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**WOODFUEL IN RWANDA: IMPACT ON ENERGY, POVERTY  
AND THE ENVIRONMENT**



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## ABSTRACT

Rwanda's landlocked location, high population density, poverty and lack of economic diversification beyond unsustainable agriculture, have shaped the energy situation and limited access to modern fuels. Woodfuel is the main source of energy for households and its trade a source of income and jobs in rural areas. Due to repeated division of ancestral property by traditional inheritance of land, currently 85.2% of households have land holding of less than one hectare. This is insufficient to grow food and fuelwood for a household of the average size of 5.5 persons. Pressure on land has led to the conversion of natural forests to agricultural land; increasing demand for woodfuel and wooden poles for houses in growing towns are additional and important factors of forest depletion. However, without well documented reports of the individual impact of each deforestation factor, woodfuels have been most blamed as the driving force of deforestation.

Attempts to reduce deforestation include restrictive regulations on wood products trade in general and woodfuel in particular. Bans and exploitation permits limited the socio-economic benefits derived from the woodfuel industry such as income and jobs in rural areas. The bans and permits, designed to alleviate the pressure on forest resources, force people to cut wood illegally for self consumption or trade. They cannot afford commercial fuels and for many woodfuel is the only cooking fuel.

This thesis investigates how the current woodfuel industry impacts on energy, poverty and forests. From a desk research on secondary data, woodfuel production, demand, supply and use were documented and their legal and regulatory framework were analysed. Policy instruments were examined to assess their conformity to sustainable management i.e whether they increase, or help to alleviate the pressure on woodfuel resources. In order to verify secondary data, the desk research was complemented by a case study on woodfuel production and consumption in the Southern province of Rwanda.

Major research findings were that: Considering woodfuel consumption under an only environmental or energy perspective has resulted in a search for a narrowly environmental or

energy solution. Both failed to solve the problem of forest depletion. Current regulations limit the benefits traditionally derived from woodfuel commoditisation leading to a negative attitude towards the implementation of policy instruments, thereby in fact increasing forest depletion.

The processes involved in producing charcoal and using it as a cooking fuel are inefficient and resource intensive. In rural settings, the proportion of the population that uses firewood is fairly consistent across the country as a result of its low cost and the lack of available alternatives. Woodfuel consumption does have an impact on the national forest resource, but it is not the only impact leading to forest depletion.

The adoption of improved wood and charcoal-burning stoves (ICS) is the easiest and cost effective strategy to reduce woodfuel demand and hence forest depletion. The barriers to large dissemination and use have not yet been evaluated. The key factors seem to be availability, relatively low cost of woodfuels, lack of improved stove diversity on the local market and government policy in regard to the woodfuel industry.

Since there is no single cause of deforestation there is no single intervention that will address it effectively. The woodfuel value chain must be considered in a wider political, socio-economic and environmental context to find a solution which is supported by the majority of stakeholders. In the country's current socio-economic context, policies, aiming to substitute or reduce woodfuel consumption, have not achieved the desired results and their implementations have not unarguably reduced deforestation.

Any policy regulating the industry must regard the sustainable production, use and trade of woodfuels as part of integrated rural development and poverty alleviation. The research recommends community-based woodfuel production and forest replenishment associations as sustainable management approaches to mobilise community support for sustainable forestry management and woodfuel production which could benefit all stakeholders.

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## LIST OF ACRONYMS

<b>AC</b>	Allowable Cutting
<b>ADB</b>	African Development Bank
<b>ADF</b>	African Development Fund
<b>AF</b>	Accessible Area Fraction
<b>BADEA</b>	Arab Bank for Economic Development in Africa
<b>BEST</b>	Biomass Energy Strategy
<b>BNR</b>	National Bank of Rwanda
<b>CBFM</b>	Community Based Forest Management
<b>CBWP</b>	Community Based Woodfuel Production
<b>CDM</b>	Clean Development Mechanism
<b>CGIS-NUR</b>	Centre for Geographic Information Systems at National University of Rwanda
<b>DC</b>	Developing Countries
<b>DFE</b>	District Forestry Fund
<b>DFP</b>	District Forestry Programme
<b>DME</b>	Department of Minerals and Energy
<b>DRC</b>	Democratic Republic of Congo
<b>EAC</b>	East African Community
<b>EARP</b>	Electricity Access Roll out Programme
<b>EDPRS</b>	Economic Development and Poverty Reduction Strategy
<b>EICV</b>	Enquête Intégrale sur les Conditions de Vie des Ménages (Integrated Household Living Conditions Survey)
<b>ELECTROGAZ</b>	National Electricity, Water and Gas Supplier Utility
<b>EJ</b>	Exajoule
<b>ESMAP</b>	Energy Sector Assistance Management Program
<b>EU</b>	European Union
<b>FAO</b>	Food and Agriculture Organisation
<b>FCCC</b>	Framework Convention on Climate Change
<b>FF</b>	Fuelwood Fraction

<b>FONERWA</b>	National Fund for Environment in Rwanda
<b>FPS</b>	Forest Protection Services
<b>FRA</b>	Forest Replenishment Association
<b>GDP</b>	Gross Domestic Product
<b>GoR</b>	Government of Rwanda
<b>GTZ</b>	Gesellschaft für Technische Zusammenarbeit
<b>GW</b>	Giga Watt
<b>HDI</b>	Human Development Index
<b>HEDON</b>	Household Energy Network
<b>HF</b>	Harvest/Cutting Fraction
<b>IAP</b>	Indoor Air Pollution
<b>ICS</b>	Improved Cooking Stove
<b>ICT</b>	Information and Communication Technology
<b>IEA</b>	International Energy Agency
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>IPP</b>	Independent Power Producers
<b>IRST</b>	Institut des Recherches Scientifiques et Technologiques
<b>ISAR</b>	Institut des Sciences Agronomiques du Rwanda
<b>JFM</b>	Joint Forest Management
<b>JICA</b>	Japanese International Cooperation Agency
<b>kWh</b>	Kilowatt hour
<b>LDC</b>	Least Developed Countries
<b>LFRC</b>	Land and Forest Research Centre
<b>LPG</b>	Liquefied Petroleum Gas
<b>MAI</b>	Mean Annually Increment
<b>MARGE</b>	Marchéage et Gestion de l'Environnement
<b>MDG</b>	Millennium Development Goals
<b>MINAGRI</b>	Ministry of Agriculture
<b>MINALOC</b>	Ministry of Local Government
<b>MINICOFIN</b>	Ministry of Finance and Planning
<b>MINICOM</b>	Ministry of Trade and Industry

<b>MININFRA</b>	Ministry of Infrastructure
<b>MINIPLAN</b>	Ministère du Plan (Ministry of Planning)
<b>MINIRENA</b>	Ministry of Natural Resources
<b>MINITERRE</b>	Ministry of Land, Environment, Forestry, Water and Natural Resources
<b>MINITRAPE</b>	Ministère des Travaux Publiques et Equipements (Ministry of Infrastructure)
<b>MJ</b>	Mega Joule
<b>MW</b>	Mega Watt
<b>NAFA</b>	National Forest Authority
<b>NDBP</b>	National Domestic Biogas Project
<b>NEDA</b>	National Energy Development Authority
<b>NFF</b>	National Forestry Fund
<b>NFP</b>	National Forest Programme
<b>NISR</b>	National Institute of Statistics of Rwanda
<b>NUR</b>	National University of Rwanda
<b>OECD</b>	Organisation for Economic Cooperation and Development
<b>OFID</b>	OPEC Fund for International Development
<b>OPEC</b>	Organization of Petroleum Exporting Countries
<b>PEI</b>	Poverty Environment Initiative
<b>PNN</b>	Nyungwe National Park
<b>PNV</b>	Parc National des Volcans
<b>PPP</b>	Purchasing Power Parity
<b>ProBEC</b>	Programme for Basic Energy and Conservation in Southern Africa
<b>PRSC</b>	Poverty Reduction Strategy Credits
<b>PV</b>	Photovoltaic
<b>REMA</b>	Rwanda Environmental Management Authority
<b>RNRA</b>	Rwanda Natural Resources Authority
<b>RWF</b>	Rwandan Franc
<b>SADC</b>	Southern African Development Community
<b>SFD</b>	Saudi Fund for Development
<b>SFM</b>	Sustainable Forest Management

<b>SINELAC</b>	Société Internationale d'Electricité des Pays des Grands Lacs
<b>SNEL</b>	Société Nationale d'Electricité
<b>SPSS</b>	Statistical Package for the Social Sciences
<b>SSA</b>	Sub-Sahara Africa
<b>SWH</b>	Solar Water Heater
<b>SWOT</b>	Strengths, Weaknesses, Opportunities and Threats
<b>TJ</b>	TeraJoule
<b>TOE</b>	Tons Oil Equivalent
<b>UBET</b>	Unified Bioenergy Terminology
<b>UEDCL</b>	Uganda Electricity Distribution Company Limited
<b>UNDP</b>	United Nations Development Programme
<b>UNEP</b>	United Nations Environment Programme
<b>UPEGAZ</b>	Unit for the promotion and Exploitation of Lake Kivu Gas
<b>USAID</b>	United States Agency for International Development
<b>US\$</b>	United States of America Dollar
<b>US\$c</b>	United States of America Dollar Cent
<b>VAT</b>	Value Added Tax
<b>WEC</b>	World Energy Council
<b>WEP</b>	Wood Energy Programme
<b>WISDOM</b>	Woodfuel Integrated Supply Demand Overview Mapping

## **FOREST RELATED TERMS COMMONLY USED IN THE THESIS<sup>1</sup>**

**Afforestation:** The conversion from other land uses into forest, or the increase of canopy cover to the 10% defined threshold for forest (FAO, 2000). Establishment of forest plantations on land that, until then, was not classified as forest implies a transformation from non-forest to forest.

**Agroforestry:** A system of land use in which harvestable trees or shrubs are grown among or around crops or on pastureland, as a means of preserving or enhancing the productivity of the land. It is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock.

**Agroforestry trees:** Trees used in agroforestry by combining agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land-use systems. They are used in alley cropping, silvopasture, windbreaks, riparian buffer strips and forest farming.

**Deforestation:** The conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold.

**Forest:** The term forest in Rwanda is defined as an “Area of at least 0.5 ha with a tree cover of more than 20%”. The trees are defined as “trees of more than 7 meters in height” (CGIS-NUR, 2007).

**Forest degradation:** Changes within the forest which negatively affects the structure or functions of the stand or site, and thereby lowers the capacity to supply products and/or services.

**Forest plantation:** A forest established by planting or/and seeding in the process of afforestation or reforestation. It consists of introduced species or, in some cases, indigenous species.

**Natural forest:** A forest composed of indigenous trees and not classified as forest plantation.

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<sup>1</sup> Non specifically referenced definitions are from Food and Agriculture Organisation, 2003.

Primary forest: Forest that has never been logged and has developed following natural disturbances and under natural processes, regardless of its age. It is referred to "direct human disturbance" as the intentional clearing of forest by any means (including fire) to manage or alter them for human use.

Reforestation: The re-growth of forests after a temporary (< 10 years.) condition with less than 10% canopy cover due to human-induced or natural perturbations (FAO, 2000).

Round wood: Wood in its natural state as felled, with or without bark. It may be round, split, roughly squared or in other forms. Round wood can be used for industrial purposes, either in its round form (e.g. as transmission poles or piling) or as raw material to be processed into industrial products such as sawn wood, panel products or pulp (Dykstra & Heinrich, 1977).

Woodfuel: Refers to both fuelwood or firewood and charcoal. Fuelwood is wood that is burned directly for energy purposes with no prior processing. Charcoal is woodfuel that has been carbonized by heating it in the absence of sufficient oxygen (pyrolysis) to prevent full combustion.

Woodlot: A usually private area restricted to the growing of forest trees, especially for building material or fuel.

Wood residues: Residues obtained from natural or managed forests or isolated trees used as fuel and in which the original composition of wood is retained (IEA, 2010). Wood residues includes, "but is not limited to", logging slash, down timber material, woody plants, and standing live or dead trees which do not meet utilization standards because of size, species, merchantable volume, or economic selection criteria and which, in the case of live trees, are surplus to growing stock needs (IEA, 2010).

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**CHAPTER ONE**  
**THE LINK BETWEEN POPULATION INCREASE, LAND HOLDING, WOODFUELS**  
**AND DEFORESTATION**

**1.1 Introduction**

Rwanda is a small, resource poor, landlocked and overpopulated country situated in central-eastern Africa. It is one of the smallest countries in Africa with an area of 26,338 km<sup>2</sup> and 57% of the population fall below the poverty line<sup>2</sup>. In 2009 the country had a GDP<sup>3</sup> per capita of US\$520, a human development index (HDI) of 0.46, which gives the country a rank of 167th out of 182 countries with HDI data available (UNDP, 2009a).

The country borders Burundi in the South for 290 km, the Democratic Republic of the Congo in the West for 217 km, Tanzania in the East for 217 km and Uganda in the North for 169 km (Figure 1). The nearest ports, Mombasa (Kenya) and Dar es Salaam (Tanzania) are respectively 1792 km and 1620 km from the capital city, Kigali. With 10,117,029 inhabitants in 2009, Rwanda is, after Mauritius, the second most densely populated country in Africa with a density of more than 500 persons/km<sup>2</sup>.

The Republic of Rwanda is divided into four provinces and the city of Kigali, 30 districts, 416 sectors, 2146 cells and 14837 villages. The cell is the smallest politico-administrative unit of the country and hence closest to the people. Therefore, this is the unit through which the problems, priorities and needs of the people will be identified and addressed. The district is the basic administrative unit of the country.

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<sup>2</sup> The method that was used (NISR, 2006b) considered the poverty line as the amount that covers the cost of an adult's basic needs which includes food that provides at least 2,500 calories per day, and basic non food products. Using the January 2006 prices, this cost was estimated at \$US158 per adult per year for the poverty line and \$US 111 for the extreme poverty line.

<sup>3</sup> Gross Domestic Product (GDP) is the total market value of all final goods and services produced in a country in a given year. It is equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.

Also known as “the land of a thousand hills”, Rwanda’s altitude ranges from 1,000-4,500 m above sea level. The highest point is Karisimbi volcano (4,507 m) in the North and the lowest Rusizi River (950 m) in the South–West. The vegetation ranges from dense equatorial forest in the North-West of the country to tropical savannah in the East. Forests cover 10.10% of the land area and comprise of natural and plantation forests (humid mountain forest, savannah, plantations of Eucalyptus, pines and coppices, degraded natural forest and bamboo).

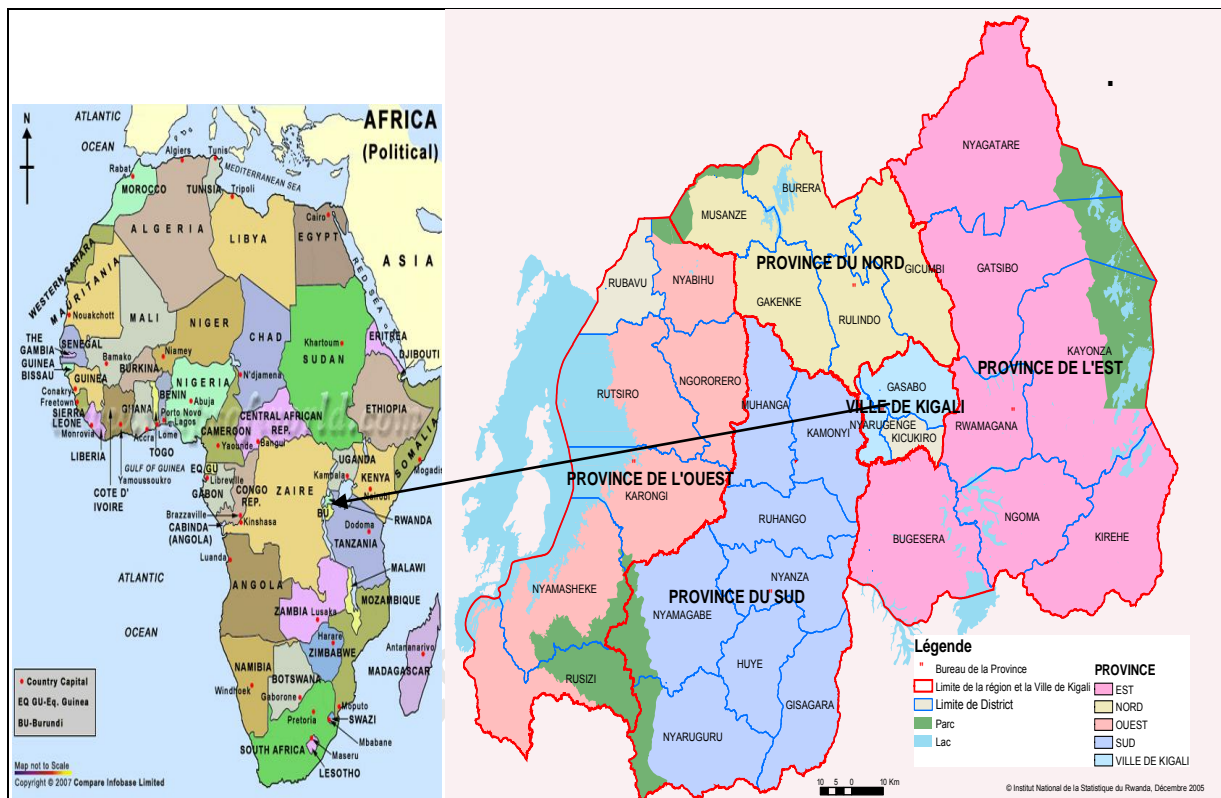


Figure 1: Rwanda in Africa

Source: Compare InfoBase, 2010 for the African map; National Institute of Statistics of Rwanda website ([www.statistics.gov.rw](http://www.statistics.gov.rw)) for the Rwanda administrative map

The first written forest law of independent Rwanda was enacted in 1988 (République Rwandaise, 1989) followed by the land law (Republic of Rwanda, 2005a) and the environment law (Republic of Rwanda, 2005b) in 2005. Traditionally land was acquired by inheritance and the population increase led to repeated division of ancestral property so that currently 85.2% of households have less than one hectare of land. Pressure on land led to the conversion of natural forests to agricultural land.

Woodfuels are the main source of energy for households, and its trade is a source of income and jobs in rural areas and its increasing demand is a significant factor in forest depletion. While conversion to agricultural land has led to forest depletion, expansion of shelter infrastructure in growing towns is equally an important factor in long-term deforestation and a crucial determinant of the fate of tree cover. However, without well documented reports of the individual impact of other factors, the need for woodfuels has been blamed as the main cause of deforestation and lead to authoritative measures to regulate harvesting (MINISTERRE, 2004b; MINISTERRE, 2006).

Attempts to reduce deforestation include restrictive regulations on wood products' trade in general and woodfuel in particular through bans and exploitation permits. These regulations have limited the socio-economic benefits of woodfuels exploitation, such as income generation and job creation in rural areas. As these benefits are part of integrated rural economic development (incomes and jobs) and incentives for forest caretaking, their limitation weakens policy instruments designed to alleviate the pressure from woodfuels trading on forest resources.

The big challenge for policy makers in forestry is to assure proper management which could ensure forest benefits to local people whilst simultaneously achieving environmental sustainability i.e. the country's forests could play a role in both economic development and environmental conservation. The conflict of interest arises from the fact that for many farmers, woodfuel production or trading is an important source of supplemental and occasional income, but often the woodfuel production and trade are unsustainable as they are need-driven. They are not properly managed and consequently degrade the natural resources. The farmers do not fully understand the degradation process and the need for sustainable management. They are therefore reluctant to accept and support woodfuel regulations for the sake of the environment.

## 1.2 Back ground

Marcoux (2000) highlights the links to forest degradation in subsistence agriculture as in Figure 2.

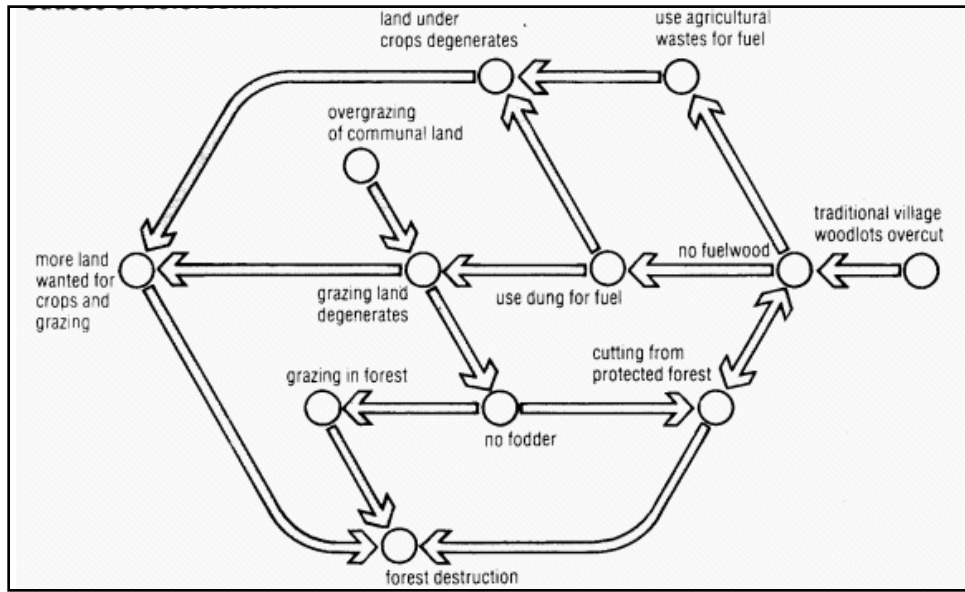


Figure 2: Factors of deforestation in a subsistence agriculture setting

Source: Marcoux, 2000.

Marcoux outlines the important factors in deforestation when population increases as follows:

- **Population increase and need for cultivable land**

Population increase is a major determinant of land clearing in subsistence agriculture, through the growth in requirements for food and wood products. When the population depending on subsistence agriculture increases, needs for food and other agricultural products increase, it is necessary either to increase the output of lands currently under cultivation, or to increase the cultivated area. The option of an increase in yields is difficult to achieve because it would require costly inputs, such as fertilizers, pesticides and irrigation, which the population could not afford. Therefore more land must be cleared at the expense of forests or wooded cover. The need for

additional land, in this case, is roughly proportional to the growth in food requirements of the population living in subsistence agriculture.

- ***Need for woodfuel***

In such case, the impact of population growth on woodfuel consumption is direct as it is on forest depletion, since energy needs are essentially proportional to population size (Marcoux, 2000).

To cover energy needs, rural households in Rwanda resort to fuelwood while the urban households consume more charcoal than fuelwood; this increases the impact on wood resources. As the annual consumption of wood products exceeds the sustainable yield of wooded areas, forests and woodlands are unsustainably harvested and gradually destroyed. In urban peripheral areas, population concentration in itself intensifies the impact on resources; the pattern of exploitation for woodfuels spreads the damage over large forest tracts. Near cities, the pattern concentrates that damage on smaller areas, with threshold effects that cause the cover to disappear completely around the cities.

- **Grazing in forests and forest fire**

Excessive pressure on the vegetal cover by animals is a crucial problem. In Rwanda, in certain areas such as Akagera National Park in the Eastern Province and Gishwati natural forest in the Western Province, the impact has been severe. Moreover, forest clearing operations may have considerable effects beyond their intended impact when they are conducted by means of fire.

Globally, contributions by direct deforestation factors are as follows: subsistence farming 63%; permanent agriculture 16%, cattle ranching 6.5%. These three factors contributed 85.5% while (over) exploitation for woodfuels; (over)exploitation for timber; infrastructure (roads, cities, mines...) contributed to 8%, 5.5% and 1% respectively (Marcoux, 2000). Therefore, global contribution of woodfuel to deforestation is fairly low.

### 1.2.1 Population growth and land tenure

As a consequence of poor family planning and poor population policy, over seven decades, the population of Rwanda has multiplied almost six times (MINITERRE, 2003). The population physiological density (people per area of arable land), is currently around 539 persons/km<sup>2</sup> (Table 1), the highest in sub-Saharan Africa. The impact of such population increase on land holding is profound. Too many people with limited resources and limited space put pressure on natural resources in general and land and forest resources in particular.

Table 1: Population increase and density from 1934 to 2009

Year	Population	Physical Density (total area of 23,338 km <sup>2</sup> )	Physiological Density (arable land of 18,740 km <sup>2</sup> )
1934	1595400	63	85
1940	1913322	81	102
1948	1806371	77	96
1950	1954870	83	104
1960	2694990	115	144
1970	3756607	160	200
1978	4831522	207	263
1991	7155391	306	382
1996	6167000	264	329
2000	7222129	309	385
2005	8440820	361	450
2007	9310000	398	496
2009	10117029	433	539

Sources: MINITERRE, 2003; NISR, 2009d

For many years Rwanda had no land laws or policies, and even if land is available, insecure tenure can be a concern for livelihoods. Secure tenure of land and trees, or clear rights to their use, are obviously of crucial importance. Also it provides incentives for rural people to improve these resources and hence gain profits from them. This is particularly true for the rural poor and

activities which take a long time to produce benefits, such as many forms of tree growing (Leach & Mearns, 2009).

In Rwanda land was traditionally acquired by inheritance, while during the colonial period (and prior to this, for many areas) the monarchy had a central and absolute control of land. During the first Republic (1962-1973) and the second (1973-1994), written law governed urban plots and land owned by religious organisations especially the Roman Catholic Church<sup>4</sup>. Customary law governed ownership of the rest of the land used by farmers for agriculture. Land was a state property, with peasants' rights limited to usufruct. Insecurity of title ownership coupled with land scarcity led to illegal land sales. There were an increasing number of illegal land transactions by households that had fallen into poverty (Semujanga, 2003).

While in the 1960s more than 50% of the people worked on more than 2 ha (UNDP, 2006), in 2009 only 5% have a land holding of more than 2 ha (Figure 3), the average family farm land size is less than 0.5 ha (NISR,209d). This is insufficient for subsistence agriculture and for most agro-business purposes<sup>5</sup>. The percentage of smaller plots is increasing and that of medium sized plots is decreasing. This leads to few 'haves' and many 'have-nots' with a decreasing number of people between these two extremes. The problem of land holding in Rwanda has undermined family ties and often turned close relatives into competitors and bitter enemies. Even today, after the 2005 land law (Republic of Rwanda, 2005b), according to the Office of the Ombudsman, land related disputes constitute about 90% of the total cases handled by this office<sup>6</sup>.

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<sup>4</sup>Rwanda is predominantly Roman Catholic

<sup>5</sup> FAO statistics state that for a farm land plot, in subsistence agriculture, to be economically viable for a family, it has to be at least 0.9 ha (UNDP, 2006),

<sup>6</sup> The New Times, Kigali of 28 May 2010

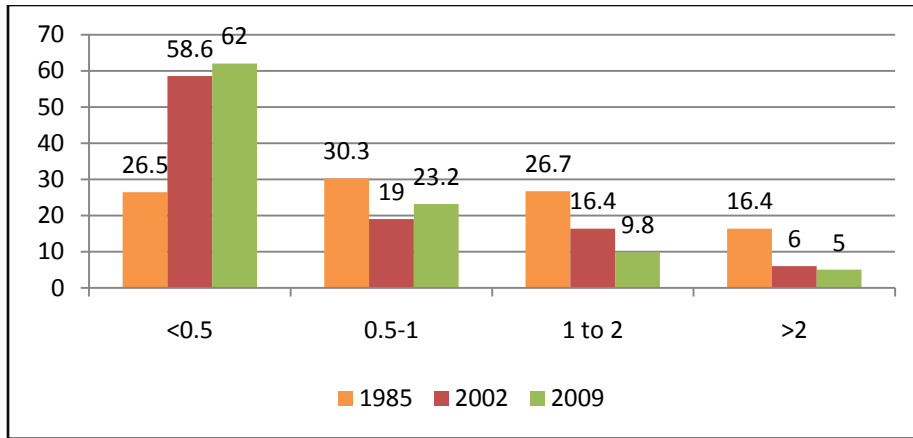


Figure 3: Miniaturization of household land holding (%) in ha (1985; 2002 and 2009)

Source of data: UNDP, 2006; NISR, 2009d

### 1.2.2 Population growth and deforestation

Rwanda's population has grown from 2.7 million in 1960 to 9.3 million in 2007. During the same time forest cover has decreased from 660 125 ha to 240 746 ha (Figure 4). The decrease in population during 1990-1996 corresponds to the 1990-1994 war and genocide against the Tutsis, when more than 800,000 Tutsis and moderate Hutus were killed and the period after this, when around three million Hutus fled the country. The population's rapid increase after 1996 is due to the massive return of refugees after the end of the war and genocide period.

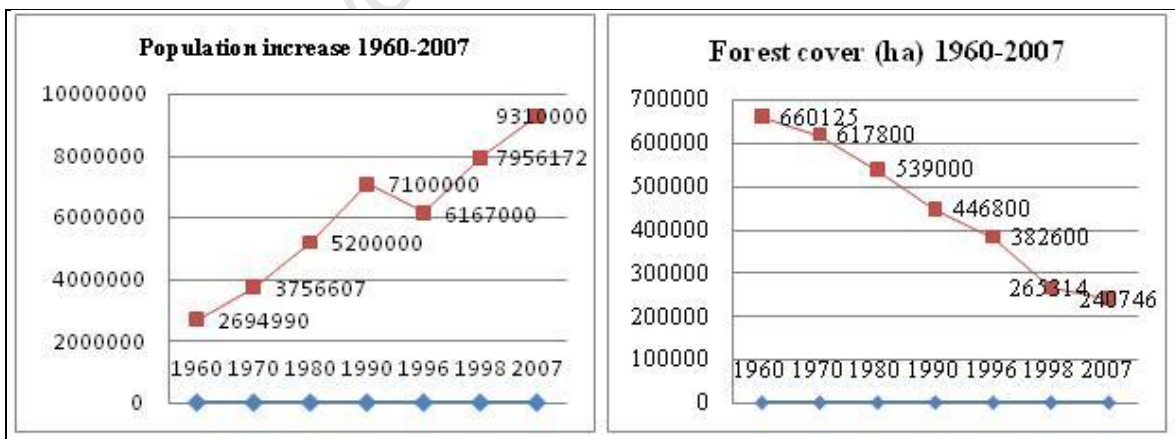


Figure 4: Population increase (1960-2007) and forest decrease (1960-2007) in ha

Source of data: MINITERRE, 2004; CGIS-NUR, 2007; NISR, 2009

Figure 5 shows changes in population and forests by decade from 1960 to 2007.

Population increase by decade was at a regular increase of around 14% until 1990 while forest decreased at almost 9% during the same period. The 1990-2000 deforestation increase is alarming and is attributable to the political instability of the war and the post war emergency period.

The 44% forest loss in 1990-2000 was mainly due to the 1990-1994 war and the post war poor forest management. Refugees, returning from neighbouring countries, encroached on forest areas because there was no or little other land to settle in the already densely populated country. Forest loss slowed down in 2000-2007 not only the time period is shorter but also because political stability returned and forest management could be implemented. During the 1960-2007 periods, 70% of forests have been deforested.

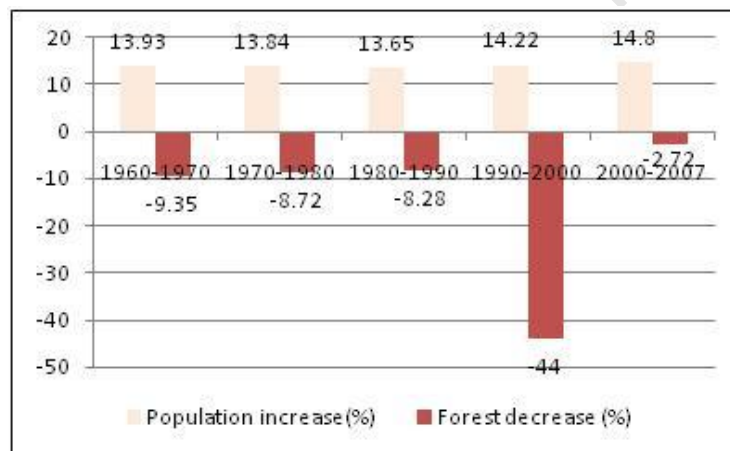


Figure 5: Population and forest evolution by decade 1960-2007 (%)

Source of data: MINITERRE, 2004a; CGIS-NUR, 2007; NISR, 2009d

### 1.2.3 Woodfuel consumption and deforestation

Commonly, woodfuels contribute from 50% to 90% of all energy consumed in developing countries, and at the same time represent about 60% to 80% of all wood consumed (Miranda, Sepp, Ceccon, Mann, & Singh, 2010). Long transport distances make petroleum products very expensive and unaffordable for the majority of rural and urban households, thus reducing access to modern fuels and making the country overly dependent on woodfuels. Lack of access to modern fuels coupled with widespread poverty makes woodfuel the most accessible - and often

the only – cooking fuel available to the majority of Rwandan households (Table 2) as well as cottage and agro-industries.

Table 2: Main fuel used for cooking (% of households)

Province	Gas	Electricity	Fuel wood	Charcoal	Biogas	Agri-residues	Other
Southern	0.4%	0.4%	91.7%	4.3%	0.1%	2.5%	0.7%
Western	0.5%	0.9%	88.0%	9.5%		0.6%	0.5%
Northern	0.3%	0.3%	94.0%	3.8%		0.9%	0.7%
Eastern	1.1%	0.8%	94.5%	2.3%		0.5%	0.8%
Average	0.6%	0.6%	91.9%	5.1%	0.0%	1.1%	0.7%

Source: MININFRA, 2009a

The four provinces in Table 2 are predominantly rural areas where fuelwood is the main cooking fuel and only few households use charcoal. For annual consumption, the area needed to grow trees for charcoal for one household is 0.7 ha to 1.3 ha of Eucalyptus plantations. Households using firewood need 0.3 to 0.5 ha of Eucalyptus plantations to support their annual firewood demand<sup>7</sup> (MININFRA, 2009a). This land is far larger than the average household land holding and most farms are too small to grow anything but food.

In Rwanda, woodfuels represent 77% of all wood needs (GTZ, 2008). Almost 97% of all rural households use woodfuels as their cooking fuel, fuelwood accounts for 91% and charcoal for 6% (MININFRA, 2009a). The increasing overall demand for wood has put additional pressure on forest resources and reduced the capacity of forests to supply wood products sustainably. There is a permanent demand/supply imbalance. With the exception of the year 1990 the deficit has always been larger than the sustainable harvest (Figure 6).

<sup>7</sup> 930 kg of charcoal per household per year; 2500 kg of firewood per household per year; plantations produce 5.2 – 9.8 t of wood per ha per year, and the charcoaling efficiency is taken as 14%.

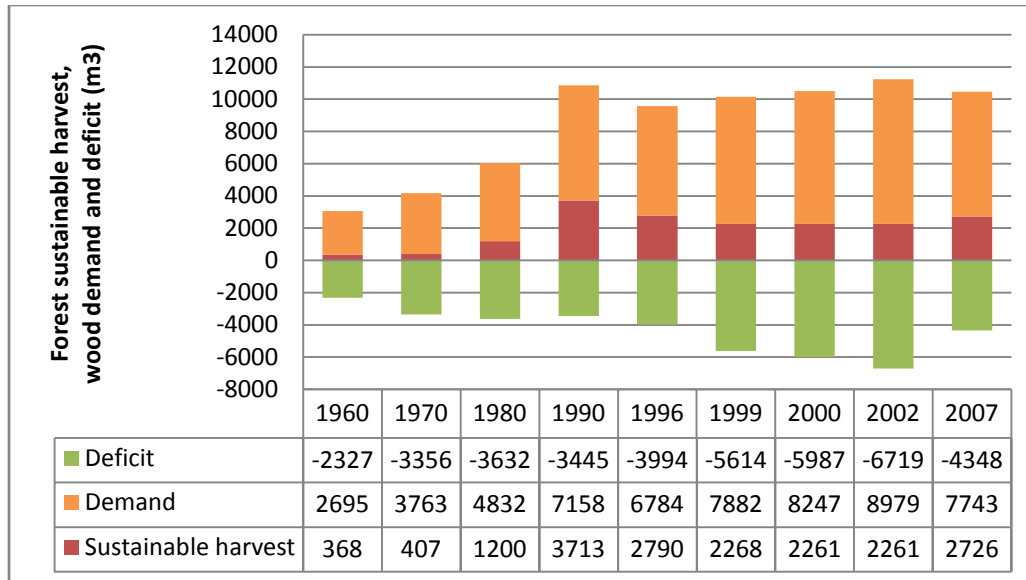


Figure 6: Forest sustainable harvesting vs. wood products demand (1000 m<sup>3</sup>) 1960-2007

Source of data: MINITERRE, 2004 a; CGIS-NUR, 2007

In 2007 the demand/supply balance for wood decreased (Figure 6) and this could be attributed to a changed forest definition. The new definition of forest<sup>8</sup> was different from the FAO definition (Lund, 2002) which was used to estimate the national wood product statistics before 2007. During the 2007 forest mapping period, no demand survey was conducted at national level and in all sectors, underestimating the harvest as well as the potential demand resulting in a lower deficit. Moreover the period coincided with dissemination of an improved woodstove designed by the army. The campaign began in 2005 and could have decreased the consumption (Doll, 2006).

Since records were kept, sustainable harvest never balanced the demand for wood and in some years the demand was nine times larger than the sustainable harvest (Figure 7) which translated into a permanent unsustainable harvest of wood products in Rwanda and consequently increased forest depletion.

<sup>8</sup>Figures are lower than the real sustainable harvest as the new national forest mapping excluded agroforestry trees, forest on road sides with a width of less than 10 m and plantations with an area lower than 0.5 ha and less than 20% of tree crown cover.

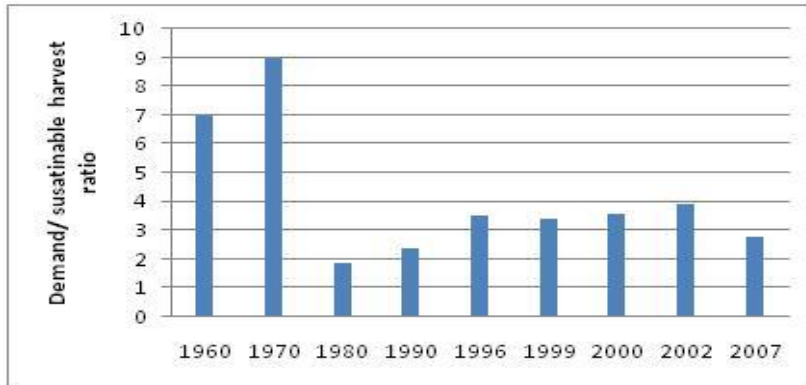


Figure 7: Wood demand / sustainable harvest ratio (1960-2007)

Source of data: MINITERRE, 2004; CGIS-NUR, 2007

The annual consumption of woodfuels in 2004 was 7,562,231 m<sup>3</sup>. The estimated annual sustainable supply potential was 3,351,700 m<sup>3</sup>, indicating a deficit of 4,210,531 m<sup>3</sup>. To balance the deficit would have led to a decline in forests at the rate of 6.3% per year (Table 3).

Table 3: Woodfuel consumption (2004)

Category	Fuel	Wood ( m <sup>3</sup> )	Percentage
Rural	Wood	6480000	86
Urban	Charcoal	849000	11
Institutions		146000	2
Industry		87231	1
Total wood demand		7562231	100
Sustainable harvest		3351700	
Annual deficit		4210531	
Equivalent ha forest lost		15593	
Total forest ha		247 500	
Annual ha forest lost (%)			6.3

Source: Butare and Hughes, 2004; CGIS-NUR, 2007

In 2007 the total wood demand was 7,743 000 m<sup>3</sup> (Figure 6). Woodfuel demand, representing 77% of all wood demand, came to 5,962,110 m<sup>3</sup>, more than twice the sustainable forests harvest of 2,726,000 m<sup>3</sup>. It is very likely that a part of the deficit of 4, 348 000 m<sup>3</sup> is not all harvested

from forests but also from land not classified as forest such as plantations of less than 0.5ha and trees on roadsides.

Close to four million tons was the 2008 estimated rural annual woodfuels consumption. The national average amounted to 501 kg/person/year (MININFRA, 2009c). As not all wood for woodfuel comes from area classified as forest, it is not possible to give exact figures of how much forest loss is due to woodfuel and how much is due to other deforestation causes, but still the figures gives a snapshot of wood stands depletion due to woodfuel.

The type of fuelwood consumed is of great relevance for depletion of the wood resource base required to meet consumption needs. In most African countries, generally four major wood types are used as woodfuel and their impact on wood resources depletion depends on which type of wood is harvested. These are stem wood, tree branches, small branches, twigs and bushes (Gaafar El Faki, 1994).

In Rwandan urban areas, stem wood is used mostly in restaurants and institutions. This woodfuel type presents the highest risk with regard to the degradation of the resource base as it requires the cutting down of the whole tree. As most of this type of wood comes from private plantations of less than 0.5 ha, it has therefore low impact on deforestation as the definition of forest in Rwanda excludes such small areas. In rural areas tree branches are used, which do not require the cutting down of the tree, and therefore, if properly practiced and administered this presents lower risks to resource base degradation. Small branches or twigs have no risk to the resource base; bushes also present little risk to wood resources as most of time these are collected as by-product from areas cleared for agriculture<sup>9</sup>.

By far the biggest concern in connection with deforestation is the urban demand for charcoal. Even if the cooking efficiency of charcoal is better than that of wood, using charcoal requires four to seven times more wood than direct use of wood for cooking. Charcoal production, with

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<sup>9</sup>Among poor households in rural and semi-urban areas, the collection of fuelwood is associated with heavy and time consuming work, mainly performed by women and children.

associated low carbonization efficiency<sup>10</sup> is a source of deforestation and degradation of forests as round wood and stems are used for charcoal. Charcoal consumption in inefficient stoves increases the amount of wood used to meet the charcoal demand contributing as such to more forest depletion. An increase in charcoal consumption linked to growing urbanization has major implications for the forestry and energy sectors and the impact upon the environment. Every 1% increase in the level of urbanization can be expected to lead to a 12% increase in electricity consumption, a 14% increase in the consumption of all petroleum fuels and a 14% increase in the consumption of charcoal (Hosier, Mwandosya, & Luhanga, 1993). Combined limited access to electricity, its affordability and the high cost of petroleum products have led to an even more rapid growth in charcoal demand for the urban market. In addition, in Rwanda accelerating urbanisation is causing an increase in demand for buildings which is stimulating a fast growth in brick making and supply of construction poles. Even if a ban on wood products for scaffolding and brick baking was imposed, it has to be strictly monitored as growth in the construction industry could lead to increased deforestation as trees are cut down to bake bricks and tiles and to supply poles used in scaffoldings.

From Figure 6 and Figure 7, it is evident that the demand for wood resources in general and woodfuel in particular far outstrips the sustainable supply from forests. Whatever the source of additional supply, the situation will continue to worsen as current country economic context cannot allow shifting to modern fuels.

The energy burden (energy expenditure expressed as a percentage of the household's total expenditure) is on average 14% of all household expenditure and poorer households spend a higher percentage than wealthier ones. In the case study of this research and only on woodfuel, poorer households spend 10% and wealthier ones 3% of their income. The remaining energy burden's percentage (4% for poor households and 11% for wealthier ones) is spent to cover other energy expenditure. This translates how the Rwandan in general and the poor in particular live a continued dependence on woodfuels with associated energy poverty<sup>11</sup>.

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<sup>10</sup> 8-10% when illegally produced and 12-14% when legally produced

<sup>11</sup> Absence of sufficient choices in accessing adequate, affordable, reliable, high quality, safe and environmentally benign energy services to support economic and human development.

The inter-linkage of the population increase, forest production, harvest and wood demand are summarised in Figure 8. The decline in natural and total forests is clear as population and wood demand increase and raises the question of how Rwanda is going to meet its future household energy demand.

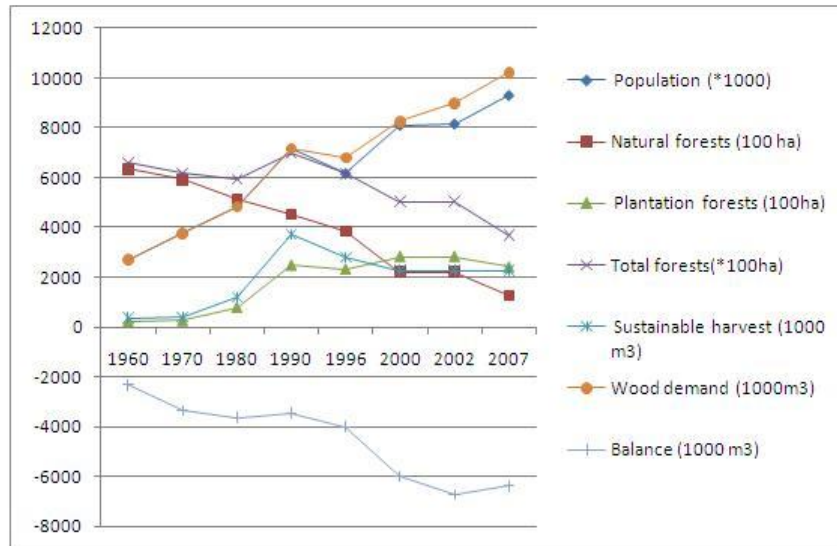


Figure 8: Population, forests, need for wood and sustainable harvests in Rwanda (1960-2007)

Sources: MINITERRE, 2004; CGIS-NUR, 2007 for 2007; NISR, 2009d

### 1.3 Problem statement

Being landlocked, overpopulated and poor, Rwanda has a permanent double energy crisis. Firstly, the price of commercial energy sources such as thermal electricity and oil products is extremely high because they are imported at high cost, using road tankers, from Mombasa and/or Dar es Salaam, the nearest ports. Electricity, even where readily available, is rarely used for cooking due to its high cost which is one of the highest in the world (US\$c 21/ kWh)<sup>12</sup>. Rwanda's electricity consumption of 21 kWh/person/year is among the lowest in the world (Figure 9). In other Sub-Saharan Africa (SSA) countries the average is around 448 kWh per person per year and 8000 kWh/person/year for developed countries (Kebede, Kagochi, & Jolly,

<sup>12</sup>13th/11/2006 Cabinet decision

2010). Rwanda's primary energy consumption is 0.17 TOE (Tons Oil Equivalent), a quarter of other SSA countries' consumption which is on average 0.6 TOE, while industrialised countries' average consumption is around 4.7 TOE (MININFRA,2009b).

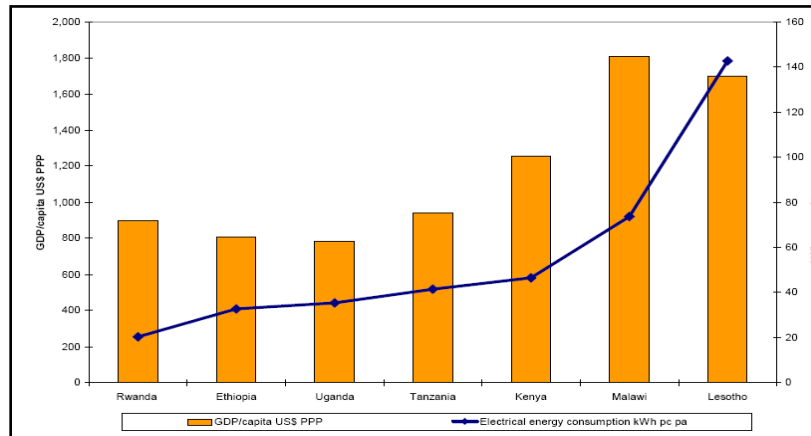


Figure 9: Comparative data on electricity consumption in Eastern and Southern Africa

Source: MININFRA, 2009b

Secondly, the country's high population density and the small size of plots, poverty and lack of economic diversification beyond unsustainable agriculture have shaped the energy situation of the country, limited access to modern energy sources maintaining the Rwandan households at the bottom of the energy ladder<sup>13</sup> and have led to a situation where the woodfuel, that the majority of the population relies upon for their basic energy needs, is becoming scarce and expensive with the increasing demand. The average consumption of woodfuels has been gradually increasing: 0.83kg/person/day in 1983 (MINAGRI, 1983); 1.2 kg/person/day in 1993 (MINITRAPE, 1993); 1.33 kg/person/day in 1994 (Hategeka, 1997) and 1.4 kg/person/day in 2009 (MININFRA, 2009c).

<sup>13</sup>Concept used to describe the way in which households move from traditional and unclean biomass fuels (dung, crop residues, fuelwood, charcoal) to modern and clean fuels (paraffin, electricity, LPG, solar.) as their economic status improves (Barnes & Floor, 1996).

## 1.4 Research Objectives

In Rwanda, as previously discussed woodfuel is and will remain the main source of household energy in medium term future. As an integrated energy resource has to be environmentally friendly and contribute to poverty alleviation to achieve sustainable development, in the woodfuel's case, many signs show that the current demand and supply will increasingly not be sustainable. To assess the woodfuel's impact on energy, forestry and poverty alleviation, the objectives of the study are to investigate threats and/or opportunities associated with:

- the link between population increase, land holdings, wood fuels and deforestation
- energy, poverty and forestry in Rwanda
- woodfuel production, consumption and environmental challenges
- woodfuel current flow chain in Rwanda,
- woodfuel sustainable production
- woodfuel and poverty alleviation

Once all strengths, weaknesses, opportunities and threats have been documented, the foremost objective is to propose a managerial strategy for a woodfuel industry oriented to energy for poverty alleviation on an environment friendly basis.

## 1.5 Research Questions

A general set of questions was formulated to guide and coordinate the research. The research questions in the following list are part of the research objectives and they also to some extent reflect the organisation of the chapters in the dissertation.

