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Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa

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ABSTRACT

More than 80% of urban households in sub-Saharan Africa use charcoal as their main source of cooking energy, and the demand is likely to increase for several decades. Charcoal is also a major source of income for rural households in areas with access to urban markets. We review studies of the socioeconomic implications of charcoal production and use, focusing holistically on the role of charcoal in poverty alleviation based on four dimensions of poverty defined by the World Bank: (i) material deprivation, (ii) poor health and education, (iii) vulnerability and exposure to risk, and (iv) voicelessness and powerlessness. We draw conclusions from household-level studies to better understand the determinants of participation in charcoal production and sale, and of urban household demand. Poorer households are more likely to participate in the production and sale of charcoal but their participation is mainly a safety net to supplement other income. Although charcoal production contributes to poverty reduction through alternative income-generation opportunities, it can also undermine production of ecosystem services, agricultural production, and human health. Reducing rural household dependence on charcoal requires coordinated policies providing alternative income opportunities for farmers, affordable alternative energy sources for urban households, and more efficient and sustainable approaches for producing and using charcoal. For future research, we emphasize the importance of large-N panel datasets to better understand the net benefits of charcoal production as a poverty-reduction strategy.

Introduction

For Sub-Saharan African (SSA) countries, charcoal is not only *the* major source of household energy for the majority of the urban population, it is also a significant contributor to national energy balances, an important source of household incomes, and a potentially renewable energy source capable of powering significant economic growth while reducing dependency of poor developing countries on costly energy imports (Arnold et al., 2006; Sepp, 2010). Several advantages make charcoal attractive for cooking and heating, especially among the urban poor. Compared to firewood, charcoal has higher energy content, is less bulky, easier to transport, and more accessible, and burns more cleanly (with less smoke) (Akpalu et al., 2011; MARGE, 2009). Further, purchased charcoal is inexpensive, readily available, and generally has a stable supply and market, relative to modern alternatives (Ellegård and Nordström, 2003). Charcoal is also linked to poverty in several ways and at multiple scales. At the macro level, woodfuels constitute a significant productive sector of the economies of many SSA countries and contribute to poverty reduction through national development, employment, and household income generation (Angelsen and Wunder, 2003).[1] Woodfuels contributed 3.5% of Malawi's GDP (Zulu, 2010) and 120,000–140,000 in direct employment in 2008 (MARGE, 2009). Charcoal alone was estimated to contribute $650 million to Tanzania's economy, 5.8 times the combined value of coffee and tea production, and the sector provided income to several hundred thousands of households in both urban and rural areas (World Bank, 2009).[2] Growing urban charcoal demand and markets provide opportunities for income generation from the production of charcoal in rural areas where it is often the most commercialized resource, and from the sale of charcoal in urban areas (Arnold et al., 2006; Kambewa et al., 2007; Luoga et al., 2000; SEI, 2002). The charcoal market also provides urban households with an affordable, convenient and reliable source of energy and associated energy services (cooking, heating, small-scale industrial uses, etc.) at relatively stable prices (Desanker and Zulu, 2001; Ellegård and Nordström, 2003; MARGE, 2009; Richardson, 2010). However, charcoal production can also have perverse effects on poverty. These include negative health impacts at the production and use sites generally associated with smoke inhalation and carbon monoxide poisoning (Akpalu et al., 2011; Arnold et al., 2006; Ezzati and Kammen, 2001; IEA, 2010); localized deforestation around cities such as Addis Ababa, Dar es Salaam, Lusaka, Maputo, Lilongwe, and Dakar, and associated environmental degradation including soil erosion resulting in

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[1] In this article woodfuel refers to both charcoal and firewood.

[2] FAO statistics show that on average the forest sector contributed 1.3% of Africa's GDP, ranging from 0.1% in Eritrea, Djibouti, Libya, Mauritania and Congo to 17.7% in Liberia (FAO, 2011), but these statistics fail to adequately capture the woodfuel contribution, which is often in the informal sector.

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lower agricultural productivity (Alem et al., 2010; Arnold et al., 2006; Kambewa et al., 2007; Luoga et al., 2000; Mwampamba, 2007; Ribot, 1999; SEI, 2002). Negative social impacts include exploitation of producers and traders by middlemen and elites, official corruption that increases transaction costs and unequal gender relations surrounding charcoal production and use that overburden women or expose them to health risks (IEA, 2002; Kambewa et al., 2007; Larson and Ribot, 2007; Post and Snel, 2003; Ribot, 1995, 2009). For the majority of urban dwellers who depend on inefficient, "inferior" or "dirty" woodfuels for energy (relative to liquefied petroleum gas (LPG) kerosene, and electricity), charcoal can also maintain, worsen, or be an indicator of poverty in the form of charcoal dependency—the so-called "charcoal trap" (Kutsch et al., 2011). Charcoal use is also associated with poor energy services and quality of life (e.g., illnesses) relative to the cleaner alternatives (Arnold et al., 2006; Desanker and Zulu, 2001; Guruswamy, 2011; IEA, 2002, 2010; Martins, 2005). However, charcoal is often considered the transition fuel because it is also higher up the energy ladder and superior to firewood, which is better than crop residues and dung.[3] Thus, it is important to analyze the extent to which charcoal production and trading currently and potentially can contribute to *net* poverty alleviation.

The growing demand for charcoal in Africa driven by high population and urbanization growth rates makes charcoal the major primary source of energy for most urban dwellers for at least another generation, yet it is paradoxical that charcoal has been relatively neglected within, and disjointed across, energy, forestry, and poverty reduction policies since the so called "woodfuel crisis" debates of the 1970s/1980s (Arnold et al., 2006; World Bank, 2001; Zulu, 2010). Although geographically differentiated within Africa (see Fig. 1B), charcoal consumption in Africa is expected to increase considerably and faster than other regions of the world (Fig. 1A; also see Ghilardi and Sander, this issue), doubling by 2030 versus a 24% increase for firewood (Arnold et al., 2006).[4] Yet, despite being/burning cleaner than firewood, crop residues, and dung, charcoal remains "the black sheep in Africa's renewable energy family" (Chaix, 2011) with a negative image as dirty, unhealthy, and primitive, if not illicit (Mugo and Ong, 2006; Sepp, 2010; Zulu, 2010). A post-conference communiqué of a gathering of 54 African Energy Ministers discussing common approaches to energy access and low-carbon economic growth given climate change held in Johannesburg in September 2011 failed to even mention charcoal (Chaix, 2011). As various authors now note, charcoal can no longer be ignored as a current and future major energy source (Ellegàrd and Nordström, 2003; MARGE, 2009; Syampungani et al., 2011; Zulu, 2010).

