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SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

Fuelwood Value Chain Analysis Literature Review Report

May 2015

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For more information on the Ghana Sustainable Fisheries Management Project, contact:
USAID/Ghana Sustainable Fisheries Management Project
Coastal Resources Center
Graduate School of Oceanography
University of Rhode Island
220 South Ferry Rd.
Narragansett, RI 02882 USA
Tel: 401-874-6224 Fax: 401-874-6920 Email: info@crc.uri.edu

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Detailed Partner Contact Information:
USAID/Ghana Sustainable Fisheries Management Project (SFMP)
10 Obodai St., Mempeasem, East Legon, Accra, Ghana

Brian Crawford	Chief of Party	brian@crc.uri.edu
Najih Lazar	Senior Fisheries Advisor	nlazar@crc.uri.edu
Patricia Mensah	Communications Officer	patricia.sfmp@crcuri.org
Bakari Nyari	Monitoring and Evaluation Specialist	hardinyari.sfmp@crcuri.org
Don Robadue, Jr.	Program Manager, CRC	don@crc.uri.edu
Justice Odoi	USAID Administrative Officer Representative	jodoi@usaid.gov

Kofi.Agbogah
kagbogah@henmpoano.org
StephenKankam
skankam@henmpoano.org
Hen Mpoano
38 J. Cross Cole St. Windy Ridge
Takoradi, Ghana
233 312 020 701

Andre de Jager
adejager@snvworld.org
SNV Netherlands Development Organization
#161, 10 Maseru Road,
E. Legon, Accra, Ghana
233 30 701 2440

Donkris Mevuta
Kyei Yamoah
info@fonghana.org
Friends of the Nation
Parks and Gardens
Adiembra-Sekondi, Ghana
233 312 046 180

Peter Owusu Donkor
Spatial Solutions
powusu-donkor@spatialdimension.net
#3 Third Nautical Close,
Nungua, Accra, Ghana
233 020 463 4488

Thomas Buck
tom@ssg-advisors.com
SSG Advisors
182 Main Street
Burlington, VT 05401
(802) 735-1162

Victoria C. Koomson
cewefia@gmail.com
CEWEFIA
B342 Bronyibima Estate
Elmina, Ghana
233 024 427 8377

Lydia Sasu
daawomen@daawomen.org
DAA
Darkuman Junction, Kaneshie Odokor
Highway
Accra, Ghana
233 302 315894

Gifty Asmah
giftyasmah@Daasgift.org
Daasgift Quality Foundation
Headmaster residence, Sekondi College
Sekondi, Western Region, Ghana
233 243 326 178

For additional information on partner activities:

CRC/URI:	http://www.crc.uri.edu
CEWEFIA:	http://cewefia.weebly.com/
DAA:	http://womenthrive.org/development-action-association-daa
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ACRONYMS

CEDECOM	Central Region Development Commission
CEWEFIA	Central and Western Region Fishmongers Improvement Association
CLaT	Child Labour and Trafficking
DAA	Development Action Association
DSW	Department of Social Welfare
FoN	Friends of Nation
SFMP	Sustainable Fisheries Management Program
SNV	Netherlands Development Organization
USAID	United States Agency for International Development
WFCL	Worst Forms of Child Labour

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1. INTRODUCTION

The United States Agency for International Development (USAID) has committed funds to the implementation of a Sustainable Fisheries Management Project (SFMP) in Ghana for five years. The objective of this five-year project (October 2014-October 2019) is to rebuild marine fisheries stocks and catches through adoption of responsible fishing practices. The project contributes to the Government of Ghana's fisheries development objectives and USAID's Feed the Future Initiative.

This literature research is intended to identify or evaluative models, case studies that is relevant for Ghana woodfuel value chain. Specifically the research is intended to establish a theoretical framework for Ghana woodfuel value chain to inform researchers' decisions on the process of effective analysis of the actors in the chain.

1.1. Wood Energy

Woodfuel is a broad term covering the direct use of wood in cooking and heating, the use of charcoal (both for households and for industrial uses) and also recovered wastes in wood-using industries. While all are important in particular situations in developing countries, the use of wood and charcoal in heating and cooking predominate and are the main energy sources for more than two billion people (Nogueira, *et al.* 1998; Mather 1990; WEC 1999).

Until the middle of 19^{th} century, majority of energy in the world was supplied by biomass (Grubler and Nakicenovic, 1988) which supplied as much as 70% of the primary energy demand. Rapid fossil fuel use during the industrial revolution has seen the quantity of biomass used decrease steadily with coal taking centre stage in 19^{th} century and refined oil and gas in 20th century (Shukla, no date).

Wood has been reported as the oldest source of energy for mankind (Massachusetts sustainable bio-energy initiative, 2008 and FAO, 2007) and by far the most important among the biomass sources. It is the fourth largest source of energy globally after petroleum, coal and gas (Takase, 1997). FAO estimates the annual wood removals to be 3.3 billion m^3 with half of it being used for energy supply (FAO, 2007). While biomass energy is mostly used in developing countries, on average supplying 80%, of energy demand (FAO, no date) joint Wood Energy Enquiry in Europe in 2007 established that wood energy is gaining importance in the OECD countries and has been growing by about 3.5% annually in 12 European countries to account for about 50% of the renewable energy used, most of it being wood pellets and briquettes for electricity generation and household heating (FAO and UNECE, 2009).

Global wood energy use is only a low 7% with developing countries accounting for the majority (FAO, 2007). Asia leads with about 44 percent of all wood fuel use; Africa follows with 21 percent and South America and the Caribbean about 12 percent each (FAO, no date). Some countries especially in sub-Saharan Africa supply more than 90% of their total primary energy demand from biomass (Bailis et al, 2007).

The production and use of woodfuel is heavily concentrated in developing countries and in particular in the tropical countries (Table 1). Asia accounts for about 44 percent of all wood fuel use, Africa about 21 percent and South America and the Caribbean about 12 percent. These figures hide the variability between individual countries. Indeed there are 34 countries where woodfuel provide more than 70 percent of their energy needs and 11 African and two other countries where woodfuels provide over 90 percent (WEC 1999).

In developing countries woodfuel makes up about 80 percent of total wood use; in Africa it averages 89 percent (Table1) and in a few countries it is almost the sole use of wood. The per capita woodfuel use also varies widely, being highest in African countries and tropical Oceania. Again, usage varies widely between countries, with 19 developing countries and four industrialised countries averaging greater than one cubic meter per person per annum (WEC 1999)

Table 1 Woodfuel use summarised by region (based on WEC, 1999)

Region	Woodfuel demand $m^3/yr \times 10^6$	% of total energy used	% of wood used for energy	% world's woodfuel use	Woodfuel per capita m^3/yr
Developing countries	1 763	15	80	77	0.40
Tropical	1 368	26	84	59	0.51
Non tropical	395	6	65	17	0.23
Africa	486	35	89	21	0.67
Asia	1 003	12	81	44	0.29
Oceania	1	52	56	<1	0.88
Latin America	268s	12	66	12	0.56
Developed countries	537	2	31	23	0.41
World	2 300	7	59	100	0.40

Notes:

1) Totals may not tally due to rounding

2) Oceania excludes Australia, New Zealand; Asia excludes Japan, Turkey and Israel; all these countries are included in the developed countries. Latin America includes the Caribbean. The limitations of this data have been discussed by WEC, 1999.

There is often great variation within a country depending on the availability of wood. Use is much greater in rural areas than in larger towns, with at least half of gross energy consumption in most developing countries occurring in rural areas, primarily for cooking and heating of households (WEC 1999). The breakdown for India shows that 152 million tonnes of woodfuel was used in the rural sector while 49 million tonnes was used in urban areas, with most of this going to hotels, restaurants and cottage industries (Ahmed 1997).

Thus high-income people prefer to replace woodfuel with cleaner, more convenient fuels, particularly in urban areas. Other studies suggest that the greatest use is in the middle income range (Mather 1990).Less obvious when looking at percentages of wood used as woodfuel for individual countries, is that the scale of production can be quite high compared to forest resources. Large volumes of woodfuel are produced from savannah woodlands of African countries, for example. As already pointed out for India large quantities come from trees grown on farms, along roadways or around the village. Furthermore, woodfuel is regularly available where fallow systems of agriculture (shifting cultivation) are used. Thus the supply of woodfuel depends not only on the forest resource, but also on the nature and condition of agriculture (Mather 1990).

In developing countries charcoal is often an important, although a small component of woodfuels (Foley 1986; WEC 1999). Limited data given by WEC (1999) suggest that about 7 percent of all woodfuel in developing countries is used as charcoal. Where it is used, then individual consumption is 100 -150 kg yr-1 (Foley 1986). Charcoal is relatively more important in Africa and Latin America than Asia. Wood residues and black liquor are generally less important in developing countries than developed countries (WEC 1999).

In addition to woodfuel there are other biomass alternatives that need to be recognised when considering woodfuel use and the potential for woodfuel. These include agro fuels in rural areas and municipal by-products in urban areas. Agro fuels such as straw, husks, dung etc., are readily substituted for woodfuel and thus make estimation of true demands more complex. For example, in India it was estimated that 22 percent of bioenergy comes from dried dung (Vergara 997).

In developing countries, most of the biomass energy is consumed in households mainly for heating and cooking and this is expected to remain the same for a long time (FAO, 2007 and IEA 2008). Woodfuel demand for cooking and heating depends on several factors like cooking method, climate, lifestyle, and the efficiency of stoves, and ranges from a minimum of 0.5-1.0 m^3/ha/year to 3.0 m^3/ha/year in the mountain area, (Takase, 1997).