The general research questions can be formulated as follows:

1. What is the link between population growth, land holdings, woodfuels and deforestation?
2. What are the different causes of deforestation in Rwanda?
3. What is the woodfuel demand and supply pattern in Rwanda?
4. Are the woodfuel policies supporting sustainable supply and rural development?
5. What is happening in the woodfuel industry on the ground?

6. Is sustainable woodfuel production feasible and can it stimulate development in rural areas?

From preliminary considerations it is clear that woodfuels continue to be used as a primary energy source in Rwanda and have in some instances a negative impact on the environment, health and poverty. This could be regarded as a problem but also as an opportunity. Woodfuel production can provide rural income and, if sustainably managed, could contribute to rural employment and poverty alleviation.

### **1.6 Justification of the research and methodology**

An integrated approach to the energy, poverty and forestry impacts of Rwanda's woodfuel industry has not been documented, and the effectiveness of current regulations has not been analysed. An analysis is required to make woodfuels and forestry policies more effective to achieve the integrated objectives of sustainable woodfuel supplies, rural development, poverty alleviation and environmental protection. In addition the links of woodfuel consumption to deforestation and the state's ineffective policies to control the woodfuel trade makes the woodfuel sector a topical area of national research.

At least three factors support and justify the research:

The first factor is the chief contribution of woodfuels to the primary energy balance compared to modern fuels. Woodfuel is an important source of income for the growing number of the rural poor. Woodfuel consumption increases vulnerability to climate change and contributes to environmental degradation because of the effect that it has on forests and woodlands. Its present largely inefficient production erodes environmental sustainability as it contributes to forest depletion. Wood pyrolysis, when making charcoal, is a source of air pollution. Its combustion in open fires in insufficiently ventilated kitchens damages health.

Second, the national electricity generation is low and the population's purchasing power too low to afford electricity for cooking, even if they have access to it. Even when people have access to electricity they can afford to use it for lighting and communication only. Access to electricity is

very low at the rate of 6%<sup>14</sup> and the share of population with access to modern fuels for cooking is almost zero (UNDP, 2009b).

Third, the legal framework regulating woodfuels is implemented in a highly top down centralised process and is designed to protect the environment particularly forests. The above mentioned reasons have motivated my interest to conduct a research on the Rwanda woodfuel consumption's impact on energy, poverty and the environment.

The methodology used in this research involved an initial review and assessment of data available complemented by a field survey of woodfuel production and consumption. As existing data is often old or not available, the search for new data and information for this research was obtained by desk research and direct and/or indirect consultations with stakeholders<sup>15</sup> in the biomass based fuels sector, personal observations and gathering of available secondary data. These are detailed in chapters one, two and three.

Recognizing the negative impact of demand-driven woodfuel production on forests, I analysed how the relations of production, consumption and policy instruments in the woodfuel value chain are shaped in order to propose new managerial and strategic approaches to alleviate the pressure of fuel demand on national woodfuel resources. These are detailed in chapter four.

The study was supplemented by a household survey and focus group discussions to identify how the woodfuel flow chain impacts on both people, from a socio-economic (energy and poverty) perspective and the environment (forest resources) from which the woodfuel is sourced.

To collect primary data on charcoal production and woodfuel demand and supply, two independent field surveys were conducted in the period between October 1<sup>st</sup>, 2009 and October 31<sup>st</sup> 2009 respectively in Nyamagabe and Huye districts of the Southern Province. Findings of

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<sup>14</sup> Nine percent is the 2012 unofficial figure from the NISR's Third Integrated Household Living Conditions under finalisation.

<sup>15</sup> Policy makers and institutional authorities, educational institutions and prisons, charcoalers, women's associations, opinion leaders, local authorities and communities.

these two field researches are detailed in chapter five. Chapter six, based on the lessons learned in previous chapters, draws final conclusions and recommendations.

The research investigations cover the 1960-2007 time period but, where necessary, ante 1960 or post 2007 sources will be referred to.

### **1.7 Ethical considerations**

The research proposal and questionnaire meet the Ethic Standards as stipulated by the Faculty of Engineering and the Built Environment's Ethics in Research (EIR) Committee. An assessment of Ethics in Research Projects form has been completed as it is a requirement for any person planning to undertake research in the above mentioned faculty before collecting or analysing data.

### **1.8 Potential use of the results**

The results of this research could be used by policy makers in the biomass energy sector, mainly the Ministry of Infrastructure (energy) and the Ministry of Natural Resources (forests) to help them address the biomass energy challenges. Without geographical limitation, the research could be used by other researchers interested in woodfuels. The wider academic community could also benefit as the published results of this research will constitute input into the national energy literature.

### **1.9 Possible beneficiaries of the research**

This research will benefit the population in providing information for organising community based forest management. District authorities will benefit through the analysis and constructive criticism of their policy guidelines implementation to reduce pressure on natural resources. The country's policy makers will benefit from the research as the current situation, where woodfuel is generated from land whose holding is increasingly reduced, will sooner or later become a source of conflict which could undermine the already fragile national cohesion.

## 1.10 Geographic area of the research

The area of research is Rwanda. The fieldwork is carried out within the Southern Province in Nyamagabe district (Kitabi sector) for production and Huye (Tumba and Ngoma sectors) for consumption (Figure 28; Appendix D and E).

The choice of these two districts was motivated by key characteristics of these areas:

Nyamagabe district (Figure 28; Appendix E):

1. Has the highest forest cover in Rwanda and Kitabi sector (hosting a portion of the Nyungwe National Park) is the highest producer of charcoal in the district.
2. Covers 38% of the national charcoal production and ranks third in firewood consumption with 860 kg/person/year, the national average consumption being 501kg/person/year (MININFRA, 2009c).

This district is therefore an interesting case where over-production and over-consumption can lead to forest overexploitation.

Huye district (Figure 28; Appendix D): Tumba and Ngoma sectors (Figure 28; appendix D):

1. Tumba and Ngoma are the most densely populated sectors of the district and even of the Southern Province with respectively 996 persons/km<sup>2</sup> and 614 persons/km<sup>2</sup> (Figure 10). The sectors contain peri urban areas of Butare town with a high number of woodfuel consumers and limited wood stock.
2. Both sectors have severe land restriction in that 32% of the population live on land of less than 0.1 ha and 81% own less than 0.5 ha of land, too small to cover both food and wood needs of the population (NISR, 2009b). Landholding in some households is so constricted that, during the field survey, some of the local people said that they do not have enough space to build a pit latrine.

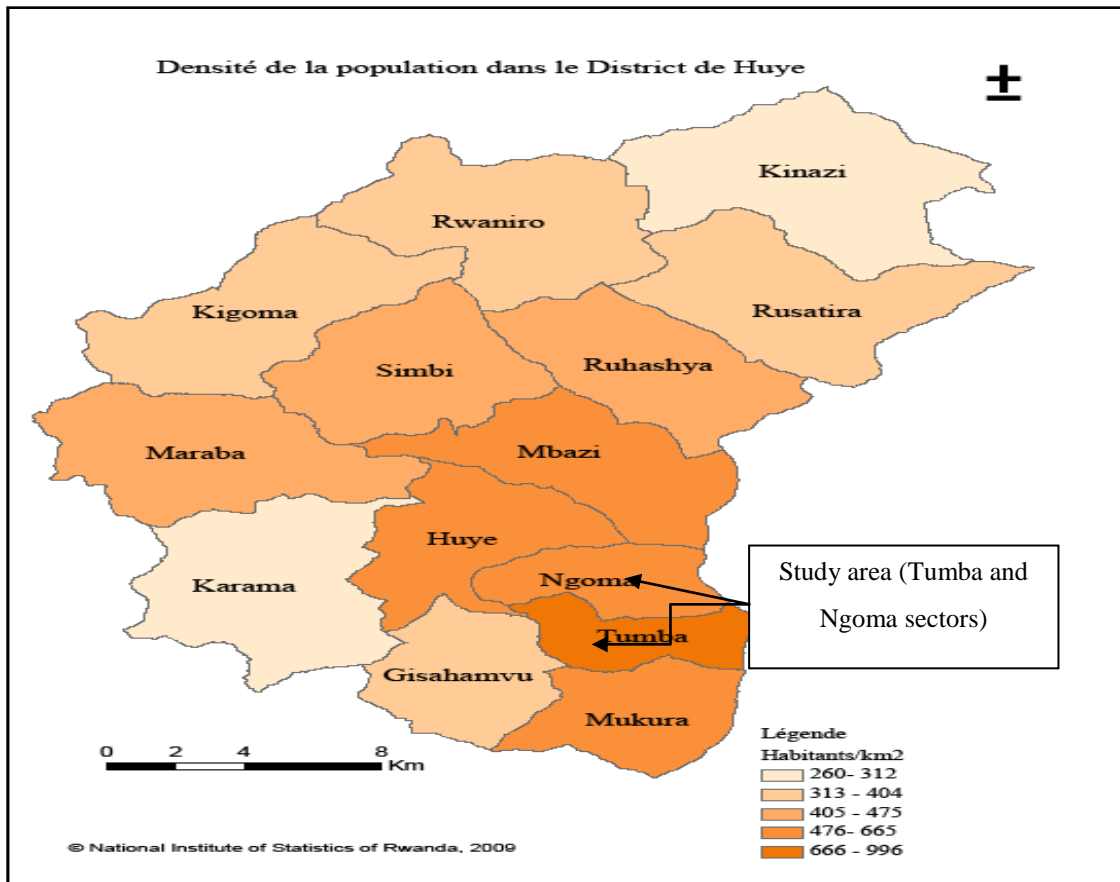


Figure 10: Population density in Huye district

Source: NISR, 2009b

### 1.11 Conclusion

The chapter highlighted the relationship between the population increase, land holding and woodfuel demand and their links to deforestation and analysed how current socio-economic context of the country shaped the present woodfuel dependence.

The problem of population increase has been discussed: poor family planning and poor population policy, both favoured population increase with associated pressure on land. As a consequence forest encroachments for agriculture, shelter expansion and woodfuel to feed the ever-growing population went unabated. The result has been continued forest depletion as a result of interlinked factors.

National data on non energy uses of wood and individual contribution of other deforestation factors are all not well documented. Also the factors of deforestation are interlinked. It is therefore difficult to attribute specific values to different contributing factors or to argue satisfactorily that woodfuel consumption - or any one of the many factors that contribute to deforestation - is generally decisive; nevertheless woodfuels have been the most blamed.

Bans and restrictive regulations have been introduced because it was believed that woodfuel harvesting is the major factor driving forest depletions and deforestation. As these regulations worked against traditional socio-economic benefits derived from the woodfuel industry, they have not achieved desired results. As there is no single factor of deforestation no isolated intervention can address it.

Even if the current socio-economic conditions were to improve and significantly reduce or even eliminate woodfuel consumption, deforestation would not immediately halt. Interlinked as they are, deforestation causes have to be handled in a wider political, socio-economic and environmental context to find solutions which meet the expectation of all stakeholders in the woodfuel flow chain. Policies regulating woodfuels need to consider their socio-economic role as providers of energy, jobs and income and at the same time protect the environment.

For the onward development of the study, I presented a problem statement followed by research objectives and questions; the justification of the research and the methodology.

It is expected that the outcome of this thesis will help all stakeholders to balance trade-offs between woodfuel's socio-economic and environmental conflicts, so that this work will have an effective impact and contribute in its way to the improvement of the Rwandan woodfuel industry.

The next chapter provides an overview of the woodfuel dominated energy sector; the widespread poverty as well as the evolution, the causes and consequences of forests depletion in Rwanda during the 1960-2007 time period.

## **CHAPTER TWO**

### **AN OVERVIEW OF ENERGY; POVERTY AND FORESTRY IN RWANDA**

#### **2.1 Introduction**

Comparable to many countries in sub-Saharan Africa (SSA), Rwanda's principal source of energy is woodfuel. Woodfuel contributes 86% to the primary energy balance and about 97% of Rwandan households are dependent on wood for cooking (NISR, 2008b). Regionally in East African Community (EAC) countries and DRC, the figures on woodfuel reliance are similar: Uganda 98%, Tanzania 96%, Kenya 90%, and the Democratic Republic of Congo (DRC) 95% (UNDP, 2009b).

Where the availability of electrical energy is limited or where energy is unaffordable for most households economic development is seriously impaired (Kebede et al., 2010). This is the fate of Rwanda with a very small modern energy sector and high dependence on biomass energy (Figure 11). Increasing population; poverty; energy poverty and woodfuel dependence as "the national cooking fuel" are linked and their combination has exacerbated forest depletion as overviewed in chapter one (Figure 8).

#### **2.2 The Energy sector in Rwanda**

In Rwanda, management of the energy sector is split between traditional energy (biomass energy) and modern energy (electricity and petroleum products). In terms of the traditional energy sector the Ministry of Infrastructure deals with user's aspects of biomass such as rational use, efficiency of consumption and the search for alternative fuels to biomass. The supply side is covered under the Ministry of Natural Resources within the forestry and environment departments, which also deals with land ownership. This division may seem logical but there is no coordination between these departments (MININFRA, 2007).

The modern energy sector falls under the Ministry of Infrastructure, which controls electricity through the national utility Electrogaz<sup>16</sup> and methane gas in Lake Kivu via the Unit for the Promotion and Exploitation of Lake Kivu Gas - UPEGAZ. The other modern energy source, petroleum products, is managed by the Ministry of Commerce.

In terms of primary energy<sup>17</sup>, the main source of energy in Rwanda is biomass which accounts, for 86% , petroleum products accounting for 11% and electricity 3% (MININFRA, 2007), (Figure 11). In SSA woodfuel accounts for 72%, petroleum 23% and electricity 5% of the total energy consumption while for the whole continent biomass accounts for more than 30%(Kebede et al., 2010).

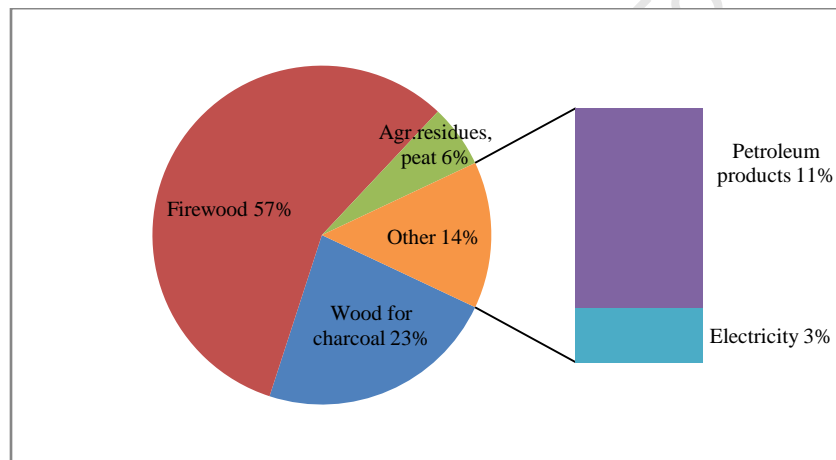


Figure 11: Primary energy balance in Rwanda

Source: MININFRA, 2007

In Rwanda, the sectorial distribution of the net energy consumption is dominated by households, accounting for 91% of demand, while the transport sector accounts for 4%, industry 3% and services 2% (Figure 12). Compared to the most advanced economy of Africa, in 2006, South Africa's residential consumption accounted for 17.7%, industry for 36.3% and transport for 25.5% (ProBEC, 2008).

<sup>16</sup> Nowadays it has changed in Energy, Water and Sanitation (EWSA).

<sup>17</sup> Primary energy includes fuels used to produce other fuels but does not include the fuels produced. For example primary energy includes wood used for charcoal making but does not include the charcoal produced from that wood.

For the whole Africa, sectorial distribution shows that residential energy use accounts for 37% of energy utilised, industry 11%, transportation 9%, agriculture/forestry and commercial/public services each account for 1%, while the remaining 40% is used by other sectors (Kebede et al., 2010).

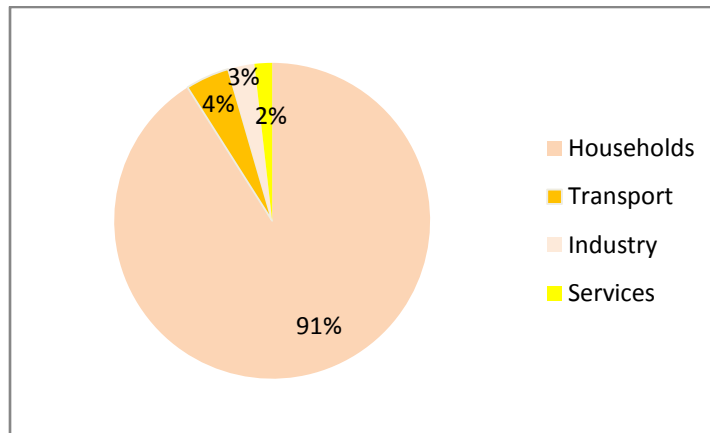


Figure 12: Net energy consumption by sector in Rwanda

Source: MININFRA, 2007

Table 4 shows the Primary Energy Balance in Tons Oil Equivalent (TOE)<sup>18</sup>. The table highlights the chief role of biomass and the low contribution of modern energy in the energy sector in Rwanda. This could predict the country's energy poverty; economic weakness and predicible forest depletion due to biomass dependence. Per capita final energy consumption is as low as 0.13 TOE while in OECD countries the average is 3.10 TOE per capita (IEA,2010).

<sup>18</sup>Conversion factors (TOE/ton). Firewood 0.36; agriculture residues 0.30; charcoal 0.69; peat 0.31; papyrus 0.41; petrol 1.05; kerosene 1.03; gasoil 1.01; fuel oil 0.98; LPG 1.10; Kivu methane gas 0.00045 TOE/m<sup>3</sup>; electricity 86 TOE/GWh.

Table 4: 2007 Primary Energy Balance (TOE) in Rwanda

[Toe] 2007	Wood	Agric.Res	Charcoal	Peat	Gasoline	Diesel	Fuel Oil	Kerosene	LPG	Methane	Electricity	Total	Percentage
Gross Supply													
Domestic production	850936	99878	420542	301							47073	1418729	
Imports					53499	88682	14802	20715	202		15308	193208	
Total	850936	99878	420542	301	53499	88682	14802	20715	202		62381	1611937	100%
Percentage	53%	6%	26%	0%	3%	6%	1%	1%	0%	0%	4%	100%	
Conversion and losses													
Electricity conversion						42364						42364	
Electricity T. & D											17810	17810	
Charcoal conversion			317802									317802	
Total			317802			42364					17810	317976	23%
Net Supply													
Total	850936	99878	102740	301	53499	42364	14802	20715	202		44571	1233962	77%
Percentage	69%	8%	8%	0%	4%	4%	1%	2%	0%	0%	4%	100%	
Demand													
Households	765842	79903	97603					20715	202		33428	997693	81%
Industries	85094	19975	5137	301			14802				8914	134223	11%
Services											2229	2229	0%
Transport					53499	46318						99817	8%
Total	850936	99878	102740	301	53499	46318	14802	20715	202		44571	1233962	100%
Percentage	69%	8%	8%	0%	4%	4%	1%	2%	0%	0%	4%	100%	

Source: MININFRA, 2007, Electrogaz, 2008

### 2.3 The modern energy sector

When the country embarked on a development phase after the 1994-2000 post genocide against Tutsi emergency phase in which the country was still settling people, restoring security and recovering from the 1994 genocide trauma, the energy crisis in general and electricity supply deficit were severe.

The modern energy sector is very small at only 69.10 MW of which 15.40 MW are imported: Four MW from Société Nationale d'Electricité (SNEL) of DRC, 11.00 MW from Société Internationale d'Electricité des Pays des Grands Lacs (International Electricity Company of Great Lakes Countries (SINELAC) and 0.40 MW from Uganda Electricity Distribution Company Limited (UEDCL) (Electrogaz, 2009). The national installed electricity capacity is composed of hydro, thermal (diesel, heavy fuel and methane gas) and solar power. Hydroelectricity accounts for 45.95% and thermal electricity for 51.09% of the national generation. This lack of generation diversity could have big challenges in periods of drought or petroleum price crises. So far in terms of energy the national offer (national generation + import – export) is around 25,719,646 kWh of which 83.03% is nationally generated, 18.75% is imported and 1.75% exported (Electrogaz, 2009).

The electrification level that is, the share of households with electricity connection is low at only 6% and a rural electrification level of 1 % (GTZ, 2009). The capital of Rwanda, Kigali, has about 2/3 of the total connections (Electrogaz, 2008). Reasons for this include low per-capita incomes but also the low national generation capacity to ensure new connections. In Africa the average electrification level is 40% and 31% in SSA (IEA, 2010).

The average yearly demand of 150,000 tons of oil products are all imported. The products are mainly used for transportation and more than 80% is consumed as diesel or petrol (NISR, 2008b). In addition to high inland transport costs from Mombasa (1792 km) and Dar es Salaam (1620 km), oil product imports are also subject to different duties and taxes. Applied taxes and duties are (i) Value Added Tax (18%); (ii) import duties, which in principle account for 30% of the CIF (Cost, Insurance and Freight) value for diesel, petrol, and LPG (Liquefied Petroleum Gas) and 5% for kerosene, and (iii) Consumer Tax on petroleum fuels of 37% of the CIF

Custom's Reference Value and an US\$c11 per litre as the contribution to the National Road Fund (NRF). So on average, retail prices of petroleum products are about 100% higher than acquisition costs. Rapid increases in world oil prices and *ad valorem* duties and taxes, have had a significant negative impact on Rwanda's growth prospects, as imported petroleum products consume more than 40% of the foreign exchange (REMA, 2009).

### 2.3.1 Power supply shortages and low service reliability

A combination of strong demand growth with unexpectedly low lake level in Bulera Lake (3 m below the normal lake level in 2004) in both domestic and shared hydropower sources, high transmission and distribution losses and the unreliability of Electrogaz's network have led to extensive and lengthy power cuts, beginning in early 2004. Load shedding, sometimes to about 50% of peak demand, supply shortages (Figure 13) have weakened prospects of attracting new investments, and have led Electrogaz to change to higher tariffs (Electrogaz, 2004).

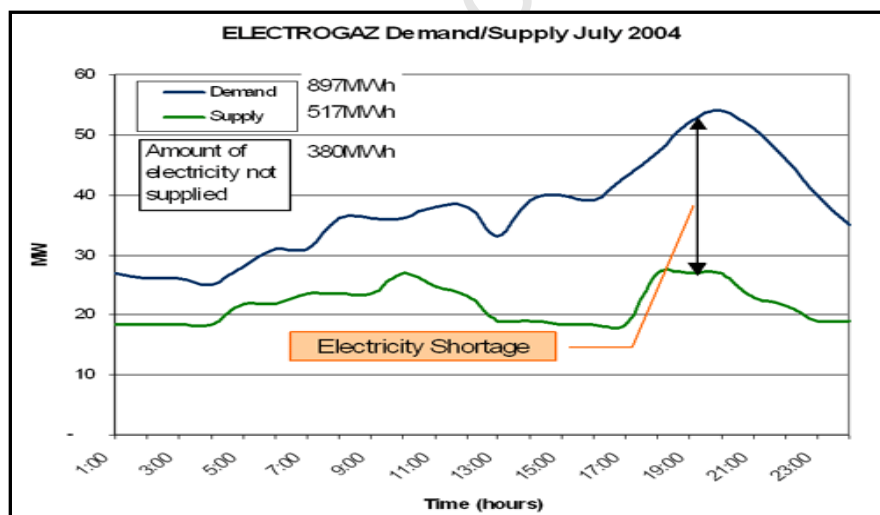


Figure 13: Supply shortage of July 2004

Source: Electrogaz, 2004

The high fuel consumption of the thermal power production (265 litres/MWh) adds to making electricity in Rwanda costly at US\$c 21/KWh<sup>19</sup> compared to \$0.08-\$0.10 in the rest of the

<sup>19</sup> 13th/11/2006 Cabinet decision

region. The average per kWh electricity tariffs (USD) are 8.5 cents in Burundi, 9.4 cents in Kenya, 10 cents in Uganda, 7.1 cents in DRC (ADF, 2010).

### **2.3.2 Severe financial imbalances**

During the 1990-1994 periods, the Government of Rwanda (GoR) failed to pay public bills to Electrogaz, which in return failed to service its own debt contracted from the GoR to rehabilitate the national grid after the 1994 genocide against the Tutsi. A complex set of cross-debt has emerged on the one hand between Electrogaz, and the Government of Rwanda, and on the other hand between SINELAC's share holder's countries<sup>20</sup> and their public utilities. As Electrogaz needs to finance large quantities of fuel and an aggressive investment program, major financial restructuring is required in order to limit electricity price shocks to the vulnerable macro economy.

### **2.4 Traditional energy sector**

Most of the energy consumption in Rwanda is in the form of woodfuel which is estimated to be 6 million tons per year (GTZ, 2008). MININFRA (2009a) has estimated the rural consumption at 4 million tons. This is likely to remain so in the near or even medium term future, unless income levels substantially increase to enable households to afford modern sources of energy. Thus, it is imperative that woodfuel demand and supply be in balance to ensure future energy supplies.

The increasing deforestation from the 1960s was sharpened with the severe deforestation of the 1990-1994 war and genocide periods. After the genocide, public forests were encroached on by internally displaced persons and refugees returning from exile. Last, but not least, large demands for wood from the revived construction industry and agro-industries, as well as institutional and commercial customers, has increased the demand/supply imbalance. After the shift, due to forest depletion, from open access charcoal production from the savannah woodlands in the Eastern Province (Bugesera and Kibungo) to private and communal woodlots in the south and southwest of the country (Leach & Mearns, 2009), average distances for large-scale movement of wood and

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<sup>20</sup> *Burundi, Democratic Republic of Congo and Rwanda*

charcoal supplies increased from 80 km to 160 km . Combined effect of inflation and increased distance to production site with associated transport costs have increased charcoal prices from US\$ 0.70 a 33 kg bag in 1994 to approximately US\$ 8.77 a 33 kg bag in 2009.

In terms of percentage, wood for non energy usage accounts for only 23%, firewood for 28% and wood for charcoal represents 49% of the national wood demand (GTZ, 2008). The demand far outstrips the sustainable supply (Table 5). If charcoal was only sourced from the area defined as forests, charcoal consumption would constitute a serious problem and increase the pressure on forest resources as the urban population charcoal demand increases with the rate of urbanisation. The urban population reached 18% of the total population in 2006 from 6% in the mid and late nineties (NISR, 2006a).

Table 5: Estimates of wood energy balance, 2008 (1000m<sup>3</sup>)

<b>Demand</b>	<b>Tons/year</b>	<b>Percentage</b>
Firewood	696	28
Charcoal wood	1209	49
Total energy	1905	77
Non energy	571	23
Total demand	2476	100
Plantation production	954	38.5
Balance	-1522	-61.5

Source: GTZ, 2008

## 2.5 Energy Potentials

Rwanda's dependence on solid fuels does not mean that the country lacks energy resource potentials. All untapped resources for power generation are about 1,400 MW (MININFRA, 2007). Development of modern energy resources - additional hydroelectricity, natural gas dissolved in Lake Kivu, peat, and geothermal - have been constrained by small market size, lack of financing and an inadequate institutional framework as some generation power plants need a

regional or multilateral agreement and/or high investments (Kivu<sup>21</sup> methane gas and Rusumo<sup>22</sup> hydropower projects).

### **2.5.1 Hydropower**

Hydropower potential is estimated at 300 MW. A total of 21 mini and micro hydro plants (MINITRAPE, 1993) existing prior to the 1994 genocide against Tutsi were damaged or destroyed and have yet to be brought back into service and the recent Hydropower Atlas project has identified 333 hydro sites with a combined capacity of 96 MW (MININFRA, 2009b). At the national level, potential small rivers are being developed and 33 mini and micro hydro-plants are being constructed and rehabilitated. This is financed by the GoR, Independent Power Producers (IPP) or through bilateral and multilateral cooperation. In regard to the IPPs, the key element is to make good technological choices for better tariffs and sustainable solutions for local people.

Regionally, there is considerable untapped hydroelectric potential on the Rusizi (Rusizi III of 145 MW and Rusizi IV of 205 MW) and Akagera (Rusumo falls of 61.5 MW) rivers, which respectively constitute borders with the DRC and Tanzania, and therefore must be developed on a bilateral or regional basis (MININFRA, 2009b).

### **2.5.2 Methane Gas**

Rwanda also has a unique energy resource in the form of methane gas dissolved in Lake Kivu, which straddles the borders of Rwanda and the DRC. The amount of methane in place is estimated at about 59 billion cubic meters of which 29 billion cubic meters are believed to be economically recoverable (UPEGAZ, 2004). The gas has a regeneration capacity of 250 million cubic meters every year (Butare&Hughes, 2004).

A small methane extraction unit installed in 1963 to supply some 8000 cubic meters of methane per day to the beer and soft drinks brewery (Brasserie et Limonaderie du Rwanda (BRALIRWA)

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<sup>21</sup>Border with DRC

<sup>22</sup>Border with Tanzania

is still operational today. Till recently, no other use was made of Kivu methane gas but in 2008 the first power generation of 1.8 MW was fed into the national power grid.

The methane gas from Lake Kivu has a potential of 750 MW in total, of which the Rwandan share will be 350 MW (the rest will be for the DRC). Not all of this will be used for power generation; plans include 250 MW for power generation, 50 MW for gas to liquid fuels and possibly fertilizer production (MININFRA, 2007). Particularly, fertilizer production would be very important for both increasing agricultural productivity in general and for small wood plantations in particular. This may have a high positive impact on the woodfuel supply.

The viability of building a pipeline system to supply gas to Kigali requires more investigations. The estimated cost of this was about US\$7 million per km in 2007 (AGIA, 2009). Just transporting gas by pipeline from Gisenyi on Lake Kivu to Kigali, using data collected in this study, would cost about US\$ 800 million, excluding the distribution network in town and not accounting for the fact that the region is very hilly and densely populated (expropriation, relocation costs). This makes the viability of building a pipeline system to supply gas in Kigali difficult.

### **2.5.3 Geothermal energy, solar energy, peat, papyrus and husks**

Geothermal energy in Rwanda's volcanic area of the Northern Province and the Western Province is estimated to have a generation capacity of between 170 MW and 320 MW respectively. The energy could be used in the form of electricity (WORLD BANK, 2008).

Solar energy, with a potential of 4.5 kWh per m<sup>2</sup> per day, should also be mentioned. If well promoted this can be a good lighting substitute in remote areas. Solar energy (photovoltaic) is a good option for remote areas for lighting and ICT in schools, offices, clinics and hospitals. Solar water heaters could be used for water heating to reduce the consumption of electricity in hospitality, clinics, hospitals and catering services and households.

Peat as a potential energy source in Rwanda is identified at 155 million dry tons. The energy content of peat (10.5MJ/kg) is low compared to wood (15.5 MJ/kg) and some peat deposits have a high sulphur content, which would lead to the deterioration of pots and pans if this fuel is used for cooking. Its high ash content also makes its household use difficult because of waste disposal problems. All peat areas are wetlands and the negative environmental impact of its extraction can outweigh its energy use benefits. This has pushed the Rwanda Environment Management Authority (REMA) to impose environmental restrictions on the use of peat as a fuel until the environmental impact and energy benefits are weighted. After the environmental impact assessment was done, since December 2009, the Cimenterie du Rwanda (CIMERWA,) a cement factory in the South West has been using peat as a substitute for heavy fuel in its processing with expectations that its annual expenditure on fuel will be reduced by 30% (Gahigi, 2009).

Papyrus are also potential energy resources, estimated at 20,000 – 25,000 ha. Papyrus plants grow to 4.5 meters and reach maturity in about 50 days; the plant has a 150-day life cycle<sup>23</sup> and thus two "crops" per year are possible under natural conditions. Yields per hectare are as high as 32 tons, which yields up to 15 tons of dry biomass. Using sustainable harvesting techniques, a theoretical maximum of about 280,000 tons (dry) of papyrus could be obtained. Environmental consequences (papyrus has a filtering effect on run-off water into the lakes and rivers) and conflicting land-use needs must be weighed before papyrus is considered as a source of energy.

Coffee and rice husks are also potential sources of energy in the country. On each 100 kg of green coffee, some 25 kg of coffee husks are obtained and on average some six thousand tons are produced every year. On average 20% of produced rice are husks and some 20,000 tons of rice husk are obtained every year (MININFRA, 2009d).

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<sup>23</sup> *After that period it falls in water swamp and begins to deteriorate.*

## 2.6 Energy demand

### 2.6.1 Demand from households and institutions

Household usage constitutes the largest share of the total energy consumption in Rwanda (91%), mainly of woodfuel (Figure 11 and Figure 12) and 81% of the primary energy demand is from households (Table 4). Energy in households and institutions is mainly used for cooking, lighting, and operating of electric appliances. Space heating is limited to areas of higher altitude of the colder areas of Northern Province. There are major differences in accessibility and affordability of energy products between rural and urban areas.

In rural areas, firewood and human power are the most used energy sources. In urban areas, charcoal remains by far the most popular fuel for cooking with households using 53% of charcoal sold through markets. The capital Kigali alone consumes 75% of the total charcoal consumption (Butare & Hughes, 2004).

NISR (2003), MININFRA (2009a) and the case study of the present study (Figure 41) all show that woodfuels remain the principal source of cooking energy for households. However, this source has negative impacts in houses, including, indoor air pollution causing both health risks and safety problems for end-users. Even if until now there is no proper study to document the burden of diseases associated with indoor air pollution in Rwanda, it is estimated that worldwide, almost two million deaths annually from pneumonia, chronic lung diseases, and lung cancer are associated with exposure to indoor air pollution resulting from cooking with biomass and coal (UNDP, 2009b). The use of this energy source is also time consuming as on average two hours per household per day are spent collecting fuelwood (Figure 38).

Urban areas use more and more electricity for lighting but generally lighting in rural areas is in most cases provided by kerosene as revealed by NISR (2003), MININFRA (2009a) and the case study of the present study (Figure 39). Electricity, even in areas where it is readily available, is mostly used for lighting, radio and television, rarely used for cooking due to its high cost. The use of other energy sources such as solar, biogas and LPG is limited by people's low purchasing power and despite various promotional efforts the use of substitutes to woodfuels is still low.

## 2.6.2 Demand from industry, transport and commercial sectors

Eleven percent of the primary energy demand (Table 4) and three percent of the energy consumed nationally are from industry (Figure 12). These industries include among others agro-processing and manufacturing industries. The use of energy by industry is inefficient due to outdated technology as well as capacity under-utilisation. This applies to various industries such as the Rwandan Textile Plant (UTEXRWA), Kabuye Sugar Factory, the Rwandan Cement (CIMERWA) and tea factories.

The transport sector accounts for eight percent of the primary energy demand (Table 4) and account for four percent of the net energy consumption (Figure 12). About 75% of all imported petroleum is consumed by the transport sector (NISR, 2008b). In 2007, the Rwandan imports of fuels reached an average CIF (Cost Insurance and Freight) cost of US \$ 4,125,000 of which US \$ 1,054,300 for diesel only. For the same year, it is estimated that Rwanda used about 5,160 barrels of petroleum oil per day for its energy consumption (Nduwayezu, 2010).

Development of the sector such as the road infrastructure network and public transport means has both direct and indirect implications for total energy consumption in the country. The energy challenge within the transport sector is to ensure efficient and safe use of petroleum products. Efficient petroleum use is determined by the standard of vehicles, the quality of the road network and the use of the most energy efficient transport means. In Rwanda most vehicles are second hand and the quality of the road infrastructure is poor.

The major energy demand of the commercial sector is mostly from the wholesale and retail shops, hotels and restaurants (Butare& Hughes, 2004). The energy consumption of the service sector remains low at two percent (Figure 12). Commerce is a significant user of woodfuel (Photo 1), with 40% of this sector's energy demand met by wood (UNDP, 2005). Restaurants are the largest consumers of fuelwood (8%) and charcoal (46%) of the sector demand (Butare&Hughes, 2004).

Massive energy losses and low energy efficiency are the major challenges in the industry, transport and commercial sectors.



Photo 1: Firewood stock at Dereva Hotel (Rwamagana District, Eastern Province), 2009

Photo: Author

### **2.6.3 Demand from the agricultural sector**

The economy of Rwanda is dependent on agriculture that contributes 34% to GDP and employs over 84% of the workforce. Agriculture is the major source of food supply and raw materials for the industrial sector. Subsistence farming is the most common activity and 52% of the agricultural labour force is female (NISR, 2009a). Almost the total energy demand in agriculture is met using human energy. Drying (tea factories) and processing (sugar factory) of agricultural products is mainly done by traditional methods using firewood. The main challenge within the agricultural sector is to ensure supply of sufficient and cost-effective energy to meet the requirements for improved agricultural activities, including mechanisation to increase productivity, agro-processing (tea factories) and irrigation.

### **2.6.4 Demand from the information and communication technology (ICT) sector**

ICTs play an important role in sustainable development of all sectors. Due to the fast growth of the ICT sector, demand for reliable electricity to support effective applications of information technology is becoming a major concern. There is a need to improve energy services, especially

electricity geared towards enhanced use of modern information technologies. The unreliable electricity supply affects the ICT sector negatively.

## **2.7 Energy Supply**

The biomass standing stock is estimated at 16,639,795 tons (ISAR, 2007). Hydro power potential is estimated at 300 MW, small hydropower sites can provide 30 MW. The country could obtain up to 750 MW from methane gas of Lake Kivu and 170-320 MW from geothermal resources. In addition Rwanda has peat reserves estimated at 155 million tons of exploitable dry peat and also daily sunshine is able to provide solar power amounting to 4.5 kWh per square meter. Except the current generation capacity of 69.10MW (Electrogaz, 2009), all the aforementioned energy potentials are not yet realised.

From table 4, the total gross supply of the primary energy is 1,611,937 TOE and the net supply of 1,233,976 TOE corresponds to 77% of the gross supply which represents a conversion loss of 23%. Aggregated, 19.34% represents the loss with charcoal conversion; 1.09% in electricity transmission (electricity transmission over long distance by old transmission lines and distribution methods, cables that are to a large extent very old, and also losses from theft) and 2.54% in electricity production (hydro power and the thermal power generation).

The Economic Development and Poverty Reduction Strategy (EDPRS) projected that a 17.1% electricity increase per year was necessary to meet the demand (4.9% per year for the productive sector; 24.5% per year for urban households and 21.5% per year for rural households). Through the EDPRS framework the government of Rwanda has drawn a road map for the energy sector until 2012 (MINICOFIN, 2007). This includes:

1. Increased electricity access (generation, transmission and distribution for domestic and export purposes)
2. Reduced cost of service and the introduction of cost reflective electricity tariffs
3. Energy diversification and security (going beyond hydro and thermal sources)
4. Strengthening the governance framework and institutional capacity.

Nothing is said about biomass energy. In a recent statement on how the Ministry is faring as far as the EDPRS programmes are concerned, the Minister of Infrastructure disclosed the programme's achievement as a boom for the Rwandan Energy Sector (Ntagungira, 2010). Still the target has been missed as only 6% of households are connected to the electricity grid and consumption is still around 21 kWh per person per year. The EDPRS projections were 25% of the population connected and electricity consumption at 60 kWh per person per year for 2010. The current electricity grid consists of around 3,300 km of different voltage levels.

The Government of Rwanda intends to increase the percentage of the population with access to electricity from the current 6% electrification level to 16% by 2012 through the national Electricity Access Roll out Programme (EARP), which aims to implement the targets formulated in the EDPRS. This translates into at least 350,000 connections to the national grid (Electrogaz, 2010).

Development partners in the electricity sector have pledged to support the EARP through various financing mechanisms and with different focus areas: Among others are:

- The Belgian Government and the European Union supporting the off-grid part of the programme through development of micro hydro and solar PV, which is already underway and new funding from the Belgian government is expected by 2011;
- The World Bank supporting the on-grid component of the programme and is mainly allocating its contribution (US\$ 78 million) for the procurement of materials;
- OPEC Fund for International Development (OFID) contributing a concessional loan of US\$ 10million and is aligning its implementation with the World Bank;
- The Saudi Fund for Development (US\$ 11.7million) and Arab Bank for Economic Development in Africa (BADEA) (US\$ 10million) giving concessional loans for electrification of 18,000 households in Kigali, Nyagatare and the Southern Province;
- Japanese International Cooperation Agency (JICA) (US\$ 20 million) supporting the rehabilitation of substations, the rehabilitation and extension of the grid and capacity building;
- The Dutch Government which has already disbursed the first tranche (EUR10 million) of the contribution to the programme (total EUR 30 million) is supporting grid extension

and connections as well as renewable energy generation. The first tranche will be used to procure materials for at least 15000 new connections;

- The African Development Bank (ADB) contributing US\$ 60 million starting from the year 2010; areas of intervention are yet to be identified.

For cooking fuels and with objectives to reduce the biomass resource depletion, reduction of indoor air pollution and saving on conventional fuel sources, the National Programme on Domestic Biogas in Rwanda (NPDBR), a Dutch Government funded project and implemented by the Ministry of Infrastructure with technical and institutional support from the Service Neerlandais des Volontaires (Netherlands Development Organisation) SNV and GTZ was initiated since 2007. It was supposed to install 15,000 fixed dome domestic size biogas plants (4-6m<sup>3</sup>) in five years in households who own at least two bovines and who have at least 20 kg of dung at their disposition on a daily basis (MININFRA, 2006). As per November 2011, only 1,600 plants were installed and for the few installed maintenance and repair have showed more failure than success, the programme has been extended to 2015.

An investment subsidy of 300 US\$ was considered for the farmers but the subsidy cost to households was low<sup>24</sup> to allow the project massive adoption. The farmer's contribution has to come from their own financial reserves and/or bank loans to farmers, at 18% interest per year and a five year repayment period, for bio digester construction.

In high wood consuming institutions substitution is taking root mainly in schools and prisons, the cooking energy demand is currently met by biogas and as in that wayten of the fourteen prisons now supplement firewood with biogas<sup>25</sup> subsequently reducing firewood consumption and costs by up to 50% (Rwembeho, 2010).

Summarily, the current available electricity generation capacity to supply is limited at 69.10 MW and is distributed by source as in Figure 14.

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<sup>24</sup> A 5 m<sup>3</sup> capacity biogas digester costs around 1,400US\$, the beneficiary has to pay 560 US\$, get a loan of 565US\$ (loan from whom?) to be paid in five years and the remaining fees are paid by the Ministry of Infrastructure.

<sup>25</sup> The project, supported by the Ministry of Environment and Forestry and the International Committee of the Red Cross (ICRC), was undertaken as part of efforts to cut down on use of firewood as a source of energy in prisons.

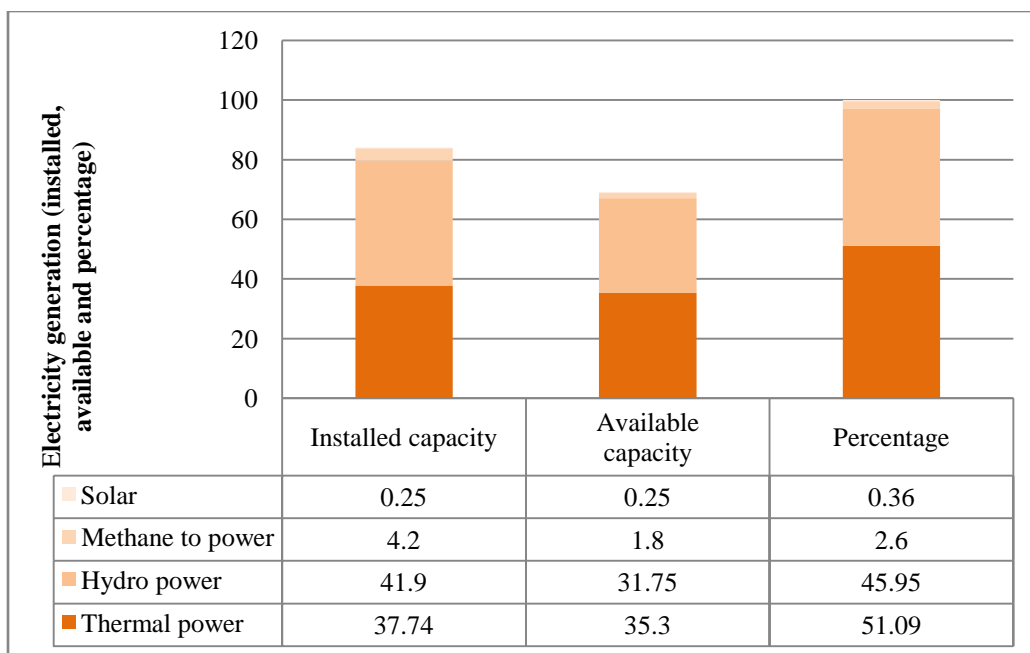


Figure 14: Electricity generation (installed, available and percentage) by source (MW)

Source: Electrogaz, 2009

## 2.8 Overview of Poverty

The most reliable data on poverty<sup>26</sup> in Rwanda are from the 2001 and 2005 Enquêtes intégrales sur les conditions de vie des ménages (Integrated living conditions surveys) referred as EICV1 and EICV2, conducted in the year 2001 and 2005 respectively. The poor in Rwanda were defined using the internationally accepted Code of Basic Needs method which estimated US\$ 180/adult/year as the poverty line and an extreme poverty line of US\$ 80 (NISR, 2006b). Based on this measure, over 60% of Rwandans live in poverty and of these 42% in absolute poverty. Using the household as a unit, 57% of households are below the poverty line<sup>27</sup>.

Rwanda has a high female population (53%), with large proportion of widows of the 1994 Genocide and single women. Women head nearly one-third, or 32%, of Rwandan households. In terms of poverty gender disparities, 62% of female-headed households lie below the poverty line compared to 54% of male-headed households.

<sup>26</sup> Poverty is predominately defined here as economic.

<sup>27</sup> A new EICV3 (2010/2011) under finalisation estimates 44.9% of the population below the poverty line and 14% below the extreme poverty line.

Nationally poverty has reduced from 60.4% to 56.9% from 2000 to 2005 but still inequality runs deep, with the richest 10% of the population holding approximately 50% of the national wealth and the poorer 50% sharing just 10% of the wealth (NISR, 2006b).

### 2.8.1 Poverty as rural phenomenon

Poverty remains a predominantly rural phenomenon. The incidence of poverty is much higher in rural areas (62.5%) than in urban areas (13.0% in Kigali and 41.5% in other towns). Rural households at 40.9% live in extreme poverty. Urban poverty is less severe, with extreme poverty at 6.3% for Kigali and 25.3% for other urban areas (Table 6).

Table 6: Poverty headcount in 2005 (Share of the population)

Area	Upper poverty line	Extreme poverty line
Kigali	13.0%	6.3%
Other urban	41.5%	25.3%
Rural	62.5%	40.9%
National	56.9%	36.9%

Source: NISR, 2006b

Increased poverty has led to labour migration from rural areas to towns and increased jobless youth in the urban areas. The main cause of migration was unemployment (43%) (NISR, 2006b).

### 2.8.2 Poverty and population density

According to the new provincial classification, the greatest reduction in poverty has been in the Eastern province where poverty has fallen from 61.8% to 50.4% in four years. Quite large reduction in poverty is also observed in the Northern Province and the City of Kigali. In the Southern Province, which was one of the poorest in 2000/01, the poverty headcount increased slightly from 65.8% to 67.4%. The Northern Province has the second highest share of poor people in Rwanda. The Southern, Northern and Western provinces are highly populated and are the poorest (Figure 15). Rwanda's ideal of large families was appropriate in traditional times of

high childhood mortality and the need for labour. As nowadays child mortality has been reduced, this traditional notion has led to a disastrous population explosion. The population explosion has deepened poverty, mainly in rural areas. The fertility rate is now at 5.5 births per woman in rural areas while urban areas have a lower fertility rate of 4.7 ( NISR, 2008a). Unfortunately, many people are not aware of the impact of overpopulation on poverty. Almost half of those individuals surveyed in the EICV2 (49.50%) identified lack of land as the main source of poverty, followed by poor soils (only 10.90% of respondents) and population pressure appears at the bottom of poverty's causes (cited only by 0.70% of those surveyed).

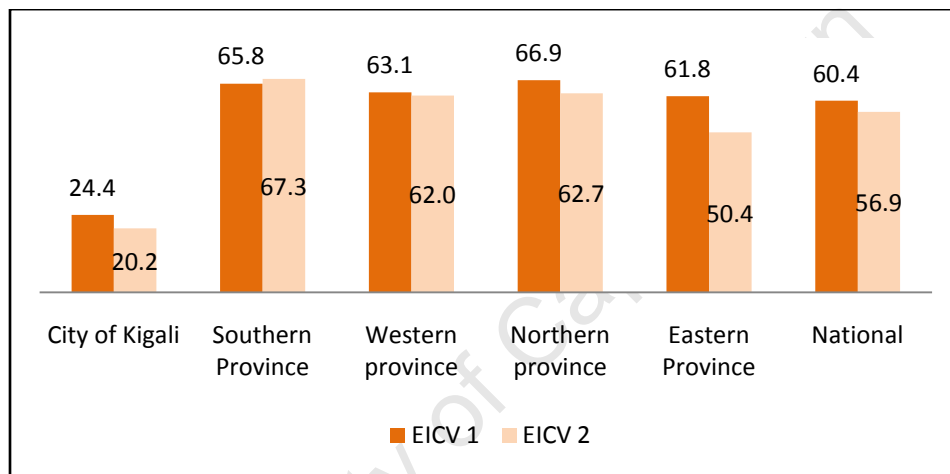


Figure 15: Poverty headcount per Province (EICV1 in 2001 and EICV2 in 2005)  
(percentage)

Source: NISR, 2006b

Another sign of poverty is the undeveloped industrial sector which is characterised by the low consumption of energy (4.5%) in the sector and high energy consumption by households (91%). These energy consumption figures are the reverse of developed world statistics, where the residential consumption is lower than consumption by industry and the transport sector. Generally, residential energy consumption accounts for 40% of the total global energy consumed annually. South Africa, for example is a developing country where industry consumes 36.3% and households only 17.9% (DME, 2006). In developed countries, households account for 25%–30% of total energy consumption. For example in the United Kingdom, domestic energy consumption is about 34% of the total energy consumption, while industry consumed 50% of energy resources. In New Zealand, residential energy use is 13% of the total annual energy demand

(Lhendup, Lehendup, & Wangchuck, 2010). National dependence on biomass as a source of energy under traditional technology is a sign of poverty as a transition from traditional to modern energy resources only occurs with an increase in income and use of modern appliances by households.

