 ha can be officially designated as a charcoal production site and registered in the land registry. At district level it has to be confirmed that the designated area has sufficient resources for the proposed extraction volume and that the land has not been allocated to other users (GoM, 2002, Decree no. 12/2002).

With the provision of the required documents, a contract for forest or woodland exploitation (*contrato de exploração*) for a period of five years can be signed between the applicant and the provincial governor. Following, the SPFFB (Provincial Services for Forest and Wildlife) grants a simple licence and a fee of 75 MZN<sup>1</sup> per stere<sup>2</sup> has to be paid by the applicant. In 2012, modifications were made to the Forest Law (GoM, 2012, Decree no. 30/2012) limiting the charcoal production to 1000 steres per year and licence and restricting the maximum individual exploitation area to 500 ha to outsider operators and 1000 ha to local people. The *guia de trânsito* — a record book that comes with the licence has to be carried along with the charcoal transporting trucks — is the main monitoring instrument for the Forestry Department. It documents the quantity of charcoal licenced, harvested and transported (GoM, 2002, Decree no. 12/2002). The law enforcement officers check (at several points along the main routes) the flow of charcoal against

<sup>1</sup> MZN Mozambique New Metical: 1 USD = 32.8 <http://www.oanda.com/currency/converter/> (last access: 01/13/2015)

<sup>2</sup> Originally 1 stere qualifies 1 m<sup>3</sup> of stacked dry firewood. Related to charcoal, 1 stere permits the production of one sack of charcoal which was originally meant to have a weight of 50 kg (SPFFB). In the study area, however, charcoal sacks are traded with a weight of 70–90 kg (Atanassov et al., 2012).

the licence and the *guia* in order to detect any illegal charcoal transporting (e.g., transporting more charcoal than licenced, transporting charcoal from other exploitation areas than allowed, operating without licence) (GoM, 2002, Decree no. 12/2002). According to the Forest Law, local communities shall receive 20% of the licence fees and 50% of the value of fines paid for Forest Law violation are supposed to be channelled back to the local communities and law enforcement officers (GoM, 2002, Decree no. 12/2002).

The policy and legal framework also establishes the concept of Community-Based Natural Resource Management (CBNRM) as key to achieving the social objective of the Forest and Wildlife Policy. Through local resource management committees (*Conselhos Locais de Gestão de Recursos Florestais*), community members should be empowered to protect their interests, to acquire licences for forest or woodland resource commercialisation, to benefit from 20% of the licence fees applied on forest and wildlife products and to ensure local law enforcement. Nevertheless, the implementation of the legal framework remains challenging as rules and regulations can easily be undermined (Nhancale et al., 2009; van der Plas et al., 2012) leading to high levels of informal charcoal production (Zulu and Richardson, 2013; Cuvilas et al., 2010; del Gatto, 2003; SEI, 2002).

### Study area

The present study is part of the interdisciplinary ACES (Abrupt Changes in Ecosystem Services and Wellbeing in Mozambican Woodlands) project, which aims to understand how woodland loss and degradation is changing ecosystem services and wellbeing of the rural poor in Mozambique. The role of charcoal, as one of the most pertinent provisioning services, was highlighted during a national stakeholder workshop held in Maputo (Nhantumbo et al., 2015).

Gaza province is currently the main charcoal production area supplying Maputo-city (Falcão, 2013; Atanassov et al., 2012) holding the highest number of charcoal licences throughout the country in the last decade (Luz et al., 2015). Within Gaza charcoal production constantly moves to new areas of mopane woodland (*Colophospermum mopane*) with increasing distance to Maputo. Mabalane district has the highest licenced charcoal production (Luz et al., 2015). Given its location as a charcoal production hotspot, our empirical work at the production level was conducted in Mabalane district, Gaza province (Fig. 1). The district has an area of 9000 km<sup>2</sup> with a population density of 3.6 persons km<sup>-2</sup> (INE, 2008). Mabalane district overlaps partially with both National Parks of Limpopo and Banhine, where charcoal

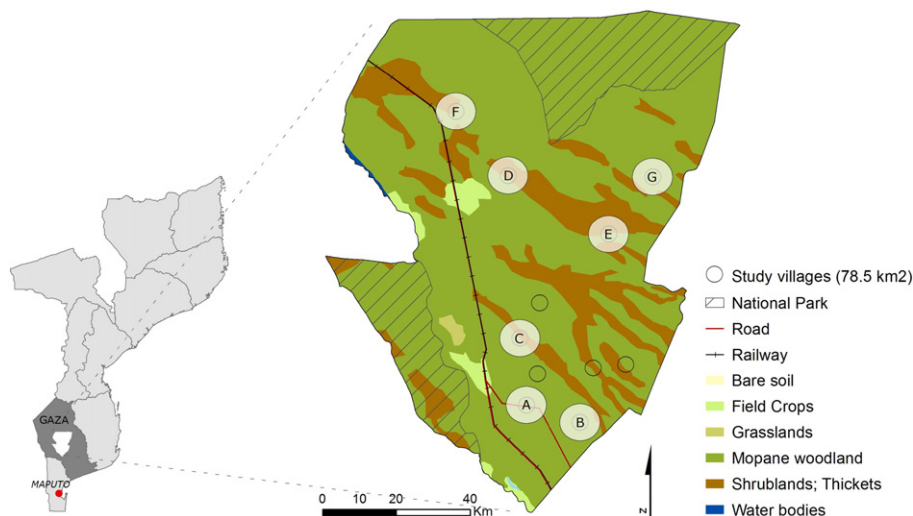
production is not licenced. Mabalane has a semi-arid climate (mean annual precipitation 500 mm with high inter-annual variations (GoM, 2005)) and a forest/woodland cover greater than 80% (own mapping), mainly consisting of Mopane woodlands. Mopane is one of the preferred indigenous hardwood species for charcoal production, as the dense wood produces slow-burning charcoal (Falcão, 2013). However, under dry conditions mopane trees have very low growth rates ranging from approx. 1.2–2.1 mm yr<sup>-1</sup> (Bila and Mabaia, 2012; Wessels, 2002). Charcoal production and commercialisation is one of the main economic activities in the district, along with low intensity rain-fed agriculture and animal husbandry under communal grazing systems (Levy and Kaufman, 2014).

### Research design and methods

The village selection for the overall ACES project was guided by a woodland degradation gradient ranging from villages with more intact woodland areas to those with degraded woodland, with more intact woodlands showing no signs of widespread harvesting of trees other than for domestic use. Seven villages at different stages of the gradient were selected having similar soils, rainfall, and vegetation types. For the present study this translated into a charcoal production gradient, from villages without charcoal production, to those experiencing a charcoal production peak, and to villages where the peak has already passed. Accordingly, the selected villages were classified in pre-boom, boom and post-boom following the criteria: 1) present number of licence holders in the community land, 2) production quantity of licenced charcoal and 3) year with highest charcoal production according to village narratives (Table 2).