Apparently, putting too much faith in the "energy transition" theory has undermined realistic, proactive policy-making on charcoal. The energy-transition theory postulates that as household incomes increase and individuals and countries develop economically, people's energy preferences will transition up an energy ladder from the "inferior" biomass fuels through charcoal – the "transition fuel" – to modern cleaner alternatives including LPG, kerosene, and electricity (Arnold et al., 2006; Campbell et al., 2003; Hosier and Dowd, 1987; Leach and Mearns, 1988).[5] Although this theory largely holds in global terms, recent evidence shows that for Africa, several obstacles make the theorized energy transition proceed more slowly than anticipated, and it ultimately may be incomplete, producing instead energy mixes that include charcoal (Chambwera and Folmer, 2007; Hiemstra-van der Horst and Hovorka, 2008; Martins, 2005; Masera et al., 2000). In addition, the negative image of charcoal – including its misperception as a major cause of deforestation and environmental degradation – has contributed to restrictive policies on charcoal including trading bans in many SSA countries. Such bans have increased production costs, reduced market access, driven the charcoal market 'underground,' increased corruption, denied governments much needed tax revenues from potential regulated exploitation, and undermined charcoal's potential as a poverty reduction tool in many SSA countries (Angelsen and Wunder, 2003; Dewees, 1995; Kambewa et al., 2007; World Bank, 2009). For instance, Tanzania and Malawi lost at least $100 million and $17.3 million in uncollected charcoal-based revenues, respectively (World Bank, 2009; Zulu, 2010).

This article reviews literature on the link between charcoal and poverty, focusing on the role of charcoal production and trading on poverty reduction in Africa. While there is a rich literature on the poverty/forest link, it is largely from the negative narrative of a "downward spiral" of poverty causing forest loss and environmental degradation, which further exacerbate poverty, with relatively little systematic analysis of how and the extent to which forests can reduce poverty (Angelsen and Wunder, 2003; Arnold et al., 2006; Ellegàrd and Nordström, 2003; SEI, 2002; Sunderlin et al., 2005). Several studies have examined the forest/poverty link looking at tropical forests generically (Angelsen and Wunder, 2003; Wunder, 2001), non-timber forest products (Neumann and Hirsch, 2000), woodfuels (Arnold et al., 2006), or local forest/livelihood interactions (Byron and Arnold, 1999; Sunderlin et al., 2005). However, few studies have examined charcoal/poverty linkages holistically, or for Africa regionally. The growing demand for charcoal has increased opportunities for income generation, rural livelihood support (production and trading), and poverty alleviation, and enabled the expansion of domestic markets, particularly in urban areas where woodfuel is scarce (Arnold et al., 2006; Campbell et al., 2007). However, charcoal production and trading also pose challenges including unsustainable production, environmental degradation and negative health impacts for households already constrained by material deprivation. Thus, for any particular location, insights on net effects of charcoal are needed.

Poverty is a complex notion. Its definitions have gradually shifted from narrow, measurement-based financial indicators to "soft" broader definitions that include notions of welfare, such as the five-capital framework (Bebbington, 1999), or sustainable livelihood approaches which draw out causes and broad categories of poverty (Angelsen and Wunder, 2003). In this paper, *poverty reduction* refers to "a situation where people are becoming measurably better off over time, in absolute or relative terms" or are "lifted out of poverty" by climbing above a pre-defined poverty line; *poverty prevention* relates to conditions under which people "maintain a minimum standard of living (even when it is below a given poverty line)," including "insurance and safety net functions" which cushion and mitigate against poverty; while *poverty alleviation* includes both poverty reduction and prevention (Angelsen and Wunder, 2003: 2). This paper follows a holistic notion of poverty alleviation based on four dimensions identified in a World Bank poverty framework: (i) material deprivation, (ii) poor education and health, (iii) vulnerability and exposure to risk, and (iv) voicelessness and powerlessness (World Bank, 2001).

Following the introduction, the second section briefly examines key historical trends, current status, and future challenges and opportunities in policies involving charcoal and poverty. Section three examines (net) economic benefits of both charcoal production and trading as means to reduce material deprivation for a range of actors including producers (small, medium, large scale), wholesalers, retailers, transporters, and forestry and police officials. The fourth section examines the downside of charcoal production, trading, and use relative to issues of vulnerability and risk/exposure including environmental degradation, health effects, and social impacts. The final section discusses current and future prospects for charcoal to effectively provide affordable energy and alleviate poverty while

[3] Thus, comparatively resource wealthy SSA can still afford to use charcoal, an option less available to South Asia.

[4] Aggregate consumption of wood for both firewood and charcoal is keeping pace with population growth rates (Arnold et al., 2006).

[5] Despite its high cost (high power requirements, distribution infrastructure and start-up costs) and levels of poverty in many SSA countries, electricity remains the main alternative to charcoal at least for urban areas where charcoal is currently the major fuel and natural gas (also with high distribution and start-up costs), is not readily accessible. However, the significance of electricity for cooking is generally low.

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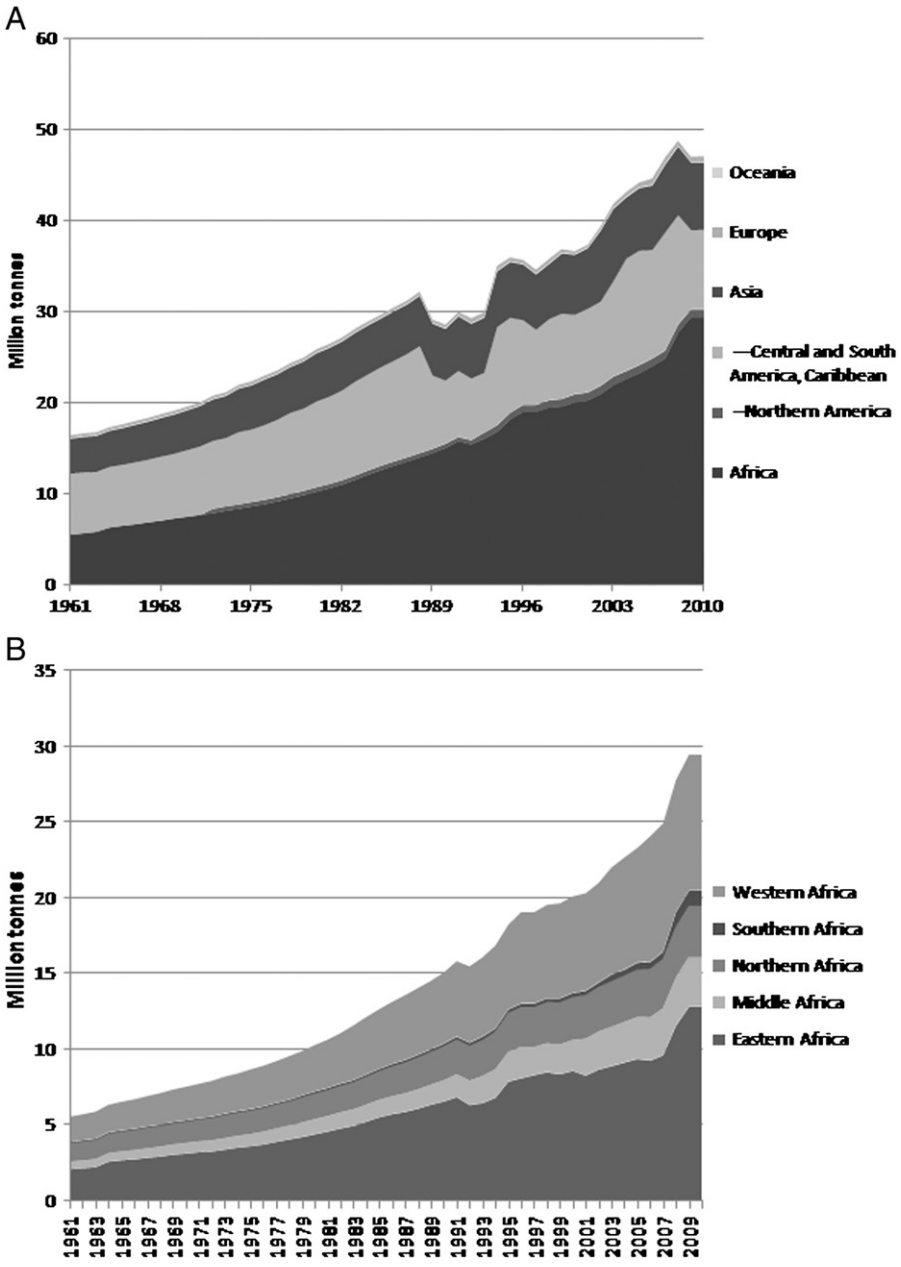