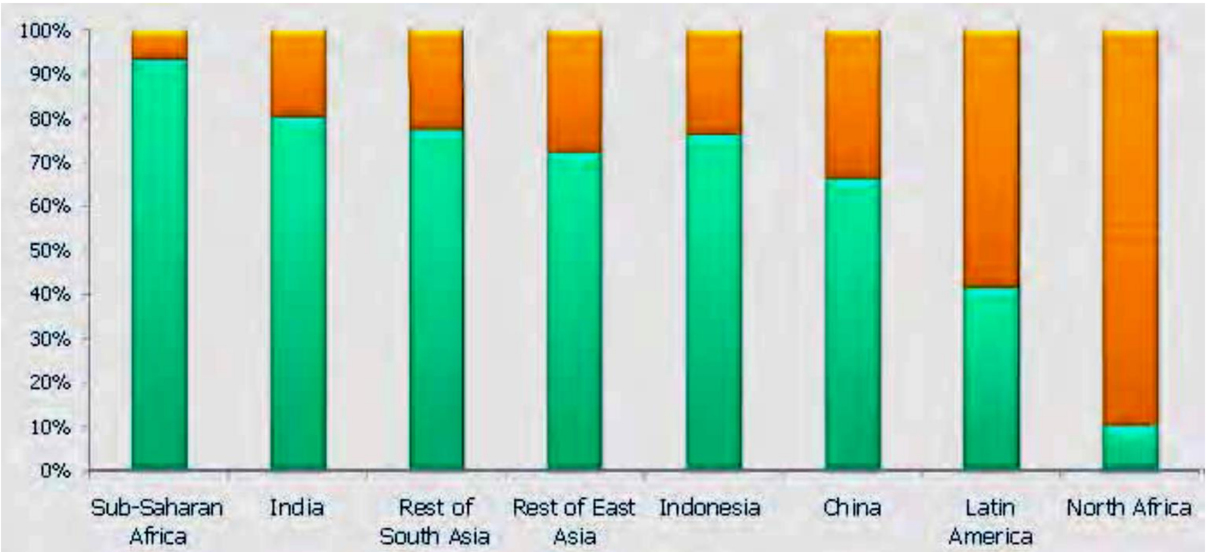

Figure 1 Household traditional biomass consumption as a percentage of total energy consumed in 2005.

Source: IEA, 2005

With the global per capita forest area in 2005 roughly estimated at 0.62 hectares, the per capita wood-growing stock is 65 m^3, and the continued population increase and forest land decrease, there is a huge deficit in global biomass supply (FAO, 2005 and Takase, 1997). 64 countries with a combined population of over 2 billion people have less than 0.1 ha of forest per capita and only ten countries account for two thirds of the global forest area (FAO, 2005) showing a huge imbalance in distribution compared to the population density. As a matter of fact, FAO (no date) reported that by the year 2000 there were over 2 billion people who wholly depended on wood and out of these,1 billion were facing acute shortages and over 100 million experienced virtual 'fuelwood famine'.

These statistics agree with the long known conclusion that wood, once regarded as a free good readily available for use, is currently a scarce resource that should be more efficiently and sustainably managed (FAO, 2007). The distance to the wood sources in many regions has increased forcing many households especially in the urban areas to rely on the nearby markets (Kituyi 2001, and IEA, 2007). As Allen observes developing countries are particularly faced with the dilemma of conservation versus consumption when it comes to wood. If wood cutting continues at its present rate, most natural forests will sooner or later disappear; but if forests are protected from cutting, or if they disappear due to overharvesting, poor rural and urban populations will be forced to shift to other, perhaps more costly, sources of energy (Allen, 1984).

Traditional biomass at 751 Mtoe in 2010 falls to 687 Mtoe in the New Policies Scenario, about 650 Mtoe in the 450 Scenario and just under 700 Mtoe in the Current Policies Scenario over the projection period. Despite greater access to modern fuels, many people in non-OECD countries, particularly in sub-Saharan Africa, continue to rely heavily on traditional biomass, essentially for cooking. Traditional biomass represents 42% of total primary energy demand in that region in 2035. (IEA, 2012)

Globally, two billion people live on less than US$1/day, about the same number as those lacking access to commercial energy (FAO COFO, 2005). Four out of five people without electricity live in rural areas in developing countries, mainly South Asia and Sub-Saharan Africa. The problem is that extending an electric grid to just a few households in rural areas can cost up to seven times the amount as in urban areas. Thus, wood-based biomass in Africa, Asia and Latin America accounts for 89%, 81%, and 66%, respectively, of total wood consumption (AFREA, 2011)

Table 2 People Relying on Wood-Biomass (millions)

	2004	2015		2030	
	A	A	B	A	B
Sub-Saharan Africa	575	627	741	720	918
North Africa	4	5	4	5	4
India	740	777	863	782	780
China	480	453	393	394	280
Rest of developing Asia	645	692	688	741	709
Latin America	83	86	85	85	79
TOTAL	**2,527**	**2,640**	**2,774**	**2,727**	**2,770**

Source: (A) World Energy Outlook, 2006; (B) World Energy Outlook, 2010.

A striking difference between SSA and other countries is that the use of wood as an energy source has generally peaked or will do so in the near future, while in Sub-Saharan Africa it is predicted to remain at current levels and may even continue to grow (AFREA, 2011).

1.2. Wood Energy Status in Ghana

In Ghana, fuelwood use is dominant in rural households: more than 2.2 million families depend on it for cooking and heating, and at least 280 000 of them use it for small-scale processing activities, such as fish smoking, gari making, pito brewing, akpeteshi distillation, pottery making, oil extraction (from palm fruits, coconut, groundnut, shea butter), thus making a significant contribution to food preservation, food security and cash earnings for rural and urban people. (FAO, Forest Energy Forum No. 9)

Ghana’s fuelwood consumption is estimated at 20.6 million cubic metres per year while it provides about 71% of the country’s annual energy demand. Woodfuel supports most informal enterprises including bread-baking, processing of oil-palm, local breweries, traditional soap making, fish smoking and traditional food services. About 90% of rural households use firewood or charcoal cooking. Demand for Woodfuel is increasing with oil prices and local government agencies derive substantial revenue from woodfuel taxes and with a potential to increase such revenues if the trade is regularised, (NCRC, 2008).

According to FAO, 2007, studies have only recently begun to address issues such as the income potential for households from woodfuel trade.

In addition, there are some 600 000 small-scale enterprises in commercial activities, such as chops bars, street food and grills, which depend on fuelwood or charcoal as their main sources of energy. (FAO, Forest Energy Forum No. 9)

Ocansey (1985), examined fuelwood exploitation in a village on the outskirts of Accra found out that the trade to Accra and other urban centres extended important economic activity for most villagers especially during fishing seasons. On the average 50.94 cubic metres of woodfuel left the village every day as compared with an estimated consumption of 1.37 cubic metres per capita per year.

Fuelwoods are obtained from deadwood in the fallow, from woods cut in clearing the fallow for the new farm, from species specifically cultivated or preserved for firewood, and from branches lopped and pruned from large trees. Women are largely responsible for the collection of firewood and its utilization in the cooking. However, the collection of firewood is a shared responsibility and men frequently bring fuelwood home when returning from work on the farm plot.

So many fuelwood species of variable quality have been identified to be in use in Ghana including Cashew nut, Talbotiella, Cassia, Azadirachta indica and Albizia. High grade firewood has the qualities of burning easily, slowly and without creating a lot of smoke. The best firewood species are considered to include; Celtis zinkeni, Azadirachta, Odum, Mahogany and some Citrus spp. However, many of these are not in common use or have other important uses such as fruits or wood (lumber). Most farmers make a compromise between quality of firewood and availability or rely on fast-growing exotic species (Amanor, 1990).

Charcoal is a very important energy source for households: its saturation ranges from 54 to 71 percent in urban areas and it is the main fuel for more than 1 million families. It is also a valuable commercial fuel, with an annual turnover of some US$60 million at current market prices. Assuming that 80 percent of this amount corresponds to labour payments at US$1.50 per day, its production and marketing create some 144 000 permanent jobs earning twice the minimum wage (US$0.75 per day). (FAO, Forest Energy Forum No. 9)

In the past, the Government of Ghana promoted the substitution of charcoal for LPG, distributing gas cylinders free of charge, and also subsidizing gas prices. This policy, aimed to decrease the utilization of charcoal because of environmental concerns, led to a pronounced increase in LPG consumption, which then had to be imported. Since the country could not afford the expense of foreign currency, the subsidies were terminated and many users reverted to the use of charcoal or fuelwood as they were not able to pay for LPG at real prices. The environmental impact of the substitution was not evaluated. (FAO, no date)

This experience shows that, in the absence of a comprehensive knowledge of the demand, a fuels substitution policy may lead to undesirable consequences for the national economy. On the other hand, since neither the environmental impact of charcoal use nor the potential for other mitigation policies were assessed, the chance to develop other, more cost-efficient alternatives was lost. It is clear now that woodfuels are produced and marketed with a minimum use of foreign currency. Thus, its substitution for electricity, LPG or other petroleum derivatives, would imply a huge increment in the oil bill, which peaked at US$246 million in 2000 - 16 percent of all country exports - and could increase by 50 percent if woodfuel supply is halved.

