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Urban energy transitions and rural income generation: Sustainable opportunities for rural development through charcoal production

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ABSTRACT

Sub-Saharan Africa's charcoal sector is rarely considered a mechanism for rural development or poverty alleviation; instead, current regulations often marginalise rural producers. The development of a sustainable sector, that does not further marginalise rural populations, is restricted by limited understanding of these stakeholders. We assess the heterogeneity of rural producers supplying two differentially sized urban charcoal markets in Mozambique. Drawing on data from 767 household surveys, our findings suggest that the size of the urban market affects the type of rural producer and their scales of production. Overall household income of producers supplying the larger urban market were proportionally more dependent on charcoal for income generation; small-scale producers in particular relied most on charcoal income, contributing >95% of household incomes. In contrast, producers supplying the smaller market had more diversified incomes, and were thus less dependent on charcoal income. Larger-scale producers were generally wealthier; their absolute incomes were higher and they were proportionally the least dependent on charcoal income. Further findings suggest that rural charcoal production was not necessarily the domain of the poorest of the poor and the existence of producers trapped in small-scale production may be a consequence of larger urban markets, rather than an intrinsic characteristic of the sector. Predicted growth of smaller urban areas and associated higher demand for charcoal will provide substantial opportunities for rural income generation, most likely leading to shifts in producers and production scales. Rather than transferring existing formal approaches, which marginalise rural stakeholders, small urban areas provide opportunities to develop equitable production systems, with potential to deliver sustainable energy and rural development. The heterogeneity of rural producers calls for better-targeted interventions that incorporate the importance of charcoal production for rural livelihoods.

1. Introduction

Urbanisation and economic growth across sub-Saharan Africa (SSA) are resulting in pronounced consumption shifts from fuelwood to charcoal (Girard, 2002), with rising demand for charcoal in many cities directly linked to population growth (Chidumayo & Gumbo, 2013). There is a predicted 40% rise in biomass energy demand across Africa by 2040 (IEA, 2017). As large villages transform into secondary urban centres, 75% of urban growth across SSA is expected to occur in cities with populations of fewer than one million (UN-Habitat, 2014), thus small urban areas represent significant future charcoal consumption zones. Per terajoule of energy consumed, charcoal is estimated to create around 200–350 jobs, a figure triple that of electricity and 20 times that of kerosene (World Bank, 2005 as cited in Mugo and Ong, 2006). As a

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source of livelihoods this makes charcoal comparable in size to cash cropping in some countries (Matly, 2000). Despite the economic importance of charcoal for rural livelihoods in SSA (Zulu & Richardson, 2013), charcoal production is rarely considered a mechanism for rural development, in strong contrast to other sectors such as agriculture. Promoting the commercialisation of forest products is thus one mechanism for rural development (Belcher & Schreckenberg, 2007; Shackleton & Pandey, 2014), and the anticipated demand for charcoal in small urban areas may provide substantial opportunities for rural income generation.

Charcoal has the potential to be a sustainable energy source (Iiyama et al., 2014), yet links between poorly regulated production practices and environmental degradation have led to restrictive management approaches that discourage the extraction of woodfuels (Mwampamba, Ghilardi, Sander, & Chaix, 2013). National charcoal policies need to reflect the importance of woodfuels in the energy sector (Dovie, Witkowski, & Shackleton, 2004), promote sustainability, ensure social equity, as well as being business-oriented (Neufeldt et al., 2015). Yet few countries have explicit legislation enabling such a sector (Mugo & Ong, 2006). Current policies are largely punitive, condemning millions of rural livelihoods to illegality (Macqueen & Korhaliller, 2011). As a result, the majority of trade in charcoal is informal (Wood & Garside, 2014).

The informality of charcoal markets is believed to be the key constraint to their sustainable management (FAO, 2007); building formal institutions is therefore considered the best way to improve sector sustainability (Schure, Ingram, Sakho-Jimbira, Levang, & Wiersum, 2013). However, current formal approaches to govern the charcoal sector in SSA, by and large, do not benefit rural producers (Schure, Ingram, Arts, Levang, & Mvula-Mampasi, 2015). Sustainable urban woodfuel sectors will be difficult to conceive and implement unless rural stakeholders receive tangible benefits (van der Plas & Abdel-Hamid, 2005), yet rural stakeholders are rarely represented in formal decision-making structures (Laird, Wynberg, & McLain, 2010). Formalisation processes create opportunities for corruption (Tsing, 2005; Zulu, 2010), and stricter rules drive stakeholders to more environmentally destructive practices outside the new system (Putzel, Kelly, Cerutti, & Artati, 2015; Speigel, 2012), leading to leakage. Under formal systems, rural producers are frequently exploited by organised 'urban elites' with access to power and capital needed to acquire licenses and transport (Ribot, 1998). In Mozambique for example, only 8% of the monetary benefits from licensed charcoal production remain in local communities, due to bureaucratic barriers in obtaining licenses and weak institutional capacity for resource governance (Baumert et al., 2016). Poor regulation, corruption, high competition, low farm gate prices and restrictive policies perpetuate this situation across much of SSA (Ndegwa, Anhuf, Nehren, Ghilardi, & Iiyama, 2016).