The causes of poverty are locally specific, for example in the 2005 living conditions survey (EICV2) at national level population increase was ranked at the bottom of the list (0.7%). In the study area population pressure is perceived as an important cause of poverty and ranks second among the perceived causes of poverty, after lack of land and slightly before ignorance. These three causes (lack of land, population pressure and ignorance) account for almost 70% of poverty's identified causes in the study area.

The surveyed households rank themselves as not poor, poor and extremely poor respectively at 13%, 77.6% and 9.5% and the lack of land is seen as the major cause of poverty.

Nationally, 19% of households have less than 0.1 ha of land, 37% less than 0.2 ha, and 59% less than 0.5 ha. Only 4% of households had access to 1 ha or more. In Huye, 81% of the households cultivate less than 0.5 ha (NISR, 2009d). Therefore it is not surprising that, for a population predominantly depending on subsistence agriculture, 97% of the sample in this study reported lack and unequal distribution of land as the main cause of poverty (Figure 16).

Focus group discussions reported that access to modern energy could help alleviate poverty as this could boost small businesses such as carpentry, milling, and refrigeration and extend their time for trading.

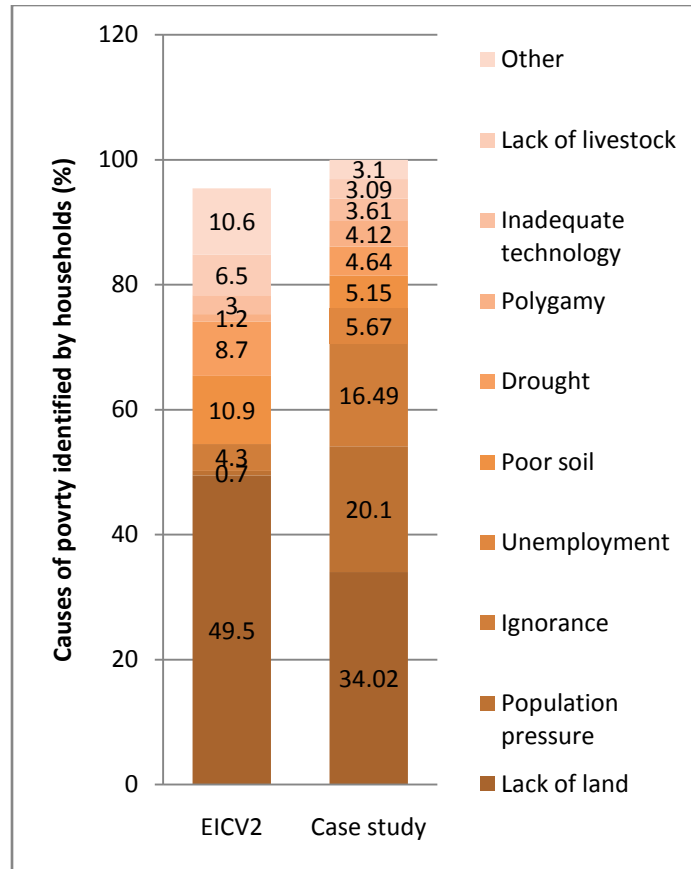


Figure 16: Causes of poverty (%): case study as compared to NISR (2006b)

Policies for poverty reduction, such as land consolidation and sharing; crop regionalisation and zero grazing are established in the country. In the studied area, the most popular is zero grazing; as it reduces conflict between neighbours and could facilitate access to biogas and ensures them low cost and high quality fertiliser from dung. The national penetration of the zero grazing policy has reached 90% in 2008 (NISR, 2009d). Due to unequal distribution of land, land consolidation and land sharing are also approved of by the “have nots” but influential groups with larger farm land are less receptive to the two policies. Crop regionalisation is government policy but its penetration will take some time, as reported by the majority of the respondents. They favour field intercropping arguing that it takes advantage of complementarities between crops. It also ensures food security locally as agriculture commodities from other regions are more expensive mostly for poor people. Lastly they feel disadvantaged due to poor road infrastructure, food distribution channels and disorganised internal markets.

### 2.8.3 National programs for poverty alleviation

As poverty in Rwanda is largely a rural problem, poverty must be first addressed at the rural level. That is the objective of the Vision 2020 ‘Umurenge’ (Sector) program as one of the government initiatives to accelerate poverty reduction at grass roots level. It is based on the promotion of pro-poor components of the national growth agenda at the village level. This will be achieved by increasing the productive capacity of the poor in rural areas through a combination of public works, promotion of cooperatives, credit packages and direct support. It aims to increase non agricultural employment and promote agglomeration settlement, that is, free more arable land by settling people in villages. Its cornerstones are the community-based participatory approach ‘Ubudehe’ and a one cow per poor household policy (Girinka) (MINALOC, 2006).

The European Union and the GoR jointly fund the “Ubudehe” programme, under the Ministry of Local Government. It is based on the tradition of mutual assistance and has a community-based participatory approach (Ubudehe) program that operates at the lowest administrative unit, the cell, and brings all members of the community together to assess their socio-economic conditions, define their priorities and decide on what to do in order to improve their well-being.

The second programme (one cow per poor family), Girinka<sup>28</sup>, aims to reduce poverty and increase food security by replacing traditional natural grazing by strict implementation of zero grazing policy. The cabinet meeting on the 12th of April 2006 approved it. The goal of the programme is poverty reduction and enhancing productivity, with economic benefits such as dairy and meat to reduce malnutrition; manure to increase soil fertility and possibility of household biogas energy. Under the programme a poor family receives a cow free of charge. When the cow produces calves, the first calf is given to the neighbour who keeps it and once it produces, then gives the next calf to another neighbour, and so on. This process is called “kuziturirana” (Credit revolving scheme) (MINALOC, 2006).

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<sup>28</sup> The criteria for selection are: less than 0.75ha of land (communal grazing possible), no cow at the selection period, erosion control and fodder (0.2 ha) and community approval and appraisal via exemplary behavior and participation in umuganda (Community work) and Gacaca (Community courts).

## **2.9 State of the environment and forestry**

### **2.9.1 Political context**

In Rwanda actions to conserve the environment started in the colonial period. Reforestation efforts have been conducted since 1920. During the colonial period, the colonial rulers until independence on 1<sup>st</sup> July 1962 stressed the preservation of natural forest ecosystems. In 1947 soil conservation and afforestation became compulsory in public forest plantations (MINITERRE, 2003). Unfortunately, these practices stopped after independence in 1962 as these plantations used unpaid labour. Since then the country's forest resources have been deteriorating. Clearance for agriculture decreased forest cover by 80% during the 1958-1996 time periods (UNDP, 2006). The 2007 national forest mapping inventoried a forest cover of only 10.10% (CGIS-NUR, 2007).

In Rwanda, like in other countries of Africa, the majority of poor rural people's incomes come directly from the environment. Natural resources play an important role in the economy of rural households, and thus the poor's livelihoods are more affected by environmental degradation. Rwanda's most pressing environmental problems are deforestation, land degradation and soil erosion which are caused by the prevalence of subsistence agriculture, and the country's high population density of 539 persons/km<sup>2</sup> (NISR, 2009d). In Rwanda, erosion on agricultural land is estimated to be 75 times greater than that which occurs in natural forested areas (Gurrierl, 2005). In agro ecosystems of Africa, Asia, and South America average erosion rates are around 30-40 tons per ha per year. An example from Nigeria approximates soil loss from a cassava field on a slope of about 12% to be 221 tons per ha per year. In other areas, sloping agricultural land under tropical rainfall loses as much as 400 tons per ha per year. In Rwanda, where mountainous areas are intensely cultivated (Photo 2) this rate is expected to be higher as some slopes are as steep as 30%. If soil erosion proceeds too far, it can convert land to desert, becoming waste land (UNDP, 2006). Nationally per year some 1.4 million tons of soil was lost by erosion (REMA, 2009).



Photo 2: Forests, slopes and marshlands converted to agricultural lands (Northern Province)

Source: Photo NISR, 2009d

The most known human induced environmental degradation in the country would have been the Rugezi marshland encroachment for agriculture which led to a hydro electricity crisis in 2004 with high economic loss from thermal generation to balance the electricity shortage; the Gishwati and Akagera National Parks destruction by resettlement after the 1994 genocide and the deforestation of Bugesera region in the 1980s for woodfuel provision to the capital city. Evidence linking overpopulation; land conversion for agriculture, and environment degradation are recorded in a 2006 UNDP/UNEP's study on Environment and Poverty Reduction in Rwanda.

Some of the findings are:

- Between 1970 and 1986, land scarcity pushed 56% of exploited acreage cultivators into poor soils in marginal land. Before that period, the previous lower limit of cultivated land was 1800 m of altitude but today the land limit is 3000 m (Robert, 1990).
- Twenty seven percent of land is cultivated on slopes of more than 20 degrees, 23% on slopes between 10-20 degrees, 16% on slopes between 5-10 degrees and 34% between 0-5 degrees.

- The fertile volcanic soil in the North-West and the previously unusable swamps and savannah region in the South and East are being used to the limits of their capacity. On the western boundary up to the Rift Valley, even the most extreme slopes are cultivated.
- Soil erosion is moderate to severe on 50% of the land surface of Rwanda. Rwanda loses up to 12,251 tons of soil per year due to soil erosion so that yield will be reduced significantly by soil erosion as land productivity on very eroded farms is 21% lower than on farms with little erosion. The most extreme case is for farms with a low share of high value crops such as coffee and bananas and low share of cultivated area on which fertilizer or organic matter has been applied. The productivity loss for these farms was estimated at about 36%.
- Rwanda is among the water scarce countries of the world, with 870 cubic meters of water available per capita per year there is high risk of food insufficiency as countries with less than 1,700 cubic meters of water per year available per capita cannot maintain food self sufficiency reliably.
- Primary forests, which covered 80% of the country in the late 1950s, have been reduced to only 5 – 8%. In the 1980s the deforestation rate was 2.3% or 2000 ha per year (UNDP, 2006).

The cost of environmental degradation in Rwanda seems to be high. Due to financial constraints, it has not yet been possible to calculate directly the costs of this degradation. However indirect evidences of the high cost that could inform policy making are available. The most obvious problem is the resulting loss of ecosystem services offered by the environment as stated above. For example, Gishwati and Mukura forests in the Western Province, the mountain forests, are close to extinction with 86% and 90% respectively cleared while the Mutara hunting domain in the Eastern Province has completely disappeared (CGIS-NUR), 2007). Forests provide many valuable environmental resources. At the watershed level, sedimentation helps regulate stream flow and maintain soil quality, limits erosion, stabilises hillsides, moderate seasonal flooding and protects natural water resources (UNDP, 2006). As tropical forests act as an effective filter between the atmosphere and the soil, any removal of the forest cover will decrease this protection leading to overland flow with the direct consequence of ground water reserve depletion and an increase in rates of erosion along stream banks, gullies and roads.

In Rwanda forest depletion and deforestation is not the result of a single factor but a complex combination of forces, such as land clearing for agriculture and settlement building, and the high dependence on wood for fuel by households. Efforts to promote sustainable biomass resources thus have a very direct environmental and energy link, as well as being central to poverty alleviation (Bush, Kanobayita, & Masozera, 2005).

There is evidence that deforestation and forest degradation constrain the economy and development options. The effects of such phenomena on the economy have been demonstrated by the effect of deforestation on the Rugezi wetlands. This led to the lowering of water levels of Lake Bulera and Ruhondo which are major sources of hydro electricity supply in Rwanda. The problem is a result of many years of degradation of forests in the catchment area of the lakes and specifically water loss in the Rugezi wetlands, the main sources of water inflows to the lakes.

Photo 3 shows the lowering of water level at the Mukungwa hydro power catchment-Musanze district-Northern province. The cost of this has been shortage of electricity that affects negatively on the economy. A direct cost has been the need to resort to electricity generated by diesel engines, which costs the government in excess of US\$ 175,440 a month. In the long run the electricity shortage has a negative impact on the growth rate of the economy and adds to the rising cost of living (Musahara, 2006).



Photo 3: Water level Lowering at Mukungwa hydropower catchment (2008)

Photo: Author

The high demand for wood for energy has further contributed to deforestation. Sustainable wood supply is lower than the national demand. The scarcity of fuelwood has been a burden for children and women collecting fuelwood. They have to walk long distances to gather firewood and the hand gathering is usually done at the expense of the children's' opportunity to go to school. In a survey undertaken in Huye district families complained about the dropout rate of children due to time needed for them to collect firewood (Mazimpaka, 2010). In recent years, the government has focused more on issues related to environmental degradation but reforestation efforts still fall far short of redressing the huge deficit in supply (MINICOFIN, 2009).

In summary:

In Rwanda, natural resource degradations are not caused by natural disasters but are human induced. They are mainly due to the increasing population which depends for its subsistence agriculture on fragmented and small farm land; for its energy needs on ever-decreasing woody biomass resources from inadequate and exhausted soil.

The current human induced environmental degradations such as clearance of forest for agriculture and settlements has contributed to deforestation and the increasing population has increased the consumption of woodfuel, thus putting more pressure on forest resources and leading to increased environmental degradation. The most pressing environmental problems are deforestation and increasing population pressure on land and forest resources that have put the natural environment under increasing threat.

### **2.9.2 Definition of forest in Rwanda**

Forests and related terms definitions and classifications are exhaustively detailed in the 2009 UNEP Report of the Second Ad Hoc Technical Expert Group on Forest Biological Diversity (Secretariat of the Convention on Biological Diversity, 2009).

The Expert Group considers the FAO definition of a forest as the basic one, but acknowledges that many other useful definitions of "forest" exist in published form. The fact that "forest" has been defined in many ways is a reflection of the diversity of forests and forest ecosystems in the world and of the diversity of human approaches to forests.

The report defines a forest as a land area of more than 0.5 ha, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use. In the case of young forests or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5 m in situ, and of meeting the canopy cover requirement (UNEP, 2009).

Lund (2002) quoting the UN-FCCC defines a forest as a minimum area of land of 0.5-1.0 ha with tree crown cover (or equivalent stocking level) of more than 10-30% with trees with the potential to reach a minimum height of 2-5 m at maturity in situ. The same refers to the UN-FAO definition of forest as a land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ (Lund, 2002). The major difference between the FAO and FCCC definitions is that the FAO excludes certain tree covered areas (roadsides) from being considered as forest whereas the FCCC definition does not.

In relation to these specificities and after consultations with specialists from the Ministry of Infrastructure, the Institute des Sciences Agronomiques du Rwanda (Rwanda Agricultural Research Institute), the Centre for Geographic Information Systems and Remote Sensing – National University of Rwanda (CGIS-NUR) and the International Institute for Geo-Information Science and Earth Observation (ITC), the term forest in Rwanda is defined as an “Area of at least 0.5 ha with a tree cover of more than 20%”. The trees are defined as “trees of more than 7 meters in height” (CGIS-NUR, 2007).

### **2.9.3 Forest cover and distribution**

Thirty years ago, it was noted that “more is known about the surface of the moon than about how much of the world’s surface is covered by forests and woodlands” (Persson, 1974). Since

then, the quantity and quality of available information has improved in some countries but has declined in others and overall remains inadequate (Shvidenko, 2005).

The first charted data on the forests in Rwanda based on aerial photography is from 1988 and constitutes a reference document, which gives the localisation, area and species of trees. An attempt to add to this knowledge was undertaken by the FAO in 2002 and many other isolated and locally specific studies have been conducted since, mostly in parks and natural reserves. A new map of Rwandan forests was produced by the Centre for Geographic Information and Remote Sensing of the National University of Rwanda in 2007 (CGIS-NUR, 2007). In Rwanda, the cartography of the forests poses particular spatial and temporal challenges. The country presents complex fragmentation in land occupation and therefore of forest cover. Natural forests and plantations with Eucalyptus as dominant species dominate the forest cover. Natural forests are identifiable as these are generally found in national parks and natural reserves<sup>29</sup>. Private and public plantation forests are often less than 2 ha and are sparsely distributed and often overlap with agricultural lands (MINAGRI, 2002).

#### 2.9.4 National forest coverage

There are seven classes of forests: humid natural forests, plantations of Eucalyptus, young coppice plantations, degraded natural forests, and plantations of pines, bamboo and savannah (Table 7).

Table 7: National Forest coverage by classes, area and percentage in 2007

Classes	Area (ha)	% of wooded area	% of National Area
Humid natural forest	79,797.86	33.15	3.35
Plantation of Eucalyptus	63,560.75	26.40	2.67
Young coppices plantations	39,204.82	16.28	1.64
Degraded Natural Forest	38,003.51	15.79	1.59
Plantation of pines	12,071.31	5.01	0.51
Bamboo	4,381.47	1.82	0.18
Savannah	3,726.81	1.55	0.16
Total	240,746.53	100	10.10

Source: CGIS-NUR, 2007

<sup>29</sup>Volcanoes National park (PNV) in the North West created in 1925. Akagera National Park (PNA) in the east created in 1934 and the Nyungwe National Park in South-West, known as a reserve since 1993 and recognized as Park in 2004

Forests are unevenly distributed with the natural forests (Table 8) concentrated in national parks and forest plantations dispersed all around the country.

Table 8: Natural Forest coverage

National Park/Reserve	Area (ha)	%
Nyungwe National Park	103863	81,78
Volcanoes National Park	16219	12,77
Mukura National Reserve	1913	1,5
Akagera National Park	1277	1
Gishwati National Reserve	1028	0,8
Busaga Natural Reserve	152	0,11
Other	2565	2
Total	127016	100

Source: CGIS-NUR, 2007

### 2.9.5 Regional nuances

The national forest cover presents a regional variation by Province with an East-West dichotomy: 42% of forest cover is in the Western Province, 36% in the Southern, 15% in the Northern, 5% in the Eastern and 2% in the Kigali city (Table 9).

Table 9: Forest cover by province

Province	Area (ha)	%
Western	103731.33	42
Southern	86831.5	36
Northern	35421.26	15
Eastern	11090.12	5
Kigali City	3633.5	2
Total	240707.71	100

Source: CGIS-NUR, 2007

Aggregated to district level, distribution of the forests shows five main categories of forest concentration by districts (Figure 17)<sup>30</sup>.

- Very high concentrations of forests in the districts of Nyamagabe, Rusizi, Nyaruguru, and Nyamasheke, all located in the South-West of the country.
- High concentration of forest in Nyabihu and Karongi districts in the Western Province and those of Musanze and Gakenke in the Northern Province.

For biodiversity conservation, the above 8 districts can be regarded as priority areas for all actions related to the management and protection of the forests within the framework of the National Forest Programme (NFP).

- Medium forest concentrations in Rutsiro and Ngororero in the West; Muhanga and Huye in the South; Burera, Gicumbi and Rulindo in North; and Gatsibo in East.
- Low concentrations in Rubavu in the West; Gisagara, Nyanza and Kamonyi in the South; Kayonza, Gasabo, Nyagatare, Rwamagana in the East and Nyarugenge in Kigali city.
- Very low concentration in Ruhango of the Southern province; Kirehe, Bugesera and Ngoma in the East; Kicukiro of Kigali City.

The low / very low forest concentrations constitute ‘hot spots’ which require special reforestation efforts.

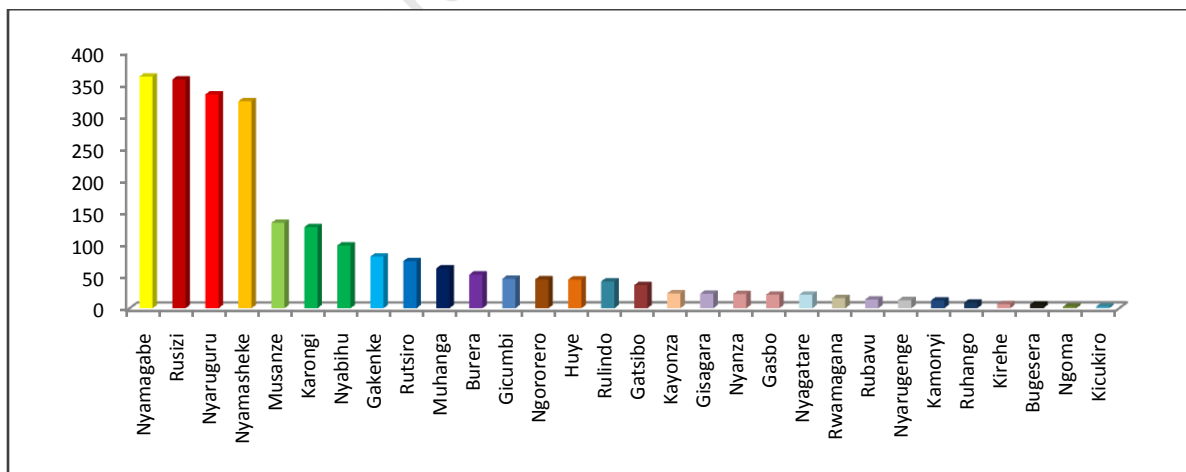


Figure 17: Forest distribution by district (in hundreds ha).

Source: CGIS-NUR, 2007

<sup>30</sup>The case study of the present study is in Nyamagabe (very high concentration) and Huye (medium concentration).

With regard to forest ownership, State and district owned forest plantations total 65%; 26% are privately owned and institutions such as associations and religious and teaching institutions own 9%.

Forest plantations increased to a maximum from 1960 to 1990. They increased after independence as land and properties belonging to killed or exiled Tutsi were redistributed as “dividends of democracy” (Semujanga, 2003) and covered with forest plantations to avoid claims or repossession by returning refugees. Since 1975 an aggressive tree planting program was a government order and every Saturday community development work (umuganda) was undertaken with the objective of increasing forest lands mainly through planting Eucalyptus and pine trees on hillsides to control erosion and provide wood for different uses. Most of the GoR plantations were created during the 1970s and at an increasingly fast rate in the 1980s. The main reason for creating these plantations was to increase the number of wooded areas, mainly on bare hills, for soil protection, improve water catchment areas, and to provide woodfuel to the population. Funds mostly came from the World Bank, European Union and the African Development Bank.

Numerous public plantations were established to respond to the necessity felt by decision makers, but without clear objectives regarding their management and utilisation. This has led to lack of monitoring and silvicultural treatments (maintenance, pruning, enrichment, and rejuvenation of the forests) resulting in progressive degradation and uncontrolled human activity in more than three quarters of inventoried state and district owned stands. The most frequent illegal activities in public forests were tree felling for timber or poles occurring in about 80% of cases; charcoal making (4%) and the creation of tracks and paths (4%) (CGIS-NUR, 2007).

## **2.10 Deforestation in Rwanda (1960-2007)**

The post independence (1962) political instability and failure to address the population problem resulted in farm land miniaturisation. The inadequate size of plots pushed people to encroach on natural forests for agriculture, grazing and housing and wood for energy and non energy uses with high forest depletion as a consequence. The 1990-1994 war periods and the 1994-2000

government programs to resettle refugees and displaced persons have put more pressure on forest resources.

In 1960 natural forest cover was 26 times the area of the forest plantations; in 2007 they were almost at parity. The natural forests have been the most affected as the natural forest depletion was on a linear and permanent decrease (Figure 18).

Since October 1990, with the outbreak of the war, severe deforestation occurred in both natural and forest plantations. In the 1990-1994 war period forests were decimated, as they were considered as ambush and camouflage facilities for the enemy. Shortly after, deforestation continued, in part by internally displaced persons and returning refugees in need of timber for housing and firewood for brick and tiles burning for construction, as during the 100 days of genocide against the Tutsi in 1994 most houses in Rwanda were destroyed (Bitanuzire, 2003).

After the war, the population and government officials neglected forest management due to a focus on other emergencies and from lack of awareness. Also woodfuel demand increased in households, schools and prisons where the number of inmates averaged 100,000 genocide suspects up from a pre-genocide average of less than 5,000 inmates. The overall 1960-2007 forest change is presented in Figure 18.

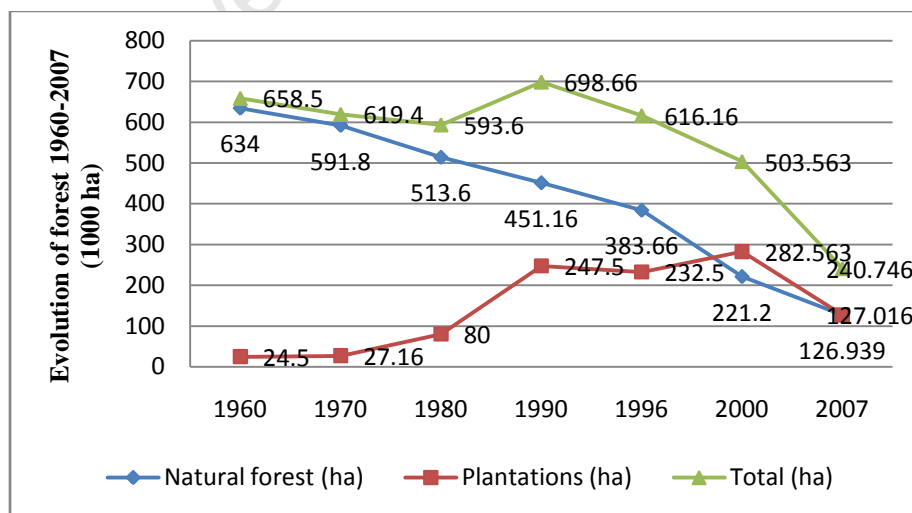


Figure 18: Evolution of forests (1,000 ha) (1960-2007) in Rwanda

Sources of data: MINITERRE, 2004 for 1960-2002; CGIS-NUR, 2007 for 2007

The post 2003 period was the period of increasing awareness of the need for environmental protection. Since 2003 one of the policies to reduce the forest depletion was a severe regulation on wood products in general and woodfuels in particular. The actual government program considers afforestation as a national priority with the objective to increase forest cover to 30% of the national land area by the year 2020, to increase agroforestry to as high as 85% of agricultural lands and to reduce woodfuel consumption from 97% to 50% ( MINICOFIN, 2000). In order to reduce deforestation due to woodfuel demand, researches from ISAR have identified 40 fast growing trees with high calorific value<sup>31</sup> (4,200- 5,000 kcal/kg) for use in the agroforestry sector (Ndayambaje, 2005). They can produce from 1.55 m<sup>3</sup>/ha/year to 4m<sup>3</sup>/ha/year that means a supplementary woodfuel production of 2,756,000 m<sup>3</sup>/year from agroforestry (ISAR, 2001). But still the established target is far behind its achievement as in 2007 the national forest cover was inventoried to be 10.10 %<sup>32</sup> (CGIS-NUR, 2007) of the national land area and woodfuel dependence is still at 97% (MININFRA, 2009a).

### **2.11 Changes of forest cover between 1988 and 2007**

In 1988 the forest law was enacted (République Rwandaise, 1989) and in 2007 the first national forest inventory was conducted (CGIS-NUR, 2007). It is of interest to assess the forest change within the period to assess what has been the role of the forest law in forest conservation. .

With GIS spatial analysis, it is possible to locate wooded areas created between 1988 and 2007 and those which disappeared during the same period. This allows an estimation of the losses (deforestation) and gains (reforestation and afforestation) for each class of tree.

For the 1988-2007 time period 25,441.4 ha in the natural forests (18.2%) and 64,366.8 ha in the forest plantations (51.4%) have been deforested. Thanks to the massive national afforestation and reforestation campaigns 52,903.7 ha were planted and 12,337.1 ha were reforested in the natural

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<sup>31</sup> Most woods burn but there are properties that differentiate their relative value for fuel. Density is the most general measure of wood burning quality. The heavier the wood (when dry) the greater its calorific value. Hence proper choice of species is critical for firewood crop establishment. Among others, trees include *Leucaena*, *Calliandra*, *Melia azedarach*, *Senna spectabilis*, and *Acacia sp*).

<sup>32</sup>These estimates are lower than the real coverage as national forest mapping excluded the agroforestry trees, forest on road sides with a width of less than 10 m and plantations with an area lower than 0.5 ha and less than 20 percent of tree crown cover.

forests, which represents an increase of 42.2% and 8.8% respectively (ISAR, 2007). Table 10 shows that from 1988 to 2007 forest coverage at national level dropped from 11.13% to 10.10%.

Table 10. Change of forest cover between 1988 and 2007

<b>Classes</b>	<b>Cover (ha) 1988</b>	<b>Cover (ha) 2007</b>	<b>Loss (ha) Deforested</b>	<b>Gain (ha) Planted</b>	<b>Balance (ha) (Loss+Gain)</b>
Natural Forest	140043.7 5.9%	126939.4 5.2%	-25441.4 -18.2%	12337.1 8.8%	-13104.4 -9.4%
Plantations	125270.2 5.2%	113807.2 4.9%	-64366.8 -51.4%	52903.7 42.2%	-11463 -9.2%
Total	265313.9 11.13%	240746.5 10.10%	-89808.2 -33.8%	65240.8 24.6%	-24567.4 -9.2%

Sources: MINITERRE, 2004, ISAR, 2007, GIS-NUR, 2007

The changes in the natural forest (9.4%) and plantations (9.2%) are almost identical. The losses and gain are expressed as percentage of the 1988 forest cover while the 1988 and 2007 percentages are the percentage of the national land area covered by forest.

Figure 19 shows the areas which have been deforested in the 1988-2005 time periods.

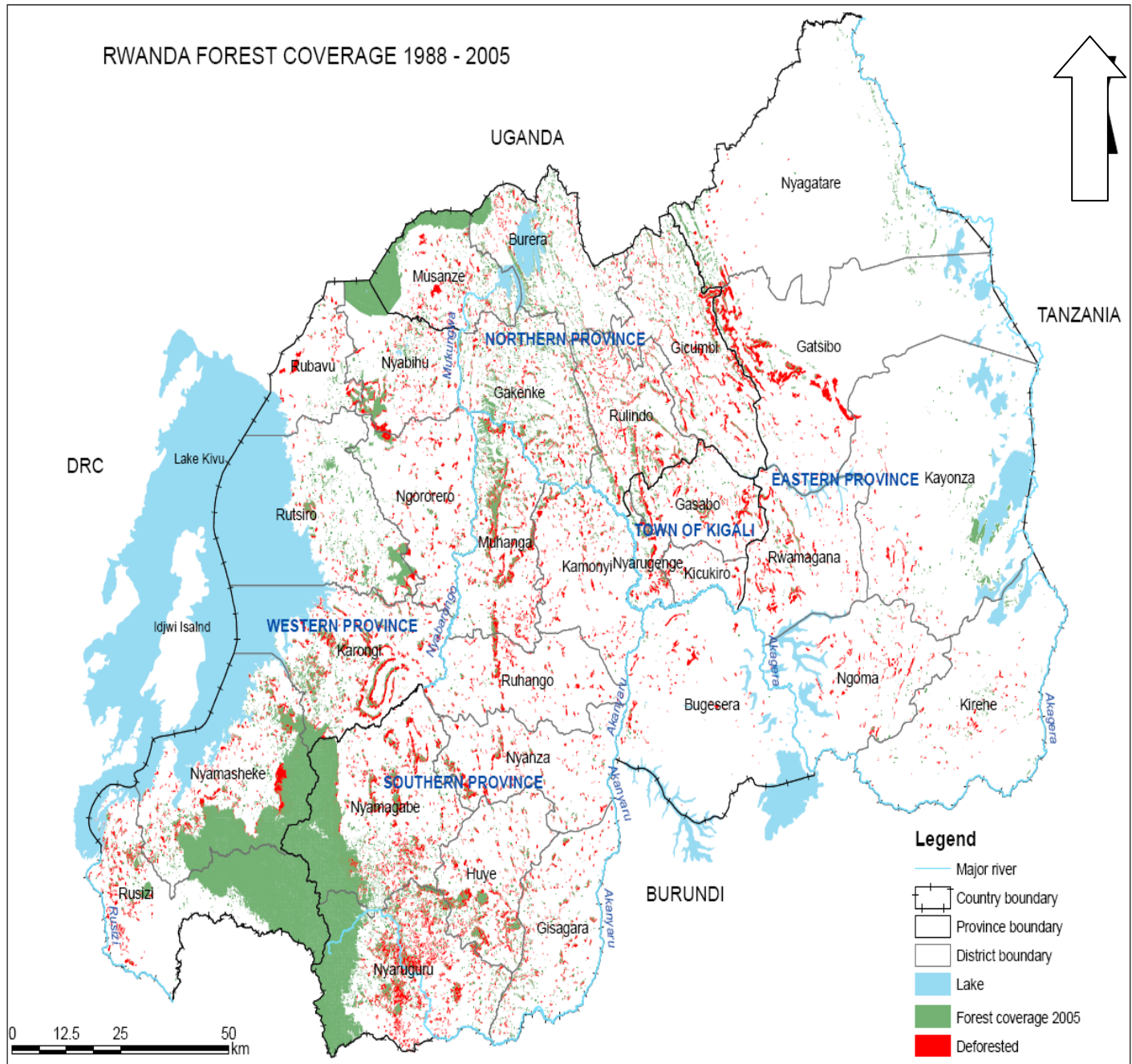


Figure 19: Rwanda forest coverage 1988-2005

Source: ISAR, 2007

## 2.12 Conclusion

The chapter presented an overview of both the traditional and modern energy sectors in Rwanda as well as an overview of poverty in Rwanda. Poverty is widespread and 57% of households live below the poverty line. Most poor live in rural areas and the government is addressing rural poverty by job creation and development programs. Forest cover, spatial distribution and variation from 1960 to 2007 show that since 1960, deforestation and forest degradation in Rwanda is a result of human driven interlinked factors and forest degradation is human induced as:

- Since 1960, deforestation was a consequence of high population growth, increasing demand on farm land, the population's displacement by internal migrations (land redistribution) and need for wood for energy and non energy services.
- During the 1990-1994 war period, forests, and the environment in general were neglected (Hitimana, 2009) and forest conservation measures did not survive the lack of attention (Bitanuzire, 2003). Community development work (Umuganda) held every Saturday by government order since 1975 was halted and for several years forest destruction went on uncontrolled and unabated. During the same period forests were regarded as good cover for ambush operations and cutting down forests was carried out as a matter of urgent policy supposedly for security need. The internally displaced in need of trees for fuel and emergency housing also contributed to indiscriminate cutting down of trees.
- After the war period, the new government had more urgent issues to attend to and consequently, off-the-road business, especially charcoal burning in forest hideouts, was lucrative business.
- The war ended with an influx of numerous, new, homeless citizens who were in need of land for their resettlement. The government had the inevitable task of accommodating them. During this period, encroachment on forests and natural reserves and occupying them was no longer illegal. Many people took the opportunity to occupy the forests and natural reserves. This unplanned encroachment on forests and reserves contributed to massive destruction of the environment.
- Equally important, after the war, the government took time to establish its authority. Forest resources activities suffered until the year 2002 from emergencies and from the

ignorance of the population and some authorities who did not have any understanding of environmental conservation.

Summarily, failures in protecting the environment included failure to anticipate the problem before the problem arises; failure to perceive the problem once arisen, and failure to solve the problem once perceived (Diamond, 2005) and as a result communal national resources deteriorated. Of concern is how to take care of the environment, and ensure that the poor fully benefit from it as a source of sustained livelihood. Anybody, from leaders to poor people, can insulate him/herself from the environmental degradation as it affects the whole country. Some problems are imperceptible as they occur slowly, but we have to learn from past mistakes to map the road ahead for sustainable harvest and management of the natural resources for energy provision and poverty alleviation.

The next chapter reviews the global woodfuel consumption through a review of some of the influential literature on woodfuel research; the general level of and reasons for consumption in developed, developing countries, the East African Community and particularly the woodfuel consumption and supply in Rwanda.

## CHAPTER THREE

### WOODFUEL CONSUMPTION AND SUPPLY

#### 3.1 General context

Historically, wood is the most important source of bioenergy. Wood has been used for cooking and heating since humans learned to use fire. Woodfuels (charcoal and fuelwood) are the world's most important form of non-fossil energy, with production and consumption concentrated in low income countries. In developed countries, wood is predominantly used for energy generation in the forest industry while in developing countries; it is also used for commercial applications (IEA, 2006a).

The world's woodfuel production amounted to 1.89 billion m<sup>3</sup> in 2007, almost 53% of the world's total round wood production (FAO, 2009b). Most of the woodfuel production took place in Asia (42% of the world total), Africa (32%), and the Americas (18% (mostly Latin America)). Additionally, 102 million m<sup>3</sup> of wood residues were used for woodfuel; Europe and Asia produced most of this (59% and 26%, respectively) (FAO, 2009b). About 45 million tonnes of wood charcoal were produced worldwide in 2007. Africa, Latin America and Asia dominated this production, with 55%, 27% (29% in all the Americas) and 15% of total world output, respectively (FAO, 2010). Woodfuel consumption increased by nearly 80% between 1961 and 1998, slightly trailing the world population growth of 92% over the same period (Mattheus, Payne, Rohweder, & Murray, 2000). Thereafter global consumption of woodfuel has remained relatively stable, at between 1.8 and 1.9 billion cubic meters per annum.

Primary solid biomass accounts for almost 10% of the world's total energy production (Sims, Schock, Adegbulugbe, Fenhann, Konstantinaviciute, Wamukonya, & Zhang, 2007). The percentage for developing countries is much higher, ranging from 13.5% of total energy production in Latin America to 19% in Asia and 26.2% in Africa. About 36 EJ of the energy obtained from solid biomass is collected as woodfuels from forests and trees outside forests in developing countries, of which about 3 EJ is used for charcoal production.

Social and economic scenarios indicate a continuous growth in the demand for woodfuels which is expected to continue for several decades. Generally in all regions of the world, per capita consumption is decreasing as a result of rising incomes, urbanization, declining availability of wood sources and increasing availability of alternative sources of energy preferred to woodfuel. The exception to the general trend is in Africa, Asia (except China) and in non-OECD countries in the Americas where total woodfuel consumption is increasing because of poverty and population growth. Non-OECD countries in Asia and Oceania, in contrast, are showing a downward trend due to rapid increases in income. In the absence of affordable alternative fuels, the number of people using biomass resources as their primary fuel for cooking will increase from 2.5 to 2.7 billion by 2030 worldwide (IEA, 2006b). Today almost half of all forest harvest is for energy with the remainder for industrial use (WEC, 2007). In Rwanda wood for energy accounts for 77% of the total wood product removal (GTZ, 2008).

### **3.1.1 The mid-1970s early 1980s interest in woodfuel research**

An increased interest in woodfuel's supply in the mid 1970s was due mainly to the rise in fossil fuel prices in 1973 and the associated energy crisis. Certain influential publications on the issue such as "The Other Energy Crisis: Fuelwood" (Eckholm, 1975) highlighted the issue of fuelwood supply, and a study by the FAO in 1981 predicted an acute deficit in the supply of this resource by 2000 and placed emphasis on the lack of a viable substitute to fuelwood (FAO, 1981). A widespread assumption was that Africa would be deforested to provide its poor with fuelwood. For a time, the crisis studies received the most attention, inspiring governments in Africa to initiate programs that would increase afforestation; improve efficiency of cooking stoves and charcoal kiln, or that would encourage consumers to switch to alternative fuels, such as kerosene and liquid petroleum gas (LPG) (Mwampamba, 2007). By the mid 1980s however, accumulating information suggested that the use of woodfuel was having less influence on forests (Arnold, Köhlin, Persson, & Shepherd, 2003).

### 3.1.2 Reappraisal of studies on woodfuels

The 1980s were the years of reappraisal. The late 1980s and the earlier 1990s was a period of adjustment following the reappraisal and proposal of more local forest management rather than the establishment of plantations (Barnes& Floor, 1996). In 1993, the International Journal on Energy Policy published a special issue dedicated to 'Urban Energy and Environment in Africa', which highlighted ongoing research and findings of the time. Works presented in the issue dismissed the 'woodfuel crisis', arguing that it was misleading and incorrect to attribute high forest loss solely to extraction for woodfuel. Expansion of agricultural land and heavy grazing pressure were presented as the major culprits for the heavy loss of forests suffered in the region (Hofstad, 1990; Hosier, 1993)

The 1990s saw a diminished interest in woodfuel research. For example, publications on woodfuel listed in the Tree-CD database reached 264 in the period 1982-1986, but dropped to 114 in 1997-2001 (Arnold et al., 2003).

Global wood demand and supply projections in the late 1990s again indicated that there could be a large and growing "gap" between demand and supply contributing to deforestation and forest degradation (Nilsson& Shvidenko,1996). However, closed canopy forests were not a prime source of woodfuel and at the global level, wood collection for fuel is not regarded by the FAO as an important cause of deforestation as most woodfuel is obtained from trees and shrubs in areas not defined as forests (Mattheus et al., 2000). Today systematic data on the source of woodfuel is still lacking, but regional studies indicate that as much as two thirds of woodfuel worldwide come from non-forest sources. Contrary to predictions of wholesale deforestation, there is good evidence that woodfuel supply can be sustainable, even in densely populated areas, if government planting programmes, and community reference woodlots and plantations were adequately managed. Increased demand for wood energy can be met in part through afforestation, agroforestry, substitution and energy saving programmes. However, expansion of afforestation programmes is constrained by the availability of land, and economic competition from alternative land uses.

## **3.2 Developing and developed countries' woodfuel consumption patterns**

There are two very different categories of woodfuel consumers. The first group, OECD member countries, use highly-efficient combustion technology under tight regulations on emissions. The second, representing by far the majority, estimated at three billion people, uses traditional methods such as three-stone fires, or small-scale appliances (cooking stoves) that are both inefficient and highly polluting.

Although the demand for domestic woodfuels leads to forest loss, in most places this demand has not yet led to significant deforestation as most domestic woodfuels used in developing countries today does not come from forests but from scrub, bush fallow and the pruning of farmland or agroforestry trees. In contrast to domestic use, however, clearing associated with agriculture, shelter expansion and the harvesting of fuelwood for small-scale industries such as brick-making, tea-curing and tobacco-drying is a significant agent of deforestation in many developing regions (Mead, 2005).

### **3.2.1 Developed countries consumption patterns**

In most industrialised countries wood energy contributes only about three percent of total energy supply, with some exceptions like Sweden and Finland where it contributes about 16% and some Central and East European countries between 12 to 18%. Wood contributes 3% of USA energy supply but, in absolute terms, USA wood energy consumption is almost double the wood energy consumption of the entire European Union. The USA case is unusual in that 60% of wood used for energy is directly harvested from forests and surprisingly, in the Organisation for Economic Cooperation and Development (OECD) regions as a whole, about 30 to 50% of all wood removed from forests is ultimately used for energy purposes (Mabee & Saddler, 2007). Future consumption in European Union countries is expected to rise due to recent EU plans to increase the proportion of renewable sources in total energy use to 20% by 2020 (EU, 2007). Recent surveys indicate that woodfuel consumption is above previous estimates in several industrialised countries and figures shown for OECD countries are therefore probably towards the lower-end of the likely range (Steierer, Fischer-Ankern, Francoeur, Wall, & Prins, 2007).

Currently, woodfuels meet much less of total energy demand in developed countries than they do in developing countries; in many developed countries woodfuel use is limited to rural areas, where it may have recreational, cultural or lifestyle values. Thirty percent of the wood harvested in developed countries (usually through logging by-products such as tops, stems and branches, and industrial by-products such as black liquor from pulp and paper mills) is used for energy, but, on average, contributing only two percent of total energy demand (Mead, 2005).

### **3.2.2 Developing countries consumption patterns**

Developing countries account for almost 90% of the world's woodfuels (fuelwood and charcoal) consumption and wood is still the primary source of energy for cooking and heating in these countries (Broadhead, 2008). Demand for fuelwood and charcoal is driven primarily by rising numbers of rural poor. Fuelwood is the predominant form of wood energy in the rural areas of most developing countries, while charcoal remains a significant energy source in many urban households in Africa, Asia and Latin America. Developing countries, especially African countries, rely mostly on wood to meet basic energy needs. Brazil, China, India, Indonesia and Nigeria account for 50% of the total world woodfuel consumption (Mattheus et al., 2000). The four countries total 45.2% of the total world population (IWS, 2010).

Estimates of wood use in Africa show that the vast majority of the harvesting is for fuelwood and that the quantities consumed in industrial applications are relatively insignificant. The share of woodfuel varies between 60% and 86% of primary energy consumption in sub-Saharan Africa and accounts for 90 to 98% of residential energy consumption (UNDP, 2009b). Fuelwood use is increasing in all Africa's regions, although at a diminishing rate. Despite its important role in the economy, quantitative and qualitative African data on woodfuels are scarce, and unreliable. Aggregate data placed Africa as an intermediate consumer in the 1980-1990 decade with an average annual consumption growth rate of 1.4% (0.8% for Europe and non OECD countries and 2.2% for Asia) and the highest per capita consumption of 0.889 m<sup>3</sup>/year (0.299 m<sup>3</sup>/year for Asia). Nigeria alone accounts for about 20% of total African consumption (FAO, 2009a). Woodfuel consumption across some SSA is shown in Figure 20. Averaged over the population using woodfuel, the gradations of colour in the figure indicate total woodfuel consumption and

the small pie charts show the fraction of wood that is used for charcoal based on multiple sources (Bailis, 2006).

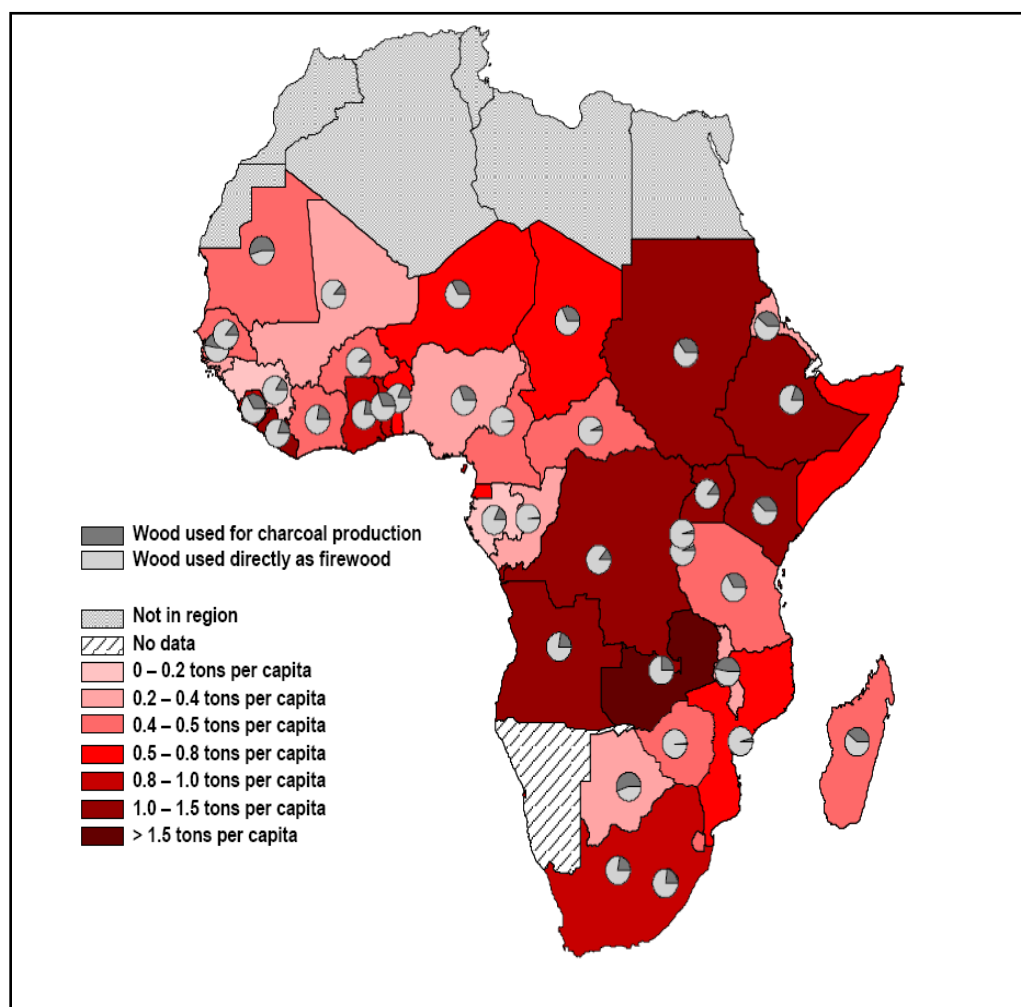


Figure 20: Annual per capita woodfuel use in SSA disaggregated by fuelwood and charcoal

Source: Bailis, 2006

The share of population relying on woodfuel indicates differing trends in total consumption. The Figure 21 shows the trend in total consumption patterns of populations relying on wood for cooking by Industrialised Countries, Developing Countries (DCs) in general, Least Developed Countries<sup>33</sup> (LDCs) and Sub Sahara Africa Countries (SSA).

<sup>33</sup> There are 50 Least Developed Countries and 45 sub Sahara African countries, with 31 countries belonging to both categories.