The Table below shows the approximate share of woodfuels in the energy matrix of Ghana. Since hydro resources are almost completely used by now, any future increase in energy demand will have to be met by either bigger oil imports or a wider use of biomass resources. It seems that practical options would be to increase sustainable production and/or to reduce the demand by means of higher efficiency in conversion and end use of woodfuels.

Table 3 Energy consumption and primary sources in Ghana, 2000

Electricity	**Oil and derivatives**	**Charcoal**	**Fuelwood**
7 838 000 MWh	1 095 000 tonnes	1 000 000 tonnes	8 200 000 tonnes
		10 700 000 m^3	10 900 000 m^3
674 100 TOE	1 095 000 TOE	3 745 000 TOE	2 870 000 TOE
8.0%	**13.2%**	**44.6%**	**34.2%**

TOE: tonnes of oil equivalent

In 2000, the annual production or yield of wood was about 30 million tonnes of which about 18 million tonnes was available and accessible for woodfuels.

Although the exploitation of wood resources for woodfuel is not the main cause of deforestation, there are indications that the preferred woodfuel species are gradually disappearing. The major charcoal production areas of Donkorkrom, Kintampo, Nkoranza, Wenchi, Damongo show physical signs of depleted woodfuel resources. As a result, producers have to travel longer distances in search of wood for charcoal production. Also, the extensive use of less preferred wood species for fuel such as nim and wawa are becoming popular.

Since a majority of households, about 80% in Ghana depend on woodfuels for cooking and water heating in addition to commercial, industrial and institutional use, the demand for woodfuel has for the past years been on the increase. As indicated above about 18 million tonnes of fuelwood was used in year 2000. If this trend of consumption continues, Ghana is likely to consume more than 25 million tonnes of fuel wood by the year 2020

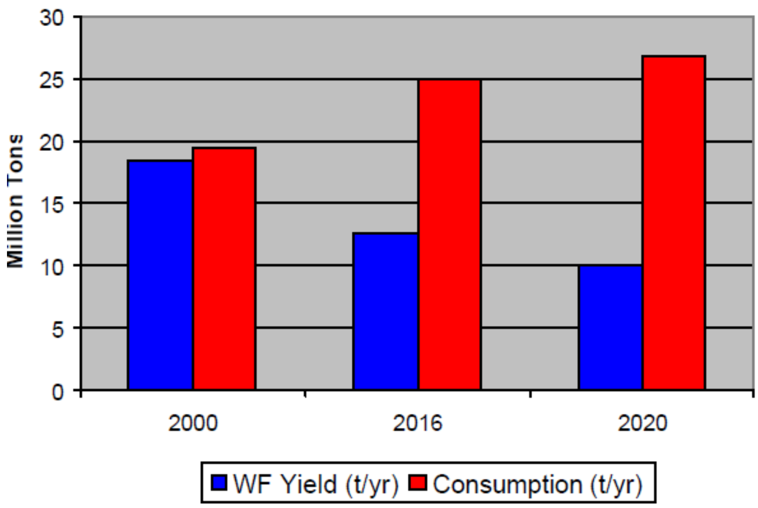

Figure 2 Woodfuel Balance of Ghana (2000-2020)

As illustrated in fig 5, by 2020 the woodfuel consumption will reach 25 million tonnes and above. Most of the woodfuel supply will come from standing stocks i.e. 15 million tonnes from standing stock and the rest 10 million tonnes from regeneration or yield. This means that woodfuel supply will no longer come from regeneration but from standing stock. The implication is a direct depletion of standing stocks hence an increase in the rate of deforestation.

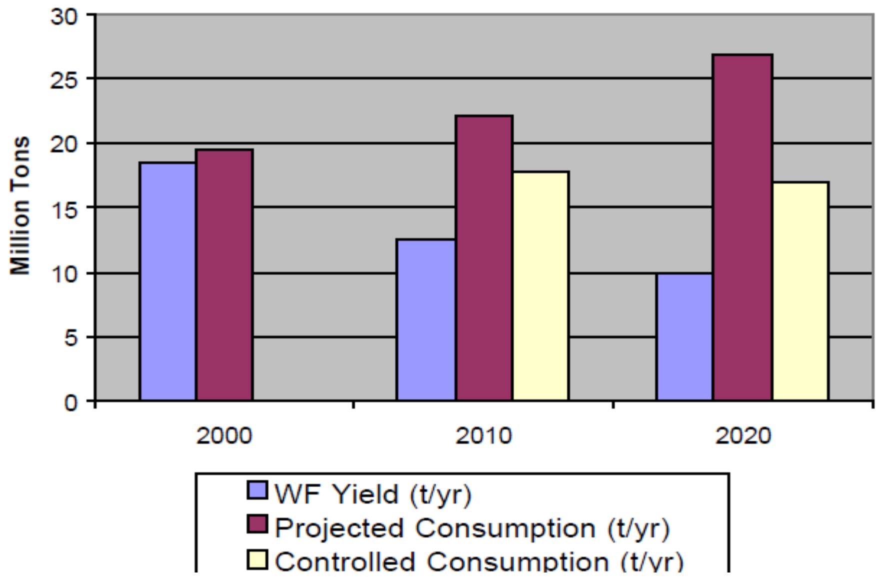

Figure 3: Comparison of Fuelwood Yields, Projected and Controlled Consumption (2000-2020)

Figure 4 Mangrove wood harvesting in Bomigo in the Volta Region of Ghana

Source: Reviewer

2. WOODFUEL CONVERSION TECHNOLOGIES

Wood can be used as a fuel in various forms. These include; solid wood, charcoal, chips, briquettes, gas and liquid fuels (Massachusetts sustainable bio energy initiative, no date, FAO, 1985, and Richter, 2009). Advancement in the conversion technologies has ensured that, wood remains competitive as a fuel compared to fossils like oil and coal (FAO, 2008a).

Table 4 Wood Conversion technologies

Conversion technology	Description
Direct combustion	Burning of solid wood in a stove to generate heat for cooking or heating. It is the oldest way of using wood as a fuel.
Advanced direct combustion	Burning of biomass in a modern boiler or furnace system. Unlike the common residential wood stove, burning wood fuel in an enclosed, oxygen regulated firebox heats an exchange device, which distributes heat through an air or water system.
Carbonisation	The wood is heated in the absence of sufficient oxygen which means that full combustion does not occur. This allows pyrolysis to take place, driving off the volatile gases and leaving the carbon or charcoal remaining.
Gasification	Involves heating biomass or other materials in an oxygen-limited environment. The resulting volatile gases (known as synthesis gas) can be used to fire a boiler, drive an engine or generator, or power a fuel cell.
Extraction	Extraction of liquid fuels such as ethanol, methanol, bio-oil, and biodiesel through pyrolysis, fermentation, and other methods for transportation and bio-refining.

Cogeneration	Production of both thermal and electrical energy by a combustion system. In most scenarios, steam produced in a boiler heats an exchange device and spins a turbine to generate electricity.
Cofiring	Combustion of multiple fuels in the same energy system. This usually means mixing a small percentage of wood with coal to fuel a large power plant. Burning wood in a coal plant can increase equipment performance and reduce pollution.

Sources: Massachusetts sustainable bio-energy initiative, no date, FAO, 1985 and Richter, 2009.

2.1. Wood Stoves

The three stones wood stove is the oldest technology of using firewood and is still used widely in the developing world especially in Africa (Practical Action, 2007). However, the stove has little capacity for secondary combustion of the flue gases which are emitted to the atmosphere. This poses a health risk to the people using the stove on top of reducing the efficiency of the stove to only 15% (George, 2006). These stoves were also blamed for massive deforestation in developing countries due to the high amount of wood consumption (Bailis et al, 2003).

These problems led to a lot of research on more efficient stoves which have resulted in several designs. The table below shows the performance of improved wood stoves in terms of efficiency compared to selected conversion technologies.

Table 5 Efficiencies of selected biomass energy stoves

Stove	Efficiency (Percentage)
Three stone	10-15
Improved wood burning stove	20-25
Charcoal stove with ceramic liner	30-35
Kerosene pressure stove	Up to 40
LPG stove	57

Adapted from Kristoferson L. A., and Bokalders V., 1991

Figure 5 Gyapa Charcoal stove

Figure 6 Tire rim charcoal stove

Figure 7 Three stone stove

Figure 8 Eno stove

Source: Reviewer

3. FUELWOOD VALUE CHAIN

3.1. Definition

A value chain is a sequence of related business activities, from the provision of specific inputs for a particular product to primary production, transformation, marketing, the final sale of a particular product to consumers (GTZ, 2007). It shows the links between the set of operators performing these functions i.e. producers, processors, traders and distributors of a particular product through various business transactions. In the wood energy sector, the value chain helps us to understand the economic flows between the actors. This makes it possible to gauge and interpret the importance of woodfuels in the regional or national economy, their contribution to job creation and income generation, potential for the creation of fiscal revenue and the impact of substitution of energy sources (FAO, 2008a, Sepp, no date).

Value chain analysis as a tool is important in understanding the sequence of related business activities from production to consumption of woodfuel, and the functions of the operators and supporters in the chain. The analysis helps to identify money flow, the bottlenecks in the chain and their causes, understand the relationships between businesses in the chain and other market players, the role of specific market functions and the rules that govern the chain (GTZ, 2007). This should lead to identification of capacities and incentives of the actors where intervention can be made to eliminate the bottlenecks (Matthias and Tapera, 2009).

The first step of a value chain analysis is chain mapping (Fasse et al. 2009). At this stage the sector is illustrated in a map-like fashion tracing the product flows within the chain which leads to a multi-layered “atlas” of the woodfuel chain. The objective is to give an illustrative representation of the identified chain actors and the related product flows. The mapped value chain shows the actors, their relationships, and economic activities at each stage with the related physical (Kaplinsky and Morris, 2001).