As urban populations grow, so too do their charcoal markets. Charcoal value chains transform to become more complex and typically longer as remaining forest resources are found at increasing distances from urban demand centres (Ahrends et al., 2010). As a result, the evolving composition of the charcoal value chain affects the distribution of benefits and profit margins amongst actors (Iiyama et al., 2017), leading to unequal benefit distributions favouring urban stakeholders (Agbugba & Obi, 2013; Baumert et al., 2016; Ribot, 1998). Furthermore, it becomes increasingly difficult to enact new laws when there are vested interests (Kweka et al., 2015). However, due to the lack of vested interest from 'urban elites' in the charcoal markets of smaller urban areas (Smith, Eigenbrod, Kafumbata, Hudson, & Schreckenberg, 2015),[1] these areas may provide opportunities to introduce best-practice production methods and more equitable governance approaches. Small cities are therefore at the frontier of charcoal sector formalisation, but despite their growing prominence across SSA, their charcoal markets and stakeholders remain understudied (Jones, Ryan, & Fisher, 2016; Smith et al., 2015). In general, there is limited systematic investigation into the heterogeneity of charcoal producers and implications for rural development (Ndegwa et al., 2016), despite growing evidence that producers are heterogeneous with respect to their motivations, demographics, market access, production scales and wellbeing outcomes (Ainembabazi, Shively, & Angelsen, 2013; Jones et al., 2016; Kambewa, Mataya, Sichinga, & Johnson, 2007; Ndegwa et al., 2016; Schure et al., 2013; Smith, Hudson, & Schreckenberg, 2017; Vollmer et al., 2017). Nuanced understandings of charcoal participation and livelihood outcomes can aid better policy development (Smith et al., 2017), yet the lack of information about rural producers undermines attempts to successfully move towards sustainable production systems that do not further marginalise them (Schure et al., 2013).

This study contributes to the growing body of work which explores the potential of charcoal production to contribute to rural development in SSA (Arnold, Köhlin, & Persson, 2006; Guild & Shackleton, 2018; Khundi, Jagger, Shively, & Sserunkuuma, 2011; Ndegwa et al., 2016; Schure et al., 2013; Syampungani, Tigabu, Matakala, Handavu, & Oden, 2017; Vollmer et al., 2017; Zorrilla-Miras et al., 2018; Zulu & Richardson, 2013). Here, we assess how urban energy transitions affect opportunities for rural income generating, by comparing rural charcoal producers supplying two differentially sized urban charcoal markets: Maputo, the capital city of Mozambique, and Marrupa a much smaller urban area, and the principal town of Marrupa District, in Niassa Province, Mozambique. We examine differences in producers' production scales, dependence on charcoal production as an income generating activity (in relation to their overall household income), and producers' demographic characteristics. We end with a discussion of the implications for rural livelihoods and sector formalisation as urban demand for charcoal grows.

2. Methods

2.1. Study areas

Like many other countries in SSA, charcoal is the main domestic urban energy in Mozambique (Brouwer & Falcão, 2004; Cuvilas, Jirjis, & Lucas, 2010). It is an important source of income generation for about 5% of Mozambique's population and annual turnover is estimated at 250–300 million USD (van der Plas et al., 2012). Whilst a variety of laws apply to charcoal production in Mozambique, its governance mostly falls under the remit of the Forestry Department (van der Plas et al., 2012). The Forest Law (1999, and subsequent revisions in 2002 and 2012) defines two types of production license: Concession licenses, which can demarcate larger areas, are available to non-Mozambican nationals and are procedurally complex, in some circumstances requiring signing off at ministerial level. Simple licenses are only available to Mozambican nationals and require a less rigorous evidence-based management plan than the concession license (van der Plas et al., 2012). License application is patchy (German & Wertz-Kanounnikoff, 2012; Salomão & Matose, 2007; Sitoe, Wertz-Kanounnikoff, Ribeiro, Guedes, & Givá, 2014) and consequently, informally produced charcoal is thought to account for 80–95% of annual consumption (Cuvilas et al., 2010; Del Gatto, 2003). When licensed, charcoal is primarily produced under the simple license.[2]

[1] Due to a combination of low market prices, shorter value chains with less opportunity for value addition, nearby access to resources and high competition with rural stakeholders.

[2] Charcoal production can be conducted under the larger concession licenses, but this is very rare and tends to be a side business of timber production. Under such circumstances special dispensation is given for charcoal production (Government of Mozambique, 1999).

