Cologne University of Applied Sciences
Institute for Technology and Resources Management in the Tropics and Subtropics (ITT)

WOODFUEL VALUE CHAINS IN KENYA AND RWANDA;

Economic analysis of the market oriented woodfuel sector

Geoffrey M. Ndegwa

MSc. Thesis

September 2010

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Economic analysis of the market oriented woodfuel sector

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Date of Submission: 30. September, 2010

This research is done for the partial fulfilment of the requirements for the Master of Science (MSc.) degree at the Institute for Technology and Resources Management in the Tropics and Subtropics (ITT) at Cologne University of Applied Sciences, Cologne, Germany

Cologne
September, 2010

I. Abstract

In developing countries, the use of traditional biomass like firewood and charcoal is quite important. They are used for heating, cooking and support to small and medium industries like beer brewing, tobacco curing, and brick making. According to GTZ, it is projected that the number of wood fuel consumers will increase from around 2.5 billion in 2004 to 2.7 billion by 2030 with Sub-Saharan Africa accounting for the highest increase. Currently, developing countries account for about 90% of global wood fuel consumption with firewood being mostly consumed in the rural areas and charcoal in the urban areas.

Rwanda's primary energy supply is dominated by biomass with wood supplying about 57% and wood for charcoal 23% while in Kenya, wood supplies about 68% of the primary energy. All the woodfuel consumed in Rwanda is sourced from plantation forests. Sourcing wood fuel from natural forests has been criticised for degrading them, while the governments react by banning the practice but not giving the people another option. A good example is the unsustainable use of charcoal in Nairobi which has been blamed for the degradation of the surrounding forests.

The woodfuel sector plays a big role in the economy of both countries. In Rwanda it is estimated that the turnover from woodfuel was about US$ 122 million in 2007 which is about 5% of the country's GDP, with the fuelwood sector having US$ 55 Million and the charcoal sector US$67Million. In Kenya, 1.6 million tonnes of charcoal are consumed each year with a turnover of about US$419 million which at 16% value added tax charged by the Kenyan Government, can contribute US$ 67 million in taxes every year.

GTZ reports that 300, 000 people depend economically on the woodfuel sector in Rwanda, while 20,000 are directly employed. In Kenya, 2 million people depend on the charcoal sector alone, which proves its importance not only as a source of energy but as a source of livelihood. These figures stress the importance of streamlining the sector in both countries with the aim of improving of its structure, and proper management, of the woodfuel resources utilisation. This would enhance its economic potential and promote development of the rural economies.

Key words; Biomass energy, charcoal, fuelwood, gross margins, Kenya, value chain analysis, Rwanda, woodfuel, woodlots.

II. Zusammenfassung

In Entwicklungsländern spielt der Einsatz traditioneller biogener Energieträger wie Holz oder Holzkohle eine entscheidende Rolle. Sie werden zum Heizen, Kochen oder als Energielieferant kleinerer und mittlerer Unternehmen wie Brauereien, der Tabakveredelung oder der Ziegelherstellung eingesetzt. Die GTZ prognostiziert einen Anstieg der Verbraucherzahlen von biogenen Energieträgern von 2.5 Millionen im Jahre 2004 auf 2.7 Millionen im Jahre 2030, wobei Sub-Sahara-Afrika den größten Anstieg verzeichnet. Gegenwärtig wird der Verbrauch biogener Energieträger in Entwicklungsländern auf etwa 90% des globalen Verbrauchs geschätzt, wobei in den ländlichen Gegenden Feuerholz und in den städtischen Gebieten hauptsächlich Holzkohle verwendet wird.

Die Primärenergieversorgung Ruandas wird beherrscht von biogenen Energieträgern, wobei Brennholz mit rund 57% und Holzkohle mit etwa 23% zur Energieversorgung beitragen. In Kenia hingegen liefert Brennholz etwa 68% der benötigten Primärenergie. Das gesamte Holz, als Basis biogener Brennstoffe, wird in Ruanda in Plantagen angebaut. Die Entnahme von Holz aus natürlich gewachsenen Beständen wurde stark kritisiert mit dem Vorwurf diese Bestände nachhaltig durch deren Abbau zu schädigen. Die Regierung reagierte mit einem Ernteverbot, ohne jedoch den Menschen vor Ort eine Alternative dazu anzubieten. Ein gutes Beispiel ist der nicht nachhaltige Einsatz von Holzkohle in Nairobi, der für die Degradierung der umliegenden Waldbestände verantwortlich gemacht wird.

Der Sparte der Energieträger auf Holzbasis kommt in beiden Ländern eine wichtige ökonomische Bedeutung zu. In Ruanda wird ihr Absatz im Jahre 2007 auf 122 Million US Dollar, etwa 5% des Bruttoinlandproduktes, geschätzt; wobei der Anteil des Brennholzsektors auf etwa 55 Millionen US Dollar und der des Holzkohlensektors auf circa 67 Millionen US Dollar geschätzt wird. In Kenia werden jährlich 1,6 Millionen Tonnen Holzkohle verbraucht, was einem finanziellen Gegenwert von etwa 419 Millionen US Dollar entspricht. Dies führt bei einer Mehrwertsteuer von 16% zu Steuereinnahmen in Höhe von 67 Millionen US Dollar. Laut GTZ stehen 300.000 Menschen in wirtschaftlicher Abhängigkeit vom Sektor der biogenen Energieträger und 20.000 sind direkt in dem Sektor beschäftigt. In Kenia hingegen stehen alleine rund zwei Millionen Menschen in Abhängigkeit vom Holzkohlesektor, was neben der Wichtigkeit als Energieträger auch seine Bedeutung als Existenzgrundlage verdeutlicht.

Diese Zahlen verdeutlichen den Rationalisierungsbedarf des Sektors in beiden Ländern, mit dem Ziel, eine bessere Struktur und ein effektiveres Management sicher zu stellen; um das wirtschaftliche Potential voll auszuschöpfen und damit die wirtschaftliche Entwicklung der ländlichen Räume in beiden Ländern weiter voran zu treiben.

Schlüsselwörter: *Biogene Energieträger, Brennholz, Bruttogewinn, Holzkohle, Kenia, Plantagenanbau, Ruanda, Wertschöpfungskettenanalyse*

III. Dedication

This report is dedicated to my family who stood by me and gave me moral support during my studies in Germany.

IV. Acknowledgements

I gratefully acknowledge the financial support provided to me by the German Academic Exchange Service (DAAD) for my Master's Study Course in Germany.

I am very grateful to Prof. Dr Johannes Hamhaber for his support and advice during the supervision of this thesis. I am also grateful to Dr. Thomas Breuer of GTZ Division 45-Agriculture, Fisheries and Food, for introducing me to GTZ, hosting me as an intern in his section, and being my second supervisor. To both I say thank you.

I would also like to acknowledge the support accorded to me by Dr. Marlis Kees, GTZ Program Manager HERA, for organising my internship in GTZ Headquarters, Escborn, GTZ Kenya and GTZ Rwanda thus giving me a smooth platform within which to conduct my research and make contacts with important organisations and experts. Other GTZ officers in Escborn who I can not forget to thank for their professional advice are Dr. Christopher Messinger of GTZ-HERA, Dr. Andreas Springer-Heinze, GTZ senior planning officer, value chain development, Mr Dominik Fortenbach and Mr Max Baumann both of Division 45, Dr. Cornelius Seegers and Dr Christiane Wegener.

Special thanks also go to Dr Gerard Hendriksen, GTZ, Senior Government Technical Advisor, Rwanda and Miss Mukulu Myra program officer GTZ, REAP- Kenya for hosting me in the research countries and making appointments with relevant institutions and experts on my behalf. Others who gave me substantial support are Mr. Augustin Hategeka, Silas Ruzigana, Gaspard Nkurikiyumukiza and Cymana Muilnda all of MININFRA Rwanda, Michel Franz, Oscar Oguru and Anna Ingwe all of GTZ, Kenya, among others.

Without the kindness and contributions of the people who provided me with useful information at the time of doing my research and writing this thesis, I would not have been able to obtain the data used in this work. For this, I would I like to thank Dr. Fridah Mugo of University of Nairobi, Mrs. Faith Odongo of Ministry of Energy, Kenya, Francis Muthami of PSDA, Kenya, Fredrick Njau of KFWG, Kenya, Prudence Ndolimana, Care Rwanda, and Dr. Valens Mulindabigwi of University of Cologne and all the farmers, charcoalers, transporters, woodfuel traders and consumers who gave me a warm welcome and patiently answered my questions.

Finally, I would like to thank my family and friends who supported and stood by me in the course of this work.

V. Table of contents

1 Introduction ... 1

1.1 Wood energy status ... 1
1.2 Research questions and objectives ... 5
1.3 Report structure ... 6
2 Analytical framework ... 7

2.1 Wood as an energy resource ... 7
2.2 Woodfuel conversion technologies ... 9
2.2.1 Wood stoves ... 10
2.2.2 Charcoal kilns ... 11
2.2.3 Charcoal stoves ... 13
2.3 Woodfuel and environment ... 14
2.4 Woodfuel markets and employment ... 15
2.5 Woodfuel and health ... 16
2.6 Woodfuel sector development policies ... 17
2.7 The value chain analysis approach for woodfuels ... 18
3 Methodology and Data availability ... 20

3.1 Methodology ... 20
3.2 Primary data collection methods ... 21
3.3 Secondary data retrieval ... 22
3.4 Value chain Analysis ... 22
3.5 Gross margin calculations ... 24
3.6 Challenges faced during the research ... 25
4 Country and woodfuel sector background ... 26

4.1 Kenya ... 26
4.1.1 General information ... 26
4.1.2 Agriculture ... 26
4.1.3 Energy ... 27
4.2 Rwanda ... 31
4.2.1 General information ... 31
4.2.2 Agriculture ... 31
4.2.3 Energy ... 33
5 Results ... 36

5.1 Economic analysis of growing wood compared to other crops ... 36
5.1.1 Kenya ... 36
5.1.2 Rwanda ... 39
5.2 Value chain analysis ... 42
5.2.1 Kenya ... 42
5.2.1.1 Fuelwood ... 42
5.2.1.1.1 Chain mapping ... 42
5.2.1.1.2 Economic analysis of the value chain ... 44
5.2.1.2 Charcoal ... 47
5.2.1.2.1 Chain mapping ... 47
5.2.1.2.2 Economic analysis of the value chain ... 51
5.2.2 Rwanda ... 56
5.2.2.1 Firewood ... 56
5.2.2.1.1 Chain mapping ... 56
5.2.2.1.2 Economic analysis of the value chain ... 58

5.2.2.2 Charcoal 62
5.2.2.2.1 Chain mapping 62
5.2.2.2.2 Economic analysis of the value chain 63
6 Discussion of results 68
6.1 Feasibility of growing wood as a cash crop in Kenya and Rwanda 68
6.1.1 Kenya 68
6.1.2 Rwanda 69
6.2 Income distribution and value addition along the value chains 70
6.3 Obstacles towards an efficient market oriented woodfuel sector 73
6.4 Overcoming the barriers to woodfuel markets development 80
7 Conclusions and recommendations 83
7.1 Conclusions 83
7.1.1 Kenya 83
7.1.2 Rwanda 84
7.2 Recommendations 85
References 87
Appendices 92
Declaration 129

VI. List of figures

Fig 1: Household traditional biomass consumption as a percentage of total energy consumed in 2005. ... 2
Fig 2: Major world charcoal producers. ... 4
Fig 3: Anagi wood stove from Sri Lanka (left) and Rocket stove used in Kenya and Uganda 11
Fig 4: Traditional earth mound charcoal kiln. ... 11
Fig 5: Brick kiln used in Kakuzi LTD and other parts of Kenya (left), and an Adam retort Kiln used in many developing countries ... 13
Fig 6: Inefficient metallic charcoal stove formally used in Kenya and Rwanda. ... 13
Fig 7: Different designs of improved institutional (top) and household (Below) charcoals stoves used in Kenya and Rwanda ... 14
Fig 8: Environmentally friendly biomass energy cycle ... 15
Fig 9: A schematic diagram of the research methodologies applied. ... 20
Fig 10: Land use in Rwanda ... 32
Fig 11: Primary energy sources in Rwanda. ... 33
Fig 12: Distribution of plantations in Rwanda by ownership ... 34
Fig 13: Variable costs for 1 hectare of selected crops in Kisii district, Kenya ... 38
Fig 14: Gross margins for 1 hectare of selected crops in Kisii district Kenya ... 39
Fig 15: Variable costs for 1 hectare of selected crops in Rwanda. ... 41
Fig 16: Gross margins for 1 hectare of selected crops in Rwanda ... 41
Fig 17: Sources of firewood in Kenya. ... 42
Fig 18: A roadside firewood vending site in Loresho, Nairobi. ... 43
Fig 19: map of Kenyan firewood value chain. ... 44
Fig 20: Quantified firewood value chain in Kenya ... 47
Fig 21: *Sources of wood for charcoal in Kenya* ... 48
Fig 22: Packed charcoal awaiting transporters in a roadside in Kakauzi. ... 49
Fig 23: A vendor transporting charcoal from a reseller to his vending cite in Eldoret, Kenya. ... 50
Fig 24: *Map of Kenyan charcoal value chain* ... 51
Fig 25: Retail and transporter prices in different estates in Nairobi ... 52
Fig 26: Quantified Kenyan charcoal value chain ... 56
Fig 27: Mobile firewood traders in Nyamirambo, Kigali. ... 57
Fig 28: *Map of Rwanda's firewood value chain* ... 58
Fig 29: Firewood stacked on the roadside awaiting buyers in Nyamagambe, Rwanda ... 58
Fig 30: Firewood vending site for freshly cut wood (Left) and old wood (Right) in Kigali ... 59
Fig 31: Quantified firewood value chain in Rwanda. ... 61
Fig 32: Poor quality charcoal from Pinus (Left) and good quality charcoal from Eucalyptus in Nyambugogo, Kigali. ... 62
Fig 33: Map of Rwanda's charcoal value chain ... 63
Fig 34: Quantified Rwanda charcoal value chain ... 67
Fig 35: Net operating income of farming systems in marginal lands in Rwanda reflecting corrected prices when the wood is sold to charcoalers and for firewood (in red and green) ... 70
Fig 36: Price share of actors in one stere of fuelwood in Kenya ... 71
Fig 37: Price share of actors in one sack of charcoal in Kenya ... 71
Fig 38: price share of actors in one stere of fuelwood in Rwanda. ... 72
Fig 39: price share of actors in one sack of charcoal in Rwanda ... 73
Fig 40: A poorly managed private Eucalyptus plantation that was harvested after 3 years for charcoal making in Nyamagambe, Rwanda. ... 74
Fig 41: Charcoal in transit to Kigali from Nyamagambe, Rwanda. ... 75

Fig 42: A vendor sells charcoal in a makeshift structure in Nyambugogo (Left) and fuelwood displayed for sale on the roadside in Remera, Rwanda. 76
Fig 43: Indoor air pollution caused by inefficient use of woodfuel. 77
Fig 44: A 12 year old boy practicing how to make charcoal in Kisii district, Kenya. 79
Fig 45: Earth mound kilns with chimneys to increase their efficiency in Nyamagambe, Rwanda. 79
Fig 46: Efficient Rocket stove for firewood promoted by GTZ (Left) and Kenya Ceramic Jiko for charcoal which has had high adoption rate in Kenya. 80

VII. List of tables

Table 1 Global forest distribution. 3
Table 2: Classification of wood fuels. 7
Table 3: Density and calorific value of selected fuels. 8
Table 4: Wood conversion technologies. 9
Table 5: Efficiencies of selected biomass energy stoves. 10
Table 6: Charcoal carbonization methods, efficiencies and investment requirement. 12
Table 7: Employment generated by different types of energy. 16
Table 8: Major risk factors contributing to morbidity and mortality in SSA and globally in 2000 17
Table 9: Country profile Kenya. 26
Table 10: Agricultural potential in Kenya. 27
Table 11: Areas of forest in Kenya and change since 1990 29
Table 12: Country profile- Rwanda. 31
Table 13: Average consumption of biomass fuels in Rwanda 34
Table 14: Charcoal consumption in Rwanda 35
Table 15: expected productive lifespan of different crops 37
Table 16: Gross margins for 1 hectare of selected crops in Kisii district Kenya 37
Table 17: Gross margins for 1 hectare of selected crops in Rwanda 40
Table 18: Summary of income distribution between actors in the Kenya firewood value chain. 46
Table 19: Retail and transporter charcoal prices in selected Kenyan towns during the wet and dry season. 53
Table 20: Breakdown of actors revenues and expenses in the Kenyan charcoal value chain.. 54
Table 21: Actors revenues and expenditure in Rwanda's firewood value chain 60
Table 22: Transporters and vendors charcoal prices in selected towns in Rwanda 65
Table 23: Breakdown of actors' revenues and expenditure in the Rwandan charcoal value chain 66
Table 24: Farmers' willingness to plant trees 69
Table 25: Interrelationship between major factors affecting the woodfuel sector 81

VIII. Acronyms

FAO	Food and Agriculture Organisation of the United Nations
FRw.	Rwanda Francs
GoK	Government of Kenya
GTZ	German Technical cooperation
Ha.	Hectares
IEA	International Energy Agency
KSh.	Kenya Shillings
KFS	Kenya Forestry Service
MININFRA	Ministry of Infrastructure, Rwanda
MOE	Ministry of Energy, Kenya
MOA	Ministry of Agriculture, Kenya
NEMA	National Environment Management Authority (Kenya)
SSA	Sub-Saharan Africa
UNEP	United Nations Environmental Programme
WHO	World Health Organisation

1 Introduction

1.1 Wood energy status

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

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

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

In developing countries, most of the biomass energy is consumed in households mainly for heating and cooking and this is expected to remain the same for a long time (FAO, 2007 and IEA 2008). Woodfuel demand for cooking and heating depends on several factors like cooking method, climate, lifestyle, and the efficiency of stoves, and ranges from a minimum of 0.5-1.0 m^3/ha/year to 3.0 m^3/ha/year in the mountain area, (Takase, 1997). However, the productivity of wood is between 4.0 m^3/ha/year in closed forest to 2.0 m^3/ha/year in conifer forest, 1.0 m^3/ha/year in savannah forest, 0.5 m^3/ha/year in low savannah, 0.1 m^3/ha/year in shrubby forest and 0.1 m³/ha/year in fallow forest. On average, 1 ha is required for one person's energy per year.

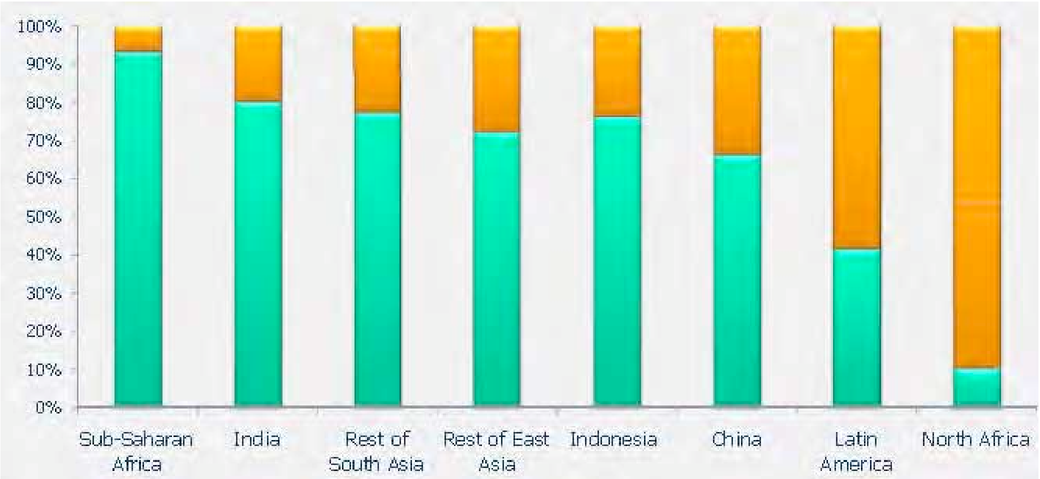

Fig 1: Household traditional biomass consumption as a percentage of total energy consumed in 2005.
Source: IEA, 2005

With the global per capita forest area in 2005 roughly estimated at 0.62 hectares, the per capita wood-growing stock is 65 m³, and the continued population increase and forest land decrease, there is a huge deficit in global biomass supply (FAO, 2005 and Takase, 1997). 64 countries with a combined population of over 2 billion people have less that 0.1 ha of forest per capita and only ten countries account for two thirds of the global forest area (FAO, 2005) showing a huge imbalance in distribution compared to the population density. As a matter of fact, FAO (no date) reported that by the year 2000 there were over 2 billion people who wholly depended on wood and out of these,1 billion were facing acute shortages and over 100 million experienced virtual 'fuelwood famine'.

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

Table 1 Global forest distribution.

Country	**Forest area (Mil. Ha.)**
Russian Federation	88
Brazil	69
Canada	68
United States	809
China	478
Australia	310
Democratic Republic of Congo	303
Indonesia	197
Peru	164
India	134
Others	1333

Source: Author's reconstruction from FAO, 2005

These challenges have lead to woodfuel production, distribution and use to become a major policy issue. With the ramifications having a great impact on vital social, economic and environmental sectors, no government can afford to overlook the sector. FAO in its publication "Sustainable Wood Energy" recommends a systems approach to wood energy production and use linking forests, trees and people in a mutually supportive and interactive chain of benefits (FAO, no date). This can only be achieved through sound planning of the wood-energy sector and careful management of the resources in a perspective of economic and environmental sustainability.

In developing countries, biomass is mostly consumed in form of firewood, charcoal and agricultural residues. About 94% of the African rural population and 73% of the urban population use woodfuels as their primary energy source (Bailis et al, 2007) with the urban settlements being heavily dependent on charcoal while rural areas are more dependent on firewood (Seidel, 2008).

For a long time, the global consumption of fuelwood has remained relatively stable, and was reported to be about 1.8 billion M^3 in 2005 up from about 1.7 billion M^3 in 1990 (FAO, 2007). Firewood continues to be used in its traditional round or split form in most developing countries but the trend has reduced in the developing world with wood chips (green or dry), wood pellets and briquettes referred as "modern fuelwood" being preferred (FAO, 2010).

Charcoal is the preferred fuel in urban areas of developing countries because of the following factors; long-life storage and low-cost transportation for its smaller volume and weight (one-third to one-fifth those of fuelwood), it's heat content is high at about 7,000 kcal/g compared to 3,000 kcal/g from dry fuelwood and 1,000 kcal/g from green fuelwood (Takase, 1997, Kituyi, 2001 and Keita, 1987).

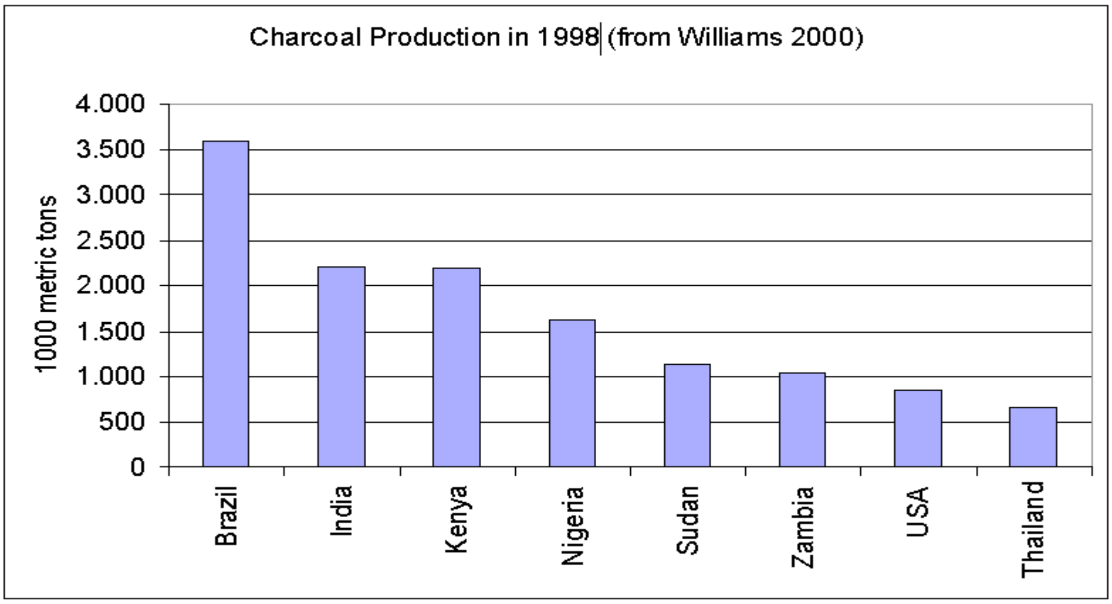

Fig 2: Major world charcoal producers.
Source: Williams, 2000

To formulate policies that will ensure sustainable supply of biomass, all the stakeholders need to be brought together to come up with the right objectives and implementation strategy. Indeed, GTZ in its publication "Biomass Energy Strategy (BEST): Woodfuel Supply Interventions. Lessons learned and recommendations" (2009) lists the four main objectives that viable biomass energy policies should address; (i)environmental and climate-friendliness (ii) security of supply, (iii) economic efficiency and compliance and (iv)health and safety.

In conclusion, OECD/IEA (2008) reported that most people who depend on biomass are poor, have or can not afford the alternatives and therefore poor biomass energy policies will greatly hurt them and keep them trapped in this vicious cycle of poverty. Since the poverty situation in developing countries is expected to persist hence reliance on biomass, the governments in the developing countries will have to give the sector more attention and come up with policies that promote sustainable production and use of biomass.

1.2 Research questions and objectives

The wood fuel sector is characterised by controversies due to the perceived environmental degradation mostly associated with it and the health effect to the final consumers. The negligence of the sector by the respective governments plus massive corruption and extortion normally subjected to the producer, transporters and traders by the police and local authorities makes it an interesting case to study. This research was conducted to help understand how the fuelwood supply chain operates, who benefits from the chain and by how much, and what are the main challenges faced by the actors. To ensure sustainable woodfuel supply, establishment of woodlots especially Eucalyptus has been constantly recommended. Bearing in mind this would have to compete with other farming systems like coffee, tea, maize and beans among others, they must be either more profitable or comparable to the other farming systems for the farmers to agree to embrace. It is to this end that the analysis of competitiveness of growing Eucalyptus in Kenya and Rwanda as compared to other land uses was done. To achieve this, four main guiding questions were formulated. These are;

1. How is income distributed in the respective fuelwood and charcoal supply chains?
2. How competitive is it to grow wood as a cash crop as compared to other crops in both countries?
3. What are the main obstacles to having a full market oriented woodfuel sector in both countries?
4. What can be done to eliminate the obstacles?

The main aim of the research was to make an economic analysis of the woodfuel sector in Kenya and Rwanda and make recommendations on how it can be transformed into a market oriented sector. The specific objectives of the study are to:

I. Analyse the income distribution in the woodfuel chains of the current woodfuel sector in Kenya and Rwanda by calculating;
   - How much does each actor earn per unit quantity and month?
   - How much does each actor have to spend?
   - How much value is added at each stage of the supply chain?

II. Carry out Gross Margin calculations to evaluate the competitiveness of growing wood for commercial woodfuel supply as compared to other crops and analyse;
   - What is the gross margin from each farming system?
   - The variable costs associated with each farming system.

- Economically, how growing of wood compares to the other farming systems.

III. Identify constraints for development of a market oriented woodfuel sector.
   - Indentify the constraints by typology.
   - Explore on their inter-relationships.

IV. Make recommendations on how the constraints can be overcome.

1.3 Report structure

This report is divided in to six major chapters. Chapter one is the introduction to the global woodfuel sector discussing major events that have shaped it over time and factors affecting it, the research question and objectives. Chapter two describes the methodologies used in data retrieval and analysis, the data sources and the challenges encountered in the course of the research. Chapter three gives the research countries' background and the wood energy status. In chapter four the results of the research are presented and these are discussed in chapter five in details. In chapter six conclusions are drawn and recommendations given that would streamline the wood fuel sectors in both countries. The data obtained during the research can be found in the appendices of this report.

2 Analytical framework

2.1 Wood as an energy resource

Wood is the oldest source of energy for mankind (FAO, 2007) and by far the most important among the biomass sources. Fuelwood and charcoal are the most common forms of woodfuel used at household level in developing countries (GTZ, 2009 and Keita, 1987). Wood-energy has an advantage of being versatile and displays a high potential for technological innovation in terms of enhanced conversion and combustion. This makes it possible to be used as a solid, liquid or gas (FAO, 2004). This is however dependent on the availability and targeted allocation of investment capital which is a major handicap in most developing countries. Sustainably sourced wood-based fuels also contribute to carbon-neutral energy supplies, promote environmental protection and the conservation of biodiversity, and help to relieve dependency on finite fossil fuels (Sepp, no date).

Table 2: Classification of wood fuels.

Fuel type	**Examples**
Solid	Fuelwood (wood in the rough, chips, sawdust, pellets), Charcoal.
Liquid	Black liquor, methanol, pyrolitic oil.
Gas	Syngas

Adapted from FAO, 2004.

In the recent times, wood has gained a lot of importance as an energy resource with reasons ranging from economic, environmental to social (FAO, 2007). FAO recommends that developing countries with vast forest resources should invest in better technologies hence reducing the dependence on imported fossil fuels whose prices fluctuate affecting the countries economy (FAO, 2008). This is based on the International Energy Agency (IEA) estimates that a US$10 increase in the price of oil can reduce GDP growth by an average of 0.8 percent in Asia, and up to 1.6 percent in the region's poor highly indebted countries. The loss of GDP growth in sub-Saharan Africa can be even higher, in some countries reaching 3 percent (IEA, 2004).

Wood energy in developing countries is mostly in form of firewood and charcoal. About 94% of the African rural population and 73% of the urban population use woodfuels as their primary energy source (Bailis et al, 2007) with the urban area heavily dependent on charcoal and rural areas dependent on firewood (Seidel, 2008).