To explore the charcoal production and trade in southern Mozambique, a commodity-chain analysis was applied, a tool to understand who benefits from the woodland resources at what stage, and using what means (formal institutions, local capacities, etc.). Details of the approach can be found in Bolwig et al. (2008) and Ribot (1998). A vertical analysis served to identify and characterise the existing charcoal supply models from rural production to urban marketing and the role that different actors play within it. The vertical analysis also allowed for the examination of the coherence between actors' behaviours and the legal framework.

Profit distribution along the charcoal supply chain was examined by analysing price margins, expenses and quantities handled by the different actors involved in the charcoal supply chain (underlying data and calculations in the supplementary information, SI 1 and SI 2). Margins



**Fig. 1.** Land cover and selected villages in Mabalane, Mozambique. While the land cover and boundaries of the district are accurately represented here, to maintain the anonymity of the villages investigated, the villages are represented by letters, and their location fictitious.



per sack were defined as gross per sack income minus per sack expenses. The net income generation was calculated by multiplying the margins per sack with the monthly volume of charcoal produced and/or traded.

It is worth noting, however, that we do not focus on the retailer commercialising charcoal within the urban areas but rather concentrate on the production side in order to disentangle the community benefits. A deeper understanding about urban marketing activities can be gained in [Atanassov et al. \(2012\)](#). Further, the transporters offering the service of charcoal transportation to the wholesalers are considered as exogenous actors, only appearing as a cost for the other actors participating in charcoal trading.

#### Data collection

Between May and October 2014, research was undertaken in the selected villages to collect quantitative and qualitative social data. For this paper relevant methods included: a) semi-structured interviews with the village leaders covering village characteristics, main livelihood activities and woodland resources, b) participatory mapping exercises helping to understand the village structure and land-use patterns, c) focus group discussions (FGD) with charcoal producers and d) semi-structured interviews with charcoal associations or village committee members (detailed in [Table 1](#)). Moreover, charcoal production camps were visited and workers were interviewed. The interviews and FGD with the charcoal producers covered charcoal production history, production processes, woodland access and distribution, licencing and control mechanisms, institutional arrangements, marketing processes and prices. Further information about the participation of the households in the charcoal production was gained through a household survey, which was run in the selected villages covering more than 80% of all households following randomised sampling ([Table 1](#)).

Transportation and licencing schemes of charcoal were investigated through interviews with truck drivers transporting charcoal from Mabalane to Maputo, and with forestry technicians from the District Services of Economic Affairs (SDAE) located in Mabalane-Sede and Combomune-Estação. Licence documentation (2009–2014) and information on the official licence regulation were gathered during a visit to the Provincial Services for Forest and Wildlife (SPFFB) in Xai-Xai. The use of multiple methodologies allowed the triangulation of findings.

#### Statistical analyses

Descriptive statistics were used to illustrate the main characteristics of charcoal producing areas and their producers. Statistical analyses (ANOVA) and Bonferroni corrected posthoc-test were conducted for the identification of statistically significant differences between groups at the 0.05 level. Mean values  $\pm$  standard error are given if not indicated otherwise. Standard errors were adjusted for nested design (households

nested in villages) through robust cluster estimation. Household and licence data were analysed using STATA (13.0). Qualitative data were analysed on a thematic basis, and offer thick descriptions of causal processes relating to the quantitative trends observed.

## Results

### Villages along the charcoal production gradient

After the civil war ended in 1992, most villagers returned from Mabalane-Sede and Combomune-Estação to their home villages. During these years, small-scale charcoal production and local commercialisation was an important activity in order to overcome years of very low agricultural productivity due to dry spells and the need for re-initiation of agriculture. With increasing demand for charcoal in Maputo-city and decreasing woodland cover around Maputo, Mabalane has become one of the major charcoal supply areas with large-scale charcoal production and commercialisation mainly driven by urban-based operators holding a licence.

The first villages targeted by large-scale charcoal production were located in the southern zone of Mabalane (village A, B and C) with good access roads and dense mopane woodlands. Within the study, these villages are classified as *post-boom* villages as they have passed the charcoal production peak between 2006 and 2009. During these years charcoal production was driven by large-scale operators bringing licences, trucks, chainsaws and workers. With decreasing woodland cover and fewer large mopane trees, in 2009 the large-scale operators started to withdraw from the areas of village A and B and moved on to new exploitation zones further north. Licence data show that only 1–3 licence holders for the period from 2009 to 2014 remain in the southern areas ([Table 2](#)). In village C, the charcoal boom stopped in 2013 when all large-scale operators withdrew from the area and the licenced charcoal volume dropped from 29,335 to 1590 sacks per year (decrease from 22 to 2 licence holders). In the year that fieldwork for this study was undertaken (2014), charcoal production by large-scale operators was at its minimum and the remaining trees were used for small-scale production by villagers. Villagers stated that production had become more difficult as they had to walk long distances to find sufficient sized trees (ref FGD). The charcoal was sold to occasionally passing trucks or in small quantities on the weekly market in Mabalane.

In *boom* villages considered (village D and E) production driven by large-scale operators started in 2011 and peaked in 2013 ([Table 2](#)). In year 2014, charcoal production was still at a very high level but as woodland resources were exhausted the number of large-scale operators also decreased. However, villagers said that they still have enough resources to continue production for several years. In village E, charcoal production did not occur to the same extent as in other villages. According to the interviews, this village consciously has refrained from becoming a key production area as they realised early that the

**Table 1**

Research sites, methodologies applied and sample size.

Sampling method	Villages							
	A	B	C	D	E	F	G	Combomune-Estação/ Mabalane-Sede
Participatory mapping	X	X	X	X	X	X	–	–
FGD with charcoal producers	X	X	X	X	X	X	X	x
Interviews (n)								
Leader	1	1	1	1	1	1	1	–
Committee member	1	–	1	1	1	–	1	2 <sup>a</sup>
Association member	2	–	–	–	1	–	1	–
Charcoal camp	3	2	3	2	8	–	–	10 <sup>b</sup>
HH survey	35	25	51	36	42	48	24	–
(% of village total)	(92%)	(86%)	(81%)	(86%)	(72%)	(87%)	(89%)	–

FGD: focus group discussion; A committee member is most of the time also “fiscal florestal comunitário”.

<sup>a</sup> Technicians from the SDAE Mabalane.

<sup>b</sup> Truck driver.