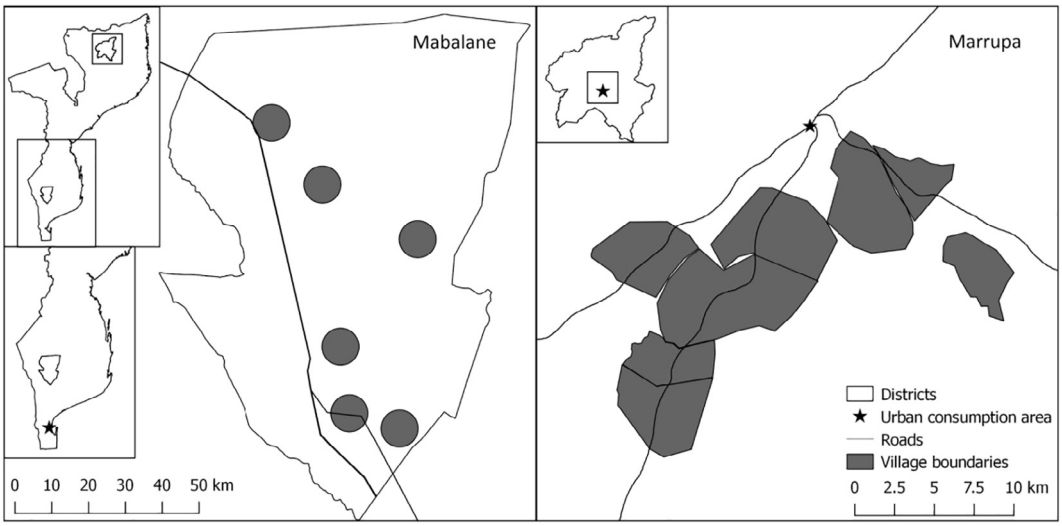

Fig. 1. Mabalane and Marrupa Districts and locations of sampled villages involved in charcoal production.

The first of our two study areas focusses on six villages producing charcoal for Maputo city (Fig. 1), the capital of Mozambique, with a projected urban population of 1.2 million in 2018 (Instituto Nacional de Estatística, 2010). Maputo city is home to the largest numbers of charcoal consumers in Mozambique; Mabalane District, Gaza Province, is currently the main rural supply area (Luz et al., 2015). In Mabalane, charcoal production is dominated by non-local (mostly urban) large-scale operators and wholesalers, who typically employ migrant producers and retain >90% of profits (Baumert et al., 2016). A high proportion of local rural households also engage in charcoal production (>65%), but benefits from charcoal production do not equate to improvements in their wellbeing (Vollmer et al., 2017), even though the environmental impacts of unsustainable production practices remain localised (Woollen et al., 2016; Zorrilla-Miras et al., 2018). Our second rural supply area examines charcoal producers from eight villages producing charcoal for Marrupa (Fig. 1), the principal town of Marrupa District, Niassa Province, in Northern Mozambique, with an urban population of 63,078 (Ministerio da Administração Estatal, 2014). Here, charcoal production is one of multiple income diversification strategies for rural households with access to urban charcoal markets, alongside small-scale shifting subsistence cultivation.

2.2. Data collection

Data were collected from villages where charcoal production occurs in Mabalane District (n = 6) between May-October 2014 and in Marrupa District (n = 8) between May-August 2015, both periods were during the agricultural off-season. We conducted semi-structured group interviews with key informants to determine prevalent income generating activities in each village. We subsequently conducted participatory wealth rankings with key informants to categorise households (defined as those eating 'from the same pot') into four wealth groups (very poor, poor, medium, rich), which were used to select participants for a household survey, using a stratified random sampling approach (Chambers, 1994; Laws, Harper, Jones, & Marcus, 2013); 220 and 547 households were sampled in Mabalane and Marrupa respectively. Data collected during the household survey included demographic characteristics (e.g. household size, headedness, education level), assets owned (e.g. livestock, bicycle), housing materials used (e.g. brick, grass) and gross household income generated in the previous four weeks and for agricultural income, since the last harvest. Seasonality may influence rural producers' access to markets, resources and also their engagement in production (Ndegwa et al., 2016; Smith et al., 2017; Zulu & Richardson, 2013), thus a caveat of the data presented in this paper is the production timescale investigated (one month). Longitudinal studies would overcome issues associated with recalled data (Nemarundwe & Richards, 2002), and help better understand seasonal patterns of producer participation.[3]

2.3. Data processing and analysis

2.3.1. Producer classifications

Following the method used by Ndegwa et al., (2016), producers were classified using hierarchical cluster analysis. Eight clustering variables were used: the total household income in MZN and the percentage contribution to the total income of seven commonly available income portfolios in both sites (formal employment, charcoal production, casual labour, commercial crop income, businesses, livestock, other environmental products and remittances), reported by the respondents. Gross income was calculated, as net incomes are subject to uncertainties (Iiyama, Kariuki, Kristjanson, Kaitibie, & Maitima, 2008). We conducted clustering computations using Ward's method and plotted the line of best cut into the dendrogram at the point with the largest changes in fusion levels (Everitt et al., 2011 as cited in Ndegwa et al., 2016) (See S1 for the classification dendrogram). Non-parametric statistical analyses (Kruskall-Wallis H, Mann-Whitney U) were conducted to compare differences between producer groups and sites. Unless otherwise indicated, means ± standard errors (SE) are given.