Solid wood is normally sold in stacked cubic meters also called stere, where one stere has between $0.65M^3$ solid wood for the well stacked straight pieces in a stere to 0.33 M^3 for twisted branches (HEDON, 2010). However, wood as an energy source has one big disadvantage of having high density and low caloric values compared to other fuels, making it economically favorable to consume at or near the point of production. Charcoal, on the other hand, has low density and higher calorific value than wood making it more convenient to transport over long distances of up to 200 KM form the production points (Keita, 1987, HEDON, 2010 and Takase, 1997).

Table 3: Density and calorific value of selected fuels.

Fuel	**Density (Kg/M^3)**	**Calorific value (MJ/Kg)**
Charcoal	180	30
Wood (30% moisture content)	650-750	12-13
Wood (Oven dry)	650-750	18-19
Kerosene	806	43
Gasoline (Petrol)	720	44
LPG	560	45

Source: HEDON, 2010.

The calorific value of wood is also highly influenced by its moisture content because some of the energy in the wood is spent to vaporise the moisture in the wood. The equation below explains the relationship between the moisture content and the net calorific value (Smith, Kaltschmitt, and Thrän, 2001).

$$(H_{u(w)}) = [H_{u(wf)} (100 - w) - 2.44] / 100$$

Where:

- $H_{u(w)}$ = Net calorific value (in MJ/kg) of the biomass at a specific total moisture
- $H_{u(wf)}$ = Net calorific value of the fully dry biomass, and w the total moisture (in %).
- 2.44 = A constant resulting from the evaporation energy of water.

From this equation, it can be concluded that the net calorific value of wood decreases with increase in moisture content. It is zero at 88% moisture content and 13-16 MJ/kg for air-dried wood which is between 12 and 20% moisture content and normally used in households.

Thermal energy yield of wood is, on average, 8% and can even go as low as 5% with the popular three-stone African stove. Charcoal on the other hand has a thermal energy yield of about 28%. Keita in his publication "Wood or charcoal - which is better" (1987) reported that charcoal wastes less energy than wood if the useful energy derived from a quantity of wood used directly is lower than the useful energy derived from that same quantity of wood converted into charcoal. In fact, 1 kg of wood gives 3500 (Kcal/kg) × 0.08 (thermal energy yield) = 280 Kcal; 1 kg of wood processed into charcoal (carbonization yield 20 percent) gives = 1 × 0.20 × 0.28 (thermal energy yield) × 75.00 (Kcal/kg) = 420 Kcal. Thus there is a net wastage of 140 Kcal of energy if, instead of processing the wood into charcoal (even with a low carbonized yield of 20%), it is used directly in a stove yielding 8% or less (Keita, 1987).

2.2 Woodfuel conversion technologies

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

Table 4: Wood conversion technologies.

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

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

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

Since this report dwells on developing countries, which mostly use wood in its solid form or in form of charcoal, the technologies that will be discussed are the ones that relate to both.

2.2.1 Wood stoves

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

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

Table 5: Efficiencies of selected biomass energy stoves.

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

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

The stoves have come in different names and shapes from maendeleo stove in Kenya, Lorena stove in Uganda to Anagi stove in Sri lanka. They however all have similar features like a ceramic liner to improve heat retention and or a chimney to conduct away the flue gases.

Fig 3: Anagi wood stove from Sri Lanka (left) and Rocket stove used in Kenya and Uganda
Source: www.hedon.info/StoveImages and Author

2.2.2 Charcoal kilns

The process of wood carbonisation is very delicate and must be carefully done to achieve maximum results. Here wood is heated in the absence of sufficient oxygen which means that full combustion does not occur. This allows pyrolysis to take place, driving off the volatile gases and leaving the carbon or charcoal remaining (Practical action, no date).

The most widely used kiln technology is the traditional earth mound kiln. This comprises of a dug pit where the wood to be carbonised is stacked in a pile and covered with a layer of leaves and earth. Once the combustion process is underway the kiln is sealed, and when the process is complete and cooling has taken place the charcoal is removed (Practical Action no date).

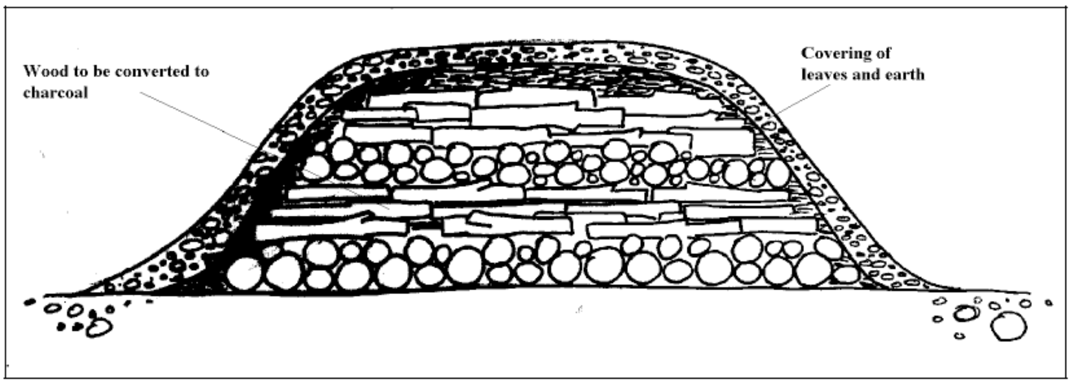

Fig 4: Traditional earth mound charcoal kiln.
Source: Practical Action (no date).

This type of kiln has been blamed for huge losses of wood with reported efficiencies of between 9% and 15% in different countries (Mugo and Ong, 2006). There are other kilns with higher efficiencies higher than 15% but these remain out of reach for most charcoal makers. These ranges from stationery brick kilns, metal kilns and concrete kilns but these have lower adoption in developing countries due to; high investment costs, lack of portability, lack of construction and operation skill among the charcoal makers (Kituyi, 2001) and free procurement of wood from government and communal trust land (Sepp, no date). The informal and sometimes illegal nature of the charcoal sector in some countries also plays a part by putting off potential investors who can afford the technologies (Karekezi et al, 2008).

Table 6: Charcoal carbonization methods, efficiencies and investment requirement.

Kiln type	Efficiency (%)	Investment cost (UD$)	Capital intensiveness	Labour intensiveness	Carbonization duration
Earth pit kilns	10-15	Low	Low	High	1-5 weeks
Brick and steel	15-30	1,013- 6,750	Medium	Medium-High	1-12 days
Large-scale/ Retorts	30-32	6,570- 756,750	High	Low	20-30 hrs continuously

Source: www.hedon.info

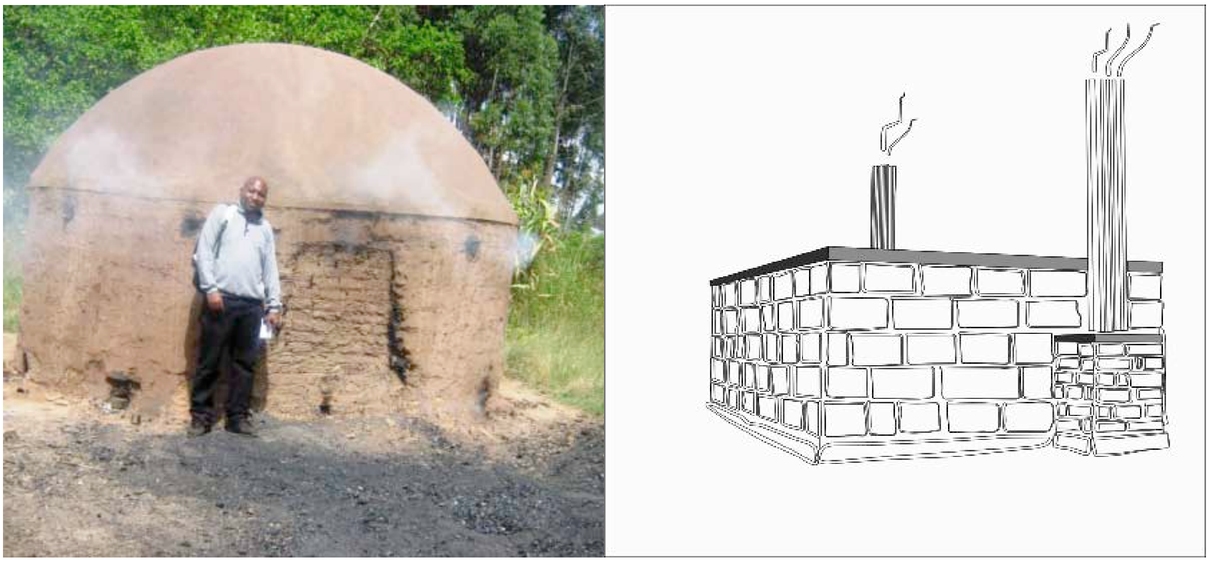

Fig 5: Brick kiln used in Kakuzi LTD and other parts of Kenya (left), and an Adam retort Kiln used in many developing countries

Source: Author and www.biocoal.org/resources

2.2.3 Charcoal stoves

The charcoal stove design determines how much energy from the charcoal will actually do useful work. The traditional charcoal stove design is metallic, with a grate to support the charcoal and allow air flow. It has very low efficiency, a factor just like in the case of wood stoves led to a lot of research to come up with a more efficient design.

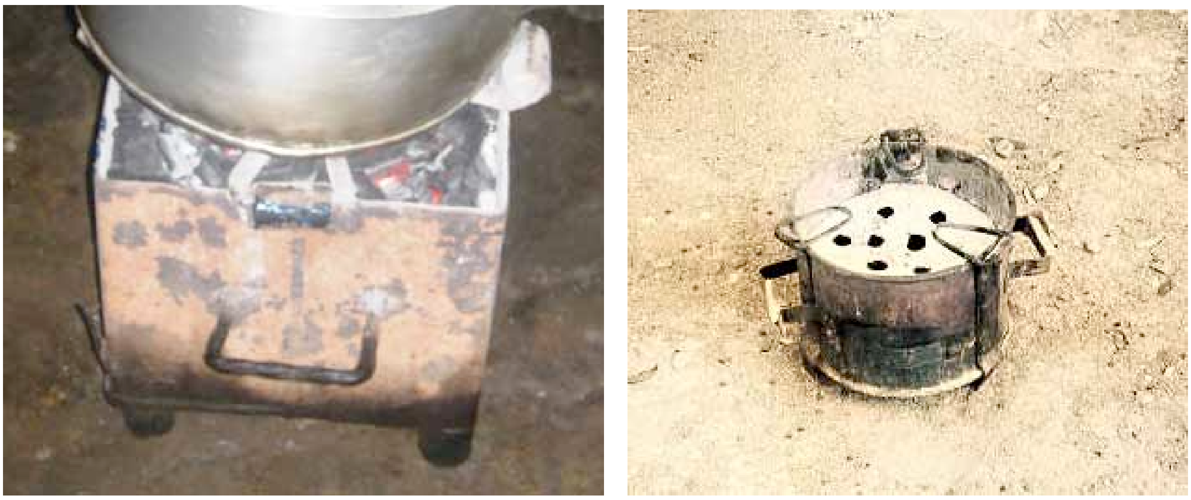

Fig 6: Inefficient metallic charcoal stove formally used in Kenya and Rwanda.

Source: Author

Most improved charcoal stoves consist of an insulating liner made of clay mixed with cement to reduce metal casing heat loss through conduction. This increases the efficiency from 15% to about 30% and leads to fuel savings of up to 50% (HEDON, 20101)

Fig 7: Different designs of improved institutional (top) and household (Below) charcoals stoves used in Kenya and Rwanda

Source: Author

2.3 Woodfuel and environment

Wood is a renewable resource which is carbon neutral, and in cases where it is sustainably produced, it replaces the CO_2 emitting fossil fuels (GTZ, 2009). With proper forest management, wood can be sustainably produced and climate friendly. For as long as the land producing the wood remains forested and is allowed the opportunity to grow, the net greenhouse gas emissions of wood-burning systems are much less than those generated by burning fossil fuels. The carbon dioxide produced by burning wood is roughly equal to the amount absorbed during the growth of the tree (Massachusetts sustainable bio-energy initiative, 2008).

When compared to coal and oil, wood fuel contains low amounts of heavy metals and sulphur. However, due to unsustainable harvesting and inefficient conversion technologies in developing countries, the woodfuel sector continues to be on of the big emitters of CO_2 in the atmosphere. In fact, Bailis et al (2007) reported the net GHG emissions from residential energy use in Sub-Saharan Africa (SSA) in 2000 were 79 MtC (61% from wood; 35% from charcoal; 3% from kerosene; and 1% from LPG). This stresses the need to adopt sustainable biomass supply practices and efficient technology for the sector to be environmentally friendly.

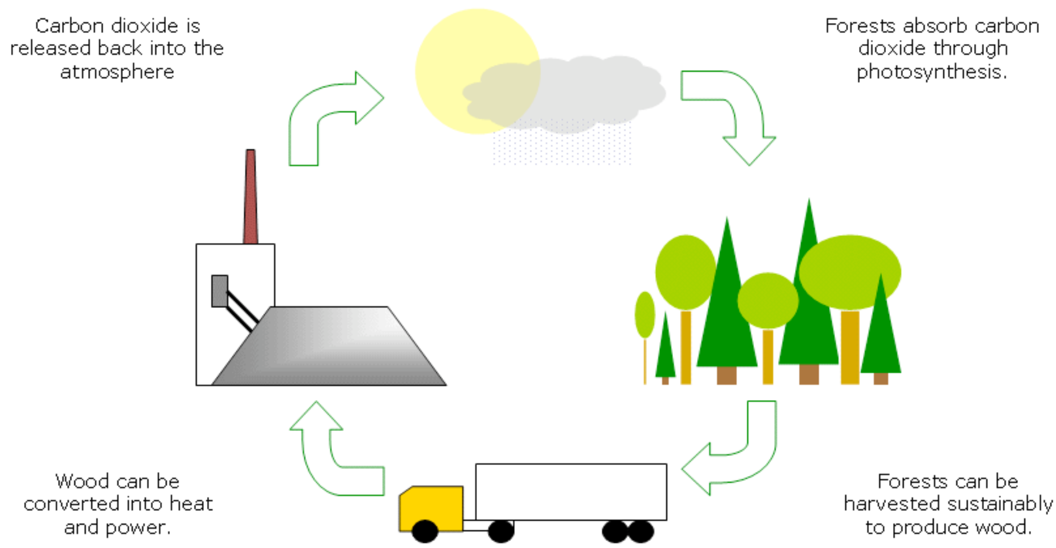

Fig 8: Environmentally friendly biomass energy cycle
Source: Massachusetts Sustainable Bioenergy Initiative (2008)

2.4 Woodfuel markets and employment

As Sepp and Mann (2009) rightfully pointed out, the woodfuel market is generally weak with under-valuated and underpriced products, despite growing scarcity of wood. The cost of wood especially in the developing countries where it is collected for free from government and trust land is never reflected in the transaction (Mugo and Ong, 2006). The under pricing generally translates into wasteful and inefficient production and consumption of wood-based fuels and creates formidable disincentives for forest management and tree growing (Sepp and Mann, 2009).

The sector is also characterized by a marked fragmentation of operators (producers, transporters and retailers) who tend to work in isolation on an individual or family basis. It is also characterized by an almost complete absence of associations, such as those that group and strengthen farmers (FAO, 2008). The fragmentation leads to poor bargaining power and lack of job security especially for the weaker links in the supply chain. Compared with other rural and urban occupations, fuelwood collection and charcoal production are occupations of the poorest members of the community who, in general, have a low social profile (Kituyi, 2001).

Despite all these problems the wood energy sector employs a lot of people all over the world, and more so in developing countries. In Kenya it is reported that the charcoal industry employs about 700,000 people both in production and trading who in turn support about 2.5 million siblings (ESDA, 2005). The figure for Pakistan is estimated at 600,000 and that of India between 3 and 4 million (Trossero, 2002).

Moreover, studies have shown that wood and other biomass resources generate at least 20 times more local employment within the national economy than other forms of energy, per unit consumed. This is due to the huge amount of manpower (unskilled labor) required for harvesting, processing, transporting and trading of the fuels.

Table 7: Employment generated by different types of energy.

Fuel	**Amount of fuel per Terajoule (TJ)**	**Employment per TJ energy in person days**
Fuelwood	62	100-700
Charcoal	33	200-350
Coal	43	20-40
Kerosene	29	10
LPG	22	10-20
Electricity	228 MWh	80-100

Source: Trossero M. A., 2002

The value added at the village level on wood energy is retained locally, helping to reduce poverty unlike fossil fuels which have to be imported acting as a drain to the national foreign currency reserve.

2.5 Woodfuel and health

The incomplete combustion of biomass in traditional stoves releases pollutants like carbon monoxide, methane, nitrogen oxides, benzene, formaldehyde, benzo(a)pyrene, aromatics and respirable particulate matter. These pollutants cause considerable damage to health, especially of women and children who are exposed to indoor pollution for long duration (Smith, 1987, Smith, 1993, Patel and Raiyani, 1997). UNEP reported that exposure to indoor pollution leads to 1.3 premature deaths especially in developing world (UNEP, 2007) with women, children and the elderly facing highest risks, owing to the long hours they spend around solid biomass fires (UNEP, 2007).

Bailis et al (2007) estimated that the inefficient urban and rural biomass conversion technologies will result in 8.1 million lower respiratory infections (LRI) deaths among young children and 1.7 million chronic obstructive pulmonary disease (COPD) deaths among adult women between 2000 and 2030 (50% of all childhood LRI deaths and 63% of all adult female COPD deaths in the 30-year interval). WHO also reported that indoor smoke and solid fuels' emissions are a significant cause of mortality and reduction in the life expectancy in the world and sub-Saharan Africa (WHO, 2003). This calls for a lot of research on better conversion technologies to avert the disaster, and make woodfuel more modern and acceptable.

Table 8: Major risk factors contributing to morbidity and mortality in SSA and globally in 2000

Risk factor	**DALYs[1] (%)**		**Mortality (%)**	
	SSA	World	SSA	World
Malnutrition	29.5	27.8	11.0	15.7
Unsafe sex	10.9	20.7	5.2	6.9
Unsafe water	5.3	5.8	3.1	3.7
Indoor smoke and solid fuels	**3.5**	**3.8**	**2.9**	**2.6**
High blood pressure	1.3	3.9	12.8	4.4
Drugs and alcohol	2.2	2.2	3.6	4.8
High cholesterol	0.6	1.7	7.9	3.4
Tobacco	0.7	1.5	8.8	4.1
All other causes	46.1	32.4	44.8	54.3

Source: WHO, 2003

2.6 Woodfuel sector development policies

Under the old perspective, biomass was viewed as a non-commercial rural resource (a poor-man's fuel) leading to governments' negligence (Shukla, no date). Most government policies were bent towards the so called "modern fuels" like electricity and petroleum products (Sepp, no date). Under the new perspective, biomass is viewed as a competitive and clean

[1] DALY means disability adjusted life-year and is a quantitative measure of population's morbidity that quantifies the severity of the illness and the time spent in each state of ill-health.

environmentally friendly energy resource. This is especially the case in developed countries, where biomass use has seen continuous growth over the years (Massachusetts Sustainable Bio-energy Initiative, 2008, UNEP and IEA 2007).

Though the international promotion of biomass as a clean fuel has been accepted in the developing world, there are still no proper policies to support the development of the sector. In some countries, the policies lack coherence and the management of the sector falls under the authority and jurisdiction of several ministries (Mugo, and Ong, 2006). Sepp and Mann (2009) give an example of Angola, Senegal and Madagascar where the supply and demand side of energy is handled by different ministries.

Kenya on the other hand, has had adhoc policies and presidential decrees banning the production and distribution of charcoal while trade and consumption has been legally accepted (ESDA, 2005). This is in contrast with the status in developing countries like Austria and Germany which gives long term support to their biomass sector hence attracting more private investment that ensure sustained growth (IEA, 2007).

FAO rightfully notes that, if the biomass sector is to develop in developing countries, the governments have to craft supportive laws, regulations and policies (FAO, 2008a, Kituyi, 2001). The policies must emphasise on energy technology, land tenure policies with a view to strengthening them, and harmonized research and development (R&D), market liberalization as well as good forestry practices. If these are all in place, FAO points out that many developing countries have the potential to produce enough biomass sustainably for their consumption (FAO, 2008a).

2.7 The value chain analysis approach for woodfuels

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

To achieve this, FAO recommends an analysis of the social and economic dimensions of woodfuel production, consumption, transport and trade to be done (FAO, 2008b). The economic magnitude of commercial physical flows is first mapped, followed by price chain analysis and the estimation of the contribution at each stage by the producers, transporters, wholesalers and retailers (Fasse et al., 2009, Kaplinsky and Morris, 2001). GTZ in the publication *"Analysis of charcoal value chains - general considerations"* notes that proper value chain analysis enables policy makers to create a favorable framework conditions which promote competitive enterprises, sustainable jobs and income for local people. Sepp (no date) adds that the evidence-based analyses of the value chain also provide the opportunity to demonstrate the added value of woodfuel production and thus help to sensitize policy makers on a source of energy hitherto neglected and left to the informal sector.

3 Methodology and Data availability

3.1 Methodology

The research started with a one and a half months internship in GTZ Headquarters in Eschborn, Germany from mid January to end of February 2010. This was for literature search and establishment of contacts with GTZ and government biomass experts in the research countries. During this period, the research proposal was written with the help of GTZ staff in Division 45 of Agriculture, Fisheries and Food.

The second phase was for data collection in the study countries and started on mid March to mid June 2010. Published literature, archival data research, interviews and site visits were the main research methods used at this phase. Semi-structured questionnaires were used for the interviews, while site visits provided a clear picture of the status of the woodfuel sector.

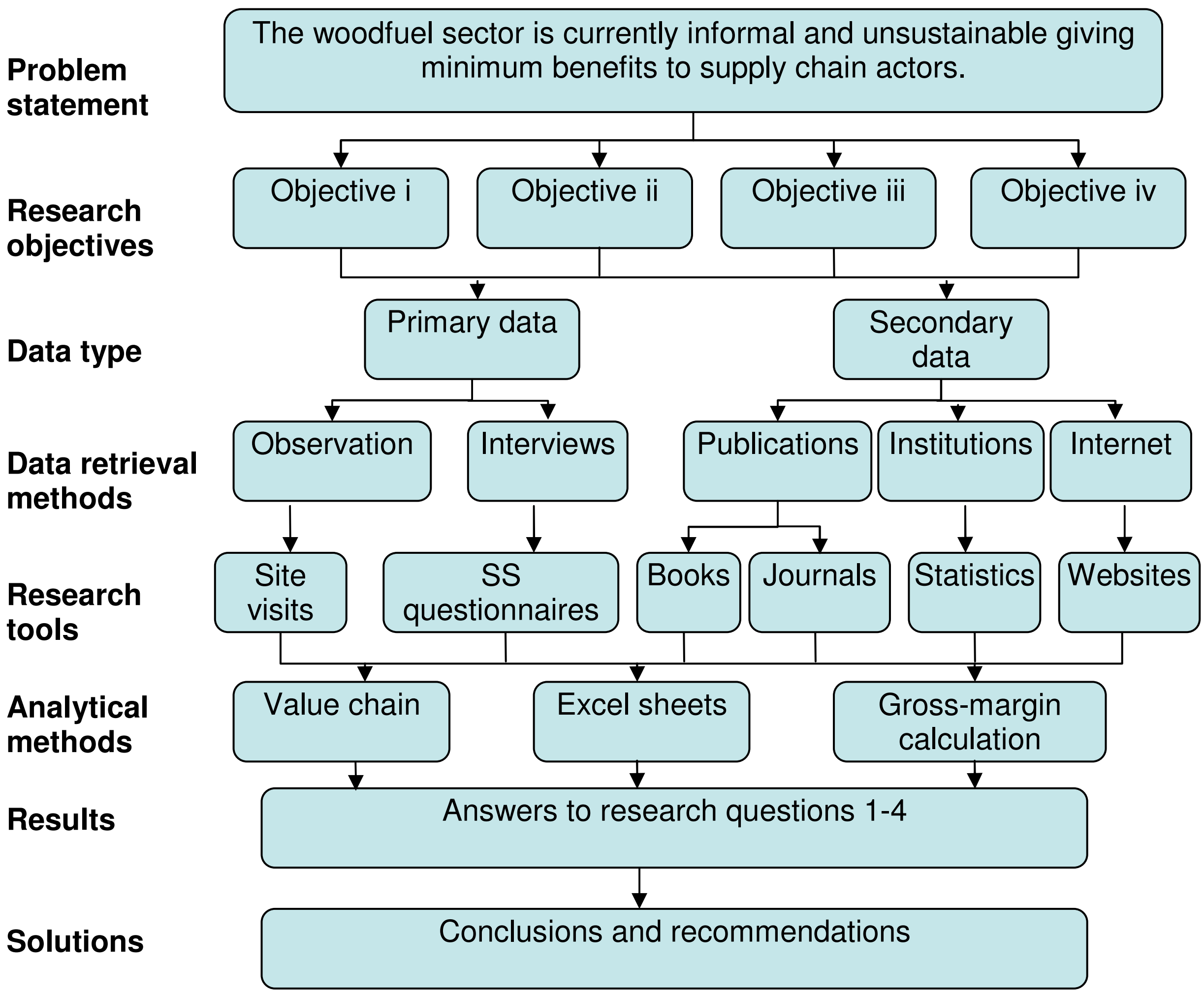

Fig 9: A schematic diagram of the research methodologies applied.
Source: Author

The final phase of the research was data analysis using excel sheets, the value chain methodology and gross margin calculations. The results were then presented in form of tables and graphs enabling the author to make conclusions on the state of the woodfuel sector. Recommendations were then made which it is hoped can help streamline the sector and lead to a fully sustainable wood fuel markets in both countries. Fig 8 shows an outline of the steps followed to during the research process.

3.2 Primary data collection methods

Two main primary data retrieval methods were used namely observation and interviews. Interviewing as a technique is primarily used to gain an understanding of the underlying reasons and motivations for people's attitudes, preferences or behavior (TVU, 2010). Semi-structured questionnaires were used to conduct the interviews because of their ability to give the interviewees a chance to express themselves as much as possible (Montello and Sutton, 2006). Other advantages of interviews are; possibility to ask follow-up in-depth questions, the interviewer is in control and can assist the respondent if they don't understand the questions, gives a possibility of investigating the motives and feelings of the respondents, and one can record the interview for future reference. However, the method has it shortcomings in that it is time consuming due to setting up the interviews and travelling, has limited geographical coverage, is expensive, respondents might be biased especially if they want to impress, create false impression or end the interview quickly and could create fear when some incriminating questions are asked (TVU, 2010).

Observation involves recording the behavioural patterns of people, objects and events in a systematic manner. Unstructured and undisguised observations were done in the woodfuel vending and production sites and photos were taken for recording purposes. The information gathered complements or sets in perspective data obtained by other means, such as interviews and reviewed literature (WLC, no date). It has the advantage of capturing the events as they naturally occur and one is able to gather information that may normally be ignored because it is so common hence regarded as insignificant (Crowther and Lancaster, 2005). However it is time consuming, expensive to travel to the sites and may be open to research bias since one can not observe rationale for action, only actions themselves (Mack N. et al, 2005).

3.3 Secondary data retrieval

During the research, secondary data sources were used extensively which included published materials like books and journals, country research bodies and government based agencies' data bases like ministries and government parastatals, and established organisations like FAO, GTZ and UN web resources. The secondary data sources were systematically scanned to identify and retrieve relevant information. Secondary data is quite cheap to obtain, less time consuming to retrieve and in most cases reliable depending on the credibility of the source (SDSU, 2010). However since they are usually gathered for purposes that differ from the researcher's objective, one is faced with some challenges like; relevance where the units and categories of data classification categories may not match the researchers need, lack of means to evaluate the data collection process hence its credibility, and finally some data may be old and outdated rendering it irrelevant (SDSU, 2010, TVU, 20101). These challenges were overcome where possible by directly contacting the responsible country-based organizations incase of data bases but it proved difficult to get response where the data sources were publication by individuals or global organizations.

3.4 Value chain Analysis

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

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

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

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

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

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

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

Value added (VA) is defined by the equation:

$$VA = Y - II$$

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

3.5 Gross margin calculations

Gross margin calculations as a tool is used by farmers to help in choosing between different farming systems. It was selected to help evaluate the competitiveness of growing wood to supply to the woodfuel market as compared to growing other types of crops. A gross margin of a crop is the difference between the gross income earned by the crop and the variable or direct costs associated with it (Abbott and Makeham, 1979). The wages of permanent workers and depreciation of machinery is normally left out when calculating the gross margins.

Gross margin = Gross income - Variable costs

Where:

Gross income is obtained by multiplying the gross output (yields) by the "farm-gate" price received for the product.

Variable costs are the costs directly linked to the crop or farm method. The more of a crop a farmer grows the more of these costs he will incur. They include; cost of seeds, spray, ploughing, water, harvesting, packing marketing, storage etc.

It is important to note that the gross margins should not be negative for any farming enterprise if the farmer is to make profits. Abbott and Makeham (1979) argues that, for semi-subsistence farmers, food security might be more important than gross margins, but if one or two crops have very high gross margin, then it is advisable to grow them and buy food from the returns.

During the research, the cash flows were estimated using the current market prices of commodities. The establishment costs for perennial crops were amortized for the entire expected lifespan of the crop using the following relationship as given by Upton (1973):

$$CA = \frac{(Q*P)*[r\,(1+r)^n]}{[(1+r)^n - 1]}$$

Where:

CA – constant annuity; *Q* -Quantity; *P* - Price per unit; *r* - interest rate; *n* – Life expectancy of the crop in years.

The interest rates used were the prevailing lending rates in April 2010 which stood at 15% in Kenya (CBK, 2010) and 16% in Rwanda (NBR, 2010).