Fig. 1. A. Charcoal production by region of the world: 1961–2010 (millions of tons). B. Charcoal production by region of Africa: 1961–2010 (millions of tons). Data source: FAOstat, http://faostat.fao.org/site/626/default.aspx#ancor.

minimizing negative socio-economic and environmental impacts. It explores the potential for synergies and win–win scenarios, and concludes with scholarly and policy implications.

Charcoal production policies and poverty in Africa

The major policy challenge is how to meet the growing demand for charcoal (and firewood) for the majority of Africa's billion people while significantly supporting livelihoods and contributing to poverty reduction, without undermining ecological sustainability. Most SSA countries are ill prepared for this challenge. The literature suggests that most charcoal production in Africa constitutes unsustainable forest mining of existing natural woodland stocks. This ultimately undermines charcoal's poverty-reduction potential. Reasons for over-exploitation include weak, misguided, neglected, underdeveloped, disjointed, overly prohibitive, contradictory or non-existent woodfuel policies and laws, combined with poor enforcement and regulatory capacity. Many studies confirm this state of affairs (e.g., Angelsen and Wunder, 2003; Arnold et al., 2006; Dewees, 1995; Leach and Mearns, 1988; Mugo and Ong, 2006; Ribot, 1993, 1995; Ribot et al., 2006; World Bank, 2009; Zulu, 2010). A recent study of East African countries showed that only Sudan and Kenya had explicit policies to promote the sustainable production of charcoal (Mugo and Ong, 2006). Woodfuel policies were mostly uncoordinated across relevant sectors including forestry/environment, energy, agriculture, and finance or economic development, breeding inefficiencies through duplication, omissions, contradictions, uncertainty/confusion, and lack of focus and political influence for the sector. Thus, it is instructive to examine woodfuel policies generically before zeroing in on charcoal.

Despite the rhetoric of managing forest resources to alleviate poverty, integration of woodfuel issues in national economic and poverty reduction policies has been inadequate or tokenistic. Reviews of national poverty reduction plans within Poverty Reduction Strategy Papers (PRSPs), poverty-reduction blueprints sponsored by the World Bank since 1999,

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generally revealed inclusion of forestry/environmental issues but cause–effect, forest(ry)/poverty analysis was superficial, unsystematic or absent. Forestry was treated less as a productive sector and more as a set of diverse activities supporting other sectors perceived to be more directly linked to poverty, e.g., agriculture and rural development (Bojö and Reddy, 2003; Hermosilla and Simula, 2007; Oskanen et al., 2003). Admittedly, with meager resources to confront more pressing and urgent priorities including food insecurity, poor health including HIV/AIDS, poor education, and rampant poverty, woodfuel/conservation investments appear as a luxury. Still, the status/role of forestry/woodfuel sectors in poverty alleviation can be enhanced nationally, by increasing and disseminating knowledge of their contributions to poverty reduction effectively, focusing international assistance on removing poverty-reduction barriers in woodfuel/forest policies, and helping forestry/woodfuel sectors to effectively make their case with finance ministries (Bird and Dickinson, 2005; Oskanen et al., 2003).

The woodfuel demand/supply situation in SSA has undergone considerable change in the past four decades. Perception has changed from alarmist (1970s) to indifference (1990s) to reawakening (2000s), and approaches from large-scale plantations and indigenous forest-protection to a mix of small-scale tree growing and protection, community management, and links to poverty reduction, with limited large-scale woodfuel production. Doomsday "woodfuel crisis" narratives of burgeoning woodfuel demand and deficits, large-scale forest-resource depletion, rampant environmental degradation and escalating poverty failed to materialize and were largely debunked as exaggerated or misguided (Arnold et al., 2006; Dewees, 1989; Leach and Mearns, 1988; Mahiri and Howorth, 2001). Consequently, the "woodfuel gap" problem was significantly downgraded (1980s–90s) and investments in forest resource conservation curtailed (Arnold et al., 2006; World Bank, 2001).[6] Net World Bank lending for forestry projects to Africa nearly halved from $516 million 1984–89 to $272 1992–99. Global funding for such projects increased during the same period from $1.97 billion to $3.5 billion, but the the biggest increase (614%) went to Eastern Europe and Central Asia regions (Lele et al., 2000). A review attributed these funding reductions, poor integration of forestry issues into the World Bank's poverty alleviation mission, and country-managers' perception of forestry investments as high risk low payoff, to the Bank's failure in meeting deforestation and poverty reduction goals of its 1991 forestry strategy (Lele et al., 2000: 40).

Woodfuel policies in SSA have focused on supply enhancement, demand management, and market interventions, but less on poverty reduction. The declining interest/investment has undermined large-scale plantation development, resulting in heavy dependence on largely unsustainable woodfuel production from existing indigenous wood stocks despite attempts to regulate and limit wood extraction and reduce deforestation through policing, wood/charcoal licensing or trading bans, and promotion of alternative private and smallholder tree growing (SEI, 2002; Wunder, 2001; Zulu, 2010). Most of these regulations have been overly restrictive and unsuccessful, and have sometimes had the opposite effect (Campbell et al., 2007; Zulu, 2010). Meanwhile, politically convenient misdiagnosis of woodfuel as the main course of deforestation gave woodfuels a negative image while deforestation continued largely via forest conversion to agriculture — the bigger cause (Dewees, 1995; Geist and Lambin, 2002). Woodfuel demand-management strategies have sought to reduce woodfuel use and perverse environmental impacts generically by 1) policing/restricting indigenous forest use in deficit areas and 2) promoting alternative energy source development, and 3) for charcoal specifically, by enhancing the efficiency of production kilns, household charcoal and wood stoves, and industrial wood-burning technology. Many SSA governments have also intervened in woodfuel markets by underpricing wood for social welfare purposes of making both charcoal and firewood more affordable to the urban poor, which undermines the dual goals of natural-resource based poverty reduction and sustainable woodfuel production via financial incentives for tree growing and indigenous forest conservation (Dewees, 1989, 1995; LTS International and ONF International, 2011; SEI, 2002). Although poverty alleviation is often stated as a woodfuel production goal, forest management including smallholder-tree growing interventions often fails to effectively link farmers to markets.