3. Results

3.1. Classification of producer groups

Hierarchical cluster analysis resulted in three groups of charcoal producers, distinguished by the numbers of bags they produced in

[3] Seasonal production data for the study areas are limited, however seasonal data from Malawi (Smith et al., 2017) suggest that production levels increase after the maize harvest (typically around April/May), partly due to lower conflicting labour requirements. The seasonal bias of this research may therefore indicate high production levels, compared to annual averages. Additionally, the seasonal bias means that the research cannot demonstrate how households behave during particular times of stress, for example due to seasonal food shortages in the pre-harvest period.

Table 1
Classification of sampled households, scales of production and income generation.

	Non-producing households	Producing households		
		Small-scale	Medium-scale	Large-scale
Percentage (n) of households sampled in each producer classification				
Mabalane (n = 220)	21 (47)	33 (72)	31 (68)	15 (33)
Marrupa (n = 547)	87 (4 7 8)	10 (57)	2 (12)	0
Mean ± SE number of bags of charcoal produced in the previous 4 weeks				
Mabalane (n = 220)	–	15.3 ± 0.86	40.3 ± 2.5	104.6 ± 12.5
Marrupa (n = 547)	–	11.4 ± 1.4	46.8 ± 10.7	–
Mean proportion (%) ± SE of charcoal income to total household income				
Mabalane (n = 220)	0	95.04 ± 1.34	76.35 ± 3.54	61.79 ± 6.76
Marrupa (n = 547)	0	66.61 ± 4.22	38.33 ± 10.48	–
Mean gross household income (MZN) ± SE generate from charcoal production in the four weeks prior to data collection				
Mabalane (n = 220)	–	4,103.5 ± 230.1	11,118 ± 642.9	29,300 ± 3567.0
Marrupa (n = 547)	–	1,046.4 ± 139.1	4,883.3 ± 1234.7	–
Mean gross household income (MZN) ± SE generate from other (non-charcoal) income				
Mabalane (n = 220)	8897.1 ± 2178.4	222.9 ± 67.7	3984.1 ± 694.3	29540.5 ± 8507.9
Marrupa (n = 547)	6627.8 ± 454.0	695 ± 124.6	9442.7 ± 2133.1	–

the four weeks prior to data collection (Table 1). Discriminant analysis confirmed that 86% of producer households were correctly classified. The prevalence of producers and producer groups differed between sites; most households (79%) produced charcoal in Mabalane, whereas most households in Marrupa did not (87%). No households produced at a large-scale in Marrupa (Table 1).

Across both sites, producer households were highly dependent on charcoal income, as it contributed between 38% and 95% of the total gross household income (Table 1). The proportion of charcoal income relevant to the total household income was greater amongst households with smaller production scales in both Marrupa (Mann-whitney U = 510.5, $p < 0.01$) and Mabalane (Kruskal-wallis H (2) = 35.958, $p < 0.0001$), thus small-scale producers were proportionally the most dependent on charcoal income, despite the fact that they produced the least amount.

Producers in Mabalane generated highest gross incomes from charcoal production, with large-scale producers generating the most (Table 1). Observed income differences between sites was due to the selling price of a bag of charcoal; in Mabalane, a bag[4] sold for 274.97 ± 3.26MZN[5] (n = 174), which was on average 2.9 times higher than in Marrupa (94.58 ± 1.96MZN, n = 66). In both sites, as production scales increased, the standard error of mean household income also increased, indicating larger variability in dependence on charcoal income with higher production scales. In both sites, only the households producing at the largest scales generated more income from other (non-charcoal) sources, than non-producing households.

3.2. Demographic characteristics

In Mabalane, large-scale producers were generally better-off (Table 2). Proportionally more large-scale producing households owned high-value assets (Fig. 2a) and owned more livestock. They had larger households (8.6 ± 0.8 members) and farmed bigger areas of land (>3 ha). Large-scale producer household heads were older (48 ± 2.6 years) and almost all were male (94%). Compared to all other groups, more large-scale producing households were listed as 'rich' (36%) and fewest (12%) listed as 'very poor' in the wealth ranking (Fig. 2b). In contrast, small-scale producer household heads were nearly a decade younger (39 ± 1.6 years) and almost a quarter (24%) were female. They reported lower levels of asset ownership (including livestock and land), and over half (53%) of the household heads had received no education (Fig. 2c). Few small and medium-scale households had used improved roofing materials, which were classified as being made from either metal, plastic or tiles (as opposed to grass, for example). Furthermore, we found no difference in the residency status of non-producer and producing households (considered permanent residents if householders had always lived in the village). However, of the non permanent-residents, the non-producing households had been present in the village for the shortest of time (8.14 ± 1.8 years). In Marrupa, the characteristics of non-producer and producer groups were consistently more homogenous. However, non-producers owned more livestock and most medium-scale producers owned high-value assets (Fig. 2a). More medium-scale producing households were listed as 'rich' (17%) and fewer (8%) listed as very poor (Fig. 2b) and we found no differences in the residency status of non-producing and producing households (Table 1). Information from village-level surveys reported a higher diversity of income generating activities other than charcoal in Marrupa, and rates of participation in varying activities differed between sites, with proportionally fewer households engaging in activities other than charcoal in Mabalane (see S2 for information on alternative income generating activities in both sites).