**Table 2**

Investigated villages along the charcoal production gradient and their main characteristics.

Village	Post-boom		Boom		Pre-boom		
	A	B	C	D	E	F	G
"Boom year"	2006	2009	2007	2011	2013	–	–
Licence holders (n)	0	1	2	66	20	0	0
Vol. licenced (sacks yr <sup>-1</sup> )	0	730	1000	47,139	13,777	0	0
HH (N(n))	38 (35)	29 (25)	63 (51)	42 (36)	58 (42)	55 (48)	27 (24)
HH producing charcoal (%)	88 ± 0.6 <sup>a</sup>	92 ± 0.6 <sup>a</sup>	92 ± 0.4 <sup>a</sup>	n.o.	64 ± 0.7 <sup>b</sup>	89 ± 0.4 <sup>a</sup>	0
HH charcoal production (sacks HH <sup>-1</sup> yr <sup>-1</sup> )	150 ± 20	90 ± 11	130 ± 24	n.o.	168 ± 36	95 ± 20	0 nsd
Village charcoal production (sacks yr <sup>-1</sup> )	5016	2401	7535	n.o.	6236	4650	0

Different letters indicated significant differences between the villages. Mean value ± standard error. Significance level at < 0.05. Bonferroni adjusted pairwise comparison. n: sample size. nsd: no significant difference. n.o.: no observation. All data refer to year 2014.

large-scale operators are the main winner of the charcoal production and do not bring great benefits to the village. Thus, the village committee restricted the number of large-scale operators in 2013, in order to preserve the remaining woodland resources for their own charcoal production and commercialisation (ref FGD). A village association supports local producers in commercialising their charcoal and informs them about the disadvantages when selling their charcoal to wholesalers with licences from other exploitation areas. The association invested in buying and maintaining a motor-driven water pump and has plans to build a borehole for livestock.

Two villages (F and G) were considered as *pre-boom* areas either because the production has not yet started or did not yet reach the levels as in the other investigated areas. In the latter case, difficult access was one of the main reasons why no large-scale operators came to the village. Villagers expressed their interest in producing charcoal if large-scale operators were to come, however, according to the interviews they would not allow the large-scale production as they observed in the other villages. In village F, an NGO project (1998–2012) implementing sustainable woodland management restricted the woodland resource exploitation to manual small-scale charcoal production (Brouwer, 2008). With the termination of the NGO project, people started to use chainsaws, but the majority of the population is cutting trees manually, which limits the production of large quantities (Table 2). According to them, with sufficient agricultural production they would refrain from charcoal production, however the main limiting factor is access to water.

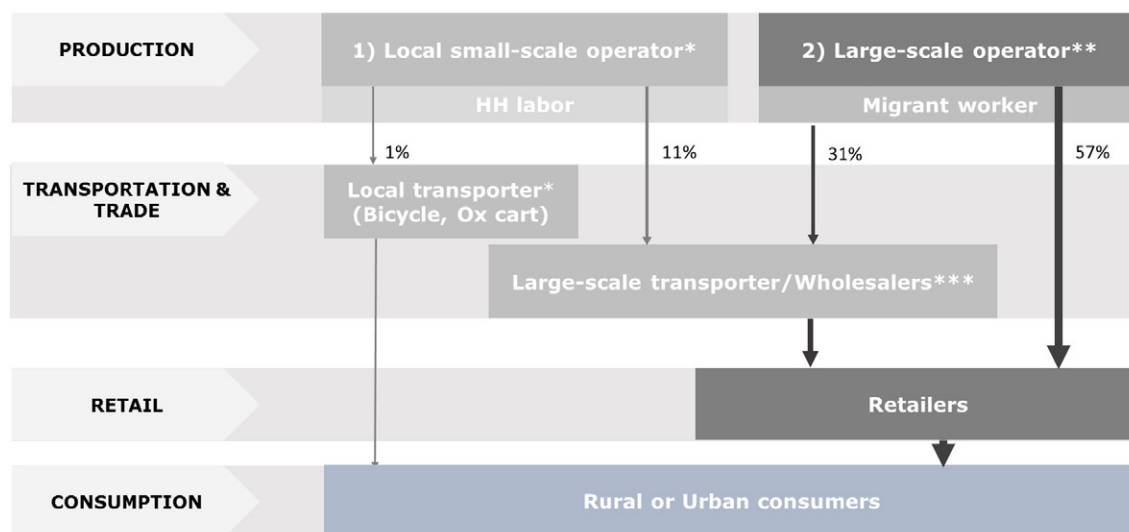
Studying villages along a charcoal production gradient showed that the relative number of households involved in charcoal production and their amount of charcoal production does not change significantly, except for village E, where fewer households are producing large quantities (Table 2). The overall charcoal production gradient appears to be driven by large-scale operators depending on the availability and accessibility of the woodland resource, village-level charcoal production rules and the influence of third-parties (NGOs) with conservation objectives.

#### Vertical analysis of the supply chains

We identified two main charcoal supply chains comprising four main actor groups: 1) Local village operators producing charcoal on a small-scale with household labour and sales to wholesalers, and 2) Large-scale operators producing and commercialising charcoal on a large-scale using migrant labour who are selling their own production to wholesalers (Fig. 2).

#### Unlicensed small-scale local village production with sales to wholesalers

The first supply chain involves local households without licences selling mainly to urban wholesalers (who transport and sell charcoal to retailers in Maputo-city). At the village level, 76% (n = 223) of the households produce charcoal with 16% of them being female headed. More than 78% (of those producing charcoal) have increased their production with chainsaws and/or by hiring temporary labour and 22% produce charcoal on a small scale relying on manual household labour



\*Generally do not have a licence

\*\*Generally do have a licence

\*\*\* Generally rent a licence (from associations or individuals)

Fig. 2. Charcoal value chains identified in Mabalane district and percentage of production volume (for seven observed villages).

force. The average annual production is  $124 \pm 13$  sacks per household, however, production is unequally distributed across the population with only 55 out of the 160 producers (34%) producing above the average, accounting for 67% of the total production. In this chain, charcoal production is an off-season activity conducted mainly during the dry season ( $5.6 \pm 0.6$  months;  $n = 170$ ) as this coincides with a period when agricultural labour demands are low. During interviews it was also stated that when agricultural production is sufficient to meet subsistence demands of the household, such as after the harvest, they do not produce charcoal. The leader of the village alone or in consultation with the village committee decides where a household can produce. On average, to each household a woodland area of  $2.5 \pm 1.2$  ha was allocated for a fee of  $430 \pm 98$  MZN paid to the community guard (*fiscal florestal comunitário*) (Table 3).