The widespread adoption of community-based forest management (CBFM) approaches including joint or co-management of public forests in most SSA countries since the 1990s (FAO, 1999) offers considerable opportunities for enhancing charcoal-based poverty reduction because of their *potential* to more deeply reach into communities, and to be more locally relevant, pro-poor, equitable, and more just than top–down government approaches (Agrawal, 2005; Blaikie, 2006; Ribot, 1999). CBFM is a paradigm shift wherein governments devolve the legal authority and rights for the management and sustainable use of forest resources from top–down, centralized control to bottom–up management by organized communities which have local institutions, economic incentives, and the primary authority for implementation, guided by a forest management plan that has been mutually accepted by key stakeholders (CBNRM Net, 2008).

However, evidence of causal links between CBFM and sustained forest management remains sparse, as Lund et al. (2009) illustrate in a review of 60 CBFM studies. Many more studies illustrate the formidable challenges in making CBFM successful (e.g., Campbell et al., 2001; Pagdee et al., 2006; Poteete and Ostrom, 2008; Zulu, 2006, 2008). In a rare exception, 15 villages in Tanzania have relatively successfully regulated forest utilization via local licensing of charcoal production, and have harvested less than annual forest growth and collected adequate revenues for forest-management with an 18% surplus to fund local community services and development in a largely accountable manner (Lund and Treue, 2008). However, the poor were disproportionately impoverished and subjected to coercive treatment, and long-term sustainability remained uncertain. Other studies confirm the capture of devolved commercial rights by local and external elites (Post and Snel, 2003; Ribot, 1993, 1995, 1999) and forest bureaucracies that marginalize local people (Blaikie, 2006; Larson and Ribot, 2007; Ribot et al., 2006; Zulu, 2010). Continual deforestation and forest fragmentation in many densely populated countries limit the capacity of CBFM for significant and sustained charcoal production (Zulu, 2010).[7]

On the supply side, factors that undermine sustainable forest management also undermine charcoal-based poverty reduction. Given current limitations and largely unproven long-term potential of CBFM approaches, it is counterproductive to discount alternative interventions including large-scale plantations, natural forest based production, forest co-management, and private production of charcoal, which together expand opportunities for charcoal-based poverty reduction (LTS International and ONF International, 2011). Studies also highlight the importance of charcoal production from trees out of forests in agrarian landscapes, including agroforestry, in West Africa (Amanor and Brown, 2006; Ribot, 2002). In Malawi, up to 40% of woodfuel sources were from such trees (Dewees, 1995; Openshaw, 1997). Other promising policy options include charcoal production from co-management based public or protected forests (Zulu, 2010), hybrid institutional arrangements that combine community and household-level charcoal production from plantations (e.g., Madagascar (World Bank, 2009)). Communities organized into charcoal associations have enhanced orderly charcoal production and trading and producers' bargaining power in charcoal trading and purchase of wood from government plantations in Sudan (Mugo and Ong, 2006).

[6] Current consensus is of localized woodfuel deficits radiating from cities, but some scholars decry the scaling back of investment as premature and suggest that the woodfuel crisis is returning (Mwampamba, 2007).

[7] A study in Mozambique suggests 2585 ha as the minimum forest size needed for silviculturally sustainable charcoal production under CBFM (Herd, 2007). Many peri-urban areas lack such forest expanses.

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In sum, charcoal (and firewood) policies in most African countries are relatively neglected and too disjointed and inadequate to address the triple challenge of reliable charcoal (and firewood) supply, environmental sustainability and poverty reduction. More broadly, "change that would support poverty alleviation for forest-based communities requires a radical rethinking of forest policy so as to counterbalance widespread regressive policies and structural asymmetries" (Larson and Ribot, 2007: 189).

Charcoal production, trading and incomes in Africa

Widespread use of charcoal as both a source of income and as a cooking fuel has numerous implications for poverty alleviation throughout SSA. The World Bank (2001) framework for understanding poverty is used here to examine both the positive and negative impacts of charcoal production, trading and use on poverty through the four dimensions of the framework (i.e., (i) material deprivation, (ii) poor education and health, (iii) vulnerability and exposure to risk, and (iv) voicelessness/powerlessness).

Material deprivation: charcoal and poverty alleviation through income generation

The literature suggests three main marketing channels for the production and trading of charcoal (Kambewa et al., 2007; Ribot, 1993, 1995; SEI, 2002). The direct marketing channel involves small-scale producers selling directly to consumers. The wholesale marketing channel involves intermediaries who buy charcoal from small-scale producers and deliver it to consumers for sale. The wholesale-retail marketing channel is more complex; where intermediaries buy charcoal from producers and sell it to secondary intermediaries who transport and package the charcoal for sale to consumers in retail markets. This channel is more common in larger urban areas, and often involves politically connected urban-based traders (Ribot, 1993, 1995; World Bank, 2009).

The market for charcoal has been described as dispersed, poorly developed, and weakly regulated (Ellegård and Nordström, 2003; World Bank, 2009). Limited capacity to enforce regulations and collect tax revenues, further undermined by corruption at checkpoints along charcoal transport routes, undercut producer net incomes and government revenues that could be used in poverty reduction (Kambewa et al., 2007; World Bank, 2009). However, the charcoal economy is extensive and links to numerous enterprises, and supports livelihoods in urban and rural areas. Stable urban demand for charcoal, ease of access to forest resources (partly due to poor enforcement of regulations), and low initial investment costs attract large numbers of people to engage in the commercial production and sale of charcoal (Arnold et al., 2006; Ellegård and Nordström, 2003). As such, the charcoal trade plays an important role in poverty alleviation in both rural and urban areas throughout SSA.

The primary actors in the charcoal value chain are producers, wholesalers, retailers, and transporters. The vast majority are farmers who are engaged in charcoal production in addition to agriculture by producing charcoal from trees felled during land clearing. The charcoal market plays a significant role in generating seasonal and full-time employment in regional value chains. Studies of the charcoal value chain have identified six direct types of employment in the charcoal market (Kambewa et al., 2007; Osemeobo and Njovu, 2004):

- Large-scale commercial production, which employs many laborers
- Casual production, which employs rural farmers in small-scale production
- Wholesale trade, which employs intermediaries (or "middle-men")
- Packaging, which employs packagers and sellers of jute (fiber) bags and grain sacks
- Transportation, which employs truck drivers and bicycle transporters, and
- Retail sale, which employs both large- and small-scale retailers

In certain cases, multiple functions are performed by the same people; for example, packaging may be performed by charcoal producers themselves, by employees of wholesale traders, or by bicycle transporters. A study of the value chain of charcoal in Malawi found that the cost structure of charcoal production varied, with the packaging and production functions representing 27% to 33% of the final value, retailers representing 24% to 33%, and transporters representing 20% to 25%. Other costs included private taxes (i.e., bribes) paid to public officials and retail market fees (Kambewa et al., 2007).