3.6 Challenges faced during the research

In the course of the research, different challenges were encountered some which affected the outcome all called for innovative ways to overcome. These challenges are:

1. Limited time for the research, which would not allow for collection of primary data hence reliance on secondary data. The secondary data proved to be quite useful especially in Rwanda where it was up-to-date.
2. Lack of up-to-date data on woodfuel sector especially in Kenya. The last conclusive survey was carried out in the year 2000 and the report published in the year 2002. The data was validated by conducting field visits to different towns in Kenya and interviews with renewable energy experts in Kenya.
3. Unwillingness of some data custodians to give some crucial data. The problem was solved by using archival data or contacting other related institutions who had similar data.
4. Reluctance of some stakeholders to give crucial data. An example is the charcoal sub-sector where some charcoalers, transporters and vendors were reluctant to disclose their financial flow mainly because the sector is considered illegal and they are always subjected to constant harassment by the authorities. The challenge was overcome by promising anonymity and convincing the respondents the research was only academic and that the government was not involved.

4 Country and woodfuel sector background

4.1 Kenya

4.1.1 General information

Kenya has a total land area of 569,250 sq. km. and an estimated population of about 39 million (CIA country statistics for Kenya, 2010) inhabitants with Nairobi and its suburbs, the central highlands and the shores of Lake Victoria having the highest population density of more than 600 people per square kilometre (Harding and Devisscher, 2009). The country has a GDP per capita (PPP) of US$1,600 and about 50% of the population leave below the poverty line.

Table 9: Country profile Kenya.

Area (km^2)	580,367
Population (Millions) (2009 estimate)	39
GDP per capita (PPP) (2009 Estimate) US$	1,600
Main Exports	Coffee, tea, pyrethrum, horticultural products, fish
Contribution of Agriculture to GDP (%)	21.4%
Population employed in Agricultural sector (%)	75%
Contribution of woodfuel to country primary supply (%)	68%
Population below poverty line (%) (2008 estimate)	50%

Source: Authors reconstruction from CIA country Statistics for Kenya and GOK, 2008.

4.1.2 Agriculture

Land in Kenya is considered a basic commodity that supports life and is very treasured. As much as 85% of the country landmass is classified as marginal lands and about 15% of land has medium to high potential. Population pressure has led to encroachment of the arid and semi arid lands (ASALs) which have a fragile ecosystem a fact that may lead to further degradation.

Table 10: Agricultural potential in Kenya.

Agro-ecological zone	**Potential land use**	**Area (in 000 Ha.)**	**% of land**
I-III	Medium to High: Agriculture, livestock (intensive), forestry.	860	15
IV and V	Marginal to medium: Agriculture (drought resistant crops), livestock(ranching)	11,500	20
VI and VII	Marginal: Livestock (extensive pastoralism)	37,400	65
Total		57, 500	100

Source: NEMA, 2004

The country has climatic and ecological extremes, with altitudes varying from sea level to over 5,000m in the highlands. The mean annual rainfall ranges from less than 250mm in semi-arid and arid areas to more than 2,000mm in high potential areas. Agriculture is the leading sector of the national economy, employing about 75% percent of the population and accounting for 26% of the country's GDP and 60% foreign exchange earning (NEMA, 2007). Out of 9.4 million ha of potentially cultivable land, only 2.8 million hectares are devoted to agriculture (GOK, 2007). Even though certain areas endure arid and semi-arid conditions, most cropping systems are rain fed, and irrigation development remains quite limited. 80% of the farmers practice subsistence farming mainly producing maize, beans, sorghum, millet, onions, peas and other traditional crops for self consumption. The main cash crops grown are coffee, tea, sisal, cotton, pyrethrum, rice, sugarcane and horticultural products meant for export market like flowers, green beans and other vegetables.

4.1.3 Energy

The principal end energy supply sources in Kenya are biomass 68 %, Petroleum 22 %, Electricity 9 % and coal at less than 1% (GOK, 2008). The energy scene thus exhibits a predominant reliance on dwindling biomass energy resource to meet energy needs especially for the rural households and a heavy dependence on imported petroleum to meet the modern economic sector needs. In the electricity sub-sector, hydropower accounts for 57 % followed by fossil- based thermal generation which accounts for 33 % and geothermal 10 %. The other forms of renewable energy, including wind, solar, biogas and micro hydro account for less than 1% (NEMA, 2007)

Over 90% of rural households use firewood for cooking and heating while 80% of urban households depend on charcoal as a primary source of fuel for cooking (ESDA, 2005). In 2006, biomass demand was estimated at 38.1 million tonnes against a sustainable supply of 15.4 million tones creating a demand-supply deficit of 60 % (NEMA, 2007). The demand is estimated to be growing at 2.7 % per year while sustainable supply was growing at a slower 0.6 % per year (GOK, 2002).

Electricity, which is purported to be the alternative to wood fuel and biomass, remains far beyond the majority poor as the cost remains high at US$0.15 per KWh (Ogweno, Opanga and Obara, 2009). The access to electricity in the country stands at 83% of the population, but only a low 18% of the people are connected to the grid (GOK, 2008). Connection is lowest in the rural areas where it stands at 4% while in the urban areas it stands at 51%.

Biomass supply comes from various forest formations. Closed forests, woodlands, bushlands and wooded grasslands account for 16,307, 703 M^3, farmlands comprising exotic tree species such as Grevillea, Eucalyptus and remnant natural vegetation 14,380,951 M^3, plantations, mainly of Eucalyptus 2,717,972 M^3 and residues from agriculture and wood based industries 3,085,800 M^3 (GOK, 2002).

The forest resource in Kenya has been declining over the years and many researchers have in the past predicted a biomass supply crises in the country from as early as the year 2000 (Beijer Institute, 1984). However, the government put a lot of efforts in promoting agro-forestry, a factor which led to an increase in the number of trees in farms continuously from 9,420,000 hectares in 1990 to 10,320,000 hectares in 2010 giving the sector some hope (KFS, 2010). This is against the continued decline in public forests, open woodlands and bush-lands, which have been either excised or converted to agricultural land.

Table 11: Areas of forest in Kenya and change since 1990

Category of forest resource (Using FAO definitions)	Area (`000 Ha.)				Percentage change from 1990-2010 (`000 Ha.)
	1990	2000	2005	2010	
Indigenous closed canopy forest	1,240	1,190	1,165	1,140	-5
Indigenous mangroves	80	80	80	80	0
Open woodlands	2,150	2,100	2,075	2,050	-5
Public plantation forests	170	134	119	107	-3.15
Private plantation forests	68	78	83	90	+1.1
Bush-land	24,800	24,635	24,570	24,510	-14.5
Farms with trees	9,480	10,020	10,320	10,385	+48.25

Source: KFS, 2010

Many woodlots are found in the foothills of Aberdare Ranges, Mount Kenya and in most communities of Central Kisii, Nyamira and Buret Districts. In large areas of Maragwa and Murang'a districts, crop lands have about 12% of woodlots (Harding and Devisscher, 2009). These are areas characterised by high population density and high demand centres of wood like tea industries. In marginal areas with low rainfall, like Kitui and Makueni, farmers do not plant woodlots since they are less productive. Majority of plantations are owned by the government especially in the Rift valley and Central Kenya.

The biomass energy sector in Kenya is faced with many problems, ranging from being blamed for forest degradation, health related diseases from emissions, shortage of supply and lack of government commitment to streamline it through proper legislations. Despite its importance to the country, the sector is not adequately reflected in national energy policies. The Energy Act 2004, which governs the energy sector, has strong bias towards electric energy and the petroleum sector, with only a token mention of biomass energy. This neglect from the government has led to the sector operating informally, and many people looking down upon woodfuel as a poor man's fuel (Sepp and Mann, 2009 and Mugo and Ong, 2006).

Households are the main consumers of biomass, with the rural area using firewood and agricultural residues while charcoal is favoured in the urban and peri-urban areas. Approximately 89% of rural households use firewood compared to 7% in the urban areas, with a corresponding per capita consumption of 741kg and 691kg in the rural and urban areas respectively. In comparison, 82% of the households in urban areas and 34% in rural areas rely on charcoal to meet their energy needs. The per capita consumptions of charcoal in urban and rural areas were 152Kg and 156 kg respectively (GOK, 2002).

The traditional three stone stoves is the most common technology in the rural areas. The Ministry of Energy reported that it was used by about 96% of the rural population in 2004 (GOK, 2004). For Charcoal, the Ministry reported an adoption rate of charcoal efficient stoves of 47% in the urban areas. However , the energy policy (2004), and the Vision 2030 for Kenya, sector plan for Energy (2008) set the goal of increasing the national adoption rate of efficient wood stoves to 30% by 2020, and efficient charcoal stoves to 100% in urban areas and 60% by 2020. The government also targets to improve the efficiency of the charcoal stoves from the current 30-35% to 45-50% by 2020 through investments in research and development. All this is with the view of conserving the available biomass resource to avoid the sector collapse predicted before (GOK, 2008).

There is an active charcoal market in Kenya, which though informally coordinated, is well organised from production to retailing sites in the urban areas. There is a big demand for the fuel in the urban areas, where production is not possible, and the people can easily afford it. Several researchers have reported that the major problem hindering development of the sector is corruption and lack of legal and policy framework to govern the sector (ESDA, 2005, GOK, 2002, Mugo and Ong, 2006 and Kituyi, 2001). ESDA (2005) reported that the lack of legal and policy framework makes the government loose about KSh 5.1 billion which it would generate as tax.

On the contrary, the fuelwood market is less developed at household level but demand is high in institutions and industries like tea and tobacco curing. A survey by Kamfor LTD (GOK, 2002) found that 76% of households obtain firewood for free either in their farmlands, government forests or from trust lands. Only 17% of the households meet their firewood requirements through purchasing, while 7% purchase and collect it for free. Firewood also is very bulky a factor that makes it suitable only for use within the vicinity of production. About 93% of the respondents in the survey stated that they use human labour to transport it with 81% of them obtaining it within a 5 km radius from their homes.

4.2 Rwanda

4.2.1 General information

Rwanda is a country in the East of the central of Africa, located between 1^{o} 04´ and 2^{o} 51´ latitude south and 28^{o} 45´and 31^{o} 15´ longitude east (MININFRA, 2009a). It has an area of 26,338 KM^2 and an altitude varying between 1,000M in the east and 4,500M in the west.

The country has five provinces namely; North, East, South, West and Kigali city, whose administration is headed by a centrally appointed Governor. These provinces are divided into 30 districts with a mayor at the helm. It has an estimated population of over 10 million inhabitants (CIA Statistics for Rwanda, 2010) and an average population of more than 321 residents per KM^2 which is one of the highest in Africa. In 2008, it had a GDP of 3,460 million US Dollars, and a healthy growth rate of 7%.

Table 12: Country profile- Rwanda

Area (Sq.km)	26,338
Population (Millions) (2009 estimate)	10.7
GDP per capita (PPP) (2009 Estimate) US$	1,000
Main Exports	Coffee, tea, pyrethrum
Contribution of Agriculture to GDP (%)	42.6%
Population employed in Agricultural sector (%)	90%
Contribution of woodfuel to country primary supply (%)	80%
Population below poverty line (%)	60%

Source: CIA country statistics for Rwanda, MINIFRA, 2009a

There are three main altitudinal zones in Rwanda namely lowlands (900-1500 m), midlands (1500-2000 m) and highlands (2000 – 4507m) (GTZ, 2010). Lowlands are situated in the Eastern province and are characterized by low precipitations of between 800 and 1000 mm/annum, high temperatures (annual mean: 21°C), a relative humidity ranging from 55 to 75 % and high seasonal rain variability compared to the whole country. In the middle lands, the annual rainfall average varies between 1000 and 1500 mm. The highlands have an annual rainfall above 1500 mm. Over 80% of Rwanda has rainfall in excess of 750 mm.

4.2.2 Agriculture

Rwanda is a poor rural country with about 90 % of the population engaged in subsistence agriculture where 30 to 50 % of the rural population on any given year do not produce a marketable surplus (worldbank, 2010). Agriculture contributes 43.2% of the country's GDP according to the CIA country statistics for Rwanda 2008 estimates. Almost 75 % of the Rwanda is used for crop growing and pasture farming, while another 20% is covered with woods. The main crops are bananas, cereals (maize, sorghum, rice, wheat), tubers (cassava, Irish potato, sweet potato, yam), legumes (soya, beans, peas), fruits (avocados, pineapple, passion fruit, guava, papaya, citrus), vegetables (cabbages, carrots, amaranths, squash, eggplant, tomatoes, onions) and the purely export market crops (tea, coffee, pyrethrum). In terms of cultivated area for food crops, the major ones are; bananas (21 %), beans (20 %), cassava (9 %), sweet potato (9 %), Irish potato (8 %), maize (8 %) and sorghum (8 %) (GTZ, 2010).

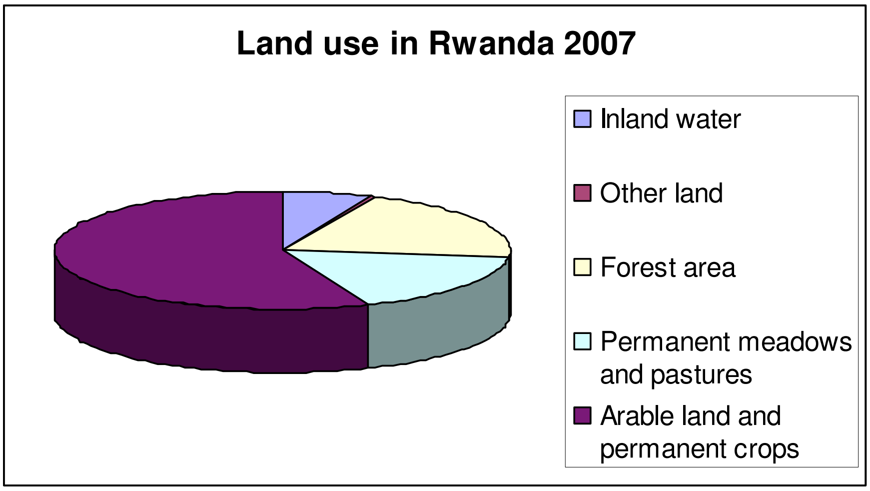

Fig 10: Land use in Rwanda
Source: FAO

The government regulates the management, organization and exploitation of land and also regulates the lease of the state land. Article 20 of the land law provides the ground for the land consolidation process which states that "It is prohibited to reduce the parcel of land reserved for agriculture of one or less than a hectare" while the 'organic Law' gives guidelines on different crops that should be grown in different ecological zones in consolidated plots to maximise on the productivity (Organic LWA N ° 08/2005 of 14/07/2005, Article 2). The law also provides that a farmer or land owner can easily loose his/her rights in case of not adhering to the rules and regulations (GTZ, 2010). There is a presidential order that limits the amount of land that one can own to 25 hectares but land lease has no limit.

The average plot size in Rwanda is 0.81 hectares, with a quarter of the population cultivating less than 0.2 hectares per household. About 50% of the cultivating households cultivate less than 0.5 ha and more than 60% of the households cultivate less than 0.7 ha. Less than 5% of the cultivating households cultivate more than 5 ha (EICV, 2006).

4.2.3 Energy

Rwanda's primary energy supply is dominated by biomass resources. Wood supplies about 57% and wood for charcoal 23% while agricultural residues and peat provide 6% and petroleum products 11% (GTZ, 2010). Only 5% of the country's population is connected to the electricity grid, with 3% being in the rural areas and 25% in the urban areas (MINIFRA, 2009). FAOSTAT (FAO, 2005) reported that in 2000 the country used 93% of the roundwood extracted for woodfuel and with consumption estimated to be growing at a rate of 2.3% per annum, the demand is expected to rise from about 1.1 MTOE in 2008 to more that 1.4 MTOE by 2020 (GTZ,2010)

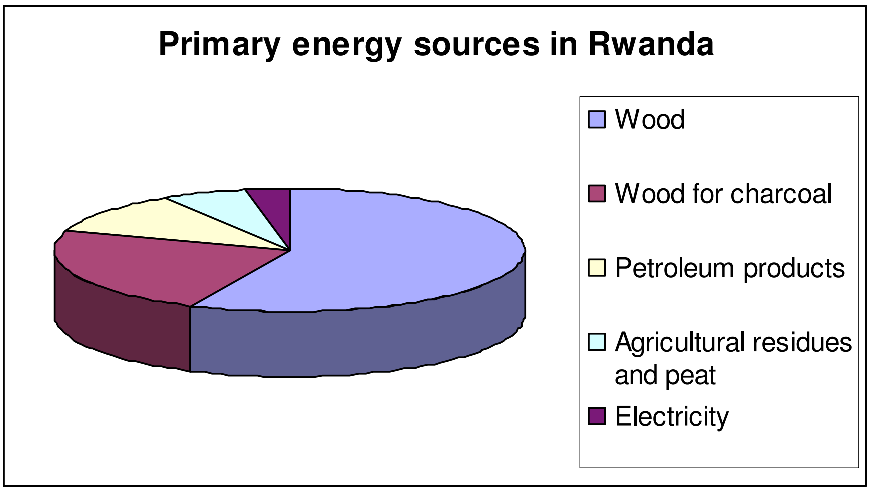

Fig 11: Primary energy sources in Rwanda.
Source: MININFRA, 2009b

Through "Vision 2020 for Rwanda" the country aims to reduce the pressure on biomass resources by ensuring at least 35% of the population is connected to the electricity grid and reducing woodfuel consumption to 50% through promotion of other energy sources like LPG and kerosene (REMA, no date, MININFRA, 2009b). This is a tall order considering the high cost of electricity (80 FRW/kWh or 0.15 USD/kWh) and LPG (FRw 2,470/kg or US$ 4,541/Tonne) making them out of reach for the common man (GTZ,2010 and MININFRA, 2009a) . LPG has to be imported from Kenya. Transportation cost and VAT makes it more expensive and uncompetitive with the biomass it is supposed to substitute (MININFRA, 2009a).

88.2% of the households use biomass inform of fuelwood at 1.45 kg/person/day while 7.9% use charcoal at 0.45kg/person/day (GTZ, 2008). There is a combined per capita demand of wood (both for fuelwood and charcoal) of 1.93kg/ person/day which creates an unsustainable situation because it largely surpasses the production capacity of 0.46 kg/capita/day (MININFRA, 2005). FAO in its publication "Wisdom for Rwanda" estimates that over 1.5 million people (20% of people residing in rural provinces) live in areas with concomitant conditions of serious woodfuel deficit and high poverty (FAO, 2010b).

Table 13: Average consumption of biomass fuels in Rwanda

Biomass fuel	**Average consumption (kg/person/day)**	**Percentage population**
Fuelwood	1.45	88.2
Charcoal	0.48	7.9
Agricultural residues	0.24	3.6
Others	-	0.3

Adopted from GTZ, 2008

Unlike many African countries, all the biomass energy demand in Rwanda is met from plantations, mostly Eucalyptus (MININFRA, 2009b). Currently, about 450,000 ha or 17% of the country is covered by forests, with 46% being natural forests and the rest public and private plantations. 65% of the plantations are state and district owned while institutions own 9% and 25% is privately owned. 30% of the state forests are left for soil protection which reduces the amount of plantations that can be harvested to 194,000ha distributed as shown in the figure below (MININFRA, 2009a).

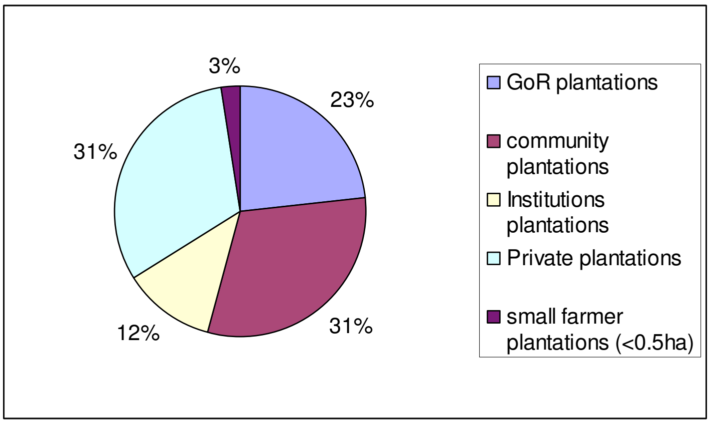

Fig 12: Distribution of plantations in Rwanda by ownership

Source, MININFRA, 2009a

Studies indicate that about 80% of firewood used in Rwanda is collected free mostly from private land hence very little goes through the market economy (Theuri, 2007). The firewood market is thus less developed with only tea factories, institutions like schools and small and medium enterprises (SME'S) buying the resource. It is estimated that annual consumption of commercial fuelwood in Rwanda is about 700,000 tonnes (MINIFRA, 2009b). While some people still use the traditional three stone stoves, many districts in Rwanda have improved stove promotion programs in place and some even claim that they are reaching close to 100% coverage rate.

Most of the charcoal is consumed in Kigali, and the main supply areas are the Southern and Western Provinces. It is estimated that about 150, 000 tonnes consumed per year with a total value of US$ 50-60 (MININFRA, 2009a), 80% of which are sold in Kigali and the rest in the small urban centres (MINAGRI 1998). The charcoal requires about 1.2 million tonnes of wood to produce placing a lot of pressure on the resource base (MININFRA, 2009b). Most of it is produced with the traditional earth mound kilns with an efficiency of about 12%.

Table 14: Charcoal consumption in Rwanda

Area	**Charcoal consumption 2008 estimates ('000 tonnes)**	**Percentage**
Kigali city	86	58
Other urban areas	37	25
Rural areas	26	17
Total	149	100

Source: MININFRA, 2009b

To reduce this pressure, improved charcoal stoves have been promoted since 1980's and currently have a penetration rate of about 50%. Among the improved charcoal stoves are the DUB 10, an all metal stove which originally comes from Burundi and the Kenya Ceramic Jiko (KCJ) originally from Kenya (MINIFRA, 2009a).

5 Results

5.1 Economic analysis of growing wood compared to other crops

5.1.1 Kenya

To evaluate the competitiveness of growing wood as a cash crop in Kenya, Kisii district was selected because data was already available from the Ministry of Agriculture and the "Farm Management Handbook of Kenya; West Kenya" (Ministry of Agriculture Kenya, 2009a). The limited time of the research could not allow collection of primary data, but the commodity prices and labour costs were validated during a tour in Kisii. Kisii also proved to be a suitable choice due to the diversity of the crops planted in the district ranging from seasonal crops like maize and beans to perennial crops like coffee, tea and sugarcane. There has been a huge drive by the government since the year 2000 to improve the benefits of farming through intensified farming a move that has seen Kisii, one of the beneficiaries of this drive, enjoy maximum yields for crops like maize, beans, sugarcane and groundnuts.

There is also high demand for Eucalyptus in the area mostly for firewood in the Tea factories and for electricity transmission poles. A visit to Nyankoba tea factory established that the factory can not meet its firewood demand deriving only 50% of its energy needs from firewood and the rest from industrial oil. The factory has undertaken several measures to promote Eucalyptus growth amongst the farmers like giving them free seedlings and raising the buying price of wood from KSh. 1,200 to 1,500 at factory gate but these incentives have not worked so far. It has been forced to invest heavily in its own plantations in Kisii and Kilgoris to ensure sustained firewood supply. The situation was found to be the same in other parts of Kenya in Central and Eastern provinces.

It was thus interesting to do economic analysis of different farming enterprises in the area to establish if it is profitable to grow Eucalyptus as compared to other crops.
When carrying out the analysis, it was assumed that:

1. A farmer who invests in seasonal crops like maize, beans, millet and ground nuts will plant for the two possible seasons in one year hence the gross margin for one season was multiplied by two.
2. That the farmers have adopted the intensified farming methods guaranteeing them high yields under favourable weather conditions.

3. The perennial crops will remain productive for the expected lifespan as published in several literature sources like FAO, Ministry of agriculture in Kenya and GTZ (2010). Table 14 shows the expected productive life span for the analysed perennial crops in Kenya and Rwanda which were used to amortize the establishment costs. All the costs before the perennial crops gave any yields were treated as establishment costs.

Table 15: expected productive lifespan of different crops

Crop	Expected lifespan (Yrs)
Coffee	25
Tea	50
Sugar cane	7
Eucalyptus- firewood (Kenya)	8
Eucalyptus- transmission poles (Kenya)	10
Eucalyptus- firewood (Rwanda)	6
Jatropha	20
Cassava	1.5
Bananas	15

Source: FAO website, Ministry of Agriculture Kenya, GTZ (2010)

A summary of the analysis for all the crops is presented in table 15 and the calculations for individual crops are shown in the appendices at the end of this report.

Table 16: Gross margins for 1 hectare of selected crops in Kisii district Kenya

Gross margins for 1 hectare of selected crops in Kisii district Kenya			
Crop	**Income**	**Variable costs**	**Expected gross margin (US$)**
Maize	1,500	1,110	390
Finger millet	1,000	398	602
Beans	1,000	597	404
Sugarcane	1,734	831	903
Tea	3,125	2,089	1,036
Coffee	2,625	1,648	977
Eucalyptus (firewood)	1,688	560	1,127
Eucalyptus (Transmission poles)	1,406	235	1,171
Sweet potatoes	2,250	1,153	1,098
Ground nuts	3,200	1,415	1,786
Irish potatoes	4,500	3,328	1,172

Source: Author

Capital availability is one of the factors that influence the decision making of the farmers on what crops to plant. It was therefore important to consider the amount of money the farmer has to set aside as variable cost for each farming system per hectare to achieve the expected gross margin. Irish potatoes have the highest variable costs per hectare at about US$ 3,300 while tea and coffee come in second and third respectively. Eucalyptus for transmission poles has the lowest variable costs at about US$ 235 while finger millet, eucalyptus for firewood and beans follow in that order. Compared to the traditional perennial cash crops of coffee, tea and sugarcane in the area, eucalyptus for firewood and transmission poles is the cheapest to invest in for farmers with limited capital outlay.

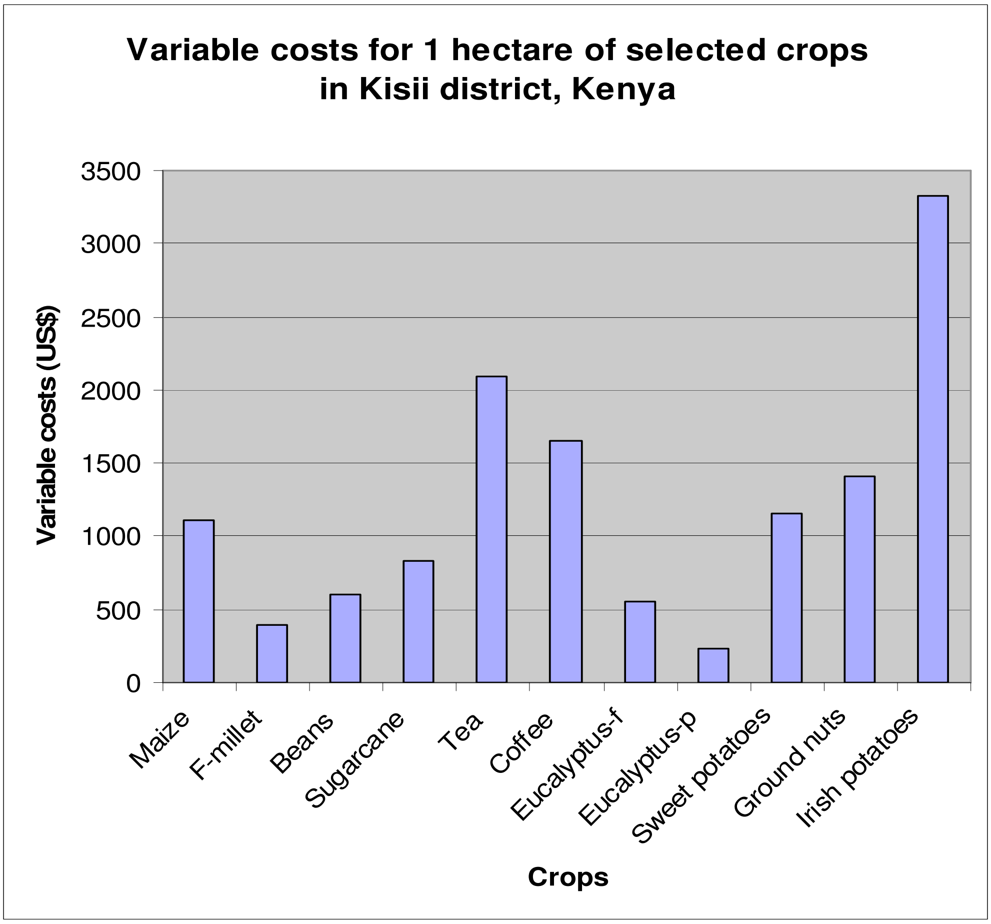

Fig 13: Variable costs for 1 hectare of selected crops in Kisii district, Kenya
Source: Author

From the analysis it was clear that ground nuts in Kisii have the highest gross margin of over US$ 1,700 while Irish potatoes and eucalyptus for transmission poles and firewood come in second. Tea, which is a major cash crop in the area, comes in slightly below, while maize has the least gross margin.