4. Discussion

Our findings confirm the heterogeneity of rural charcoal producers (Kambewa et al., 2007; Ndegwa et al., 2016), and provide evidence to suggest that the size of the urban market affects both the type of rural producer and their scales of production. The stronger the demand for charcoal, the larger the incentive to increase production (Belcher, Ruíz-Pérez, & Achdiawan, 2005), which may be why we only found large-scale rural producers operating in Mabalane, where selling prices were higher. However, whilst these households are 'large-scale' in comparison to other rural households, in contrast to the non-local (mostly urban) operators and wholesalers, they still produce at small-scales. Large-scale production typically means producing more than 100 bags per month (Kambewa et al., 2007), so despite the heterogeneity of producing scales found in this study, almost all the producers were operating

[4] *Bags* of charcoal were sold in 50 kg maize sacks. Whilst we did not collected data on the weight of each bag, estimates suggest that these bags typically weigh between 33 and 38 kg (FAO Openshaw 1983; Kambewa et al., 2007), depending on the species of tree and water content.

[5] The conversion rate ranged from $1 USD = 31.3MZN at the start of data collection (1st May 2014), to $1 USD = 44.3MZN at the end of data collection (1st December 2015) (XE, nd).

Table 2
Demographic characteristics of non-producing and producer households.

	Mabalane (n = 220)					Marrupa (n = 547)			
	Non producing households	Producing households			Test	Non producing households	Producing households		Test
	(n = 47)	Small-scale (n = 72)	Medium-scale (n = 68)	Large-scale (n = 33)		(n = 478)	Small-scale (n = 57)	Medium-scale (n = 12)	
Female headed household % (n)	32 (15)	24 (17)	12 (8)	6 (2)	H(3) = 11.979, p > 0.01	20(93)	16(9)	(0)	H(2) = 3.2517, p = 0.19
Age of household head	44 ± 3	39 ± 1.6	42 ± 1.9	48 ± 2.6	H(3) = 7.5247, p = 0.06	43 ± 0.8	36 ± 1.8	41 ± 3.8	H(2) = 4.8565, p = 0.09
Household size	5.6 ± 0.6	5.6 ± 0.4	6 ± 0.5	8.6 ± 0.8	H(3) = 13.897, p < 0.01	4.9 ± 0.1	5.2 ± 0.2	6.6 ± 0.9	H(2) = 5.4873, p = 0.06
Permanent residency	38 (18)	39 (28)	25 (17)	18 (6)	H(3) = 6.855, p = 0.08	28 (1 3 4)	21 (12)	5 (3)	H(2) = 1.2809, p = 0.53
Years lived in the village	8.14 ± 1.8	10.31 ± 1.09	11.37 ± 0.85	13.52 ± 1.62	H(3) = 11.848, p < 0.01	5.88 ± 0.34	4.72 ± 0.88	2.98 ± 0.51	H(2) = 5.2344, p = 0.07
Land holding (ha)	2.7 ± 0.4	1.7 ± 0.2	2.1 ± 0.3	3.2 ± 0.5	H(3) = 16.075, p < 0.01	2 ± 0.1	1.5 ± 0.1	1.8 ± 0.3	H(2) = 1.3325, p = 0.51
Households with improved roof material % (n)	81 (38)	64 (46)	60(41)	79 (26)	H(3) = 7.754, p = 0.051	1(3)	(0)	(0)	H(2) = 0.43556, p = 0.8
Cattle	4.7 ± 1.1	3.2 ± 1.2	2.8 ± 0.9	12.9 ± 2.6	H(3) = 30.854, p < 0.0001	0	0	0	–
Chicken	3.7 ± 0.8	1.5 ± 0.4	4.7 ± 1.2	8.7 ± 3.1	H(3) = 7.721, p = 0.052	6.4 ± 0.4	4.6 ± 0.8	3.8 ± 1.7	H(2) = 2.7508, p = 0.25

at small-scales. A study by Baumert et al. (2016) found that in Mabalane district, non-local operators produced on average almost seven times the amount[6] produced by a rural household each year. Wealthier households are better situated to take advantage of new market opportunities, as they have better access to land, capital, labour, skills and connections (Belcher et al., 2005). We found that large-scale rural producers were best-off in most senses, generated higher gross incomes and owned higher value assets (including land and livestock). However, whilst our data do not allow for causal analysis, it is probable that most 'large-scale' producing households had the assets to enable them to produce at higher levels. Absolute charcoal incomes were highest for large-scale producers in Mabalane, supporting evidence that charcoal production is not principally the domain of the poorest of the poor (Mwampamba et al., 2013). Larger-scale producers may further invest charcoal income into diverse income generating opportunities, leading to wealth accumulation, thus improving household resilience (Marschke & Berkes, 2006; Ndegwa et al., 2016). However, to determine any causality between asset accumulation and charcoal production, longitudinal analysis of livelihood trajectories would be required.

