Wood fuel production, utilisation, marketing and conservation strategies in Social Forestry

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Introduction

Woodfuels consist of three main commodities: fuelwood, charcoal and black liquor. Fuelwood and charcoal are traditional forest products derived from the forest, trees outside forests, wood-processing industries and recycled wooden products from society. Black liquors are by-products of the pulp and paper industry. Woodfuels, as well as other traditional sources of energy such as agricultural residues and animal dung, have an important role in the lives of the rural populations in developing countries. Fuelwood and charcoal, the commonest forms of woodfuel, are used widely as household power sources in poor rural neighbourhoods in developing countries. Dependence on woodfuels to meet household energy needs is especially high in most of sub-Saharan Africa, where 90% to 98% of residential energy consumption is met by woodfuels.

According to estimates, African woodfuel consumption reached 623 million m^3 in 1994. This consumption level means that Africa has the highest per capita woodfuel consumption (0.89 m^3/ year) compared to other continents (eg Asia 0.3 m^3/ year) (FAO. 1999).

All African countries (except the five North African countries and South Africa) still depend heavily on wood to meet basic energy needs. In the various African regions, woodfuel share ranges from 61% to 86% of primary energy consumption, with a major part (74% to 97%) consumed by households. The management of woodfuel resources and demand should be considered a major issue in energy planning processes in Africa.

On the other hand, woodfuel consumption is a major contributor to total wood removal, accounting for around 92% of total African wood consumption and contributing to greenhouse gas emissions. Woodfuel use is therefore a major local and global environmental issue in Africa, and should be fully integrated into forestry planning and environmental protection processes.

In addition, woodfuels play a major socio-economic role in almost all African countries. Within the family, women are generally the most concerned by fuelwood issues since they devote a lot of their time to fuelwood gathering and cooking tasks; charcoal production and marketing on the other hand tend to be more formalized and male-specific, helping to provide jobs and substantial revenue for rural and urban people. These activities represent significant economic value in many countries, accounting for approximately US$ 6 billion for the whole of Africa. More than US$ 1 billion of this amount was made up by charcoal (FAO. 1999).

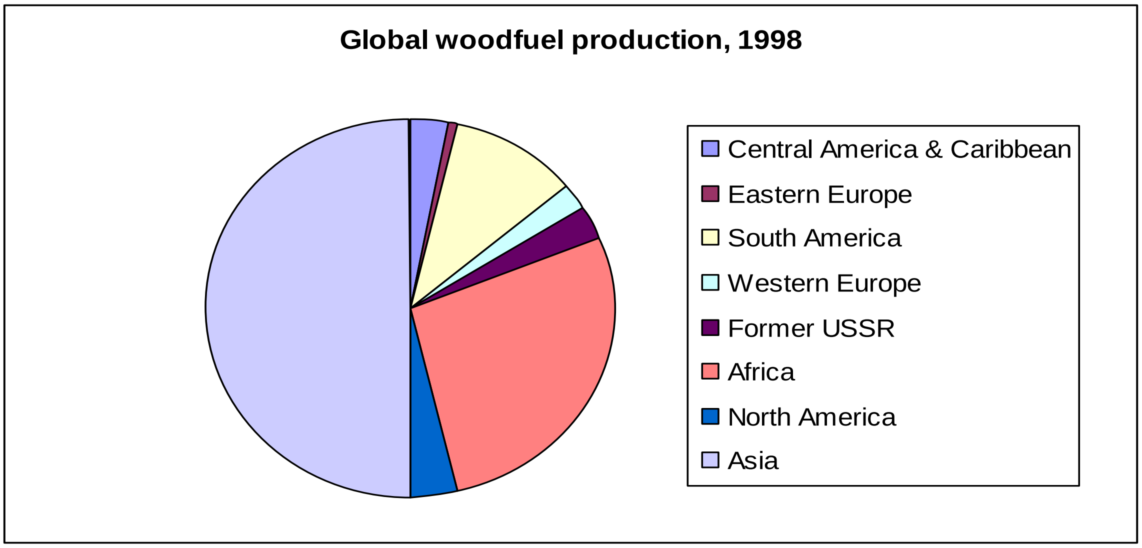
While fuelwood traditionally accounted for a major part of total woodfuel consumption, the social and economic changes associated with urbanisation will lead to a significant shift from fuelwood to charcoal, increasing its energy, environmental, economic, and social role in Africa in the future.