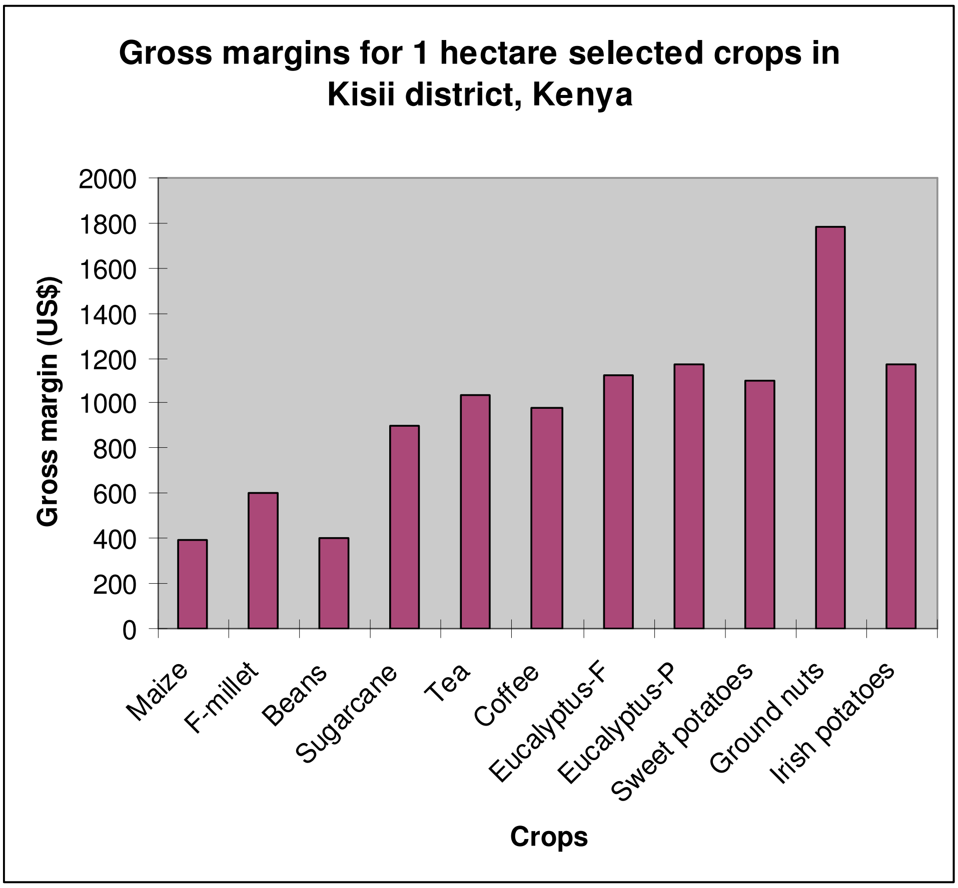

Fig 14: Gross margins for 1 hectare of selected crops in Kisii district Kenya
Source: Author

5.1.2 Rwanda

The analysis for Rwanda was based on data gathered by GTZ during a study on the Bio-fuel potential in 2009 and whose results were published in the Bio-fuel study for Rwanda (GTZ, 2010). This data was validated by checking the commodity prices in the month of April in the country. Although the study by GTZ did extensive analysis for different farming systems from traditional farming, marginal lands and intensified farming, in this research, I concentrated on the analysis for intensified farming system. The reason for choosing this is that the country has been promoting intensified farming through the Ministry of Agriculture and several NGO's like Care International, USAID and IFDC (International Centre for Soil Fertility and Agricultural Development) so as to increase yields and ensure food security. As such, it was important to evaluate the performance of Eucalyptus with this fact in mind and see its performance against other crops under intensified cropping system.

The analysis was also done under the same assumptions as in Kenya and the establishment of perennial crops were also amortized for the expected productive life span of the crops at 16%

interest rate. Table 16 shows a summary of the analysis while more detailed analysis on crop by crop bases can be found in the appendices.

Table 17: Gross margins for 1 hectare of selected crops in Rwanda

Gross margins for 1 hectare of selected crops in Rwanda			
Crop	**Income**	**Variable costs**	**Expected gross margin (US$)**
Cassava	5,034	1,061	3,973
Bananas	2,966	1,624	1,342
Jatropha	1,078	797	281
Eucalyptus-firewood	483	157	326
Sugar cane	1,939	680	1,259
Coffee	2,802	1,921	881
Irish potatoes	6,429	5,936	493
Sweet potatoes	3,724	2,900	824
Maize	2,745	1,722	1,023
Sorghum	2,559	1,823	736
Rice	5,990	1,680	4,310
Beans	1,619	1,198	421
Ground nuts	3,538	1,584	1,954
Wheat	3,724	2,117	1,607

Source: Author

Irish potatoes have by far the highest variable costs at almost US$ 6000 per hectare per year followed by sweet potatoes. Eucalyptus has the lowest variable cost by far at US$ 157 making it the cheapest option for a poor farmer to invest in.

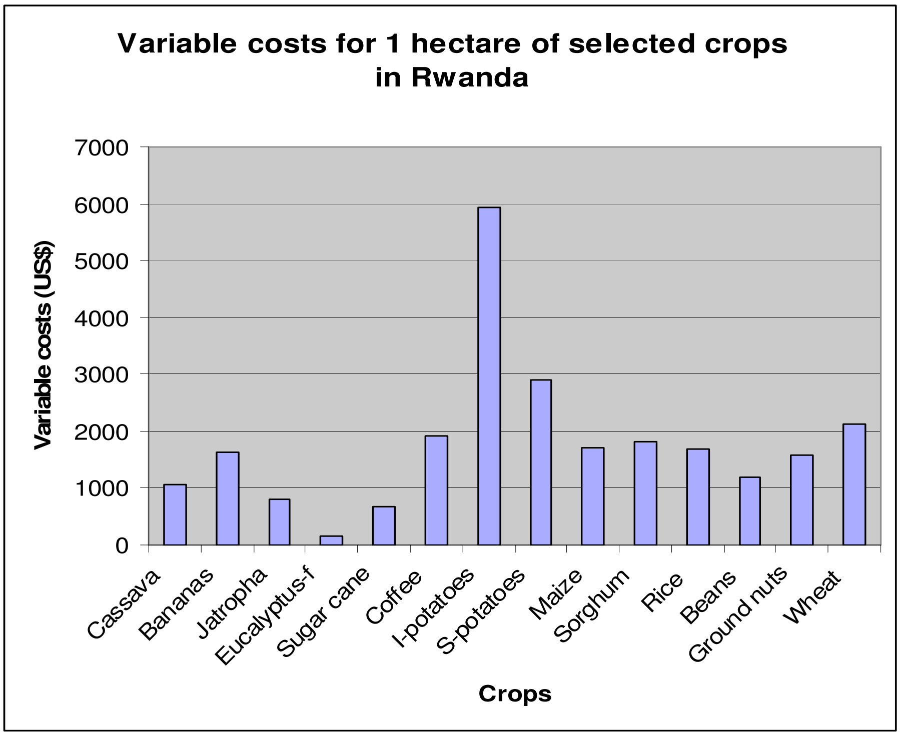

Fig 15: Variable costs for 1 hectare of selected crops in Rwanda.
Source: Author

Rice and cassava have the highest gross margins in Rwanda under intensified farming system at US$4300 and about US$ 4000 respectively. On the other hand, eucalyptus, jatropha and beans have the lowest gross margin, with the perennial crops like coffee, bananas and sugar cane performing far much better than eucalyptus.

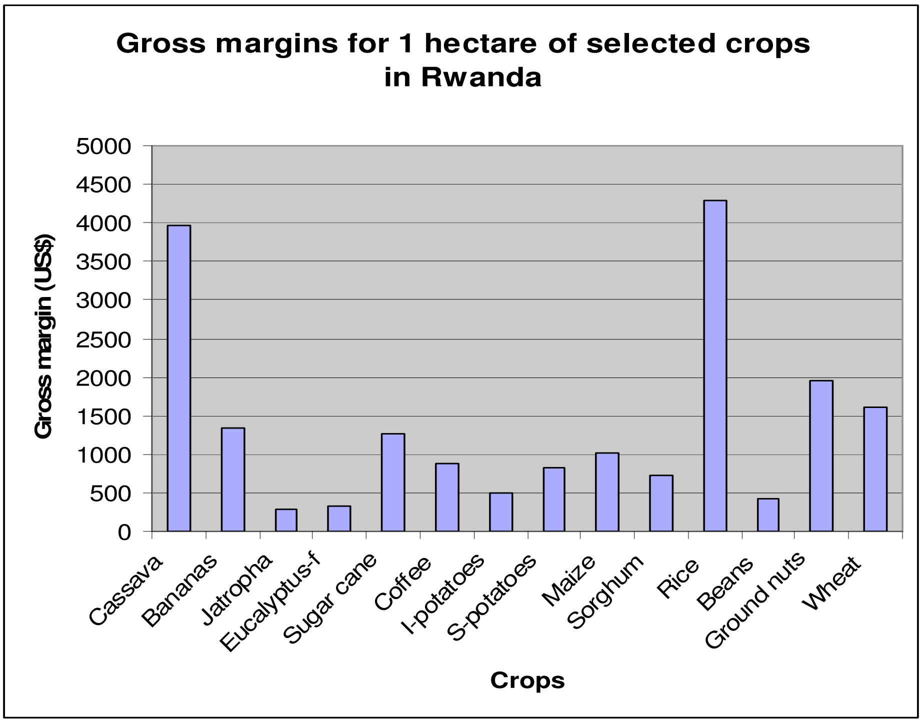

Fig 16: Gross margins for 1 hectare of selected crops in Rwanda
Source: Author

5.2 Value chain analysis

5.2.1 Kenya

5.2.1.1 Fuelwood

5.2.1.1.1 Chain mapping

The fuelwood value chain in Kenya is quite informal and poorly developed. This is mainly because firewood is mostly used in the rural areas, where it is collected for free or paid in kind[2] reducing its economic value. A survey made by Kamfor (GOK, 2002) found that in the year 2000, 64% of firewood was sourced from agro-forestry, with the rest coming from trust land, gazetted forests and from purchases that the consumers could not explain the origin. Of the 64% from agro-forestry, 25% was sourced from boundary and fences, 13% from crop land, 8% from woodlots, 5% from roadside and 13% from neighbours.

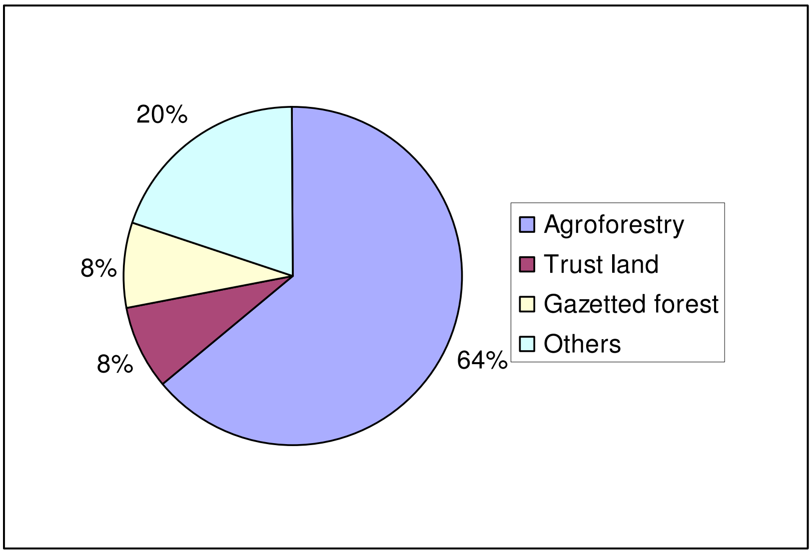

Fig 17: Sources of firewood in Kenya.
Source: Author's reconstruction from GOK, 2000

A spot check around major urban centres in Kenya revealed some informal small-scale firewood trade especially around informal settlements. Most of the wood traded in Nairobi is sourced from the neighbouring peri-urban areas like Kiambu, while trees cut down by city council during landscaping or infrastructure development within the city contribute to the supply. In some vending sites, only waste wood from construction sites or wood workshops were available with the vendors stating there is scarcity freshly cut wood.

[2] through exchange of other goods and services as was found in parts of Murang'a and Kisii

Firewood in the other urban centres is sourced from the neighbouring rural areas mostly within a radius of 20 kilometers. All the vendors that were interviewed procure their wood directly from the farmers or from construction sites. It was not surprising though to find no firewood vendors in small towns like Murang'a where it was reported that consumers get their supply directly from farmers, or people who transport head-loads of wood daily to the town from the neighbouring rural areas.

On the other hand, the institutions that rely on firewood like schools have transporters who buy the wood from the source and sell it directly to the school. The transporters buy standing trees from the farmers, fell them and size them to 1M logs. The cost of harvesting is therefore incurred by the transporters. Tea factories buy their wood directly from the farmers but insist that the farmers have to fell the trees, cut them to 1M long logs and stack them into steres. The factory has two price structures for the wood, one factory-gate price for those who are able to transport it and farm gate price for those who can not.

Schools rely mostly on transporters for wood supply. Buruburu Girls in Nairobi buys its wood from the transporters supplied in seven ton trucks carrying 9 steres of wood while Muranga High school procures wood in ten ton truck carrying 12 steres. The transporters buy standing trees from the farmers, fell and size it incurring all the harvesting costs. The transporters also supply wood to some traders though this market is small compared to the institutional.

Fig 18: A roadside firewood vending site in Loresho, Nairobi.
Source: Author

The traders that indicated that they buy their wood from transporters normally place an order to the transporters for a certain amount of wood and this is delivered in to their vending site. They then sell the wood in small bundles in makeshift structures or open air spaces minimising their operation expenses. A simplified map of the fuelwood value chain in Kenya is shown in Fig. 19.

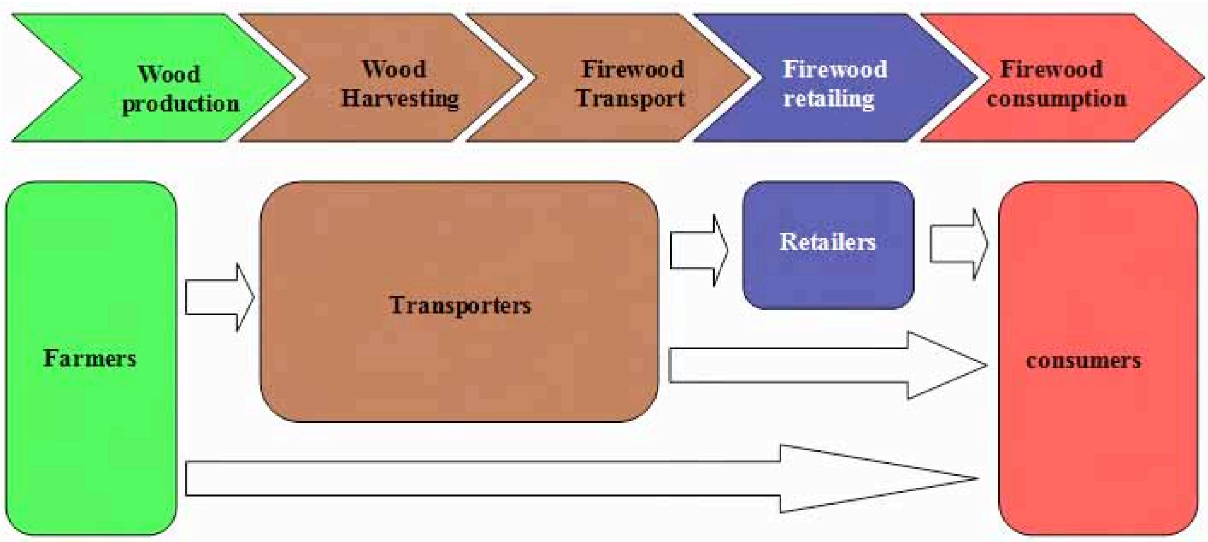

Fig 19: map of Kenyan firewood value chain.
Source: Author

5.2.1.1.2 Economic analysis of the value chain

The fuelwood sector is quite complex and not linearly organised as presented in the map above. The price of wood varies greatly depending on the buyer and the intended market. For the purpose of this analysis, farm-gate prices paid by transporters to a farmer which is about KSh.800 per stere were used. It must be noted that this is just an estimate based on information obtained from a transporter in Muranga since most farmers sell standing trees and the final price is determined by his ability to bargain with the potential buyer.

Tree farming in Kenya for a long time has been under the docket of the Forest department, and currently the Kenya Forestry Service (KFS). However until recently with the formulation of the “The Agriculture (Farm forestry) rules, 2009”, “The forest (Charcoal) Regulations, 2009” and the “The forest (Harvesting) rules, 2009”, private farmers were not monitored by the KFS, and operated just like any other farming activity. Currently, all farmers, regardless of their farming enterprise have to maintain 10% of their farmland under tress and cannot harvest without the approval of a forest officer and issuance of a harvesting permit. The farmers however complain of the corruption involved with the issuance of the permits and having to pay extra money for the permit, while others who farm crops like maize, tea and coffee are not subjected to this permit.

Lack of finance to establish the woodlots due to lack of credit facilities and long duration before maturity of the trees are the other challenges the farmers cited as hampering development of their business.

The transporters have to negotiate the final price with the farmers and this range from KSh.800 to 1,200. They then harvest the wood and transport it to the institutions or vendors in the urban centres. The main challenges they face are; harassment by corrupt police and city council officials who demand bribes, limited finances for business expansion and lack of a vibrant market in the city. The institutions normally issue them with a tender for wood supply and they get paid after delivering the wood an arrangement which requires a huge investment outlay. A breakdown of the expenses incurred by the transporters is given in table 18.

During the research, it was observed that in Eldoret, Murang'a, Kangemi and Mombasa, vendors sell their wood in small bundles of two or three pieces of wood (depending on the size of split wood) each retailing at KSh. 50. With each stere giving about 50 such bundles, the vendor is able to sell Ksh. 5, 000 per stere of wood. Vendors in the upper class estates of Nairobi like Loresho sell their wood in small 30 centimetres long half-split logs with a radius of about 120 centimetres for Ksh. 5 a piece and are able to get an income of up to Ksh. 8,000 a stere. The residents use the wood for warming their houses during the cold months and not for cooking, therefore this is a special case and can not be used to evaluate the price structure of wood in the country.

The vendors interviewed complained of city council officials and police harassment, lack of credit facilities, limited market and lack of support from the government. Table 18 gives a summary of the expenses and income distribution between different actors in the firewood supply chain per stere of wood.

Table 18: Summary of income distribution between actors in the Kenya firewood value chain.

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

Source: Author

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

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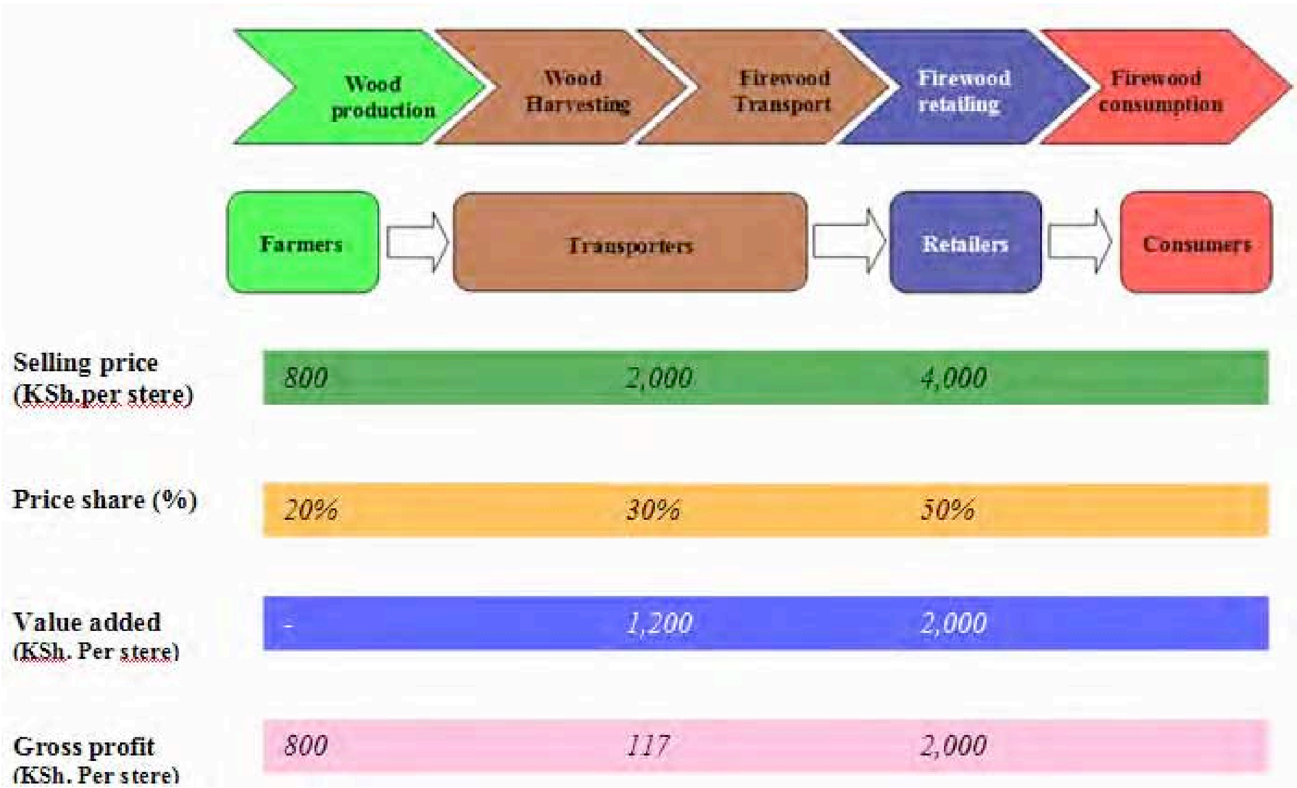
[3] Calculations based on 12 steres of wood which is the capacity for one 10 tonne truck normally used with vehicle hire standing at KSh 4000 for distances below 40 Km.
[4] At KSh. 3,000 including the driver and one helper but one has to fuel.
[5] At KSh. 3,000 per trip.
[6] Includes harvesting, loading and offloading for 1 ten tonne truck.
[7] KFS forest produce movement permits fee of KSh.1000 per lorry load
[8] The figure is KSh. 1,500 if they sell to institutions like schools meaning they have to negotiate for lower prices with farmers or truck owners to make profit.
[9] Group security at KSh. 400 per month per person



Challenges	*-Corruption* *-Finances*	*-Corruption* *-Fianaces* *-Limited market*	*-Corruption* *-Finances*	*-Health risk from emissions*

Fig 20: Quantified firewood value chain in Kenya
Source: Author

5.2.1.2 Charcoal

5.2.1.2.1 Chain mapping

The charcoal value chain though informal, is quite well established with a distinct production, transportation and retail line. However, as noted by several other researchers (Sepp and Mann, 2009, Mugo and Ong, 2006, ESDA, 2005 and Kituyi, 2001), the value of wood used for charcoal production is not reflected in the value of the charcoal. Putting the charcoalers who vandalise government forests for charcoal making aside, most of the other charcoal is not made from wood grown for charcoal making (ESDA, 2005 and Kamfor, GOK, 2002). Most of the charcoal is made from indigenous wood species, which are either cleared for farm-land extension, shifting cultivation or simply as an income generating activity in ranches or individual farms. In some cases, the charcoalers are contracted to make charcoal from other people's ranches or farms after which they share the charcoal with the owners.

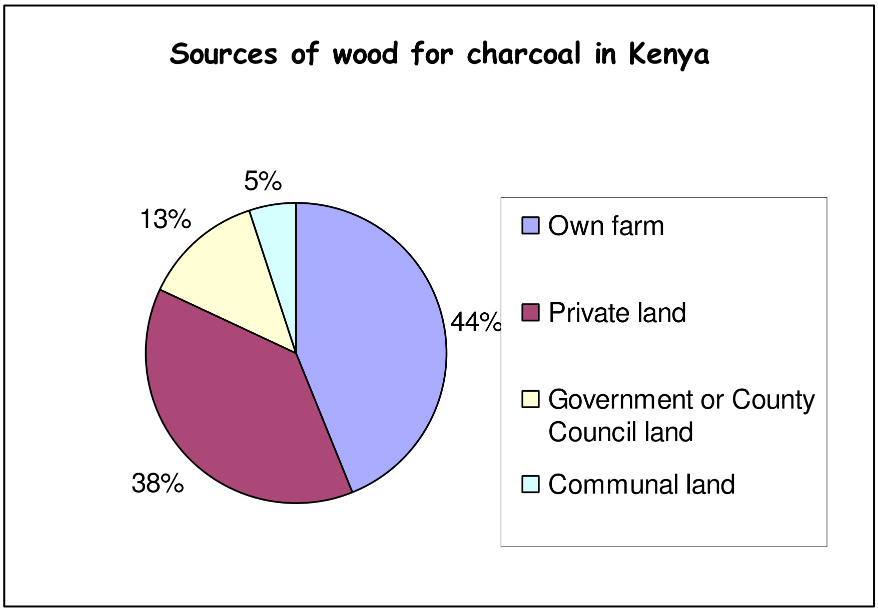


Fig 21: *Sources of wood for charcoal in Kenya*
Source: ESDA, 2005

Wood harvesting is done by the charcoalers, who cut the wood and stack it systematically in a pile into an earth mound kiln. The kiln is then fired and left for between seven and fourteen days for the charcoal to be ready depending on the amount of charge (Quantity of wood fed into the kiln). After cooling, the charcoal is offloaded from the kiln and packed into bags which range from 28 to 42 kilograms with 35kg being the average. The charcoaling process, from tree felling to packing takes between ten to twenty one days depending on the amount of the charge.

The packed charcoal is sold to the transporters at the charcoaling site or transported to the roadside, mostly using human labour, awaiting customers who are either transporters to the urban centres or consumers who directly procure their charcoal from the charcoalers. The transporters come with their packing bags which they give to the charcoalers after getting a packed bag of charcoal. ESDA (2005) in its national charcoal survey established that the main customers sourcing charcoal directly from producers include charcoal vendors (56%), households (22%), food business (13%), other business (2%) and social institutions (2%).

Fig 22: Packed charcoal awaiting transporters in a roadside in Kakauzi.
Source: Author

There are many modes of transporting the charcoal to the markets ranging from humans, bicycles, donkey carts, pickups to trucks. Human, donkey carts and bicycles have limited capacity and can not be used for long distance transport. Pickups and trucks are the most commonly used means of transporting the charcoal by transporters. A truck can carry anything between 200 and 250 sacks of charcoal depending on the tonnage.

The transporters interviewed complained of sustained police harassment on roadblocks when transporting the charcoal to the urban centres. A transporter in Eldoret said that the police normally detain his truck even though he produces his transport permit which they bluntly tell him, “That will not buy *Unga*[10] for my family”. A former transporter in Kisii Mrs Josephine Otieno, said that the police ran her out of business through bribes. She said that every trip the police in Kisii demanded KSh.5,000 on top of the bribes she had to pay on the way at roadblocks, failure to which they would confiscate the whole truckload, take her to court and sell the charcoal at KSh.200 per sack as per the current KFS (Kenya Forestry Service) regulations on impounded illegal charcoal. In the end she had to sell her truck to cover for the many debts she had accumulated to rescue her consignment and she was reduced to a mere vendor.

[10] Maize flour in Kiswahili used for making *Ugali* a staple meal in Kenya.

To evade the police harassment, transporters ferry their charcoal at night where there is reduced police presence, but one can hardly make one trip without paying bribes. Others, especially the vendors who procure their charcoal from the charcoalers, exploit the KFS regulation that one can transport up to five sacks of charcoal without a transport permit by using buses or long distance haulier trucks which operate along these routes.

Other challenges cited by the transporters are lack of finances to buy truck for those who don't own one, poor road infrastructure which are impassable during the rain season, harassment by illegal cartels like "mungiki" who demand illegal payments.

Fig 23: A vendor transporting charcoal from a reseller to his vending cite in Eldoret, Kenya.
Source: Author

The vendors are the last in the charcoal value chain and sell directly to the final consumers. There are no clear charcoal wholesalers or retailers, since most vendors sell their charcoal in sacks, debes (20 Litres metal buckets) or 4 litres paint tins to other resellers and final consumers. For these reason they will only be categorised as vendors and not broken down into wholesalers and retailers.

Most of the vendors operate in open yards or tin-shacks in government or private plots where they pay little or no rent. Nairobi vendors cited constant harassment by city council officers who demand bribes failure to which they get arrested and charged with "Dumping[11]" a charge which carries a prison sentence or a KSh.40,000 fine. However, vendors interviewed in other urban centres did not report direct police harassment, but their concern is that when the transporters are harassed, they hike the charcoal price to recover the bribe money, or stop delivering charcoal to the localities where they are subjected to more harassment creating artificial charcoal scarcity.

From the information above, it can be concluded that the charcoal value chain is not linear but a web with many actors overlapping from one stage of the chain to the next. However taking the main actors in the chain, we can come up with a simplified map of the chain as shown in fig 24.

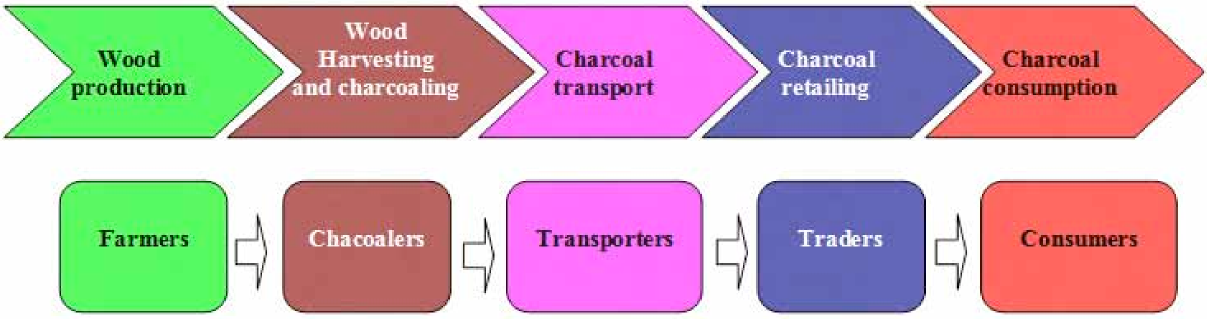


Fig 24: *Map of Kenyan charcoal value chain*
Source: Author

5.2.1.2.2 Economic analysis of the value chain

The charcoalers sell the charcoal in sacks of between 28kg and 35 kg to transporters at a cost of KSh. 350 (Author's interview in Kitui) who transport it to the urban centres, in this case Nairobi. The charcoalers also reported that they make about 20 sacks of charcoal in one kiln per month. They cited harassment by the area chiefs, lack of capital to expand business and invest in modern charcoaling kilns, lack of modern and efficient charcoal making skills, dwindling number of favourite indigenous tree species and exploitation by the transporters who pay them very little for the charcoal.