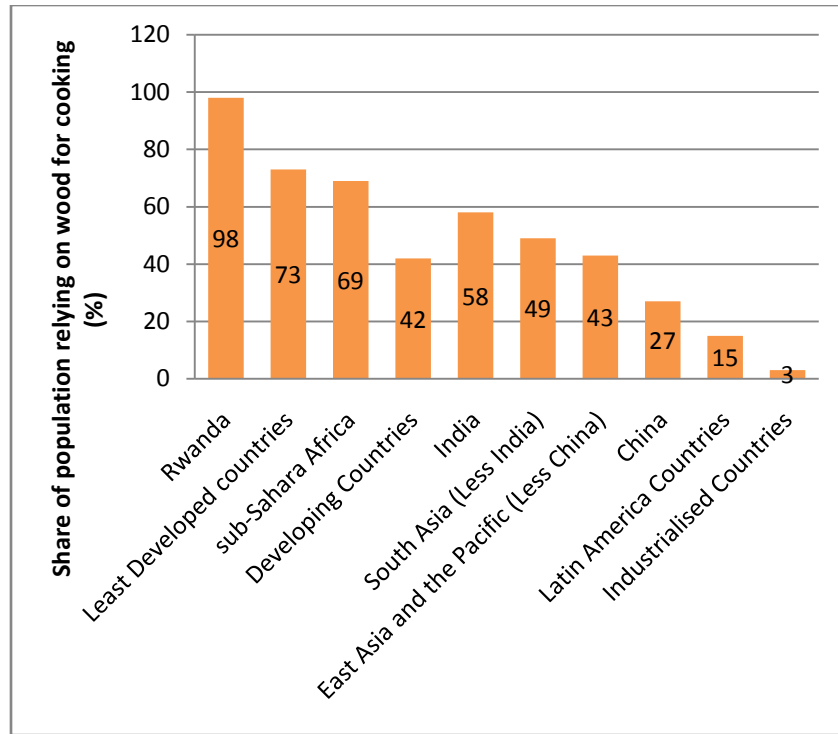


Figure 21: Share of population relying on wood for cooking by region, 2007

Source: UNDP, 2009b for DCs, LDCs and SSA; Mabee et al., 2007 for industrialised countries

### 3.2.3 Regional overview

Regionally, in Eastern African Community (EAC) countries (Burundi, Kenya, Rwanda, Tanzania and Uganda) and the Democratic Republic of Congo woodfuel contributes 96.46 % of cooking fuel (UNDP, 2009b). In the EAC countries fuelwood is the main fuel in rural areas and charcoal is the most used fuel in urban areas. The aggregated contribution of charcoal and fuelwood is as in Figure 22.

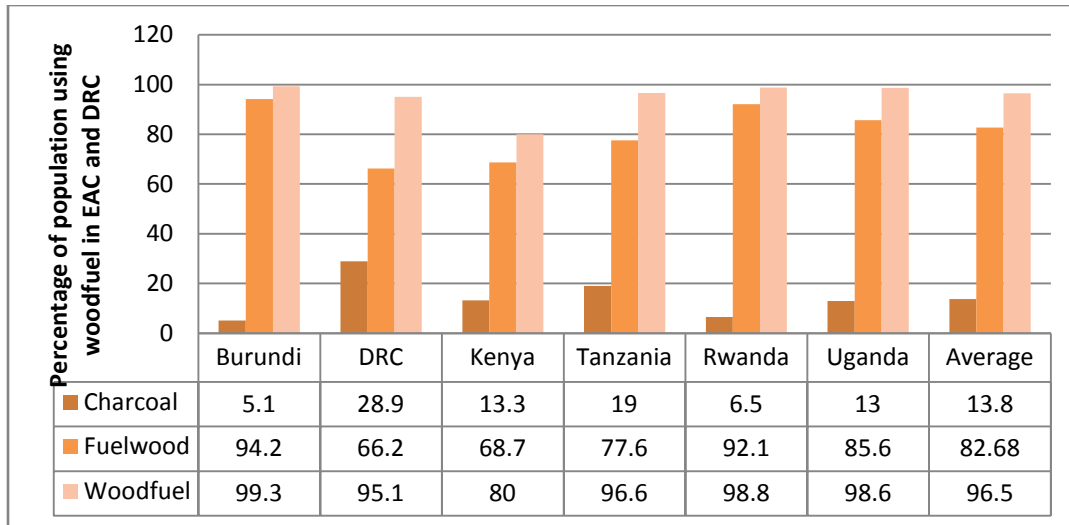


Figure 22: Percentage of population using woodfuel for cooking in EAC and DRC

Source: UNDP, 2009b

The East African Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) (Rudi, 2005) shows the average balance for EAC countries. In general the deficit is more acute near expanding towns and peri-urban areas. The demand and supply balance has a larger deficit in Rwanda and Burundi. These two countries are “hot-spots” and need appropriate actions to be taken to balance the demand/supply (Figure 23).

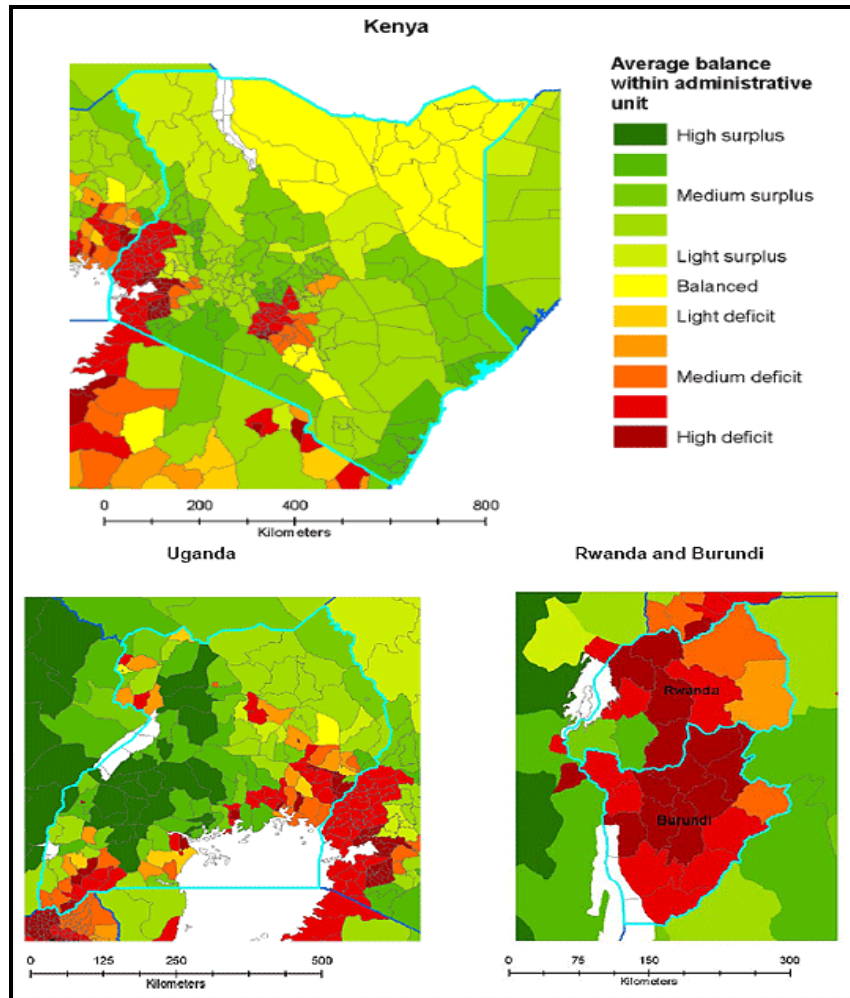


Figure 23: Woodfuel consumption and supply balance

Source: Rudi, 2005

Summarily, the World Energy Council 2007 survey of energy reveals that statistics on woodfuel use are poor in both developed and developing countries because of insufficient institutional awareness, resulting in different approaches to making estimates. There are many different government bodies involved in the woodfuel sector. The lack of reliable statistics exacerbates the problems of supply management and the mitigation of negative impacts from the use of woodfuels. For example, forestry departments are concerned with the total wood flow out of forests; energy department concerns are with estimates of household, commercial and industrial energy requirements, while environmental regulators are concerned with resource depletion (soil, water and biodiversity) and emissions impacts, and the health sector may be following the effects of household emissions on chronic diseases (WEC, 2007). Consequently due to difficulties in

collecting accurate information on woodfuels, caution is required in interpreting data. To harmonize definitions and conversion factors for adequate data collection and estimation, the Wood Energy Programme (WEP) of FAO published the Unified Bioenergy Terminology (UBET) in 2004 (FAO, 2004).

### **3.4 Environmental Impacts of woodfuel consumption**

FAO (2010) recognizes that the environmental impacts of the woodfuel production and harvesting practices vary in nature and extent according to the scale, intensity and type of production and harvesting system used, and can be either positive or negative.

The greatest environmental benefit of woodfuels is that, when produced and harvested sustainably, they provide a renewable source of energy with low net carbon emissions. Woodfuels are derived from vegetation that sequesters atmospheric carbon during growth, releases it to the atmosphere when converted to energy, and takes it back up as it re-grows. The use of woodfuels can offset fossil-fuel use and contribute to national efforts to reduce greenhouse gas emissions. Other potential environmental benefits include improvements in biodiversity, soils and water through the creation of a woodfuel resource (such as tree-planting on degraded agricultural land and hills sides); the reduction of forest fuel loads (and therefore the risk of wildfire) through thinning or the removal of logging residues; and improved forest ecosystem health through the rehabilitation of degraded forests and woodlands.

There is also a range of environmental risks associated with woodfuel production because harvesting may be more intensive than that required for conventional timber production. Overharvesting such as the clear felling (currently in practice in Rwanda for charcoal production) of forests and of trees outside forests is another potential risk. Woodfuel production systems, therefore, should be designed so that they do not diminish the quantity and quality of soils and water mainly in marshlands; decrease site productivity; adversely affect biodiversity; create excessive carbon emissions or other air pollution; or decrease the ecological integrity of landscapes (FAO, 2010).

### 3.4.1 Harvest induced impacts

To minimize the adverse harvesting's impact on the environment, sustainable harvesting is advised. There is a need for a strategic shift from a demand driven exploitation to production oriented management to avoid deforestation. Often to maximise profit charcoal makers practice clear felling without replenishment which negatively affects the environment (Photo 4).



Photo 4: Clear felling for charcoal in Nyamagabe District

Photo: REMA, 2009

When estimating actual or potential sustainable wood supplies, an important distinction has to be made between (i) clear felling (often limited to plantations) and (ii) sustainable harvesting. Estimation of woodfuel demand and supply need to be calculated to avoid severe environmental consequences (see Box 1).

### Box 1: Sustainable harvesting (Hedon, 2009)

Forest area (A) is land area of more than 0.5 hectares, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use.

Mean stock density (D) per hectare is the average total volume of wood in cubic metres per hectare. The mean annual increment (MAI) is the total increase in volume (of wood) of a stand per hectare per year (except for plantations, the MAI is often estimated as 2.5% of the forest stock density).

The allowable cut (AC) is the amount of wood that may be harvested annually (or over a given period) per hectare, according to the governing rules. In overexploited stands this figure is often significantly below the MAI, in order to rehabilitate the stand. The accessible area fraction (AF) represents the share of forest area accessible for exploitation (on a regional level, a factor of 40-50% is often applied, depending on the population density). The fuelwood fraction (FF) is the share of wood volume destined for woodfuel production. Forest owners are eager to increase their profits by selling their produce as lumber or poles etc. as these often achieve much higher prices on the market than fuelwood. The harvest/cutting fraction (HF) is the volume harvested after the percentage of harvesting losses has been deducted. Harvesting losses can amount to 10% of the allowable cut.

A distinction must be made between “Clear felling (Stock)”:  $A \times D \times FF \times HF$  (for clear felling, 100% of land accessibility is assumed) and “Sustainable harvesting (yield estimation or forest management)”:  $A \times AC \times AF \times FF \times HF$ .

As an hypothetical example, a forest area of 100 ha in Rwanda on a sustainable harvest can produce only 18 m<sup>3</sup>, while on a clear cutting basis produces as much as 1,350 m<sup>3</sup> meaning 75 times more than the supply under sustainable harvest conditions which actually mines the wood resource (Table 11).

Table 11 : Estimating actual and potential wood supplies

Supply factors	Hypothetical data	Units
A - Forest Area	100	ha
D - Mean stock density	15	m <sup>3</sup> /ha
MAI - Mean annual increment	0.375	m <sup>3</sup> /ha/yr
AC -Allowable Cut	0.250	m <sup>3</sup> /ha/yr
AF - Accessible area fraction	0.8	
FF - Fuelwood fraction	1.0	
HF - Harvest/Cutting fraction	0.9	
Example of stock and yield estimation:		
<b>Clear felling:</b> $A \times D \times FF \times HF$ (100% of land accessibility is assumed )= $100 \text{ ha} \times 15 \text{ m}^3/\text{ha} \times 1.0 \times 0.9 = 1350 \text{ m}^3$ .		
<b>Sustainable harvesting:</b> $A \times AC \times AF \times FF \times HF=100 \text{ ha} \times 0.250 \text{ m}^3/\text{ha} \times 0.8 \times 1.0 \times 0.9 = 18 \text{ m}^3$		

Harvest induced impact is less severe for rural consumers as rural fuelwood users typically collect small amounts of wood daily, and thus the forestry impact is dispersed and much less severe. Also rural users may collect dead wood or twigs and branches which allow the trees to regenerate.

Charcoal production is responsible for the large scale felling of wood, which leads directly to deforestation and subsequently to soil erosion (Photo 4). More importantly, charcoal demand is higher in densely populated urban areas and harvesting wood for charcoal production is an intensive process, concentrated in a small area over a short period of time. In some cases, wood is taken illegally from state land, and producers are under pressure to harvest the wood and make charcoal as fast as possible. Combining the sustained activity of charcoal production (demand driven) with the unsustainable harvest of forest clearing (supply driven) may result in forest clearing solely for charcoal production, with direct adverse environmental impacts.

### 3.4.2 Woodfuel and climate change

If biomass is harvested at a rate that is sustainable, using it for energy purposes does not result in any net increase in atmospheric carbon dioxide, a greenhouse gas. If the fuel is harvested sustainably, then the CO<sub>2</sub> is reabsorbed by the replacement of biomass, and can be carbon neutral. In this case, only the products of incomplete combustion (PIC) are considered problematic (MacCarty et al., 2007). When woodfuels are produced sustainably and used as an alternative to fossil fuels, the net emissions of greenhouse gases such as carbon dioxide are minimal because a similar volume of gases emitted during combustion is sequestered by the next crop of trees. This benefit is recognized in the Clean Development Mechanism (CDM) initiatives to promote greenhouse gas reductions through afforestation and renewable energy projects. IEA (2009) recommends that in order to accurately assess the overall impacts on greenhouse gas emissions of woodfuel production and harvesting systems, a number of other factors must be considered, including: changes in carbon stored in soil, litter and trees as a result of changes in land use and management regime; the consumption of fossil fuels during woodfuel production, transport, conversion and waste disposal; temporal variations in carbon stock and fluxes; overall effects on the range of greenhouse gases, which includes carbon dioxide, methane and nitrous oxides; complete life-cycle analyses of products and systems (IEA, 2009). To minimise the impacts of woodfuel production on greenhouse gas emissions, management plans should consider the impacts of land-use change on the carbon balance and incorporate the most energy-efficient methods available at each stage of production.

Woodfuels production and consumption affects global warming in several interrelated ways. Emissions during charcoal production are significant compared to those from charcoal burning as charcoal is produced via pyrolysis, or thermal degradation, of biomass. This partial combustion, in an oxygen-poor environment, results in formation of products of incomplete combustion (PICs), such as CH<sub>4</sub>, CO, alkanes, alkenes, oxygenated compounds and particulates, therefore the global warming impact of biomass pyrolysis for charcoal may be greater than that of biomass burning (Kammen & Lew, 2005).

Emissions during the woodfuel burning can also affect global warming but when stoves are well designed with precise internal dimensions to control the flow of air, in order to burn the wood cleanly and transfer heat efficiently to the cooking pot, laboratory tests show savings of 40% of fuelwood (50% if a pot skirt is used); 50 to 70% of particulate emissions; and 50 to 60% of carbon monoxide emissions, compared to three-stone fires (ARC, 2010)

In Malawi, a kitchen survey and tests on the improved portable ceramic stove showed reduced wood consumption in sampled households by 39% on average, in some cases saving more than 50% of fuel used previously (ECOFYS, 2009). Both studies concluded that the improved stoves significantly reduce fuel consumption and greenhouse gas emissions. Typical savings vary from one to two tons of CO<sub>2</sub> (equivalent) per year per stove (ARC, 2010). Comparable results have been revealed by the “Assessment of wood-burning cookstove emissions and fuel-efficiency” study in Rwanda by Susan Doll in 2006.

Instead, to reduce the environment and climate change impact of woodfuels consumption, sustainable wood harvesting, improved charcoaling technologies and improved stoves programmes have to be concurrently practiced for forests conservation and environmental sustainability.

Conversely climate change is expected to impact on forests and consequently on woodfuel supply. To mitigate the environment and climate change impact on woodfuel demand and supply some forecasts exist (Kirilenko & Sedjo, 2007). Kirilenko & Sedjo (2007) state that the responses of forestry to climate change are likely to be multifaceted. On some sites, species more appropriate to the climate will replace the earlier species that are no longer suited to the climate. In general, the same source affirms that we would expect planting and associated forestry operations to tend more toward higher latitudes, especially from some tropical sites, should they warm substantially. Plantations would likely shift toward more subtropical regions from tropical ones. Climate change impacts on forestry and a shift in production preferences will translate into social and economic impacts through the relocation of forest economic activity. Distributional effects will involve businesses, landowners, workers, consumers, governments, and tourism. Net benefits will accrue to regions experiencing increased forest production, whereas regions with

declining activity will likely face net losses. Although forest-based communities in developing countries are likely to have a modest impact on global wood production, they may be especially vulnerable because of limited adaptability in rural, resource-dependent communities to respond to risk in a proactive manner.

### **3.5 Woodfuel use and the MDGs achievement**

Eight Millennium Development Goals (MDGs) were adopted in 2000 and designated to eradicate extreme poverty by 2015 (IEA, 2010). Energy can contribute to the achievement of many of these goals but the MDGs contain no goal specifically related to energy. The only indicator related to energy is for CO<sub>2</sub> emissions: total, per capita, and per US\$ 1 GDP (Purchasing Power Parity (PPP)) under goal 7. At the 12<sup>th</sup> International Energy Forum (IEF) in Cancun in March 2010, the IEF called for the international community to set up a ninth goal, specifically related to energy, consolidating the evident link between modern energy services and achievement of the MDGs (IEA, 2010). Although the sustainable access to energy is not treated as a priority in itself in the MDGs, most of them have a direct energy implication, particularly Goal 1 (Eradicate extreme poverty and hunger). Today 2.7 billion people in developing countries rely, for cooking primarily on biomass with inefficient devices and 1.4 billions lack access to electricity (IEA, 2010). In order to reduce by 2015, the number of people without effective access to modern cooking fuels by 50% and make improved cookstoves widely available, every day, around 1.5 million additional people have to get access to improved cooking energy.

Poor access to modern fuels delays the national development and poverty reduction and hinders the achievement of the Millennium Development Goals (MDGs). Assuming a sustainable woodfuel supply (afforestation, efficient charcoal production) and efficient and clean burning stoves (fuelwood and charcoal), woodfuel use can contribute, in its way, to the achievement of the MDGs.

Goals 1 and 7: Eradicate extreme poverty and hunger and ensure environmental sustainability.

The use of biomass for energy from sustainable resource management and efficient and clean stoves leads to improved economic development, poverty alleviation and environmental sustainability, especially in rural areas.

Sustainable management of forest and sustainable woodfuel supply include: Sylvicultural treatment (plantation, maintenance, pruning, enrichment, and rejuvenation of the forests) is a process where jobs are created in rural areas for the poorest people living on less than US\$1/day. Replacing unregulated mining of wood resources by sustainable harvesting for charcoal production can save as much as 75% of trees (Hedon, 2009) and as such contribute to environmental sustainability (MDG 7).

Efficient and clean burning stoves contribute to achieve goal one and seven as: Improved woodfuel stoves use saves around 40% of fuel and therefore saves both trees and money which would be otherwise foregone. In such way the benefits of the devices come in the form of reduced pressure on natural resources and income saved from fuel purchase and rehabilitation of degraded ecosystems.

Goal 2 and 3: Achieve universal primary education and Promote gender equity and empower women.

With fuel and time saving efficient stoves, the physical burden and time spent by children and women associated with hand gathering of fuelwood are reduced and children have more time to attend school and women have more time for remunerative and other family tasks, such as agriculture, cooking and child-caring, which impacts on the nutrition and health of families. As women largely determine the energy consumption patterns of households, training of women in production and commercialization of stoves and woodfuels increases their incomes and their status in the community by becoming entrepreneurs.

Goals 4, 5, 6: Reduce child mortality; improve maternal health; and combat HIV/AIDS, malaria and other diseases.

Improved woodfuel stoves use significantly reduce greenhouse gas emissions and reduce indoor air pollution contributing as such to low risk of respiratory diseases and eyes infections especially in women and younger children.

Goal 8: Develop a global partnership for development.

Research in improved forest management and designing of efficient and clean stoves could develop a global partnership in development through the enlargement of existing household energy networks and institutions.

Summarily a well designed improved household woodfuel energy provision could impact almost all goals as summarised in Table 12.

Table 12: Household improved woodfuel energy provision and MDGs

Impact	Effect on	Goal
Woodfuel saving,	Forest conservation; GHGs savings, environmental protection	MDG7
Time saving fuelwood collection cooking time)	Children and women drudgery (more time available)	MDG2, 3
Reduced indoor air pollution (Improved cooking stoves)	Respiratory diseases by improved safety	MDG 4, 5, 6
Incomes increase and money saving (production, use and commercialisation of ICS)	Income generation, business and job creation	MDG1
Multilateral research in forest management and designing ICS	Develop a global partnership for development	MDG8

### 3.6 Woodfuel energy content and supply distance

Charcoal has about double the energy content of wood per unit weight. That means its transport cost, per unit energy, will be about half that of wood, assuming that weight is the limiting factor on the load being carried. There are, thus, two counterbalancing factors determining the cost, per unit energy, of charcoal and firewood when they are delivered to a city market. At the point of origin, when they are being loaded onto the truck, the charcoal is slightly more costly. But for each kilometre it is carried, there is a saving in its transport compared with that of firewood. The greater the distance the charcoal is carried, the more this is able to offset its initial cost. At a certain distance from the city, there is therefore a point at which, in principle, the combined transport and production cost of the two fuels, per unit energy, are equal. This is referred to as the “break-even distance” (Foley, 1986) or “crossover point” (Chomitz & Griffiths, 2001), for wood and charcoal transportation. How far this is depends on the assumptions used for transport costs, wood and charcoal production costs, at the charcoal yield. Using East African data, Earl cited in Chomitz & Griffiths (2001) calculated it to be 82 km. Charcoal use is then only competitive beyond the break-even distance. Therefore, when fuelwood is available, before the cross over point it is more economic to use fuelwood to save energy, incomes and wood resources. Still customers don’t only choose between fuels on the basis of the price per unit of energy, in Rwanda for example, affordability and availability are determinant factors which influence fuel choice (Mazimpaka, 2010).

### **3.7 Petroleum Link**

Even though charcoal use may be encouraged as it provides jobs and incomes in the poor rural and urban areas, petroleum costs and petroleum dependency are an inextricable part of charcoal price increases related to its transportation. Transport costs are a significant portion (27%) of the total charcoal cost at city market<sup>34</sup> and transport distances increase with time, as nearby stocks of forests are depleted, with resultant transport cost increases (Chomitz & Griffiths, 2001). When transport costs are a significant fraction of total costs, with the increasing supply distances any fluctuations in petroleum prices will likely have an effect on real charcoal prices. Actually any change or speculation in the petroleum price increases charcoal price irrespective of the means of transport. Therefore, although feedstock may be sustainably and locally grown, charcoal

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<sup>34</sup>Case study of present study finding.

production is strongly linked to the petroleum industry, from both an energy and economic perspective.

### **3.8 Woodfuel consumption and supply in Rwanda**

#### **3.8.1 The role of woodfuels in Rwanda**

Even though the Rwandan Government actively encourages the use of energy other than biomass, the contribution of biomass resources to the national energy balance remains high at 86% of primary energy balance (MININFRA, 2007). Through Vision 2020, the contribution is supposed to fall from the current 86% to 50% by 2020 (MINICOFIN, 2000). This can only be achieved if 35% of the population is connected to the country's electricity grid and if they also can afford to use electricity. That target is not realistic, given the fact that no important improvements in electricity access have occurred half-way to the endpoint in 2020. Accounting for 86% of the final energy balance, woodfuels are used as a main fuel by low, middle and high-income groups in the country. Despite the relatively high cost of woodfuels, they remain the most affordable source of energy for the Rwandan population, relative to its substitutes (electricity and petroleum products) which are expensive and mostly unavailable. Woodfuel is a useful alternative as it saves foreign exchange that would otherwise be used to import expensive petroleum products. The country's electricity generation is only 69.10MW and electrification level is only six percent of the population. Woodfuels are a renewable resource and, properly managed, their production and consumption can be sustainable at least until economically viable alternatives are available.

#### **3.8.2 Contribution of woodfuels to national economy**

Woodfuel is an important source of income, and contributes to poverty reduction. In 2007, a survey (MININFRA, 2007) revealed that the woodfuel sector generated US\$ 122 million (5% of GDP), almost twice as much as electricity sales (US\$65 million), three times the value of coffee exports in the same year (US\$38 million), and twice that of tea production (US\$48 million). The contribution of charcoal, alone, to the rural economy is large. With a total market for charcoal of

about 150,000 tons per year, the total value is about US\$50-60 million. This is the equivalent of more than 2% of GDP. Moreover, some 50% (US\$26.3 million) of this value remains in rural areas, where it is distributed among farmers/wood growers and charcoalers and is, as such, an engine of rural development. Transporters have a market of \$19.7 million for the transport of charcoal to towns, and retailers earn a total of US\$ 6.6 million for selling charcoal to end-users. In addition, planting trees for charcoal can be a profitable enterprise for all actors of the production and supply chains. As a survey undertaken in October 2009 shows, charcoalers make a 37% profit on each bag produced and the retailer makes 17% net revenue (Mazimpaka, 2010). The charcoal sector in Rwanda is a significant source of employment. In the year 2008, 300,000 rural households drew income from the woodfuel value chain: 8,000 charcoalers; 7,000 tree fellers; 2,000 retailers and 200 to 300 transporters were employed in the sector (MININFRA, 2009d).

The World Bank/ESMAP estimates of employment per TeraJoule (TJ) of energy consumed in person days indicate that charcoal creates between 200 and 350 jobs per TJ compared to electricity between 80 and 110 jobs and kerosene only 10 (Mugo & Ong, 2006) . Charcoal production and trade contributes to the economy by providing rural incomes, tax revenue and employment, therefore promoting the woodfuels industry will create more jobs and incomes in the country than the modern energy sector which is actually very limited.

The pattern is similar in the other countries in the region. In Kenya, recent estimates are 1.6 million tons worth US\$ 400 million which, at the 16% VAT charged by the Kenyan government, should contribute US\$ 64 million in taxes every year. The charcoal industry in Kenya employs about 200,000 in production alone. In Uganda, production provides 20,000 jobs and generates more than US\$ 20 million a year for rural people. In the Licuati region of Mozambique 65.4% of rural incomes are derived from charcoal (Mugo & Ong., 2006). Despite its significant contribution, however, charcoal has been kept out of the formal economies of these countries, mainly because its importance is not well understood and appreciated resulting in clandestine charcoal making which escapes paying tax.

The woodfuel sector constitutes an engine for the rural economy, but it also contributes to environmental destruction in rural areas, mainly by leading to deforestation and then erosion.

### 3.8.3 Woodfuels demand

Every year some 5.5 million m<sup>3</sup> of wood is used in Rwanda by households and institutions for cooking and heating, which represents 90% of all firewood consumed in the country. Industrial use (tea and sugar factories, restaurants, bakeries) is much lower at 155,550 m<sup>3</sup> per year (MININFRA, 2009d). Considering charcoal making efficiency (10-14%), and the country's urbanisation rate (20%), and the general annual population growth (2.7%), the demand/supply balance remains unsurmountable (Table 13). Locally there are no data available to explain the source of wood to compensate for the “shortfall” of wood, but elsewhere alternative supplies come from scrub, bush fallow, clearing of farm land, dry tree branches and agroforestry trees (Mead, 2005).

Table 13: Demand and sustainable supply of wood products (1960-2007) (1,000m<sup>3</sup>)

Year	Sustainable supply	Demand	Balance
1960	368	2695	-2327
1970	407	3763	-3356
1980	1200	4832	-3632
1990	3713	7158	-3445
1996	2790	6784	-3994
1999	2268	7882	-5614
2000	2261	8247	-5987
2002	2261	8979	-6719
2007	2726	7743	-4348

Sources: MINITERRE, 2004 for 1960-2002; MININFRA, 2009a for 2007

### 3.8.3.1 Industrial demand

At industrial level, tea factories are the highest consumers of firewood which is used in the tea drying process. On average 4.20 steres<sup>35</sup> are used to produce one ton of dry tea, therefore with an average production of 17594 tons<sup>36</sup> of tea/year (Butera, 2009), this drying process consumes about 26,000 tons of dry Eucalyptus wood (39,789 m<sup>3</sup>) per year. Assuming a forest production of 15 m<sup>3</sup> per year per hectare, this represents almost 2,652 ha of trees cut per year or 1% of the land under forest plantation, estimated to be around 240,748 ha. In addition to deforestation for the tea drying process, conversion of forests to tea plantations contributes more to deforestation as forests cleared for plantations are permanently lost and will never regenerate. Soil erosion may not be a problem as well managed tea plantations protect soil against erosion.

Photo 5 and Photo 6 show firewood stocks and a wood boiler at Mulindi and Sorwathe tea factories in Gicumbi and Rulindo districts, in the Northern Province of Rwanda.



Photo 5: Firewood stock at Mulindi

<sup>35</sup> 1m<sup>3</sup>=650Kg and 1 stere of dried Eucalyptus =350Kg; 4.20 steres =1470kg

<sup>36</sup> Calculations are based on the 20,474 tons; 19,965 tons and 16,342 tons of dry tea produced respectively in 2007, 2008 and 2009.



Photo 6: Wood boiler at Sorwathe

### **3.8.3.2 Institutional and commercial demand**

Statistics on woodfuels used in catering services such as restaurants and hotels are not often available but estimates show that 1-20 % of woodfuels used in urban areas are used in the sector ( Energy Development Institute, 1999). Institutional fuelwood consumption was on average 148, 707 tons in 2004 of which schools consumed 35% followed by wood for brick-burning industry 21% and prisons 13% of the sector wood demand (Butare& Hughes, 2004). In prisons the consumption of firewood per day is approximately 3 m<sup>3</sup> of firewood per 1200 inmates (Uwizeye, 2005). Progress has been made in the installation of biogas plants in 10 of the 14 prisons in the country, subsequently reducing firewood costs by up to 50% (Rwembeho, 2010). With the government's Instruction No 0001/2004 of 16/07/2004, the use of wood in brick burning was banned and hopefully a significant wood stock will be saved. Today sawdust and rice husks are used in brick baking but still the illegal use of wood is common practice.

### **3.8.3.3 Demand from households**

Energy remains very expensive in Rwanda, accounting for 14% of all non-food expenditure of households (NISR, 2006a). The main source of household energy is biomass. The household consumption of wood taken from the growing stock of trees is estimated at on average 500 kg/person/year, which is of the same magnitude as consumption in Malawi (550

kg/person/year)(MARGE, 2009) or South Africa with an average between 500 and 700 kg/person/yea (ProBEC, 2008).

A survey by the Ministry of Infrastructure (MININFRA, 2009a) conducted in 2009 shows that rural household woodfuel consumption was close to 4 million tons/year (MININFRA, 2009c). The most used species of tree for this purpose is Eucalyptus (Table 14).

Table 14: Rural household woodfuel consumption, 2009 (tons)

Species/genus	Eucalyptus	Greveria	<i>Lantana camara</i>	Others	Charcoal	Agriculture residues	Total
Quantity ( Tons)	2,977,958	335,351	327,453	109,320	59,825	57,210	3,900,008

Source: MININFRA, 2009c

In summary, with an average production of 15 m<sup>3</sup>/ha/year and one cubic meter of dry Eucalyptus weight of 650 kg, the woodfuel demand from institutions (148,707 tons), households (4 million tons) and industry- tea factories only- (26,000 tons) total almost 4,174,707 tons, equivalent to 6,422,626 m<sup>3</sup> or a production of 428,175 ha of clear felled trees. This represents 177% of the 240,748 ha which constitute the national natural and plantations forest cover all together.

If this amount of woodfuel would come from forest , the country would have either experienced severe shortage of wood products or within less than one year all land area under forests would have disappeared countrywide, it is therefore most likely that most of woodfuels do not necessarily come from areas defined as forest in the strict sense. Therefore either wood product demands are overestimated or forest covers are extremely underestimated. The second alternative is the most plausible. The newly established Rwanda National Resources Authority (Republic of Rwanda, 2011) is reviewing the definition of forest adopted in 2007 to include areas which were excluded in 2007 in order to improve both the forest cover and production figures. But still, even if there are no, hundred per cent, reliable statistics on woodfuel consumption, urbanisation will increase charcoal consumption in Rwanda. The growing use of charcoal even in rural area (MININFRA, 2009a) will increasingly put pressure on the fuel's resource as; according to Hosier et al. (1993) for each one percent increase in urbanisation there is a 14% increase in charcoal consumption. Mugo and Ong (2006) estimate that charcoal consumption increases yearly by 6% in the Eastern African region.

### **3.8.4 Woodfuel sources and supply**

When dealing with the woodfuel sources and supply, one must differentiate between actual sources of supplies or woodfuel available, and potential supply, which could be made available with integrated and sustainable resource use. Another distinction needs to be made between direct sources (trees, shrubs...) and indirect sources of supply involving recovered woodfuels using only residues or dead plant matter that still has energy use (Chalico & Riegelhaupt, 2001).

#### **3.8.4.1 Sources of woodfuels**

In Rwanda woodfuel supply is different from the supply of this resource in most other African countries as most of the country's woodfuel comes from private and community forest plantations (Table 15) rather than from natural forests (Butare, 2004; MININFRA, 2009a).

Major sources of fuelwood are private forest plantations at 73%; community forest plantations at 22%; while government forest plantations contribute 4%. Sources of wood for charcoal are at 72% from private forest plantations, 16% from community forest plantations and 6% from government forest plantations. The remaining unidentified sources, 6% for charcoal and one percent for fuelwood, could be illegal sources mainly from natural or public forests (Butare et al., 2004).

Nine percent of households use crop residues while 29% of fuelwood users use purchased fuelwood and 57% use fuelwood collected from a variety of sources including small plantations, dead wood, farm and homestead trees and the five percent of the population using charcoal use charcoal made from forest plantations (MININFRA, 2009a). The total off-take of wood for fuelwood and charcoal making, from land area defined as forest, is therefore less than previously thought. Despite the small plot sizes and competition with other land use such crop farming, if agroforestry was developed in Rwanda, there is the possibility that private tree plantations could satisfy a large part of household woodfuel needs in the country and consequently their impact on deforestation lessened. And with the ban on fuelwood for brick and tile making and better control of wood stocks, exploitation of forests for woodfuel is likely to decrease.

Table 15: Source of woodfuel supply

Source	Fuelwood	Charcoal
Private forest plantations	73%	72%
Community forest plantations	22%	16%
Government forest plantations	4%	6%
Others	1%	6%

Source: Butare et al., 2004

### 3.8.4.2 Charcoal sources of supply

In the 1980s, most charcoal consumed in Kigali was produced in the Bugesera region, located about 60 km away South from the city. In the same period the region became deforested, the population fell into acute poverty and the GoR, to protect the few remaining forests in the region, enacted a series of measures to prevent their exploitation for charcoal (Leach & Mearns, 2009). By 1987 reduced resources forced charcoal to be sourced from trees in the Kibungo region, 120 km away from Kigali, by October 1987, 85% of the charcoal used in Kigali was from that region and 15% was from natural woodlands (ESMAP, 1987). Both regions in the Eastern Province have been heavily deforested and nowadays charcoal is mainly produced from the Southern (70%), Western (27%) and Northern (3%) provinces at an average distance of 180 km from the city (Figure 24).

The fact that all charcoal is sourced from only three provinces is doubtful, as I personally eye witnessed the charcoal production in the Eastern Province - my province of origin -, nevertheless the 2007 statistics don't mention the Eastern province production. This makes some of the official reports questionable mainly when some restrictive measures are underway.

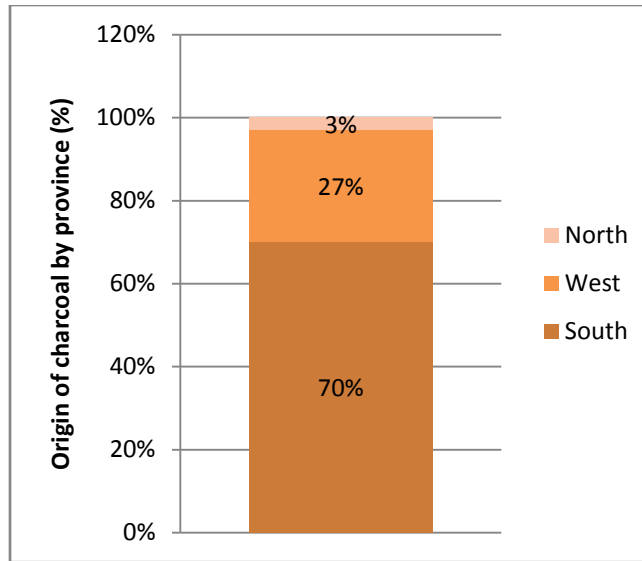


Figure 24: Origin of charcoal by province in 2007

Source: Data from MININFRA, 2007

By district, Nyamagabe is the main supplier with 38%, followed by Karongi 18% and Ruhango 17% all in the Southern Province (Figure 25). The case of Nyamagabe can be understood as it has the highest forest cover nationwide. But the third position of a district like Ruhango, ranked fifth (out of thirty) from the bottom in forest cover by district is surprising and may be an evidence of forest overexploitation. The absence of districts like Rusizi and lower rank of Nyaruguru respectively ranked second and third (Figure 17) in forest cover is not a proof of a complete ban but confirm the unreliability of some districts statistics. For example Nyaruguru was cited as one of the main suppliers of fuelwood and charcoal during the case study which was part of this research, but officially contributes to only 3% and is ranked sixth highest charcoal supplier to the capital city.

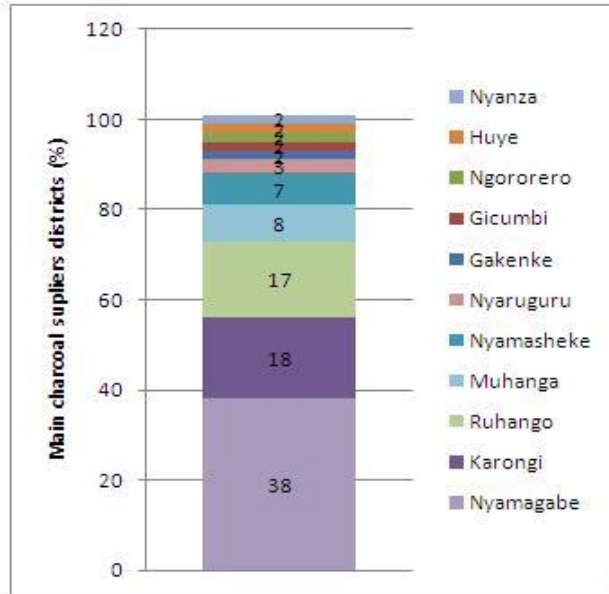


Figure 25: Origin of charcoal by main supplier districts

Source: MININFRA, 2007

Only twelve districts appear as charcoal suppliers (MININFRA, 2007) but definitely by my own experience in all districts charcoal is also produced at least for local consumption.

Where charcoal is used mainly for centralized, urban markets, transport distances increase with time, as nearby stocks of forests are depleted, so future transport costs may constitute a much greater amount of the total cost.

### 3.8.5 Production technology and efficiency

In Rwanda, low energy efficiency is the main challenge in woodfuel burning (efficiency of local stoves) in general and charcoal production (low efficiency of traditionally used charcoaling method) in particular. Charcoal is traditionally produced in earth kilns and about 2/3<sup>rd</sup> of the energy content of the wood is typically lost in the charcoaling process. The wood equivalent is seven times larger, leading to wood resource depletion. With the current 14% efficiency seven kilogramme of wood are needed to produce one kilogramme of charcoal which costs five times the price of one kilogram of fuelwood as revealed the case study of the present research.

As charcoal has double the energy content of fuelwood on a kg basis, 29 MJ and 15.5 MJ per kilogram respectively (MARGE, 2009), in term of energy efficiency, 108.5 MJ are needed to produce 29 MJ which means 79.5 MJ or 73% of energy is lost in the transformation process<sup>37</sup>.

Nationally, wood for charcoal represents 420,542TOE (100%) of the gross supply in the primary energy balance and 317,802TOE accounts for conversion and losses (75.5%) which reduces the 26% charcoal's contribution in the gross supply to only 8% of the net supply (Table 4). The energy efficiency of the process is dependent upon many factors: kiln type, moisture content of the wood, wood species, wood arrangement, and the skill of the producer. In Rwanda, programmes have been implemented to increase the efficiency of charcoal kilns but often new techniques are adopted for brief periods and then discarded (MINITRAPE, 1993). Although improved stoves and kilns are desirable to conserve resources and reduce emissions, they must be accompanied by training and education. For example, when various types of cooking stoves were recorded in Kigali in 1994, the improved cooking stove was shown to be used in only one percent of the households' surveyed (Hall, Yushi, & Mao, 1994). Today's estimates report a 55.48% improved stove penetration rate in households. In institutions and restaurants, the penetration rate is assumed to be higher (MININFRA, 2009c). That the larger establishments like prisons and schools use improved cooking stoves more than individual households may be indicative of the high capital cost for improved stoves or lack of education concerning fuel savings within households.

### **3.8.6 Cooking cost with different fuels**

The cost of cooking with modern fuel remains very high to compete with and reduce woodfuel consumption and thus curb its environmental impact on wood resources. Compared to its potential substitutes, woodfuels remain cheap and the most affordable fuel. Fuelwood is far the cheapest option, as its cooking cost is half that of kerosene and charcoal (Figure 26). To cook

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<sup>37</sup>Seven kilogramme of wood are needed to produce one kilogramme of charcoal. In term of energy 15.5MJ/kg\*7kg i.e. 108.5MJ are used to produce 29MJ/kg\*1kg i.e 29MJ of charcoal energy. This represent a loss of (108.5MJ-29MJ) 79.5MJ of wood energy content which represents 73.3% ((79.5/108.5)\*100) of energy lost in the transformation process.

with electricity is three times more expensive than fuelwood and LPG is about six times the fuelwood cost. The comparison is valid only for households using purchased fuels and results represent a snapshot of the current situation as prices evolve all the time and so do cooking costs.

In the current socio-economic situation, the competitiveness of these fuels shows that the energy transition from traditional to modern fuels remains difficult to achieve in Rwanda, and therefore it is important to raise efficiency in both woodfuel production and consumption mostly for charcoal.

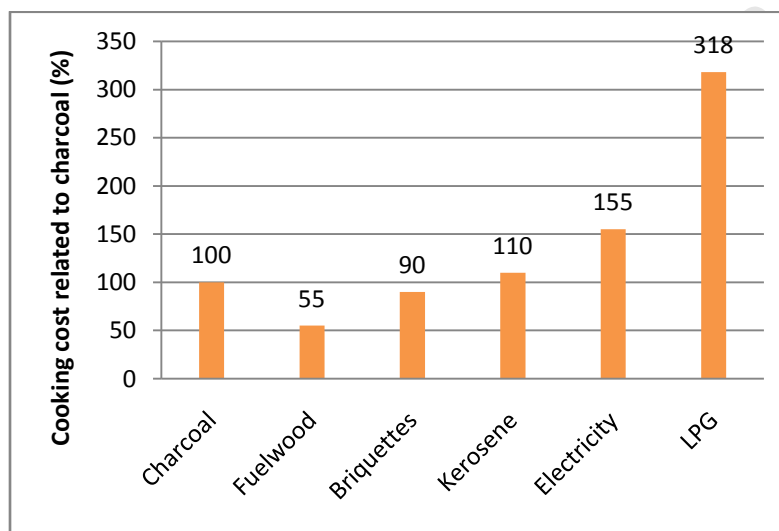


Figure 26: Percentage of cooking costs for different fuels

Source: MININFRA, 2007

The relative competitiveness of various cooking fuels was analysed according to their current retail prices. Their energy contents and the efficiency of the cooking devices with which they are typically used (MININFRA, 2007; MARGE, 2009). The analysis was based on the hypothesis that a household needs a certain amount of “useful energy” (the energy that goes into the pot), whatever the fuel used.

Charcoal in the Rondereza –a ceramic-metal stove with a ceramic fire place was used as the baseline fuel/stove combination against which the other energy sources were compared. That is, compared to charcoal, how much of each of the other fuels would have to be used to deliver the equivalent amount of useful energy of charcoal burned in a typical metal/ceramic stove to deliver the same amount of energy to the cooking pot, enabling the same quantity of food to be cooked.

Based on comparative figures the amount of each fuel that would be required annually for cooking by an average household cooking exclusively with that fuel was assumed. Knowing the costs of each fuel, a comparison of the annualised costs of cooking with the different fuels was estimated. The cost of a stove was not included.

### **3.8.7 Performance and weakness in the woodfuel industry**

#### **3.8.7.1 Performance**

The main strength of the woodfuels sector has been its ability to supply in a fairly regular way locally produced fuels at reasonable costs. That is a good achievement for a sector where people work independently.

As far as charcoal is concerned, the major performance of the sector is that it is becoming more professional and more efficient: the performance of hundreds of charcoal kilns was measured in the late 1980s and early 1990s and the average transformation efficiency (on a weight-by-weight basis) was calculated to be around 1 bag per stere, or a transformation efficiency of 10% (Karenzi, 1994). A 2008 survey by the Ministry of Infrastructure found that the highest conversion rate in Rwanda was 14% in Nyamagabe district of the southern province.

For example, using the earth mound kiln, about 12% efficiency is normal in Zambia; 11-15% in Tanzania; 8-12% in Ethiopia; 9-12% in Kenya and in Mozambique efficiency was found to range from 14% to 20% (Kammen & Lew, 2005). In the most efficient kilns an efficiency of 28% has been achieved and in Laikipia, Kenya, the retort kilns have attained 35-45% (Mugo & Ong, 2006).

#### **3.8.7.2 Weaknesses**

The key weakness in the industry is that charcoal is still produced with traditional technology, little operational control of kilns (sticks as chimneys), manual loading and unloading, and primitive quantitative and qualitative control (manual closure of secondary chimneys). The industry operates with uneducated, sometimes illiterate teams of labourers, which makes it more

difficult to inject professionalism into processes and modernize the sector. The most important weakness is that the sector operates increasingly in a non transparent and uncoordinated way as district authorities do not have a unified approach in the way the woodfuel business is run and monitored.

In addition, forest management has faced significant challenges for many years, mainly due to inadequate institutional capacity (complex and conflicting government regulations, poor monitoring of guideline implementation, non unified taxation system). There are insufficient forestry personnel (one forest officer at district level), and deficiency in forest data, coupled with the failure to prioritise woodfuel at policy level. Bans on wood products have led to clandestine tree cutting for energy and non energy supply. It also curbed the enthusiasm for tree planting which is one of the three strategies to balance the demand/supply- to prevent forest degradation, alleviate energy poverty, and reduce environment abuse. The three strategies are planting more, substituting more and saving more.

Lastly investment costs to modernise charcoal production is very high and funding remains low despite the fact that woodfuel trade is a profitable business. Local banks are not ready to give a loan of more than US\$ 500 to charcoal makers, as reported by charcoalers in the focus group discussions held for this research in October 2009 in Nyamagabe district.

### **3.9 Conclusion**

The chapter dealt with the general context of woodfuel use with the main findings being that woodfuel is indistinctively used in developed and developing countries and provides around 10% of the world total energy production. In developing countries they provide about one-third of total energy and in some sub Saharan regions, they contribute as much as 80 percent of the primary energy.

In developed countries they are mostly used in rural areas and increasingly used a renewable source of energy to reduce greenhouse gases emissions. In developing countries poverty, non affordability and unavailability of modern fuels are the drivers of woodfuel consumption in both rural (fuelwood) and urban (charcoal) areas.

In both developed and developing countries, woodfuel harvesting generates more employment per unit energy than other energy sources. They generate twenty times more employment in rural areas of developing countries than do the other energy sources. In the developed countries, the renewable energy industry is one of fastest-growing sectors and employment opportunities set to 800,000 jobs in the bioenergy sector by 2020 (FAO, 2010).

Seemingly climate change mitigation will raise the demand to reduce the GHG emissions and positively influence the supply through an increase in global production.

In Rwanda woodfuel remains the chief energy source. In 2007 it generated as much as 5% of GDP, almost twice as much as electricity sales and three times the value of coffee exports in the same period and twice that of tea production. The contribution of charcoal, alone, to the rural economy is the equivalent of more than 2% of GDP. Moreover, some 50% its value remains in rural areas, where it is distributed among farmers/wood growers and charcoalers and is, as such, an engine of rural development.

The demand is mainly from households but industries, institution and commercial sectors also have their share in woodfuel consumption. As the supply is concerned, around 80% of wood for energy comes from plantations of less than 0.5 ha which thus fall outside the definition of forest in Rwanda and charcoal production from natural forests is negligible as the remaining rainforest is conserved by an expanded network of federally-protected areas. Aggregated wood product demand/supply outstrips the sustainable production.

As production technology is concerned, the current low efficiency in charcoal production is resource depletive as a minimum of seven kilograms of fuelwood is transformed to get only one kilogramme of charcoal. In terms of energy more than 70% of fuelwood energy content is lost in the transformation process. The increasing cost of woodfuels due to the transport distance associated to the resource depletion are highly linked to the petroleum industry, and any fluctuation of petroleum prices negatively affects woodfuel costs.