Of the local producers, 91% sell charcoal to wholesalers, whereas 9% supply local markets directly, with selling prices varying between 250 and 300 MZN per sack. Most wholesalers come from urban areas and usually own trucks, but others have to rent a truck and licence or transport charcoal with the train that passes Mabalane once a week. Estimating the number of wholesalers is difficult, as anybody with good relations to charcoal producers and connections to licence holders can enter this business. Also, some of the former charcoal-producing large-scale operators switched entirely to the wholesaler business using their own licence to buy charcoal from different areas.

#### Large-scale production and commercialisation by operators holding an official licence

The second identified supply chain is composed predominantly of urban-based men. In 2014, 156 people officially held a production licence for the district of Mabalane. Of these, 81% were non-residents and 35% were female. The large-scale operators set up charcoal production camps in the communities' woodlands and transport the charcoal to urban markets in Maputo. There, charcoal can be sold for as much as 900 MZN per sack. In past, large-scale operators annually contributed to the villages on the basis of materials (e.g., construction materials such as cement or poles). This has changed recently to monetary contribution in the range of 25,000–30,000 MZN for an exploitation period of five years. On average,  $359 \pm 169$  ha of woodland was allocated to each large-scale operator (Table 4).

The men working in the camps are 83% migrant workers from Inhambane province, who work during the dry season (mainly March to November) (Table 4). They are supplied with chainsaws and fuel as well as with food and water by the owner of the camp (*patrão*). In most cases their salary is paid in the form of fuel with which the workers are allowed to produce their own charcoal in the same woodland area and to sell it to wholesalers passing by, resulting in a 30–40% share in total production. The following were identified as the main reasons for the predominance of migrant workers in the charcoal production camps: First, most migrant workers have better technical knowledge on how to produce charcoal than the locals and second, they have long-standing relations with their employers and tend to relocate with them to new production frontiers, thus, mutual trust has been established.

**Table 3**  
Main characteristics of the village production model.

Characteristic	Mean $\pm$ SD
Woodland area distributed to each household (ha)	$2.4 \pm 1.2$
Contribution paid to community guard for area distribution (MZN)	$430 \pm 98$
Annual household production (sacks $\text{yr}^{-1}$ )	$124 \pm 13$ (SE)
1) Manual household labour only	$77 \pm 10.2$
2) Use of chainsaw and/or hired labour	$140 \pm 16$

SE: standard error. Data from focus group discussions and HH survey.

**Table 4**  
Main characteristics of the large-scale operator model.

Characteristic	Mean $\pm$ SD
Provenance of licence holders (156 in year 2014)	Mabalane district centres: 19% Maputo/Matola: 50% Other urban areas: 31%
Area distributed to each licence holder (ha)	$359 \pm 169$
Annual licenced charcoal per licence holder (2013) (sacks)	$829 \pm 245$
Contribution to village (MZN $\text{yr}^{-1}$ )	25,000–30,000
Workers per camp	$7 \pm 4$
Origin of workers	Inhambane district: 83%
Size of kiln (sacks)	$40 \pm 14$
Kilns produced per month and worker	1
Payment of workers	30–40% share of production

#### Individual and association licencing

Individual licence holders do not always exploit their woodland areas; instead they rent part of their licences to wholesalers who buy charcoal from different communities. This is forbidden and subject to heavy fines (20,000 MZN): it leads to a discrepancy between the area licenced and the actual exploitation area (GoM, 2002, Decree no. 12/2002). Such discrepancy prevents the 20% revenue obtained from licence fees from reaching the communities where charcoal has been extracted. It also negatively affects woodland exploitation monitoring. In theory, law enforcement officers (*fiscais*) from the SPFFB are regularly controlling the exploitation areas of the licence holders and their adherence to the management plan. In case of non-compliance, licences can be withdrawn. However, monitoring and enforcement are weak, exacerbated by low staff numbers and the high number of licences. It is noteworthy that regulation of the charcoal sector is further undermined by its vulnerability to corruption. Even though local communities and law enforcement officers receive a compensation when identifying and reporting illegalities (GoM, 2002, Decree no. 12/2002), bribing at checkpoints along the charcoal transportation route seems to be routine. On their way to Maputo-city, truck drivers ( $n = 10$ ) reported paying bribes “refreshments” of 200–1500 MZN to the officers at the checkpoints (9 in total). Overloading of trucks, non-conformity of exploitation area with licenced area, non-stamping of the licences, and transportation without licence can be bought at each checkpoint. According to these statements “private taxes” can reach up to 8% of the retail price if no licence is used at all. All these circumstances lead to the fact that only part of the charcoal sold on urban markets is produced in accordance to the Forest Law. We estimate that 45% of the charcoal produced in the selected seven villages is licenced (calculation see S3). It should be noted that the licenced volume probably exceeds the sustainable yield due to over optimistic assumptions about tree growth rates.

Most local producers do not hold individual licences due to the bureaucracy and the high cost of the licencing process. It was stated by local people that they do not know how to apply for an individual licence and that information about annual meetings at district level for the distribution of the land to charcoal operators are not well communicated. Particularly because of recent changes in law (GoM, 2012, Decree no. 30/2012) concerning the licence duration and management plans, local people feel poorly informed about the legal situation.

Village producer associations, if in place, can help to legalise the commercialisation of the charcoal produced by locals. Each association can apply for a licence (1000 steres per year) and use it for the sale of the members' charcoal. Those living more than two years in the community can become a member for a low entrance fee. The association either sells the charcoal to wholesalers on the train or to clients with trucks, charging a fee of 120 MZN per licenced sack on top of the charcoal price of 250 MZN per sack. With this fee the licence costs (75 MZN per sack) are covered and a gain of 45 MZN per sack remains within the association for community projects (e.g., such as the borehole in village E, describe above).