In contrast, households may become trapped in producing charcoal, whereby they produce at levels that cannot provide more than their subsistence requirements (Delacote, 2009). Small-scale producers may struggle to invest capital back into production, either because they simply do not generate enough income, because there are greater demands on their income, or because there are few incentives or opportunities to invest, for example due to insecure property rights (Angelsen & Wunder, 2003). Small-scale producers in Mabalane generated subsistence incomes, which were highly dependent on derived charcoal income (contributing >95% of household incomes), suggesting that these households may be trapped in menial production scales, with limited opportunity to diversify income sources. Under these circumstances, small-scale rural charcoal production may be detrimental to rural households in the long-term, as higher returns encourage a movement away from diversified (and more resilient) livelihoods (Arnold & Perez, 2001; Chidumayo & Gumbo, 2013). To be resilient, rural production systems such as charcoal production require low-risk options that provide short-term returns on investment; these requirements are essential for both managing risk and ensuring sustainability (Vanlauwe et al., 2014). However, current charcoal production systems are far from resilient as many rural producers are highly vulnerable to risks associated with environmental degradation attributed to unsustainable production practices (Lattimore, Smith, Titus, Stupak, & Egnell, 2009; Woollen et al., 2016), associated punitive enforcements (Smith et al., 2017), and as our findings suggest, menial production levels, where households supplying large urban markets are unable to diversify their income strategies. In contrast, small-scale producers in Marrupa had higher levels of alternative income sources, highlighting lower dependency in general. Unlike the small-scale producers in Mabalane, small-scale producers in Marrupa seemed not to be trapped in menial production. Our findings therefore suggest that the existence of households trapped in low production may be a consequence of larger urban markets, which typically have more inequitable value chains (Agbugba & Obi, 2013; Ribot, 1998), rather than an intrinsic and inevitable outcome for all rural charcoal producers.

Dependence on charcoal production can be both out of choice (i.e. because profit margins are good and markets are stable), or

[6] This calculation was based on the reporting of licensed production only. It is likely that this is a gross underestimation, as an estimated 80–95% of marketed charcoal is unlicensed in Mozambique (Del Gatto, 2003; Cuvilas et al., 2010). The study by Baumert et al. (2016) found that almost all rural households producing unlicensed charcoal sold to the non-local operators.