Last not least, the chapter detailed how well integrated woodfuel consumption can positively contribute to the MDGs achievement.

In the next chapter, the legal and regulatory framework for the Rwandan woodfuel industry will be discussed as it is the cornerstone for its sustainability. Policy instruments will be assessed and

friendly managerial approaches which could consider the interests of all stakeholders in the woodfuels industry for future sustainability proposed.

## **CHAPTER FOUR**

### **THE LEGAL AND REGULATORY FRAMEWORK FOR WOODFUELS IN RWANDA**

#### **4.1 Introduction**

As discussed in chapter three, woodfuels are of prime importance in Rwanda and have socio-economic benefits at least in four respects.

- Their contribution to the national energy balance remains high (Table 4) and woodfuels remain the most affordable source for household energy.
- They constitute a useful alternative to imported fuels, and save the country's meagre foreign exchange that would otherwise be used to import expensive petroleum products.
- Woodfuels are a renewable resource and, when properly managed, the resource can be sustainable at least until affordable alternatives are available.
- Finally yet importantly, woodfuel is an important source of income, and thus contributes to poverty reduction.

Conversely inefficient traditional production and consumption technologies contribute to environmental degradation in general and forest degradation in particular.

In the absence of a well-documented understanding of the different deforestation factors, woodfuels have generally been blamed as the main cause of forest decline. An attempt to reduce deforestation has been made through restrictive regulations on the commoditisation of wood products through bans and exploitation permits. These regulations have, however, ignored the socio-economic benefits of woodfuels. Despite the importance of forest and tree resources, it was only in 1988 that the country endorsed the organic law on forests (République Rwandaise, 1989). Other environmental laws followed: The National Decentralisation Policy in 2000 (Republic of Rwanda, 2000); the National Environment Policy to ensure sustainable protection and

management of environment and natural resources in Rwanda has been in place since November 2003 (Republic of Rwanda, 2003a); the National Energy Policy (Republic of Rwanda, 2004a) and the National Land Policy (Republic of Rwanda, 2004b) were enacted in 2004. The National Forest Policy (Republic of Rwanda, 2004c) was formulated in 2004, after the country had lost two thirds of its forest in the preceding four decades.

The new Constitution of Rwanda (Republic of Rwanda, 2003b) determines the modalities for safeguarding the environment. Article 49 states: “Every citizen is entitled to a healthy and satisfying environment. Every person has the duty to protect, safeguard and promote the environment. The State shall protect the environment”. It is based on this philosophy that the following laws were enacted:

Organic Law No. 4/2005 of 08/04/2005, determining the modalities of protection, conservation, and promotion of environment in Rwanda (Republic of Rwanda, 2005a) Organic Law No.8/2005 of 14/07/2005: determining the use and management of land in Rwanda (Republic of Rwanda, 2005b)

and

Organic Law No.16/2006 of 03/04/2006: establishing the Rwanda Environmental Management Authority (REMA) (Republic of Rwanda, 2006a)

and

Organic Law No.17/2008 of 20/06/2008: establishing the National Forestry Authority (NAFA) to deal with policy, planning, and promotion of forest activities ( Republic of Rwanda, 2008a).

The National Energy Development Authority (NEDA) to be responsible for the energy sector (biomass energy included) was supposed to be created in 2008, but has not yet been officially established (MININFRA, 2009b).

Through the decentralization policy, districts oversee the implementation of all policies and regulations. At district level there is only one officer in charge of the environment and one in charge of forests to assist in integrating environmental and forestry issues with the district planning process at the local level. It is obvious that with a constrained budget and given the fact

that duties would involve a good deal of field work, this is a particularly difficult responsibility for one official (Republic of Rwanda, 2008b).

The formally established institutions of relevance to woodfuels are the Rwanda Environmental Management Authority (REMA) and the National Forestry Authority (NAFA). REMA imposes its vision on forest and biomass energy, and all regulations are seemingly restricted to the aim of preventing environmental abuse – explaining why environmental policy overlaps with and directs forest and energy policies in the matter of woodfuels (Chemonics International, 2008).

## **4.2 Policies**

To be successful, woodfuels' policy instruments must provide satisfactory outcomes for forests, energy, poverty alleviation and the environment. That is, the population must benefit from woodfuels as the national dominant energy source and source of income and woodfuels must be grown and harvested on an environmentally sound basis.

### **4.2.1 National Land Policy**

For many years Rwanda had no written land law or policy. The first formal Rwandan land law was the Organic Law No 08/2005 of 14/07/2005 (Republic of Rwanda, 2005b) determining the use and management of land. Its objectives are firstly to improve land management and, secondly, to give occupants of the land security of tenure. The law institutes the principle of legal land (Art1). It comprises the zoning of land (urban and rural; private; state-owned land; district, town and municipality land; land in the public domain); the management, organisation and exploitation of land; rights and obligations of landlords; prescriptions and penalties.

The following policy provisions are incorporated into the organic law:

All Rwandans enjoy the same rights of access to land; any discrimination either based on sex or origin in matters relating to ownership or possession of rights over the land is prohibited; women and men have equal rights over the land.

Land use should be optimal. Households will be encouraged to consolidate plots to ensure that each holding is not less than one hectare in size (neighbours must consolidate their respective land to improve crop yields under the land consolidation policy).

Titles to all land should be registered so that it can be traded, except where doing so would fragment the land into plots of less than one hectare. The land policy calls for a minimum threshold of 1 ha for land holding although the law does not say so explicitly; it is unclear whether lands under 1 ha will be eligible for title registration. In practice this can't apply to urban land.

The policy forbids the allocation of “agro-pastoral” land to “non-professionals”, without specifying the exact meaning of professional in agro-pastoral activities. These provisions could have major implications for Rwanda’s poor as 80% of households have landholdings of less than one hectare (NISR, 2009a). Therefore only 20% of households are eligible for land title; the others will not benefit from the law and have no right or security of tenure on their land (Table 16).

Table 16 Area of land holding (ha) by household

Area intervals (ha)	Percentage of households	Cumulative
<0.20	26.3	26.3
0.20-0.49	30.5	56.8
0.50-0.99	23.2	80.0
1.0-1.99	14.0	94.0
2.0-2.99	3.6	97.6
3.0-3.99	1.2	98.8
4.0-4.99	0.6	99.4
5.0-9.99	0.5	99.9
>10	0.1	100

Source: NISR, 2009a

Title deeds can only be transferred with the consent of all family members (parents and mature children). A land tax will be imposed; undeveloped land reverts to the state after three years. A maximum holding of 50 ha is allowed for any individual landowner.

Persons occupying two hectares and those with customary holdings of between two hectares and 30 ha will be recognized as the rightful owners if they have a development project and a development plan.

The above measures do not give security of tenure as there are conditions required to be rightful owner of your own land. This impedes land development as there are restrictions on land rights and titles. The sharing of owned land refers to land encroached on, after 1994, when an owner was killed or exiled, where the owner or his heirs claim repossession, the land is shared and that land sharing is not subject to compensation. This sharing of owned land without compensation is unjust and frustrates the original landowner and is source of conflicts between land sharers. Land title for customary holdings of more than two hectares, with a compulsory development plan, contradicts the second objective of land security of tenure, as people are not allowed to use their land as they wish.

The policy and law seeks to reduce poverty by encouraging production efficiencies through a modern commercialised agriculture sector but investment in a crop like wood, with a long rotation cycle, is likely to be negatively affected for categories of farmers with less than one hectare (that is, without a title to the land). In fact, there is no land right as there is a lot of pressure on the land; and rural people are forced to move from their land to planned settlement areas without compensation so that the rest of the land (their land) can be used for community agricultural expansion and other income-generating activities. Both land sharing and land consolidation have been in practice since 2007 but related regulations come later in 2010. Land sharing was officially established by a Land and Environment Ministerial Order N<sup>o</sup> 001/16.01 of 26/04/2010 (Republic of Rwanda, 2010a) and a land consolidation by a Ministerial order no Ministerial Order N<sup>o</sup> 14/11.30 of 21/12/2010 (Republic of Rwanda, 2010b).

As confirmed by this study in the focus groups discussions during field research in October 2009, in the study area, there was no clear and widespread input from local populations before basic policy decisions were reached. While the government claims that it has made efforts to broaden the consultative process in planning for critical issues of land use, communications have

only come down from government to those who will be affected and according to the Office of the Ombudsman, land-related disputes have constituted about 90% of the cases they have dealt with in 2010<sup>38</sup>.

#### **4.2.2 National Forest Policy**

Increased demand for wood products and subsequent massive exploitation earlier in the 20th century led to a need for reforestation and the first moves in this direction took place between 1920 and 1948. The afforestation policy ceased with independence in 1962, and resumed in the early 1970s with an aggressive afforestation program through community development work (Umuganda) held every Saturday by government order and institutionalisation of a tree planting day in 1976. Sometimes trees were planted without adequate planning. For example, Eucalyptus was planted within that period in marshlands. As supposedly they posed ecological problems, they were cleared and uprooted in May 2006 (Ministry of Land, Environment, Forestry, Water and Mines Instruction N<sup>o</sup> 001/02/2006). In 1986 the ten-year National Forestry Programme (NFP) was introduced, to encourage long-term forest conservation, to increase forestry production and improved use, and to appraise the decline of forests (EU, 2007). The first attempt at developing a national forest policy dates back to 1993 and the policy adopted in 2004 was based on a draft from that year – which was-, despite the socio-economic changes, supposed to be still valid a decade later. As there was no recent inventory, it was very difficult to know the standing stock to forecast sustainable supply, nor was there sufficient data on national wood product consumption in order to forecast demand, which meant that the guidelines were inevitably flawed. Deforestation had increased in the 1990s time period (Figure 4 and Figure 5). There was on average 8.8% of forest loss per decade since 1960 until 1990; and an alarming loss of 44% during the 1990-2000 decade (Figure 5). The 2004 policy targeted the protection of forests and trees in the name of conserving the environment, but to date illicit clearings, illegal cutting and trees poaching are still common practice (ISAR, 2007). The 2007 national forest inventory revealed that the national forest cover was 10.10% of the total land area against the 30% planned for 2020 (CGIS-NUR, 2007).

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<sup>38</sup> *The New Times*, 28 May 2010

Since 2003, based on the evidence of deforestation and invoking existing forest law (specifically Article 83 as well as Article 49 of the Constitution which addresses environmental protection), the government has raised awareness of the need to control wood product use to limit its contribution to deforestation. The most important measures taken include three banning instructions:

Instruction No 01/2003 of 14/07/2003<sup>39</sup> banned tree cutting for scaffoldings; a cutting license and transport permit were required for all wood products, as well as authorisation from the forest officer for cutting trees within 15 m on roadside.

Instruction No 0001/2004 of 16/07/2004<sup>40</sup> (MINITERRE, 2004b) banned cutting trees before their maturity, using wood for fires for making bricks and tiles, and all activities in marshlands (this provision referred to Article 49 of the Constitution, not the Forest Law).

Instruction No 001/2006 of 03/02/2006 (MINITERRE, 2006) required authorisation for cutting, transporting and selling wood, issued by the mayor of district for cutting an area of forest of more than two hectares, and by the sector official for an area less than two hectares. No authorisation is required for cutting for own consumption. The Minister of Forestry must authorise harvesting of GoR forests, and the executive secretary of the sector authorises cutting of district forests and trees within 15 meters of roadsides.

The ban policies have not been operative, as revealed by a 2008 survey (GTZ, 2008) which showed that in five of the important charcoalproducing districts 31% of production was illegal.

### **4.2.3 Forest Legislation**

In 1930 a Decree concerning the cutting and selling of wood was enacted, primarily aimed at requiring prior authorisation for any cutting or sale of wood and a decree with the same requirement was enacted on 18 December 1993 (MINITERRE, 2003). The first written forestry law was the Organic Law No47/1988 of 05/12/1988 (République Rwandaise, 1989). In 2002 a Forest Protection Service was created by the Prime minister's order to deal with forest

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<sup>39</sup> 25<sup>th</sup> Cabinet Resolution referred to forest law

<sup>40</sup> 09<sup>th</sup> Cabinet Resolution referred to constitution

encroachment, mainly in parks and natural reserves, and in the same year a State Minister for forestry was appointed. A ministerial order was issued in February 2003 to establish procedures governing the public forest management contract and in December 2008 the National Forest Authority was established.

#### **4.2.4 Decentralization policy**

A decentralization policy was implemented by the adoption of laws and regulations establishing the provinces (delegated entities), districts, sectors and cells (decentralized entities) in 2001. Shortcomings and weaknesses prompted a new round of public reforms in 2006, reducing the provinces from ten to four and districts from 106 to 30. Districts are responsible for promoting and developing agriculture, animal husbandry, forestry, tourism and environmental conservation, within the framework of District Community Development Plans. Biomass-based energy resources management is also assumed at the district level. In the district, development plans for forests are mentioned because they are supposed to be under threat of disappearing, private plantations are not incorporated, and improved stoves are sometimes mentioned as a partial solution to rescue forests. However, none of the recently developed local development plans deal fully with the forestry sector (GEF, 2006).

Districts manage budgets which are directly transferred from the central government. They are also in charge of collecting some taxes from diverse products. The charcoal sector is one of the main sources generating funds through taxation and permits<sup>41</sup>. One relevant example is the intervention of district officials in terms of regulation of the charcoal sector, each district with its own rules, which vary from outright prohibition on production to a ban during several months of the year.

Decentralisation is a new strategy to improve service delivery to the population, and it is still incomplete. It is a long process, and coordination of institutions is not yet at a level to support effective and equitable forest management. Other challenges are the lack of institutional capacity in decentralized units and of qualified staff (one forest officer for each district), and underfunding, resulting in weak law enforcement which leads to poor forest management

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<sup>41</sup> Tree cutting, charcoaling and woodfuel transport permits.

(Republic of Rwanda,2008b) and, often, to corruption - mostly related to speeding up the wood products exploitation permit.

#### **4.2.5 Environmental policy**

The Rwanda Environmental Management Agency (REMA) established by Organic Law No 04/2005 of 08/04/2005 has become an important player in the country to ensure that economic activities are sustainable and not damaging to the environment. While the environmental sector is run on a relatively organised basis as it has an implementing authority, the forest sector is run according to the legislation of 1988 (under review), creating confusion and conflict in implementing new guidelines in the areas of forestry and environmental management. Therefore forests are managed from only an environmental perspective, neglecting their socio-economic context (with the exception of ecotourism, as this generates foreign exchange).

To ease service delivery and access and for environmental reasons such as land consolidation, the new government habitat policy is currently moving people into cluster villages (Imidugudu) further away from their lands and their energy sources, which will affect their fuelwood supply and make the firewood collection journey longer. People are resisting this relocation. As reported by the New Times, “District officials have blamed the slow progress of the land consolidation programme on poor settlement patterns and the unwillingness of people to relocate to designated villages”<sup>42</sup>.

#### **4.2.6 National Energy Policy**

Most of the energy policy attention until recently has focused on increasing electricity generation capacity to attract investors, while biomass energy has been neglected as an option. The policy focuses on moving away from traditional biomass to modern sources of energy that can stimulate economic activity and reduce poverty, in line with the Rwandan 2020 vision (MINICOFIN, 2000). Rwanda vision 2020 aims to transform the country into a middle income nation. To achieve this, six interwoven pillars have been identified through a national consultative process

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<sup>42</sup>The New Times issues 1427 of 31 May 2010

(1997 -2000). These include good governance, efficient state, skilled human capital, vibrant private sector, world class physical infrastructure, and modern agriculture and livestock, all geared towards national, regional and global markets.

Through the Economic Development and Poverty Reduction Strategy (EDPRS), the GoR encourages the use of energy other than biomass. The target for 2020 is that at least 35% of the population should be connected to electricity, up from the current 6%, and for solid fuels consumption to decrease from 97% to 50%.

The National Energy Policy and Energy Strategy (MININFRA, 2009b), under revision, states that woodfuel usage has potential serious environmental implications and recognizes that it can't be sustainable unless managed properly. But doesn't explain how this is to be achieved.

The policy supports subsidies only on modern energy resources: "Resources availability for energy subsidies is primarily to enhance access to modern forms of energy, to reduce the cost of energy to those who already have access to electricity<sup>43</sup>"; and "all current electricity customers will contribute to the Universal Access Fund to provide access subsidies". No level of contribution is specified.

No net energy transition from solid biomass fuels to modern energy services has been achieved and the energy consumption is just an enduring biomass mix as solid biomass is used by around 97% the population as readable on Figure 27 where AR refers to agriculture residues. The EDPRS's national target is to achieve 35% access to electricity and modern fuels by 2020, and to achieve the national MDG's target (access for 50% of those not connected) by 2015. Even if these access targets were achieved, modern fuels would not be sufficiently competitive to reduce the dependence on biomass to the 50% target in 2020.

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<sup>43</sup>For new customer, a set fee of 56,000RWF (all inclusive) is perceived from any potential customer at < 50m on roadside. Fifteen thousand are paid before connection and the remaining is paid in installments for one year. For those who already have access to electricity Compact fluorescent lamps were subsidized, normally the price of one CFL is around 1,000RWF but was only 200RWF (quarter price) per lamp was paid to reduce the cost.

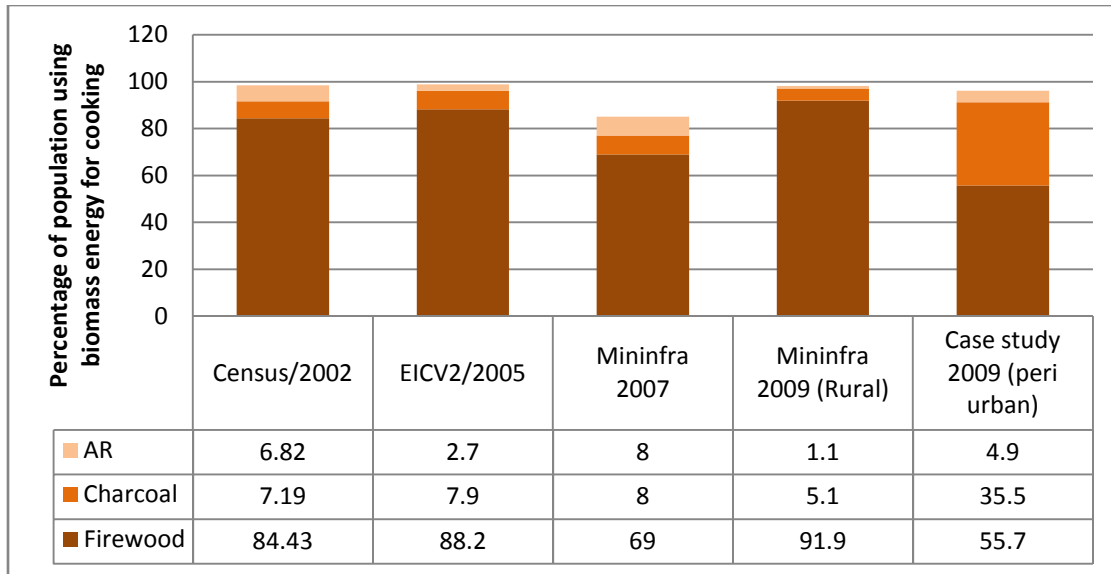


Figure 27: Changing pattern of percentage of population using biomass energy for cooking

Sources: NISR, 2003; NISR, 2006a; MININFRA, 2007; MININFRA, 2009a and present study

Petroleum fuels and electricity remain unaffordable for households, who will continue to depend on lower-cost biomass fuels at least for cooking (see Figure 25). This makes it relevant to re-evaluate the importance of biomass energy, to make its supply sustainable and to avoid encouraging the use of petroleum products except where biomass energy is not competitive, as in the manufacturing and transport sectors.

The energy policy and energy strategy under revision proposes the removal of regulatory restrictions such as bans on wood products. As the restrictions are a source of mismanagement, a regulatory framework review would be efficient if bans could be only applied to natural forests. Removal of bans and the very bureaucratic wood harvesting permit issuance would improve management by supporting the commoditisation chain of woodfuel from woodlots and forest plantations only. The socio-economic benefits would lead to improvements in management practices, while at the same time the impact of woodfuel consumption on energy, poverty and the environment could be addressed.

### **4.3 Weakness in implementing guidelines related to forest management**

The 1988 forest law provides mechanisms for managing trees and forests of more than two hectares and the modalities of tree cutting and sustainable harvesting. It also defines the specifics of the transportation, commercialization of wood products; tree planting on roadsides (10 m tarmac to 15 m mud road), and forest conservation and exploitation. The law also legislates for the keeping of statistical records on forest management. Implementation of the law, however, is problematic due poor record keeping.

#### **4.3.1 Weakness of policy instrument: Provisions and practices**

Section 1 of the forest law (Art 64-73) clarifies procedures for cutting and replenishment. In the case of sustainable cutting, mature trees are marked by the forest officer and only these may be cut. A permit is required for this, which is valid for three months, with a three months extension period, and, once applied for, the permit is issued in less than 30 days. The only tax mentioned in the law is one percent of the sale from any type of forest product, to be paid to the National Forest Fund (NFF). No permit is required for the production of wood from personal plantation for own consumption. Cut woodlot stands must be sustainably managed by the owner and the official in charge of forests at local level bears the responsibility of monitoring the replenishment and evaluation of the post harvest replenishment process. As the forest officer has no means of transport, the charcoal maker must pay for his transport to assess if the stand is mature. However the forest officer who visits the stands to be harvested neither measures the wood stand area nor marks trees to be cut. This was confirmed by charcoal makers during the October 2009 field research for this study. It means that officials don't respect exploitation instructions, and even immature trees are cut, leading to clear felling which is illegal, as defined by instruction No 01/2003 establishing a ban on cutting trees before maturity.

In addition, before the permit is issued, extra taxes (detailed in Chapter five) to the one percent tax for the NFF are paid for the issuance (transport for the forest officer to and from the area of harvest, fees for the district Education Fund and for any other ongoing district activity). The one

percent tax for NFF is paid at the bank. The extra taxes constitute the district's income and are paid to the district cashier.

The cutting permit is legally supposed to last for three months, but in some extreme cases is arbitrarily limited to one week, depending on the area to be cut. Practically it is only valid for one month with 15 days extension as its extension is left to the issuing authority's discretion. That short period of time (as the charcoal maker will be fined if the carbonization is not completed after one month) reduces the possibility of wood drying and therefore the carbonization efficiency. The forest officer, due to financial or time limitations, does not come back to check for post harvest management. When not available, the forest officer sends an untrained delegate (local defence<sup>44</sup>) for estimates of maturity as reported during the field research, and thus the monitoring system becomes ineffective.

Inventory and statistics keeping, the responsibility of the National Land and Forest Research Centre (LFRC)<sup>45</sup> at district level, is not done as the LFRC is not yet operational. Obviously, if woodfuel statistics are not kept at district level, they will not be available on a national basis, and all planning in the woodfuel sector is based on mere estimates.

Section 2 of the law (Art 74-79) clarifies procedures for clear felling (excision) and replenishment procedures. Before the forest excision an equal area of forest in another place must be afforested. Due to the limited amount of land available (Table 16) the forest owner will not have another free piece of land for new afforestation and excised land will be converted to agriculture land. Here again, due to financial constraints, the forest officer is not able to monitor the replanting and the survival rate of any tree planted.

Section 3 (Art 80-82) concerns transport permits, which are supposed to be given free and issued for one round trip only. In practice, validity time is left to the discretion of the issuing authority, which can easily lead to corruption.

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<sup>44</sup> *Proximity police at sector level*

<sup>45</sup> *The centre was supposed to be responsible for inventories and statistics, research on wood technology and utilization, forest economics and forest products marketing.*

The Forest Protection Service, which monitors policy instruments, only operates in national parks and reserves. Woodfuel products transport permit checking points at the production site exits and at city entrances were removed in April 2004, making illegal trading a common practice. Information from woodfuels dealers revealed that these checking points were local sources of bribery and corruption, as they were locally established by sectors or even cells without legal status.

As most of the required management measures fall on the forest officer, the above weaknesses can be partially attributed to weak institutional capacities. The requirements are beyond existing staff capacities (numerically and financially). Hence forests have been degraded, not exclusively by the need for fuels, but mainly as a result of deliberate clear felling, and conversion for agriculture and housing, due to lack of monitoring and evaluation of post-harvest management. The increasing distances for charcoal provision (from Bugesera and Kibungo region (on average 80 km) to the south (180 km); the widening circles of deforestation around expanding cities, and the landscape changes, with the reduction in area of natural forests and parks, are evidence of the process.

The collection of statistics on forests and forest products are required by all holders of wood products exploitation permits but it is not done. The only reliable consumption figures come from industry (tea factories) and institutions like prisons and schools, as they have to report their wood consumption with their monthly expenditure. Households do not keep woodfuel consumption records and few available data are from short surveys or national censuses. This poor data collection makes it impossible to get a real picture of the national woodfuel consumption to determine its impact on forest depletion in general and deforestation in particular.

#### **4.3.2 Weaknesses of energy and forest policies**

The 2004 national forest policy was prepared soon after the 1994 genocide against the Tutsi, in the period when the country was facing more serious problems (ADF, 2001). It focuses on problems and constraints, and presents little in the way of solutions and opportunities. The policy

recognizes the lack of national institutional capacity, the weakness of forest regulation implementation, and the lack of data on consumption of wood and by-products which would enable appropriate economic studies. The policy does not recognize the need to meet, on a sustainable basis, people's need for wood and other forest products and services. Rather, it calls for a reduction in "dependence on woodfuel as a source of energy" through switching to unavailable and unaffordable modern fuels. These weaknesses in providing solutions and opportunities may be the cause of a low level of interest in tree planting and caretaking. The 2008 National Agriculture Survey revealed that 28% of surveyed households reported having not a single tree on their land, and only 15% had planted new trees on their land in 2008 and the 2009 EDPRS implementation report reported that 30% of trees planted in 2008 did not survive.

In summary, the Energy and Forestry Policies clearly are weak and are under revision. Revised policies should be less sectorial but more integrated into local and national sustainable development plans if forests are to be protected and still contribute to economic development. As long as the two policies neglect to recognize the socio-economic value and importance of woodfuels, especially for the rural areas, sustainable woodfuel production will not be achieved and the pressure on forests will increase. The current regulations on woodfuel which only take the natural resources on an only environmental perspective is neither sustainable nor pro poor and this is reinforced by the ineffectiveness of ban policies as discussed earlier. They are not sustainable as the population is firstly not educated to feel the acuity of environmental degradation, they can lose enthusiasm in tree planting or simply eliminate planted trees to replace them by other crops easily sellable; operate clandestinely in woodfuel production and selling. Therefore the government loses taxes; and the policy is not pro poor as the rural tree growers can't sell the trees any time they have an emergent need of money.

#### **4.3.3 Weaknesses of bans as a regulated production measure**

Despite the fact that deforestation has a complex set of causes such as forest conversion to agricultural land, use of wood in construction and furniture, the government of Rwanda (GoR) linked more deforestation to woodfuel consumption and has since 2003 imposed restrictions or an outright ban on trade and use of wood products. In an effort to halt the damage caused by the

trade in wood products, the GoR imposed restrictions on production and transportation of wood products, mainly charcoal. The most controversial is the ban on use of woodfuels in brick and tile making (MINITERRE, 2004b) and the ban on charcoal production (MINITERRE, 2006). Having no alternative to woodfuels, producers work clandestinely. Once bricks or charcoal have entered the urban areas – even illegally produced - their trade becomes legal.

Bans, permits and all related authorisations were put in place as a measure to regulate production and protect forests. Ban periods; permit delivery and taxation were left to the discretion of the district. In terms of regulation the decentralized tax and delivery system, without general national guidelines, made the system too bureaucratic to be efficient. Operating clandestinely, the producer works hastily and fearfully, and does not dry wood before carbonisation or firewood selling. Clandestine production hinders post-harvest management and probably contributes more to deforestation than would have done well regulated woodfuels production (Box 2).

Box 2: The impact of illegal charcoal production on wood resources

An analysis of legal and illegal charcoal production shows that the efficiency of the illegal charcoaling process ranges from 7% to 10% and the normal charcoalers obtain between 12% and 14%<sup>46</sup>. The conclusion is that a reduction can be obtained of between 10% and 35% of the total quantity of wood needed for the production of charcoal by legalizing the industry. This would be the equivalent of 10-15% of the sustainable output of commercial woodfuels from all plantations combined in Rwanda if no charcoal was illegally produced. A very large economic benefit can be obtained immediately as result of an intervention in the regulatory environment. Farmers have planted their trees expecting to earn money and they should be allowed to decide when to cut trees in order to maximize their earnings. As soon as they see the profits from this operation, they will try to replicate profit-making behaviour. Farmers with wood plantations already said that they have more trees now than a few years ago, so reduced regulatory requirements are likely to only enhance wood production (MININFRA, 2009a).

Everywhere where bans have been imposed, they have proven to be unhelpful in protecting forests, but have increased illegality in production. In Chad and Tanzania bans on charcoal were

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<sup>46</sup> 14% is obtained in Nyaruguru district.

removed after causing social unhappiness as they were associated with bribes; in Uganda after a ban on charcoal production lasting twenty years charcoal is still the main urban fuel (Zulu, 2010). The effectiveness of the 1930 decree requiring prior authorisation for any tree cutting or sale of wood is uncertain, but its successor of 1993 certainly failed. The 2003, 2004 and 2006 instructions with the same injunction also failed, with 50% of woodfuels producers reported to evade taxes ([MININFRA, 2007); 31% of surveyed charcoalers admit to engaging in illegal charcoaling (GTZ, 2008). Illegal charcoal production constitutes a loss of 441 964 tons/yr of wood that would not be cut if charcoal production was fully legal<sup>47</sup>, representing 29% of the total volume of wood needed to meet the national charcoal annual consumption of 150,000 tons (MININFRA, 2009a). Wood is still used for scaffolding, bricks and tiles are baked with wood, and charcoal is made and transported by night. These clearly support the hypothesis that the current woodfuel regulations are neither sustainable nor pro poor. If, as is clearly the case, the bans do not work, why continue with them?

#### **5.3.4 Financial instruments**

For petroleum products taxation is clear: value added tax; import duties; consumer tax and a contribution to the national road fund. On average, retail prices of petroleum products are about 100% higher than acquisition costs. In the traditional energy sector, a lack of coordination, transparency and a unified taxation approach leads to undercover production, speculation pushing prices upwards, and corruption.

Currently, taxes on traditional fuels are set by the district authorities, who choose their own levels. Some are levied in the form of a permit rather than a tax per se. For example, a wood exploitation permit in former Butare and Cyangugu provinces is taxed at US\$ 3.5 monthly, in Kibungo the tax is set at US\$ 7.5 per hectare per month; in Ruhengeri and Gisenyi Provinces, except for permit charges, no tax is paid. For charcoal a tax of US\$ 10 to US\$ 20 is generally paid per produced bag (33 kg); in Ruhengeri on one bag a US\$ 20 tax is paid to the district; US\$ 10 for the local defence and US\$ 5 for hygiene tax to clean the woodfuels' section at the market (Butare & Hughes, 2004). The only official tax, which is everywhere the same, is one

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<sup>47</sup> *Wood is not dried completely, which reduces the carbonization efficiency. When wood is well dried the efficiency is assumed to be 14%, while when not dried it drops to 12%.*

percent for the NFF. The total value, including additional costs for obtaining the permits<sup>48</sup> was calculated to be about 9% of the production cost, based on a survey conducted with wood owners, charcoal makers and transporters in October 2009 (Mazimpaka, 2010). Taxes levied on woodfuel, 6% at production site and 2% at city market, are very low and the trade benefits mainly the charcoal master (a 37% benefit of the total cost at production site); the transporter is 27% of the total cost at city market, the retailer earns 10% and the tree grower share is 32%.

#### **4.3.4 Institutional coordination**

The following ministries play a role in the biomass energy sector: Infrastructure, Natural Resources, Agriculture, Local Governance, Finance and Planning, and Commerce. The Ministry of Infrastructure deals with user aspects of biomass such as rational use, efficiency of consumption and the search for alternative fuels to biomass. The supply side is covered under the Ministry of Natural Resources within the Forest and Environment departments. This department deals also with land ownership. There is no coordination on the demand and supply between the ministries. At district level, authorities are not aware of the markets for woodfuels for local development but are only concerned how woodfuels can contribute to their own budget through taxes. This plethora of institutions leads to a very small output in terms of planning, monitoring and evaluation.

No institution is directly and fully accountable on the woodfuel value chain. There is rather a set of institutions, each with different interests and responsibilities in the sector leading to the kind of Diamond's Excuse that "It is Somebody Else's Problem" (Diamond, 2005). The consumption of biomass energy, its sourcing, production, transport and trade, all fall under separate regulatory bodies, and coordination is severely affected. Institutional coordination is lacking as there is no inter-ministerial task team to manage the sector or formulate strategies. Even with good policies and regulations, best practice in policy implementations and law enforcement are of prime importance to reduce the pressure of woodfuels on already-strained forest resources.

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<sup>48</sup> Additional costs could include travel time to the District Office to register the application, contributions to the travel costs of the District official so that he can visit the plantation, additional travel to verify that the permit is issued, and sometimes a small fee to the local official for expediting the process.

#### 4.4 The road ahead

Given that no proper forest management plans and consistent statistics are available to determine the individual contribution of woodfuels to deforestation, the effects of woodfuel production are subject to speculation which results in limiting their value chain. Restrictive policies, underfunding and understaffing, and inertia on the part of the bureaucracy, all hinder implementation of policy instruments. As some of the regulations (bans and over-bureaucratic licensing processes) limit the socio-economic benefits traditionally gained from the woodfuels trade, they miss the objective of alleviating the pressure on wood resources.

National targets to substitute or reduce woodfuel consumption<sup>49</sup> have neither been achieved nor actually reduced forest depletion. As where woodfuels are the principal forest product within a given region or country like it is the case in Rwanda, sustainable management and use of the forest are imperative, the study proposes a shift from the present forest management at district level to a Community Based Forest Management (CBFM) approach through Community Based Woodfuel Production (CBWP) and Forest Replenishment Association (FRA).

The main goal of adopting these two approaches in Rwanda is to build on experiences, which have been gained in both strategies in several locations for 20 years. Analyses of their failures and successes can lead to improvement of forest management and the woodfuel flow to ensure that woodfuel provision contributes to poverty alleviation in an environment friendly way.

These approaches should ensure that all competing factors in deforestation are evenly addressed to safeguard woodfuels energy provision while alleviating poverty in an environmentally sound way.

CBWP and FRA are proposed based on the following criteria:

The two strategies address commercial woodfuel production, which usually supplies a concentrated market, leading to forest degradation and eventually deforestation around or far away from the markets. This happened in Bugesera region formerly supplying the capital Kigali city market (Leah & Mearns, 2009) and could happen within today's main supplier locations.

These two strategies have been in operation for the past 20 years, in different regions and under different political circumstances, generating a considerable track record of lessons learned.

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<sup>49</sup>Through EDPRS, the target for 2020 was to reduce the woodfuel consumption from 95% to 50% which actually is not realistic.

CBWP and FRA were tested on two continents with different backgrounds (Miranda et al.,2010) and when well coordinated and locally adapted could be of high interest for the sustainable management of Rwandan forest resource and woodfuel industry.

CBWP and FRA are distinct from each other and provide valuable points of contrast: CBWP engages communities in forest management on community/publicly-owned lands, a common system of land tenure in Sub-Saharan Africa; FRA engages private farmers in forest management on privately-owned lands, a common system of land tenure in Latin America. Both land tenure are not mutually exclusive in Rwanda. Both strategies address the basic needs for promoting sustainable forestry among participants: full rights over the end product, full stakeholder responsibility for its sustainable management, and provision of incentives.

One major criteria for both strategies is that “commercial woodfuel is traded and has economic value, with a clear commercial interest for all those involved: farmers and rural villagers, traders and consumers” (Miranda et al., 2010). The strategy is based on the fact that “sustainable forest management depends on a balanced combination of effective forest governance/law enforcement, and particular incentives for local stakeholders (such as technical assistance and promotion of transparent and equitable market frameworks) who together should facilitate the emergence of true market prices” (Miranda et al., 2010). These are the chief weaknesses of the Rwandan woodfuel industry as overviewed in the current chapter (4.3).

#### **4.4.1 Community Based Woodfuel Production**

The Community Based Woodfuel Production transfers the management responsibilities usually administered by a country’s national or state-level forest service to local communities. This can be a community comprising several villages as in Senegal or a single village- as in Niger and Chad- located in proximity to productive forests. Communities must organize a management committee as their representative body, and must apply sustainable management techniques to forest resources. In return, interested villagers create user groups and are entitled to harvest and sell the forest products for their own benefit. A service contract between the user groups and the village management committee specifies harvesting areas, standards and quotas.

Community-based woodfuel production must be regarded as part of an overall rural development strategy, replacing the quasi-monopolies usually enjoyed by urban-based charcoal traders. The approach aims to improve rural livelihoods and thereby helps to reduce poverty while at the same time protecting the environment and promoting democratic principles.

After nearly 20 years of experience in transferring forest management rights to local populations, CBWP has proven that sustainable production of woodfuel can be achieved and has proven instrumental in promoting forest rehabilitation and reducing deforestation rates. In Niger<sup>50</sup> and Senegal<sup>51</sup> a considerable annual increase in the forest stock was reported after local communities took over the management of their forest resources. Madagascar provides an example of CBWP being used for both forest production and forest protection<sup>52</sup> (Miranda et al., 2010).

Decentralization of forest management indirectly benefited democratization, civil society development, and conflict resolution in the areas where it was implemented. Different socio-economic environments and ecological conditions in different countries make it difficult to provide a “blueprint” for CBWP. Prevailing circumstances on the ground may require adaptation. Shaping sustainable woodfuel production requires intervention on two levels: policy formulation and enforcement, as well as practical implementation (Miranda et al., 2010). All these benefits and developments are at young stage in Rwanda and it would be a great success if CBWP could mature them.

The lessons learned from the CBWP are highly similar to the challenges experienced in Rwanda.

The lessons learned include:

- woodfuels do not yet receive the policy attention they deserve;
- woodfuels remain underpriced in many locations;
- corruption and oligopolistic marketing structures obstruct the formalization of woodfuel value chains;

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<sup>50</sup>Niger was the first country to implement CBWP in the early 1990s, with a view to supplying urban demand centers on a sustainable basis. Today, about 300 woodfuel markets have been created which contribute to the supply of the country’s principal centers of demand (Miranda et al., 2010).

<sup>51</sup> Senegal benefits from a very active donor community (World Bank, USAID, GTZ etc.) that has been focusing on community-based forest management since the late 1990s. Today, the sustainably managed zones created under these three programs account for more than 20% of Senegal’s current household energy supply from renewable resources.

<sup>52</sup> To date, nearly 6,000 ha have been planted, providing an annual increase in income of more than 20% for more than 2,000 rural households.

- supervision and law enforcement by government forest service agencies are often ineffective and arbitrary;
- long-term rights to forest land and devolution of management authority provide strong motivation to producers for investing in sustainable woodfuel production;
- economic benefits are the driving force for sustainability;
- scarcity of forests spurs reforestation; and
- long-term support structures are necessary to sustain results.

#### 4.4.2 Forest Replenishment Associations

The establishment of the Forest Replenishment Associations began in Brazil when in 1965 the Brazilian government recognized the dangers in unregulated exploitation of its forest resources, and passed the Forest Act (Law 4771) to regulate the forest sector. Lacklustre implementation of the law, and differing interpretations on the part of State governments combined to give rise to a consumer movement that created a new model of sustainable wood production. Unhappy with this situation, in 1985 a group of small and medium-sized brick and tile producers from the region of Penapolis in São Paulo state rebelled against paying the tree-values, and instead created their own Forest Replacement Association (Miranda et al., 2010). Why wait for such attitudes in Rwanda when the situation could be timely redressed?

Under the FRA model, private sector consumers of wood that are obligated by law to replace their wood consumption and do so through the payment of a replacement fee (tree-value) to a FRA. The value of the replacement fee is calculated based on the firm's estimated consumption. The FRA then invests in production of fast-growing tree seedlings, usually of high genetic quality, and provides them for free to surrounding small and medium-sized farmers<sup>53</sup>. Technical assistance is provided, and sometimes other additional incentives are included such as fertilizer or wire for fencing (Miranda et al., 2010). Assistance could be provided as it is actually a

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<sup>53</sup>In Brasil, in 2002 the participation of small and medium-sized farmers in the country's forest plantations was only 8%, and by 2006 this figure rose to 25% of all reforestation done, representing nearly 40% if considering only new areas reforested. In Nicaragua FRA enhanced tree farming program to successfully address unsustainable fuelwood production and expanding the production of quality fuelwood that supports the sustainable development of the state's charcoal industry, with nearly 90,000 ha of planted eucalyptus trees between 2003 and 2009 (Miranda et al.,2010).

practice in Rwanda for other perennial crops where fertilizers are given to farmers and are paid back after harvest.

The major demand of Rwandan tree growers is that farmers have full ownership of the grown trees and are free to dispose of them as they wish. The government supervises but doesn't manage the operation of FRAs as well as the forest replacement fees collected from consumers.

On the basis of strengths, weaknesses, opportunities and threats analysis of the FRA model lessons learned were identified which can inform improved implementation and replication of this strategy for sustainable wood production in Rwanda. These include:

- farmers see multiple benefits in participating in FRAs, especially the incentives (technical assistance, free high-quality seedlings, fertilizers) that play a key role in their satisfaction and the success of their small forest plantations;
- business consumers of wood also benefit from FRA participation having a legal and guaranteed supply of quality wood;
- FRAs can be an effective partner of government in encouraging business consumers of wood to mitigate the impact of their consumption on forests; and
- FRAs can be developed without major donor support or with minimal support such as seed capital.

FRAs could help farmers with small pieces of land to get land titles by consolidating them for tree-growing purposes, as the national land policy calls for a minimum threshold of one hectare for land holding<sup>54</sup> (Republic of Rwanda, 2005b).

The experiences reviewed provide evidence for recognizing sustainably sourced woodfuel as an environmentally friendly, renewable, socially acceptable and widely established source of energy. CBWP and FRA represent different experiences of sustainable production of commercial woodfuel on two continents and could be successively replicated in Rwanda. While none of the models presented can be used as an exact blue-print, they do have strong potential for success if adapted to local conditions and actors. Likewise, the lessons learned and guiding principles point to significant potential for forestry innovation and improvement of livelihoods. However, legal-

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<sup>54</sup>Although the law does not say so explicitly, it is unclear whether lands under one hectare will be eligible for title registration.

regulatory, administrative and economic framework conditions are pivotal determinants of success.

Once legal and regulatory frameworks are scrupulously enforced through CBWP and FRA, woodfuels get their true value: tax revenues are paid to the treasury, producers are paid according to true cost, and traders profit increase. When the community is free to manage its wood production and the market is guaranteed, the socio-economic benefits work as incentives for farmers to plant more trees and sustainably manage them (Box 2).

#### Box 2: Socio-economic benefits as incentives for tree growing

In Ethiopia, some private producers, particularly in the peri urban areas (and many rural areas), are now beginning to produce wood in response to the very strong current demand for poles in the housing construction market. The farmers typically plant Eucalyptus trees in small woodlots near or inside their compounds and in lines around their compounds with very tight spacing (0.30 by 0.30 meters, amounting to approximately 100,000 trees per hectare) for the purpose of harvesting thin poles in four or six years.

Such large volume of poles will also generate correspondingly large volumes of fuelwood; at least 25% of the total volume is sold as fuelwood or branches, leaves and twigs. A higher fuelwood percentage is probably warranted. Poles used for scaffolding, for example, will eventually be sold as fuelwood after two or three uses. Likewise, poles used for fencing will eventually be replaced and old wood will become part of fuelwood supply. Housing entrepreneurs bid an average price per tree on the small woodlots ready to be harvested. The participating farmers are enjoying very healthy economic returns as a result (Christophersen, 1997).

One risk is the price increase for woodfuels, which is beneficial for producers, but affects poor consumers negatively prompting them, why not, to more efficient use of fuels which could boost the current low adoption on ICS. Promotion and dissemination of improved wood and charcoal stoves is more cost effective way to save wood than producing more wood to meet the population driven increase in woodfuel demand (Box 3).

Sustainable tree production and an energy saving culture combined with the national policy of developing alternative indigenous energy sources such as biogas and peat can reduce the current

demand/supply imbalance. This could prevent the impact of woodfuel consumption on deforestation and degradation of the natural resource base in Rwanda. It could also avoid the import of more commercial energy using scarce foreign exchange reserves.

### Box 3: Saving always better than generation

If improved stoves save 25% of fuel, one million cubic meters of wood will generate 225,000 tons of fuelwood saved (supposing one solid cubic meter of fuelwood weighs 900kg). Given that one hectare of planted Eucalyptus produces 100 m<sup>3</sup> of wood every five years (or 20m<sup>3</sup>/ha/per year), of which, say 25% is fuelwood; the large volume will be sold as poles which fetch higher market prices. Only 25 m<sup>3</sup> will be used for /sold as fuelwood, or a total of 22,500 kg of dry weight equivalent to 22.5 tons. This volume, however, will be available only once every five years and yet an annual volume of this magnitude will require a total of five hectares planted one year apart. To produce 225,000 tons of fuelwood per year equals to annual saving of 50,000 hectares this must be planted every year for five years totalling to 250,000 hectares).

It is obvious that improved stoves are far more cost-effective, particularly in view of the fact that stoves will generate savings right away- there is no waiting period. If all the fuelwood were used in the improved stoves and the annual consumption was four tons per year, then only 45,000 stoves would have to be sold per year for five years to generate the savings equal to wood produced on 250,000 hectares (Christophersen & Butare, 2000).

CBWP and FRA will reduce natural resources degradation, reduce poverty, enhance the legal and regulatory framework for woodfuel in Rwanda and contribute highly to environmental conservation. They will revitalise the lost enthusiasm in tree planting, enhance the fuel saving culture and if incomes rise, contribute to woodfuel substitution. Therefore addressing simultaneously the energy, poverty and environmental impact of woodfuel consumption on forest resources by planting more, substituting more and saving more- the three pillars in safeguarding biomass supply- will fully address the negative impacts of woodfuel consumption on forest depletion.

#### 4.4.3 Proposed structural organisation of locally adapted CBWP and FRA

Rwandans have shown in recent years enough organisational capacity and maturity in solving their own problems at grass roots level. Few examples include among others:

The Jurisdiction Gacaca (based on traditional courts) to deal with genocide trials (Republic of Rwanda, 2006b);

Community policing in matter of security and the Mediation committee of conciliators (Abunzi) created in 2006 (Republic of Rwanda, 2006c) to deal with civil business or disputes concerning tangible goods or land which are in charge of providing a framework for obligatory reconciliation before cases are transferred to jurisdictions of the first degree for civil or penal business provided by the law.

All these above committees are operational in every administrative cell of the country (Republic of Rwanda, 2006c). Similarly, management committees in CBWPs could be elected at cell and sector levels as it is common practice for all basic structures in the country.

These examples inspire confidence that CBWP approach could be successfully adopted and managed in Rwanda preferably under the umbrella of the newly created Rwanda Natural Resources Authority (RNRA)<sup>55</sup> (Republic of Rwanda, 2011). Rwandans have proven positive feedback to the “forest scarcity hypothesis mechanism”, meaning that deforestation makes forest products scarcer and increases the economic value of remaining forests. This increased value in turn directly translates into better forest management and the establishment of woodlots and tree plantations. With the growing scarcity of woodfuel, agricultural production gradually loses its relative advantage, and woodfuel production becomes a viable option for local landholders. As a consequence, forest cover begins to rise (Miranda et al, 2010).

In the Rwandan case the replenishment could be integrated in the CBWP as the basic mechanism of a FRA is that small, medium-sized and other wood consuming businesses collaborate to create a reforestation program and participants in these consuming businesses are bound by the

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<sup>55</sup>RNRA mission is to lead the management of promotion of natural resources which is composed of land, water, forests, mines and geology. It is entrusted with supervision, monitoring and to ensure the implementation of issues relating to the promotion and protection of natural resources in programs and activities of all national institutions.

regulation to replace through reforestation, or other sustainable practice, the wood they consume. This should be easily done through the CBWP unit which supply the business.

These structures could also contribute to forest policy instruments, and promote rural socio-economic development, as farmers will have ownership of the wood produced and be free to decide its end use. CBWP therefore assist in environment management, poverty alleviation, create jobs, and support good governance by developing the culture of democracy as local committees will be elected by local population. They present benefits for tree growers (farmers), woodfuel traders and users, and the government. Government involvement in forest management will be reduced to supervision, technical assistance when needed and proper regulation. At implementation level, an adaptation from the government of Kenya Forests (charcoal) regulation (GoK, 2009) could provide a model.

#### **4.4.4 Proposed working framework of CBWP and FRA.**

A forest conservation committee at cell level is first created to set up a licensing committee which delivers a woodfuel producer license to organised commercial woodfuels associations. Before issuance of licenses the association provides a registration certificate. A record sheet has to be filled indicating the origin and destination of woodfuels; tree species, number of trees; estimated volume to be harvested and type of technology to be used for charcoal. The association is required to provide a reforestation/conservation plan, under the close supervision of the conservation committee, for the area where the woodfuel is produced.

Transporters will not be able to freely move commercial woodfuels from one place to another without a woodfuel movement permit, issued by the licensing committee of the conservation committee.

In the adapted CBWP approach, forest user groups must pay a percentage/tax (to be fixed) out of their proceeds to the community. Part of the taxes would be used to promote investments in social infrastructure as felt by the local community such as schools, road networks to ease woodfuels movement etc. Another part would be remitted to the RNRA to purchase seeds as is required in the existing permit system, (the one percent of the sale paid to the NFF was supposed to do so). The user groups will pay a fee to the village forest management committee which will be used for investments in sustainable forest management.