Transporters hire the trucks at Ksh. 15,000 per trip inclusive of the driver and one helper but have to fuel the truck usually at a cost of KSh. 10,000 per trip. As stated earlier, they also have to pay illegal payments that could be anything between KSh. 10,000 and 20,000 before the consignment reaches it destination. Some transporters use pickups trucks (with a capacity

[11] Dumping is disposing of garbage in public places and carries prison sentence or a KSh.40,000 fine.

of 50 sacks) but this is not economical bearing the long distances of transport. For this reason, most of the charcoal used in the urban centres is transported by big truck capable of carrying up to 200 sacks per trip. A transporter interviewed in Kitui, Mr. James Kamau, said that he makes four trips every month, transporting about 200 sacks hence 800 sacks in a month. Table18 shows a breakdown of the expenses incurred by the transporters and other actors.

The transporter price to the vendor is not fixed and fluctuates depending on the season and the scarcity of charcoal. It is more difficult to make charcoal during the rainy season which makes it scarcer hence expensive. The trucks drivers who have to drive to remote areas with bad weather roads normally get stuck or their vehicles breakdown making the transporters to hike their prices to cover the incurred costs. The retail prices are also always fluctuating depending on the transporter prices.

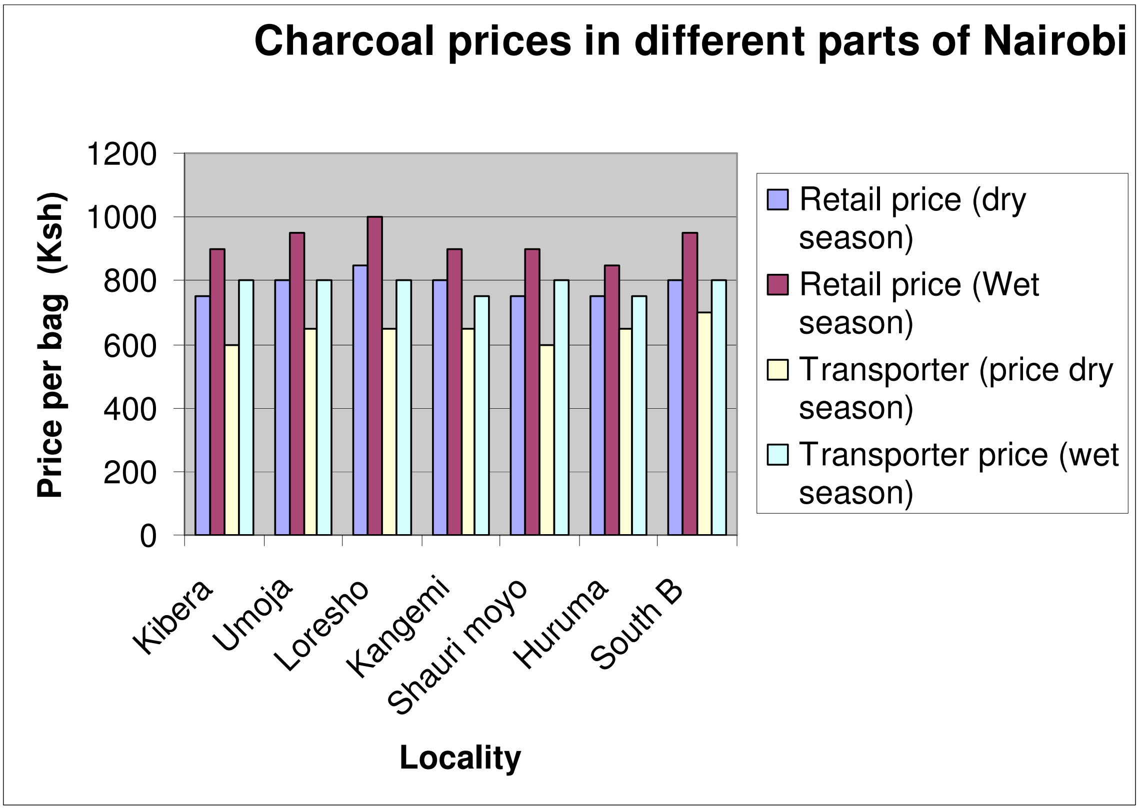


Fig 25: Retail and transporter prices in different estates in Nairobi
Source: Author

In Nairobi the vendors buy the charcoal from the transporters at a cost of between KSh. 600 and 700 in the dry season and KSh.750 and 800 in the wet season. They in turn sell the charcoal at a price between KSh 750 and 850 in the dry season and KSh. 850 and 1,000 in the wet season depending on the estate. Table 19 shows the charcoal transporter and retail prices in both the dry and wet seasons. It is important to note that Kitui, which is at the centre of charcoal producing zone, has the lowest charcoal prices amongst the towns visited because of short transport distances and handling costs.

Table 19: Retail and transporter charcoal prices in selected Kenyan towns during the wet and dry season.

	Charcoal retail prices in Kenya		**Charcoal transporter prices**	
Town	**dry season**	**Wet season**	**price dry season**	**wet season**
Nairobi				
Kibera	750	900	600	800
Umoja	800	950	650	800
Loresho	850	1000	650	800
Kangemi	800	900	650	750
Shauri moyo	750	900	600	800
Huruma	750	850	650	750
South B	800	950	700	800
Average	***785.71***	***921.43***	***642.86***	***785.71***
Mombasa				
Mtwapa	750	900	600	800
Likoni	750	900	650	750
Old town	800	950	600	800
Mwembe tayari	800	950	650	800
Average	***775***	***925***	***625***	***787.5***
Eldoret				
Kimumu	650	850	550	700
Huruma	700	850	500	650
West	700	900	550	750
Average	***683.33***	***866.67***	***533.33***	***700***
Kisii	750	950	600	800
Kitui	550	700	450	550
Muranga	700	900	600	750
Average of sampled towns	707.73	877.18	575.19	728.87

Source: Author

Most of the vendors operate in open yards or tin-shacks in government or private plots where they pay little or no rent. The expenses they incur are group security for the charcoal, which they pay KSh 100 per week per person, taxes which they pay to the city council and illegal payments to council officials as shown in table 20.

There is a difference of KSh.169.45 between the wet season and dry season charcoal retail prices and KSh.153.68 for the transporter prices per bag. Since there are 5 wet months in Kenya, between March and May and November and December, a weighted retail and transporter price can be calculated as follows:

Weighted retail charcoal price = (5/12*877.18) + (7/12*707.73) = 778.83

Weighted transporter charcoal price = (5/12*728.87) + (7/12*575.19) = 639.22

Where: 5 is the total no. of wet months in one year.

7 is the total no. of dry months in one year

12 is the total no. of months in one year.

Table 20 gives a breakdown of the actors' revenue and expenses. The vendors interviewed stated that they sell about three sacks of charcoal per day, thus about 80 sacks per month.

Table 20: Breakdown of actors revenues and expenses in the Kenyan charcoal value chain

Actor	**Variable costs per sack (KSh)**	**Revenue (Selling price)**	**Gross profit (Revenue – costs)**	**Value added (Revenue- previous actor's revenue)**
Charcoalers				
Wood	100			
Labour	-			
Security	-			
Illegal payments	50			
Permits	-			
Sub-total	50			
Sales		350		
			300	-
Transporter[12]				
Charcoal	350			
Vehicle hire[13]	75			
Fuel[14]	50			
Labor[15]	20			
Transport permit[16]	7.5			
Taxes[17]	29			

[12] Based on a ten tonne truck which transports 200 sacks of charcoal per trip

[13] Includes driver and one helper

[14] KSh. 10,000 worth of fuel is used and is not part of the hiring fees.

[15] For loading and off-loading

[16] KFS forest produce movement permits fee (between KSh.1000 and 1500 per lorry load depending on tonnage)

[17] Includes cess fees in by the council of origin area and destination. For charcoal from Kitui, the following taxes are levied; Kitui County Council cess fee (KSh. 20 per bag), Kitui Municipal cess fee (Kenya shillings 1800 per lorry load) and Nairobi city council fee (KSh. 1500 per lorry)

Illegal payments[18]	75			
Sub-total	606.50			
Sales		639.22[19]		
			32.72	289.22
Retailer				
Charcoal	639.22			
labour	-			
Taxes	10			
security	10			
Illegal payments	30			
Sub-total	689.22			
Sales		778.83[20]		
			89.61	139.61

Source: Author

A study done by ESDA in 2005 (EDSA, 2005) established that there are 200,000 charcoal producers in the country, and about 500,000 vendors and transporters combined. It also established that 1.6M tonnes of charcoal are made per annum which is equal to 45,714286 bags of charcoal weighing 35kg. The same report reported that, only 56% of the charcoal produced is sold to the transporters for vending while the rest is sold to households (22%), institution (2%), food businesses (13%) and other businesses (2%). This means that only 25.6M (56% of 45,714,286) sacks are transported by transporters and if each transports 800 sacks per month (9,600 per year) then we can calculate that:

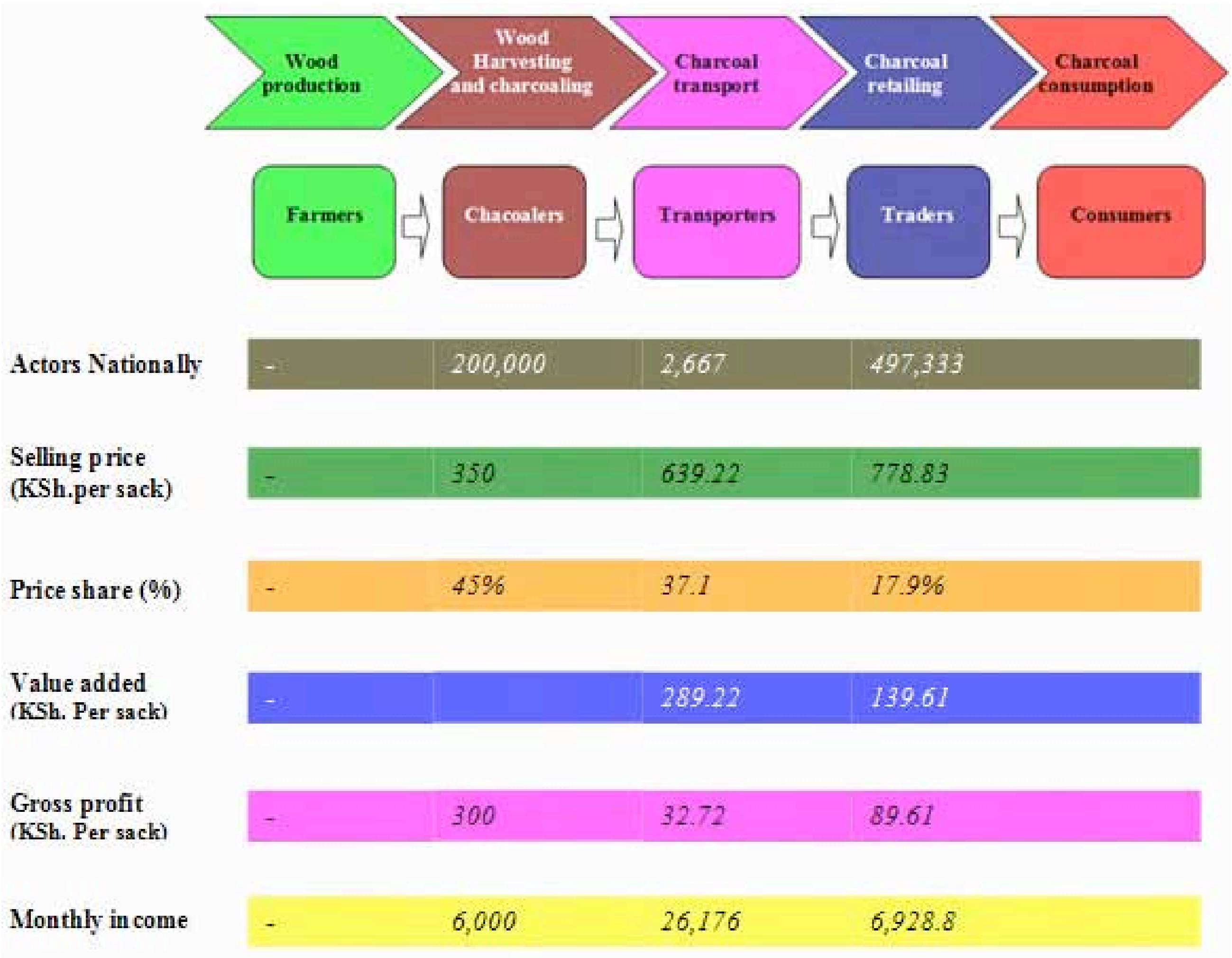
- Number of transporters in Kenya = 25,600,000 sacks/ 9,600 = 2,667

Comparing the Kenyan case with Rwandan case where statistics show that 150,000 tonnes (about 1/10 that of Kenya) of charcoal are consumed each year and there are 200 to 300 transporters, we can comfortably assume that there are 2,667 transporters in Kenya hence about 497,333 vendors.

[18] The transporter indicated that he pays about KSh.15,000 per trip on roadblocks but this figure can sometimes go upto KSh. 20,000 depending on the number of roadblocks.

[19] Weighted transporter average

[20] Weighted vendor average



Challenges	*-Corruption -Finances -Technicl skills -Exploitation by brokers -Lack of policy and legal framework -Lack of organisation*	*-Corruption -Finances -Poor infrastructure -Lack of policy and legal framework -Illegal cartels*	*-Corruption -Finances -Lack of policy and legal framework -Price fluctuation -Lack of organisation*	*- Health risk from indoor air pollution -Price fluctuation*

Fig 26: Quantified Kenyan charcoal value chain
Source: Author

5.2.2 Rwanda

5.2.2.1 Firewood

5.2.2.1.1 Chain mapping

Just like in Kenya, the firewood sector in Rwanda is characterised by many consumers in the rural areas who obtain it for free, leaving the market to institutions and a few informal small scale vendors in the urban areas. In Kigali, there are a few vendors who trade on freshly cut firewood which is procured from the neighbouring Kigali Rural. Some vendors also trade in waste wood from constructions sites and demolished houses. It is important to note that Kigali is undergoing a phase of modernisation, where old semi-permanent houses are being demolished to pave way for ultramodern houses and this has acted as a major source of firewood for the vendors.

Institutions like schools and prisons depend heavily on transporters for firewood supply. The transporters buy the wood from the farmers which are already felled and sized awaiting buyers. Some negotiate with the farmers and buy standing tress in which case they incur all the harvesting costs. They then use seven and ten tonne trucks which can transport between twelve and fifteen steres of wood.

The vendors buy their wood from the farmers and sell it in small bundles in open yards. They sell about two steres of wood per week translating to eight steres in a month. They normally complain of facing direct competition from farmers in the neighbouring Kigali rural who transport head-loads of wood and Pendle it around the city. Nyamirambo and Nyambugogo are some of the areas where this head loads trading starts as early as five o’clock in the morning.

Fig 27: Mobile firewood traders in Nyamirambo, Kigali.
Source: Author.

Taking the main actors in the chain, a simplified map of the firewood sector in Rwanda is shown in fig 27

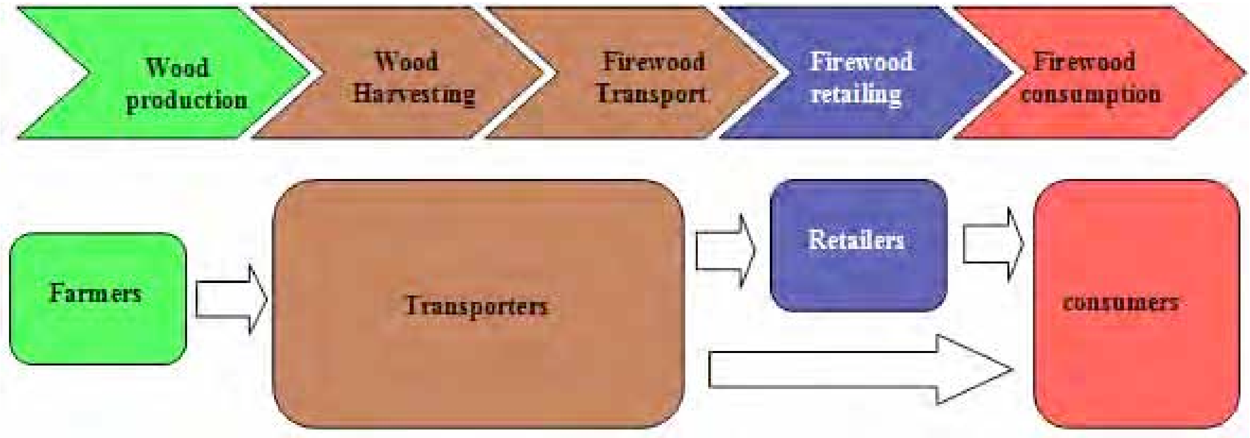


Fig 28: *Map of Rwanda's firewood value chain*
Source: Author

5.2.2.1.2 Economic analysis of the value chain

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

Fig 29: Firewood stacked on the roadside awaiting buyers in Nyamagambe, Rwanda
Source: Author

The farmers harvest the wood and stack it into steres along the roadside awaiting transporters from the urban centres. They therefore incur the cost of harvesting, but get the advantage of controlling the amount of wood they sell hence maximising their returns as compared to selling standing trees. They also get to keep the small branches and twigs for their use. In Nyamagabe a farmer spends about FRw. 6,000 to harvest and transport a lorry load of 12 steres of wood to the roadside which translates to FRw. 500 per stere (Author's interview). The wood is then sold at Frw. 3000 per stere. Other expenses incurred by the farmers include a forest fund of FRw 2000 and cutting permit fees as shown in table 21. The main challenges faced by the farmers are lack of finances to properly manage the woodlots, limited market which force them to sell the wood to charcoalers fetching lower prices, small land parcels, difficulty in obtaining harvesting permits and the long duration they have to wait before they can harvest the wood for sale in comparison to other crops like maize.

Most transporters use their own trucks for transporting the wood and the use the same to transport merchandise for their or other peoples businesses in the rural areas on the way back from Kigali. This way they are able to maximise on their returns making the transportation business more attractive. They buy a stere of wood at FRw. 3,000, transport it to the city and sell it to vendors or institutions at FRw. 10,000. Their expenses include fuel, vehicle servicing taxes and labour. Table 21 shows a breakdown of the expenses incurred by a transporter interviewed in Kigali. The transporter Mr Emmanuel Bayiza in Kigali said he is able to make about 30 trips per month but due to limited demand, he only makes about 18, and engages in other businesses in his free days. The main challenges faced by the transporters are; lack of finances to expand their business, poor road network, limited market for the wood, difficulty in getting transport and permits.

Fig 30: Firewood vending site for freshly cut wood (Left) and old wood (Right) in Kigali
Source: Author

Vendors buy wood from the transporters at FRw.10,000 per stere and sell it in small bundles at between FRw. 300 and FRw. 400. A vendor is able to make 40 bundles from a stere which he sells at Frw. 400 translating to FRw. 16,000 per stere. He is able to sell on average 2 steres per week hence 8 steres per month. They operate in an open undeveloped plots hence does not pay rent. His expenses are only taxes and security as shown in table 21. The main challenge faced by vendors is lack of finances to buy enough stock.

Table 21: Actors revenues and expenditure in Rwanda's firewood value chain

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

Source: Author

[21] Based on a transporter in Kigali who transports firewood from Kamunyi in Southern province and makes about 20 trips per month.

[22] At FRw 30,000 per trip

[23] The transporter pays about FRw 200,000 per month for insurance and maintenance and makes about 20 trips per month which would translate to FRw 10,000 per trip or FRw. 833 per stere when transporting 12 steres.

[24] At FRw 100,000 per month for the driver and FRw.60,000 for helper

[25] At FRw 5,000 per month

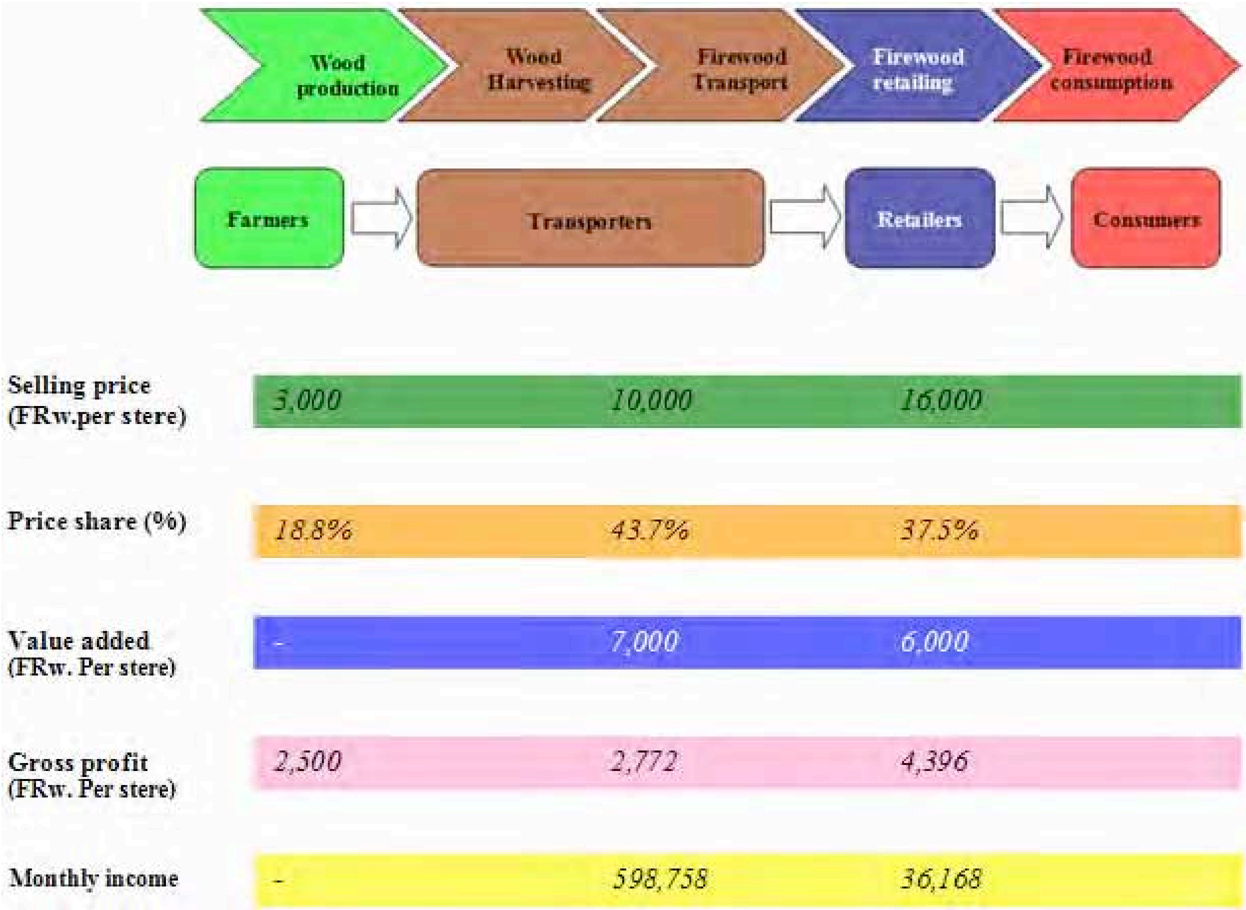
[26] Includes vehicle tax (transport permit), patent and other miscellaneous expenses which the transporter estimated at FRw. 50,000 per month

[27] Most of the retailers interviewed said they sell about 2 steres of wood per week amounting to 8 steres per month.

[28] Includes tax called patent at FRw. 40,000 per annum other taxes at 5,000 per month

[29] Includes FRw. 1,500 sector security and FRw. 3,000 private security per month

From this information, a quantified value chain of the firewood sector, showing the incomes, profit and value added is presented in Fig. 31.



Challenges	*- Acquiring harvesting permits* *-Finances* *- Limited land* *-Long rotation period*	*-Acquiring transport permits* *-Finances* *-Limited market*	*-Finances*	*-Health from emissions*

Fig 31: Quantified firewood value chain in Rwanda.
Source: Author

The farmers do not engage in selling wood as a day to day business hence it is difficult to quantify their monthly income from the trade. As for the transporters, they are able to make a profit of FRw.2,772 per stere, translating to FRw. 33,264 per trip. A transporter who makes 18 trips per month makes about FRw. 598,758 or US$ 1032.33[30]. This figure could rise to FRw. 997,920 if the transporter is able to transport 30 steres of wood. A vendor makes a profit of FRw. 4,396 per stere, which when he/she sells 2 steres a week makes FRw. 35,168 per month.

[30] Exchange rate: 1US$ = FRw. 580

5.2.2.2 Charcoal

5.2.2.2.1 Chain mapping

The charcoal value chain in Rwanda is quite unique compared to many others in developing countries in that 100% of the charcoal is produced from woodlots. The most favoured trees are Eucalyptus species though there is some charcoal made from Pine, but this is regarded as low quality and has lower market value. The farmers who say that Pine requires more attention to produce and takes longer than Eucalyptus thus tend to shy away from growing the tree due to its limited market and marginal returns.

Fig 32: Poor quality charcoal from Pinus (Left) and good quality charcoal from Eucalyptus in Nyambugogo, Kigali.
Source: Author

The Charcoalers buy the wood from the farmers, fell, cut it into logs and stack it in earth-mound kilns. Some charcoalers season the wood for up to 7 days before putting it into the kilns, a factor which improves the efficiency of the conversion process. There is no standard unit of measurement for the wood and the farmers negotiate with the charcoalers according to the size of the trees and the numbers of stems in a woodlot.

The charcoalers are informally organised, leave for four districts in the Western province where an international NGO, CARE Rwanda, has organised some charcoalers into associations and trained them on good charcoal making practices. These districts are Gisagara, Huye, Nyamagabe and Nyaruguru. However, there were complaints that it was doing too little since out of the 1000 charcoalers who were shortlisted for training, only 100 were trained leaving the majority of them still following the unsustainable practices. Some charcoalers interviewed in Nyamagabe, who didn't benefit from this training, expressed their wish to be trained.

The charcoalers are responsible for obtaining the harvesting permit from the sector. Most use family labour for harvesting and stacking, while a few contract other people who they pay about Frw. 500 per man day. Depending on the charge fed into the kiln, the charcoal making process takes between seven and fourteen days after which it is removed and packed into bags weighing about 35kg. These are transported to roadside where in is stacked awaiting purchase by transporters. The chacoalers cited; lack of finances to expand their business or invest in efficient kilns, lack of technical skills to make charcoal more efficiently and difficulty in obtaining harvesting permits as the main challenges they face.

The transporters sell the charcoal to both the vendors and directly to the consumers. They drive around the city estates and selling to consumers who can afford to buy their charcoal in sacks. This is seen by the vendors as direct competition since they buy the charcoal at the same price as the vendors.

The vendors sell their charcoal in sacks, metal tins and sometimes buckets. They are situated in designated charcoal markets, general markets or undeveloped parcels of land. They have one thing in common that, they operate in open yards or in tin/plastic paper roofed structures. From this information, a simplified map of the charcoal chain is presented in figure 33.

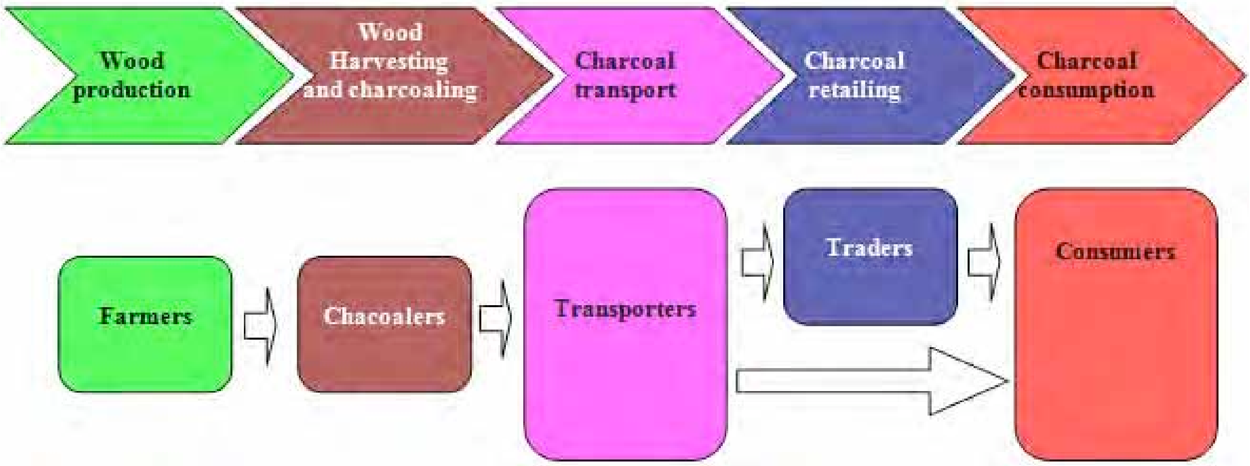


Fig 33: Map of Rwanda’s charcoal value chain
Source: Author

5.2.2.2.2 Economic analysis of the value chain

The charcoal value chain is very important both to the actors and the economy of Rwanda, contributing about 5% of the country’s GNP (GTZ, 2008). As explained earlier there is no set unit of measurement for wood but an interview with two charcoalers in Nymagambe gave a relationship that can be used to estimate the wood cost.

Mr Munyakuza Celesine stated that for a woodlot that he pays FRw. 60,000, he is able to get 60, 35kg sacks of charcoal while Mr Musabyimana Silvestre another charcoaler in the same area said for a woodlot that he buys for FRw. 20,000, he is able to make 20 sacks of charcoal. From the above relationship, we can be able to estimate the coast of one stere of wood, bearing in mind that the earth mounds kilns used in Rwanda yields on average 1.4 sacks of charcoal (MININFRA, 2009a). If we take the example of the first charcoaler, it means that he needs about 43 (60 sacks/1.4) steres of wood. This translates to FRw.1,400 (FRw.60,000/43) per stere of wood used. This is comparable to GTZ's survey findings in 2008 (MINIFRA, 2009a) that the cost of wood for one bag of charcoal in Rwanda is FRw. 1,031.