Woodfuel production

Woodfuels come from a variety of supply sources, such as forests, non-forest lands and forest industry by-products. In 1998, 3.2 billion m^3 of wood were harvested worldwide, more than 50% of which was used for woodfuel (WEC, 2004). It has often been said that most woodfuel are obtained from forests, contributing to deforestation in a major way. However, it is now estimated that considerable amounts of woodfuels come from non-forest areas, such as village lands, agricultural land, agricultural crop plantations, homesteads and trees along roadsides.

The production of woodfuels is estimated to cover nearly 6% of the world energy requirement, although there are undoubtedly some difficulties in quantification. Woodfuels' share is thus larger than that of hydro and other renewable energy resources, but smaller than that of nuclear (WEC, 2004). Asia and Africa use 75% of global woodfuels. Note that Woodfuel production in 1998 totalled 1.8 billion cubic meters (Matthews E. 2000)

Figure 1: Global woodfuel production in 1998



A re-evaluation of woodfuels has shown that considerable amounts are now estimated to come from non-forest sources. Woodfuels continue to be used traditionally in rural areas of developing countries where they remain a burden for women and children to collect and, owing to their incomplete and inefficient combustion, also hazardous to health. Whilst rising income levels and urbanisation in developing countries have resulted in a reduced share of woodfuels in their overall energy use, changes in energy and environmental policies, such as global warming mitigation, in developed countries have led to an increased use of woodfuels, often as modern biomass. A special Report on Emissions Scenarios produced by the Intergovernmental Panel on Climate Change (IPCC) has concluded that although the longer-term maximum technical energy potential of biomass could be large (around 2 600 EJ), this potential is constrained by competing agricultural demands for food production, low productivity in biomass production, etc.

Despite a growing interest in Biomass (other than wood), as a result of energy market reforms, environmental concerns, and technological advances, the major remaining challenges are the low combustion efficiency and health hazards associated with traditional use of bio-energy. Because of the many difficulties in assessing the energy potential of residues, it is suggested that the focus should be on the most successful forms such as sugar cane bagasse in agriculture, pulp and paper residues in forestry and manure in livestock residues. The modernisation of biomass use relates to a range of technological options, such as gasification, co-firing with fossil fuels, micro-power, tri-generation, and ethanol.

There are various charcoal production methods, however, the most commonly used is the traditional earth mound which yields the lowest recovery rates (<15%). Some of the high yielding kilns such as the Metal kiln, the Masonry kilns and Retort kilns require high investment and thus would be suitable where there is a substantial quantity of fuelwood. Social aspects related to charcoal production are seen in particular communities where charcoal production is an off-season enterprise to generate some income for the family.

The energy efficiency of the process is dependent upon many factors: kiln type, moisture content, wood species, wood arrangement, and the skill of the producer. Many programs over the past century have been implemented to increase efficiency of charcoal kilns.

Table 1 shows the levels of fuelwood production in some African countries. These figures should not be taken as definitive, precise measurements but as, in general, no more than indicative of the magnitude involved. Where necessary, fuelwood volumes in cubic metres have been converted into tonnes by using an average density of 0.725.

Table 1.0 Wood: land area, forest area and fuelwood production in 1999

	Total land area	Forest area	Fuelwood production
Country	Thousand square km		Million Tonnes
Algeria	2 382	21	1.6
Angola	1 247	698	4.6
Benin	111	27	2.5
Botswana	567	124	1.5
Burkina Faso	274	71	9.2
Burundi	26	1	5.0
Cameroon	465	239	11.2
Cape Verde	4	1	0.1
Central African Republic	623	229	2.4
Chad	1 259	127	1.7
Comoros	2	N	0.2

Congo (Brazzaville)	341	221	2.1
Congo (Democratic Rep.)	2 267	1 352	36.5
Côte d'Ivoire	318	71	6.9
Djibouti	23	N	0.1
Egypt (Arab Rep.)	995	1	1.8
Equatorial Guinea	28	18	0.3
Eritrea	101	16	2.9
Ethiopia	1 000	46	48.0
Gabon	258	218	0.8
Gambia	10	5	0.7
Ghana	228	63	6.5
Guinea	246	69	5.7
Guinea-Bissau	28	22	0.3
Kenya	569	171	29.3
Lesotho	30	N	1.2
Liberia	96	35	1.3
Libya/GSPLAJ	1 760	4	0.4
Madagascar	582	117	8.1
Malawi	94	26	8.2
Mali	1 220	132	5.7
Mauritania	1 025	3	0.2
Mauritius	2	N	N
Morocco	446	30	7.6
Mozambique	784	306	15.8
Namibia	823	80	1.5
Niger	1 267	13	3.1
Nigeria	911	135	91.6
Réunion	3	1	N
Rwanda	25	3	4.2
São Tome and Principe	1	N	0.1
Senegal	193	62	3.3
Seychelles	N	N	N
Sierra Leone	72	11	2.3
Somalia	627	75	2.7
South Africa	1 221	89	8.2
Sudan	2 376	616	6.4
Swaziland	17	5	0.5
Tanzania	884	388	34.5
Togo	54	5	2.4
Tunisia	155	5	2.1
Uganda	200	42	16.2
Western Sahara	266	2	