Charcoal production – which typically involves cutting big trees into smaller logs and burning them in an earthen kiln – is primarily the work of men and older boys in rural villages. The charcoal is primarily meant for sale rather than use, as village wives are usually expected to collect branchwood for firewood for their own cooking and heating (Chileshe, 2005). Charcoal production enhances social and economic security in rural areas, and is an important source of non-farm income for some households which burn and sell charcoal for cash to buy grains and other household commodities when food supplies run low in the off-season. Often farmers clear land of trees for crop farming, and convert the wood into charcoal for sale. Thus, investment costs for charcoal production are low, and in some cases, returns on investment are reported to be high (Osemeobo and Njovu, 2004). However, net gains can be negative if the costs of labor, wood and other raw materials and opportunity costs are included. A cost-benefit analysis of charcoal production in a Miombo woodland in eastern Tanzania produced a negative net present value (NPV) of US$868 per hectare (Luoga et al., 2000). Still, charcoal production, distribution, and sale provide lucrative opportunities to support rural livelihoods and household income, particularly in the agricultural off-season (Chileshe, 2005; Osemeobo and Njovu, 2004). The implications of the charcoal economy for rural livelihoods may be significant given the prevalence of charcoal use and high rural poverty rates.

Charcoal is produced in Africa throughout the year, although there are seasonal variations. Production is highest during the rainy season, primarily because of higher demand; firewood is less useful when it is wet and electrical power is less reliable during the rains for the relatively few who can afford to use it for cooking. The resulting higher prices during the rainy season also attract rural households to charcoal production as a coping strategy against food insecurity (Kambewa et al., 2007). The charcoal market also offers opportunities for urban households to participate through the formation of small-scale retail businesses (Ellegård and Nordström, 2003) as well as in packaging and transportation (Kambewa et al., 2007). Studies of market participation have found that most of those engaged in the charcoal trade did not have alternative income-generation opportunities (Arnold et al., 2006; Openshaw, 1997; SEI, 2002; World Bank, 2009). This underscores the economic importance of charcoal for rural producers even though actual proceeds are generally inadequate to lift households out of poverty (Wunder, 2001).

The primary benefit of charcoal production by rural farmers is for income generation, which underscores its importance for livelihood sustenance, alleviation of poverty and material deprivation given the lack of alternative income opportunities, especially during the off-season. Studies have found that the net annual income from charcoal production compares favorably with the mean income earned by maize farmers (Osemeobo and Njovu, 2004). In most cases, the casual charcoal producer is also a maize farmer, who uses the money earned from the sale of charcoal to support farming activities in terms of seed and fertilizer procurement and land preparation. Participants in the charcoal market tend to be poorer individuals who work as small-scale producers or traders, and have limited alternatives for earning

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a living. In such cases, charcoal production can have important trickle-down effects and prop up small local businesses including bicycle (important form of transport) repairers, restaurants, bars, produce markets and traders (Zulu and Kalipeni, 2009).

Casual participation in the charcoal market is relatively common among rural farmers for several reasons. In addition to easy wood access and entry (low initial investment costs beyond own labor), charcoal production helps bridge seasonal gaps in income for farmers and helps generate working capital after clearing land in preparation for planting at the start of a new agricultural year. Charcoal also provides a "safety net" in times of hardship (Arnold et al., 2006; Shackleton and Shackleton, 2004) or in years marked by low crop yields to sustain their households. Participation in the charcoal market often fluctuates inversely with agricultural and urban labor markets; that is, the number of people involved in woodfuel markets has been found to increase when crop income falls and when urban job opportunities shrink (Arnold et al., 2006).

In urban areas, charcoal provides income opportunities through small retail businesses. In addition to income generation, charcoal also provides secondary social benefits in terms of employment, income distribution, and social stability. A study investigating the areas supplying charcoal to three southern African cities found that about 240,000 people were involved as producers, transporters, or retailers in these activities, which provided upwards of 70% of their cash income (SEI, 2002). Charcoal also supports employment for charcoal stove producers, traders, and scrap metal collectors and traders in urban areas (World Bank, 2009).

As a major commercial activity in and near forested areas, charcoal provides income, employment and social stability across all wealth strata. However, the benefits and power are not shared equally across the value chain. In some cases, rural farmers are exploited by intermediaries to keep charcoal prices low, to the benefit of the wholesale traders. To entice producers, wholesale traders from urban areas provide farmers credit or cash advances to meet their needs during the off-season for crop farming, and they help farmers to secure necessary permits for production (Osemeobo and Njovu, 2004). In addition to its potential role in alleviating rural poverty, the charcoal trade provides income opportunities in urban areas through micro- and small-scale retail enterprises that include women (Ellegàrd and Nordström, 2003; IEA, 2002). Poor households are more likely to be involved in the sale of charcoal and other forest products, in part because of material deprivation and the lack of alternative livelihoods (Shackleton and Shackleton, 2006).

Material deprivation: urban poverty alleviation through energy provision

While charcoal is the main source of cooking fuel for most urban households, it is particularly vital for poor households who lack alternative sources. In most countries in eastern and southern Africa, over 90% of urban households use charcoal to some extent (IEA, 2002). A study of the charcoal markets in southern African cities found that consumption of charcoal grew during 1990–2000 by about 80% in both Lusaka and Dar es Salaam, with the proportion of households in the latter reporting charcoal as their principal fuel increasing from about 50 to 70% over the same period (SEI, 2002). Thus, although charcoal is preferred over firewood, dependence on charcoal as a cooking fuel and the relatively poor energy services and opportunities it offers are related to poverty (material deprivation) because most urban households cannot afford modern, alternative cooking fuels (Ellegàrd and Nordström, 2003; Kambewa et al., 2007).

Lower-income households generally consume more charcoal per capita, but wealthier households also use charcoal. Although wealthier households tend to use more charcoal, total expenditure on charcoal has been found to be similar among lower-income and higher-income households (Akpalu et al., 2011). Lower-income households often pay a higher price per kilogram for charcoal because they buy it in smaller packages; wealthier households will typically purchase larger quantities for a lower price per kilogram. Furthermore, households in poorer high-density areas generally pay a higher price per bag than households in wealthier low-density areas (Kambewa et al., 2007).

Rapid population growth, urbanization and improved incomes are generally associated with decreases in firewood use and increases in charcoal consumption (Arnold, et al., 2006), but persistently low household incomes in SSA mean that woodfuel demand will also increase in the short to medium term because even as some households move up to charcoal, not enough are moving up in the energy ladder beyond charcoal to alternative fuels to offset aggregate woodfuel-demand increases. Thus, per capita consumption of firewood has been declining while charcoal consumption is increasing in importance (Whiteman et al., 2002). The growth rate in charcoal consumption in Africa between 1990 and 2000 was roughly double that of firewood consumption (Arnold et al., 2006). Charcoal prices have been surprisingly stable at around 10 US cents ($0.10) per kilogram for the past couple of decades (Ellegàrd and Nordström, 2003), and the demand is assumed to be price inelastic (Chomitz and Griffiths, 2001; Zein-Elabdin, 1997).

Most analyses of woodfuel demand have estimated negative income elasticities (Arnold et al., 2006; Hughes-Cromwick, 1985; Shackleton and Shackleton, 2006), implying that households will convert to modern fuels with an increase in income. However, charcoal is frequently the "transition fuel" to which households switch first when they move away from firewood. In practice, the income elasticity of demand for charcoal changes as income changes; specifically, income elasticity of charcoal demand will decrease as income increases, turning negative at the uppermost strata (Hughes-Cromwick, 1985; IEA, 2010; Zein-Elabdin, 1997). Therefore, both firewood and charcoal are assumed to be "normal" goods for lower-income households and "inferior" goods for higher-income households, meaning that the income elasticities of demand become negative as income increases. However, urban households are generally more likely to use charcoal due to wood scarcity, thus the switch to an inferior good occurs at a higher income level for charcoal users (Arnold et al., 2006).