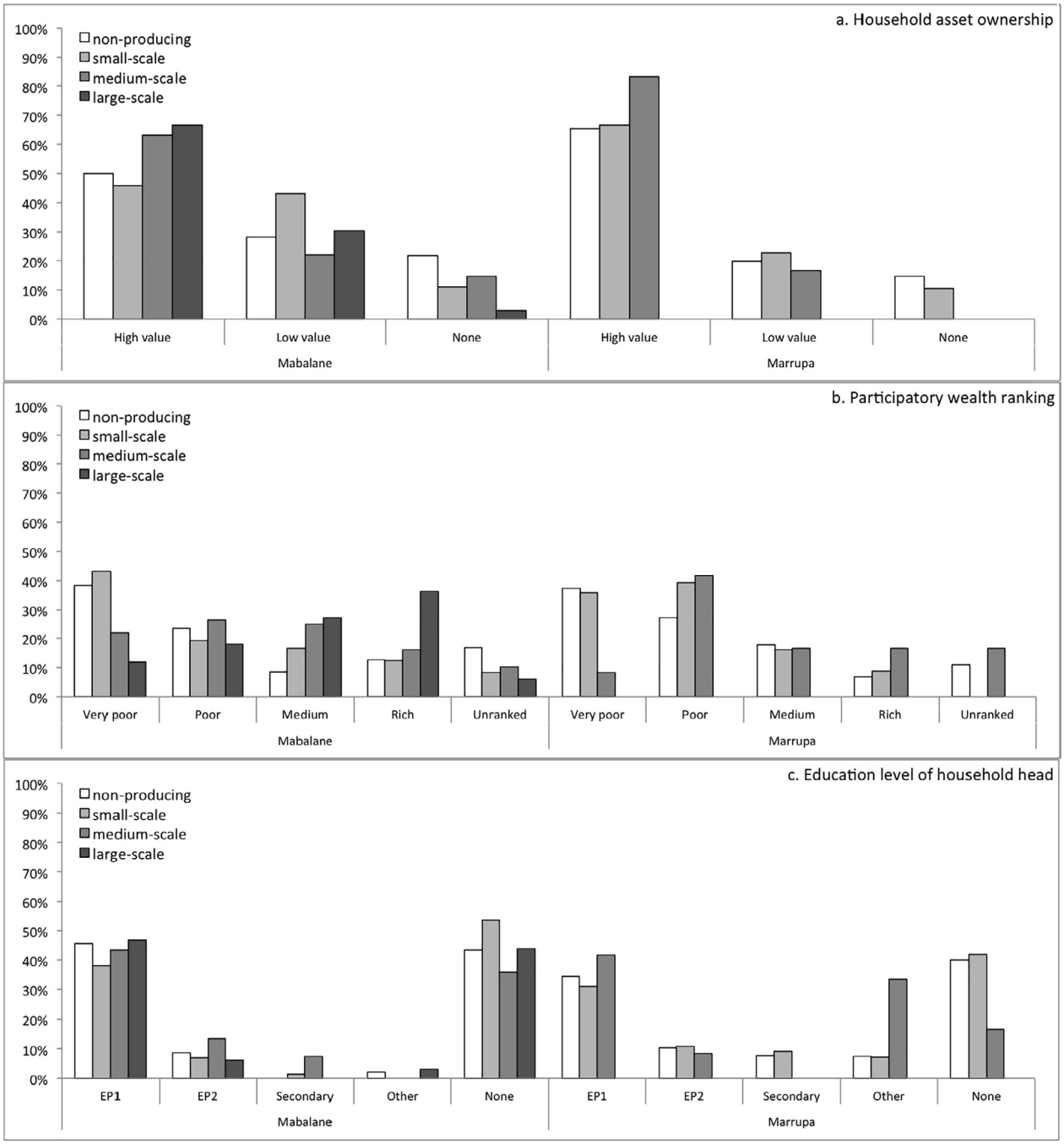

Fig. 2. Demographic characteristics of non-producing and producer households, with respect to their a) ownership of household assets, b) participatory wealth rank and c) education level of the household head. Primary school in Mozambique is free and compulsory. EP1 relates to grades 1–5 of primary school, EP2 relates to grades 6–7 of primary school.

because of a lack of choice (i.e. because there are no alternative income generating opportunities). In this study, we found that wealthier households produced the highest amounts of charcoal on average, suggesting that they were able to take advantage of the market, and benefit from good profit margins. Yet, we found that despite the large amounts produced, this contributed a small amount to their overall income. In this respect, we did not find 'large-scale producers who had high 'dependence', as they had alternative income sources. In contrast, households who produced smaller amounts had fewer alternative sources of income, thus these households were identified as more 'dependent' on charcoal. In this case, their dependence was due to lacking alternative incomes.

Fewer women participated with increasing scales of production, corroborating findings of others (Khundi et al., 2011; Mulenga, Hadunka, & Richardson, 2017; Ndegwa et al., 2016; Schure, 2014). Labour requirements, resource access and the illicit nature of the sector are cited as reasons for the general low participation of women (Zulu & Richardson, 2013). However, charcoal production remains an important and independent income generating activity for women (Butz, 2013; Jones et al., 2016). In contrast to others (Ribot, 1995), we found no evidence to suggest that rural producers migrate to the area in pursuit of charcoal production, as we found no differences between the residency status of non-producer and producing households in either site. Furthermore in

Mabalane, non-producing householders had on average lived in the villages for the shortest amount of time. Whilst the rural producers sampled in our study appear not migrate with charcoal production, the producers employed by the non-local (mostly urban) operators and wholesalers do migrate between production areas (Baumert et al., 2016). These findings therefore demonstrate a further differentiation between producers and production models.

4.1. Policy implications: The formalisation frontier

Long term future efforts to phase out urban charcoal will eventually require alternative income opportunities, especially for more vulnerable households that are heavily dependent on charcoal production for income generation. In the intermediary however, the heterogeneity of producers and expected growth of urban demand for charcoal calls for targeted interventions that incorporate the role of small-scale production amongst rural households. A narrow focus on agricultural development pathways (e.g. Markelova, Meinzen-Dick, Hellin, & Dohrn, 2009) overlooks alternative land use mechanisms for rural development, despite the fact that off-farm income generation is essential for improving rural livelihoods (Frelat et al., 2015). Forest and woodland resource commodification is touted as a win-win solution for dual poverty-environmental outcomes (Adams et al., 2004; Leakey, 2001). However, engaging in unmanaged wild harvesting provides limited benefits, due to trade-offs between environmental and socioeconomic outcomes of an unsustainable charcoal sector (Vollmer et al., 2017; Zorrilla-Miras et al., 2018). Sustained livelihood benefits from commercial forest resources, such as charcoal, typically require secure resource rights (Belcher et al., 2005), so securing land tenure in rural supply areas as charcoal urban markets develop should benefit small-scale rural producers. Further, the requirements to generate substantial incomes from forest products, and thus reduce poverty (for example by commercialisation and up-scaling production and trade), are often unattainable for poorer households. This requires access to certain assets such as capital and business contacts (Arnold & Perez, 2001), which, by definition, the poor cannot access (Belcher & Schreckenberg, 2007). One way to improve small-scale producers' access to formal institutions is through collective action, such as the formation of associations (Macqueen et al., 2014; Nhantumbo, Macqueen, Cruz, & Serra, 2013). First and foremost however, including informal, small-scale rural producers when defining the aims and outcomes of charcoal interventions is vital.