An example of local success to save the forest could be learned from the Nyungwe and Volcano natural parks case. In 2005 Nyungwe and Volcano parks were on the verge of complete destruction by neighbouring populations. In a search of a win-win strategy to protect the park from poachers and forest encroachment, local committees for park conservation were created (including renowned poachers) and trained. Part of the income from ecotourism was used for social infrastructures (Tusabe, 2010). The GoR initiated the “Revenue Sharing Scheme” whereby five percent of tourism revenues from the park fees are injected into local community projects around national parks. This is to ensure that the local people consider the parks as their own. Local government needs to ensure the participatory selection of local projects to finance. The accountability is improved through writing action plans that need to be delivered each year. Action plans are developed jointly by local, district and park experts. The project funds pay for a range of environmental protection initiatives (tree planting, soil erosion control, and fencing protected areas to reduce encroachment from poachers and limit animals’ movements in neighbouring population’s crops), and projects related to education, health care, water and sanitation, basic infrastructures, food security, and income generation activities (Tusabe, 2010). Why should the same not apply in forests outside parks? Why not replicate the Revenue Sharing Scheme in the woodfuel industry to stop illegal practices and ensure sustainable forest management? It could promote villages’ solidarity to prevent the woodfuels trade being pursued outside the legal channels, thereby reducing inequalities in the woodfuels value chain.

While the woodfuels trade is at present profitable to districts and to urban charcoal masters, it leaves local people with very little to show for their labour in tree growing and woodfuel production, including charcoal making. The two approaches can support rural economic development and improve the sustainability of woodfuel resources. With these systems rural people producing the fuel feel themselves as stakeholders sharing benefits, and not as intruders or forest invaders - as is the case today with the district forest management system. The CBWP will ensure a more sustainable and equitable distribution of the woodfuel trade revenues. When local people share benefits they are more stimulated to improve production processes and de facto become forest caretakers and better implement plantation and management strategies.

## 4.5 Conclusion

The chapter covered woodfuel related policies and policy instruments. The main finding being that the heavy reliance on woodfuels in primary energy and energy consumption in Rwanda is often seen as damaging to the environment in general and forests in particular forcing the policy makers to adopt unpopular harvesting measure. As a result, despite its importance, woodfuel is not given the policy attention it deserves and is not properly regulated. Factors such as uncontrolled population growth, limited land tenure, poverty, and poor governance have had more impact on the degradation of Rwanda's forests than woodfuel production and consumption. The impacts of woodfuel use are not necessarily negative for all groups of actors or under all circumstances. Nor do they necessarily lead to permanent environmental change if exploitation regulations are fully respected. Misunderstanding of this situation, coupled with top-down forest management at district level lead to restrictive guidelines ignoring the socio-economic benefits which flow from the woodfuels value chain. Over-bureaucratic processes in an understaffed and underfunded sector have proven to be ineffective. Environmental policies overlap the biomass energy sector, with the Ministry of Natural Resources handling the supply side and the Ministry of Infrastructure dealing with the demand side. This management structure, not relevant to the modern energy sector<sup>56</sup>, has shown itself to be ineffective. Energy policies recommend a move away from traditional biomass energy in favour of unavailable and unaffordable modern fuels. The environmental policy imposes very restrictive harvesting regulations which prompt woodfuel producers to operate illegally, leading to production which is not sustainable. Forest protection is not achieved, neither is wood energy sustainably produced nor poverty alleviated. Given that in the foreseeable future biomass will remain the primary source of energy, it is imperative to develop the biomass energy sector in a way that is more orientated to energy for poverty alleviation and more environmentally sound, before the transition from traditional to modern energy sources can be achieved.

A participatory approach, where the local population contributes to production and management could be more successful, as the targeted integrated development must be achieved with the people and not for the people. In order to reinforce policy instruments, community forest

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<sup>56</sup> Petroleum products importation, storage and distribution fall under one ministry, the Ministry of Commerce and Electricity under the Ministry of Infrastructure through the national utility, Electrogaz

management through CBWP and FRA are proposed as viable strategic approaches to alleviate the pressure of fuel demand on national woodfuel resources. Their structural organisations as well as working framework are proposed and both devolve responsibilities to local communities for sustainable, environmentally sound forest management and poverty alleviation. In that way the woodfuel production and consumption impacts on energy, poverty and environment are addressed, not in isolation, but simultaneously. They have proven to be successful in sub-Saharan Africa countries (Senegal, Niger, and Madagascar) and Latin America (Brazil, Nicaragua), and could be successful in Rwanda too.

The next chapter investigates, through a case study, the charcoal production and supply chain from the wood purchase, exploitation permits negotiation and carbonisation processes to the charcoal transport to city markets. The consumption patterns are analysed in a household woodfuel consumption survey and focus group discussions.

## CHAPTER FIVE

### CASE STUDY ON WOODFUEL PRODUCTION AND CONSUMPTION

#### 5.1 Introduction

The desk study of the previous chapters shows that woodfuels are the main fuel used in Rwanda and contribute to poverty alleviation and income generation in rural areas. Its demand is increasing with population increase especially the charcoal demand in urban areas thus putting more pressure on forests and woodlands due to a large demand/supply imbalance. Regulations on woodfuel create conflicts of interest as on the one hand policy makers have the obligation to protect the environment and on the other hand tree growers, woodfuel traders and users claim full right to benefit from the industry as a source of energy and income. This conflict makes it difficult to implement the policies designed to protect the environment.

To verify and complement secondary data, a woodfuels survey was carried out in the period between October 1<sup>st</sup> and October 31<sup>st</sup> 2009. The woodfuels flow chain was studied. The charcoal production, transport and sale were investigated in the district of Nyamagabe and the woodfuel's consumption was investigated in Huye district both in the Southern Province of Rwanda. Districts and cells of the case study are as on Figure 28.

Nyamagabe district was selected because it is the major supplier of charcoal (38%) to the capital city and the district has the highest forest cover (15%) in Rwanda. The study was undertaken in the southern sector of Kitabi which includes a small area of the Nyungwe National Park. The choice of Kitabi was motivated by the fact that it has the highest forest cover in the district and also to investigate if clandestine charcoal making was still done within the park.

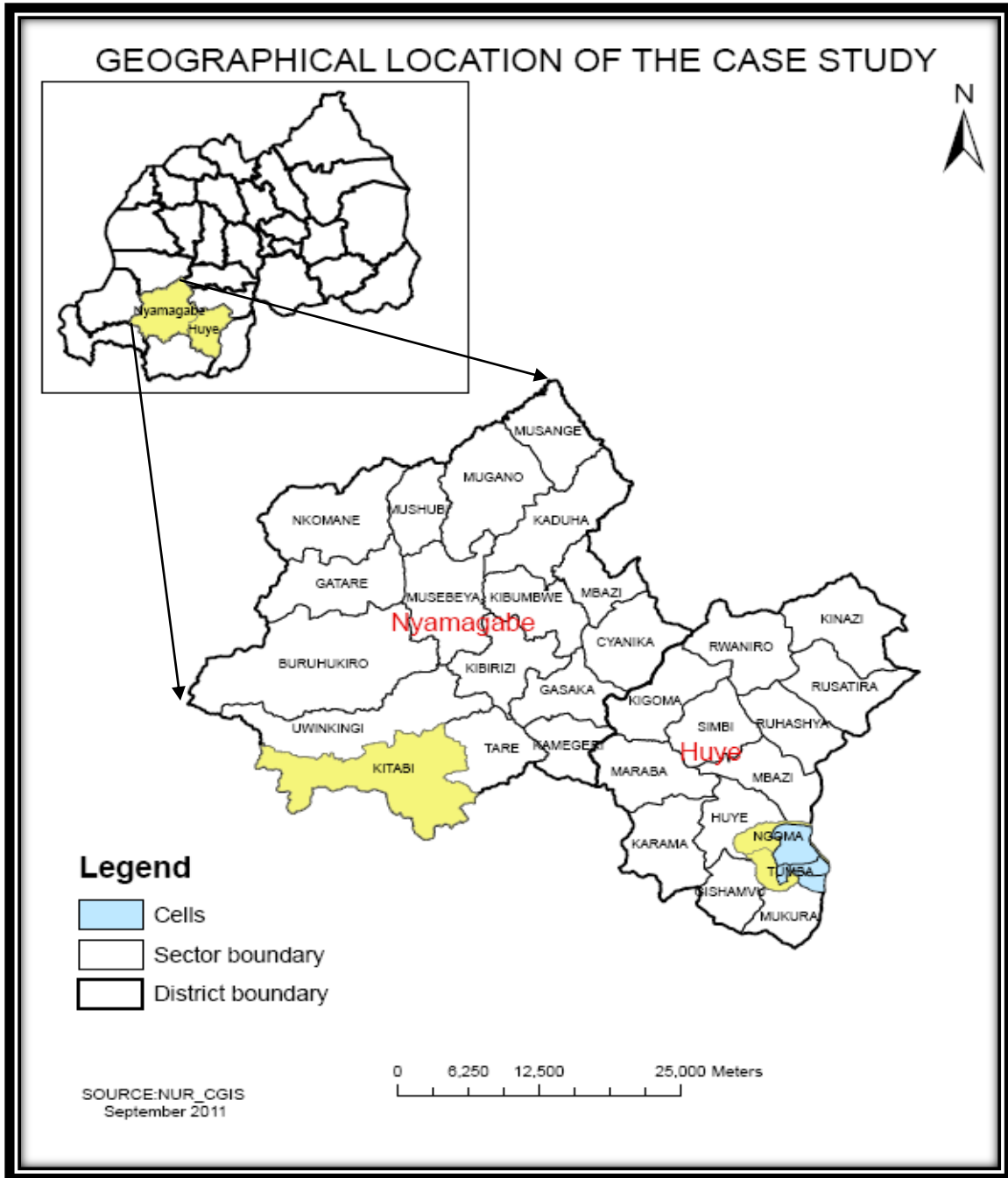


Figure 28:Geographic location of the case study

Map: Author

At producer level, the case study focuses on charcoal production where the journey of the charcoal dealer is investigated from the wood purchase's negotiation to the charcoal making, selling and transport to city markets. This involved moving with the charcoal makers' team while they cut trees, dried, packed and covered the kiln, carbonised and extracted charcoal to be

transported to the roadside for final transport to trade sites. The objective is to assess the policy implementation from both officials and charcoal producers; the effectiveness of charcoal technology and how the produced charcoal incomes are shared among stakeholders in the production process. Beside the physical results of the production informal discussions were conducted with two charcoal masters, their two foremen and occasionally with the labourers.

At consumers level woodfuel supply and use were investigated. The share of fuelwood and charcoal in the energy burden of the households was assessed and the reasons why woodfuel remains the most popular fuel in spite of modern fuels' availability. In addition woodfuel use and appliances were investigated. Anevery second house survey was complimented by household woodfuels consumption focus groups discussions. The survey was carried out with the help of a carefully designed questionnaire. The questionnaire was first developed by the Energy Research Centre, University of Cape Town in 2003 and was adapted for the Rwandan case.

The study was carried out in the two sectors of Butare city, the second largest city of Rwanda located in Huye district in the Southern Province. The two sectors are namely Tumba and Ngoma. Four cells, namely, Cyarwa, Cyimana, Gitwa in Tumba sector and Kabutare in Ngoma sector were covered. Cyimana and Cyarwa are peri-urban informal settlements with a small urban area near the city centre of Butare. The households surveyed in Cyimana included 30 households in its urban informal settlement and 28 households in the peri-urban informal settlement. In Cyarwa 30 households were respectively surveyed in both urban and peri urban informal settlement. In both Gitwa, urban informal settlement, and Kabutare, urban formal settlement, 61 and 26 households were respectively surveyed. Making a total of 205 households for the woodfuel consumption survey.

In each of the study areas, a household survey of selected households was undertaken. It was designed to elicit information on patterns of energy consumption, with focus on woodfuels consumption and expenditure as well as demographic and resource access profiles. Household data were collected by administering a questionnaire to every second household that agreed to respond. The focus group discussions (fgd) comprised among other, women head of households

(when they were available in the cell), the cell executive committee<sup>57</sup> and the village executive committee<sup>58</sup> members when living in the surveyed cell.

The choice of the FGD members was motivated by the fact that the members of these executive committees are the daily managers of the community in the cell or village; they are the planners, conflict managers and spokespersons to higher levels of the local administration. All socio-economic problems are discussed and very often solved at the executive committee level.

Regarding enumerators, third year National University of Rwanda students in the department of Statistics and Social Sciences living in the area (in off-campus accommodation) were selected and trained as enumerators.

After data collection, the next step involved an analysis of the data obtained. In the data analysis households were divided into five income groups (quintiles) and their fuel/energy supply, end use and use of appliances were analysed. Within the second step and with scientific tools (the SPSS statistical software package) the data was analysed to obtain general characteristics (descriptive statistics) and an accurate picture of the woodfuel flow chain in the area of study.

In the last step and from the gathered information and results of data analysis, the strengths, weaknesses; opportunities and threats (SWOT) from the analysis were used to draw conclusions and provide recommendations.

## **5.2 Charcoal production**

Stakeholders in the charcoal flow chain are local government, wood owners (growers), charcoalers, transporters, retailers and users. Actors in production are wood owners and charcoalers.

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<sup>57</sup> Comprised of the cell coordinator; the secretary; the in-charge of development; the in-charge of security; the in-charge of education, culture, and mass mobilization; the in-charge of youth, sports and entertainment; the in-charge of finance; the in charge of health and social affairs; the in-charge of women affairs and the in-charge of information.

<sup>58</sup> Comprised of the village coordinator; the in-charge of social affairs; the in-charge of security and immigration and migration in the village; the in-charge of information and education; and the in-charge of development.

There are three types of charcoalers: charcoal masters, foremen and labourers. The charcoal master actively searches for wood to be carbonised and makes deals with wood owners. He also makes necessary contacts for obtaining wood cutting permits with the local authorities. The foreman works for a charcoal master or for a wood owner and manages the team of workmen. He does not have funds to buy the trees up front, but can make a deal about sharing the output or negotiate a salary. The labourers carry out the work and are either paid a salary or share the output. The charcoal master often applies this latter system if he is not the wood owner and when he does not personally supervise the carbonisation. In the latter case he offers around 30% of the bags produced to the labourers. The charcoal flow chain is schematically shown in Figure 29.

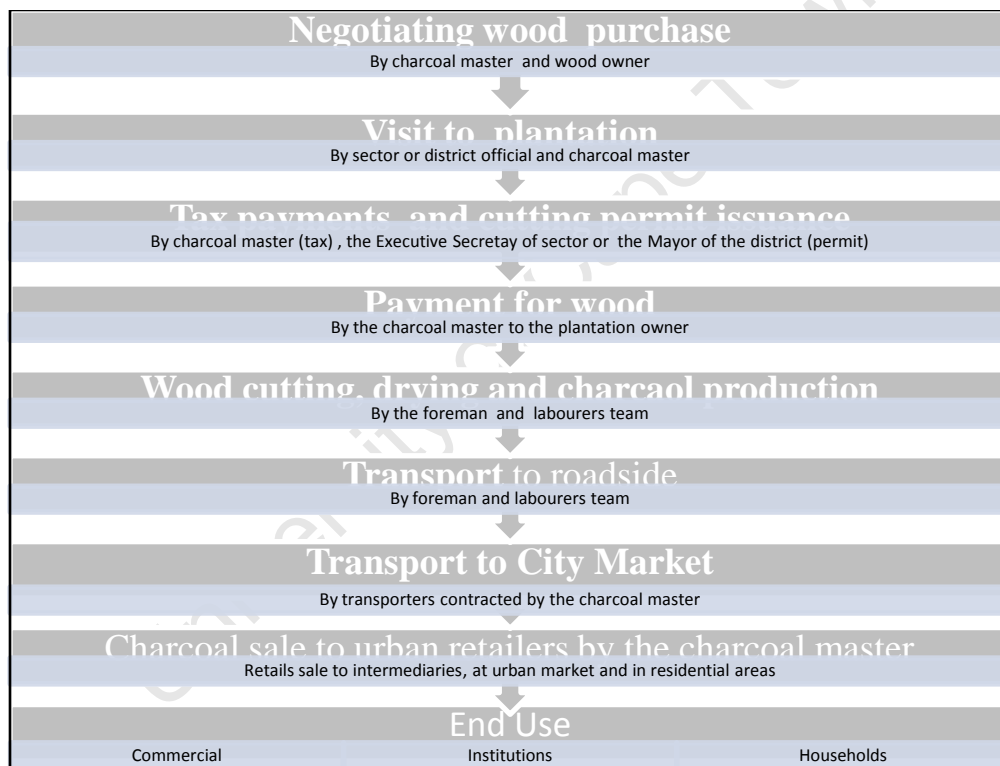


Figure 29: Woodfuel flow chain

### 5.2.1 Wood exploitation permit process

The charcoal master first deals with the plantation owner and both agree on the price to be paid. They write a motivation letter to the official in charge of forestry in the sector/district. After more or less one week the charcoal master must pay transport for an official from the sector to

undertake a field visit to the wood stand and supposedly measure the acreage of the stand (Photo 7). When the wood stand is estimated to be sufficiently mature to be harvested, sector taxes are paid and a cutting permit is issued by the Executive Secretary of the sector for less than two hectares or the mayor for a larger stand. Apart from the National Forest Fund tax (1% of the wood stand sale value), irregular taxes (like a US\$ 3.5 tax for wood exploitation permit and US\$ 1.75 for the Education Fund etc.) are paid depending on the running activities of the sector and not necessarily related to forestry. It is only after the tree cutting permit is issued that the agreed cost is paid to the wood stand owner. This takes more or less one week after the visit but can take longer in some cases as disclosed by some charcoal masters. In the district, the cutting permit is officially supposed to last three months, but is usually valid for only one month with a fifteen day extension.



Photo 7: Inspection of a recently cut stand and visit to a standing one

Photo: Author

The purchase is not on measured acreage basis, as required by the wood permit, but on a rough approximation which makes it difficult to collect the exact tax due to the NFF. For example, a wood stand worth (US\$ 350) can produce 100 timbers or 180 bags of charcoal when bought for timber or charcoal production purposes. These two forest end uses are not mutually exclusive, once the section is bought, the biggest trunks of wood, more than 50 cm tree Diameter at Breast Height (DBH), which can't easily be carbonised, are used for timber production (Photo 8). For

good carbonisation efficiency, 25 cm to 50 cm trees DBH are recommended (Zulu, 2010). As no DBH measurement is done as confirmed by the foremen even trees with less than 25 cm DBH are cut which is against the harvesting policy.



Photo 8: Timber production is part of forest depletion

Source: REMA, 2009

### 5.2.2 Production process

At the charcoal production site and for one kiln, a minimum of four people per day for two days are employed in wood cutting, splitting and preparation of the kiln. Four people per day for two weeks are employed in the carbonisation process. A nine people per day labour force for two days is necessary for the kiln unloading and a six person per day for two days are engaged in bags filling and charcoal's transport to roadside. Four people are employed for the truck packing. The per diem is 1,000 RWF (US\$1.70).

There are three main steps in charcoal production:

- Felling and cutting trees into shorter logs fitting the kiln's size, done by the labourers under supervision of the foreman
- Drying of wood under supervision of the foreman (logs are left in the open air for one week)

- Carbonization, including kiln preparation, packing, firing and unloading charcoal, done by the labourers under supervision of the foreman.

There are two types of traditional mound kilns used, namely the above ground or underground kilns depending on the terrain slope. For an underground kiln a charcoal pit is first dug. Traditional kilns are used but the charcoal producers are aware of more efficient kilns like the “Casamance kiln”. However the required investment for these, particularly the purchase and welding together of three oil barrels for the chimney, discourages their use. The traditional kilns reduce the burden of transporting trees to the kiln –for fixed kiln - but reduce carbonisation efficiency.

The foreman makes sure that the tree felling takes one day and recruits the labourers accordingly<sup>59</sup>. This is to make sure that the all processes fall within the validity period of the permit. Here we have to specify that the tree cutting method is a clear felling which leaves large tracts of land bare and exposed to erosion (Photo 4, Photo 9).



Photo 9: Recently cut stand and uncovered kiln site

Photo: Author

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<sup>59</sup> On average eight labourers are involved in the tree felling process on a 1000 RWF per diem basis.

Cut trees are carried to a level area where they are split according to the size of the kiln by a team of four labourers on average. Common kilns are four meters long, three meters wide and two meters in height (Photo 10).



Photo 10: Preparation of an above ground kiln

Photo: Author

On average, before carbonization the wood is left to dry for one week. In the study area a traditional above ground kiln was used on a slope. Split and dried wood is packed into the kiln, and covered with leaves and mud on top and on all sides, leaving a small window to start ignition (Photos 11 and Photo 12).



Photo 11: Kiln packing and covering Photo 12: Ignition window

Photo: Author

There after starts the kiln ignition (Photo 13). Ignition takes about one hour depending on how dry the packed wood is and after the first smoke appears which is a sign that ignition succeeded. Otherwise the ignition is restarted.



Photo 13: Kiln's ignition.

Photo: Author

After the first smoke appears the ignition window is covered (Photos 14) and closed (Photo 15).



Photo 14: Ignition window closure    Photo 15: Fully closed window

Photo: Author

After ignition has started, the labourers stick wood poles through the top of the kiln, creating a simulated chimney which seemingly improves the carbonisation efficiency (Photos 16).



Photo 16: Sticks used as chimneys

Photo: Author

Under close supervision of the foreman, two labourers - on a rotational basis- remain on site with their kiln for the carbonisation period to prevent possible fire hazards, and to control the carbonisation by closing secondary chimneys which can contribute to low efficiency. When white smoke appears the carbonisation is almost complete (Photo 17). Carbonisation takes two weeks.



Photo 17: Carbonisation is almost complete

Photo: Author

On average such a kiln can produce between 35 and 40 bags of an average 33kg/bag<sup>60</sup>. An approximately 40 bag capacity kiln ignites easily and has better carbonisation efficiency than larger ones. The aforementioned US\$ 350 woodland can be packed in five kilns, each one with a 40 bag capacity. As there is no wood weighting before carbonisation, it is very difficult to estimate the kiln efficiency.

Kiln unloading needs a team of 9 labourers and takes one day. After the mud is removed (beginning at the sides) two persons unload charcoal using picks; two others add fresh mud to cool the charcoal and five pick charcoal to pack in bags (Photo 18). The labour used in kiln unloading (as well as in tea harvesting) in the sector Kitabi, includes children (Photo 18) which affects their schooling. In charcoal producing areas the rate of children not attending school and the school dropout rate are high (40.2% and 31.8% respectively) (NISR, 2009c).

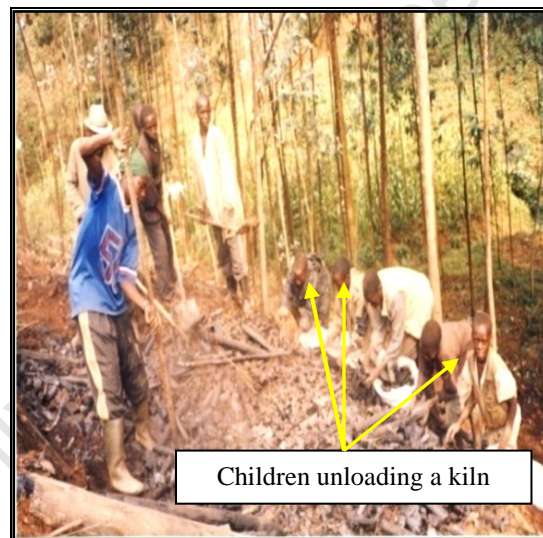


Photo 18: Kiln unloading

Photo: Author

The filled bags are not immediately covered, to allow ventilation. It's only when the bags have to be transported to the nearest road side that the tops are covered with leaves and sealed with cords (Photo 19). Sealed bags are transported to the closest roadside, where a guard remains with the

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<sup>60</sup>*I weighed some unloaded bags before they were packed to the truck*

bags until they are packed into a truck (Photo 20). The average weight of the 40 bags was in the range of 30-35 kg. The average weight of produced bags is 33 kg.



Photo 19: Bags sealing



Photo 20: Bags packing on truck

Photos: Author

The price of one bag at the production site is around US\$6. In many cases the charcoal transporter pays money in advance to the charcoal master. This seems to be of mutual benefit as on the one side the transporter is sure that nobody else will buy the produced charcoal, on the other side the charcoal master is sure that his charcoal will be sold without delay.

In labour, at the production site, for only one kiln, on average a minimum of four persons/day team for two weeks are employed in cutting, splitting, drying of wood, preparation and packing of the kiln. Two persons per day for two weeks are employed in the carbonisation process control and nine persons per day for two days are necessary for the kiln unloading and charcoal transport to roadside while four persons are employed in truck packing.

Along the entire chain of the woodfuel trade employment is created and income generated for wood owner, charcoal master, foreman and labourers. At the rate of 1000RWF<sup>61</sup> per diem, 106,000RWF are earned by the labourers involved in the charcoal production process.

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<sup>61</sup> 1US\$=570RWF

Environmentally, the dimension of unloaded charcoal shows that even non mature trees have been carbonised which contributes further to forest depletion and reduces the carbonisation efficiency as young trees burn more than they carbonise. The site of carbonisation is not recovered after kiln unloading which can contribute to erosion on the former kiln site as it shows on Photo 21



Photo 21: Unloaded kiln

Photo: Author

### **5.2.3 Charcoal price structure at the production site**

The price difference in charcoal depends on the type of wood used but also on production and transport costs. Savannah charcoal is expensive but preferred as it is heavier and burns longer than Eucalyptus charcoal but most of the charcoal from the studied area is made from Eucalyptus wood which is more difficult to light. Sometimes cheaper pine charcoal is produced but it has a lower quality as it is light, easily ignites and burns fast.

The production costs include the wood cost which accounts for 32% of the total cost, the charcoaling cost is 26% of the total cost and depends mostly on the location of the kiln in relation to the roadside; taxes (cutting permit and carbonisation tax (taxes levied from any burned kiln) account for 6%. The business is profitable, as a profit of 36% is made on each bag sold at the production site. The price structure at the production site is shown in Figure 30.

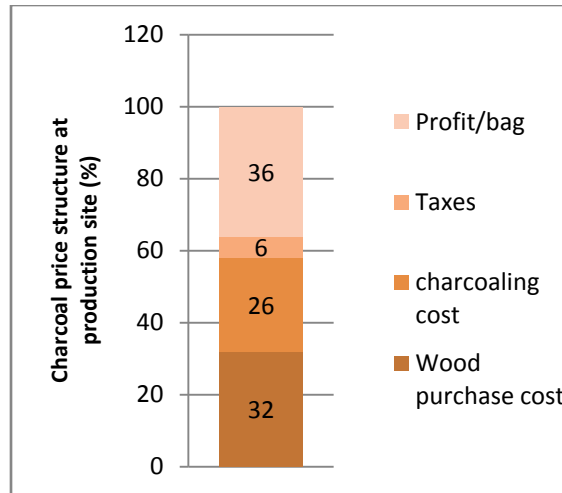


Figure 30: Breakdown of costs and profit at production site (%)

In fact the charcoal master and the wood owner benefit more as they share respectively 32% and 36% of the business, while the foreman and his labourers' team share is at 26% and the district or sector share in taxes is as small as 6% of the total cost.

#### 5.2.4 Charcoal transportation and distribution

When the charcoal is to be transported to the city market, charcoal is collected along the road side sometimes through a pre-arranged deal whereby transporters (retailers) pay in advance to finance the cutting and carbonization and thereafter come to transport it. Some transporters specialize in the transport of charcoal and the transporters make deals with many charcoalers. A charcoal transport permit, specifying where the charcoal must be delivered from the district is required for any movement of charcoal from the production site. To obtain a charcoal transport permit the transporter needs to present a cutting permit and pays around one US dollar to the district. Once the transport permit is delivered, the transporter has to pay to a local district tax collection officer US\$ 8 per packed bag. The main vehicle used in the transport is a pick-up truck or a light truck (Photo 22).



Photo 22: Bags transport to city market

Photo: REMA, 2009

Once in town, transporters have three ways to sell their charcoal: through intermediaries at the city entrance for redistribution; at an urban market site with a section for charcoal, where charcoal is sold to consumers or distributors or door to door in residential areas.

### **5.2.5 Charcoal price structure at city market**

The price structure at city markets includes the purchase cost at the collection point at the roadside accounting for 44% of the total cost; the transport cost to the city market (27%), and transport taxes paid to a district tax collector on each bag packed valued at 2% of the total cost. Once sold at the city market a 17% profit per bag is made (Figure 31).

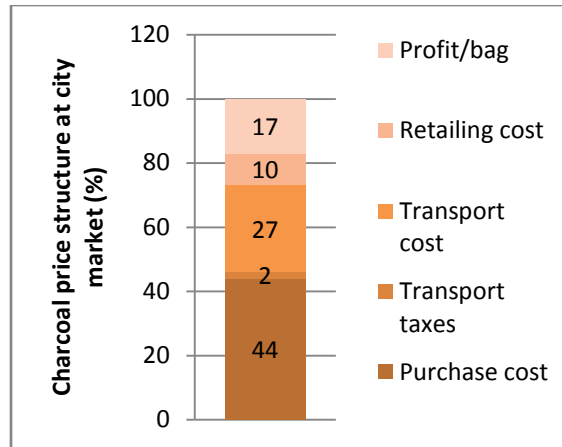


Figure 31: Breakdown of costs and profit at city market (%)

Although feedstock may be sustainably and locally grown, charcoal prices are strongly linked to petroleum prices. Since transport costs are a significant fraction of total costs (27%), due to the long transport distances involved, any increase in the petroleum price affects the transport cost and retail price. Charcoal price increases also in rainy period as revealed by focus groups discussions.

### 5.2.6 Policy instruments

As policy and regulations regarding wood exploitation permits (tree cutting and transport) are concerned, I observed some major irregularities. Among others, extra taxes paid to the district to finance any running activity in the district; validity of the permit shortened; no acreage of woodstand; no volume of cut trees and no DBH are taken. As well as no weighting of produced charcoal is done to estimate the kiln efficiency.

Short validity time of the permit limits the drying process which impacts on carbonisation efficiency and increases emissions during the carbonisation process. Lack of acreage, volume and DBH measurement leads to speculation on the real price paid to the wood owner and allows charcoal master to pay less to the National Forest Fund tax. As no DBH measurement are taken, clear felling is a common practice with cutting down of immature trees which contribute to forest degradation. As all required measurements are not done, it is very difficult to keep statistics on wood product in general and woodfuel in particular which is a big challenge for woodfuel

demand /supply assessment. No kiln efficiency can be calculated to assess the transformation losses of the process as no wood volume and unloaded charcoal measurement are taken.

### **5.3 Woodfuels consumption in the studied area**

The consumption survey was conducted in Tumba and Ngoma sectors of Huye district. The choice of both sectors was motivated by the fact that the peri urban interface is characterised by strong urban influence, easy access to markets, services and other inputs, and a ready supply of labour, but has a relative shortage of land and higher costs of woodfuels, and is subject to risks from urban growth. Both sectors are under urban influences (they supply an urban area) and within the urban fringe (area of demand). These peri-urban areas therefore present both rural and urban woodfuel consumption characteristics: Fuelwood in Cyimana and Cyarwa as well as charcoal in Gitwa and Kabutare. An analysis of woodfuel consumption in these areas can lead to a better understanding of the woodfuel challenges met in poor rural and urban areas and can allow the drawing of consistent conclusions on issues pertaining to the woodfuel demand, supply and end use in Rwanda. Households were sampled choosing every second household willing to respond which lead to a sample size of 205 households.

Results presented in this sub chapter are from the present case study. The principal data sets are those that detail household woodfuels energy use, it is nevertheless useful to present the socio-economic and demographic contextual information which will enable a greater level of comparative analysis. To this end, information on household demographics, income and employment patterns have been included. These made it possible to understand how livelihood's conditions influence or are influenced by woodfuels consumption.

#### **5.3.1 Income groups of households**

A sample of 205 households was surveyed, recorded responses in ten households were incomplete and calculations are based on 195 households. Sampled households are shown in Table 17.

Table 17: Number of surveyed households by cell

Sector	Cell	Households			
		Sampled	Valid data	Total households in cell	Percentage sampled
Tumba	Cyarwa	60	58	272	22.05
	Cyimana	58	56	240	24.16
	Gitwa	61	55	234	26.06
Ngoma	Kabutare	26	26	217	11.98
Total		205	195	963	21.28

Based on the monthly income of all respondents, households were distributed into five income groups (quintiles) and their supply, purchase, and use of woodfuels were analysed, as well as appliances used for burning woodfuels.

By rising income, these quintiles are Q1 (Low), Q2, Q3, Q4 and Q5 (High)) as shown in Table 18. The lowest monthly income was found to be 1,000 RWF (US\$ 1.75) and the highest 850,000 RWF (US\$ 1491). The mean monthly income is 63,200 RWF (US\$ 110). Self employment is the dominant employment circumstance at 27.4%. Twelve percent of households fall under the poverty line of 90,000RWF (US\$ 158) per year as estimated from the EICV2 (NISR,2006b).

Table 18: Income ranges for quintiles in RWF

<b>Mean</b>		63200
<b>Median</b>		35000
<b>Std. Deviation</b>		91290
<b>Minimum</b>		1000
<b>Maximum</b>		850000
<b>Quintiles</b>	<b>Percent</b>	Income groups (RWF)
	0-20	Q1 (< 15000) Low
	20.1-40	Q2 (15001-30000)
	40.1-60	Q3 (30001- 43100)
	60.1-80	Q4 (43101- 89600)
	80.1-100	Q5 (>89601) High

N=195

The peri-urban rural cell of Cyimana is the poorest as 69.2% of households fall in Q1; 38.5% in Q2; 7.7% in Q3; 15.4% in Q4 and only 7.4% in Q5. It is followed by Cyarwa with 17.9% of households in Q1; 41% in Q2 and Q3 also at 41%; 23.1% in Q4 and 17.9% in Q5. The peri urban cells with urban characteristics Gitwa and Kabutare are the wealthier with respectively 43.6% and 30.8% of households in Q5 and 38.5% ; 23.1 % in Q4 (Figure 32).

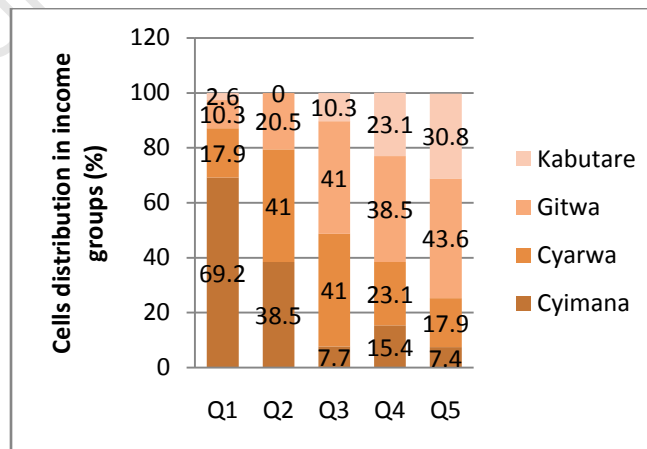


Figure 32: Proportion of income groups in the four cells (%)

As generally found in Rwanda even in the study area, poverty is a rural phenomenon: The closer the cell is to the city (Butare), the higher the household income. Kabutare (Ngoma sector) and Gitwa (Tumba sector) border the city centre, while Cyimana and Cyarwa are respectively behind Gitwa at 3 and 4 km South from the city.

### **5.3.2 Demographic characteristics**

The age of respondents was between 19 and 89 years. The average age was 24 years. The average household size is four persons - lower than the 5.5 persons household size at national level- with the minimum household size being one person and the largest eight persons. In the study area, females represent 50.5% of population and males 49.5% while female headed households make up 34% of the surveyed households<sup>62</sup>. These include mainly widows from the 1994 genocide; single mothers and households whose male heads are in prison as these peri urban areas have been very active in (Butare city) killings during the 1994 genocide against the Tutsi.

In the study area 18.40% have no schooling, 0.80% attended literacy school, 15.50% completed primary school, 20.00% did some secondary school, 8.10% completed secondary school and only 0.70% completed tertiary education. The high rate of uneducated people has negative impact to local development.

### **5.3.3 Housing and amenities**

The majority of households (62%) own houses which have at least three rooms and one separate building and 36% rent houses. Two percent are provided with accomodation and these include civil servants and disabled or poorest survivors of the 1994 genocide against the Tutsi. Building materials used for houses include timber and daub 53.43%, bricks 21.00%, concrete blocks 12.75% and precast concrete 12.75%. Roof material is clay tiles at 50.00%; zinc/metal 49.50% and 0.50% are grass thatched houses.

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<sup>62</sup> Nationally female population represents 53% and women head nearly 32% of Rwandan households (NISR,2008a)

The majority of households (95.08%) have access to clean water with 60.10% having a shared tap, 22.66% a tap in yard and 12.32% a tap in house. For the households sharing a tap, access to nearest tap is less than 500 m and only 3.52% of them walk more than 500 m to access a tap. Respondents without tap have difficulties accessing protected water (a well or borehole) as 17.57% of them cover more than 500 m to access protected water sources. Houses with separate bathrooms account for 53.27%. Sewerage systems comprise water-borne 5.82%, pit latrine 67.20%. The remaining 26.50% of households have no sanitation facility and share sanitation with neighbours.

### 5.3.4 Electricity connection in the study area

On average 32.5% of households have electricity connections. Cyimana at 10.3%, Cyarwa 18.3%, Gitwa 47.5% and Kabutare 80.8%. As from Figure 33, wealthier cells Gitwa and Kabutare more represented in Q4 and Q5 are the ones with higher electricity connection (Figure 33).

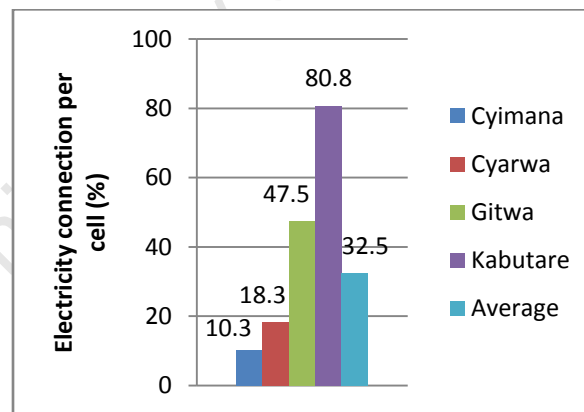


Figure 33: Electricity connection (%) per cell in the study area

All the study area is covered by the national electricity grid. As expected, per income group, electricity connection increases with income as Q1 and Q2 are both connected at 7.7%; Q3 by 20.5% while Q4 and Q5 are connected at 46.5% and 82.5% respectively (Figure 34).

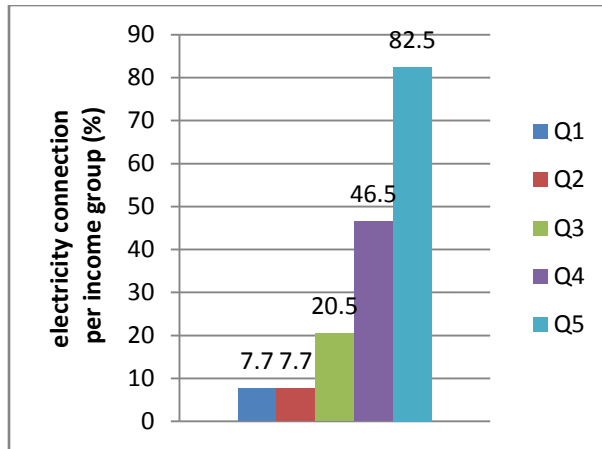


Figure 34: Electricity connection per income groups (%)

### 5.3.5 Charcoal supply purchase and use

Charcoal is available to 83.7% and used by 61.0% of surveyed households. There are no professional charcoal makers in the area. Charcoal used comes from neighbouring districts (Nyamagabe and Nyaruguru) (Figure 1) or sectors (Mukura and Gishamvu) (Figure 10). Charcoal is purchased from a member of the community or a specialised dealer for small quantities. For larger amounts, bags are bought directly from people transporting them as head loads or collected by bicycle from charcoal dealers stocks (Photo 23) or charcoal selling section at the market (Photo 24). For small quantities charcoal is sold by bucket (akadobo) or small heap (akarundo).



Photo 23: Charcoal dealer stock (Butare)



Photo 24 Charcoal section (Butare city market)

Photos: Author

The average weight of charcoal in buckets is 2 kg depending on the seller. For either bags or small measures, the price of charcoal has undergone changes from 2006 to 2009 with a 25% increase for the year 2009. The price increase was higher than the national inflation rates (7% in 2007; 9% in 2008 and 15% in 2009) in the same time period (Table 19).

Table 19: Charcoal price change 2006-2009 in RWF and US\$

Year	Price/33kg bag	% increase on bag	Price /2kg bucket	% increase on buckets	Inflation
2006	2000 RWF (US\$ 3.5)		200 RWF (US\$c 35)		
2007	2500 RWF (US\$ 4.4)	20	250 RWF (US\$c 44)	25	7%
2008	3000 RWF (US\$ 5.3)	17	250 RWF (US\$c 44)	0	9%
2009	4000 RWF (US\$ 7)	25	300 RWF (US\$c 53)	17	15%

Source: Present research case study's survey

There is a close relationship between household income and the amounts of charcoal bought. High income groups, Q5 and Q4, buy charcoal by bag at 73% and 46%. respectively. Low income groups purchase less frequently by bag: 3% in Q1 and 5% in Q2 while 28% of the medium income group households in Q3 buy per bag (Figure 35).

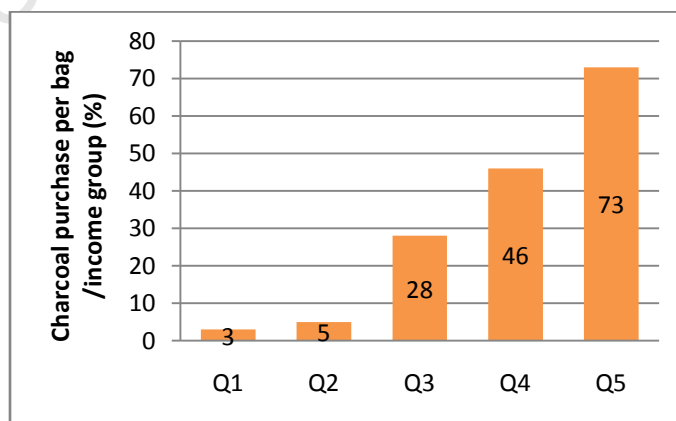


Figure 35: Purchase per bag by income group (%)

Low income households buy in small amounts which is more expensive. A 33 kg bag costs (US\$ 7) and 2 kg bucket (US\$ 0.53). This means that one kilogramme bought by bag will cost US\$ 21<sup>63</sup> and a kilogramme bought by bucket will cost US\$ 26. The US\$ 5 difference per kilogramme represents a 19% extra expenditure for low income groups purchasing in small amounts. Any increase in charcoal price will affect more poor consumers than wealthier ones. Cells like Gitwa and Kabutare have established “Cell charcoal shops” at village level in order to manage price speculation by local sellers. The FGD revealed that these cell’s shops are effective and they plan to extend them to fuelwood.

The average daily household consumption of charcoal is 2.4 kg. As 5.81 kWh is the average daily amount of electricity required for cooking (MININFRA, 2007), household using electricity will spend daily US\$ 1.22 while a household using charcoal will spend US\$ 50 or 2.4 times less. This can partially explain the low energy transition and the fact that even high income groups use charcoal for cooking. Nationwide, only 0.1% of the population use electricity for cooking (NISR, 2003) and in the studied area 1% use electricity for cooking.

The interviewed charcoal sellers make a good profit of 70,000 RWF (US\$ 123) per month on average which is higher than the mean household’s monthly income of 63, 200 RWF (US\$ 111) in the study area.

### **5.3.6 Fuelwood supply, purchase and use**

Fuelwood is available to 77% of households in the area of study and used by 72%. In all income groups, self-provision is supplemented or combined with purchased supply. Fuelwood is self collected by 40%, bought by 44% and 16.40% of households both collect and buy firewood. As expected, fuelwood collection decreases with income as 45% of Q1, 34% of Q2, 30% of Q3; 26% of Q4 and 18% of Q5 collect fuelwood while the purchase of fuelwood increases with income with 25% in Q1, 54% in Q2; 60% in Q3; 68% in Q4 and 82% in Q5 (Figure 36).

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<sup>63</sup> The price of one kWh of electricity.

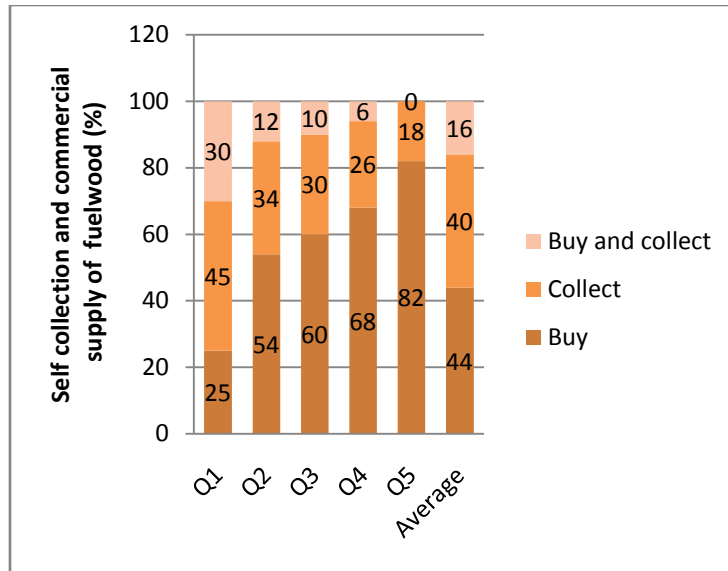


Figure 36: Self provision and commercial supply of fuelwood

### 5.3.7 Fuelwood collection

The fact that on average only 45% of the households in the study area collect fuelwood and 44% buy fuelwood (Figure 36) is not proof that fuelwood is cheap or that there are high revenues in the area but a sign that there is not enough fuelwood to collect at least on private land. Self collected wood comes from forests (public or private) at 48%; agricultural land (26%); neighbours' land (16%) and less often from individual land (9%). The frequency of collection is on a daily basis for 30.5% of households, every second day for 40.7% or once a week for 27.0% of households.

Apart from being hard work to do as reported by 14% of surveyed households and long collection distance for 11% of households, fuelwood collection is frequently a source of risks. Twenty one percent of wood stand owners dislike it that fuelwood be collected from their plantation and in 20% of cases conflicts arose with guards of private and public plantations in the study area. Fuelwood collection is particularly difficult in rainy season (16%). Deaths were reported when wood poachers were pursued by guards of the National University Arboretum bordering on the area of study as revealed during the focus group discussions.

Despite such risks, women and children are the main suppliers of firewood, women accounting for 42%; male and female children accounting for 29% and 19% respectively; men account for only 9%. Fuelwood collection is as in Figure 37 where other 1% refers to house-keepers.

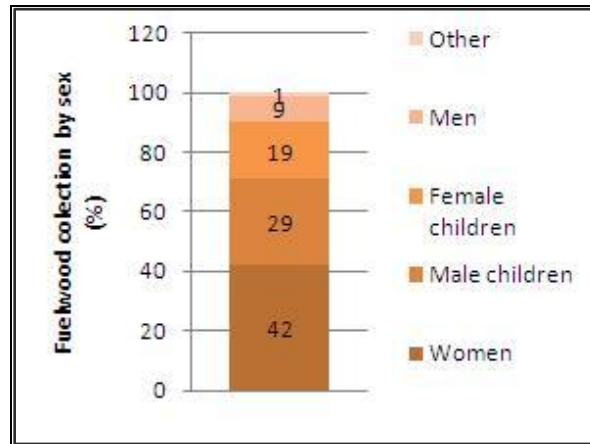


Figure 37: Fuelwood collection by sex

Only dry wood is collected for fuelwood and this work is time consuming and the high percentage of children (48%) participating in such tasks (Figure 37) has an impact on their education and in the study area school dropout rate is high at 31.8% (NISR, 2009b).

Photo 25 shows a woman collecting small fallen dried branches in the National University Arboretum and Photo 26 shows school girls (blue uniform) guarding fuelwood at Rango market's fuelwood section in Tumba sector.



Photo 25: Women collecting dead branches Photo 26: Schoolgirls guarding fuelwood for sale

**Photos: ISAR, 2007 for Photo 25; Author for photo 26**

The wood collection journey takes at least two hours (Figure 38). The collection time (2 hours) and the frequency of collection (every second day on average) show that household members, particularly women and children invest a considerable amount of time and energy in fetching fuelwood. They spend six to eight hours weekly collecting fuelwood

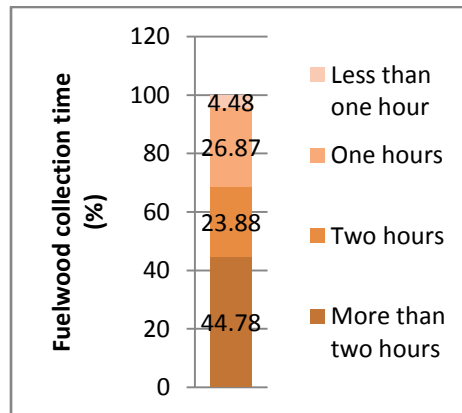


Figure 38: One trip fuelwood collection time (%)

For large amounts (truck load), as for charcoal production, once the wood cutting permit is issued, cut wood is transported to the roadside and packed in steres<sup>64</sup>. Transporters collect wood from the roadsides and take them to retailers, who sell wood directly to households or commercial users, or to the wood section in town markets. For small quantities of wood collected to be sold in town, it is split into head loads to be sold at the firewood section of the market (Photo 27). The average head load weighs 20 kg and costs around US\$ 88, which shows that one kilogramme of fuelwood costs only US\$ 4.4 which is five times cheaper than one kilogramme of charcoal but with half the energy content per kg.