Negative impacts of charcoal production on poverty

Despite the potential for charcoal to contribute to poverty alleviation and ease the effects of material deprivation, several negative impacts of charcoal production and dependence have been noted. Excessive extraction of forest resources for fuel threatens the sustainability and integrity of forest ecosystems that underpin the very livelihood opportunities that support poverty alleviation and food security (Richardson, 2010). Indoor air pollution from charcoal stoves contributes to respiratory infections in children and lung diseases in adults (Akpalu et al., 2011; Bailis et al., 2005). Charcoal may hinder poverty alleviation in SSA in three general ways that align with the other three dimensions of poverty (World Bank, 2001). First, charcoal production increases vulnerability and exposure to risk by contributing to environmental degradation through deforestation, soil erosion, and increases in greenhouse gas emissions. This environmental degradation may undermine the benefits of participation in the charcoal market discussed above. Second, charcoal production and use are related to human health through negative impacts such as smoke inhalation, lung disease, injury, and death. Third, the social impacts of charcoal production and trade may increase voicelessness, particularly for female-headed households, given the gender-based divisions of labor in the charcoal market and the implications for energy security. Variations in the legality of charcoal trading also increase incidence of corruption, exploitation, arbitrary increases in transaction costs, and marginalization of women and the poor. These negative impacts of charcoal on poverty alleviation are expounded in the following sections.

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Vulnerability and risk: environmental impacts of charcoal production and trade

Forest ecosystems have a profound impact on rural livelihoods and food security throughout SSA (Richardson, 2010). Forests support livelihoods in rural communities through provision of food, fuel, shelter, fodder, medicine and income from sales of these products. Forests enhance food yields by protecting biodiversity that is essential to human survival. Forests also supply diverse and vital ecosystem services to people, including carbon sequestration, waste treatment, nutrient cycling, pest control, and pollination of crops and other vegetation. Trees in forests and in agroforestry systems help control soil erosion and protect cropland and pasture. However, charcoal production and demand have contributed to localized deforestation around numerous African cities, and the associated environmental degradation and soil erosion have led to lower agricultural productivity (Alem et al., 2010; Arnold et al., 2006; Kambewa et al., 2007; Luoga et al., 2000; Mwampamba, 2007; Ribot, 1999; SEI, 2002). Deforestation has also been associated with disturbances in hydrological cycles that lead to desertification and increased salinity (Richardson, 2010). Deforestation and environmental degradation threaten forest integrity and ultimately the sustainable provision of other forest resources and ecosystem services upon which poor households depend (Pimentel et al., 1997; Richardson, 2010). In that sense, the environmental impacts of charcoal production and trade increase the vulnerability of rural households and exposure to risks that are associated with poverty.

The rise in fossil fuel prices in the 1970s gave rise to a heightened concern with energy issues, including an interest in the impact of the use of wood as a source of energy on a large scale (Arnold et al., 2006; Eckholm, 1975). Lack of reliable data constrained analysis, and early estimates focused on the measurement of woodfuel gaps, the margin by which projected demand exceeded estimated annual growth, leading to the crisis narratives discussed earlier. One key study estimated in 1980 that two billion people depended on woodfuel and other biomass, and predicted that by 2000, 2.4 billion people would face acute woodfuel scarcity due largely to overcutting (DeMontalembert and Clément, 1983). By the mid-1980s, it became clear that woodfuel shortages had not materialized to the extent that was predicted in the studies of the woodfuel gap, and woodfuel use did not appear to pose as serious a threat of widespread deforestation (Arnold et al., 2006). However, more recent studies have noted localized woodfuel scarcities (Ahrends et al., 2010; Clancy, 2008; Mwampamba, 2007; SEI, 2002). An analysis of case studies in tropical countries found that woodfuel extraction is an important factor in deforestation, particularly in areas in Africa where wood harvesting is prevalent (Chidumayo and Gumbo, this issue; Geist and Lambin, 2002). A World Bank study of six countries in West Africa found that extraction was a source of deforestation where charcoal production is concentrated (Ninnin, 1994). More recently, woodfuel burning is linked to significant contributions to global warming, with long-term, broader negative impacts (e.g., Brocard and Lacaux, 1998 for West Africa and Kutsch et al., 2011 for Zambia). Thus, the discrediting of the "woodfuel crisis" as exaggerated should not provide a false sense of security against real charcoal-driven deforestation and environmental degradation that can undermine poverty reduction, just as using charcoal as a scapegoat for all deforestation fails to adequately address the problem. The ecological integrity of forests is vital to poverty alleviation in Africa, mostly because of the dependence of the poor on forest resources (Richardson, 2010).

Human health: impacts of charcoal use

Charcoal use can lead to serious health damage from indoor smoke pollution. Ambient air pollution and personal exposure levels from cooking with charcoal are high; traditional cooking stoves may result in exposure to toxic pollutants that pose extreme risks to human health (Akpalu et al., 2011). Possible effects include respiratory diseases, such as asthma and acute respiratory infections; obstetrical problems, such as stillbirth and low birth weight; blindness; and heart disease (IEA, 2002).[8] Traditional charcoal stoves emit large amounts of carbon monoxide and other noxious gasses. Women and children suffer most because they are exposed to fumes from cooking fires for the longest periods of time. Studies have found a positive association between indoor air pollution from cooking stoves and acute lower respiratory infections in children and obstructive lung diseases in adults (Akpalu et al., 2011; Ezzati and Kammen, 2001). Recent attention has focused on encouraging use of improved stoves out of increased concern for the need to reduce damage to health from air borne particulates and noxious fumes associated with the burning of firewood and charcoal (and other forms of biomass). The rationale behind improved stoves is that the fuel efficiency of traditional stoves can be raised or even multiplied by simple modifications in design in order to reduce overall woodfuel consumption and consequently reduce deforestation, and reduce emissions of pollutants, thereby improving public health (Zein-Elabdin, 1997). A wide range of improved stove designs can be found, and reported fuel savings vary from 10% to 60% (e.g., Bazile, 2002; Bhattacharya et al., 2002; Maesa and Verbist, 2012).

The ability of improved stoves to engender a significant and lasting reduction in charcoal and firewood consumption is jeopardized by the presence of secondary effects, in the form of additional consumption of woodfuels. This consumption may result from gains in real income generated by the use of more efficient appliances (income effects), or from downward adjustments in charcoal prices following the initial reduction in fuel requirements (price effects) (Zein-Elabdin, 1997). Damage to health caused by emissions from stoves may be considered a low priority issue as compared to health problems related to water supply and sanitation (Arnold et al., 2006). Additional studies of household behavior will be needed in order to understand the determinants of adoption and use of improved stoves.

However, other reports suggest that the evidence linking indoor air pollution to increased respiratory infection is limited, and that there is currently no convincing evidence that improved stoves lead to improved health (Arnold et al., 2006; DFID, 2002). Improved stoves may be most effective in places with low demand elasticities, since it will encourage households to move up the fuel ladder (Zein-Elabdin, 1997).