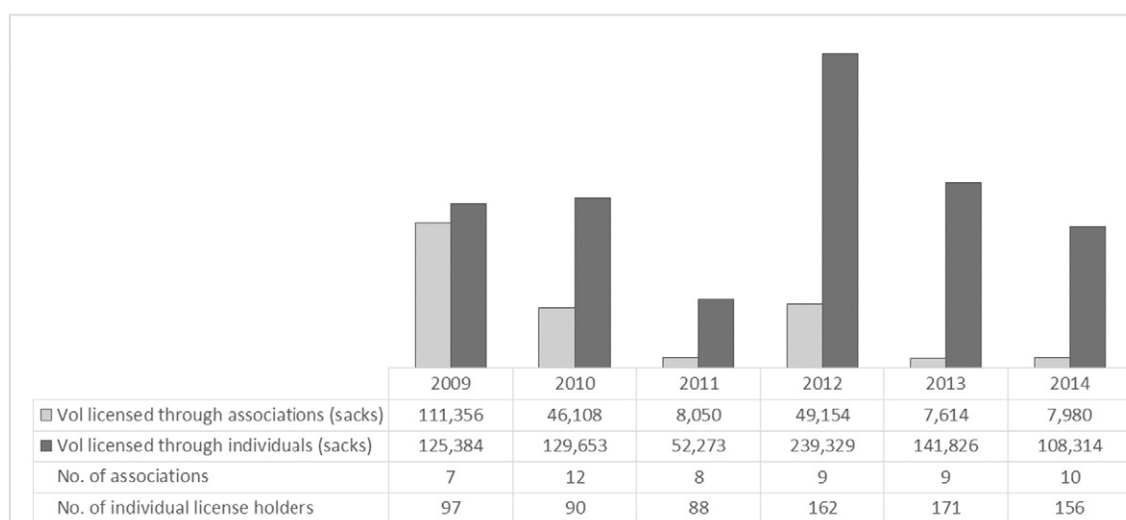


Fig. 3. Volume (steres) of licenced charcoal produced yearly in Mabalane, separated into licencing through associations and through individuals. 1 stere equals one sack.

However, the licence history at district level (2009–2014) (Fig. 3) shows that over the last five years the charcoal volume licenced to associations decreased by 90%, while the volume licenced to individual operators did not change substantially. In the same timeframe, the number of associations remained stable, whereas the number of individual licences increased from 97 to 152. Focus group interviews revealed the following factors as reasons for the reduced production by associations: 1) the increasing number of large-scale operators facilitated the market access of the local producers, thus associations as commercialisation channels were not needed; 2) the introduction of the *plano de manejo* in 2012 increased the administrative burdens for licence application; and 3) the increase of the licence price from 30 MZN to 75 MZN per licenced stere in 2012 coincided with decreasing charcoal production rates in most villages, thus rendering the association's work economically unviable. However, 4) in villages with sufficient woodland resources and high charcoal production, association work was severely restricted through the official limitation of the licence volume per association-nucleus to 1,000 steres per year, as stated by the umbrella association situated in Combomune. In 2009 92,612 steres were commercialised through this association, compared to 1000 steres in 2014. This lower licence capacity does not suffice for the commercialisation of the community charcoal. Thus, most of the charcoal is sold to large-scale operators or to wholesalers who rent licences from third parties. Eventually, not only the revenue generated through association work

is lost but also the revenue from 20% of the licence fee no longer reaches the community whose resources were extracted.

#### Profit distribution along the value chain

The highest margin per sack was generated by the large-scale operators (Fig. 4 A). This group can act as producer, transporter and wholesaler. As such, they collect profits at multiple levels. Wholesalers have the second highest margin per sack. However, they earn the highest monthly income: their traded charcoal volume is higher than that of the other actors as they buy charcoal from different producers and use multiple licences (Fig. 4B, C). For all charcoal traded without licence the margin would increase by 16% for the large-scale operators and by 43% for the wholesalers. Local producers and migrant workers have the lowest margin, volume and income.

#### Revenues at community level

Within the large-scale supply chain, most of the revenues arising from charcoal production and commercialisation are transported out of the communities: only 8% of the total revenues generated at the district level remain with the villagers (Table 5). As the workers come, in majority, from Inhambane and live in charcoal camps largely independent from village economies, most salaries do not remain in the community where the wood is extracted. Theoretically, if the production is

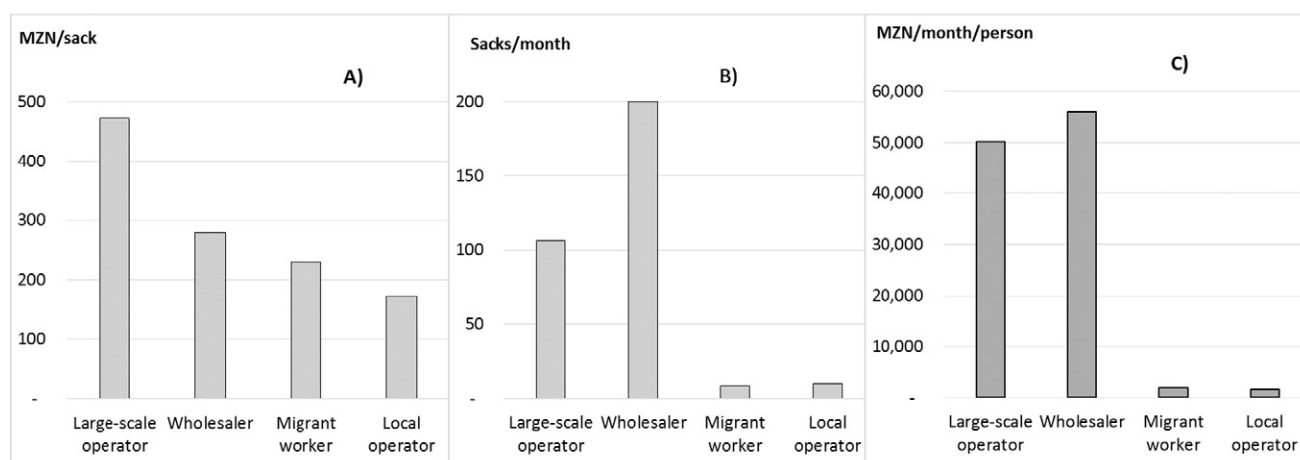


Fig. 4. Income generation for each actor group: A) Income margins per sack; B) Volume of monthly produced/traded charcoal; C) Average net income per month per person.



**Table 5**  
Revenues at community level depending on charcoal supply chain.

	1) Local small-scale operation	2) Large-scale operation
	MZN per sack	MZN per sack
20% of licence fee	15	15
Fee collected by associations	45	–
Contribution to village by operator	–	25
<b>Revenues to community</b>	<b>60</b>	<b>40</b>
Income margins of local operator	173	–
Income margins of wholesalers/ operator	280	487
	%	%
<b>Proportion of total annual revenues remaining in village</b>		
Community fund	12	8
Individual	33	–
<b>Total</b>	<b>45</b>	<b>8</b>

licenced legally and 20% of the licence fee is arriving in the community, and if the large-scale operators are contributing their share to the village this equates to 40 MZN sack<sup>-1</sup>.

In contrast, the involvement of local producers in the value chain increases local income (Table 5). When commercialisation of charcoal is done through local associations, extra revenues stay in the village and the percentage of the total annual revenues remaining increases to 45%.

