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Institute of Water and Energy Sciences (Including Climate Change)

LIFE CYCLE ASSESSMENT ON ECONOMIC FEEDBACKS IN THE CHARCOAL VALUE CHAIN IN LUSAKA DISTRICT, ZAMBIA

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EXECUTIVE SUMMARY

Charcoal production and trade in much of southern Africa, Zambia included is presented as a set of activities with adverse environmental impacts largely because the socio-economic benefits of charcoal production and trade have been downplayed. Lusaka district represent about 32% of Zambia's urban population and charcoal is a primary source of energy for 85% of urban households and the industry contributes to 500 000 people employed as charcoal producers, transporters and vendors. Despite this, charcoal has remained underpriced by more than 20-50% in relation to the economic costs thus affecting the producer who then exacerbate the negative environmental impacts.

The study presents the scale and economic value of the charcoal industry in Zambia, by assessing the key players along the value chain, the mechanism for revenue generation and distribution of income. Life Cycle Assessment (LCA) was used to assess the economic feedbacks (inputs and outputs) along the charcoal value chain in Zambia. This is through structured interviews with the key actors on how much money is put in (expenditure) and what the returns (profits/losses) are at each stage of the value chain.

The study found out that the value chain was largely inefficient with revenues and profit shares skewed in favor of the transporters 120% and vendors (wholesalers 25% and retailers 33%). However, the transporter and producer also bear less of the costs as much of the costs are covered by the wholesaler moving charcoal from the producer to the retailer. Further the study found out that the higher number of actors made the value chain complex thus increased on the economic costs. There were three links of charcoal supply with different actors, such as the charcoal producers, roadside wholesalers, transporters, market wholesalers, retailers (market, household, mobile), agents, middlemen and institutions/govt departments.

Therefore, the study recommends a formalization of the charcoal value to reduce exploitation along the chain. Further recommends training in business skills along the value chain so that profits are not only concentrated in the hands of the vendors and transporters. But so that profit will be distributed along the entire value chain.

Keyword: Economic, Energy, Efficiency, Recovery

RÉSUMÉ

La production et le commerce du charbon de bois dans une grande partie de l'Afrique australe, la Zambie inclus sont présentés comme un ensemble d'activités ayant des impacts environnementaux négatifs, en grande partie parce que les avantages socio-économiques de la production et du commerce du charbon de bois ont été minimisés. Le district de Lusaka représente environ 32% de la population urbaine de la Zambie et le charbon est une source d'énergie primaire pour 85% des ménages urbains et l'industrie contribue à 500 000 personnes employées comme producteurs de charbon de bois, transporteurs et vendeurs. Malgré cela, le charbon de bois est demeuré sous-évalué de plus de 20 à 50% par rapport aux coûts économiques qui affectent le producteur qui aggravent les impacts environnementaux négatifs. L'étude présente l'ampleur et la valeur économique de l'industrie du charbon en Zambie, en évaluant les acteurs clés le long de la chaîne de valeur, le mécanisme de génération de revenus et la répartition des revenus. L'évaluation du cycle de vie (LCA) a été utilisée pour évaluer les retombées économiques (intrants et résultats) le long de la chaîne de valeur du charbon en Zambie. C'est grâce à des entretiens structurés avec les acteurs clés sur la quantité d'argent et les retombées (profits / pertes) à chaque étape de la chaîne de valeur. L'étude a découvert que la chaîne de valeur était en grande partie inefficace avec les revenus et les parts de bénéfices faussés en faveur des transporteurs 120% et les vendeurs (grossistes 25% et détaillants 33%). Cependant, le transporteur et le producteur ont également moins de coûts, la majeure partie des coûts étant couverte par le grossiste en mouvement du charbon de bois du producteur au détaillant. En outre, l'étude a révélé que le nombre plus élevé d'acteurs faisait en sorte que la chaîne de valeur augmentait ainsi sur les coûts économiques. Il y avait trois liens d'approvisionnement en charbon de bois avec différents acteurs, tels que les producteurs de charbon de bois, les grossistes en bordure de route, les transporteurs, les grossistes de marché, les détaillants (marché, ménage, mobile), les agents, les intermédiaires et les institutions / départements du gouvernement.