The second step involves quantifying the value chain in detail. This is addition of quantifiable data about;

- Number of operators in each category.
- Number of jobs and employees for each stage of the chain.
- Prices paid at each chain link between stages.
- Volumes and turnover in each chain stage.
- Shares of product flow of the different sub-chains / distribution channels.
- The chain supporters and suppliers.

The third step is economic analysis of value chains and it complements which deepens the quantification, with more emphasis on economic efficiency. This step is quite important because assessing the cost structure allows the identification of critical points that need to be addressed (GTZ, 2007). At this stage, the flow of revenues accruing at various stages of the value chain is analysed in regard to;

- Income and profit, prices, and quantities of the goods handled by the different actors.
- Distribution of income and profit within and among the groups along the value chain.
- The mechanisms which determine revenue generation and revenue sharing in a given setting.

The value added is also calculated at this step. This is the new wealth created by a productive activity and is calculated by subtracting the wealth (II) which had to be consumed in the production process of the product from the gross value Y of the product (FAO, 2005c). It measures the creation of wealth, hence the contribution of the production process to the growth of the economy (Kaplinsky and Morris, 2001). The total value added is the summation of the value added for each step of the chain as well as the overall value added of the entire chain (Fasse et al. 2009).

Value added (VA) is defined by the equation: VA = Y - II

Finally the opportunities and constraints in the value chain are analyzed through the analysis of the roles, mandates, rights and responsibilities of the concerned stakeholders, their respective capacities and weaknesses considered (GTZ, 2007). This helps to pinpoint specific weaknesses of the current setting, and to devise technically as well as socially adapted responses.

3.2. Mapping

The contrasting characteristics between rural and urban fuelwood consumption also determine how fuelwood supplies reach the final energy consumers. In rural areas, fuelwood is not usually a commodity that is traded as in urban areas. Available data show that in most cases, fuelwood in rural areas are collected freely from the local environment, while most, if not all, urban households buy fuelwood and charcoal from traders and retailers. However, there are indirect costs associated with acquisition and use of fuelwood in rural areas. These costs are linked to the accessibility of fuelwood sources. Rural households, in particular women and children, in many cases spend considerable time and travel great distances to collect fuelwood. In urban areas, woodfuels are commodities that compete with other fuels to satisfy household energy needs. Moreover, there is stronger tendency for urban fuel use to increase, diversify, and switch from fuelwood and charcoal to commercial fuels (for example, LPG and kerosene). Thus, fuel consumption patterns in urban areas may be changing more rapidly than in rural areas. (FAO, no date)

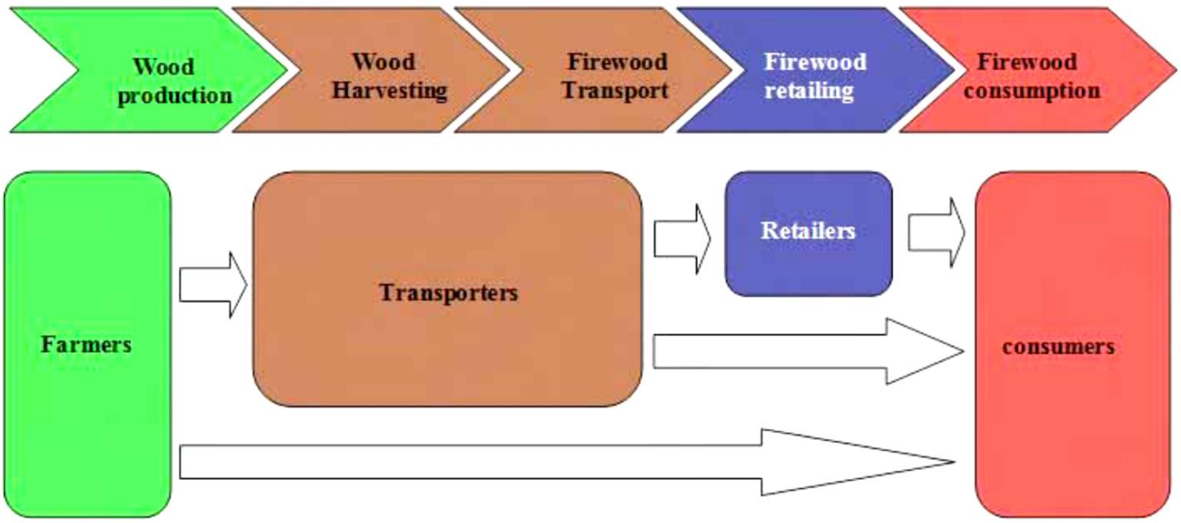

Figure 9 Fuelwood value chain Mapping

Source: Geoffrey M. Ndegwa, 2010

In this context, woodfuel flow is about rural/urban trading network existing in relation to woodfuel use in urban areas and the fuelwood collection practices in the rural areas. In both cases, information about the actors involved, in particular their socio-economic status, volume and types of woodfuel traded or collected, sources of fuelwood are important. For urban fuelwood, information should include distribution, trading and pricing practices, including the prices of alternative fuels. (FAO, no date)

Information about rural/urban trading network is important because the associated activities constitute one major source of income particularly for the rural people, as fuelwood in urban areas come from rural areas. On the other hand, information on fuelwood collection practices in rural areas, coupled with knowledge of fuelwood sources, address the issue of accessibility and the (indirect) costs associated with fuelwood collection. In urban areas, moreover, fuelwood prices are affected by distribution, trading and pricing practices. (FAO, no date)

Figure 10 Basic Steps to a Typical Value Chain

Source : Jolien et al. (June, 2014)

The major groups of actors involved in the wood-fuel value chain are producers, transporters, traders, wholesalers, retailers, consumers and (traditional and official) authorities. As seen from Figure 7 the wood-fuel value chain is complex, involving many different groups. Participatory mapping by actors and stakeholders can assist in identifying roles, stakes and bottlenecks within the value chain. Less visible or marginalised groups need to be actively included in these exercises. Jolien et al. (June, 2014)

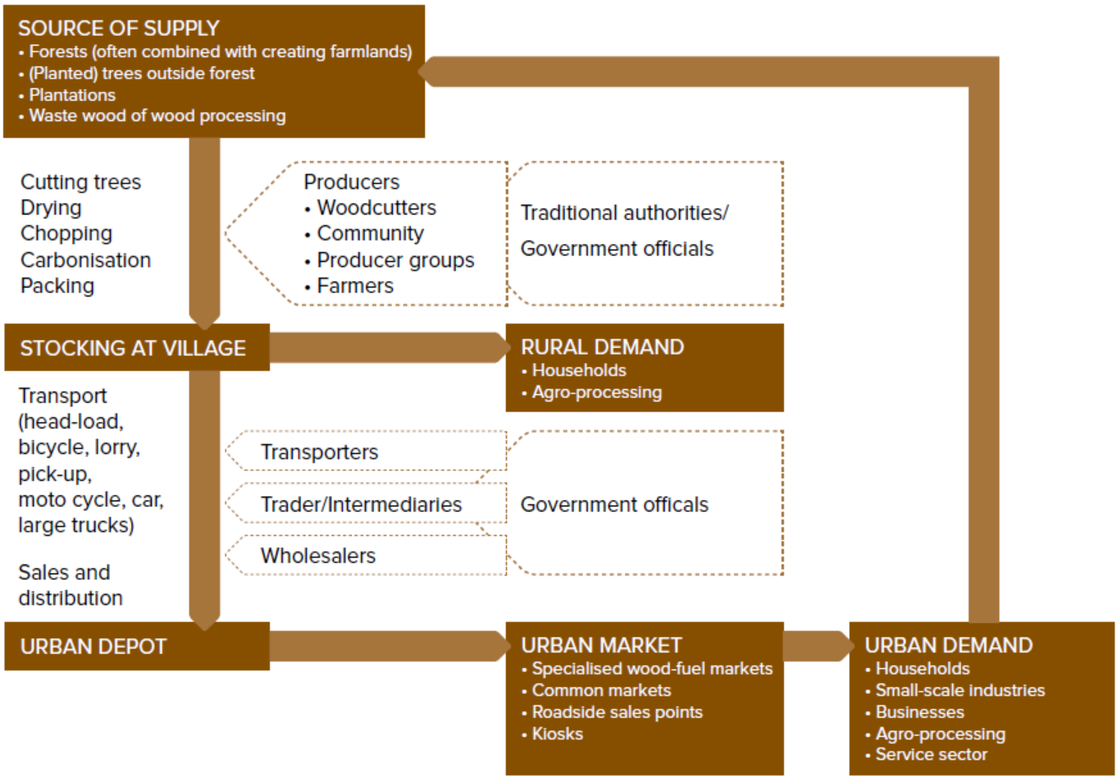

Figure 11 Wood-fuel value chain and main actors involved

Adapted from Jolien et al. (June, 2014)

3.3. Actors and Functions

3.3.1. Production

Wood-fuel can be sourced from a number of places; including natural forests, trees on farms, plantations, residues from forest harvesting, salvage harvesting (sick or damaged trees) and silvi-cultural thinning (Jolien et al. June, 2014). Wood-fuel for urban demand is often derived when forestlands are converted to farmlands, or, when markets are attractive, it is directly harvested from forests or agroforestry systems. Smaller quantities are sourced from plantations or from waste wood of timber operations.