Their other expenses are labour (for felling, cutting to logs, making the kiln, packing and transporting to the roadside), cutting permit fees at FRw 10,000 and forest fund fees at FRw 2,000. Table 23 shows a breakdown of the expenses the charcoalers incur in the course of making charcoal. The charcoalers make about 40 sacks of charcoal per month unless there is a ban on charcoal making by the government.

The transporters buy the charcoal from the charcoalers at a cost of FRw. 2,500 or charcoal from Pinus and FRw. 3,500 for charcoal from Eucalyptus. However, due the low value of charcoal from Pinus, it is not very common hence the market is dominated by charcoal from Eucalyptus. Most transporters have their own trucks, and just as is the case with firewood, they have business in the rural areas where they procure the charcoal. They thus transport the charcoal to Kigali and on the way back transport merchandise for their businesses. According to Mr. Sikubwabo Albert, a transporter from Tare in Nyamagabe, the main expenses incurred are fuel, vehicle insurance and maintenance, transport permit fees, labour and taxes. He also said that he transports charcoal to Kigali 8 trips a month due to the time required to consolidate a whole truck load of 200 sacks from the charcoalers. This information was used to make the analysis for the transporters. Table 23 gives a breakdown of the expenses incurred by the transporters based on the information given by Mr Sikubwabo Albert.

Since most of the charcoal is sold in Kigali, the analysis of the transporter and vendor prices was based in the city. The transporter prices were found to vary from estate to estate. Out of the estates visited, it was lowest in Nyambugogo at FRw. 5,300 and highest in Gikondo, Gisozi and Kimironko at FRw. 5,500 per sack. The average transporter price from the visited estates was calculated to be FRw. 5,540 per sack. The transporters also sell the charcoal directly to the consumers at the same price, which is a big concern for the vendors who claim they offer direct and unfair competition. They pointed lack of finances, difficulty to get transport permits and poor road infrastructure as the main problems they encounter.

Table 22: Transporters and vendors charcoal prices in selected towns in Rwanda

Town	**Estates**	**Transporter price (FRw.per sack)**	**Vendor price (FRw. Per sack)**
Kigali			
	Nyambugogo	5,300	5,600
	Kimironko	5,500	6,000
	Gisozi	5,500	6,000
	Nyamirambo	5,400	6,000
	Gikondo	5,500	6,000
Average		***5,440***	***5,920***
Butare		4,000	4,500
Gisenyi		3,800	4,300

Source: Author

The vendors sell the charcoal sacks between FRw. 5,600 and 6,000 or the tins famously known as “Akadomo” retailing between FRw. 200 and 300.The prices are almost the same in the estates visited with the only notable difference being in Nyambugogo, possibly because it is the gateway of all the charcoal consumed in Kigali from the Eastern and the Western provinces. In Nyambugogo, a sack of charcoal was sold at FRw. 5,600 while in the other estates it stood at FRw. 6,000. The calculated average price of a sack of charcoal from the estates visited is FRw. 5,920. The vendors operate in designated charcoal vending sites where they don’t pay rent but have to pay taxes to the local authority FRw. 5,000, security Frw. 3,000 and cleaning fees FRw 3,000 per month as shown in table 23. The vendors interviewed said they sell on average 3 sacks of charcoal per day, translating to 90 sacks a month. The vendors pointed out lack of finances as the major challenge they face in the course of their business.

Table 23: Breakdown of actors' revenues and expenditure in the Rwandan charcoal value chain

Actor	Variable costs per sack (FRw.)	Revenue (Selling price)	Gross profit (Revenue – costs)	Value added (Revenue- previous actor's revenue)
Charcoalers[31]				
Wood[32]	1,000			
Labour[33]	333			
Security	-			
Forest fund[34]	33			
Cutting permit[35]	167			
Sub-total	1,533			
Sales		3,000		
			1,467	2,000
Transporter[36]				
Charcoal	3,000			
Fuel[37]	600			
Labor[38]	100			
Transport permit[39]	25			
Other expenses[40]	200			
Taxes[41]	100			
Sub-total	3,925			
Sales		5,440[42]		
			1,415	2,440
Retailer[43]				
Charcoal	5,440			
labour	-			
Taxes[44]	56			
security[45]	33			
Cleaning fees[46]	33			
Sub-total	5,562			
Sales		5,920[47]	358	
				480

Source: Author

[31] Based on a charcoaler's experience in Nyamagabe who made 60 sacks of charcoal and harvested the wood from a woodlot about 0.4 Ha.
[32] Based on earlier calculation of FRw 1.400 per stere which makes 1.4 sack of charcoal translating to FRw.1,000 per wood required to make one sack of charcoal.
[33] For felling, making kiln, packing and transporting charcoal to the roadside estimated at FRw. 20,000.
[34] At FRw 2,000 per woodlot to be harvested
[35] At FRw.10,000 per woodlot less that 1 Ha.
[36] Based on a data from a transporter who transports charcoal from Nyamagabe to Kigali with his own truck. with a capacity of 200 sacks per trip making 8 trips per month.
[37] At FRw. 120,000 fuel for a return trip to Kigali
[38] At FRw. 160,000 for driver and helper for one month assuming they make 8 trips per month.
[39] Charged at FRw. 40,000 per month per truck.
[40] The transporter said sometimes he has to pay people to help load and offload, food, accommodation and other miscellaneous expenses amounting to about FRw. 40,000 per trip
[41] Paid at the sector of origin.
[42] Calculated average for Kigali
[43] Based on calculation for a vendor who sells 3 sacks of charcoal per day as per gathered data.
[44] At FRw. 5,000 for local authority taxes per month
[45] Group security at FRw.3,000 per month per person.
[46] At FRw. 3,000 per person per month
[47] Calculated average for Kigali

A study commissioned by GTZ in Rwanda in 2008 (GTZ, 2008) established that 150,000 tonnes of charcoal are consumed in the country per annum. It also found that there are 8,000 charcoalers in the country, most of them in the Sothern and Western provinces. In addition, there are about 200 to 300 transporters and 2000 charcoal vendors.

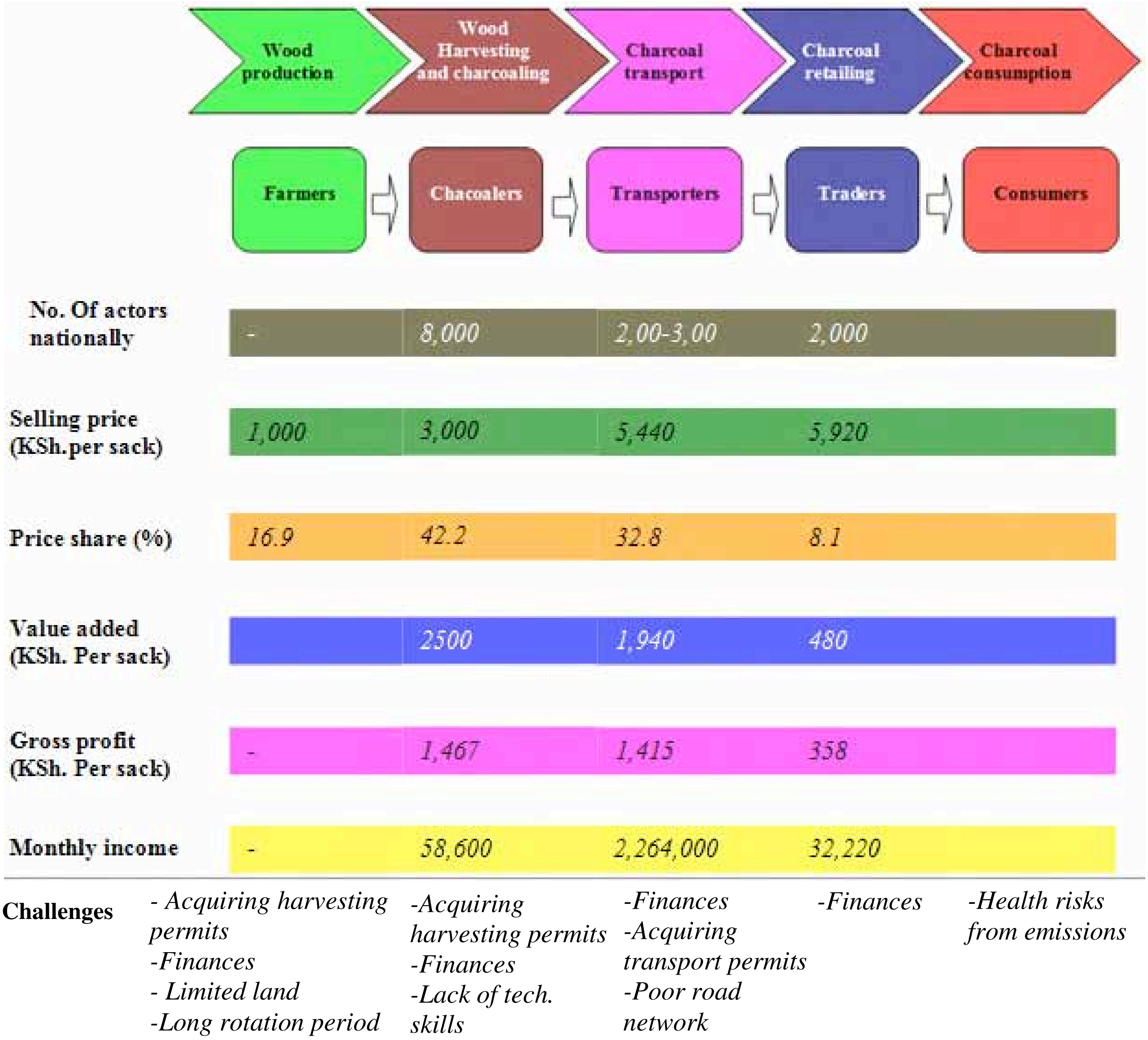


Fig 34: Quantified Rwanda charcoal value chain
Source: Author

6 Discussion of results

6.1 Feasibility of growing wood as a cash crop in Kenya and Rwanda

6.1.1 Kenya

The business of growing Eucalyptus in Kenya has been proposed by several authors as the best option for ensuring sustainable biomass supply to a country that is highly dependent on Biomass. The analysis shows that growing eucalyptus for both firewood and transmission poles is quite competitive with only groundnut providing substantially more income. A similar study done in the coast province showed that it is profitable to grow Eucalyptus for firewood (KFS, 2009) while Cheboiwo and Martin (2004) concur that it is profitable to grow it in all lands suitable for agriculture but not in marginal areas.

Having established that it is profitable to grow Eucalyptus, other factor that might affect its adoption by farmers are markets and land availability. Tea factories and tobacco industries (Firewood), KLPC (transmission), Pan Paper Mills (Pulp and paper) and the timber industry are some of the established markets for Eucalyptus wood in the country. During the survey, it was found that there is a huge unmet demand for Eucalyptus especially in Tea factories. Nyankoba Tea Factory in Kisii has to operate at 60% firewood and 40% industrial oil while Githambo Tea Factory in Muranga have to settle for 50% due to lack of firewood. The continuing rural electrification program by Kenya Power and electrification Program (KPLC) is another sector that has a huge demand for transmission poles with most of it requirements currently being met through importation from South Africa (KFS, 2010). Ogweno, Opanga and Obara (2009) further list some of the major sectors that continue to be heavily dependent on Eucalyptus as: With this huge demand for Eucalyptus, the market will remain good for the Kenyan Eucalyptus farmers.

A study done by Senelwa et al (2009) established that farmers in Kenya have left on average 15% of their land fallow, and 76% of the farmers interviewed expressed their willingness to plant tress for the first time, while for those who already had trees 88% were willing to plant more, possibly due to the benefits they had already received.

Table 24: Farmers' willingness to plant trees

Region	**Farmers willing to plant trees 1st time (%)**			**Farmers already with tress (%)**	
	Yes	***No***	***Undecided***	***Yes***	***No***
Nyanza	82.8	13.8	3.4	88.2	11.8
Central	85.7	3.6	10.7	96.4	3.6
Riftvalley/ Western	84.6	7.7	7.7	93.1	6.9
Coast	20	73.3	6.7	60	40
Average	***76***	***13.82***	***7***	***88***	***12***

Source: Senelwa K. et al, 2009

As such, it can be concluded that; growing Eucalyptus is quite profitable in Kenya, there is private land that is fallow and can be used for this purpose, there is a big market for the products and the farmers are also willing to adopt tree planting in the country. The government should therefore craft policies that will give support to the farmers and remove the barriers to woodlots investments, invest in research and development on improved species and better management practices.

6.1.2 Rwanda

From the analysis, it is not profitable to grow Eucalyptus under intensified farming system in Rwanda. The main reason behind this is the low price paid for firewood and wood for charcoal. While in Kenya a stere of firewood sells at US$15 in the tea factories which are the main buyers, firewood in Rwanda is sold at about US$6 when sold as firewood and as low as US$2 when sold to charcoalers to make charcoal.

The second main reason is lack of high value competing market for the wood. While in Kenya there is a big competition for Eucalyptus for firewood, transmission poles, props for making scaffoldings in building sites and timber, in Rwanda the main use of Eucalyptus is firewood, building posts and charcoal making. There is a government directive that all tea factories should grow Eucalyptus enough for their use reducing industrial firewood demand for Eucalyptus. The main customers are thus nearby institutions and charcoalers who dictate the price they pay to the farmers.

A study done by GTZ on the profitability of growing different crops in Rwanda (GTZ, 2010) established that in marginal lands Eucalyptus is the only profitable enterprise. A critical look at the data used however established that the gross margin was somehow inflated since it used the price of firewood as US$10 per stere while in the actual sense the price of firewood is only US$6 per stere. A review of the price would see the gross margin reduce to US$105 for firewood sold at US$ 6 and US$-32 when wood is sold to the charcoalers at US$2.4 which is the usual price as shown in Fig 28. This further confirms Cheboiwo and Martin (2004) observation that Eucalyptus farming is not profitable in marginal land as mentioned earlier.

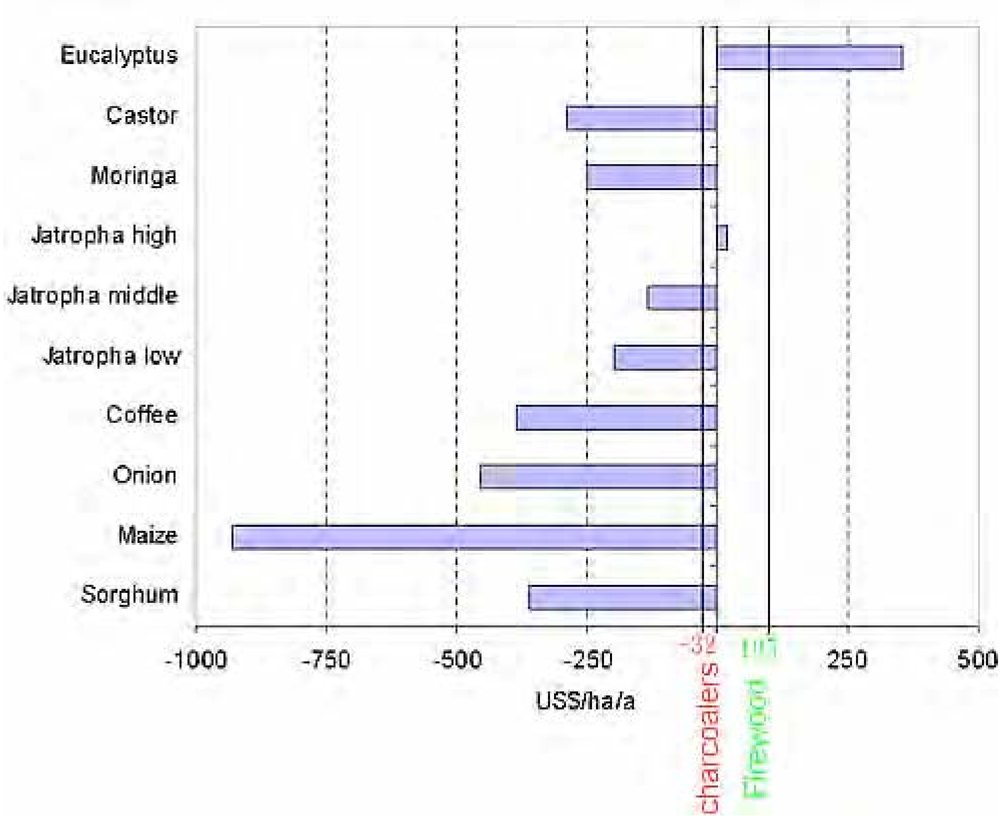


Fig 35: Net operating income of farming systems in marginal lands in Rwanda reflecting corrected prices when the wood is sold to charcoalers and for firewood (in red and green)
Source: GTZ, 2010 and author.

6.2 Income distribution and value addition along the value chains

The income distribution along the fuelwood value chain in Kenya shows that the vendors make the highest amount of money per stere of wood sold at about 28%. The farmer's income excluding the establishment expenses is only 20% of the final price of fuelwood to the consumer while the transporters make about 12%. The vendors however sell about 8 steres of wood per month translating to a profit of KSh.11,600 per month. The transporters who have the possibility to transport about 15 trips of wood per month each with 10 steres would make the highest profit of about KSh.67,500 per month. This means that the amount of money remaining in the rural areas is about 20% of the final price share of a stere of wood. This does not mean that the farmers do not make profit as the analysis before showed that Eucalyptus farmers for firewood have higher gross margin than most other farming enterprises.

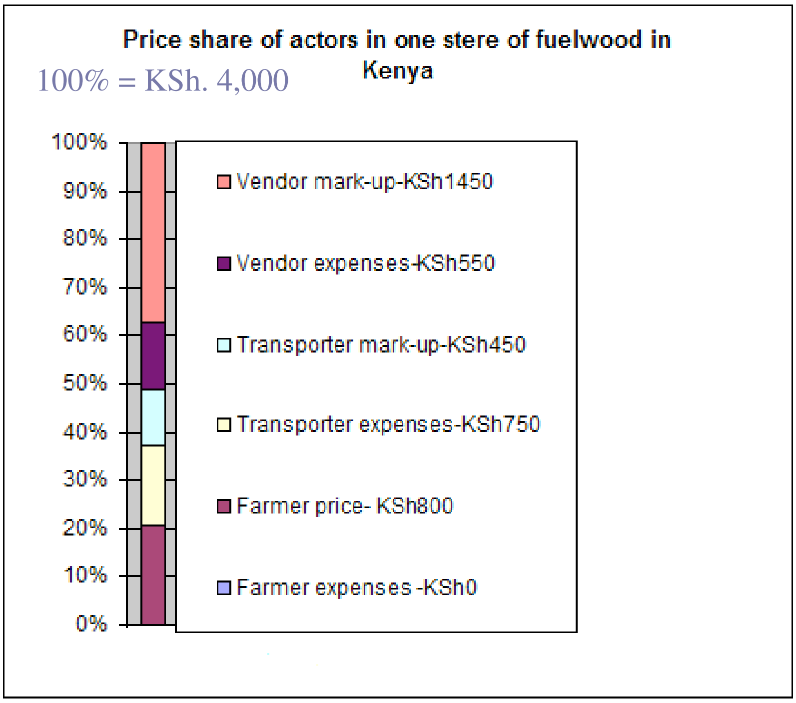


Fig 36: Price share of actors in one stere of fuelwood in Kenya
Source: Author

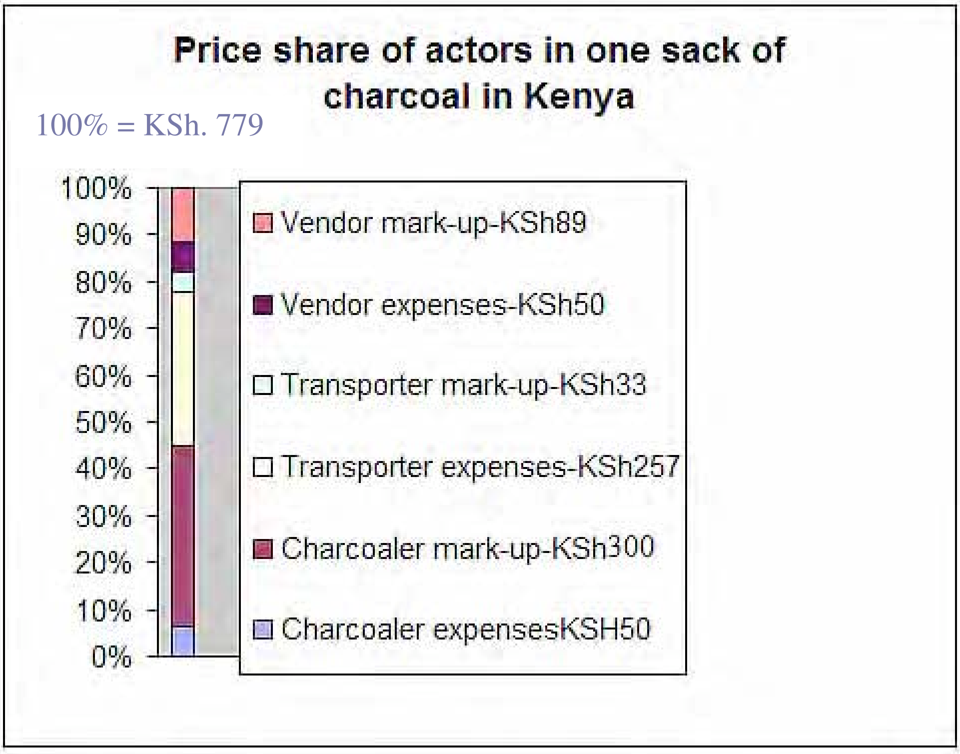


Fig 37: Price share of actors in one sack of charcoal in Kenya
Source: Author

For the charcoal value chain, the charcoaler is the biggest beneficiary pocketing about 40% of the total price of charcoal per sack, assuming that he/she does not pay for the wood. The vendor has the second highest returns per sack with the transporter taking only about 4%. The transporter expenses account for a large chunk of the final price of charcoal mostly due to the long distance of haulage and illegal payments on the way. However the transporter makes significantly more that any other actor per month at about KSh 26,176 with the vendor and charcoaler earning KSh.6,928 and 6000 respectively as shown in the previous chapter.

Just like in the Kenyan fuelwood chain, the vendors make the highest amount of money per stere of wood sold in Rwanda. The farmers come second while the transporters come in last. The transporter expenses account for a huge chunk in the final price share at FRw4,228 due to the bulky nature of the wood. On a monthly bases, the transporters have the possibility of reaping the highest benefits at almost FRw.600,000 while the vendors make a mere Frw. 36,128 as shown in the previous chapter. The farmers make some money as shown by the gross margins in Rwanda but their returns are limited if they grow the wood in marginal lands.

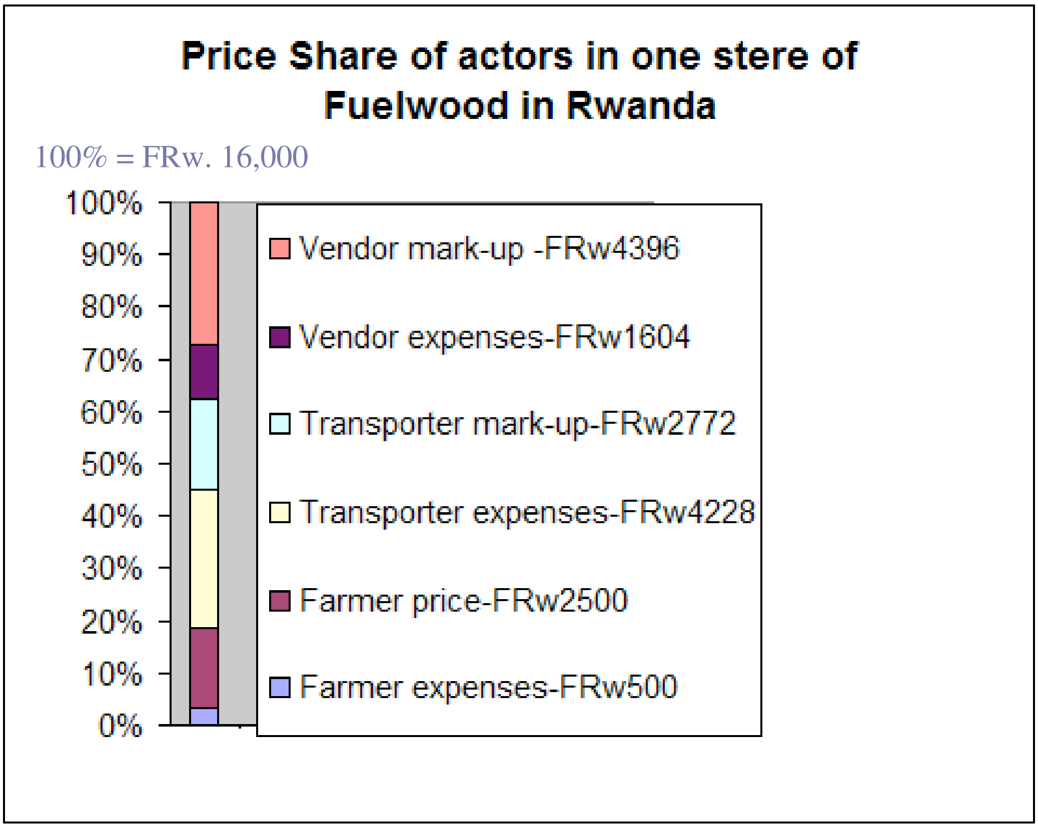


Fig 38: price share of actors in one stere of fuelwood in Rwanda.
Source: Author

The charcoaler`s and transporter profit in one sack of charcoal is almost equal while the vendor makes the least amount from one sack of charcoal. This is a big mismatch bearing in mind the amount of sacks a transporter is able to handle in one month while a charcoaler can only make limited amount of charcoal. This mismatch is clearly reflected in the amount of money the transporter can make in a month standing at over FRw 2 Million while the vendor makes FRw 32,220 and the charcoaler, FRw 58,600 as calculated in the previous chapter.

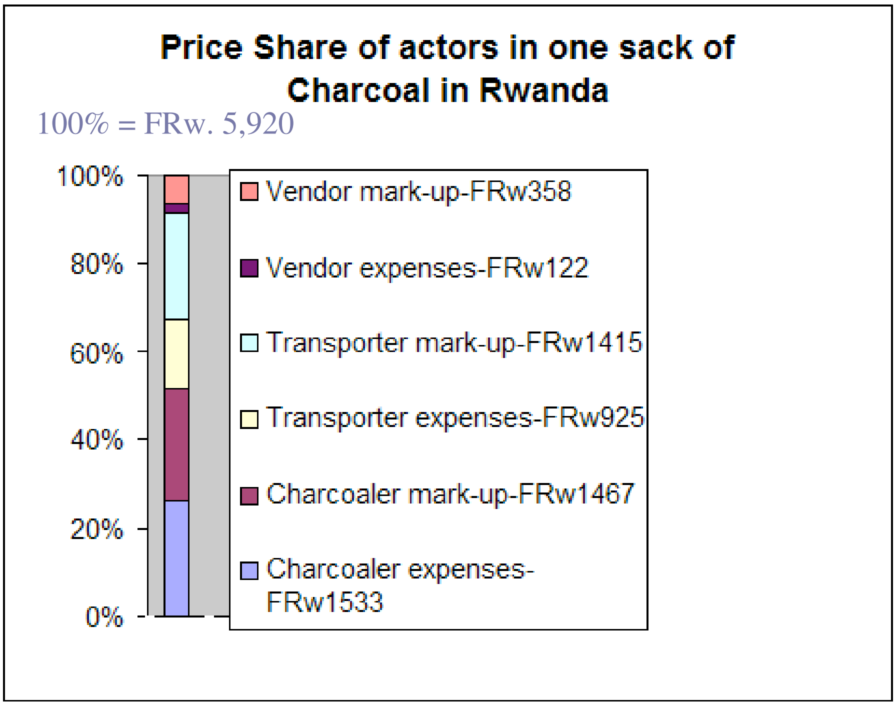


Fig 39: price share of actors in one sack of charcoal in Rwanda
Source: Author

6.3 Obstacles towards an efficient market oriented woodfuel sector

While it is true that the woodfuel markets in the developing countries are poorly developed, they still remain quite important as a source of livelihood for the rural poor and for supplying households and small and medium enterprises with energy. It is therefore imperative to analyse the sector with the aim of indentifying the main obstacles hampering the development with a view to eliminating them for the benefit of the rural livelihoods and ensuring sustainable biomass energy supply.

From the findings, the main obstacles can be categorised as; Financial, legal and legislative, health, environmental, social, organisational, technical skills and technological.

- ***Financial***

Most of the actors face financial difficulties when it comes to expansion of their business. The farmers would like to use modern farming techniques which entail use of fertilizers, insecticides, pesticides and labour all which requires huge investments. Though this would guarantee improvement in yields, the farmers do not have the capacity to raise the required amount. In Rwanda, this was clearly visible where Eucalyptus plantations of the government and institutions are managed better than the farmers' plantations. This leads to minimal returns, a fact which was also well documented in a research by GTZ (MINIFRA, 2009) that most small-scale plantations have a production of 20% of the potential. In Kenya, it is possible to access a bank loan, with land as a security, but most farmers are reluctant to take a bank loan to establish a plantation due to the high interest charged at 15%, hence few turn to these services. In Rwanda, it is difficult for farmers to get a bank loan to establish a plantation as pointed out by some farmers in Nyamagambe meaning they have to use their meagre savings. The general poverty of the Rwandan farmers also sees them harvest the wood 2 to 3 years before the recommended 6 years period to get money for their consumption greatly reducing the productivity of the plantation.