Par conséquent, l'étude recommande une formalisation de la valeur du charbon pour réduire l'exploitation le long de la chaîne. Recommande en outre la formation aux compétences professionnelles le long de la chaîne de valeur afin que les bénéfices ne soient pas seulement concentrés entre les vendeurs et les transporteurs. Mais pour que le bénéfice soit réparti sur l'ensemble de la chaîne de valeur.

Mots-clés: Energie, économique, efficacité, récupération

DECLARATION

I, **LYAMBAI Martin,** hereby declare that this thesis represents my personal work, realized to the best of my knowledge and that no similar work has been submitted to this or any other university for a degree, diploma or other academic qualification. I also declare that all information, material and results from other works presented here have been fully cited and referenced in accordance with the academic rules and ethics.

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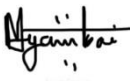	25/09/2017	TLEMCEN
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LIST OF ABBREVIATIONS

PAUWES	Pan African University Institute of Water and Energy Sciences (Incl. Climate Change)
LCA	Life Cycle Analysis
CIFOR	Centre for International Forestry Research
USD	United State Dollar
GRZ	Government of the Republic of Zambia
CHAPOSA	Charcoal Potential for Southern Africa
GDP	Gross Domestic Product
IAPRI	Indaba Agriculture Policy Research Institute
REN21	Renewable Energy Agency
KES	Kenyan Shilling
MK	Malawian Kwacha
ZMK	Zambian Kwacha
KMoE	Kenya Ministry of Environment
CVC	Charcoal Value Chain
NAFA	National Forest Authority
CPAs	Charcoal Producer Associations
LCC	Life Cycle Costing
FD	Forestry Department
BCP	BioCarbon Partners

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Chapter One: INTRODUCTION

Charcoal and firewood are collectively referred to as fuelwood, a major source of cooking and heating energy for most urban households in sub-Saharan Africa (Aridam, 2014). However, according to the Government of the Republic of Zambia, charcoal production is a major driver of deforestation and environmental degradation. Zambia's annual rate of deforestation is 0.33%, a quarter of which of is reportedly due to charcoal production (Kaplinsky and Morris, 2001). Charcoal production is driven by urban demand, with a typical urban household consuming an estimated 1.3 tonnes of charcoal per year. To produce this amount of charcoal, close to 8 tonnes of wood is required and the effects on forests have been noted as being largely negative (Aridam, 2014).

Charcoal consumption in many countries tends to occur on a small scale, and involves numerous end-users who make frequent purchases in small quantities, without much concern for the economic and environmental impacts of their consumption (Kammen and Lew, 2005).

Generally charcoal production takes place on a small scale and, charcoal producers are likely to be poor, with low economic capacity and few productive assets. They often turn to charcoal production because they lack the skills or opportunities for diversifying into other livelihood activities. On the other hand, charcoal consumers are drawn from all points of the income distribution and are primarily, though not exclusively, urban.

Drawing the literature review from the 2005 National Charcoal Survey study from Kenya has 200,000 charcoal producers accounting for 40 per cent of half a million people directly involved in the charcoal trade, who support 2.5 million dependents. About 1.6 million tonnes of charcoal are produced annually which translates to USD 400 million annually at current market prices. By 2013, the number of charcoal producers had gone up 25 per cent and stood at 253,808 producing 2.5 million tonnes indicating a significant increase in the 5-year period (Arindam, 2014).