Production essentially entails cutting the trees, chopping to a practical or requested size, drying and packing for transport. (Jolien et al. June, 2014)

The main actors involved at the level of production are specialised woodcutters, community members, farmers and formal and informal authorities. Producers are the primary actors in terms of the number of income generating opportunities created. (Jolien et al. June, 2014)

In Ghana, the bulk of woodfuels amounting to 90 percent is obtained directly from the natural forest. The remaining 10 percent is from wood waste i.e. logging and sawmill residue, and planted forests. The transition and savannah zones of Ghana, mainly the Kintampo, Nkoranza, Wenchi, Afram Plains, Damongo districts provide the bulk of dense wood resources for woodfuels. However, woodfuel resources are depleting at a faster rate as a result of unsustainable practices in the production and marketing of the product that incurs high levels of waste. According to the UN Food and Agriculture Organisation (FAO), the rate of deforestation in Ghana is 3% per year

Woodfuel production in Ghana is mainly associated with three major ecological zones: the rain forest; the moist deciduous forest; and the savannah woodland. The total forest cover, according to FAO statistics (1995), is stated as follows:

Table 6 Forest Cover 1995 (FAO)

Rain forest `000 ha (%)	Deciduous forest `000 ha (%)	Savannah woodland `000 ha (%)	Total cover `000 ha (%)
9 022 (40)	8 405 (37)	5 327 (23)	22 754 (100)

The majority of woodfuel production activities occur in the savannah woodland located in the Brong Ahafo, Ashanti, Eastern and Volta regions. The main wood species preferred by producers are Kane (*Anogeissus leiocarpus*) and Ongo (*Terminalia avicenioides*). Several other species are also used. Charcoal production sites, in most cases, are within 100 m of the wood collection area. Most of the wood utilized for charcoal production originates from felling and crosscutting trees on fallow lands, as well as farmlands, using such tools as chainsaws and axes. Logging and sawmill residues in the form of wood offcuts are also used for charcoal production in the Ashanti and Brong Ahafo regions.

3.3.2. Processing

Processing can be carried out by the same people involved in production or by specialised wood processing groups. In the case of charcoal producers, two types of charcoal makers are generally distinguished: (1) rural citizens, mostly farmers, who produce charcoal as a by-product of transforming forestlands into farmlands (and sometimes of timber logging) and; (2) specialised producers, urban or rural citizens working in groups who are moving around, following production frontiers. (Jolien et al. June, 2014)

Fuelwood is used to produce charcoal. It is estimated that about 100m tons of charcoal are produced annually worldwide, although this figure may be regarded as a conservative estimate, (Hall et al, 1996).

Charcoal production is an integral part of the informal economy of many developing countries and utilized by small scale operators involving a large number of small farmers and rural poor people. Charcoal is produced from forestry residues resulting from the expansion of agriculture and pasture land, waste from wood processing sawmills and forestry's thinning and more professionally from biomass plantations, (Manso-Howard B. 2011)

In developing countries, charcoal is used mainly as a domestic fuel for cooking and heating, but it is also an important industrial and reducing agent fuel. It is used in numerous metallurgical industries especially pig-iron, foundries and forges in cement factories and for chemical applications. Contrary to popular belief, charcoal consumption has increased in recent years and is becoming a major source of energy as many people from the rural and urban areas of developing countries convert from wood to charcoal use. (Manso-Howard B. 2011)

Sometimes, it is urban merchants who hire woodcutters to produce the charcoal. Charcoal making for commercialisation, nowadays, is mainly an activity executed by men.

Although charcoal is popular for its energy density (it contains around 33 MJ/kg or twice that of wood) and it is easier to store and transport compared to fuel-wood, the low energy efficiency of traditional earth charcoal kilns means that around 7 kg of wood is needed to produce 1 kg of charcoal. Most carbonisation takes place in traditional earth kilns with an energy efficiency of around 13-15 per cent.

3.3.3. Distribution and Retail

Wholesalers can be characterised into two groups: those with their own transport and those which hire transportation. Wholesalers without their own transportation pay a fixed price for a truckload before organising further sales, directly, or via retailers. Retailers buy fuel-wood and charcoal from the wholesaler. Sales are either organised via depots or direct to markets and semi-industrial consumers. Retailers buy fuel-wood and charcoal from the wholesaler and repack the product in smaller quantities for sale in the different neighbourhoods. Retailers resell at specialised wood-fuel markets, common markets, at roadsides in local neighbourhoods or in small kiosks. Their clients are generally the poorer urban citizens who cannot afford to buy an entire bag of charcoal. (Jolien et al. June, 2014)

In Ghana the main participants in the woodfuel trade are the producers, transporters, merchants (intermediaries and dealers), retailers and consumers. Woodfuel supply in the three ecological zones in Ghana is shown in percentages in Table 8.

Table 7 Woodfuel Supply by Ecological Zone (Percentage)

Ecological zone	Regional share (%)	Ecozone (%)
Savannah	Brong Ahafo 50.7	
	Eastern (Afram) 14.6	79.0
	Northern 6.9	
	Volta 4.0	
	Upper West 2.1	
	Upper East 0.3	
Deciduous forest	Volta 5.0	
	Central 4.5	15.0
	Ashanti - Sawmills 2.2	
	- Others 1.8	

	Eastern 1.0	
Rain forest	Western 5.9	6.0

There is an indication that about 50 percent of the woodfuel supply is from the Brong Ahafo region while 79 percent of the total supply comes from the savannah zone. The deciduous forest provides about 15 percent of the woodfuel supply.

3.3.4. Transport and Trade

Transport varies from head-loading, bicycles and motorcycles, to donkey carts, cars, pick-up trucks, Lorries and large trucks. Modes of transport depend on the distances that have to be covered and the financial means of the traders. (Jolien et al. June, 2014)

Transporters, or traders, are often men, mostly urban based, who travel around production zones to collect wood-fuel or travel to a village after being contacted by producer groups. Wholesalers, who have their own means of transport, are also sometimes involved in transport and trade. (Jolien et al. June, 2014)

Traders fulfil an important role in collecting the product at the production sites and co-ordinating and financing production, transport and sales.

In regional capitals woodfuel, especially charcoal, is delivered to the markets and to major retail outlets in towns where there are no big markets. Direct sales are carried out from trucks to households, but only to a very small extent. Wholesale of charcoal is carried out at these market centres where retailers and individual consumers obtain their supplies or consignments. In residential areas, small-scale retailers, mostly women, retail charcoal in small measuring units equivalent to one kilogram.

Involvement in transport and trade is relatively expensive, which is why fewer people are able to engage in this activity. The extent of their role and influence varies among countries and locations. (Jolien et al. June, 2014)

3.3.5. Consumption

Households are the main consumers of wood-fuel for cooking, followed by small scale industries, the agro-processing sector and the services sector which includes businesses such as bakeries, breweries, restaurants, brick makers and aluminium forgers. (Jolien et al. June, 2014)

The energy mix is different for rural and urban households. Rural households are more likely to depend on naturally available fuels such as fuel-wood, agriculture waste and cow dung. Urban households use fuel-wood, charcoal and petroleum or LPG or electricity depending on the country. At a household level, the choice for energy is part of a complex decision making process influenced by: size of household, area of residence, fuel availability, income, education, available labour, cultural preferences and oil price. (Jolien et al. June, 2014)

In terms of consumption, households are major consumers of woodfuel in Ghana; little woodfuel is consumed by the commercial and industrial sectors. Exports of charcoal fuel to the United Kingdom in 1988 accounted for 210 tonnes. The export of charcoal to Europe is alleged to have been on the increase under the trade policy of non-traditional exports. (FAO Forest Energy Forum No. 9 n. d)

A comparison of the data from FAO and the Ministry of Mines and Energy on woodfuel production and consumption from the period 1980-1994 indicates that there has been a tremendous increase in the consumption of woodfuels (see graph below).

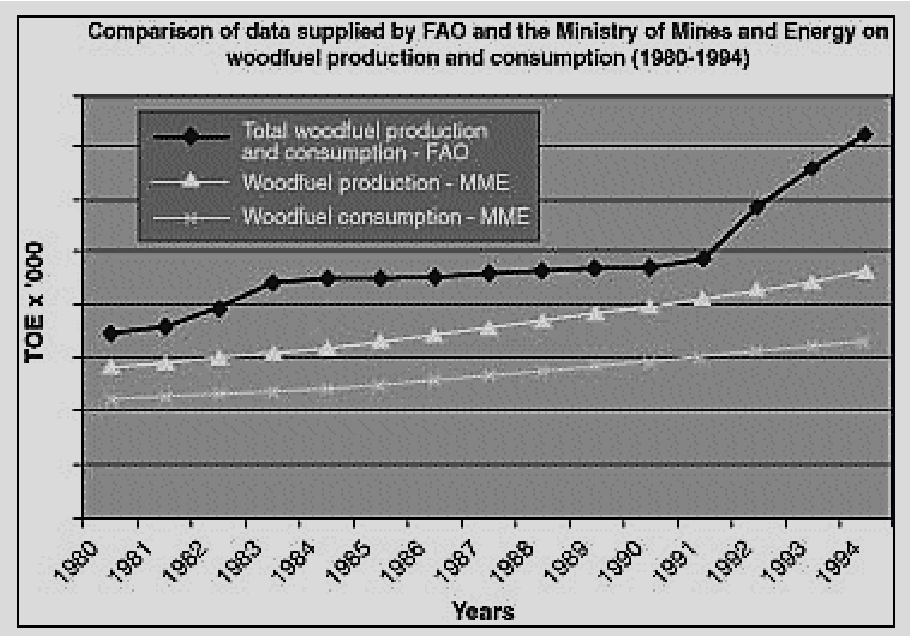

Figure 12 A graph showing woodfuel production and consumption in Ghana

Source: (FAO, n. d.)