Zambia	743	313	8.0
Zimbabwe	387	190	10.8
Total Africa	**29 636**	**6 499**	**428.3**

Ref: World Energy Council (WEC), 2004

Woodfuel utilisation

In countries with significant fossil fuel resources like Gabon, Nigeria, and Angola, biomass constitutes the majority of national energy consumption. Moreover, it is clear that household electrification rates are quite low. The regional average is roughly 23 percent of households (Bailis R. et al.,2004). However, electricity tends to be the most expensive option for cooking, so that even in countries where household access exceeds the regional average, biomass fuels still dominate energy supply. In addition, biomass is typically used in different forms in SSA. (Bailis R. *et al.* 2004).

There are many problems facing people and the environment from the use of wood and charcoal-burning stoves: heavy labour finding, cutting and carrying wood, usually by women and girls; degradation of the environment from loss of trees and resulting erosion and habitat destruction; emissions of products of incomplete combustion including carbon monoxide, nitrogen and sulphur oxides and various organic compounds as well as particulate matter; and, the health damage inflicted by particulate matter which contributes to acute respiratory infection —the leading cause of illness in developing nations.

The technology of improved cooking stoves is available. However, they are not readily adopted due to production costs (material could be expensive due to importation of fabricating material), final product cost (this could be high due to the high material cost), training costs (people would have to be trained in making the improved stove and how to use it), resistant to change (people may be resistant to change the stoves they use), availability of woodfuel (it is getting scarce), availability of funds to develop new efficient stoves.

Case study – Development of the Kenya Ceramic Jiko

The Kenya Ceramic Jiko (KCJ) is a portable improved charcoal burning stove consisting of an hour-glass shaped metal cladding with an interior ceramic liner that is perforated to permit the ash to fall to the collection box at the base. A thin layer of vermiculite or cement is placed between the cladding and the liner. A single pot is placed on the rests at the top of the stove.

The KCJ is the result of research on stove design, efficiency, and patterns of usage initiated in the 1970's and actively continued through the 1980's

The Kenya Ceramic Jiko (KCJ)

The process of research, development, demonstration and then commercialization that led first to the KCJ and then to other stove models in Kenya was seeded by international and local development funds. After explicit consideration a decision was made not to directly subsidize commercial stove production and dissemination. Initially stoves were expensive (~ US$ 15/stove), sales were slow, and the quality was variable. Continued research and refinement, and expanded numbers and types of manufacturers and vendors increased competition, and spurred innovations in materials used and in production methods. The wholesale and retail network for stoves is now extensive. The KCJ can be purchased in a variety of sizes. Prices for KCJ models have decreased to roughly US$ 1 - 3 depending on stove size, design and quality (Kammen, D.1995). This decrease is consistent with the 'learning curve' theory of price reductions through innovations that result from experience gained in the manufacturing, distribution, marketing and sales process.

The ceramic liner of the KCJ degrades over time, and needs to be replaced. Street vendors of stoves, and many of the larger stove sales outlets take 'used' stoves back, discounting the purchase of a new stove. The liners of the old stove are then removed, the metal cladding is repaired, if needed, and the stove is reassembled, repainted, and resold. This process has also served to involve a wider informal sector economy in the stove process.

Reductions in fuel use associated with the KCJ and other improved stoves have been examined in a number of countries. In Kenya charcoal use among a sample of families using the KCJ fell from 0.67 to 0.39 kg/charcoal/day. This totals over 600 kg of charcoal/year for an average family, and a savings of over $US 60/year. A study in Rwanda prior to the war found charcoal use fell from 0.51 kg/person/day to 0.33 with the use of improved stoves. Personal incomes in Kenya and Rwanda average $300 - 400/year (Karekezi and Ranja, 1997).

The KCJ is derived from a 'bucket' stove that a team of Kenyan researchers examined in Thailand, and then was successively adapted to east African cooking practices. The stove has continued to evolve in response to usage, metal fatigue and other tests, as well as in response to feedback from stove users.

The KCJ stove design has now been transferred, or has been the model for locally adapted stove designs or initiatives, in a number of other nations, including Ethiopia, Malawi, Niger, Rwanda, Senegal, Sudan, and Uganda (see Table 1).