<sup>64</sup> Woodpile weighting 350kg for dried Eucalyptus.



Photo 27: Firewood section at Rango market (Tumba)

Photo: Author

Some individuals specialise in illegal house-to-house selling of wood mainly cut illegally from GoR or district plantations. This is the usual supply for households and small businesses in the area. Results from the survey showed that fuelwood prices have increased by 84% in the last three years (2006 to 2009). To avoid unpreventable price increase, high income households buy fuelwood in steres (a small truck load) that can last up to 6 months, depending on the type of stove used by the household, as revealed by respondents. Only 4% of the households sell fuelwood and the monthly profit from firewood selling is lower (US\$ 53) than for charcoal selling (US\$ 123).

The average daily consumption of fuelwood is 6.1 kg costing around US\$c 26.84. A household using fuelwood will spend roughly half the cost paid by a household using charcoal (US\$c 50).

#### **5.4 Fuels by end use**

In the study area, except LPG, all fuels are available but the household use of any specific fuel is influenced by two factors. The first consideration for any cooking fuel is the cost or affordability (59%) and the second is its availability (53%). For lighting fuels, affordability accounts for 62% and availability for 58% as shown in Table 20. Brightness and safety are less of a consideration in the fuel choice, implying that the use of any fuel is a determined by income rather than preference. If all fuels were equally affordable and available respondents indicated they would

prefer to use electricity: 95% preferred electricity for lighting, 45% for cooking, 60% for heating and 81% for ironing. But even if they had electricity, 81% of surveyed households would not use it, except for lighting, due to its prohibitive cost. No fuel transition from solid fuel to modern fuels has occurred in the study area.

Table 20: Fuel use and choice (%)

Service	Use of two main fuels	Use of two second fuels	First reason for fuel choice	Second reason for fuel choice
Lighting	Kerosene 53 ; Electricity 34	Candles 78; Kerosene 13	Affordability 62	Availability 58
Cooking	Wood 56; Charcoal 35	Charcoal 42 ; Wood 31	Affordability 59	Availability 53

#### 5.4.1 Lighting fuels

Kerosene, electricity and candles are the main fuels used for lighting in all income groups and they total 97.4%; solar, gas and wood are used to a lesser extent (Figure 39). Kerosene is by far the main source of lighting (52.1%) and is mostly used by lower income groups Q1, Q2 and Q3 at 84.6%, 72.2% and 64.1% of households respectively. The higher income groups' main lighting fuel is electricity used by 84.6% of households in Q5 and 51.4% in Q4. Kerosene use decreases with income while electricity use increases with income(Figure 39).

The use of electricity for lighting (35.3%) is higher than the average households' connection (32.5%) in the study area, most likely due to some illegal connection from neighbours.

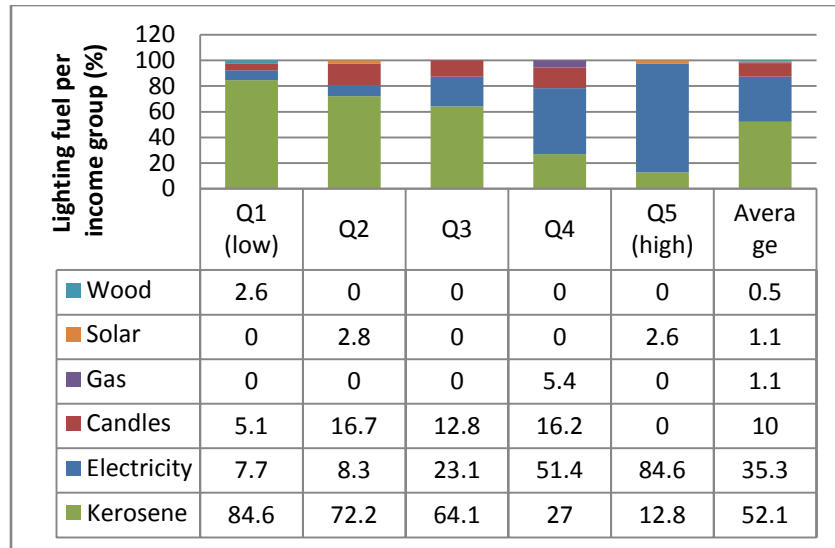


Figure 39: Lighting fuel by income group (%)

#### 5.4.2 Cooking fuels

In all quintiles, households are multiple fuels users and combine mostly firewood and charcoal for cooking. Biomass remains the dominant cooking fuel used by 96.1% of households, slightly lower than the national level of 97% for the same year 2009. Fuelwood (55.7%) and charcoal (35.5%) are the most used fuels for cooking. Fuelwood is the most used fuel. It is commercially available and it can be collected for free but charcoal must be purchased. The use of fuelwood decreases with income whilst the use of charcoal increases with income. The use of electricity for cooking in lower income groups is surprising and may be the result of illegal connections (Figure 40).

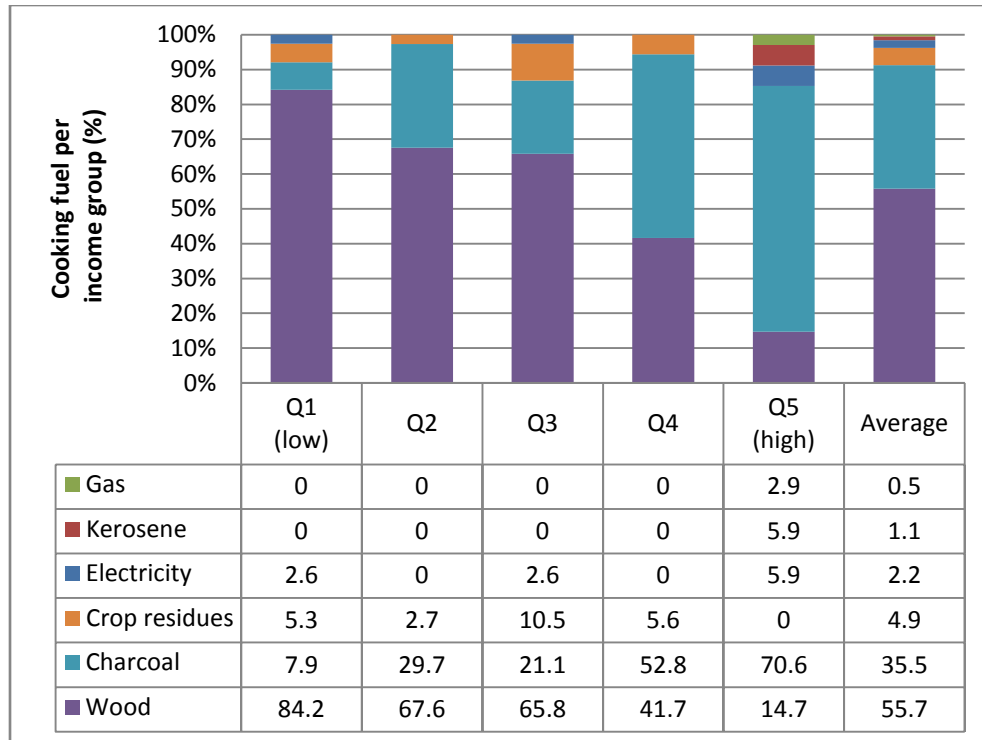


Figure 40: Cooking fuel by income groups (%)

79% of households use fuelwood on a daily basis and 21% use it occasionally: biweekly or once per week. On a daily basis, fuelwood use by income groups decreases with income in all income groups at a rate of 13% on average between Q1 and Q2; Q2 and Q3. The decrease is smaller between Q3 in Q4 (3%) and greater between Q4 to Q5 by 21% (Figure 41).

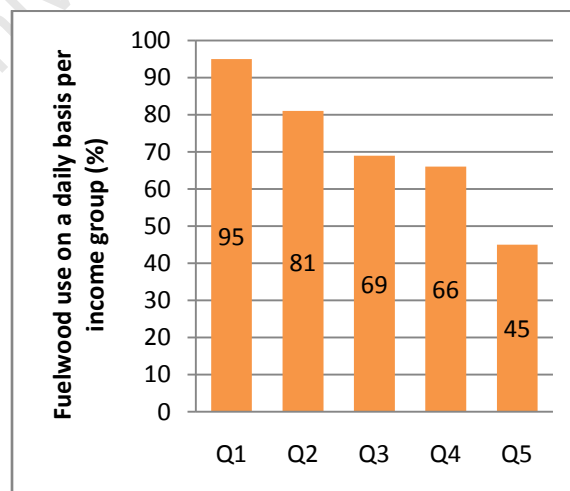


Figure 41: Daily use of firewood by income group

From FGD, the culture of saving on cooking fuels and reducing energy expenses is part of the households' energy planning. Even if some fuels like kerosene are widely used for lighting, the use of costly fuels for cooking remains extremely low which infers the non affordability of modern fuels. FGD unanimously declared that the tree cutting restriction has increased woodfuels' price but still, compared to other fuels, the availability and relatively low cost make charcoal and firewood the most used fuels.

### 5.4.3 Income spent on woodfuels

The mean income of the sampled group is 63,200 RWF (US\$ 111)<sup>65</sup>. With a monthly average consumption of two bags of charcoal totalling 8,000 RWF (US\$ 14), on average households using charcoal as the single cooking fuel would have spent 13% of their income on charcoal in 2009. Figure 42 shows that the share of income spent on woodfuel decreases with increasing income.

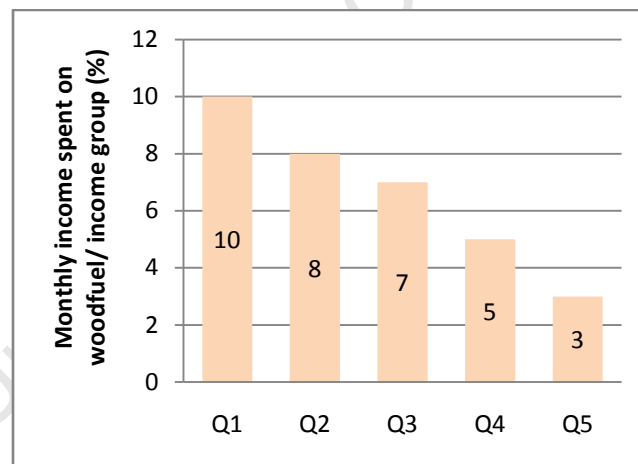


Figure 42: Percentage of income spent on woodfuels (Monthly)

On average 40% of households in all income groups collect fuelwood which is not reflected in household's energy burden as it is difficult to attribute an exact monetary value to self collected fuelwood as the frequency; distance and time spent in collecting fuelwood differ from household to household. Additionally, the energy burden is very difficult to assess as households do not

<sup>65</sup> The 2009 exchange rate was US\$1=570RWF.

keep records for household expenditure. The EICV2 (NISR, 2006a) has estimated the energy burden in Rwanda at 14%. In the study area the contribution of charcoal and fuelwood use for cooking by income is as in Figure 43.

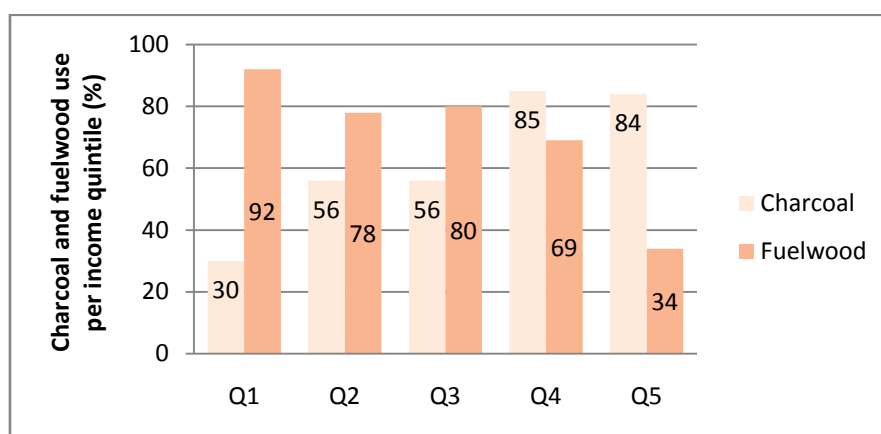


Figure 43: Combination of fuelwood and charcoal use for cooking by income group (%)

#### 5.4.5 Fuel saving strategies

To save on fuel cost, households adopt different woodfuel management strategies such as:

- Hot meals, which take longer to cook like beans, being prepared in large quantity with fuelwood instead of charcoal and are used for later meals;
- Utilising woodfuel as efficiently as possible by retaining and extinguishing all scraps of wood or extinguishing burning charcoal with water after the meal is cooked;
- Cooking excess food at one time to be warmed or eaten cold for the next mealtime with consequence that food could deteriorate.

#### 5.5. Woodfuels stoves

In the study area 41% of households have charcoal-burning stoves. Sixteen percent use outside fire places, 29% use inside fire places while 13% have improved wood-burning stoves (Figure 44). All stoves use either charcoal or fuelwood, any model of stove on local market burns both fuels. One percent use other stoves.

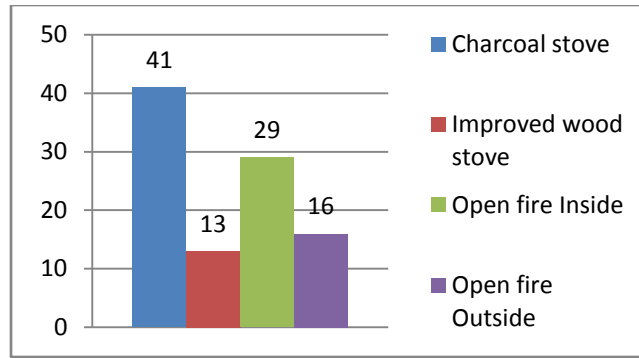


Figure 44: Distribution of stoves by type (%)

The distribution of charcoal, improved wood-burning and open fires stoves among income groups are reflected in Figure 45. As readable on Figure 45, outside open fire are more used in Q2, open fire inside-with risks associated to indoor air pollution- in Q1, improved wood stove mainly used in Q3 while charcoal stoves are mostly used in Q5.

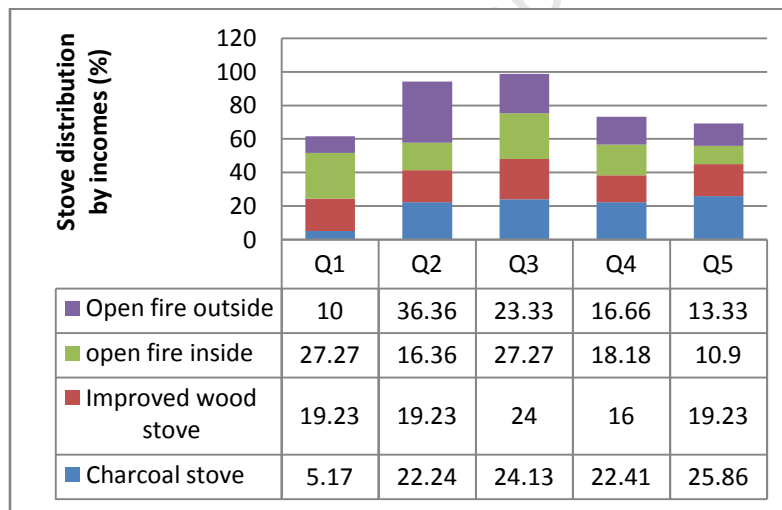


Figure 45: Distribution of woodfuelburning stoves among income groups

### 5.5.1 Charcoal stoves

Canamake and Rondereza stoves (Photo 28) are the popular stoves in the study area. A Canamake is a ceramic stove and a Rondereza was previously an all metal stove, but the current model used in the studied area is a ceramic-metal one with a ceramic fire basket. The ceramic

Canamake is very cheap and costs US\$c 350 but breaks easily and Rondereza costs US\$ 1.5. Both stoves are designed by local craftsmen and have no standardised sizes.



Photo 28: Canamake and Rondereza stoves

Photo: Author

In almost all houses, these stoves are used outside which could reduce efficiency by wind convection but reduces indoor air pollution. The relative low cost of these two stoves, lack of local diversity in charcoal stoves limits the opportunity to upgrade to more efficient stoves and make greater saving on fuels. The researcher's earlier comparative efficiency studies of locally used stoves are illustrated in Figure 46.

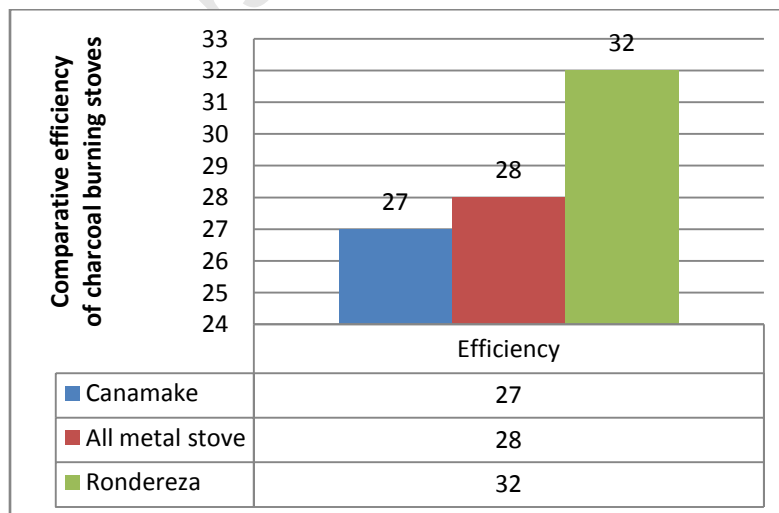


Figure 46: Comparative efficiency of charcoal burning stoves (%).

### 5.5.2 Fuelwood stoves

The traditional three stones open fires (Photo 29) are still common and are used by 45% of surveyed households.



Photo 29: Traditional three stone open fire

Photo: Author

In the study area, the improved wood-burning stoves are used by 13% of households. The most disseminated is the army stove (Photo 30). Since 2005, the built-in stove was an initiative of the Rwandan Defence Forces (RDF) through all its units. Soldiers first built improved cooking stoves (ICS) for the poorest households; thereafter selected local people and trained them in construction of ICS as on Photo 30. Once back in villages, trained builders trained neighbours and so on



Photo 30: Improved (Army stove) wood burning stove under construction

Photo: REMA, 2009

Measured efficiency of the three stoves, Canamake and Kenyan Upesi which is today being sold in Rwanda are reflected in Figure 47.

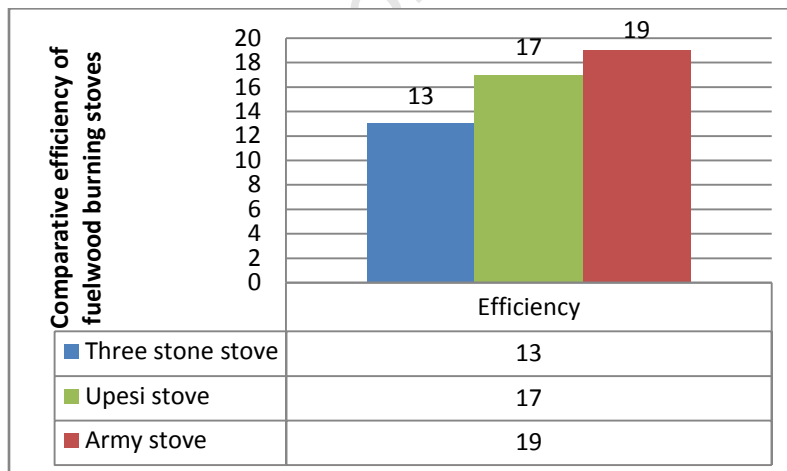


Figure 47: Comparative efficiency of fuelwood burning stoves (%)

Architecture of ICS differs by income. In low income households improved stoves are built-in rectangular mud stoves with two or three pot openings (Photos 31) and only some have chimneys.



Photo 31: Improved wood stoves in low income households

Photo: Author

The type of improved fuelwood stove used depends on the household's purchasing power as the building cost depends on desired design and can be as high as US\$ 100. Photo 32 and Photo 33 show the type of fuelwood ICS in mid and high income households.



Photo 32: Mid income indoor wood ICS      Photo 33: High income indoor wood ICS

Photo: Author

Only 9% of wood-burning stoves used in the study area are connected to a chimney. It is therefore obvious that the local population is exposed to indoor air pollution mostly by the lowest income group (Figure 48).

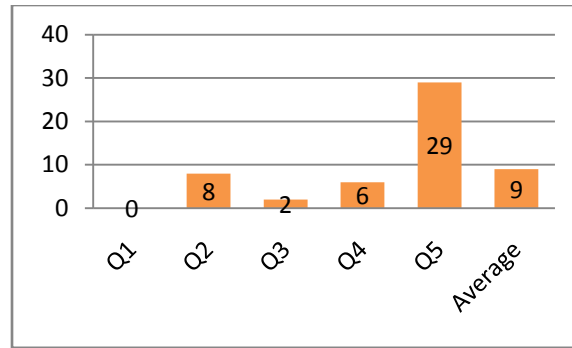


Figure 48: Households with fuelwood stoves connected to chimneys (%)

From the survey the only health problem which could be related to indoor air pollution (IAP) were eye problems indicated by 6% of households, mostly affecting children under five years. From the FGD it was clear that they are not aware of IAP as they revealed that people braaing for commercial purposes in bars are the only ones affected by smoke exposure and related diseases, not those using woodfuel in household kitchens. FGD reported that such persons hardly survive five years in such jobs.

A survey by NISR (2009c) gives the improved fuelwood cooking stove penetration rate to be 55% at national level. The Eastern Province has the highest penetration rate with 74% of households using these stoves, followed by the Southern Province with 63%. The Western Province is in third position with 60% and the Northern Province in fourth position with 56%. Penetration rate in Kigali<sup>66</sup> city is at 20%. Huye, district of our case study, the penetration rate is 58%, five percent lower than the overall penetration of the province and only 13% of surveyed households have improved fuelwood burning stoves.

National figures very often are from districts' reports who want to prove that they have fulfilled their annual "Performance Contracts" (Imihigo) signed every year between the district mayor and the President of the Republic. So in general, these data should be used with caution as the wood consumption does not decrease with alleged improved cooking stoves penetration rate.

For example Nyaruguru district in the Southern Province assumes a penetration rate of 60% and the wood consumption is 1147 kg/person/year, whereas Musanze in the Northern Province with a

<sup>66</sup>Kigali City and other towns use mostly charcoal for cooking.

penetration rate of 43% household average fuelwood consumption is only 247 kg/person/year (Table 21).

Table 21: Wood consumption, household size and improved stove penetration<sup>67</sup>

Province	Northern Province			Southern Province			National
District	Burera	Ngororero	Musanze	Nyaruguru	Ruhango	Nyamagabe	
Household size	5.8	5.5	5.8	5.9	5.6	5.9	5.5
Improved Stove	44.0	45.9	43.0	59.8	43.94	58.3	55.48
Woodfuel consumption	297.0	291.0	247.0	1147.0	982.0	860.0	501.0

Source: NISR, 2009c and MININFRA, 2009a

In 2007 an average annual consumption of 1,640 kg of wood per household for a traditional stove and 1,260 kg for an improved stove was reported (USAID , 2007).

MININFRA (2009c) survey claims a consumption of 2,755 kg of woodfuel per household<sup>68</sup> per year for Rwanda which translates in a 52% increase in woodfuel consumption in two years despite an anticipated increase in ICS use.

As there are no official or independent evaluations to demonstrate, at national level, the dissemination, the actual use and the level of savings (efficiency) of these ICS, there is need of an in-depth study to check if these ICS are actually installed and really used, or if the alleged penetration rates and woodfuel consumptions are as they are reported.

Three main factors limit the improved stove adoption as revealed the FDG:

- First, the locally available improved wood-burning stoves are built-in ones; therefore only people living in their own house can transform it to build an improved wood-burning stove. People who rent houses are not allowed to do so.

<sup>67</sup> Fuelwood consumption are expressed in kg/person/year, household size in persons and stove penetration in percentage.

<sup>68</sup> 5.5 persons per household and 501 kg/person/year

- Second, generally households respond most to fuel savings when fuel is very scarce or highly monetized. In the study area, even the low income groups can still collect fuelwood (45%) and the cost of fuelwood is relatively low at four US\$c per kilogramme. Third, and to a lesser extent, is the general lack of diversity in improved cooking stoves on the local markets, both for charcoal and fuelwood.

## 5.6 Conclusion

The charcoal production and trade contribute to job creation and income generation in both rural and urban areas. Along the entire chain, wood owner, charcoal master, foreman, labourers, retailers and transporters are getting their share of income. Conversely, the clear felling and other malpractices within the process could lead to deforestation and soil erosion, but, managed on an environmentally sound basis, the business could be environmentally benign and provide a permanent source of income and contribute as such to rural and urban poverty alleviation.

Still some challenges persist, apart from the tree-cutting permit issuance, the local government doesn't scrupulously monitor the wood exploitation process (tree-cutting, keeping statistics or tree replenishment) as required by the harvesting regulations. Immature trees are cut and carbonised which leads to both low efficiency and forest depletion. The tree-cutting permit is valid for a short time period and affects the wood-drying period. This impacts on carbonisation efficiency as part of energy will be lost in drying the wood under carbonisation; carbonisation emissions are also higher with wet wood than dried wood. More flexibility in wood-exploitation permit would extend drying time, improve efficiency, and reduce carbonisation emissions.

Neither wood nor charcoal is weighed before or after carbonisation to assess the efficiency of carbonisation to forecast the supply. Traditional charcoaling technology is less efficient and contributes to forest depletion but modern kiln technologies are more expensive mainly for capital investment. Working in charcoal dealer associations could facilitate access to loans for first investment in modern kilns to make a more professional and modern charcoal industry.

There is need for technology to change so as to increase the efficiency of kiln carbonisation. With the current 14% charcoal production efficiency, seven kilogram's of wood are needed to produce one kilogramme of charcoal which costs five times the price of one kilogram of fuelwood. Investigations revealed that actually there is no more illegal charcoal making in the Nyungwe National Park which actually is a great achievement in the conservation of the park. Conversely as the labour used in kiln unloading comprises school age children, the proposed CBWP management committee as representative of the community in the charcoal industry should control and prevent child labour in such activities and reintegrate them in schools.

Woodfuel consumption in the study area remains high at 96% of household cooking needs, one percent less than the national figure of 97%. Locally, there is lack of diversity of ICS models and woodfuel is available and still affordable which delays the massive adoption of the improved woodfuel stoves program. Among the few locally existing wood-burning stoves, the Army stove is more efficient (23%) compared to the Kenyan Upesi under popularisation (20%) and the three stones (14%). For the charcoal burning ones the clay and metal (Rondereza) is the most efficient (32%), the all metal (28%) and the clay stove Canamake (26%). One could think that the yearly woodfuel price increase which remains high compared to national inflation would push people to adopt the improved woodfuelburning stoves but still only 13% have improved cooking stoves while 41% have improved charcoal-burning stoves.

Farm land holding is very small as 32% of households have less than 0.1 ha which reduces accessibility to collected fuelwood on individual land. This makes it difficult for the poor to access fuelwood for collection and they have to pay 10% of their meagre incomes for woodfuel. The IAP awareness is very low as only 9% of households are connected to a chimney. Therefore, there is need for an aggressive ICS programme campaign to save wood, incomes and life.

The fuel transition is an enduring biomass mix. Overall woodfuels are used by all income groups for cooking. Charcoal being more used by high income groups and fuelwood by lower ones. Modern fuels are hardly used for cooking.

The wood products' regulation on cutting, transport and carbonisation are perceived as the main cause of woodfuel price increase and producers and consumers call for its removal. They do not

oppose environmental resource management's regulation but its policy instruments. They are ready to be collaborative in sustainable woodfuel and forest management that will make regulation more effective. Policy makers therefore must be more responsible in monitoring the implementation of law and regulation while local government at district and sector level should strictly implement guidelines as recommended by due authority. One of the examples given by interviewed persons concern the delay on wood cutting permit, when someone wants to cut and sell wood from his own plantation in urgent need of money such as for school fees or a hospital bill to be paid. Poverty level is high as 77.6% admit to be poor and lack and unequal distribution of land are the chief factors of poverty in the study area.

University of Cape Town

## **CHAPTER SIX**

### **CONCLUSIONS AND RECOMANDATIONS**

#### **6.1 Introduction**

Rwanda is a poor, landlocked and very densely populated country in Eastern Africa. It has no proven fossil fuel resources and depends mainly on biomass energy. High population density, poverty and woodfuel dependence are linked to environmental degradation. The interdependent impacts of these factors deepen poverty, hasten environmental degradation and result in energy poverty.

Rwanda's population is predominantly rural and is largely dependent on subsistence agriculture. Population growth and the lack of modern technology-based agriculture lead to smaller and smaller land holdings and decreasing harvests and deepening rural poverty.

The population grew six fold in seven decades and more people required more land for food, fodder and woodfuels. They converted forests and marginal land often on steep mountain slopes. The absence of conservation practices lead to widespread soil degradation resulting in poor harvests and the need to convert more land to agriculture. With the growing population the demand for wood, both fuelwood and other round wood, outstripped supply from the forest.

#### **6.2 Energy, poverty and forestry in Rwanda**

Biomass is the main source of energy in Rwanda and accounts for 86% of primary energy, petroleum products make up 11% and hydro and thermal power for electricity are 3%. All petroleum products have to be imported by road tankers from the East African ports Mombasa and Dar es Salaam at a distance of 1792 km and 1620 km respectively. Retail prices of petroleum products are 100% more than acquisition cost and the import of petroleum products consumed over 40% of Rwanda's foreign exchange earnings. The high dependence on biomass for energy is comparable to other neighbouring countries and many countries in sub-Saharan Africa.

Poverty is widespread in Rwanda and 57% of households live below the poverty line. High poverty levels and high population growth rates impact on forestry resources in several ways. More people need more farmland for growing food and fodder as well as houses and general

infrastructure such as roads and schools. More forestry products are also required, for example, poles are needed for building houses and woodfuels for cooking. From 1960 to 2007, the natural forest cover decreased from 685 500 ha to 127 000 ha and in 2007 forest covered only 10.1% of the country. At the same time population increased from 2.7 million to 9.3 million. In this period government, alarmed by the disappearance of large tracts of forest, encouraged tree planting and forest plantations outside natural forests and forest plantations increased from 24 000 ha in 1960 to 127 000 in 2007. It is estimated that clearance for agriculture contributed about 80% to deforestation. The need for fuelwood and charcoal did contribute to deforestation but very much less than agriculture.

The high dependence on woodfuels is due to the high cost of modern fuels such as electricity, LPGas and kerosene. Even if households have an electricity connection, electricity is only used for lighting, refrigeration and communication and woodfuels are used for cooking.

### **6.3 Woodfuel consumption and supply**

Worldwide woodfuel consumption increased by nearly 80% from 1961 to 1998 slightly lagging behind the world population growth of 92% over the same time period. However, globally per capita consumption of woodfuels is decreasing due to rising incomes, urbanization, declining wood resources and increasing access to modern energy sources. In 2007 almost half of all forest harvest was for energy and the remainder for industrial use. Only in Africa, Asia except China and non-OECD countries in the Americas, total woodfuel consumption is increasing due to poverty and population growth. In Eastern Africa on average, 96.46% of the population use woodfuels for cooking, 82.68% use fuelwood and 13.8% use charcoal. Due to high levels of poverty and steady population growth it is expected that woodfuel consumption will continue to rise in developing countries putting a strain on areas from where the woodfuel is obtained. This strain is more acute near expanding towns and in peri-urban areas.

In Rwanda, 77% of the total wood product removal is for energy use. About 80% of wood for energy is grown on plantations of less than 0.5 ha and these small plantations are not defined as forest in Rwanda. Natural forests are conserved by a network of federally controlled areas and wood cutting and charcoal production is negligible. Charcoal is produced very inefficiently and

seven kilograms of fuelwood are transformed to only one kilogram of charcoal. The introduction of more efficient charcoal technologies would contribute to conserving the fuelwood resource.

The environmental impact of woodfuel production and harvesting can be positive or negative. When produced and harvested sustainably, they are a renewable source of energy with low net carbon emissions. Tree planting on degraded soil can improve biodiversity, soil and water resources. Main environmental risks are associated with overharvesting and clear felling. To maximize profits, charcoal makers in Rwanda practice clear felling without replanting leading to deforestation and subsequent soil degradation. Emissions from charcoal production via pyrolysis release products of incomplete combustion into the environment which contribute to global warming. Emissions from woodfuel burning in open fires also contribute to global warming. Improved stoves can reduce these emissions by 50 to 70% and save fuelwood by 40 to 50%. Practising sustainable harvesting and using improved cookstoves is also important in order to support the Millennium Development Goals.

The contribution of woodfuels to the national economy is significant. In 2007, the woodfuel sector generated US\$122 million (5% of GDP) almost twice as much as electricity sales. About 50% of this amount remains in rural areas distributed among farmers, wood growers and cutters and charcoalers. The woodfuel industry creates jobs, alleviates poverty and has the potential to be an engine of growth in rural areas.

Annual woodfuel demand by households and institutions is 5.5 million m<sup>3</sup>. Industrial demand is much lower at 155 550 m<sup>3</sup> per year. Tea and sugar factories, brick firing (despite the ban), restaurants and bakeries use woodfuels.

Some progress has been made substituting biogas for fuelwood and 10 out of 14 prisons have installed biogas plants reducing their fuelwood demand by 50%.

In Rwanda woodfuel supply is different from other African countries as most of the woodfuel is sourced from private and community forest plantations and not from natural forests. Private forest plantations contribute 73% to the woodfuel supply, community forest plantations 22% and government plantations 4%. Households obtain biomass fuels from a variety of sources. Nine percent of households use crop residues for cooking, 26% purchase fuelwood and 57% collect fuelwood from small plantations, farms and homesteads. The wood for charcoal which 5% of households use for cooking is harvested from forest plantations.

In the 1980s the Eastern districts supplied most charcoal to the capital Kigali at a distance of initially 60 km and later 120 km as the nearer areas were deforested. At present 70% of charcoal consumed in Kigali is produced in Southern and 27% in Western districts at a distance of about 180 km. Charcoal for local consumption is produced in all districts.

In Rwanda low energy efficiency in woodfuel burning and particularly in charcoal production are common. Charcoal is produced in traditional earth kilns and 73% of the energy content of the wood is lost in the charcoaling process. Efficient charcoal kilns had been introduced in the 1980s but the new technologies and kilns were adopted only for a short time and then abandoned. These good technologies were abandoned once the subsidies were stopped. Since 2011 onwards they are being again revigorated by some NGO's and government projects supported by IFDC<sup>69</sup>, Care International, Vi – Life, World Bank through EWSA, PAREF<sup>70</sup> through Belgium Technical Cooperation and Netherlands Embassy. For example within SEW<sup>71</sup> Project, there are currently 54 charcoal makers cooperatives with 26 already trained on improved techniques. In addition, a well organized national Professional Charcoal Makers Cooperative (PCMC – Rwanda) is playing a great role in improved carbonization techniques training under support of IFDC/SEW Project<sup>72</sup>. Improved cookstoves and kilns are desirable to conserve wood resources and reduce emissions and their dissemination must be accompanied by repeated training and education.

The woodfuel industry in Rwanda is well established and its main strength is that it supplies regularly locally produced fuels at reasonable cost. Restrictive government measures such as bans on tree cutting did not result in shortages or alarming price increases. Compared to modern energy sources such as electricity, kerosene and LPG, woodfuels remain the least expensive cooking fuels and they are easily available in Rwanda. The major barriers to modernize the industry are low efficiency of charcoal production and the low priority of woodfuels at policy level.

It is concluded that woodfuels in Rwanda, if well managed, could be sustainably produced with little impact on deforestation.

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<sup>69</sup>International Fertilizer Development Center

<sup>70</sup>Projet d' Apuit à la Reforestation (Reforestation Support Project)

<sup>71</sup>Sustainable Energy Production Through Woodlots and Agroforestry

<sup>72</sup>[www.ifdc.org/Nations/Rwanda](http://www.ifdc.org/Nations/Rwanda)

## 6.4 Woodfuel and related policies in Rwanda

The heavy reliance on woodfuel for energy in Rwanda is seen as damaging to the environment and to forests. Policies regulating the production and use of woodfuels have to consider that

- The contribution of woodfuels to the national energy balance remains very high and woodfuels are the only affordable source of household energy and will remain so, at least, in the medium term future.
- Woodfuels are the locally produced alternative to imported fuels and save limited foreign exchange
- Woodfuels are a renewable resource and, when well managed, can be sustainably produced until alternatives become available
- In rural and urban areas woodfuels are an important source of income and contribute to poverty reduction

Globally, contributions to direct deforestation from subsistence farming is as high as 63%; permanent agriculture 16% and (over) exploitation for woodfuel 8% (Marcoux,2000). Therefore, global contribution of woodfuel to deforestation is fairly low. In the absence of evidence based understanding of the different factors leading to deforestation, in Rwanda, woodfuels have generally been blamed as the main cause of natural forest decline but today woodfuels are not sourced from natural forests but from forest plantations. If woodfuel plantations are well managed, harvesting of woodfuel does not necessarily lead to environmental change, forest depletion and soil degradation.

Misunderstanding this situation coupled with top-down forest management at district level lead to restrictive guidelines ignoring the socio-economic benefits which flow from the entire woodfuels value chain. The forest sector is understaffed and underfunded and is ineffective to implement over-bureaucratic regulations at the local level. At the national level, the Ministry of Natural Resources handles the supply side of the biomass sector and the Ministry of Infrastructure deals with the demand side. This management structure appears to be ineffective as it is difficult to address the closely related aspects of the woodfuel sector holistically. Energy policies recommend a move away from traditional biomass fuels in favour of unavailable and unaffordable imported modern fuels. Environmental policies impose very restrictive harvesting regulations prompting woodfuel producers to operate illegally leading to hurried, clandestine and

unsustainable woodfuel harvesting and charcoal production. Forest protection and regeneration is not achieved, woodfuels are not sustainably produced and the benefits of the industry are not well distributed to alleviate poverty.

Woodfuels will remain the primary source of energy in the foreseeable future and it is necessary to regulate the sector in such a way as to support sustainable harvesting and production of woodfuels as well as to optimize the socio-economic benefits the sector can provide. The sustainable use of the traditional woodfuels should be a step towards modernizing the sector as well as leading to the transition of modern energy sources.

To implement a sustainable woodfuel production, it is proposed to shift from the present forest management at district level to a Community Based Forest Management (CBFM), Community Based Woodfuel Production (CBWP) and Forest Replenishment Associations (FRA) adapted to the Rwandan situation. Miranda (2010) confirm that these approaches have been in operation for the past 20 years in different regions and under different political circumstances (Senegal, Niger in Africa and Brazil and Nicaragua in Latin America). CBFM engages communities in forest management on community/publicly-owned land and FRA works on privately owned land. Both types of ownership are common in Rwanda. The strategies promote sustainable forestry among participants as well as full rights over the end product, full stakeholder responsibility for sustainable management and provision of incentives. The strategies seek to implement a balanced combination of effective forest governance/law enforcement and particular incentives for local stakeholders and the emergence of a transparent and equitable market framework.

## **6.5 Understanding the situation on the ground – conclusions from the case study**

A woodfuels survey was carried out to verify and complement the secondary data analyses in the earlier chapters. Fuelwood and charcoal production, transport, sale and consumption was investigated in two districts in the Southern province of Rwanda.

Woodfuel use in the two areas remains very high and 96% of households cook with it - one percent less than the national average of 97%.

Households have very small farming plots and 32% of the poor have less than 0.1 ha making subsistence farming impossible and access to self collected woodfuels from their own land difficult. The poor have to purchase woodfuels paying 10% of their income.

Comparable to the 77% national average, in the study area, about 76% of trees cut are for woodfuels, the remaining are cut for kraals, fences, poles, fuelwood and charcoal making. Local people feel that wood cutting and charcoal making is overregulated and wood cutting permits take too long to obtain. Sixteen percent of fuelwood sellers and 4% of charcoal makers admit to illegal tree cutting from public plantations.

Woodfuels are easily available and still affordable delaying the adoption of improved cookstoves. There are some locally sold improved woodfuel cookstoves. The Army fuelwood stove is more efficient (23%) than the Kenyan Upesi stove (20%) and the three stones (14%). There are three charcoal stoves available. The clay and metal Rondereza stove is more efficient (32%) than the all metal stove (28%) and the clay stove (26%). The yearly price increase of woodfuels has not yet pushed people to widely adopt the improved woodfuel stoves. Only 13% of households have improved fuelwood stoves while the improved charcoal stoves are more widely used (41%).

Some of the regulations are not conducive to saving woodfuel resources. The tree cutting permit is valid for a short period of time and this affects the wood drying process and the efficiency of the carbonisation process as part of the energy will be lost in drying the wood. Carbonisation emissions are also higher with wet wood than with dry wood. Extending the duration of the wood exploitation permits would extend drying time, improve efficiency and reduce carbonisation emission.

The district authorities do not carefully monitor the wood exploitation process and are not keeping statistics on tree cutting and replenishment as required by the harvesting regulations. Immature trees are cut and carbonised leading to low carbonisation efficiency and forest depletion. Neither wood nor charcoal is weighed before or after carbonisation to assess the efficiency of the process and estimate supply.

The woodfuel production and trade contributes to job creation in both rural and urban areas. Along the entire value chain wood owners, charcoal masters, foremen, labourers, transporters and retailers are getting their share of income. These shares could increase and wood resources could become more sustainable if the links in the chain as well as the entire chain become more efficient.

## **6.6 Recommendations**

The general recommendation is for the government to use a participatory approach and make all people involved in the woodfuel chain stakeholders of the national woodfuel enterprise. Other specific recommendation such as decentralising responsibilities and incentives to the local level will flow from the general conclusion.

### **6.6.1 The role of the Rwandan Government**

Government should acknowledge the value of woodfuels as the chief source of energy for the people and recognise and enhance the socio-economic benefits of woodfuels.

Firstly, Government decision makers need to halt the demand driven exploitation of this natural resource to adopt production oriented management of woodfuels. For this to happen, a participatory bottom-up energy planning approach is needed, with input from the community, to understand peoples' priorities and needs. A bottom-up process where beneficiaries are involved in decision making is more likely to be effective than a top-down approach where the population feels frustrated as they have not expressed their views and needs. Community governance has an important role to play in the sustainability and effectiveness of infrastructure and energy service delivery. Communities need to be involved in energy project planning to facilitate their implementation and ensure proper management of energy resources. For this reason their inputs need to be considered during policy development. On this basis it is possible, even for low-income population groups, to share the environmental, economic, and social benefits of sound energy policies.

Secondly, the GoR should consider creating one institution responsible for the coordination of the energy sector at national level, as has been done in other countries (Mali and Madagascar for Biomass and Electricity) or set up a separate body dealing only with biomass energy like in Sudan where there is a specific institution, a government parastatal, to implement wood energy policies (Christophersen & Butare, 2000). This will ensure coordination of the energy sector and avoid the present situation where biomass resources are regulated under different ministries. It is time for the GoR to do away with conflicting policies and institutional interference by

implementing the long awaited National Energy Development Agency (NEDA) which has been planned but has not yet been established. Once this energy agency is created, the GoR should allocate it adequate financial and human resources. The principal mission of such institution would be to develop an efficient and effective system regulating the industry.

Thirdly, the GoR should revisit policies on energy, forests and other environmental concerns to clarify the exact role of biomass energy which meets, over all income groups, 86% of household energy demand. Ensuring the sustainable supply and efficient usage of woodfuels should be an urgent government objective, and should include the promotion of alternative energy sources, strengthening of institutional capacity, and the installation of a strong monitoring and evaluation system for the sector.

Fourthly, planning tools should be used to evaluate the woodfuel demand/supply balance and identify the “hot spots” (regions where the deficit is high and need immediate intervention to avoid deeper deforestation). Interventions have to be developed at local level, as woodfuel problems are often locally specific. Some districts, even with high forest resources (Nyamagabe) are being overexploited and even the districts which are less endowed with forestry resources (such as Ruhango) are currently key producers of woodfuels which, after a short period, could result in local forest degradation.

Fifthly, the sector would benefit from government encouragement of the private sector (hotels, motels, restaurants) cooperation in switching to cleaner fuels like LPG for cooking and solar for water heating to save on electricity in such institutions (substitute more). But for this to happen these imported fuels need to be subsidised. Large scale adoption of improved cookstoves for households and institutions can reduce wood and charcoal consumption significantly through the energy conservation policies (save more). Research institutions like Institut de Recherches Scientifiques et Technologiques (IRST) together with the department of energy should invest more in research on woodfuel stoves to improve efficiency, standards and dissemination of efficient improved stoves in both households and institutions.

Last but not least, there is a need to strengthen the institutions involved in forest management both financially and in personnel as the sector is understaffed and underfunded. This will help in monitoring and evaluation of wood planting programs and implementation of policy instruments.

## **6.6 Decentralising woodfuel production**

With regard to the decentralised units (districts) supporting forest management and economic productivity, the following recommendations could help in mapping the road ahead.

First, institutions involved in the charcoal value chain, mainly the Ministry of Natural Resources (environment) and the Ministry of Infrastructure (energy), should intervene and advocate to local administrations that charcoal is not a forbidden fuel, that it can be produced relatively efficiently if the conditions are right, and that it is a major contributor to the economic development of the sectors and the districts.

Second, the districts could organise joint forest management (JFM) by community-based forest management committees (CBFM) through CBWP and FRA at sector and cell level. This could stop illegal cutting in public plantations. To improve forest production requires management plans for restoring public and district plantations. Forest production could also be increased by planting appropriate trees for specific locations and by correct cutting methods. To increase charcoal carbonisation efficiency and reduce wood consumption, local bodies of professional charcoalers could be trained and organised into a formal association recognized by the local authorities. Monitoring, evaluation and record keeping on replenishment, as requested in the tree cutting permits, needs to be strengthened, to avoid forests being converted to agricultural land and to improve woodfuel statistics. These processes could be monitored by the CBFM.

Third, improvement and enforcement of the taxation system is vital, as the present decentralised tax system, without general guidelines, is too bureaucratic and is therefore not respected. It is estimated that about 31% of charcoal is illegal and in total 50% of all woodfuels producers evade taxes. An increase in taxation will on the one hand increase woodfuel prices, but on the other hand, push users to use fuel saving stoves to minimise both wood and fuel expenditure and

charcoal makers to more efficient kilns (to maximize profits). In both cases there will be a net reduction in woodfuel consumption (saving more). The existing licensing and restriction system provides profits to districts which do not reinvest in reforestation. The one percent transaction fee paid to the NFF as required by the law is not enough to ensure seed supplies and increased forest plantation (planting more). The harmonisation of the permit system with a unified standard system based on the taxation of products at transport level and licensing enforcement based on the involvement of the local community is therefore required. Fixed taxes for every category of tree chopped will be paid (fuelwood, wood for charcoal, poles), with a percentage going to the local government for plantation management and another to the NFF to be strictly used for reforestation efforts (forests regeneration or planting). A high tax on charcoal production will encourage producers to construct more efficient kilns and consumers to adopt more efficient stoves.

Fourth, regulations prohibiting the production of woodfuels do not help farmers, the rural or urban population, or the local administrations. It would be best if regulations are as light as possible to encourage farmers to plant trees and charcoal makers to use efficient carbonisation methods (wood drying, improved kilning). For both public and private plantations, regulations should be in place but not fixed, rather, dynamic as the sector progresses and more challenges and opportunities arise to enable a rapid response to unforeseen changes and fraud.

Fifth, woodfuel dealers could be encouraged to form cooperatives, for example women's cooperatives, as in Rwanda women and children are the main actors in woodfuel collection or purchase. These cooperatives could organise wood sellers or charcoal makers in associations to promote economic productivity and rational utilisation and make it easier to access funds (loans) from local micro-finance institution like Umurenge SACCO (Savings and Credit Cooperatives) no available in each sector to make the sector more professional and productive.

Sixth, the study does not pretend to be exhaustive but could serve as a starting point for future studies on woodfuels and other forest resources in Rwanda. Further interdisciplinary research could identify the interaction of demographic processes and the demand for forest resources as well as forest resource changes and their causes over time.

This would lead to identifying priority areas for action and the development of holistic strategies and programmes to mitigate the adverse environmental and socio-economic impact on human populations and find ways of making the local people beneficiaries of their forests and taking over the stewardship of their environment.

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## REFERENCES

- ADF. (2001). Rwanda: Forestry Management Support Project. Kigali, Rwanda: African Development Bank.
- ADF. (2010). Interconnection of Electric Grids of Nile Equatorial Lakes Countries: Burundi, Kenya, Uganda, DR Congo, and Rwanda. Tunis, Tunisia: African Development Bank.
- AGIA.(2009). *Alaska natural gas pipeline*. Retrieved May 18, 2009, from <http://www.gov.state.ak.us/agia>.
- ARC. (2010). Aproveco Research Centre. Retrieved October 24, 2010, from <http://www.aprovecho.org>.
- Arnold, M., Köhlin, G, Persson, R., & Shepherd, G. (2003). *Fuelwood revisited: What has changed in the last decade?* Jakarta, India: Center for International Forestry Research.
- Bailis, R. (2006). *Fuel from the Savanna: The social and environmental implications of the charcoal trade in sub-Saharan Africa*. (Unpublished PhD thesis) University of California, Berkeley, CA.
- Barnes, D., & Floor, W.M. (1996). Rural energy in developing countries: A challenge for economic development. *Annual Review of Energy and Environment*, 21:497–530.
- Bitanuzire, S. (2003). Rwanda Forests-Their abrupt destruction and recovery programme. Proceedings of the XII World Forestry Congress. Quebec City, Canada: FAO.
- Broadhead, J. (2008). *Forest and energy: Key issues*. Rome, Italy: Food and Agriculture Organisation.
- Bush, G., Kanobayita, A., & Masozera, A. (2005). *Mainstreaming poverty- environment linkage in the european community's development assistance*. Kigali, Rwanda: Rwanda Environment Management Authority.
- Butare, A., & Hughes, M. (2004). *Energy biomass supply survey*. Kigali, Rwanda: Ministry of Finance and Economic Planning.
- Butera, A. (2009). *Statistical data on wood consumption in tea factories*. Kigali, Rwanda: Office des Cultures Industrielles du Rwanda-THE.
- CGISR-NUR. (2007). National Forest Mapping. Butare, Rwanda: National University of Rwanda.