The FAO source of woodfuel consumption from the above graph depicts two critical periods (1982-1984 and 1991-1994). The graph shows that sharp increases occurred in woodfuel consumption. Although no serious analysis of the data has been carried out, it is assumed that some changes in socio-economic factors might have occurred within these periods. (FAO Forest Energy Forum No. 9 n. d)

3.4. Economic Analysis

The fuelwood sector is quite complex and not linearly organised as presented in the value chain map above. The price of wood varies greatly depending on the buyer and the intended market.

3.4.1. Kenya Scenario

For the purpose of this analysis, farm-gate prices paid by transporters to a farmer which is about KSh.800 per stere were used. It must be noted that this is just an estimate based on information obtained from a transporter in Muranga (Kenya) since most farmers sell standing trees and the final price is determined by his ability to bargain with the potential buyer.

Table 8: Summary of income distribution between actors in the Kenya firewood value chain

Actor	Variable costs (KSh)	Revenue (Selling price)	Gross profit (Revenue – costs)	Value added (Revenue- previous actor's revenue)
Farmer (farm-gate)				
Harvesting	-			
Sales		800		
			800	
Transporter[3]				
Wood buying price	800			
Vehicle hire[4]	250			
Fuel[5]	250			
Labour	150[6]			
Transport permit[7]	100			
Sub-total	1,550			
Sales		2,000[8]		
			450	1,200
Retailer				
Rent	-			
Labour	-			
Taxes	300			
security[9]	50			
Illegal payments	200			
Sub-total	2,550			
Sales		4,000		
			1,450	2,000

Source: Geoffrey M. Ndegwa, 2010

From the table, the vendors seem to make the highest profit per stere of wood sold compared to the transporters. The vendors interviewed said that they sell about two steres of wood per week, translating to a profit of KSh.11,600 per month. The farmers have not engaged in the wood selling business and sell the wood when in need of money for school fees, medical or other urgent needs thus it is not easy to quantify how much they make per month from selling wood. (Geoffrey M. Ndegwa, 2010)

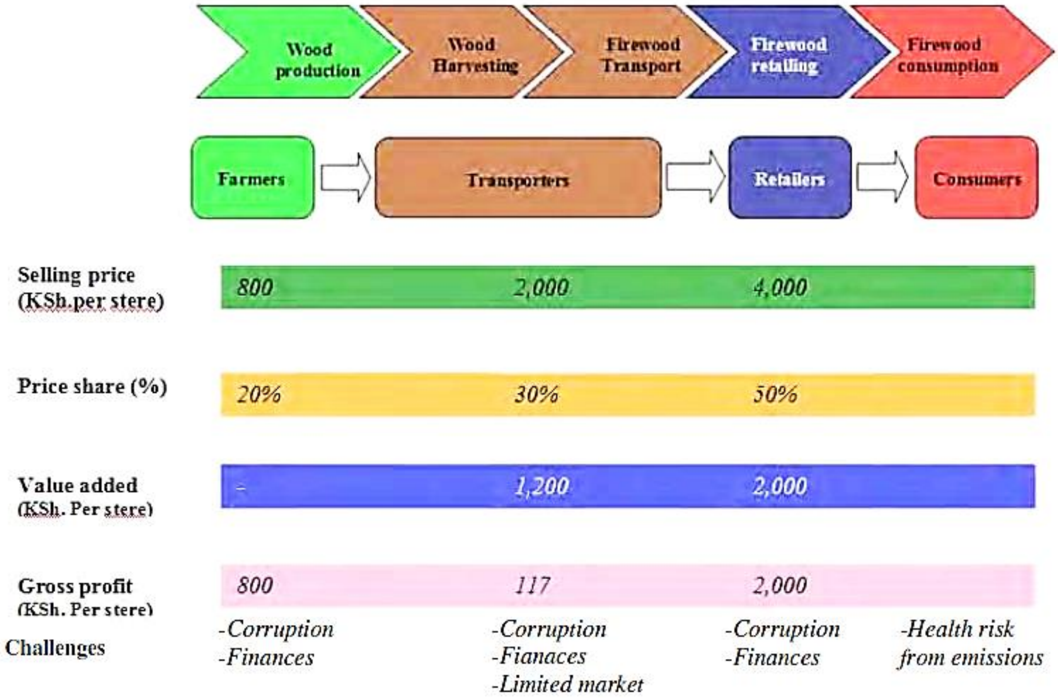

Figure 13 Quantified firewood value chain in Kenya

Source: Geoffrey M. Ndegwa, 2010

3.4.2. Rwanda Scenario

Figure 14: Firewood stacked on the roadside awaiting buyers in Rwanda

Source: Geoffrey M. Ndegwa, 2010

As discussed in the previous section, most of the wood is traded informally with only a small proportion consumed traded moving along the supply chain. The analysis of the supply chain was based on the firewood that moves regularly along the chain, which might be the way forward if the sector is to be sustainable and economically beneficial to the stakeholders, especially the farmers

Table 9 Actors revenues and expenditure in Rwanda's firewood value chain

Actor	Variable costs (FRw.)	Revenue (Selling price)	Gross profit (Revenue – costs)	Value added (Revenue-previous actor's revenue)
Farmer (farm-gate)				
Harvesting	500			
Sales		3,000	2,500	-
Transporter[21]				
Wood buying price	3,000			
Vehicle Fuel and service	2,500[22]			
Vehicle insurance[23]	833			
Labour	667[24]			
Transport permit	20[25]			
others[26]	208			
Sub-total	7,228			
Sales		10,000		
			2,772	7,000
Retailer[27]				
Wood buying price	10,000			
labour	-			
Taxes[28]	1,042			
security[29]	562			
Sub-total	11,604			
Sales		16,000		
			4,396	6,000

Source: Geoffrey M. Ndegwa, 2010

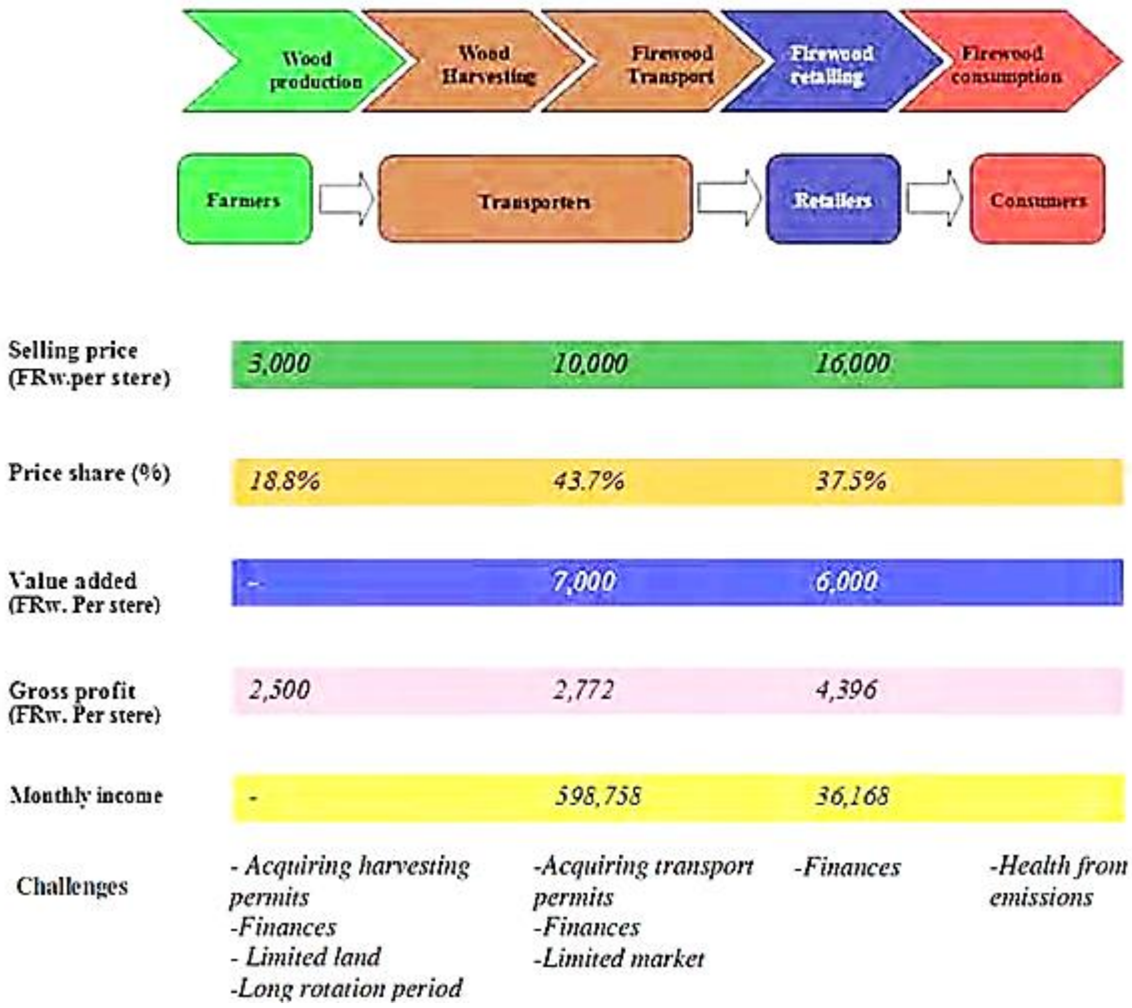

Figure 15 Quantified firewood value chain in Rwanda

The farmers do not engage in selling wood as a day to day business hence it is difficult to quantify their monthly income from the trade. As for the transporters, they are able to make a profit of FRw 2,772 per stere, translating to FRw. 33,264 per trip. A transporter who makes 18 trips per month makes about FRw. 598,758 or US$ 1032.3330. This figure could rise to FRw. 997,920 if the transporter is able to transport 30 steres of wood. A vendor makes a profit of FRw. 4,396 per stere, which when he/she sells 2 steres a week makes FRw. 35,168 per month.