Table 1: Estimates of the number of improved stoves disseminated in Eastern and Southern Africa (Karekezi and Ranja, 1997).			
Country	**Urban**	**Rural**	**Total**
Kenya	600,000	180,000	780,000
Tanzania	54,000	--	54,000
Uganda	52,000	--	52,000
Ethiopia	23,000	22,000	45,000
Rwanda*	30,000	--	30,000
Sudan	27,000	1,400	28,400
Zimbabwe	11,000	10,000	21,000
Burundi*	20,500	--	20,500
Somalia*	15,400	--	15,400
* Civil strife has significantly impacted stove programs and/or reduced the number of improved stoves in use.(--) indicates data not available.			

The Maendeleo stove borrows the insulating element from the ceramic Jiko without the metal outer covering. The ceramic liner is set down in the middle of the open fireplace; it is then reinforced with mud and stones. A pot placed atop the stove heats almost as quickly as one on a Kenya ceramic Jiko. Indoor smoke is reduced considerably through more efficient combustion. Further, a Maendeleo stove is usually placed near a wall of the hut so that smoke can climb along the wall and exit more easily.

The Maendeleo stove costs as little as 80 cents; more than 100,000 of them have been disseminated so far (Kammen, D. 1995). This rural success story helped to spawn a third-generation cook stove, the *Kuni Mbili* ("two-stick") stove, which has a larger firebox to accommodate wood instead of the charcoal typically used in urban settings.

Woodfuel Marketing

Unlike most other energy types, firewood is not often traded through normal channels. It is not usually purchased although there are indications that this is changing and that it is becoming increasingly commercialised. There are two major pricing structures of firewood: small scale and large scale. These include distant urban centres or firewood-using enterprises such as tea factories. For small scale a farmer (with surplus trees) may choose to sell to neighbours on standing tree basis. A visual assessment of the tree is made and a price negotiated depending on the tree size. Farmers may also cut small wood from branches and small thinning and sell these in bundles either at farm level or in adjacent small trading centres. For households that live in the vicinity of gazetted forests, considerably lower prices for small-scale firewood is charged. This was meant to benefit poor households and usually collected as headloads. In addition to this communities could derive firewood supplies from forest upon monthly rate of Ksh 39. A household was issued with a permit to remove a daily headload of firewood from the forest on condition the permit was produced on every trip to gather firewood. This arrangement was difficult to enforce as different members of the household used the same permit for multiple entries. This meant that more wood was extracted that was paid for. The availability of an almost free supply of fuelwood created little incentive for people to grow trees or buy wood in the market place.

The second major firewood structure is that of large-scale consumption. Usually firewood dealers have agents who go looking for farmers with substantial commercial tree resources. The dealers negotiate a deal on individual basis or an agreement is made that once trees are felled they will be stacked and sold on stack basis. These stacks are then resold at urban centres to firewood merchants who in turn resell the firewood to small scale users, households, restaurants etc in smaller quantities.

Unlike firewood, charcoal is a highly commercialised commodity whose trade is fairly an informal market. Only a small proportion of households produce charcoal for own use, while the majority of households buy charcoal mainly for cooking. The charcoal production is done by small producers operating in rural areas. Charcoal being a relatively high-quality and high density fuel, it can be transported economically over long distances in bags to main urban centres. The traders usually travel around to several producers in the rural areas to purchase sufficient quantities to fill their trucks. The traders sell to charcoal retailers at specific locations. In general, it appears that profits are quite modest for traders.

Vendors sell charcoal on a volume basis, sometimes by the bag but usually they re-pack into smaller quantities (e.g. a 4-litre paint tin or metal bucket (debe).

Formation of cooperatives to assist in marketing of charcoal and firewood are being established. This is especially possible where communities are planting their own trees and managing them. The benefits are many since it is a collective venture – economies of scale take effect.