- Chalico, T. A., & Riegelhaupt, E.M. (2001). *A guide for woodfuel surveys*. Rome, Italy: Food and Agriculture Organisation.
- Chemonics International. (2008). Rwanda Environmental Threats and Opportunities Assessment (ETOA) 2008 Update. Kigali, Rwanda: United State Agency for International Development.
- Chomitz, K.M, & Griffiths, C. (2001). An economic analysis and simulation of woodfuel management in the Sahel. *Environmental and Resource Economics*, 19(3), 285-304, doi:10.1023/A: 1011184808319.
- Christophersen, K, & Butare, A. (2000). *Rwanda energy sector rehabilitation study on safeguarding biomass supply: Biomass assessment*. Kigali, Rwanda: Ministry of Energy, Water and Natural Resources.
- Christophersen, K. (1997). *Caleb petroleum gas project: Household energy*. Addis Ababa, Ethiopia: Ministry of Mines and Energy.
- Compare Infobase Limited. (2010). Maps of the world. Retrieved June 15, 2010, from <http://www.infobase.co>.
- DME. (2006). *Digest of South African energy statistics*. Pretoria, South Africa: Department of Minerals and Energy.
- Diamond, J. (2005). *Collapse*. London, UK: Penguin.
- Doll, S. (2006). Assessment of wood-burning cookstove emissions and fuel-efficiency. *Earth Institute Fellow Columbia University*. Columbia
- Dyksta, D.P., Heinrich, R. (1997). *FAO model code of forest harvesting*. Rome, Italy: Food and Agriculture Organisation.
- Earl, D. (1975). *Forest energy and economic development*. Oxford, UK: Clarendon Press.
- Eckholm, E. (1975). *The other energy crisis: Firewood*. Washington, DC: Worldwatch Institute.
- ECOFYS. (2009). *Integrated biomass energy conservation project-Malawi, version 2*. Lilongwe, Malawi: Republic of Malawi.
- Electrogaz. (2004). *Annual Report: 2004*. Kigali, Rwanda: Electrogaz.
- Electrogaz. (2008). *Anual Report: 2008*. Kigali, Rwanda: Electrogaz.
- Electrogaz. (2009). *Power and energy generation: Status of August 2009*. Kigali, Rwanda: Electrogaz.

- Electrogaz.(2010). The sustainable energy development project Electricity Access Scale-up Roll-out Program (EARP).Kigali, Rwanda: Electrogaz.
- Energy Development Institute. (1999). Charcoal Potential in Southern Africa. Stockholm, Sweden: Stockholm Environmental Institute.
- ESMAP. (1987). *Rwanda: Improved charcoal production techniques* (ESMAP Report 065/87). Washington, DC: United Nations Development Programme.
- EU. (2007). *Promoting biofuels as credible alternatives to oil in transport*. Press release. Brussels, Belgium:European Union.
- Foley, G. (1986). *Charcoal making in developing countries*. London, UK: Earthscan.
- FAO. (1981). Map of the fuelwood situation in the developingcountries. Rome, Italy: Food and Agriculture Organisation.
- FAO. (2000). Forest Ressources Assessment. Rome,Italy. Food and Agriculture Organisation.
- FAO. (2003).Global Forest Resources Assessment update -2005 – FRA - 2005 –draft- Terms and Definitions. Rome, Italy: Food and Agriculture Organisation.
- FAO. (2004). Unified bioenergy terminology. Rome, Italy: Food and Agriculture Organisation.
- FAO. (2008). *Understanding forest tenure in Africa: Opportunities and challenges for forest tenure diversification. Forestry policy and institutions Working Paper No.19*. Rome, Italy: Food and Agriculture Organisation.
- FAO. (2009a). *FAO corporate document repository*. Retrieved March 21, 2009, from <http://www.fao.org>.
- FAO.(2009b). FAOSTAT. Retrieved March 21, 2010, from <http://www.fao.org>.
- FAO. (2010). *Criteria and indicators for sustainable woodfuels*. Rome, Italy: Food and Agriculture Organisation.
- Gaafar El Faki, A. (1994). *Studies on consumption of forest products in the Sudan: Woodfuel consumption in the household sector*. Khartoum, Sudan: Forest Development in the Sudan.
- Gahigi, M. (2009). Peat mining saves CIMERWA. *The Newtimes*. Retrieved June 12, 2009, from [http:// www.newtimes.co.rw](http://www.newtimes.co.rw).
- GEF. (2009). District development plans updated to reflect biodiversity. Kigali, Rwanda: United Nations Development Programme
- GoK. (2009). The forest (charcoal) regulations (draft). Nairobi, Kenya: Government of Kenya.

- GTZ. (2008). *Rwanda biomass energy strategy: Executive summary*. Kigali, Rwanda: Gesellschaft fur Technische Zusammenarbeit
- GTZ. (2009). *The solar energy market in Rwanda*. Berlin, Germany: Gesellschaft fur Technische Zusammenarbeit.
- Gurrierl, J. (2005). *Virunga-Bwindi Region:Analysing the region's watershed for water supplies to local communities*. Ogden, Utah: United States Department of Agriculture.
- Hall, D., Yushi, S., & Mao, O. (1994). *Biomass energy and coal in Africa*. London, UK: African Energy Policy Research Network.
- Hategeka, A. (1997). *Guidelines for biomass energy policy implementation in Rwanda*. London, UK: Zed Books London.
- Hitimana, B. (2009, February 28). Rwanda: Country reports growth despite high inflation. Kampala, Uganda: *East African Business*, p. 12.
- Hofstad, O., 1990. A simple model of wood supply and clearing of African woodlands with special reference to Tanzania. *Journal of World Forest Resource Management* 5 (1).
- Hosier, R.H., 1993. Charcoal production and environmental degradation: environmental history, selective harvesting and post-harvest management. *Energy Policy* 491–509.
- Hosier, R.H., Mwandosya, M.J., & Luhanga, M.L (1993). Future energy development in Tanzania: The energy cost of urbanisation. *Energy Policy*, 21(5), 524-542. doi: 10.1016/0301-4215(93)90039-I.
- HEDON.(2009). Household Energy Network. Retrieved March, 2009, from <http://www.hedon.info>.
- ISAR. (2001). *Rapport annuel du programme Agro-Forestière*. Butare, Rwanda: Institut des Sciences Agronomiques du Rwanda .
- ISAR. (2007). *Inventaire des ressources ligneuses au Rwanda*. Kigali, Rwanda: Institut des Sciences Agronomiques du Rwanda.
- IEA. (2006a). *Key world energy statistics: OECD*. Paris, France: International Energy Agency.
- IEA. (2006b). *World energy outlook*. Paris, France: International Energy Agency.
- IEA. (2009). *Bioenergy task 38: Greenhouegas balance of biomass and bioenergy systems*. Paris, France: International Energy Agency.
- IEA. (2010). *Energy poverty: How to make modern energy access universal*. Paris, France: International Energy Agency.

- IWS. (2010, August 24). *Internetworldstats*. Retrieved August 24, 2010, from <http://www.internetworldstats.com>.
- Kammen, D., & Lew, D.J. (2005). *Review of technology for the production and use of charcoal*. Berkeley, CA: Renewable and Appropriate Energy Laboratory.
- Karenzi, P. (1994). *Biomass energy and coal in Africa*. London, UK: Zed Books London.
- Kebede, E., Kagochi, J., & Jolly, C.M. (2010). Energy consumption and economic development in sub-Saharan Africa. *Energy Economics*, 32(3), 532-537.
- Kirilenko, A.P., & Sedjo, R.A. (2007). Impact of climate change on forest sector. Proceeding of the National Academy of Sciences of the United States of America, volume 104, No 50.
- Leach, G., & Mearns, R. (2009). *Beyond the woodfuel crisis: people, land and trees in Africa*. London, UK: Earthscan.
- Lhendup, T., Lehendup, S. & Wangchuck, T. (2010). Domestic energy consumption in urban Bhutan. *Energy for Sustainable Development*, 14(2), 134-142. doi:10.1016/j.esd.2010.04.004
- Lund, H. (2002). *Published definitions of forests and land use/cover and related terms*. Rome, Italy: Food and Agriculture Organisation.
- Mabee, W. E, & Saddler, J.N. (2007). *Forests and energy in OECD countries*. Rome, Italy: Food and Agriculture Organisation.
- MacCarty, N., Damon, O., Still, D., Bond, T., Roden, C. & Willson, B. (2007). *Laboratory comparison of the global-warming potential of six categories of biomass cooking stoves*. Creswell, OR: Aprovecho Research Centre.
- MARGE. (2009). *Malawi biomass energy strategy*. Lilongwe, Malawi: Government of Malawi.
- Marcoux, A. (2000). Population and deforestation. *Rome, Italy: Population and the environment*, FAO.
- Mattheus, E., Payne, R., Rohweder, M., & Murray, S. (2000). *Pilot analysis of global ecosystems: Forest ecosystems*. Washington,DC: World Resources Institute.
- Mazimpaka, E. (2010). Rwanda Facing a Woodfuel Crisis. *International Conference on Domestic Usage of Energy* (pp. 33-40). Cape Town: Cape Peninsula University of Technology.
- Mead, D.J.2005. Forests for energy and the role of planted trees. *Critical Reviews in Plant Sciences*, 2(5): 407–421.

- MINITRAPE. (1993). *Bulletin des Statistiques Energétiques du Rwanda, Edition 1992*. Kigali, Rwanda: Ministère des Travaux Publics et de l'Energie.
- MINAGRI. (1983). Enquête sur l'utilisation du bois au Rwanda, 1981–1982. Kigali, Rwanda : Ministry of Agriculture.
- MINAGRI. (2002). *Production agricole, superficie et utilisation des terres*. Kigali, Rwanda: Ministry of Agriculture.
- MINICOFIN. (2000). *Rwanda Vision 2020*. Kigali, Rwanda. Ministry of Finance and Economic Planning.
- MINICOFIN. (2007). *Economic Development and Poverty Reduction Strategy*. Kigali, Rwanda: Ministry of Finance and Economic Planning.
- MINICOFIN. (2009). *Economic Development and Poverty Reduction Strategy (EDPRS) Implementation Report*. Kigali, Rwanda: Ministry of Finance and Economic Planning.
- MININFRA. (2006): Implementation Plan of the National Programme on Domestic Biogas in Rwanda (final draft). Kigali, Rwanda: Ministry of Infrastructure.
- MININFRA. (2007). *Rwanda Biomass Energy Strategy, Volume 2-Analysis*. Kigali, Rwanda: Ministry of Infrastructure.
- MININFRA. (2009a). *Biomass Energy Strategy, Volume 3: Rural Supply and Demand*. Kigali, Rwanda: Ministry of Infrastructure.
- MININFRA. (2009b). *National Energy Policy and National Energy Strategy 2008-2012*. Kigali, Rwanda: Ministry of Infrastructure.
- MININFRA. (2009c). *Rwanda Biomass Energy & Stoves Survey*. Kigali, Rwanda: Ministry of Infrastructure.
- MININFRA . (2009d). *Rwanda Biomass Energy Strategy, Volume 2: Background and Analysis*. Kigali, Rwanda: Ministry of Infrastructure.
- MINITERRE.(2003). *National Energy Strategy and Action Plan for the Conservation of Biodiversity in Rwanda*. Kigali, Rwanda: Ministry of Lands, Environment, Forestry, Water and Mines.
- MINITERRE. (2004a). *National Forestry Policy*. Kigali, Rwanda: Ministry of Lands, Environment, Forestry, Water and Mines.

- MINITERRE. (2004b). Instruction N<sup>0</sup> 0001/2004 of 16/07/ 2004 establishing a ban on using wood for fires for making bricks and tiles. Kigali, Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines.
- MINITERRE. (2006). Instruction N<sup>0</sup> 001/2006 of 03/02/ 2006 establishing a request on authorization for cutting, transporting and selling wood and wood product. Ministry of Lands, Environment, Forestry, Water and Mines.
- MINALOC. (2006). Vision 2020 Umurenge program. Kigali, Rwanda. Ministry of Local Government.
- Miranda, R. Sepp, S., Ceccon, E., Mann, S., & Singh, B. (2010). *Sustainable production of commercial woodfuel: Lessons and guidance from two strategies*. Washington, DC: Energy Sector Management Assistance Program.
- Mugo, F., & Ong, C. (2006). *Lessons of eastern Africa's unsustainable charcoal trade*. ICRAF working paper no. 20. Nairobi, Kenya: World Agroforestry Centre.
- Musahara, H. (2006). *Economic Analysis of Natural Resource Management in Rwanda*. Kigali, Rwanda: Poverty and Energy Initiative/Rwanda Environment Management Authority.
- Mwampamba, T.H. (2007). Has the woodfuel crisis returned? Urban charcoal consumption in Tanzania and its implications to present and future forest availability. *Energy Policy*, 19(2007) 4221-4234, doi:10.106/j.enpol.2007.02.10.
- NISR. (2003). *IIIème Recensement Général de la Population et de l'Habitat, 16-30 août 2002*. Kigali, Rwanda: National Institute of Statistics of Rwanda .
- NISR. (2006a). *Enquête intégrale sur les conditions de vie des ménages*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2006b). *Preliminary poverty update report (Integrated living conditions survey 2005/2006)*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2008a). *Demographic statistics*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2008b). *Rwanda in statistics and figures*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2009a). *Comprehensive food security and vulnerability analysis and nutrition survey*. Kigali, Rwanda: National Institute of Statistics of Rwanda.

- NISR. (2009b). *District baseline- Huye*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2009c). *District baseline- Nyamagabe*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2009d). *National agriculture survey*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- NISR. (2010). *Rwanda Development Indicator 2009*. Kigali, Rwanda: National Institute of Statistics of Rwanda.
- Ndayambaje, J. (2005). *Agroforestry for wood energy in Rwanda. Workshop on alternatives sources of energy in Rwanda*. Kigali, Rwanda: Institut de Recherche Scientifique et Technologique.
- Nduwayezu, J. 2010. *Socio- economic impact of biodiesel production in Rwanda*. Kigali, Rwanda: Institut de Recherche Scientifique et Technologique.
- Nilsson, S., & Shvindenko, A. (1996). *Do we have enough forests? IUFRO Occasional Paper No. 5 ISSN 1024-414X*. Laxenberg, Austria: International Union of Forestry Research Organisations.
- Ntagungira, G. (2010, July, 26). *A boom in Rwanda energy sector*. *The Newtimes*, p.14.
- Persson, R. (1974). *Review of the world forests resources in the early 1970s*. Stockholm: World Forests Resources, Royal College of Forestry.
- ProBEC. (2008). *A synthesis report on biomass energy consumption and availability in South Africa*. Pretoria:, South Africa: Programme for Basic Energy and Conservation in Southern Africa.
- Republic of Rwanda. (2000). *The National Decentralisation Policy*. Kigali, Rwanda: Ministry of Local Government.
- Republic of Rwanda. (2003a). *The National Environment Policy*. Kigali, Rwanda: Ministry of Lands, Environment, Forestry, Water and Mines.
- Republic of Rwanda. (2003b). *Constitution of the Republic of Rwanda. Official gazette of the Republic of Rwanda No special of 4<sup>th</sup> June 2003*. Kigali, Rwanda: Office of the Prime Minister.

Republic of Rwanda. (2004a). Energy Policy for Rwanda. Kigali, Rwanda:Ministry of Infrastructure.

Republic of Rwanda. (2004b). The National Land Policy. Kigali, Rwanda: Ministry of Lands, Environment, Forestry, Water and Mines.

Republic of Rwanda. (2004c). The National Forest Policy. Kigali, Rwanda: Ministry of Lands, Environment, Forestry, Water and Mines.

Republic of Rwanda . (2005a). Organic Law No. 4/2005 of 08/04/2005, determining the modalities of protection, conservation, and promotion of environment in Rwanda. Official Gazette of the Republic of Rwanda No. 04/2005 of 1 May, 2005. Kigali, Rwanda: Office of the Prime Minister.

Republic of Rwanda. (2005b). Organic Law No.8/2005 of 14/07/2005: determining the use and management of land in Rwanda. Official Gazette of the Republic of Rwanda No 18/2005 of 15 September, 2005. Kigali, Rwanda: Office of the Prime Minister.

Republic of Rwanda. (2006a). Organic Law No.16/2006 of 03/04/2006: establishing the Rwanda Environmental Management Authority (REMA). Kigali, Rwanda: Official Gazette of the Republic of Rwanda No 11/2006 of 1<sup>st</sup> June 2006. Office of the Prime Minister

Republic of Rwanda. (2006b). Organic law n° 28/2006 of 19/6/2006 establishing the organisation, competence and functioning of Gacaca courts charged with prosecuting and trying the perpetrators of the crime of genocide and other crimes against humanity, committed between October 1, 1990 and December 31, 1994.Kigali, Rwanda: Official Gazette No special of 19/06/2004 of 12 July 2006. Office of the Prime Minister

Republic of Rwanda. (2006c). Organic law No 31/2006 of 14/08/2006 on organisation, jurisdiction, competence and functioning of the mediation committee. Kigali, Rwanda: Official Gazette No special of 16 August 2006. Office of the Prime Minister

Republic of Rwanda. (2008a). Organic Law No.17/2008 of 20/06/2008: establishing the National Forestry Authority (NAFA).Kigali, Rwanda: Official Gazette of the Republic of Rwanda No 19/2008 of 1<sup>st</sup> October, 2008). Office of the Prime Minister.

Republic of Rwanda. (2008b). Supporting Fiscal Decentralisation in the Agricultural Sector: Developing Guidelines and a Training Manual for Utilisation of Earmarked Grants to Districts. Kigali, Rwanda: Ministry of Agriculture and Animal Resources.

- Republic of Rwanda. (2010a). Ministerial Order No 001/16.01 of 06/04/2010 determining the modalities of land sharing. Official gazette of the Republic of Rwanda No19 of 10/05/2010.Kigali, Rwanda:Office of the Prime Minister
- Republic of Rwanda. (2010b). Ministerial Order No14/11.30 of 21/12/2010 determining the models of land consolidation and its productivity. Official gazette of the Republic of Rwanda No52/ of 27/12/2010.Kigali, Rwanda: Office of the Prime Minister
- Republic of Rwanda. (2011). Organic Law establishing Rwanda Natural Resources Authority (RNRA) and determining its mission, organisation and functioning. Official Gazette of the Republic of Rwanda No10 Of 07/03/2011.Kigali, Rwanda: Office of the Prime Minister
- République Rwandaise. (1989). Loi No 47/ 1989 du 5 Décembre portant Organisation du Régime Forestier. Journal Officiel No3 du 1<sup>er</sup>Février 1989.Kigali, Rwanda: Ministère de la Justice
- Rudi, D. (2005). Spatial woodfuel production and consumption of selected african countries. Rome, Italy: Food and Agriculture Organisation.
- REMA. (2009). *Rwanda state of environment and outlook*.Kigali, Rwanda: Rwanda Environment Management Authority.
- Rwembeho, S. (2010). Nsinda prison gets biogas Plant. *The New times* (14315).
- Robert, E.F. (1990). The dynamic of human-Environment Interaction in the Tropical Agrosystems of Rwanda: Implication for Economic Development and Environmental Stability. Mountain Research and Environment, Vol.10, No 1. Utah, USA. International Mountain Society.
- Secretariat of the Convention on Biological Diversity. (2009). Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Montreal, Canada: United Nations Development Programme.
- Semujanga, J. (2003). *Origins of genocide*. Stanford: Humanity Books.
- Shvidenko, A. B. (2005). *Forest and woodlands in millenium ecosystems assessments: Ecosysytems and human well being: Current state and trends*. Washington, DC: Island Press.

- Sims, R.E.H. Schock, R.N, Adegbululge, A., Fenhann, J., Konstantinaviciute, I. Wamukonya, N., & Zhang, X. (2007). *Energy supply. Climate change 2007: Mitigation. Contribution of Working Group III to the fourth assessment report of the Intergovernmental Panel on Climate Change*, pp. 251–322. Cambridge, UK: Cambridge University Press.
- Steierer, F.-A., Fischer-Ankern, A., Francoeur, M., Wall, J., & Prins, K (2007). *Wood energy in Europe and North America: a new estimate of volumes and flows*. Geneva, Switzerland: UNECE/FAO.
- Tusabe, R. (2010). *From poachers to park wardens: Revenue sharing scheme*. *Mountain Forum Bulletin X* (1), 91-93.
- UNDP. (2005). *Pilot projet on environment mapping, phase II*. Kigali, Rwanda: United Nations Development Programme.
- UNDP. (2006). *Environment and poverty reduction in Rwanda. An assessment*. Kigali, Rwanda: United Nations Development Programme.
- UNDP. (2009a). *Human development report 2009*. New York, NY: United Nations Development Programme.
- UNDP. (2009b). *The energy access situation in developing countries: a review focusing on the least developed countries and sub-Sahara Africa*. New York: United Nations Development Programme.
- UPEGAZ. (2004). *Physico- chemical study of Lake Kivu*. Kigali, Rwanda: Unit for the Production and Exploitation of Lake Kivu Gaz.
- USAID. (2007). *Fuel efficient stove programs in IDP settings-summary evaluation Repor. Kampala, Uganda*. United State Agency for International Development.
- Uwizeye, J. (2005). *Impact, financial and economic analysis of Karubanda prison biogas projet*. Kigali, Rwanda: Kigali Institute of Science and Technology.
- WEC. (2007). *2007 Survey of Energy Resources*. London, UK: World Energy Council.
- WORLD BANK. (2008). *Building sciences, technology and innovation in Rwanda: Developing pratical solutions to pratical problems*. Kigali, Rwanda: World Bank Author.
- WORLD BANK. (2011). *Rwanda Economic Update: Seeds for Higher growth*. Kigali, Rwanda: World Bank

Zulu, L. (2010).The forbidden fuel: Charcoal, urban woodfuel demand and supply dynamics, community forest management and woodfuel policy in Malawi. Michigan: *Energy Policy*,38(2), 3717-3730.**doi:** *10.1016/j.enpol.2010.02.05*

## APPENDICES

### Appendix A: Survey Questionnaire

#### Information on Household Obtained In Advance

Surname of household

---

Site or house number

---

Physical address

---

Section / sub village, locality name

Urban informal planned [1]      Urban informal unplanned [2]

Peri – urban informal planned [3 ]      Peri-urban informal unplanned [4]     

Traditional (remote) rural village [5]      Rural settlement [9]

Other (specify)

---

Electricity meter number.....

The information we collect from you will be treated anonymously and you and your household will not be named in our report.

## SECTION A: HOUSEHOLD ROSTER

In this first set of questions, we will ask about your household and household members

**A01** What is your first name?.....

### Members of Household

<b>A02</b> First name Write name of respondent in row a.	<b>A03</b> Sex Male (1) Female (2)	<b>A04</b> Age at last birthday?	<b>A05</b> What is the highest level of education she/he has completed? Choose from the list below: No schooling [0]; Literacy courses [1] ; Completed primary school [2] ; ;Some primary school [3] Completed secondary school [4]; Some secondary school [5] Vocational (eg. Technical) [6] Some vocational [7] Completed Tertiary [8] Some tertiary [9] Other (specify).....	<b>A06</b> What are her/his employment circumstances? Choose from the list below: Employment fulltime [1] Employment part time [2] Employment casually (piece jobs) [3]; Self-employed [4]; pensioner/retired [5]; Disabled [6] Student (including school children) [7]; Housewife/home maker [8] Unemployed [9] ; Unemployed, in training [10] ;Unemployed, looking for work [11]; Preschool child [18] Other [19] (specify).....	<b>A07</b> Where does he/she live most of the time? Choose from the list below: Always in this house [1] Same locality but in another house [2];Neighbouring town or village [3]; Neighbouring city [4]; Capital city [5] Provincial city [6]; Another town/village [7]; Boarding school in another town or village [8] ; Other (specify) .....	<b>A08</b> In the last 12 months has any member of your household required treatment for an episode (s) of: <i>If No, GOTO</i> <i>A10, if Yes,</i> which of the following ones: Asthma [1]; bronchitis [2]; Pneumonia [3] Burns [4]; Kerosene poisoning [5]; Eye problems [6]; tuberculosis (TB) [7]

Example: Priscilla	F	35	22	4	1	
a.						
b.						
c.						
d.						
e.						
f.						
g.						

A02	A09	A10	A11	A12	A13	A14	A15	A16
<p>First name Write name of respondent in row a. Same as for page 2</p>	<p>What type of work do they do? Include part-time, informal selling of any kind and piece jobs. Officials/Administrators [1]; Professionals [2]; Technicians [3] Sales workers [4] Office &amp; clerical [5] Craft (trade) workers [6]; Operatives [7] Labourers [8] Service workers [9]; Other (specify)..... ..... .... (specify).....</p>	<p>If household member/s have own business (self-employed), what type of business do they have? store/shop [1]; Neighbourhood store selling from home [2] Hawker in nearby town [4] Sewing [6]; Baking [7] Brewing beer/alcohol [8] Carpentry [10]; Cell phone service (pay phones) [13] Collecting water or firewood for other people [16]; Don't know [99] Other (specify)..... (specify).....</p>	<p>If household member/s receives a pension/grant, what type of pensions / grants do the persons receive? govt old age pension [1]; private employer/work pension [2]; govt. disability grant [3] govt. unemployment benefit [4] retrenchment payment [5]; child support grant [6]; foster child grant [7] pension received by dependants from deceased person's employer [8] Other (specify)..... .....</p>	<p>How much do they earn per month net? (net income is income after deductions) Every day [1] Every week [2] every two weeks [3] every month [4]; every 2-3 months [5] every six months [6] once a year</p>	<p>How often do they contribute money to this household? (Write the code number which corresponds.) Every day [1] Every week [2] every two weeks [3] every month [4]; every 2-3 months [5] every six months [6] once a year</p>	<p>How much do they contribute to this household each time? (Amount in local money.)</p>	<p>Which of the following items does he or she contribute to the household? Fill in nature of any contribution Everything [1] No / Nothing [2] Money [3]; Groceries [4] Money and groceries [5] Tools [6]; Rent [7] Transport cost [8] Clothing [9]; Furniture [10]; Appliances [11] Labour [12]; Pay loans [13]; Medical expenses [14] Other (specify) ..... .....</p>	<p>Give the monthly value of these contributions in local money</p>

		.....			[7] infrequently [8]; never [9]			
Example: Priscilla								
a.								
b.								
c.								
d.								
e.								
f.								
g.								

**A17** Does the household get money/remittances from members or persons living elsewhere?

(e.g., child support, rent)? Yes [1] No [2]

If no, GO TO A 20.

If yes,

**A18** How often does the household get money/remittances from elsewhere?

At least once a month [1] Twice a year [3] Never

Four times a year [2] Infrequently [4] Other (specify).

**A 19** How much is received each month?

Amount in local money.....

**A 20** Does the household get money from selling farm produce? (e.g., cattle, milk, goats, vegetables)

Yes [1] No [2]

If no, GO TO A 23

If yes,

**A 21** How often?

Every day [1] Once a week [3] Once a month [5] Twice a year [2] Once a year [4]

**A 22** How much does the household obtain per month by selling?

Amount in local money.....

**A23** Give us your *best estimate* of the total monthly or yearly **INCOME** of your household:

**Monthly:** Amount in local money.....

**Yearly:** Amount in local money.....

### Household expenditure

**A24** Every household has to buy / pay for a large variety of things. Please tell us how much your household spends in total per month or per year on each of the following items.

Use the box below for calculations. Where there is no expenditure, write “none” Items you buy	Value of items bought by household in local money. Indicate average monthly or yearly. Monthly
<b>a.</b> Food and groceries ( <i>excluding fuels</i> )	
<b>b.</b> Clothes	
<b>c.</b> House rent	
<b>d.</b> Personnel transport (car /van): fuel, maintenance, etc	
<b>e.</b> Public transport (bus, taxi, etc)	
<b>f.</b> Repayment of bank loans	
<b>g.</b> Repayment of cash loans	
<b>h.</b> Bond (housing) repayment	
<b>i.</b> Savings including saving clubs (IKIMINA)	
<b>j.</b> Electricity and/or Water	
<b>k.</b> Medical expenses(MUTUEL)	
<b>l.</b> School (TUITION FEES) / Yearly	
<b>m.</b> Remittances to members of the family living elsewhere (child support, second family, alimony etc)	
<b>n.</b> Telephone (landline and mobile)	
<b>o.</b> Labour (home help, gardeners, cooks etc)	
<b>p.</b> Eating / drinking outside the home	
Other (specify).....	

**A25** Give us your *best estimate* of the total monthly or yearly EXPENDITURE of your household:

**Monthly:** Amount in local money.....

**Yearly:** Amount in local money.....

**SECTION B: INFORMATION ABOUT YOUR HOUSE / DWELLING**

**Structure of the house**

**B01** Do you own or rent your house or are you provided with accommodation?

Own [1]                  Rent [2]                  Home provided [3]

**B01a** If renting or paying nominal fee – how much are you paying per month? *Amount in local money*.....

**B02** How many separate buildings make up your house/dwelling excluding separate toilet(s) but including separate kitchen(s)?

**B03** How many habitable rooms in total are there in your house/homestead?

**B04** Does the household use a charcoal and/ or wood stove for cooking? Yes [1] No [2]

*If no, GOTO B06*

If yes,

**B05** Is this stove connected to a chimney? Yes [1] No [2]

**B06** What is the material of your house’s wall?

Concrete Block [1] Brick [2] Precast Concrete [3] Timber and Daub [4]

**B07** What is the Roof material?

Grass [1] Zinc /metal [2] Tiles [3] Others specify.....

**Electric lighting**

**B08** How many electric lights are there all together inside your house/dwelling?

If no electric lighting in house GOTO B10

**B09** How many outside electric lights are connected to your dwelling?

**B10** How many sockets are there to plug in appliances inside the house?

**Household amenities**

**B11** What is the household’s most common source of drinking water? Tap in house [1] Tap in yard [2] Tank [3] Shared tap [4] Hand pump [5]; Tube well[6]; Surface well [7]; spring [8];

River [9]; Other (specify)

**B12**If your household is not using an inside tap or tap in the yard, what is the distance to the nearest tap? Less than 100m [1]; 100m to 199m [2]; 200m – 500m [3]; If more than 500m, specify the distance in kilometres [4].....km

**B13** If no access to tap water, what is the distance to the nearest protected water source (well, borehole etc)? Less than 100m [1]; 100m to 199m [2]; 200m – 500m [3]

If more than 500m, specify the distance in kilometres [4]....km

**B14** Does your house have a separate bathroom? Yes [1] No [2]

**B15** Does your house have an inside toilet? Yes [1] No [2]

**B16** What type of sewerage system does your house/homestead have? Water-borne sewerage [1]; Pit-latrine [2]; No sanitation facility [3]; Other (specify).

### SECTION C: FUELS USED FOR DIFFERENT PURPOSES IN THIS HOUSE

Now we would like to know what type of fuels are used by the household.

**C01** What is the main fuel, second and third fuels the household uses for **lighting, cooking, heating water and ironing**? (If household does not have a third fuel, write 0)

End-use	What is the main fuel, second and third fuels the household uses for lighting, cooking, water heating and ironing? Electricity [1] Candles [2] Kerosene (paraffin) [3] Gas [4] Wood [5] Crop residues [6] Charcoal [7] Solar [9] Other (specify)		
	Main fuel	Second fuel	Third fuel
<b>A. Lighting</b>			
<b>B. Cooking</b>			
<b>C. Water heating</b>			
<b>D. Ironing</b>			

**C02** What are the most important reasons the household uses this as the main fuel for **lighting and cooking**? (Put the code in the 1st column in the box, which most closely reflects the respondent's first answer. If there is more than one response do the same for the 2nd and 3rd choices.)

A. LIGHTING				B. COOKING			
Reasons	1st	2nd	3rd	Reasons	1 st	2 nd	3 rd
Affordable/ cheap [1]				Affordable/ cheap [1]			
Easily available [2]				Easily available [2]			
Bright light [3]				Easy to use [4]			
Easy to use [4]				Safe [5]			
Safe [5] specify				Other (specify).....			

**C03** If you had a choice and all fuels were available in your area, which fuels would the household like to use most for **lighting,cooking, heating and ironing?** What are the reasons (s)?

<b>End-use</b>	Which fuel would the household like to use most if it had a choice? Electricity [1] Candles [2] Kerosene (paraffin) [3] Gas [4] Wood [5] Crop residues [6] Charcoal [8] Solar [9]Other (specify).....	If the fuel of your choice is not used regularly, what are the reason(s) for this? Too expensive to use [1] Fuel/electricity not available in the area [2] Have no electricity connection [3] Don't have appliances [4] Other (specify).....
<b>A) Lighting</b>		
<b>B) Cooking</b>		
<b>C) Heating</b>		
<b>D) Ironing</b>		

## SECTION D: CHARCOAL SUPPLY, PURCHASE, USE AND APPLIANCES

### Charcoal supply and use

**D01** Is charcoal generally available in your area? Yes [1] No [2] Don't know [3]

**D02** Does the household use any charcoal at any time of the year? Yes [1] No [2]

If no, GOTO section I.

If yes,

**D03** What are the main things the household does with charcoal? Indicate Yes [1] or No [2]

A. Cooking		D. Ironing		G. Other (specify).....	
B. Heating the home		E. Baking			
C. Brewing beer		F. Heat water			

**D04** How often does your household use charcoal?  
 Every day [1] Once per week [2] 2 times per week [3] 3 to 4 times per week [4]; Once per month [5] 2 times per month [6] 3 times per month [7]; Less often/irregularly [8] During power failures [9] When no electricity units [10]; Other   
 (specify).....

**D05** Does the household make charcoal or buy or do both? ; Make charcoal [1] Buy charcoal [2] Make and buy charcoal [3]; if they do not make charcoal, GOTO H10

If they **make** charcoal,

**D06** How often does the household make charcoal?  
 Once per week [1] Once a month [2] Two times per month [3];   
 Other (specify).....

**D07** How much charcoal does your household usually make at one time?  
 Three bags (include weight in kg/ pounds) [1] Five bags (include weight in kg/ pounds) [2]   
 Other (specify).....

**D08** How long does this charcoal last?   
 Less than 1 week [1] 1 week [2] 2 weeks [3]; 1 month [4]   
 Other (specify) .....

**D09** Who in the household usually makes charcoal?

.....

If the household does not buy charcoal, GOTO H14.

If they buy charcoal,

**D10** How often does the household buy charcoal?

Every day [1] Once per week [2] 2 times per week [3] 3 to 4 times per week [4]; Once per month [5] 2 times per month [6] 3times per month [7] Less often/irregularly [8] During power failures [9] When no electricity units [10] ; Other specify...

**D11**How much charcoal is generally bought at one time?

(Number of sacks and weight in kg)

Number of sacks.....

Weight.....kg

**D12** How much does the household pay for this charcoal?

Amount in local money.....

**D13** How much does your household spend on charcoal per month?

(Calculate with respondent). Amount in local money.....

**H14** Does your household sell charcoal?Yes [1] No [2]

If no, GOTO H17

If yes,

**D15** How much charcoal does your household sell per month?

Quantity and weight kilogram.....

**D16** How much income does the household get per month from selling charcoal?

Amount in local money.....

**D17** Who are your usual suppliers? *Indicate Yes [1] or No [2]*

A. Members of the community		C. Specialist charcoal dealer	
B. Shop		D. Other (specify).....	

**D18** Do you know the location from where your charcoal comes from?

Yes [1] No [2]

If yes give the name of the location.....

**Appliances for burning charcoal**

**D18** Does your household have appliances for burning charcoal? Yes [1] No [2]

If no, GOTO section I.

If yes,

**D19** Which ones does the household have? *Indicate Yes [1] or No [2]*

A. Charcoal stove		B. Other (specify).....	
-------------------	--	-------------------------	--

If yes give the name of the charcoal stove.....

**D20** What was the price of charcoal last 3 years?

Year	RWF/ Sack	RWF/Akadobo	RWF/Akarundo
2008			
2007			
2006			

**D21** What is the distance to purchase charcoal?

Less than 1km [1] More than 1km [2]

**SECTION E: FIREWOOD SUPPLY, PURCHASE, USE AND APPLIANCES**

**Firewood supply and use**

**E01** Is firewood generally available in your area? Yes [1] No [2] Don't know [3]

**E02** Does the household use any firewood at any time of the year? Yes [1] No [2]

If no, GOTO section J

If yes,

**E03** What are the main things your household does with firewood? *Indicate Yes [1] or No [2]*

A. Cooking		D. Heat water		G. Baking	
B. Heating the home		E. Ironing		Other (specify).....	
Lighting		F. Brewing beer			

**E04** How often does your household use firewood?

Every day [1] once per week [2] 2 times per week [3] 3 to 4 times per week [4] Once per month [5] 2 times per month [6] 3 times per month [7] Less often/irregularly [8] During power failures [9] When no electricity units [10]

Other (specify).....

**E05** Does the household collect firewood or buy or do both?

Collect firewood [1] Buy firewood [2] Collect and buy firewood [3]

If they **buy** firewood, GOTO question I10.

If they **collect** firewood,

**E06** How often does the household collect firewood?

Every day [1] Every second day [2] Once a week [3]

Other (specify) .....

**E07** How much firewood does the household generally collect at one time?

One head load collected by one person [1] Two head loads collected by two people [2]

One truck/ bakkie load [3] One cart load [4]

Other (specify).....

**E08** How long does this firewood last?

Less than one week [1] 1 week [2] 2 weeks [3] 1 month [4]

Other (specify).....

**E09** Who in the household usually collects firewood?

Women [1] Men [2] Female children [3] Male children [4]

Other (specify).....

**E10** Where do you collect firewood?

Own land [1] Natural forest [2] Neighbour's land [2] River bank [3] Agricultural land [4]

Others (specify).....

**E11** How many times does it take to collect firewood?

Less than 1 hour [1] One hour [2] 2 hours [3] More than 2 hours [4]

If they **buy** firewood,

**E12** What problems do you experience collecting firewood?

.....

**E13** What species of wood do you often use for (.....). Give local names (three)

Cooking.....

House construction.....

Kraal construction.....

**E14** How often does your household buy firewood?

Every day [1] once per week [2] 2 times per week [3] 3 to 4 times per week [4]

Once per month [5] 2 times per month [6] Less often/irregularly [7]

During power failures [8] When no electricity units [9]

Other (specify).....

**E15** How much firewood does your household generally buy at one time?

(Weight in kilograms) .....kg

**E16** How long does this firewood last?

Less than one week [1] 1 week [2] 2 weeks [3] 1 month [4]

Other (specify).....

**E17** How much does the household pay for this firewood?

Amount in local money.....

**E18** How much does your household spend on firewood per month?

Amount in local money.....

**E19** Does the household sell firewood? Yes [1] No [2]

If no, GOTO I18

If yes,

**E20** How much firewood does the household sell per month?

Weight in kilograms.....

**E21** How much income does the household get per month from selling firewood?

Amount in local money.....

**E22** Who are your usual suppliers for firewood? Indicate Yes [1] or No [2]

A. Member/s of the community		B. Shop		Other (specify).....	
------------------------------	--	---------	--	----------------------	--

**E23** How far from home are your usual suppliers?

Less than 1 km [1] 2 to 5 km [2]; 6 to 10 km [3] ; More than 10 km [4]

**E24** Does your household pay for transport to get to your suppliers?

Yes [1] No [2]

If yes

**E25** How much does the household pay for the return journey including the transport of firewood? *Amount in local money*.....

**Type of woodfire place**

**E26** Does your household have any woodfire place / stove? Yes [1] No [2]

*If no, GOTO Section J*

If yes,

**E27** What type of fireplace / stove does your household have? *Indicate Yes [1] or No [2]*

A. Outside fireplace	B. Inside fireplace	C. Special wood stove	D. Other (specify).....
----------------------	---------------------	-----------------------	-------------------------

**E28** Is the fire place connected to a chimney? Yes [1] No [2]

**E29** Have you noticed fluctuations or changes in the price of fuelwood during the past year?

Yes [1] No [2]

**E30** Please explain these fluctuations

**SECTION F: DEFORESTATION AND ENVIRONMENT**

**F1** Who cut the last forest in your area?

Yourself [1] Wood sellers [2] Charcoal makers [3] Government [4]

Others (specify).....

**F2** For what purposes the last forest has been cut?

Firewood [1] Charcoal making [2] Settlement [3] Agriculture [4]

Others (specify).....

**F3** Would you like to grow trees for yourself?

Yes [1] No [2]

**F4** What problem do you foresee in growing trees?

Too dry [1] No seeds [2] No land [3] Government regulations on harvesting [4]; Grazing by animals [5] Others (specify)

**F5** What do you consider more important to grow next to your house?

Agro forestry trees [1] wood for fuel [2] shade trees [3] Fruit trees [4]; Others (specify).....

**F6** Would you say there is enough woodland around your village to meet the present village needs for fuelwood? Yes [1] No [2] Don't know [3]

**F7** Would you say there is sufficient wood to meet future generation's fuelwood needs? Yes [1] No [2] Don't know [3]

**F8** Is there enough wood supply for building near your village? Yes [1] No [2] Don't know [3]

**F9** Would the supply be enough for next generations? Yes [1] No [2] Don't know [3]

**F10** Do you know some species of wood which have disappeared recently from your area? Yes [1] No [2] Don't know [3]

**F11** Thinking back over the last two years, would you say that the natural woodland around your place have increased or decreased? Increased [1] Decreased [2] Stayed almost the same [3] Don't know [4]

**F12** What do you think is the major benefit of planting trees? Tick one reason

Fuelwood	<input type="checkbox"/>	Environmental protection	<input type="checkbox"/>
Non forest products (honey, ropes...)	<input type="checkbox"/>	Provision of shade	<input type="checkbox"/>
Poles	<input type="checkbox"/>	Provision of fruits	<input type="checkbox"/>
Commercial sale of timber	<input type="checkbox"/>		<input type="checkbox"/>

**F13** Do you think there have been major changes in the quality of the environment apart from the change in wood cover?

Changes	Rate of change				
	Very high	High	Medium	Small	Very small
Fertility of farmland					
Drying of streams					
Pasture land					
Vegetation cover					
Rainfall					
Erosion					
Agriculture land					

**F14** Have you been sensitized about the forest and environmental laws?

Yes [1] No [2]

**F15** Do you know any substitute to fuelwood?

Yes [1] No [2]

**F16** Which ones? Enumerates

.....

**F17** What do you think about the wood cutting permit in a private plantation?

### SECTION G: POVERTY

Now let's talk about the theme of poverty. We'd like to know what you think of poverty and what its causes are.

**G01** In your opinion, what are the main types of poverty your community experiences?

Choose **one** cause only

Lack of land [1] Poor soil [2] Drought/Weather [3] Lack of livestock [4]

Ignorance [5] inadequate infrastructure [6] inadequate technology [7]

Sickness [8] polygamy [9] Lack of access to water [10] Population pressure [11]

Others (specify)

**G02** What would you say are the TWO principal causes of poverty in your community?

a).....

b).....

.....

**G03** To reduce poverty the GoR has recommended some policies. Please give short comment

Land consolidation

.....

Crop regionalization

.....

Zero grazing

.....

Land sharing

.....

**G04** Do you think that land in Rwanda is evenly distributed?

.....

**G05** Why does a person sell his land?

.....

**G06** If you had to rate your community as a non-poor community, a poor community or a very poor community, what would you rate your community?

Not poor [1] Poor [2] Extremely poor [3]

**G05.** Why do you say this?

.....

**G06.** In this community are some people poorer than others? Yes [1] No [2]

**G07.** How many [proportion] poor people are there in this community?

All [1] More than half [2] About half [3] Less than half [4] Few [5]

None [6]

**Appendix B: Tree Cutting Permit**

REPUBULIKA Y'U RWANDA

N<sup>o</sup>: .....



INTARA Y' AMAJYEPFO  
 AKARERE KA HUYE  
 B.P. 35 BUTARE  
 Tél.: 530362 Fax: 530196  
 URUHUSHYA RWO GUTEMA IBITI (Permis de coupe de bois)

Demandeur	Etat	District	Secteur	Privé
Usaba	Leta	Akarere	Umurenge	Umuturage

Nom (Izina): .....  
 Adresse (aho abarizwa).....Carte d'identité (Irangamuntu N<sup>o</sup>).....

Boisement de	Etat	District	Secteur	Privé
Ishyamba rya	Leta	Akarere	Umurenge	Umuturage

PRELEVEMENT AUTORISES (ibigomba gutemwa)

Numéro de boisement (nimero y'ishyamba) ..... Région (Intara) : **Amajyepfo**, Akarere (District) : **Huye**, Umurenge (Secteur) : ..... Cellule (Akagari) : ..... Nombre d'arbres à couper (umubare w'ibiti bizatemwa) : ..... Age (imyaka rimaze) : ..... Superficie (ubuso bw'ahatemwa) : ..... Distance du bureau de District (Uko hareshya uturutse ku Karere) ..... Raison de la coupe (Impamvu zitumye bitemwa)


Bois d'œuvre, bois de feu (ibiti bibazwa cyangwa ibicanwa)

Espèce	DHP moyen	Hauteur	Vol	Nombre	Vol. Total	Prix/Stère	Prix tot.	Taxe FFN
Ubwoko	Umurambararo	Uburebure	Unit.Moy	d'unités	Ubunini	ou m <sup>3</sup>	Agaciro	1%
			Ubunini	Umubare	bw'ibiti	Igicro/siteri	k'ibiti	Amahoro
			bw'igiti 1	w'ibiti	bizatemwa	cg kuri m <sup>3</sup>	bizatemwa	1%
				bizatemwa				

En conformité avec le rapport de martelage et mesurage (Bigomba kuba bihuye na raporo yo kubitera no kubipima)



## Appendix C: Woodfuel transport Permit

REPUBULIKA Y' U RWANDA		N°.....	
			
INTARA Y' AMAJYEPFO			
AKARERE KA HUYE			
Email: <a href="mailto:huyedistrict@yahoo.fr">huyedistrict@yahoo.fr</a>			
TéL.:530362			
<h3 style="color: blue;">URUHUSHYA RWO GUTWARA, AMAKARA/IMBAHO/IBITI</h3>			
<b>1.1.1.1.1</b> Permit for charcoal, timber and Wood transport ( <b>siba ibitari ngombwa</b> )			
1.1.1.1.2	1.		AMAZINA
	(Names).....		
1.1.1.1.3	2.	AHO	ABARIZWA
	(Address).....		
1.1.1.1.4	N°C.I.....		
1.1.1.1.5	AKAGARI (Cell).....		
1.1.1.1.6	UMURENGE (Sector).....		
1.1.1.1.7	AKARERE (District).....		
1.1.1.1.8	INTARA (Province).....		
1.1.1.1.9	3. YEMERIWE GUTWARA (Product to be transported):	AMAKARA (Charcoal)/IMBAHO	
	(Timber)/IBITI (Pole).		
1.1.1.1.10	( siba ibitari ngombwa)		
1.1.1.1.11	4.		AHOBIVA
	(From):.....		
1.1.1.1.12	5.		AHOBIJYA
	(To):.....		
1.1.1.1.13	6. IMODOKAIZAKORESHA (ubwoko)	(Type of vehicle to be	
	Used):.....		
1.1.1.1.14	NUMERO	ZA	PULAKI (PLate
	Number):.....		
1.1.1.1.15	IZINA	RY'UMUSHOFERI	(Driver
	Name):.....		
1.1.1.1.16	7. IGIHE	URUHUSHYA	RUZAMARA (Permit

- Duration):.....
- 1.1.1.1.17 Bikorewe i Huye (Done at Huye), kuwa  
(Date).....
- 1.1.1.1.18 Bigenzuwe na ( Controlled by):Byemejwe na (Certified by):
- 1.1.1.1.19** Ushinzwe Ibidukikije N’Umutungo Kamere Umuyobozi ufite amashyamba mu  
Nshingano ze
- 1.1.1.1.20** In charge of Environment and Natural RessourcesIn charge of Forests
- 1.1.1.1.21**
- 1.1.1.1.22
- 1.1.1.1.23 **N.B:** -Uru ruhushya ntabwo rurenza igihe cy’amezi atatu kandi rutangwa ku kintu kimwe  
gusa(imbaho,ibiti,inkwi,amakara)
- 1.1.1.1.24 ( The permit is valid for 3months and is delivered for product only(timber, poles,  
firewood,charcoal)
- 1.1.1.1.25 -Usaba uru ruhushya yerekana kopi y’uruhushya rwo gutema rw’ibyo asahaka gutwara:  
imbaho,ibiti,inkwi,amakara.
- 1.1.1.1.26 (The permit is issued after presentation of cutting permit with specification on Wood product  
to be transported: timber,poles,firewood or charcoal).
- 1.1.1.1.27 -Uru ruhushya rwemerwa gusa iyo ari umwimerere (THE PERMIT IS ACCEPTED WHEN IT  
IS ORIGINAL))
- 1.1.1.1.28 -Uhawe uruhushya yiyemeje gukurikiza amategeko n’amabwiriza ariho mu Gihugu cyane  
arebana n’ubusugire bw’amashyamba(reba itegeko n°47/1988)ryo kuwa 05Ukubozi 1988  
rigenga ibyerekeye amashyamba mu Rwanda).
- 1.1.1.1.29 ( The bearer must conform to the law no 47/1988 of 05 December relative to forests in  
Rwanda)



Appendix E: Nyamagabe Administrative Map

## NYAMAGABE ADMINISTRATIVE MAP