3.5. Sustainability Issues

3.5.1. Production and Processing

- *Pressure on the resource and deficit of sustainable supply*: These pressures are greatest in regions where there is a high demand for wood-fuel and less abundant resources
- The large number of poor income households involved in production: Many people are involved at the level of wood-fuel production and processing and these activities provide important socio-economic benefits for these people, notably cash income.
- The lack of awareness and knowledge of sustainable management practices: In many regions, local populations have no knowledge of planned felling or sustainable

extraction methods. Furthermore, there is little practice of tree planting and the transfer of techniques and awareness has been insufficient.

- The failure of large scale wood-fuel plantations: Plantations have been hampered by unclear ownership, low wood-fuel prices (due to undervaluation of the resource) and a lack of replanting experiences by the local population.
- An overall lack of good resource governance leads to indiscriminate resource extraction by small or large actors. Local administrations have conflicting interests and lack capacity for effective control.
- Tenure and access rights are not secured: Tree planting requires a long-term investment, which is often unrealistic for the immediate needs of poor populations. Traditional authorities often assign land for agriculture purposes and for a shorter period of time. Official land tenure procedures can be complicated and costly.
- A possible conflict of interest in using trees or land for fuel and using these resources for other purposes, such as timber, food, medicinal use, fruits etc., as well as clearing for infrastructure. It is important that social considerations are taken into account in determining use of land: for example for food security, energy security etc.
- Producers encounter unequal distribution of benefits vis-à-vis the traders and wholesalers, which is sometimes reinforced by the permit and quota systems.
- Charcoal kilns have low energy efficiency: Carbonisation of wood into charcoal generally takes place in traditional earth kilns that are constructed underground or aboveground. Most carbonisation takes place in traditional earth kilns with an energy efficiency of around 13-15 per cent. Thus, the present transition to charcoal in Africa’s urban centres puts additional pressure on peri-urban wood resources.

3.5.2. Transport and Trade

- Higher costs for transport due to longer distances: With growing scarcity in the supply of woodfuel, the distances and the costs of accessing and transporting woodfuel have increased. Road networks and means of transport are often in bad condition, hampering transport- especially during the rainy season.
- The bad condition of roads, the use of old and badly maintained vehicles and lack of storage facilities increase GHG emissions.
- Wood-fuel prices do not reflect their true economic value: Under-pricing of the resource leads to an economic incentive for conversion of the resource base to other economic uses which are traded for higher returns.
- The illegal wood-fuel trade: In many countries there is a parallel woodfuel trade besides the legal one, which is largely uncontrolled and evades taxes. Also forestry officials may be prone to bribes while doing the work.
- At the level of the market, additional regulations are sometimes applied by local government regarding sales. A multitude of government departments in the value chain can lead to confusion with producers and traders and competition among the tax levying bodies. For supply to the city of Kinshasa, a total of 12 state services impose taxes on wood-fuel transporters and sellers.
- The influential role of the transporter and intermediary in wood-fuel value chains: In spite of the high transportation costs, it is motorised transporters, merchants and wholesalers who gain most revenues, because they receive a relatively high share of the product’s end price and handle large quantities. The extent of their roles and influence varies among countries and locations. In Burkina
- Faso, for example, merchants hold a relatively high level of power in the value chain, as they are the owners of the trade quotas. This is often at the expense of woodcutters

who are being pressured to not respect sustainable harvesting rules and to exceed official quotas. The intermediary role of transporters and traders has been insufficiently taken into account in policy interventions.

- Demand side pressure on the transporters/traders for particular - often endangered and illegal - species of wood is not often considered in the design of interventions while it can have a marked influence on degradation of forested areas and loss of key species.

3.5.3. Consumption

- Energy security of the poorest groups: The major benefit of wood-fuel is the energy-security it provides to the vast majority of Sub-Saharan African households. With the continuing increase of wood-fuel consumption and largely unsustainable production, prices for urban households continue to increase. The poorest households pay a higher price because they purchase the relatively expensive small bags of charcoal or bundles of fuel-wood, as they cannot afford to buy a larger stock at once. Fuel switching is hampered because of costs and lack of access to alternative energy sources. Any efforts to internalise the environmental costs of unsustainable use will invariably hit the poorest hardest. It is therefore critical that ways to fulfil the basic energy needs of the poorest households are met.
- A growing demand for fuel-wood and charcoal in urban centres puts growing pressure on wood resources. This results in more time and effort needed for collecting wood for domestic use by the rural populations (mostly women and children) and increasing prices for urban populations. Insufficient data on wood-fuel demand complicates supply-demand planning.
- Fuel switching is hampered because of the costs and the lack of access: A full comprehension of cooking energy’s lifecycle is needed to compare GHG emissions. However a move towards technologies such as improved biomass-, biogas and producer gas-fired stoves, can provide a lower cost and lower emissions alternative. Bio digesters need initial investment and availability of cow dung, water and continuous management of the installation. The initial investment can be an obstacle in a rural context where wood-fuel is generally considered a free good. Innovative finance options to allow the poor to access funds need to be introduced.
- The low use of improved cooking stoves: In rural areas, the purchase costs of more energy efficient stoves can be an obstacle for poor families. Consumers lack information or cash for improved stoves (even though they would save costs eventually). The use of ICS to reduce wood-fuel consumption remains low; around 6 per cent throughout Sub-Saharan Africa.

3.6. Interventions to Address Sustainability Issues

3.6.1. Production

Potential interventions at the level of production include (1) improved forest management; (2) improved energy efficiency; and (3) alternative wood sources. (Jolien et al. 2010)

Improved management of tree resources (i.e. management of fallows and degraded forests, agroforestry and plantations)

Management of tree resources, including public and private initiatives in fallows and degraded forests, agroforestry and plantations, should be improved. This could include providing start up finance and/or transferring rights, skills and techniques, for example: assistance in the development of forest management plans, assisted natural regeneration techniques for preservation of multiple-purpose tree species, reintroducing trees in agricultural systems and managing village plantations with species for multiple uses.

Decentralised woodfuel management should be part of wider landscape planning and decentralisation processes (Jolien et al. 2010)

The indiscriminate chopping of wood - including young trees and the trampling of new shoots - is considered to be a major impediment for regrowth.

Interventions should consider improvement of tree harvesting techniques in both managed and unmanaged areas. (Jolien et al. 2010)

Initiatives for public and private reforestation and plantations need to be introduced. Examples, such as the Mampu agroforestry experience in DRC (see Box 4), suggest that degraded lands can be reforested and contribute to carbon sequestration objectives, wood-fuel supply and improving livelihoods and food security. Legal options that ensure tenure of private or community plantations are a key element to ensure sustainability and need to be coordinated within broader national policies. (Jolien et al. 2010)

Wood-fuel from plantation forests, sustainably managed forests and/or agroforestry plots needs to be promoted over wood-fuel from uncontrolled harvesting or threatened tree species. The promotion of land use for the purpose of tree planting may need to be subsidised, given the lower returns compared to production of agriculture crops and the long term investments needed. (Jolien et al. 2010)

Ways to address land rights and use issues should be established at the community level. For instance, a solution should be found for those who are willing to plant trees but are prevented from doing so by present rules. This implies support for more community based management systems and structures. (Jolien et al. 2010)

Increased energy efficiency of carbonisation

Increasing the energy efficiency of carbonisation is one of the solutions with the highest potential for reducing GHG emissions. Charcoal kilns in Africa are often traditional earth kilns with low energy efficiency. Improving kiln technology and technical skills on how to build kilns could improve these efficiencies and diminish the amount of wood-fuel needed (Jolien et al. 2010). This involves the introduction of improved carbonisation techniques, materials and skills.

Factors that influence the efficiency are the way and direction the wood is piled; the size and humidity of the wood, and; the monitoring of airflow during carbonisation. In traditional kilns, half of the wood energy is lost in pyrolysis gases. Cogeneration of heat and electricity from these pyrolysis gases can reduce the carbon footprint by over 50 per cent and it is a promising technique for rural development in Sub-Saharan Africa.85

Availability of finance to allow the transition to improved kilns, particularly for the poorest households, will be critical for uptake.

Use of alternative wood or biomass

Improving the use of alternative wood or biomass sources requires tapping into other available opportunities such as (1) the waste wood of timber companies or wood processing industries and (2) the production of charcoal briquettes from charcoal dust, waste wood and alternative biomasses, such as waste from agriculture production.

A case in Ghana, which consists of replacing wood energy with a mix of oil palm residue and oil palm kernels as fuel, is reported to produce good results to mitigate wood-fuel related deforestation. A useful tool is available – the Alternative Charcoal Tool – to assess the suitability of a biomass feedstock, technology and market and related production costs:

Diverting away from wood-fuel production would need consideration of possible alternative income generating activities for those who would lose this livelihood activity.