Value adding to woodfuel such as production of briquettes from biomass residues is coming up fast. There is a niche market for such briquettes e.g. poultry keeping barbeque etc

Carbon sequestration

The biomass sector provides the most important near-term opportunities for reducing greenhouse gas (GHG) emissions and sequestering carbon in Africa. There are mitigation options in forestry, agriculture and other land-use such as range and grasslands. Mitigation options used here refer to those measures and policies that can lead to a reduction in the emission of greenhouse gases from the biomass sectors and/or through increased absorption and storage of carbon, both in perennial vegetation, detritus, soils, and in long-term biomass products. In most land- use changes involving decomposition and oxidation, GHG may be emitted. They include carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), nitrous oxide (N2O), oxides of nitrogen (NOx) and other non-methane hydrocarbons (NMHC). Although CO2 forms the bulk of these gases emitted in the biomass sectors, it can be reabsorbed by vegetation via the process of photosynthesis and through organic matter replenishment in soils. On the other hand, the emitted trace gases accumulate in the atmosphere for their entire residence period.
It is estimated that net carbon emissions from the biomass sectors amount to 1.6 +- 1.0 billion tons per year, most of which originate from lower latitudes, and that forests from the mid and high latitudes have a net sequestration of 0.7 +/- 0.4 billion tons per year

1. Africa's share of anthropogenic emission of greenhouse gases has been estimated at about 4% of global net emissions, adding to about 0.3 billion tons of carbon per year, mostly from forestry and land-use changes
2. Despite the relatively low contribution to the atmospheric accumulation of GHG, Africa has a large potential of increasing the emissions from land-use changes due to persistent dependence on primary resources for subsistence farming and over dependence on biomass as a primary source of energy. The Zaire basin alone has a large reservoir of carbon estimated to exceed 20 billion tons. Under current or accelerated rate of depletion of the region's forests, most of this carbon can be released in a few decades. On the other hand, Africa has a large expanse of arable land, which could be used to undertake various mitigation measures intended to increase the stock of carbon stored on land.

The most applicable options for the region include forest protection and conservation, improved forest management, the use of improved cook stoves, short- and long-rotation forest plantations, agroforestry and natural regeneration, and the expanded use of sustainably procured timber and non-timber wood products.

It is argued that biomass can directly substitute fossil fuels, as more effective in decreasing atmospheric CO2 than carbon sequestration in trees. The Kyoto Protocol encourages further use of biomass energy.

Summary and Policy Recommendations

The environmental and social impacts of charcoal production and consumption are extensive and intertwined, such that an integrated view is essential in policy making. For each country or charcoal market, the following questions must be addressed on a case by case basis:

- What are the charcoal flows?
- Where is the 'charcoal wood' grown and is it grown sustainably?
- Is charcoal produced by poor peasants in the off-season or by large, organized groups?

- Does the charcoal policy have the unintended impact of forcing the peasants to choose between fuel and food production?
- How far is the charcoal transported and what are the energy and monetary inputs?
- Who consumes the charcoal?
- How does the local industry work in each region?
- What are the local environmental impacts of charcoal production?
- Is there forest conversion to non-indigenous fast-growing species and monoculture plantation cropping?
- Pricing - what is the *real* cost of charcoal?
- How can the market price reflect these real costs without detrimentally affecting consumers?
- How can charcoal be priced such that sustainable plantation wood can be used cost-effectively?

Charcoal is attractive in terms of domestic energy policy projects in that all charcoal transactions involve money, so that projects *can* have financial returns. so

- Should charcoal be substituted?
- Do policy-makers want to encourage use of charcoal, which is an indigenous product and stimulates a domestic industry, but which is currently being produced unsustainably and may lead to destruction of forest resources and all associated environmental ramifications?
- Or do they want to encourage substitution with petroleum fuels, upon which most of the developed world depends, but which may have to be imported and whose supplies are uncertain?
- How should charcoal be priced such that substitution to other fuels could be encouraged?

Since the rate of fuelwood consumption exceeds that of replenishment, a number of measures have been adopted to rectify the supply-demand imbalance, in order to enhance environmental preservation. To achieve this objective, programmes aimed at promoting energy conservation through the use of technically efficient but cost-effective end-use technologies have been adopted. By means of programmes of public information and education, farmers are being encouraged to plant more trees, to increase the supply of tree seedlings and to engage in agro-forestry.

Current and potential future uses of bio-energy

The increasing interest in biomass for energy since the early 1990's is well illustrated by the large number of energy scenarios showing biomass as a potential major source of energy in the 21st century. Biomass resources are potentially the world's largest and most sustainable energy source - a renewable resource comprising 220 billion oven-dry tonnes (about 4 500 EJ) of annual primary production (WEC, 2004)). The annual bio-energy potential is about 2900 EJ, though only 270 EJ could be considered available on a sustainable basis and at competitive prices. The problem is not availability but the sustainable management and delivery of energy to those who need it.

Residues are currently the main sources of bio-energy and this will continue to be the case in the short to medium term, with dedicated energy forestry/crops playing an increasing role in the longer term. The expected increase of biomass energy, particularly in its modern forms, could have a significant impact not only in the energy sector, but also in the drive to modernise agriculture, and on rural development.

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