As it has been extensively pointed out in the report, corruption has greatly affected the development of the woodfuel sector. This is because it affects production, transportation and trade thus basically all the parts of the chain reducing the financial benefits. It has also pushed several people out of business confining them to absolute poverty.

Fig 40: A poorly managed private Eucalyptus plantation that was harvested after 3 years for charcoal making in Nyamagambe, Rwanda.
Source: Author

The charcoal making business is considered a poor mans business in both countries. Most do it for subsistence hence have little savings if any. The informality of the sector, coupled with criminalisation in Kenya means that the charcoalers do not have access to bank loans. They therefore do not have the capacity to invest in more efficient kilns which are expensive and have the potential to increase their efficiency.

The transporters require a lot of investment to buy the charcoal or wood, pay for the means of transport (for those who hire) or fuel (for those who own trucks) and pay for the labour. While it is possible to get loans for those who own trucks with the truck as security, constant arrests and corruption means that the risk of default is quite high in case he can not raise the required fine or bribe. The informality of the business also means that it can not be used as security in a bank greatly reducing sources of finance.

Fig 41: Charcoal in transit to Kigali from Nyamagambe, Rwanda.
Source: Author

The vendors need to raise enough money to buy enough stock of charcoal or fuelwood. While most stock anything from three to over a hundred sacks of charcoal or one to ten steres of wood, a large stock means one can easily act as a wholesaler hence boosting the sales volume and the profit. The vendors operate informally and most don't have an operating licence and are not registered business enterprises. This means they can not use their business as security to get loan limiting their chances of securing a loan for expansion.

Fig 42: A vendor sells charcoal in a makeshift structure in Nyambugogo (Left) and fuelwood displayed for sale on the roadside in Remera, Rwanda.
Source: Author

- ***Legal and legislative***

The woodfuel sector in Kenya and Rwanda has for a long time operated in a legal vacuum without policies and laws guiding the production, trade and consumption of wood and charcoal, and where legislations have been made, they have been either piecemeal or misguided and without a proper implementation framework. This has left it very susceptible to abuse with cartels and corrupt government officials taking control with the aim of benefiting themselves. The effect has been high market prices and little benefits to the actors. However, notable efforts have been made in both countries to streamline the operations. The formulation of important regulations in Kenya namely; "The Agriculture (Farm forestry) rules, 2009", "The forest (charcoal) regulations, 2009a", "The forest (Harvesting) rules, 2009b" and "The forest (participation in sustainable forest management) rules, 2009c" is the first step in this direction. In Rwanda, the "Biomass energy strategy" (MINIFRA, 2009a) and the "National energy policy and National energy strategy 2008-2012 (MINIFRA, 2009b) reflects the importance and efforts the government is putting towards streamlining the sector.

By the time of this research, the policies and legislations in both countries were newly published, and a framework and infrastructure for their implementation was being established. Since these are the first steps in formalising the sector, one can only hope that the policies and legislations will fully and implemented and lead to a favourable environment where the sector can thrive.

- ***Environmental***

The woodfuel sector especially charcoal has been for a long time blamed for environmental and forest degradation. Although this has been proven not to be entirely true, it has led to many governments banning charcoal use or putting stringent restrictions to control its production and use. However, weak or corrupt law implementation agencies have meant that instead of the directives protecting the forests, they end up hurting the poor who can not afford the switch to alternative fuels and legitimate actors in the supply chain who have to pay bribes to operate.

Firewood use and charcoal making and use have been pointed out as cause of green house gases emission which leads to global warming. Use of inefficient conversion techniques and technologies are mostly to blame for the emissions but adoption of the modern and efficient technologies due to the high costs and related operational constraints.

- ***Health***

The emissions from charcoal and firewood use are one of the major causes of indoor air pollution which mostly affects women and children. Though this can be easily rectified by use of improved stoves with chimneys or having a secondary flue gases combustion chamber, this requires investment which is difficult to raise for the poor people. Free access of wood in the rural areas leaves investment in an improved stove as the last priority for the residents making the situation even worse.

Fig 43: Indoor air pollution caused by inefficient use of woodfuel.
Source: http://www.overthehorizon.net/images/addis-hut-smoke1.jpg

- ***Social***

The society has negative perception that woodfuel is a poor-man's fuel and the trade, a poor-man's business. This has meant that the policy makers (usually rich) continue to ignore the sector and only step in when they are making uninformed declarations that end up hurting the sector. The charcoal making has also been left to the poor, mostly semi-illiterate members of the society who have no technical know-how, hence limiting technology adoption and investment.

- ***Organisational***

The informality of the sector means that the actors are not organised in to groups hence lack collective bargaining power. For this reason, the farmers are price takers from charcoalers or firewood transporters, and charcoalers and the vendors are price takers from the transporters who don't have a constant price, leading to great fluctuations in the final market prices. The transporters who mostly have the financial muscles and connect the producers to the traders end up dominating over the rest reaping maximum benefits while the others have to contend with what is offered.

Lack of organisation also means that the actors do not have a single voice to push for their case with the authorities when important legislations are formulated. Most do not even know the importance or the contents of the legislations, leading to failure during the implementation.

Both countries have noted this as a problem and have addressed it in the above mentioned legislations where charcoalers and vendors are now by law supposed to form associations through which they are to get their operation permits. Through the organisations the actors can now access loans from micro-finance institutions while and the government and NGO's can organise training sessions on proper production, handling and marketing practices. This has already kicked off in Rwanda, with the government having engaged CARE Rwanda to help form associations and conduct training in the Southern province and contracting Camco, a Kenyan based company, to do the same in the western Province, the major charcoal sources in Rwanda. In Kenya, the process has not started but Ministry of Energy confirmed it is among the planned activities to kick-off in the next year.

- ***Technical skills***

Most charcoalers learn the trade from watching others do it or simply by being engaged by relatives or friends as they make charcoal. They don't have the required technical skills which lead to use of highly inefficient practices hence wood wastage. The fact that most of them are either illiterate or semi-literate, leads to lower adoption of modern and efficient technology which require technical skill to operate.

Fig 44: A 12 year old boy practicing how to make charcoal in Kisii district, Kenya.
Source: Author

While proper and systematic arrangement of wood coupled with addition of chimneys has been shown to improve the efficiency and quality of charcoal in Rwanda, few people have these skills, and some who have them do not practice due to the intensive labour and care required.

Fig 45: Earth mound kilns with chimneys to increase their efficiency in Nyamagambe, Rwanda.
Source: Author

- ***Technological***

There has been great technological advancement and adoption of firewood and charcoal conversion technologies in both countries. Efficient charcoal and firewood stoves have been promoted since 1980, and although the firewood stoves have had lower adoption, charcoal stoves have been well received with both countries recording over 50% adoption hence leading to saving up to 50% in fuel consumption.


Fig 46: Efficient Rocket stove for firewood promoted by GTZ (Left) and Kenya Ceramic Jiko for charcoal which has had high adoption rate in Kenya.
Source: Author

The main problem lies with adoption of new efficient technology in charcoal making with more than 95% of charcoal consumed being made using the highly inefficient earth mound kilns. The main reasons for this as mentioned earlier are the financial investment required, lack of operational skills and criminalisation of the charcoal making process which rules out expensive investments.

6.4 Overcoming the barriers to woodfuel markets development

The challenges facing the woodfuel sector in both countries are not independent but rather interconnected with the effects of one spilling over to the others. It is therefore not possible to solve one problem expect to automatically eliminate all the problems in the sector. The matrix in table 25 shows the interrelationship between different factors in the woodfuel sector their possible effects. From the matrix, one is able to identify the factors that have greatest negative effect and also the possible areas that can be addressed leading to the most significant positive change.

Results / Factors	Poverty	Corruption	Lack of finances	Low tech. adoption	Technical skills	Environmental degradation	Lack of legal framework	Lack of organisation	Health risk
poverty		**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**-**	**-**	**XXX**
Corruption	**XXX**		**XXX**	**X**	**X**	**-**	**-**	**XXX**	
Lack of finances	**XXX**	**XXX**		**XXX**	**XXX**	**XXX**	**-**	**X**	**XX**
Low tech. adoption	**XX**	**-**	**X**		**X**	**XXX**	**-**	**-**	**XXX**
Technical skills	**X**	**-**	**X**	**XXX**		**XXX**	**-**	**-**	
Environmental degradation	**XXX**	**-**	**XXX**	**-**	**-**		**-**	**-**	**XX**
Lack of legal framework	**XXX**	**XXX**	**XX**	**XXX**	**XXX**	**XXX**		**XXX**	**XXX**
Lack of organisation	**XX**	**XXX**	**XX**	**XX**	**XX**	**XX**	**-**		-
Health risk	**XXX**	**-**	**X**	**-**	**-**	**-**	**-**	**-**	
Key: XXX- strong influence, XX- Moderate influence, X- Minimum influence, - no influence									

Table 25: Interrelationship between major factors affecting the woodfuel sector
Source: Assessment by author

By formulating proper legal and legislative framework, the government can eliminate corruption and ensure the sector is properly organised and formal. This would in turn attract more investors injecting the much needed cash, accelerate technology adoption. Within this framework, the government can design and implement tax structures that would capture the money initially lost through corruption and plough it back to the sector to improve the road infrastructure, organise the actors in to formal organisations, start micro-credit institutes to assist poor actors, research and development on more efficient technologies, initiate training workshops to the actors on best practices in growing trees, harvesting, charcoal making, packing and transport, marketing and conversion technologies.

When the actors are organised in to associations, they can easily access loans from micro-finance institutes and under group guarantee programmes. This would make the scarce financial resource more available enabling them to acquire efficient technologies and better operation and management skills thus increasing their productivity and reducing poverty. With adoption of efficient charcoal making and conversion technologies, there would be less wastage of the wood resource resulting in increase in supply without having to consume more thus reducing the pressure on natural forests.

It can therefore be concluded that the first step towards streamlining the sector is formulation and implementation of favourable legal and policy framework within which the sector can thrive. This has already been done in Kenya and Rwanda but the implementation, which is always a big challenge in many developing countries, will determine to what extent the reform process will be a success.

7 Conclusions and recommendations

7.1 Conclusions

The woodfuel sector is very important to Kenya and Rwanda not only for energy supply but also as a source of employment and a potential for important tax base if properly managed. The fact that its production and processing (for charcoal) takes place in the rural areas, which have less job opportunities, reduces job-search related rural-urban migration which is a big problem in developing countries. This research highlighted the potential in the whole sector to play a key and significant role in the rural and urban poor economic development helping to fight poverty in line with the Millennium Development Goals. The major conclusions that can be drawn from this research are:

7.1.1 Kenya

- Growing Eucalyptus is quite profitable in comparison with other farming systems especially in fertile land hence it should be encouraged to alleviate the woodfuel supply crises in the country. However, despite the farmers showing willingness to plant trees, land being available and a huge unmet demand for eucalyptus as reported in a study by Senelwa et al, some farmers have continued to invest in less profitable farming enterprises while others leave their land fallow. More research is thus recommended to ascertain why some farmers are not ready to invest in tree growing.
- There is great demand for Eucalyptus in the country for woodfuel, timber, building posts and props and electricity transmission which has ensured an active market and good prices for the farmers.
- The firewood markets are poorly developed because it is mostly consumed in the rural areas where it is freely accessible or residents use agricultural residues. The main markets for firewood are institutions and industries like tea and tobacco curing with minimum household consumers in the urban areas.
- The charcoal chain has well established structures from production, transport and trade but still continue to be hampered by lack of a proper operational legal framework. This has perpetuated corruption and prejudice against the actors (charcoalers, transporters and traders) denying it the opportunity to flourish and reach its maximum economic potential.

- The price of wood is not reflected in the final price of charcoal since it is obtained for free from private and trust lands or as a by-product of land conversion to agriculture. For the production to be sustainable, it is recommended that all the charcoal should be produced from only sustainably produced wood which would push the price to the real market price. Efficient charcoaling technologies like brick and improved earth kilns could ensure high recovery rates compensating for the increase in wood price which would in turn bring sustainability to the sector. This would see the charcoalers increase their earnings and also recover the investment costs for both the wood and the kiln.
- Financial constrains, corruption, low technology adoption in charcoal making technologies and charcoal making skills are the major issues that need to be addressed to ensure sustainable supply, maximum economic benefits to the actors, job creation and sustainability, reduced harmful gases emissions and enhanced revenue collection by the government.
- The government has already made important legislations to streamline the sector but the implementation has still not commenced. Many stakeholders on the ground do not know about the legislations or the contents while those who do still doubt the police and corrupt government officials who gain from the status quo will be willing to fairly implement them.

7.1.2 Rwanda

- Eucalyptus farming business is profitable but growing other traditional crops like cassava, rice and Irish potatoes has more returns to the farmers. Lack of an active competing market, except timber which requires higher investment; better management and a longer rotation period, limits the farmers' markets to transporters and charcoalers who pay them very low prices compared to Kenya. Several farmers decide to make charcoal from their wood in order to maximise their returns instead of selling it to the charcoalers.
- Due to poverty, many farmers can not afford to properly manage their plantations, some even harvesting the wood after only three years instead of the recommended six to be able to meet other financial obligations.
- The firewood supply chain is poorly developed with only institutions as the main customers while households procure wood from their farms or use agricultural residues.

- At about US$ 6, the price of a stere of wood to the transporters is the same as that of a sack of charcoal from the charcoalers to the transporters. This is a big price distortion since 1 stere of wood makes about 1.4 sacks of charcoal, and bearing in mind all the time and resources that have to be invested in the charcoaling process, the price of charcoal to the transporters ought be significantly higher than it is now. It is unfair that the farmers have to "subsidise" the charcoal by selling a stere of wood to the charcoalers at about UD$ 2, in stead of US$ 6 the transporter price as shown in the report making their business even less attractive. The Rwandan government has of late initiated a drive to reform the charcoal sector and bring the price of charcoal down making it more affordable. However it is recommend that these sector reforms should aim at bringing fairness in distributions of income throughout the supply chain and having charcoal sold at its real price in the market.
- The Government has already taken the first step of reforming the charcoal sector by involving CARE Rwanda and CAMCO in training the charcoalers and organising the charcoalers and charcoal vendors, but this has not embraced the farmers. It is recommended that the farmers, being the source of wood should also be integrated into this process to be able to address the above mentioned price disparities.

7.2 Recommendations

Though woodfuel sector problems are country and to some extent area specific, based on this research some general recommendation are put forward. These are;

- Formulation and implementation of legislations that will stem corruption and promote sustainable and efficient production, conversion, distribution and trade in woodfuels. This should be accompanied by a long-term action plan with a two-pronged approach laying emphasis on supply side management in establishing fast growing tree plantations and efficient conversion technologies and demand side management by vigorous promotion of efficient biomass stoves.
- Establishment of a woodfuel management body consolidating all the functions and organizations in the sector which are currently scattered all over different government ministries and agencies. This should be followed by creation of a woodfuel Development Fund to facilitate development production, trade and use managed by the body. Such a fund could provide money for research, development and promotion of efficient technologies, and organize skill development and marketing workshops to

the actors. The fund could raise revenues through taxes imposed on the sector and also benefit from both government and donor funding.

- The process of policymaking should be improved through; raising the effectiveness of public participation, inter-ministerial coordination and multidisciplinary collaboration, participation of affected stakeholders including the poor and the marginalized groups and the private sector whose investments would bring in the scarce financial resources. There is also the need for transparency, accountability and easy access to information to build confidence in the whole process.
- Regular surveys and development of a comprehensive databank on production, conversion and consumption trends which is important in planning or monitoring and evaluation to establish effectiveness of formulated policies.
- Involving research institutions on research and dissemination of efficient technologies. Schools would be used to sensitize the students and pupils on importance of adopting efficient stoves which hopefully would be passed on to the parents.

These recommendations if taken into consideration, the woodfuel sector would be transformed in to a thriving and economically beneficial sector to the actors and country as whole.

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Appendices

Appendix 1: Calculation of gross margins of 1 hectare of selected crops in Kenya and Rwanda.

Gross margin for one hectare of maize farming in Kisii District					
Spacing: 75cm by 30 cm					
Population: 17,777					
Variety: Medium to High Altitude Varieties					
Item	**Units**	**Quantity** (Per Ha.)	**Price/unit** (Ksh./unit)	**Total cost** (KSh/ha)	**Total costs** (KSh/ha/yr)
Variable costs					
Establishment costs (A)					
Maize seeds	kg	62	20	1,240	2,480.00
Fertilizer- DAP	50kg bag	4	3,750	15,000	30,000.00
CAN fertilizer	50kg bag	4	1,600	6,400	12,800.00
Land preparation	Man days	20	200	4,000	8,000.00
Planting	Man days	10	200	2,000	4,000.00
1st & 2nd weeding	Man days	40	200	8,000	16,000.00
Sub-total				**36,640**	**73,280.00**
Other cost (B)					
Storage dust (Actelic 1%) 50gm/bag	bags	2.5	230	569	1,138.00
Packing Gunny bags	No.	40	30	1,200	2,400.00
Fertilizer and seeds transport	Pick-up hire	1	2,000	2000	4,000.00
Shelling, airing and treating	Man days	10	200	2,000	4,000.00
harvesting	Man days	10	200	2,000	4,000.00
Sub-total				**7,769**	**15,538.00**
Total variable costs (C) = A+B				**44,409**	**88,818.00**
Yields (E)	90kg bags	30	2,000	**60,000**	**120,000.00**
Gross margin = E-D				**15,591**	**31,182.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***194.89***	***389.78.00***

Gross margin for 1 hectare of finger Millet Kisii District					
Spacing: 30 x 5cm					
Plant Population: 266,667					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total Cost** (Ksh./Ha)	**Total costs** (KSh/Ha/yr)
Variable costs					
Establishment costs(A)					
Millet seeds	kg	5	120	600	1,200.00
Land preparation	Man days	20	200	4,000	8,000.00
Planting	Man days	10	200	2,000	4,000.00
1st and 2nd weeding	Man days	20	200	4,000	8,000.00
Harvesting	Man days	20	200	4,000	8,000.00
Seeds transport	Public transport	1	100	100	200.00
Sub-total				**14,700**	**29,400**.00
Other costs(B)					
Threshing, winnowing, bagging & treating	Man days	10	200	1,000	2,000.00
Packing Gunny bags	bags	7	30	210	420.00
Sub-total				**1,210**	**2,420.00**
Total variable costs (C)= A+B				**15,910**	**31,820.00**
Yields (D)	90 kg bags	10	4,000	**40,000**	**80,000.00**
Gross margin = D-C				**24,090**	**48,180.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***301.12***	***602.25.00***

Gross margin for 1 hectare of Beans in Kisii district					
Spacing: 45 by 15 cm					
Plant Population: 59,259					
Variety: Medium to High Altitude Varieties					
Production costs					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh/Ha/yr)
Variable costs					
Establishment costs(A)					
Beans seeds	2 kg bag	25	160	4,000	8,000.00
CAN fertilizer	50 kg bag	2	2,500	5,000	10,000.00
Land Preparation	Man days	20	200	4,000	8,000.00
Planting	Man days	10	200	2,000	4,000.00
1st & 2nd weeding	Man days	20	200	4,000	8,000.00
Seedlings transport	Public transport	1	100	100	200.00
Sub-total				**19,100**	**38,200.00**
Other costs(B)					
Storage dust (Actelic 1%) 50gm/bag	bags	2	230	460	920.00
Packing Gunny bags	no.	10	30	300	600.00
harvesting	Man days	10	200	2,000	4,000.00
Threshing, winnowing, bagging & treating beans	Man days	10	200	2,000	4,000.00
Sub-total				**4,760**	**9,520.00**
Total variable costs (C) = A+B				**23860**	**47,720.00**
Yields (D)	90kg bags	10	4,000	**40,000**	**80,000.00**
Gross margin = D-C				***16,140***	**32,280.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***201.75***	**403.50**

Gross margin for 1hectare for Industrial Cane in Kisii District					
Spacing 1.5m x drill (furrows). Cane is sold to Sony Sugar Factory					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh./Ha/yr)
Variable costs					
Establishment costs(A)					
Ploughing	Man days	20	200		961.44
Furrow marking	Man days	10	200		480.72
Planting materials (sects)	No		7,500		18,027.02
Planting	Man days	20	200		961.44
DAP fertilizer for planting	50kg bag	5	3,750		4,506.75
Weeding	Man days	20	200		961.44
Urea fertilizers for topdressing	50kg bags	5	1,600		1,922.88
NPK Fertilizers for Topdressing	50kg bags	5	2,500		3,004.50
Fertilizer transport	bag	15	20		72.10
Topdressing	Man days	3	200		144.21
Sub-total					31,042.54
Other recurrent costs (every 16 months) (B)					
Urea fertilizers for topdressing	50kg bags	5	1,600	8,000	6,000.00
NPK Fertilizers for Topdressing	50kg bags	5	2,500	12,500	9,375.00
weeding	Man days	20	200	4,000	3,000.00
Top Dressing	Man days	3	200	600	450.00
Fertilizer transport	Bag	10	20	200	150.00
Harvesting and loading	Man days	20	200	4,000	3,000.00
Cane transport	tonnes	30	600	18,000	13,500.00
Sub-total				**47,300**	**35,475.00**
Total variable costs (C) = A+B					**66,517.54**
Yields (every 16 months) (D)	Tonnes	74	2,500	**185,000**	**138,750.00**
Gross margin = D-C					**72,232.45**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)					**902.90**

Gross margin for 1 hectare of Tea in Kisii District					
Spacing: 4x2½ ft. Plant population = 10,500					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh./Ha/yr)
Variable costs					
Establishment costs(A)					
Land preparation by Round-up	L	5	950		713.15
Bush and tree stump clearance	Man days	25	200		750.69
Digging holes	Man days	35	200		1,050.96
seedlings	No	10,500	7		11,035.18
Seedlings transport	Car hire	1	8,000		1201.10
Planting	Man days	30	200		900.83
DAP fertilizer for planting	50Kg bag	6	3,750		3,378.11
NPK Fertilizer for Topdressing	50kg bags	17	2,500		6380.88
Fertilizer transport	bag	23	20		69.06
Weeding (4)	Man days	120	200		3,603.32
Topdressing	Man days	3	200		90.08
Bringing tea into bearing	Man days	100	200		3,002.77
Sub-total					**32,176.19**
Recurrent costs (Annual) (B)					
NPK Fertilizers for Topdressing	50kg bags	17	2,500	42,500	42,500.00
Top Dressing	Man days	3	200	600	600.00
Fertilizer transport	Bag	17	20	340	340.00
Tea plucking costs	kg	12,000	7.5	90,000	90,000.00
Tea baskets	No.	10	150	1,500	1,500.00
Sub-total				**134,940**	**137,940.00**
Total variable costs (C) = A+B				**167,116**	**167,116.00**
Yields (D)	kg	10,000	25	**250,000**	**250,000.00**
Gross margin = D-C				***82,884***	***82,884.00***
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***1,036.04***	

Gross margin for 1 hectare of Coffee (Arabica) in Kisii District					
Spacing: 2x2m. Plant population = 2,500. Variety: Ruiru 11					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh./Ha/yr)
Variable costs					
Establishment costs(A)					
Land preparation by Round-up	L	5	950	75.59	
Bush and tree stump clearance	Man days	25	200	773.49	
Digging of holes	Man days	100	200	3,093.98	
seedlings	No	2,500	10	3,867.48	
Seedlings transport	Car hire	1	8,000	1,237.59	
Planting	Man days	50	200	1,546.99	
SSP fertilizer for planting	50Kg bag	8	1,150	1,423.23	
NPK Fertilizer for Topdressing	50kg bags	17	2,500	6,574.72	
Fertilizer transport	bag	23	20	71.16	
Weeding (2)	Man days	60	200	1,856.39	
Topdressing	Man days	3	200	92.81	
manure	Tonnes	20	3,000	9,281.96	
Seedlings transport	Canter	1	8,000	1,237.59	
				31,133.04	
Sub-total					
Recurrent costs (Annual) (B)					
CAN Fertilizers for Topdressing	50kg bags	12	2,500	30,000	30,000.00
Top Dressing	Man days	3	200	600	600.00
Fertilizer transport	Bag	12	20	240	240.00
Forliar feed spray (Flower & Fruit)	L	10	250	2,500	2,500.00
Ring weeding	Man days	20	200	4,000	4,000.00
Organophosphate (Malathion)	L	20	290	5,800	5,800.00
Nordox Super Spray	Kg	15	640	9,600	9,600.00
Decomposed coffee pulp transport (manure)	Truck	3	4,000	12,000	12,000.00
Spraying (4 times)	Man days	60	200	12,000	12,000.00
Picking cherries & Delivering to factory (from yr 3)	Man days	120	200	24,000	24,000.00
Sub-total				**100,740**	**100,740.00**
Total variable costs (C) = A+B				**131,873**	
Yields (D)	kg	7,000	30	**210,000**	**210,000.00**
Gross margin = D-C				***78,127***	
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***976.58***	

Gross margin for one acre of Eucalyptus for firewood and charcoal in Kisii District					
Spacing: 2.0m by 2.0m					
Rotation age: 8 years					
Population: 1,600					
Item	**Units**	**Quantity** Per Ha.	**Price/unit** (Ksh./unit)	**Total cost** (KSh/ Ha.)	**Total cost** (KSh/Ha./yr)
Variable costs					
Establishment costs(A)					
Seedlings	No.	1,600	10		3565.60
Fertilizer- DAP (for planting)	kg	30	70		467.98
Confidor	Liters	2.5	2,500		1392.81
Furadine	kg	5	1,000		1114.25
Fencing (barbed wire, posts, nails, labour)		400	40		3565.60
Land preparation	Man days	20	200		891.40
Staking out	Man days	10	200		445.70
Pitting	Man days	50	200		2228.50
Planting	Man days	20	200		891.40
Weeding(3)	Man days	60	200		2674.20
Seedlings and fertilizer transport	Car hire (Canter)	1	6,000		1337.10
Sub-total					**18574.555**
Other costs(B)					
Felling and sizing (with power saw)	days	20	10,000	200,000	25,000.00
Arranging	Man days	50	200	10,000	1,250.00
Sub-total				210,000	26,250.00
Total variable costs (C)= A+B					**44,825.00**
Yields (D)	$1M^3$ Stacks	900	1,200	1,080,000	**135,000.00**
Gross margin =(D- C)					**90,175.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)					**1127.19**

Gross margin for 1 acre of Eucalyptus for transmission poles in Kisii District					
Spacing: 2.0m by 2.0m					
Rotation age: 8 years					
Population: 1,600					
Item	**Units**	**Quantity** Per Ha.	**Price/unit** (Ksh./unit)	**Total cost** (KSh/ Ha.)	**Total cost** (KSh/Ha./yr)
Variable costs					
Establishment costs(A)					
Seedlings	No.	1,600	10		3,188.03
Fertilizer- DAP (for planting)	kg	30	70		418.42
Confidor	Liters	2.5	2,500		1,245.32
Furadine	kg	5	1,000		996.26
Fencing (barbed wire, posts, nails, labour)	Meters	400	40		3,188.03
Land preparation	Man days	20	200		797.00
Staking out	Man days	10	200		398.50
Pitting	Man days	50	200		1,992.52
Planting	Man days	20	200		797.00
Weeding	Man days	20	200		797.00
Seedlings and fertilizer transport	Car hire (Canter)	1	6,000		1,195.51
Sub-total					**15,013.64**
Other costs(B)					
Thinning	Man days	100	200	20,000	2,000.00
Felling and sizing (with power saw)	Man days	40	200	8,000	800.00
Arranging	Man days	50	200	10,000	1,000.00
Sub-total				38,000	3,800.00
Total variable costs (C)= A+B					**18,814.00**
Yields (D)	Poles	750	1,500	1,125,000	**112,500.00**
Gross margin =(D- C)					**93,686.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)					**1,171.07**

Gross margin for 1 hectare of Sweet Potatoes in Kisii district					
Spacing: 2.0m by 2.0m					
Plant Population: 29,630					
Production costs					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh/Ha/yr)
Variable costs					
Establishment costs(A)					
Round up	Litre	5	950	4,750	9,500.00
Insecticide (Diazinon)	28mls	1	50	50	100.00
Land preparation	Man days	20	200	4,000	8,000.00
Planting	Man days	30	200	6,000	12,000.00
1st to 3rd weeding	Man days	20	200	4,000	8,000.00
Vines (from farmers bulking plots)				2,500	5,000.00
Transport – vines and other inputs	Pick-up hire	1	3,000	3,000	6,000.00
Sub-total				**24,300**	**48,600.00**
Other costs (B)					
Water for cleaning tubers	20 liters Jerry can	480	10	4,800	9,600.00
Packing Gunny bags and extending crowns	No.	200	50	1,000	2,000.00
harvesting	Man days	30	200	6,000	12,000.00
Cleanin, bagging and loading on truck	Man days	50	200	10,000	20,000.00
Sub-total				**21,800**	**43,600.00**
Total variable costs (C) = A+B				**46,100**	**92,200.00**
Yields (D)	145kg bags	90	1,000	**90,000**	**180,000.00**
Gross margin =D-C				***43,900***	**87,800.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***548.75***	**1,097.50**

Gross Margin for I hectare of groundnuts in Kisii District					
Spacing = 45x15cm;(e.g. Red valencia variety)					
Plant population = 59,259					
Item	**Unity**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh/Ha/yr)
Variable costs					
Establishment costs(A)					
Groundnut seeds	kg	50	60	3,000	6,000.00
Seed dressing insecticide (Murtano @5g/kg)	kg	25	50	2,500	5,000.00
Seedlings transport	Pick-up hire	1		1,080	2,160.00
Land preparation	Man days	20	200	4,000	8,000.00
Planting	Man days	10	200	2,000	4,000.00
1st and 2nd weeding	Man days	40	200	8,000	16,000.00
Sub-total				**20,580**	**41,160.00**
Other costs(C)					
Insectcide spray (Malathion)	Litres	5	580	2,900	5,800.00
Spraying	Man days	21	200	4,200	8,400.00
Harvesting	Man days	20	200	4,000	8,000.00
Threshing	Man days	120	200	24,000	48,000.00
Packing Gunny bags	kg	30	30	900	1,800.00
Sub-total				**36,000**	**72,000.00**
Total variable costs (D)= A+B+C				**56,580**	**113,160 .00**
Yields (E)	90 kg bags	20	6,400	**128,000**	**256,000.00**
Gross margin = E-D				***71,420***	**142,840.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				**892.75**	**1,785.50**