3.6.2. Transport and Trade

The main categories of interventions to improve outcomes of wood-fuel transport and trade are (4) promoting sustainable transport and trade; (5) more energy efficient trade and transport, and; (6) organisation of the wood-fuel value chain.

(4) Promote and control sustainable transport and trade

Sustainable transport and trade that promotes wood-fuel from plantation forests and avoids wood extraction from valuable or threatened tree species can be promoted by targeting corruption and violations of sustainable management norms by the different actors along the value chain. This requires raising awareness on rights and responsibilities among all actors, providing sufficient salaries to controlling officials and implementation of other anticorruption measures or grievance mechanisms

Wood-fuel needs to be sold at a price that reflects its true economic cost which reflects the sustainability of supply. Higher prices will stimulate more investment in the sector. However, as indicated before, the relative costs will invariably fall on the poorest, so supporting measures targeting the poor should accompany any price increases.

There need to be stiffer penalties for the illegal extraction of wood for fuel, particularly for the illegal extraction of valuable or threatened tree species; this would need to be backed up by stronger enforcement.

Differentiated taxes could be introduced to stimulate woodfuel supply from sustainable management practices and/or specific regions. Such a differential tax system was successfully introduced into the rural wood markets in Mali and Niger

Energy efficient trade and transport

Infrastructure, storage and market facilities should be improved for more energy and cost efficient transportation. Examples of activities that can contribute to this are promotion of sustainable production at minimum distances from urban markets; provision of warehouses to keep the product from deteriorating; and scaling-up and organisation of transport.

Better organisation along the wood-fuel value chain

The wood-fuel value chain needs to be organised in a way that gives a voice to the many actors involved and that addresses the unequal distribution of power and benefits. Transporters and intermediaries may play an active role in this, as they know both sides of the value chain. There needs to be awareness raising on rights and obligations among all actors and avoiding of regulations that stimulate a monopolistic position of transporters/ traders in determining prices, harvesting practices and qualities vis a vis the producers.

Transporters/wholesalers, producers and consumer groups should be brought together to strategies for sustainable supply. In Burkina Faso, the association of transporters/ wholesalers (Tiis-la-Viim) and producers launched common tree plantations some years ago. Though the effectiveness of this initiative is still to be proven, this synergy shows promise.

3.6.3. Consumption

Several options exist at the level of consumption and their outcomes and possible leakages deserve close attention within the context of a low carbon economy. Solutions include (7) wood-fuel efficient technology; (8) fuel switching; and (9) revaluing wood energy within the national energy strategy.

Promote wood-fuel efficient technology

The use of ICS for higher energy efficiency at the level of consumption should be promoted. These improved stoves need to rely on market mechanisms, be supported with awareness raising campaigns and be adapted to the local context.

Other energy efficiency measures such as use of dry wood and use of auto cookers/hotboxes to reduce wood consumption should also be promoted.

Modern techniques, such as cogeneration of charcoal to produce electricity or production of charcoal briquettes for commercial or industrial demand, need to be introduced.

Major impediments to introducing wood-fuel efficient technology are the upfront costs and the availability of capital to pay for the initial investment. Innovative financing options need to be explored.

Fuel switching

Facilitating the transition to other types of energies, based on proper information on costs and benefits as well as emission comparisons, is important. LPG, ethanol gel and biogas are potential household fuels that reduce not only GHG emissions but also negative health impacts. Such a transition needs to be supported by awareness raising campaigns and (temporary) subsidising policies (prices, quantities, up-front costs), with special consideration given to energy access by poor households.

With regard to local industries, the dolo gas stove for the local millet beer breweries in Burkina Faso offers an interesting example that eliminates wood-fuel entirely and at the same time underlines how new solutions need to be supported by subsidies and appropriate financial mechanisms

Revalue the place of wood-fuel in national energy strategies

It is important to recognise the economic value and the importance of wood-fuel as a source of energy and contributor to energy security of households and businesses.

The ecological and climatic value of wood-fuel energy as a renewable energy source that can restore degraded land, enhance biodiversity and reduce CO_2 emissions must also be recognised.

Data on wood-fuel consumption, which includes quantification of costs, livelihood benefits and CO_2 emission savings from demand side interventions, should be collected.

Table 10 Steps of the value chain, major risks and institutional conditions to mitigate risks

Step of value chains	Intervention	Major risks	Institutional conditions
Production and processing	Improve management of tree resources	• Other drivers of deforestation; wood-fuel is combined with other drivers • Unsecure access and tenure rights • Competition of land use for other sectors • Loss of livelihood activities; reduced participation by poorest	• Baseline and date to monitor changes in forest areas (GHG emissions); impacts on poor • Support for participatory forest management • Providing tenure rights • Appropriate benefit sharing mechanism
	Increase energy efficiency of processing		
	Use alternative wood/biomass source		
Trade and transport	Control for sustainable trade	• Regulation can exclude groups and distort market • Conflicts of interest over tax revenues • Difficult to keep free riders out of the system	• Monitor capacity of local management units and forest services • Associations which effectively represent different actor groups (including the poor) • Framework for dialogue between actor groups
	Efficient trade and transport		
	Organisation of the value chain		
Consumption	Increase energy efficiency of consumption	• Higher prices for consumers • Increasing energy needs (urbanisation and population growth) • Emission balance of fuel switching can be negative • Uncertainties of adopting new technologies	• Coherent wood-fuel policy based on supply/demand and sustainability • Monitoring and data on consumption • Effective technology extension agencies
	Fuel switching		
	Revalue wood energy in national policy		

Adapted from Jolien et al. 2010

4. POLICIES AND LAWS GOVERNING THE FUELWOOD SECTOR

4.1. Forestry Commission Ghana

The Forestry Commission (FC) was established by an act of parliament, Act 571 of 1999 to bring under one commission, the main public bodies agencies implementing the functions of protection, development, management and regulation of the forests and wildlife resources and provide for related matters. Under this Act 571, the FC has been made responsible for the regulation of the utilization of forests and wildlife resources, conservation and management of those resources and the co-ordination of policies related to them. Under the Act, the Ministry of Lands and Natural Resources has ministerial responsibility for the commission. The commission is composed of the following who are appointed by the President in consultation with the council of state:

- The chairman

- The chief executive of the FC
- A representative from the national house of chiefs
- A representative of the wildlife trade and industry
- A representative of the Ghana Institute of Foresters
- A representative of NGOs involved in wildlife and forest management
- A representative of lands commission
- And three other persons with financial, commercial or managerial experience nominated by the President at least one of whom shall be a woman.
- A representative of the timber trade and industry

Currently there are three (3) divisions under the FC and each is headed by an executive director who takes responsibility for the day-to-day management of the division and is answerable to the commission through the Chief Executive in the performance of his/her duties. The divisions are: Forest Services Division (FSD); Wildlife Division (WD) and Timber Industry Development Division (TIDD), (FC charter, 2001).

The following are the various laws and regulations governing the forestry sector:

Forest and wildlife policy 1994, which provides the basis to develop the national forest estates and a timber industry that provides the full range of benefit required by society in an ecologically sustainable manner that conserve environmental and cultural heritage.

Timber Resources Management Act, 1997, (Act 547). This Act provides for the qualification of timber concessions, grants of timber rights and permits, timber utilization contracts, terms, payment of timber royalties, management of timber operations and other operational regulations.

Timber resources management (Amendment Act 2002, Act 617). An act to amend the timber resources management act 547 to exclude from its application land with private forest plantation, to provide for maximum duration and maximum limit of area of timber rights, to provide for incentives and benefits applicable to investors in forestry and wildlife and to provide for matters related to these.

Timber Resources Management Regulation, (LI 1649 of 1998). This regulation provides for the procedure for the grant of timber rights to timber operations, terms and conditions for Timber Utilization Contracts, Timber Utilization Permits, Salvage Permits, and Royalties/Stumpage fees, Measurement of timber products, timber registration, chainsaw registration, and prohibition of chainsaw to convert timber into lumber for sale, offences and penalties among others.

Timber Resources Management (Amendment) Regulation 2003, LI 1721. This regulation amends sections of LI 1649 in the manner of bidding, pre-qualification application forms, requirements, evaluation, bidding procedures, terms and conditions of contracts and monitoring functions of district and regional managers of the FC, review and payments of forest fees and stumpages.

Forest Protection Amendment Act 2002, (Act 624). An Act to amend the old forest protection decree of 1974 (NRCD 243)–to provide for higher penalties for offences therein and also to provide for related purposes.

POLICY CONSIDERATIONS

1. The forestry sector to ensure sustainable management of the country’s natural forests and woodlands;

2. Design and implementation of a regulatory framework for commercial transportation and marketing of woodfuel.
3. Establishment of the needed institutional framework to enhance and co-ordinate woodfuel related activities as an integral part of national energy development.
4. Improved technologies and higher levels of efficiency in the production of charcoal and use of woodfuels.
5. Development, promotion and introduction of alternative fuels for the substitution of woodfuels.

5. CONCLUSION

This literature review highlighted the various actors and their economic analysis of the fuelwood value chain. The major conclusions that can be drawn from this review are:

Fuelwood data does not reflect the supply and demand dynamics in a country. There is the need to re-visit the quality of data on fuelwood to reflect supply and demand situations. Also to collect data and compile statistics on fuelwood supply, distribution, consumption and trade in relation to the fish smoking sub-sector.

The analysis from other countries shows that, income from the production level is low, income from the transportation level is much higher and income from retailing level recording the highest.

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