Substitution among cooking fuels is common across SSA, as in most other developing regions. Substitution between charcoal and firewood is common in rural areas, while LPG and kerosene are frequently substituted for charcoal in urban households (Akpalu et al., 2011). A shift from cooking with wood to charcoal reduces the overall health risk by a factor of more than four. A shift to kerosene results in a reduction by a factor of six. Using LPG reduces the overall health risk by a factor of more than 100 (IEA, 2002).

Voicelessness: social impacts of charcoal production and trade

Charcoal enhances or undermines poverty reduction when planned or incidental elements of its production and trading strengthen or weaken the voice, power and independence of individuals. For instance, CBFM approaches and enabling laws and policies are generally seen as having the potential to empower local communities and enhance tenure security, inclusion, user rights and access to forest resources, local decision-making and capacity for self reliance, equity, and social justice (Agrawal, 2005; Arnold et al., 2006; Blaikie, 2006; Lele et al., 2000; Lund and Treue, 2008; Ribot, 1993, 1999, 2002). However, struggle over access to forest resources (including charcoal production and trading opportunities) and power relations of domination and marginalization

[8] Pollutants from combustion of biomass fuels including charcoal have been associated with more than 1.6 million deaths globally each year, roughly 400,000 in SSA alone (Bailis, 2005; Ezzati et al., 2002).

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characterize forest resources management and distributional outcomes (Agrawal, 2005; Ribot, 1993, 1999; Richardson, 2010; Robbins, 2012; Zulu, 2008, 2010). Voicelessness, powerlessness and dependency arise from various sources. These include threats of physical force, arbitrary exercise of bureaucratic power, corruption and lack of predictability of state authorities. These factors undermine legal protections of producers/traders from exploitation and increase transaction costs, elite capture, gender inequity, and marginalization of the poor and women (World Bank, 2001). Exploiting the poor in patron–client relationships surrounding charcoal production/trading, and unnecessarily burdening them beyond their ability to utilize new economic opportunities outside their tight zone of socio-economic security also exacerbate poverty. Voicelessness and powerlessness also undermine charcoal-based poverty reduction in other ways linked to material deprivation, poor health, and vulnerability or risk exposure, and can help determine winners (often the powerful) and losers (usually the poor and powerless).

Senegal provides a classic case of community voicelessness/powerlessness over charcoal commercial rights despite ostensibly accommodating laws. Although new forest laws (1998) devolved meaningful powers to communities to manage forest resources, to license or produce charcoal under a state-controlled quota system, and to choose not to commercially exploit their forests, the charcoal sector was really controlled by networks of forestry officials and urban charcoal cartels who exploited village forestry resources despite local opposition, and employed foreigners to produce the charcoal (and benefit financially) while the villagers bore the costs of charcoal-induced environmental degradation and associated firewood shortages (Larson and Ribot, 2007; Ribot, 1998). This also reflects the arbitrary use of bureaucratic power, which includes selective implementation of forest laws and delaying tactics to deny communities' opportunities for commercial charcoal production and poverty reduction, as also noted elsewhere (Ribot et al., 2006; Zulu, 2010).

Restrictions on legal charcoal production and trading in some African countries not only reduce income-generation and poverty-reduction opportunities, but by driving charcoal into the informal sector, they also expose small-scale producers to mistreatment, physical violence, seizure of their produce and/or bicycles, and extortion by corrupt police and forestry officials, thereby increasing transaction costs and reducing net incomes (Kambewa et al., 2007; SEI, 2002; World Bank, 2009; Zulu, 2010). Power differentials in the value chain also affect distribution of charcoal profits. A recent analysis in Tanzania shows that a few intermediaries (transporters and wholesalers) retained half of total profits while producers shared only a third and urban retailers (including women) received only 17% (World Bank, 2009). Poverty and poor/lack of organization undermined the negotiating power of independent producers and ability to retain a larger share of charcoal's market value relative to transporting and wholesaling elites (often organized into informal trading cartels). This scenario repeats itself elsewhere, such as in Malawi (Kambewa et al., 2007; MARGE, 2009; Zulu, 2010), and ultimately undermines poverty reduction strategies. Interventions should include measures informed by value-chain analysis to help small producers and retailers retain more of the charcoal value, e.g., by removing some middlemen or organizing producers into associations to enhance their bargaining power.

Impacts of helplessness and added risk extend to health and safety. Charcoal production and transportation also have a physical toll including injury. In southern Malawi, subsistence charcoal producers and small-scale traders would transport 40–75 kg of charcoal manually or by bicycle for up to 18 h and distances of up to 40–50 km to urban residential areas where they sold their charcoal (Zulu and Kalipeni, 2009). Even then, in the context of a ban on charcoal trading, the producers/traders risked losing their charcoal and suffered emotional and "physical abuse at the hands of armed forest-patrol teams which sporadically impounded the illegal charcoal and their bicycles" (p. 264). Most producers, average age 38, said they stayed in charcoal production/trading out of desperation.

Prospects of and limits to charcoal production as a tool for poverty reduction—a conclusion

A review of the charcoal/poverty literature shows that charcoal production and trading offer many win–win opportunities and can help to alleviate poverty at multiple scales: enhanced government revenues from charcoal licensing and taxation and significant contribution to GDP nationally, meeting productive energy needs in urban areas inexpensively and potentially sustainably, and increasing household incomes in both rural and urban areas while providing incentives for tree growing and conservation. In particular, the reviewed literature suggests that legalized and regulated charcoal production can help to enhance net positive poverty-alleviation outcomes for a larger number of participants in the charcoal value chain, particularly the rural poor, although more empirical supporting evidence is required. However, the relationship between charcoal and poverty is complex and there are limits to charcoal-based poverty alleviation — see Table 1 for a summary of positive and negative impacts along the four dimensions of poverty (World Bank, 2001). The best-case scenario for the majority of beneficiaries is the continual supplemental role of charcoal as a "safety net" that rarely lifts people out of poverty. Despite its seasonal and supplemental nature, charcoal provides locally significant income in otherwise economically depressed and poor peri-urban areas, and provides potential synergies for further poverty reduction. Charcoal proceeds are often used to buy agricultural inputs and can enhance agricultural productivity and food security. Charcoal incomes often provide "seed" money (capital) for alternative income generating activities, and have other positive downstream economic effects in producing areas.

For most urban dwellers, the use of charcoal for energy provides potential savings in energy expenditures relative to the growing costs of petroleum-based alternatives (LPG and kerosene) and electricity (costly, unreliable, and many houses are not connected to it).

Table 1
Charcoal and poverty alleviation in sub-Saharan Africa.

The table shows the positive and negative impacts of charcoal production and trading on the World Bank's (2001) four dimensions of poverty.