Gross margin for 1 hectare of Irish Potatoes in Kisii District					
Spacing: 75cm by 30 cm					
Population: 17,777					
Variety: Medium to High Altitude Varieties					
Item	**Units**	**Quantity**	**Price/unit** (Ksh./unit)	**Total costs** (Ksh./Ha)	**Total costs** (KSh./Ha/yr)
Variable costs					
Establishment costs(A)					
Irish potato seeds	130 kg bag	30	1200	36,000	72,000.00
Manure	Tons	7	3000	21,000	42,000.00
CAN fertilizer	50kg bag	7	2500	17,500	35,000.00
Fungicide (Sancozeb)		15	490	7,350	14,700.00
Seedlings & fertilizer transport	Car hire (canter)	1	8,000	8,000	16,000.00
Land preparation	Man days	20	200	4,000	8,000.00
Planting	Man days	20	200	4,000	8,000.00
1st to 3rd weeding	Man days	60	200	12,000	24,000.00
Top Dressing	Man days	3	200	6,000	12,000.00
Sub-total				**115,850**	**231,700.00**
Other costs(B)					
Insecticide (malathion) spay	Liters	7	580	4,060	8,120.00
Spraying	Man days	21	200	4,200	8,400.00
Packing Gunny bags	No.	1,000	30	3,000	6,000.00
Harvesting & loading	Man days	30	200	6,000	12,000.00
Sub-total				**17,260**	**34,520.00**
Total variable costs (C) = A+B				**133,110**	**266,220.00**
Yields (D)	110kg bags	150	1,200	**180,000**	**360,000.00**
Gross margin = D-C				***46,890***	**93,780.00**
Gross margin in US$ (Exchange rate 1US$= KSh. 80)				***596.125***	**1172.25**

Gross margin for one hectare of intensified cassava farming in Rwanda					
Production costs					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Toatl costs** (Frw/ha/yr)
Variable costs					
Establishment cost (A)					
1st and 2nd ploughing	man days	110	500		44,090.59
Manure	kg	20000	15		240,494.10
Manure transport		1	25000		20,041.18
NPK 17.17.17	50 kg bags	6	700		3,366.91
NPK transport		6	1000		4,809.88
Planting	Man days	30	500		12,024.71
Planting and manure spreading	man days	20	500		80,16.471
Weeding (3) and NPK spreading	Man days	70	500		28,057.65
Earthing up	Man days	20	500		8,016.47
Sub-total					***368,918.00***
Other costs (B)					
Bags		400	300	120000	*80,000.00*
Harvesting	Man days	50	500	25000	*16,666.67*
Ingendo + Ubwikorezi				200000	*133,333.30*
Peeling and drying	Man days	50	500	25000	*16,666.67*
Sub-total					**246,666.70**
Total variable costs(C)					***615,584.70***
Yields (D)		30000	146	4380000	**2,920,000.00**
Contribution margin(D-C)					***2,304,415.00***
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**3,973.13**

Gross margin for 1 hectare of intensified banana plantation in Rwanda					
Production costs					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs(A)					
1st and 2nd ploughing	day	110	500		9,864.66
Manure	kg	22000	15		59,187.98
Manure transport		1	2200		394.58
NPK 17 17 17	kg	138	700		17,325.93
NPK transport		1	13.8		2.47
Digging holes	day	50	500		4,483.93
Plants	No.	1100	2000		394,586.54
Plants transport	day	10	500		896.78
Planting and manure application	day	15	500		1,345.18
Mulching		1	50000		8,967.87
Sub-total					**497,055.97**
Recurrent costs (Annual) (B)					
Plantation management (removal of old leaves, removal of flowers, removal of old bulbs, staking, pest control etc)	day	88	500	44000	***44,000.00***
Other costs (C)					
Harvesting and selling	day	52	500	26000	*26,000.00*
Packing		1250	300	375000	*375,000.00*
Sub-total					***401,000.00***
Total variable costs(D)					***942,056.00***
Yields (E)		20,000	86	1720000	**1,720,000.00**
Contribution margin (E-D)					***777,944***
Gross margin in US$ (Exchange rate: 1 US$ = 580RwF)					**1,341.28**

Gross margin for one hectare of intensified jatropha plantation in Rwanda (on normal land)					
Item	**Unit**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
Land clearing and stupms uprooting	day	60	500		5,060.01
Manure	kg	14000	15		35420.07
Manure transport		1	17500		2951.67
NPK 17.17.17	kg	300	700		35420.07
NKP Transport	50Kg bags	6	1000		1012.00
Digging holes	day	30	500		2530.00
Plants	No.	1600	40		10794.69
Plants transport	day	10	500		843.33
Planting and manure spreading	day	15	500		1265.00
Sub-total					**95296.87**
Annula cost (B)					
NPK 17.17.17	50kg bags	7	35000	245000	245,000.00
NKP Transport		7	1000	7000	6,000.00
Weeding (2) and NPK application	day	50	500	25000	25,000.00
Mulching	day	40	500	20000	20,000.00
Pest control				30000	30,000.00
Pruning	day	10	500	5000	5,000.00
Bags		20	300	6000	6,000.00
Harvesting and selling	day	60	500	30000	30,000.00
Sub-total				368000	**367,000.00**
Total variable costs- C (A+B)					**462,297.00**
Yields (D)		2500	250	625000	**625,000.00**
Contribution margin (D-C)					***162,70.00***
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**280.52**

Gross margin for one hectare of Eucalyptus plantation in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
Labor (clearing, Digging holes, planting)	day	50	500		6,784.74
Seedlings	No	1600	23		9,987.14
Manure	kg	14000	15		56,991.87
Manure Transport	No	1	17500		4,749.32
Pest control		1	30000		8,141.69
Sub-total					**86,654.78**
Other costs (C)					
Harvesting and selling	day	50	500	25000	4,166.66
Sub-total					**4,166.66**
Total variable costs –D (A+B+C)					***90,821.452***
Yields (E)	Steres	480	3500	1680000	**280,000.00**
Contribution margin (E-D)					***189,178.55***
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**326.16**

Gross margin for one hectare of sugar cane in intensified farming system in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	Days	110	500		13,618.69
Manure	kg	25000	15		92,854.75
Manure transport		1	31250		7,737.89
Fertilizer (P2O2)	kg	60	700		10,399.73
Fertilizer (N)	kg	125	700		21,666.10
Fertilizer (K2O)	kg	150	700		25,999.33
Fertilizer Transport	50 kgBags	7	1000		1,733.28
Cuttings	kg	8000	15		29,713.52
Planting	Days	5	500		619.03
Earthing up and NPK application	Day	20	500		2,476.12
Sub-total					**206,818.48**
Annual costs (B)					
Weeding	Days	20	500	10000	*6,666.66*
Mulching	Days	40	500	20000	*13,333.33*
Harvesting and selling	days	70	500	35000	*23,333.33*
Fertilizer (NPK)	50kg bags	6	35,000	210000	*140,000.00*
Fertilizer Transport	50 kg bags	6	1000	6000	*4,000.00*
Sub-total					**187,333.33**
Total variable costs-C (A+B)					***394,151.82***
Production (Every 18 months) (D)		120000	12.5	1500000	**1,125,000.00**
Contribution margin (D-C)					***730,848.17***
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**1,260.08**

Gross margin calculation for one hectare of intensified coffee plantation farm in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	110	500		9,020.69
Manure	kg	100000	15		246,018.92
Manure transport		1	125000		20,501.57
NPK 20 10 10	kg	1000	700		114,808.83
NPK transport	50Kg bags	20	1000		3,280.25
Digging holes	day	50	500		4,100.31
Plants		2500	50		20,501.57
Plants transport	day	10	500		820.06
Planting and manure spreading	day	15	500		1,230.09
Weeding	Day	32	500		2,624.20
Sub-total					**422,906.52**
Annual expenses (B)					
CAN fertilizer for topdressing	50kg bags	12	30,000	360000	360,000.00
Fertilizer transport	50kg bags	12	1000	12,000	12,000.00
Weeding	day	16	500	8000	8,000.00
Mulching	day	50	500	25000	25,000.00
Production & formation pruning	day	10	500	5000	5,000.00
Insecticide (Dursiban)	l	1	5000	5000	5,000.00
Dursiban spreading	day	12	500	6000	6,000.00
Bags		42	300	12500	12,500.00
Harvesting (5 times)	day	425	500	212500	212,500.00
Pulping				25000	25,000.00
Washing				10000	10,000.00
Drying				10000	10,000.00
Sub-total					***691,000.00***
Total variable costs-C (A+B)					***1,113,906.53***
Annual yields (D)		2500	650	1625000	**1,625,000.00**
Contribution margin- (D-C)					***511,093.47***
Gross margin in US$ (Exchange rate:1 US$ = 580 Frw)					881.19

Gross margin for one hectare of intensified Irish potatoes in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total cost** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	120	500	60,000	120,000.00
Manure	kg	20000	15	300,000	600,000.00
Manure transport				25,000	50,000.00
NPK 17.17.17	50kg bags	6	3500	210,000	420,000.00
NPK transport	50kg bags	6	1000	6000	12000.00
Seeds	kg	2000	250	500,000	1,000,000.00
Seeds transport				2,500	5,000.00
Planting, manure & NPK spreading	day	60	500	30,000	60,000.00
Weeding	day	10	500	5,000	10,000.00
Earthing up	day	15	500	7,500	15,000.00
Dithane	kg	20	4000	80,000	160,000.00
Thiodan	L	1	5000	5,000	10,000.00
Dithane/Thiodan spreading	day	25	500	12,500	25,000.00
Sub-total				**1,243,500**	**2,487,000.00**
Other costs (B)					
Irrigation	day	30	500	15,000	30,000.00
Security	day	60	500	30,000	60,000.00
Agricultural Technical Assistance	day	12	4000	48,000	96,000.00
Transport				250,000	500,000.00
Bags		250	300	75,000	150,000.00
Harvesting and selling	day	120	500	60,000	120,000.00
Sub-total				***478,000***	***956,000.00***
Total variable costs(C)				**1,721,500**	**3,443,000.00**
Yields(D)		165000	113	**1864500**	**3729000.00**
Contribution margin (D-C)					**297,250.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**493.10**

Gross margin for one hectare of intensified Sweet potatoes in Rwanda					
Production costs					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha) (Frw/ha/year)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs(A)					
1st and 2nd ploughing	day	60	500	30000	6,0000.00
Manure	kg	20000	15	300000	60,0000.00
Manure transport				25000	50,000.00
NPK 17.17.17	50kg bags	6	35000	210000	420,000.00
NPK transport	50kg bags	6	1000	6000	12,000.00
Cuttings		10000	5	50000	100,000.00
Planting and manure spreading	day	50	500	25000	50,000.00
Weeding (3) and NPK spreading	day	70	500	35000	70,000.00
Earthing up	day	15	500	7500	15,000.00
Pest control				5000	10,000.00
Sub-total				**693500**	**1,387000**.00
Other costs (B)					
Irrigation	day	35	500	17500	35,000.00
Bags		250	300	75000	150,000.00
Harvesting and selling	day	50	500	25000	50,000.00
Ingendo + Ubwikorezi				30000	60,000.00
Sub-total				**147500**	**295,000.00**
Total variable costs(C)				***811000***	**1,682,000.00**
Yields (D)		18000	60	**1080000**	**2,160,000.00**
Contribution margin (D-C)					**478,000.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**824.13**

Gross margin for one hectare of intensified maize farming in Rwanda					
Item	**Unit**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	(Frw/ha/year)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	60	500	30000	60,000.00
Manure	kg	10000	15	150000	300,000.00
Manure transport				12500	25,000.00
NPK 17.17.17	50 kg bags	5	35000	175000	350,000.00
NPK transport	50 kg bags	5	1000	5000	10,000.00
Seeds	kg	50	400	20000	40,000.00
Planting and manure spreading	day	20	500	10000	20,000.00
Weeding (2) and NPK spreading	day	20	500	10000	20,000.00
Démarriage	day	6	500	3000	6,000.00
Earthing up	day	15	500	7500	15,000.00
Pesticide(Dursban 48%)	l	1.5	3000	4500	9,000.00
Pesticide (Tilt)	l	0.5	5000	2500	5,000.00
Pesticide application	day	8	500	4000	8,000.00
Sub-total				**434000**	**868,000.00**
Other costs (B)					
Irrigation	day	30	500	15000	*30,000*.00
Bags		35	300	10500	*21,000*.00
Watching, Harvesting and threshing	day	80	500	40000	*80,000*.00
Sub-total				**65500**	**131,000.00**
Total variable costs (C)					***999,000.00***
Yields (D)		4000	199	**796000**	**1,592,000.00**
Contribution margin (D-C)					**593,000.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**1,022.41**

Gross margin for one hectare of intensified sorghum farming in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	60	500	30000	60,000.00
Manure	kg	11000	15	165000	330,000.00
Manure transport				13750	27,500.00
NPK 17.17.17	50 kg bags	5	35000	175000	350,000.00
NPK transport	50kg bags	5	1000	5000	10,000.00
Seeds	kg	30	350	10500	21,000.00
Planting and manure spreading	day	20	500	10000	20,000.00
Weeding and NPK spreading	day	11	500	5500	11,000.00
Démarriage	day	7	500	3500	7,000.00
Earthing up	day	10	500	5000	10,000.00
Pesticide (Dursban 48%)	l	1.5	3000	4500	9,000.00
Dursban spreading	day	8	500	4000	8,000.00
Sub-total				**431750**	**863,500.00**
Other costs (B)					
Irrigation	day	30	500	15000	*30,000*.00
Bags		40	300	12000	24,000.00
Harvesting and threshing	day	140	500	70000	*140,000*.00
Sub-total				**97000**	**194,000.00**
Total variable costs (C)					**1,057,500.00**
Yields (D)		3500	212	**742000**	**1,484,000.00**
Contribution margin(D-C)					**426,500.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**735.34**

Gross margin for one hectare of intensified wheat farming in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	60	500	30000	6,0000
Manure	kg	10000	15	150000	30,0000
Manure transport				12500	2,5000
NPK 17.17.17	50kg bags	5	35000	175000	35,0000
NPK transport	50kg bags	5	1000	5000	1,0000
Urea	50kg bags	2	30000	60000	120,000
Urea transport	50kg bags	2	1000	2000	4,000
Seeds	kg	200	350	70000	140,000
Planting, manure & NPK application	day	20	500	10000	20,000
Weeding and urea application	day	11	500	5500	11,000
Earthing up	day	10	500	5000	10,000
Pesticide (Dimethoate)	l	1.5	3000	4500	9,000
Dimethoate application	day	8	500	4000	8,000
Sub-total				**533500**	**1,067,000**
Other costs (B)					
Bags		35	300	10500	21,000
Harvesting and threshing	day	140	500	70000	*140,000*
Sub-total				**80500**	**161,000**
Total variable costs (C)				***614000***	**1,228,000**
Yields (D)		4000	270	**1080000**	**2,160,000**
Contribution margin (D-C)					**932,000**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**1,606.89**

Gross margin for one hectare of intensified rice farming in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	60	500	30000	60,000.00
NPK 17.17.17	50kg bags	5	35000	175000	350,000.00
NPK transport	50kg bags	2	1000	5000	10,000.00
Urea	50kg bags	2	30000	60000	120,000.00
Urea transport	50kg bags	2	1000	2000	4,000.00
Seeds	kg	75	700	52500	105,000.00
Nursery	day	15	500	7500	15,000.00
Planting and NPK application	day	20	500	10000	20,000.00
Weeding (2) and urea application	day	21	500	10500	21,000.00
Irrigation	day	40	500	20000	40,000.00
Pesticide (Propiconazole)	l	1.5	3000	4500	9,000.00
Propiconazole spraying	day	8	500	4000	8,000.00
Sub-total				**381000**	**762,000.00**
Other costs (B)					
Watching	day	60	500	30000	60,000.00
Bags		30	300	9000	18,000.00
Harvesting, threshing and vannage	day	140	500	70000	140,000.00
Sub-total				**109000**	**218,000.00**
Total variable costs-C (A+B)					**980,000.00**
Yields (D)		3000	579	**1737000**	**3,474,000.00**
Contribution margin					**2,494,000.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**4,300.00**

Gross margin for 1 hectare of intensified beans farming in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	60	500	30000	60,000.00
Manure	kg	10000	15	150000	300,000.00
Manure transport				12500	25,000.00
DAP	50kg bags	2	500	50000	100,000.00
DAP transport	50kg bags	2	1000	2000	4,000.00
Seeds	kg	100	400	40000	80,000.00
Planting and manure spreading	day	25	500	12500	25,000.00
Weeding and DAP spreading	day	23	500	115000	230,000.00
Earthing up	day	10	500	5000	10,000.00
Pesticides				4500	9,000.00
Sub-total				**318000**	**636,000.00**
Other costs (B)					
Irrigation	day	20	500	10000	20,000.00
Bags		15	300	4500	9,000.00
Harvesting and threshing	day	30	500	15000	30,000.00
Sub-total				**29500**	**59,000.00**
Total variable costs-C (A+B)					**695,000.00**
Yields (D)		1500	313	**469500**	**939,000.00**
Contribution margin (D-C)					**244,000.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**420.68**

Gross margin for 1 hectare of intensified Groundnut farming in Rwanda					
Item	**Units**	**Quantity**	**Price/unit** (Frw/unit)	**Total costs** (Frw/ha)	**Total costs** (Frw/ha/yr)
Variable costs					
Establishment costs (A)					
1st and 2nd ploughing	day	60	500	30000	60,000.00
Manure	kg	10000	15	150000	300,000.00
Manure transport				12500	25,000.00
NPK 17.17.17	50kg bag	2	35000	70000	140,000.00
NPK transport	50kg bag	2	1000	2000	4,000.00
Seeds	kg	100	700	70000	140,000.00
Planting and manure spreading	day	20	500	10000	20,000.00
Weeding and NPK spreading	day	23	500	11500	*23,000*.00
Earthing up	day	10	500	5000	*10,000*.00
Pesticide (Dursban)	l	1.5	3000	4500	*9,000*.00
Dursban spreading	day	8	500	4000	*8,000*.00
Sub-total				**369500**	**739,000**.00
Other costs (B)					
Irrigation	day	40	500	20000	40,000.00
Ubugenzuzi	day	12	4000	48000	96,000.00
Bags		15	300	4500	9,000.00
Harvesting, threshing and vannage	day	35	500	17500	35,000.00
Sub-total				**90000**	**180,000.00**
Total variable costs(A+B)					**919,000.00**
Yields(D)		*1500*	*684*	***1026000***	**2,052,000.00**
Contribution margin (D-C)					**1,133,000.00**
Gross margin in US$ (Exchange rate: 1 US$ = 580 Frw)					**1,953.44**

Appendix 2: Sample questionnaires used to collect primary data in Kenya and Rwanda.

Questionnaire to the Woodfuel consumer

This questionnaire is for collecting information on woodfuel consumption in the country. It will aid at establishing the main woodfuels consumed, amount spent on the woodfuels and reasons for choosing a particular fuel. The results of this research will help in the value chain analysis of the woodfuel sector and how it can be transformed into a market oriented profitable and sustainable sector. The information collected during this research is only for academic purposes and will be treated as confidential.

Name………………………………………………………………………… *(Optional)*

Location details: Region...................................... District..

Fuel type..................................Date...

1. How much fuel do you consume per day/ month (kg/ stere/sacks)? …………………..
2. How much do you spend on the fuel per day/ month? …………………………………
3. From which species is the fuel mainly from? …………………………………………..
4. Do you like the species? YES NO If no, which one do you prefer?
    a. ……………………………………………
    b. ……………………………………………
    c. …………………………………………….
5. Dou you use any other type of fuel? YES NO
6. If yes, which one/s? ……………………..How much (kg/L/Stere/sacks)? …………
7. Why do you use the fuel?
    a. Like it
    b. Readily available
    c. Cheap
    d. Easy to use
    e. No other alternative
    f. Others (specify) ………………………………………………..
8. Do you have an improved stove? YES NO

Questionnaire to the farmers

This questionnaire is for collecting information on farming in the country. It will aid in establishing the main crops grown, estimated costs and revenues and the challenges faced in the day to day farming life. The results of this research will help in the value chain analysis of the woodfuel sector and how it can be transformed into a market oriented profitable and sustainable sector. The information collected during this research is only for academic purposes and will be treated as confidential.

Name……………………………………………………………….. *(Optional)*
Location details: Region...................................... District..
Main crop..................................Date..

1. How long have you been a farmer?..years/months
2. What is the size of the farm? .... Do you own it? YES NO
3. Do you have any other occupation? YES NO
4. How much harvest do you have per year/season/rotation period? ....
5. How much do you sell? ....
6. At what price do you sell per kg/ sack/stere? ....
7. List daily/monthly/yearly expenses related to your farming activities?
   a. Seeds/seedlings.....................................
   b. Land preparation....................................
   c. Planting...
   d. Fertilizers/ manure..................................
   e. Weeding..
   f. Pesticides..
   g. Pruning..
   h. Harvesting and selling............................
   i. Land lease...
   j. Equipments..
   k. Taxes..
   l. Others (specify)......................................

8. What are the main problems you face in the course of your farming activities?

   a. ....

   b. ....

   c. ....

   d. ....

9. Do you get any support from any organisation or government department? | YES | NO |

10. If your answer is yes, which ones?

   a. ....

   b. ....

   c. ....

11. If your answer in 9 is yes, what type of support?

   a. ....

   b. ....

   c. ....

   d. ....

12. What changes would you like to be implemented to make your working environment better?

   a. ....

   b. ....

   c. ....

   d. ……………………………………………………………………………………

Questionnaire to the firewood traders

This questionnaire is for collecting information about the firewood business in the country. It will aid in establishing the type of wood you sold, estimated costs and revenues and the challenges faced in the day to day firewood business life. The results of this research will help in the analysis of the woodfuel sector and how it can be transformed into a market oriented profitable and sustainable sector. The information collected during this research is only for academic purposes and will be treated as confidential.

Name…………………………………………………………………… *(Optional)*
Location details: Town/ city..
Estate..Date...

1. How long have you been in this trade?..years/months

2. Who are your main customers?

   a. ....

   b. ....

   c. ....

3. What species of wood do you mostly sell?

   a. ....

   b. ....

   c. ....

4. Do the customers like the wood species? YES NO

   If no, which other species do they prefer?

   a. ....

   b. ....

   c. ....

5. How much wood do you sell per day/month? ....

6. Where do you source it from? ....

7. How much do you pay for the wood? ....

8. What is the selling price of the wood? ....

9. List daily/monthly/yearly expenses related to your business activities?

a. Rent..................................

b. Transport..........................

c. Labour..............................

d. Security............................

e. Others...............................

10. What are the main problems you face in the course of your business activities?

a. ....

b. ....

c. ....

d. ....

11. Do you get any support from any organisation or government department? YES NO

If Yes, which ones?

a. ....

b. ....

c. ....

12. If the answer in 11 is yes, what type of support?

a. ....

b. ....

c. ....

d. ....

13. What changes would you like to be implemented to make your business and working environment better?

a. ....

b. ....

c. ....

Questionnaire to the firewood transporters

This questionnaire is for collecting information on firewood transportation business in the country. It will aid at establishing the main means of firewood transport, estimated costs and revenues and the challenges faced in the day to day firewood transportation business life. The results of this research will help in the analysis of the woodfuel sector and how it can be transformed into a market oriented profitable and sustainable sector. The information collected during this research is only for academic purposes and will be treated as confidential.

Name……………………………………………………………………………… *(Optional)*
Location details: Town/ city...
Estate...Date..
1. How long have you been in this trade?...years/months
2. What mode of transport do you operate? ....

3. Do you own it? YES NO

4. How much firewood can it transport per trip? ....

5. Which are the main pick-up and destination points of the firewood you transport?

   a. Pick-ups...

   b. Destinations...

6. How much firewood do you transport per day/month? ....

7. Do you own the firewood you transport?
…………………………………………………………………………………

8. If the answer in 7 is no, how much do you charge for the transport (per load/ stere)? .....

9. List daily/monthly/yearly expenses related to your business activities?

   a. Fuel..

   b. Maintenance...........................

   c. Labour......................................

   d. Taxes ………………………………………

   e. Others (specify)...........................

10. What are the main problems you face in the course of your business activities?

   a. ....

   b. ....

   c. ……………………………………………………………………………………

11. Do you get any support from any organisation or government department? YES NO

If yes, which ones?

a. ....

b. ....

c. ....

12. If the answer in 11 is yes, what type of support?

a. ....

b. ....

c. ....

d. ....

13. What changes would you like to be implemented to make your business and working environment better?

a. ....

b. ....

c. ....

Questionnaire to the charcoal traders

This questionnaire is for collecting information on charcoal trade in the country. . It will aid at establishing the type of charcoal sold, estimated costs and revenues and the challenges faced in the day to day charcoal selling business life. The results of this research will help in the analysis of the woodfuel sector and how it can be transformed into a market oriented profitable and sustainable sector. The information collected during this research is only for academic purposes and will be treated as confidential.

Name…………………………………………………………………………… *(Optional)*
Location details: Town/ city...
Estate...Date..

1. How long have you been in this trade?..years/months.

2. Do you have another occupation? YES NO

3. If yes, which one?

4. Do you have any employees or people who assist you? YES NO

   If yes, how many? ....

5. Who are your main customers?

   a. ....
   b. ....
   c. ....

6. From which wood species is the charcoal that you sell mostly made?

   a. ....
   b. ....
   c. ....

7. Do the customers like the charcoal? YES NO

8. If the answer in 7 above is no, which species do they prefer?

   a. ....
   b. ....
   c. ....

9. How much charcoal do you sell per day/month? ....

10. Where do you source it from? ....

11. How much do you pay for the charcoal per sack? ....

12. How much do you sell the charcoal per sack/ tin? ....

13. List daily/monthly/yearly expenses related to your business activities?

    a. Rent................................
    b. Transport..........................
    c. Security…………………………..
    d. Labour...............................
    e. Others...............................

14. What are the main problems you face in the course of your business activities?

    a. ....
    b. ....
    c. ....

15. Do you get any support from any organisation or government department? YES NO

16. If yes in 15, which ones?

    a. ....
    b. ....

17. If yes in 15, what type of support?

    a. ....
    b. ....
    c. ....

18. What changes would you like to be implemented to make your business and working environment better?

    a. ....
    b. ....
    c. ....
    .

Questionnaire to the charcoal transporters

This questionnaire is for collecting information on charcoal transportation business in the country. It will aid at establishing the main means of charcoal transport, estimated costs and revenues and the challenges faced in your day to day business life. The results of this research will help in the analysis of the woodfuel sector and how it can be transformed into a market oriented profitable and sustainable sector. The information collected during this research is only for academic purposes and will be treated as confidential.

Name…………………………………………………………………………… *(Optional)*

Location details: Town/ city..
Estate..Date...

1. How long have you been in this trade?..years/months

2. What mode of transport do you operate?

3. Do you own it? YES NO

4. How much charcoal can it transport per trip? ....

5. Which are the main pick-up and destination points of the charcoal you transport?

   a. Pick-ups...

   b. Destinations...

6. How much charcoal do you transport per day/month? ....

7. Do you own the charcoal you transport? ....

8. If the answer in 7 is no, how much do you charge for the transport (per load/ sack)? ....

9. List daily/monthly/yearly expenses related to your business activities?

   a. Fuel...

   b. Maintenance.............................

   c. Labour..

   d. Taxes ………………………………………..

   e. Others (specify)...........................

10. What are the main problems you face in the course of your business activities?

    a. ....

    b. ....

    c. ....

    d. ....

    e. ....

11. Do you get any support from any organisation or government department? | YES | | NO |

12. If yes, which ones?

    a. ....

    b. ....

    c. ....

13. If your answer in 11 is yes, what type of support?

    a. ....

    b. ....

    c. ....

    d. ....

14. What changes would you like to be implemented to make your business and working environment better?

    a. ....

    b. ....

    c. ....

    d. ....

Appendix 3: Institutions visited in Kenya and Rwanda

Institutions visited in Kenya

Institution	Location	Contacted person
Nyankoba tea factory	Kisii	Production manager
Githambo tea factory	Murarandia	Production manager
Kanyenyaini tea factory	Kangema	Production manager
Ikumbi Tea Factory	Kigumo	Production manager
Kahatia Secondary school	Muranga	Secretary
St. Charles Lwanga	Kitui	Bursar
Matinyani Sec	Kitui	Bursar
Kitui School	Kitui	Bursar
Shimo La Tewa Sch	Mombasa	Cateress
Mombasa High school	Mombasa	Cateress
Uthiru Girls High school	Nairobi	Bursar
SOS technical training Institute	Nairobi	Principal
Buruburu Girls high school	Nairobi	Cateress
Chebisas Boys	Eldoret	Bursar

Institutions visited in Rwanda

Institution	Location	Contacted person
SOS Technical High School	Kigali	Chief chef
St Andrews College	Kigali	Principal
FAWE Girls School	Kigali	Head cook
Green hills Academy	Kigali	Financial controller
University of Rwanda	Butare	Restaurant manager
Prison	Remera, Kigali	Warden

Declaration

Name Geoffrey M. Ndegwa

Matr. No.: 11065079

I, Geoffrey M. Ndegwa, declare hereby on oath that this Master Thesis in hand has been made independently and without the help of any other than acknowledged.

The thoughts taken directly or indirectly from external sources are made recognizable as such. This thesis was not presented to any other examination authority either in the same or similar form and till now it has not been published.

Cologne, Signature

I do further agree to a later publication of this Master Thesis, may it be in parts or entirely within the ITT publications or within the scope of the ITT's public relations.

Signature