As elsewhere in SSA, despite the continued drive towards formalising Mozambique's charcoal markets, large numbers of informal, small-scale rural producers remain (Butz, 2013; Del Gatto, 2003; Jones et al., 2016; Schure et al., 2013; Smith et al., 2017). There is therefore currently an impasse between a rigidly defined view of formalisation that favours large-scale production models and the reality that there are more small-scale producers engaged in charcoal production, unable to meet the requirements of the law. Despite repeat calls for contextually relevant charcoal governance (e.g. Mwampamba et al. 2013; Schure et al. 2013; Zulu and Richardson 2013; Baumert et al. 2016; Vollmer et al. 2017), most approaches across SSA adopt top-down, national-level, environmental governance blueprints (Schure et al., 2013). As demand for charcoal increases alongside the growth of smaller urban areas, our findings suggest that shifts in production scales and in producers are likely, generating opportunities for rural development. The scale of the market and value chains affects the distribution of benefits (Iiyama et al., 2017); as urban charcoal markets grow, their value chains become more complex, with more unequal benefit distributions, typically favouring more powerful urban stakeholders (Agbugba & Obi, 2013; Baumert et al., 2016; Ribot, 1998). Cities demanding larger volumes attract more vertical integration and political involvement (The World Bank, 2009, 2010), but 'urban-elites' (Smith et al., 2015) and 'trapped' small-scale producers appear not to exist in the charcoal value chains of smaller urban areas. The markets of smaller urban areas therefore provide novel opportunities to develop new, more equitable and sustainable production systems; they are the 'formalisation frontier'.

Charcoal production plays an important flexible role in rural labour markets, not only in-spite of its informality, but because of it (Jones et al., 2016). Rather than submitting charcoal markets of smaller urban areas to carbon-copies of top-down restructuring through licensing requirements and costs, new policy approaches could incentivise sustainable production for larger producers whilst maintaining flexibility for smaller, occasional producers. Soft-touch, gradually introduced regulation, a reduction in the cost and difficulties in obtaining a license and encouraging sustainable practices through tax incentives could benefit specialised producers. For small-scale rural producers, initiatives that encourage sustainable practices and locally driven land-use planning, whilst maintaining the ability for flexible (informal) production might be a complementary and alternative way forward. Rather than organise rural producers to meet formal requirements, approaches could look to make sustainability requirements better fit the reality of their production models. To put another way, given the importance of informality for the livelihoods of small-scale rural charcoal producers, it is perhaps more useful to consider how informality can be better engaged with, and provided for. Therefore, as smaller urban areas grow, key challenges include: understanding how to recognise and allow for the benefits of informality whilst enhancing sustainable practices, ensuring that benefits are not captured by 'urban elites' and rural producers do not become 'trapped' in menial production scales, and environmental impacts do not undermine local livelihoods (Shackleton & Pandey, 2014).

Informal institutions are important for the management of natural resources (Leach, Mearns, & Scoones, 1999; Mowo et al., 2013). Incorporating informal and existing woodfuel management schemes into interventions can lead to more sustainable outcomes (Bensel, 2008). In Tanzania for example, *Ngitili,* a traditional natural resource management system used by pastoralists (Barrow, Kaale, & Mlenge, 2003), has been shown to be effective in achieving both ecosystem service management and poverty alleviation goals (Patenaude & Lewis, 2014). Thus an important future step should be to look to existing institutions, rather than using formalisation to impose forest management norms. There is therefore a need for studies that engage with the complexities of formalisation (Speigel, 2012; Tschakert, 2009), assessing its impacts and constraints (Schure et al., 2013), particularly for small-scale resource users. Further lessons on engaging with informality may be gleaned from the literature and experiences on the governance of artisanal mining and commercialisation of non-timber forest product, which are increasingly proposed approaches to informal markets that do not necessitate formalisation (Hirons, 2011; Speigel, 2012).

5. Conclusion

Our study provides evidence to suggest that the size of the urban market affects the scales of production, levels of dependency on charcoal as an income source, and producers' livelihood outcomes. The heterogeneity of rural producers in our study sites challenges current policy approaches and calls for better-targeted interventions that incorporate the role of informal rural producers. We found that rural charcoal production was not principally the domain of the poorest of the poor, as wealthier households produced more charcoal. However, small-scale producers, supplying

large cities can become trapped in production, with limited opportunity to diversify income sources. In this sense, small-scale charcoal production may be disruptive to rural households in the long-term, particularly when the resource-base is undermined by unsustainable harvesting. In contrast, these 'trapped' small-scale producer appear not to exist in the production systems supplying smaller urban areas. The existence of households trapped in menial production may be a consequence of larger cities, often with vested interests and inequitable value chains, as opposed to an intrinsic characteristic of the sector. Smaller urban markets may therefore provide novel opportunities to develop more socially equitable and sustainable production systems.

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Declaration of interest statement

There are no conflicts of interest associated with this submission

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.worlddev.2018.08.024.

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