In Table 6, the mean proportion of total annual income among the main identified actors is exemplified for three villages: one which already passed peak charcoal production, one with current high charcoal production volumes, and one which has not yet reached high volumes of production (see Table 2 for village characteristics). It becomes obvious that the *profit-boom* experienced in the high production areas is mainly produced and collected by the external agents. With very high volumes they get the highest share of the produced profits, theoretically leading also to highest revenues to the community fund compared to the pre- and post-boom-villages (1.9 m MZN for village E). However, even though most of the villagers knew about the revenue from 20% licence fee payment, in none of the villages visited could the people say where the money is located or if any investment is planned, nor could the monetary contribution of the large-scale operators to the community be clearly stated. Moreover, only part of the produced charcoal is licenced officially.

## Discussion

From the results the following key messages can be drawn: Under the current value chain structure, a) incentivised by resource availability and access, and little local regulations, the charcoal boom and

woodland exploitation is driven by large-scale operators integrated in production, transportation and wholesaling and predominantly coming from urban areas, b) most profits generated through charcoal production leave the communities, as is common in many value chains, c) the bureaucratic licencing application process with high costs and non-transparent procedures excludes local people from greater integration into charcoal commercialisation.

Despite this, communities benefit from charcoal production: buyers coming with trucks to the village open access to markets, charcoal production offers an off-season activity, charcoal sale brings cash to the village, migrant workers bring charcoaling skills, and large-scale operators give monetary contributions in return for woodland use rights. Although migrant workers are not contributing to the local economy where the charcoal is produced, in the workers' home districts many households are benefiting from their income. It can be argued that net gains from charcoal production are likely to be negative if external costs (such as opportunity costs of wood and labour) are internalised and that the profit is realised at the expense of other potential uses of the woodland (SEI, 2002; Luoga et al., 2000). While a link between charcoal production and poverty alleviation has been shown elsewhere (e.g., Schure et al., 2014a, 2014b; Zulu and Richardson, 2013; Arnold et al., 2006), the question remains as to how communities can maximise their benefits for better pro-poor charcoal production.

To answer this question, we examined our data through the access approach lens proposed by Ribot and Peluso (2003) and Ribot (1998). Access is defined here as “ability to benefit from things” (pg. 1 in Ribot and Peluso, 2003) and high benefits can be generated when a bundle of access factors are fulfilled (Ribot and Peluso, 2003; Ribot, 1998). Large-scale operators have such a “bundle of power” (pg. 1 in Ribot and Peluso, 2003); they have access to woodlands, to transportation means, to licences and to markets and they have the ability to maintain their access. Access to capital clearly plays an important role to overcome high barriers of entry adherent to the transportation business and to buy commercialisation rights in form of licences and private agreements. In contrast, although villagers have resource access, the majority have little control over the access of others. They have no market access either in the form of transportation, or in the form of commercialisation rights. Large-scale operators and wholesalers open the access to markets partly as they come to the villages with trucks and licences. However, the negotiation power of local producers remains very low. Ribot (1998) argues that access to markets might be more important than control over woodland. Our case appears to demonstrate this too. Access to markets through licences and transportation means is a prerequisite for increasing the margin and turnover of local charcoal production. On the other hand, local populations need to regain control over woodland access in order to prevent their wood

**Table 6**  
Total annual income distribution amongst the main actor groups of the value chain and revenue remaining in the community in exemplar pre-boom, boom and post-boom villages in 2013.

	Large-scale operator	Wholesaler	Migrant worker	Local operator	Community fund <sup>a</sup>
<b>Pre-boom village F</b>					
People engaged in production	0	2	0	49	–
Total annual charcoal prod. (thousand sacks)	0	4.6	0	4.6	–
Total annual income (million MZN)	0	1.3	0	0.8	0.3
Mean proportion of total annual income (%)	<b>0</b>	<b>55</b>	<b>0</b>	<b>33</b>	<b>12</b>
<b>Boom village E</b>					
People engaged in production	22	9	154	37	–
Total annual charcoal prod. (thousand sacks)	28.0	21.3	15.1	6.2	–
Total annual income (million MZN)	13	5.9	3.4	1.1	2.4
Mean proportion of total annual income (%)	<b>49</b>	<b>24</b>	<b>13</b>	<b>5</b>	<b>9</b>
<b>Post-boom village B</b>					
People engaged in production	1	1	7	27	–
Total annual charcoal prod. (thousand sacks)	1.0	2.7	0.3	2.4	–
Total annual income (million MZN)	0.5	0.7	0.1	0.4	0.2
Mean proportion of total annual income (%)	<b>24</b>	<b>41</b>	<b>3</b>	<b>21</b>	<b>11</b>

<sup>a</sup> The community fund consists of revenues collected through the 20% licence fee, the contributions from large-scale operators and the fees collected by associations (Table 5).

resources –on which most of the villagers depend– from being entirely exhausted.

The Law on Forest and Wildlife (GoM, 1999) sets standards for a sustainable and equitable charcoal sector but, as revealed by this study, there are several limitations: 1) commercialisation rights can be attained in the form of licences, however, licences can only be received after a bureaucratic process including the preparation of a forest management plan (see also Zulu, 2010; Nhancale et al., 2009). Communities are unlikely to be able to fulfill all requirements as knowledge and information are lacking at the local level. Thus, licencing systems effectively exclude rural communities from legal resource commercialisation (e.g., Minten et al., 2013; Ribot, 1993). 2) Local communities are encouraged to co-manage their woodland resources through the formation of community management committees (*Comités de Gestão Comunitária*), but weak institutional capacities at the local level render community-management programmes for sustainable production and the management of generated community funds difficult (Brouwer, 2008). 3) According to the law, villagers have the right to control the woodland exploitation on their community land, as any decision about the intensity of charcoal production within a community (number of licence holders and large-scale operators) has to be taken at district level under community consultation. However, in reality, most villagers do not have any clarity about the charcoal exploitation system and about community rights, but state that final decisions are usually made by the village head and the district governor as “the forest does not belong to the community but to the state” (ref FGD). Ribot (1998) also observed that village leaders often accept large-scale operators even if the village population has objections, either because of the benefits they might gain or because of pressure. 4) Greater participation of the communities in local woodland governance is targeted through the employment of community guards (*fiscais florestais comunitários*) controlling the woodland exploitation along with the forest officers. However, community guards did state that they do not have the means to control woodland exploitation due to limited equipment (mobility and communications). Moreover, lacking effectiveness of monetary incentives (i.e., 50% share of fines with law enforcement officers), social pressure from community members and susceptibility to bribes undermine the effectiveness of these guards (Brouwer, 2008). Particularly in remote areas, personal relationships and informal rules matter more than formal laws (Pereira and Joaquim, 2002; SEI, 2002).