Dimensions of poverty	Support for poverty alleviation	Negative effects on poverty
Material deprivation	Income generation Affordable (urban) and renewable source of energy Tax revenues enhance GDP, fund poverty reduction, conservation	Potentially unsustainable dependency Labor diversion threatens food security
Vulnerability and exposure to risk	Socio-economic safety net Reliable fuel (urban users)	Deforestation, loss of ecosystem services Environmental degradation
Health and education	Burns cleaner than firewood, crop residues	Disease and death from pollution Physical injury from production, transport
Voicelessness and powerlessness	Empowerment and equity, e.g. under CBFM	Elite capture of use rights, market power Marginalization of the poor Shifts greater share of farm labor to women

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The savings can be used for other household needs. Policies that formalize charcoal production and trading will provide more employment and income opportunities to urban charcoal retailers (including women), transporters and wholesalers and small-scale charcoal-stove producers. Charcoal also represents a significant improvement in the quality of energy services over firewood and crop residues. However, for the majority of users, charcoal's role in the short-medium term is essentially the maintenance of the status quo rather than reduction of material and energy poverty, while still providing a small proportion of urban dwellers the pathway to transition up the energy ladder to cleaner fuels and 'superior' energy services based on improved household incomes.

Charcoal production, trading and use also have negative impacts on poverty reduction. Production causes localized but growing circles of deforestation and environmental degradation around urban areas – charcoal's "urban ecological footprint" (Clancy, 2008) – which ultimately undermines ecosystem services including elements of agricultural productivity and increases the vulnerability of poor farmers to food and livelihood insecurity. Charcoal production also undermines agricultural productivity by diverting male labor (since charcoal is a predominantly men's activity) from agriculture, while at the same time overburdening women with food growing in attempts to make up for the labor gap, thereby reinforcing or exacerbating gender inequities that undermine the economic independence and voices of women. In urban areas, charcoal-burning air pollution causes illness and death among users, especially women and children. This weakens the productive and poverty-reduction potential of household members. Finally, the lack of negotiating power and voice among independent charcoal producers and retailers allows concentration of the share of the market value of charcoal in the hands of a few powerful, politically connected, urban-based transporters and wholesalers. Cartel-like networks of forestry officials, urban and local elites often control access to forest resources and charcoal markets, and marginalize or exploit rural communities while saddling them with the resulting costs of environmental degradation. Policy interventions should be evidence based including measures informed by value-chain analysis to help small-scale producers and retailers retain more of the charcoal value, e.g., by removing some middlemen or organizing producers into associations to enhance their bargaining power (as in Mugo and Ong, 2006).

The reviewed literature also shows continuing growth in urban charcoal demand with rapid population growth, urbanization and increasing costs of alternative fuels, and affirms the dominance of charcoal in SSA countries' energy balance in the coming few decades (e.g. IEA, 2002, 2010). Anticipated fuel switching from woodfuels to more 'modern' energy sources under the energy transition hypothesis (Zein-Elabdin, 1997) is not straightforward in SSA. It is proceeding at a slower pace than anticipated given persistently high levels of poverty (affordability), structural problems with access to main alternatives (LPG, kerosene and electricity), and cultural factors. Findings therefore point to an incomplete transition and continued dependence on charcoal within a fuel mix in the foreseeable future (Chambwera and Folmer, 2007; Hiemstra-van der Horst and Hovorka, 2008; Hosier and Dowd, 1987; Martins, 2005; Masera et al., 2000; Zulu, 2010). Thus it is time for African governments to remove their heads out of the sand and proactively reform charcoal policies and laws to promote regulated, sustainable production and trading of charcoal.

Charcoal and poverty issues are complex and require multi-faceted and integrated approaches both on the production and demand side. Current policies in most SSA countries are lacking, disjointed across relevant sectors, or too restrictive (e.g., charcoal bans) and inadequate to address the triple challenge of reliable charcoal (and firewood) production and supply, environmental sustainability (including charcoal based government revenues for conservation), and poverty reduction. There is a need for radical rethinking to promote pro-poor and pro-sustainability charcoal policies that are coordinated across relevant sectors (e.g., forestry, agriculture, water, energy, micro-finance, trade, and finance or economic development), remove restrictions to regulated commercial charcoal production and provide appropriate, graduated economic incentives and penalties to ensure clearly defined and verifiable sustainability as an important start. Further, legalization or formalization of charcoal production, distribution and trading would not only expand economic opportunities for poverty reduction, but would also minimize arbitrary use of bureaucratic power, incentives for corruption, and mistreatment of charcoal producers and traders. Limited state capacity to implement charcoal policy, including regulated sustainable production, bureaucratic inertia and structural inequities and land-tenure insecurities are other challenges that require addressing. However, caution is required lest the reforms are too hurried for current implementation capacity and make matters worse. Charcoal policy innovations should also address the negative and politically controversial image of charcoal through concerted and targeted evidence-based advocacy highlighting the woodfuel sector's benefits as an important productive economic sector deserving higher prominence in key economic development blueprints, including PRSPs.

Ultimately, there are no policy panaceas. A plurality of flexible carefully targeted and locally appropriate approaches (including CBFM and co-management) integrated around the issue of charcoal and poverty reduction is the way forward. For instance, properly targeted, implemented, and scaled up, CBFM that devolves meaningful levels of authority to communities offers a unique opportunity to expand commercial utilization rights to communities, enhance property rights, address issues of equity, while enhancing the combined potential for sustained forest management, charcoal production and poverty reduction. However, CBFM has limitations. It has to be supplemented with promotion of private tree growing (within and off farms), larger-scale plantations (e.g., Sudan, Mugo and Ong., 2006), and co-management or concessionary arrangements in indigenous public forests (LTS International and ONF International, 2011; World Bank, 2009; Zulu, 2010) in a multi-faceted approach to expand supply and income opportunities. However, how charcoal supply, poverty reduction and forest conservation goals can be made compatible in practice requires further research. Integrated policies that create synergies among woodfuel production, sustainable forest management, and poverty reduction are needed.

The uniquely long gestation periods to produce wood (tree growing, forestry) for charcoal is already economically unattractive and there is need for appropriate incentives. To start with, on the demand side, governments should confront the politically risky yet essential measured removal of wood under-pricing policies and other market imperfections in order to reflect the true value of charcoal, which will act as an incentive for investment in more sustainable production of charcoal. Promotion of appropriate and more efficient charcoal production kilns along with more effective control of indigenous forest harvesting would also help reduce the amount of wood used, lower production costs and promote conservation. Promotion of the use of more efficient charcoal stoves in urban areas would produce energy savings that would at least partly compensate for anticipated charcoal-price increases and the higher wood use per tonne of charcoal produced relative to a tone of firewood. The resulting reduction of the negative impacts of charcoal use and production would make potential improvements in charcoal-based rural and urban employment more significantly positive in terms of poverty reduction because there would be fewer negative impacts (World Bank, 2009). Overall, considerable enhancement in institutional capacity (financial, human, technical) and donor support will be required for the effective regulation of the charcoal trade and the gradual but necessary step of bringing the largely informal charcoal sector into the formal, tax-based economy to expand economic opportunities, poverty reduction, and contribute revenues to regulate sustainable charcoal production. Links with initiatives on climate-change adaptation and mitigation, especially Reducing Emissions from Deforestation and Forest Degradation (REDD, REDD$^+$) offer new opportunities

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for synergistic mobilization of resources and purpose to promote sustainable charcoal production and poverty reduction.[9] For now, charcoal production and trading provide much needed incomes to poverty stricken rural and urban dwellers, but the extent to which poverty-reduction opportunities are expanded and made sustainable depends less on some panacea and more on locally specific mixes of production and trading related policy interventions including incentives and penalties, and contextual demographic, economic, socio-political, ecological and other factors.

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[9] REDD+ includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

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