As Nhancale et al. (2009) stated, the current situation clearly rewards those who contribute little to local development and sustainability. Thus, the charcoal sector has become dominated by urban operators who exploit large-scale community woodland resources, facilitated by constantly increasing urban demand and easy access. The market operates as monopsony in which many local producers are confronted with a limited number of large-scale operators placing them at a disadvantageous position in terms of price setting and woodland governance. Communities without functional associations are likely to lose more.

Altogether, it is clear that charcoal production in Mabalane district lacks strong local institutions that govern the use of resources and associated monetary revenues. Already Brouwer and Magane (1999) called for the restriction of woodland access to non-residents through the reinforcement of the local population's power of control. Access to commercial rights by woodland dependent communities has to be improved and the business capacity of the communities has to be strengthened (Nhancale et al., 2009; Schreckenbergh and Luttrell, 2009). Moreover, community participation in field monitoring and Forest Law enforcement, e.g., monitoring the investment of the 20% licence fee, has to be an integral development and should be supported (del Gatto, 2003). Here, associations play an important role in channelling the trade of the village charcoal producers, reducing costs and increasing political and market bargaining power (Macqueen et al., 2006). Associations can give structure to the currently largely informal sector and help local people to sustainably earn from their woodlands (Macqueen et al., 2006).

Notwithstanding, the legal framework appears to be a key barrier to legal resource commercialisation by local communities. It may be that this barrier could be overcome with stronger local institutions and a “public service” rather than a “regulation” approach to woodland resources, viewing them primarily as resource for rural development rather than an environmental problem (Deweese et al., 2010). Within the bounds of the current approach, several adjustments to the legal framework could be made that would reduce the burden on small-scale producers and the need for capacity building. These include a) reducing costs and administrative procedures for local small-scale producers; b) increasing the licence volume for local associations; c) increasing transparency of the licencing and commercialisation process.

## Conclusion

Our value chain analysis makes clear that most of the profits are generated by large-scale operators and wholesalers, while little revenue remains in the communities whose woodland resources are exploited. Difficulties in receiving commercialisation rights to communities hinder their value chain integration and reduce their profit generation from charcoal production. Despite their *de facto* rights of control over their woodlands, the communities do not have the ability to govern their resources due to weak institutional capacities.

We highlight the necessity of interventions targeted at the redistribution of total profits along the value chain and the transfer of woodland governance to the local communities. The following measures are key:

- Development of strong local institutions for charcoal commercialisation and woodland management;
- Information and extension services provision to villages, district and central government actors about their rights, responsibilities, obligations, and management options (e.g., more efficient conversion of wood to charcoal) regarding charcoal production, trade and use;
- Adjustment of the legal framework to make it easier for small-scale charcoal producers to participate in the trade legally;
- Rigorous enforcement of regulations along the value chain (exploitation areas, transportation routes) and transparency of its monitoring.

It remains to be analysed how revenues created at village level are distributed horizontally and to what extent the villagers benefit equitably. Investment of the charcoal revenue in productive assets is key if charcoal is going to be a route out of rural poverty.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.esd.2016.06.003>.

## References

- Ahrends A, et al. Predictable waves of sequential forest degradation and biodiversity loss spreading from an African city. *Proc Natl Acad Sci U S A* 2010;107(33):14556–61.
- Angelsen A, Wunder S. Exploring the Forest – poverty link : key concepts, issues and research implications. CIFOR occasional paper, 40. ; 2003. p. 68.
- Arnold JEM, Köhlin G, Persson R. Woodfuels, livelihoods, and policy interventions: changing perspectives. *World Dev* 2006;34(3):596–611.
- Atanassov B, Mahumane G. Biomass value chain analysis – Maputo/Matola. Mozambique: EuropeAid/127640/SER/MZ; 2012.
- Atanassov B, et al. Mozambique urban biomass energy analysis. Maputo, Mozambique: Ministry of Energy; 2012.
- Bila JM, Mabaia N. Crescimento e fitossociologia de uma floresta com *Colophospermum mopane*, em Mabalane, Província de Gaza, Moçambique. *Pesquisa Florestal Brasileira*, 32(72). ; 2012. p. 421–7.
- Boberg J. Competition in Tanzanian woodfuel markets. *Energy Policy* 1993;21:474–90.
- Bolwig S, et al. Integrating poverty, gender and environmental concerns into value chain analysis. DIIS working paper no 2008/16; 2008.
- Brouwer R. Country report Mozambique. Sustainable Forest Management and Conservation Project. FANR/SADC – GTZ; 2008.
- Brouwer R, Magane DM. The charcoal commodity chain in Maputo: access and sustainability. *South Afr For J* 1999;185(1):27–34. [Available at: <http://www.tandfonline.com/doi/abs/10.1080/10295925.1999.9631223>].
- Chavana R. Estudo da cadeia de valor de carvão vegetal no sul de Moçambique. Maputo, Mozambique: IIAM Instituto de Investigação Agrária de Moçambique; 2014.
- Cuvelas CA, Jirjis R, Lucas C. Energy situation in Mozambique: a review. *Renew Sustain Energy Rev* 2010;14(7):2139–46.
- del Gatto P. Forest law enforcement in Mozambique: an overview. Maputo, Mozambique: Ministry of Agriculture, National Directorate of Forestry and Wildlife; 2003.
- Deweese PA, et al. Managing the Miombo Woodlands of Southern Africa: policies, incentives and options for the rural poor. *J Nat Resour Policy Res* 2010;2(1):57–73.
- Falcão MP. Charcoal production and use in Mozambique, Malawi, Tanzania, and Zambia: historical overview, present situation and outlook. Maputo, Mozambique: UEM Universidade Eduardo Mondlane; 2008.
- Falcão MPMP. Produção e Consumo Doméstico de Combustíveis Lenhosos em Moçambique. Universidade Nova de Lisboa; 2013.
- Chilardi A, Mwampamba T, Dutt G. What role will charcoal play in the coming decades? Insights from up-to-date findings and reviews. *Energy Sustain Dev* 2013;17(2):73–4.
- GoM. Government of Mozambique: Law on Forest and Wildlife (Law 10/99 of 7 July 1999), LEX-FAOC020106. 1999. Available at: <http://faolex.fao.org/faolex/index.htm>.
- GoM. Government of Mozambique: Decree no. 12/2002 approving the Regulation on Forest and Wildlife, LEX-FAOC066163. 2002. Available at: <http://faolex.fao.org/faolex/index.htm>.
- GoM. Government of Mozambique: Perfil do Distrito de Mabalane Província de Gaza. Maputo, Mozambique: Ministério da Administração Estatal; 2005.
- GoM. Government of Mozambique: Decree no. 30/2012 establishing forestry exploitation requirements with an ordinary licence, LEX-FAOC119020. 2012. Available at: <http://faolex.fao.org/faolex/index.htm>.
- GoM. Government of Mozambique: Estratégia de Conservação e Uso Sustentável da Energia da Biomassa. Mozambique: Ministério da Energia; 2013.
- GoM. Government of Mozambique: Proposta do programa quinquenal do governo 2015–2019. Maputo, Mozambique: Governo de Moçambique; 2015.
- Instituto Nacional de Estatística (INE). Estatísticas do distrito Mabalane. Maputo, Mozambique: Instituto Nacional de Estatística; 2008.
- Kambewa P, et al. Charcoal: the reality. A study of charcoal consumption, trade and production in Malawi. London, UK: International Institute for Environment and Development (iied); 2007.
- Levy C, Kaufman B. Charcoal for food. Livelihood diversification in two peasant communities in Mozambique. In: Fakier K, Ehmke E, editors. *Socio-Economic Insecurity in Emerging Economies: Building Social Spaces*. Abingdon: Routledge; 2014.
- Luoga EJ, Witkowski ET, Balkwill K. Economics of charcoal production in miombo woodlands of eastern Tanzania: some hidden costs associated with commercialization of the resources. *Ecol Econ* 2000;35(2):243–57.
- Luz AC, et al. Charcoal production and trade in southern Mozambique : historical trends and present scenarios. World Forestry Congress XIV; 2015. [Durban].
- Macqueen D, Korhaliller S. Bundles of energy. The case for renewable biomass energy. London, UK: International Institute for Environment and Development (iied); 2011.
- Macqueen D, et al. Working together: Forest-linked small and medium enterprise associations and collective action. IIED Gatekeeper Series; 2006. p. 125.
- Minten B, Sander K, Stifel D. Forest management and economic rents: evidence from the charcoal trade in Madagascar. *Energy Sustain Dev* 2013;17(2):106–15.
- Nhancale B, et al. Small and medium Forest Enterprises in Mozambique. IIED Small and Medium Forest Enterprise Series No 25; 2009.
- Nhantumbo I, et al. Making the links between woodlands and wellbeing: a multi-stakeholder approach. IIED briefing papers; 2015.
- NL Agency. Making charcoal production in Sub Sahara Africa sustainable. Utrecht: Ministry of Economic Affairs, Agriculture and Innovation; 2010.
- Pereira C, Joaquim A. *Projecto Licuati: Experiências e lições*. Mozambique: Universidade Eduardo Mondlane; 2002.
- Puna N. Charcoal supply chain study in Mozambique. In: Kwaschik R, editor. *Proceedings of the "Conference on Charcoal and Communities in Africa."*; 2008.
- Ribot JC. Forestry policy and charcoal production in Senegal. *Energy Policy* 1993;21(5):559–85. [Available at: <http://linkinghub.elsevier.com/retrieve/pii/030142159390041D>].
- Ribot JC. Theorizing access: Forest profits along Senegal's charcoal commodity chain. *Dev Chang* 1998;29(2):307–41.
- Ribot JC, Peluso NL. A theory of access\*. *Rural Sociol* 2003;68(2):153–81. [Available at: <http://doi.wiley.com/10.1111/j.1549-0831.2003.tb00133.x>].
- Schreckenbergh K, Luttrell C. Participatory forest management: a route to poverty reduction? *Int For Rev* 2009;11(2):221–38. <http://dx.doi.org/10.1505/for.11.2.221>. [Available at: ].
- Schure J, et al. Formalisation of charcoal value chains and livelihood outcomes in central and West Africa. *Energy Sustain Dev* 2013;17(2):95–105.
- Schure J, Dkamela GP, et al. *An Approach to Promote REDD + Compatible Wood-fuel Value Chains*. SNV Netherlands Development Organisation; 2014a.
- Schure J, Levang P, Wiersum KF. Producing woodfuel for urban centers in the Democratic Republic of Congo: a path out of poverty for rural households? *World Dev* 2014b;64(Supplement 1):S80–90.
- SEI. *Charcoal Potential in Southern Africa (CHAPOSA)*; 2002 [Stockholm, Sweden].
- Shively G, et al. Profits and margins along Uganda's charcoal value. *Int For Rev* 2010;12(3).
- Tscharntke T, et al. Author sequence and credit for contributions in multiauthored publications. *PLoS Biol* 2007;5(1):0013–4.
- van Beukering P, et al. Optimization of the charcoal chain in Tanzania. *PREM Working Paper*, 07/03; 2007. [Available at: [http://www.prem-online.org/archive/15/doc/PREM\\_WP\\_07-03.pdf](http://www.prem-online.org/archive/15/doc/PREM_WP_07-03.pdf)].
- van der Plas RJ, et al. Mozambique Biomass Energy Strategy; 2012 [Maputo. Available at: [http://www.euei-pdf.org/sites/default/files/files/field\\_pblctn\\_file/EUEI\\_PDF\\_Mozambique\\_BEST\\_Final\\_Report\\_Dec2012.pdf](http://www.euei-pdf.org/sites/default/files/files/field_pblctn_file/EUEI_PDF_Mozambique_BEST_Final_Report_Dec2012.pdf)].
- Wessels D. Mopane woodland management. 2002. Available at: [http://www.dfid.gov.uk/r4d/PDF/Outputs/Forestry/R7822\\_-\\_Q2\\_-\\_Management\\_mopane\\_veld.pdf](http://www.dfid.gov.uk/r4d/PDF/Outputs/Forestry/R7822_-_Q2_-_Management_mopane_veld.pdf).
- World Bank. *Energy Strategy Approach Paper*, Washington DC. 2009. Available at: <http://siteresources.worldbank.org/EXTESC/Resources/Approach-paper.pdf>.
- World Bank. *Wood-Based Biomass Energy Development for Sub-Saharan Africa. Issues and Approaches*, Washington, DC. 2011. Available at: <http://bases.bireme.br/cgi-bin/wxislind.exe/iah/online/?IscScript=iah/iah.xis&src=google&base=REPIDISCA&lang=p&nextAction=lnk&exprSearch=174341&indexSearch=ID>http://linkinghub.elsevier.com/retrieve/pii/S0301421511002084http://www.who.int/healthinfo/g.
- Zulu LC. The forbidden fuel: charcoal, urban woodfuel demand and supply dynamics, community forest management and woodfuel policy in Malawi. *Energy Policy* 2010;38:3717–30.
- Zulu LC, Richardson RB. Charcoal, livelihoods, and poverty reduction: evidence from sub-Saharan Africa. *Energy Sustain Dev* 2013;17(2):127–37.