Similarly, a study commissioned by Kenya Forest Service estimates an increase in the value of charcoal trade by 400 per cent which stood at USD 1.6 billion in 2013. In 2013, an average producer dealing with 30 bags of charcoal earned USD 95 per month as compared to USD 2,150 for transporters transporting 900 bags/month and USD 547 for wholesalers dealing with 200 bags/month and USD 143 for retailers based on 16 bags/month. The charcoal producer therefore

benefits least in the value chain due to lack of market structures, ineffective implementation of laws and high levels of corruption (Arindam, 2014). This also shows lack of literature on economics of charcoal in Zambia thus drawing literature from other countries with a good example of Kenya. Therefore, this study will establish a benchmark of literature for Zambia with specific reference to the structure and function of the charcoal value chain and the economics of the value chain.

In an ideal situation most of the woody biomass is obtained from trees owned by producer's farms (44%), private lands (38%), government land (13%) and communal land (5%) (Arindam, 2014). However, on average, more trees were removed from government forests in those districts that had protected forests (Arindam, 2014). The average cost of a mature, whole tree to a charcoal producer is USD 6.50, frequently obtained for 'free' in return for labour, in particular when forest lands were cleared for agriculture. Over 90 per cent of charcoal producers used inefficient, traditional earth-mound kilns with recovery rates of as low as 10 per cent (i.e. 1 kg of charcoal for every 10 kg of wood burned) (Smith, et al. 2015, Arindam, 2014).

In most settings, knowledge of the characteristics and role of other actors in the value chain – including middlemen, transporters, traders and retailers is limited and largely based on anecdotal evidence. The charcoal value chain provides valuable information about markets it provides, key insights about inter-firm cooperation and competition, governance, barriers to entry and geographic coverage (Kaplinsky and Morris 2001, Kaplinsky 2000). Therefore, the characteristics of charcoal value chains remain largely ignored in the literature. Understanding charcoal production, trade and consumption has important implications for sustainable development in the charcoal sector. One common way to determine the relative impact occurring over the whole value chain of charcoal is to deploy Life Cycle Assessment (LCA) (Girard, 2002). With this method the economic inputs, outputs, and the potential impacts of system are compiled and evaluated throughout the product's life span. Therefore, the focus of this research is using LCA to assess the economics feedbacks on the structure and function of the charcoal value chain in Zambia. Further provide detailed information on the profits and margins for participants on the supply side of the charcoal market, economic returns of human and social capital, asset ownership, and location of activity.

1.1 Problem Statement

Charcoal is a key bio-energy resource in Zambia, providing domestic energy for 70% of urban households. The charcoal industry also creates jobs for wood producers, charcoal producers, transporters and vendors. Despite this the charcoal industry has remained informal and profits have remained in the hands of a few actors. This has made it hard for the government to collect revenue and make the industry sustainable. From the supply side charcoal was supposed be a million-dollar enterprise but charcoal actors have instead remained poor. It is in this line that this research will perform an economic analysis of the charcoal value chain in Lusaka Zambia and provide information on economic feedback such as the flow of breakdown of costs, revenues/income/profit, prices, and quantities of the goods handled by the different actors at different stages of the value chain of charcoal. A life cycle assessment is employed to assess which stage of the product value chain has high economic costs and how it can be optimized.

1.2. Key Research Questions

1. Who are the actors along the charcoal value chain in Lusaka, Zambia?
2. What mechanism determines costs/revenues in a given setting of the charcoal value chain?
3. How is the distribution of income and expenditure within and among the groups along the charcoal value chain?

1.3 Research objective

The objective of this research is to provide information on the scale and economic value of the charcoal industry from the dominant charcoal producing regions within the proximity of Lusaka, Zambia and provide a sound basis for policy development that reduces the economic inefficiency of the charcoal industry. The specific objectives of the study are as follows:

- Identify the key actors in the value chain of charcoal in Lusaka, Zambia.
- Identify the mechanisms which determine costs/revenues in a given setting of the charcoal value chain.
- Determine distribution of income and expenditure within and among the groups along the charcoal value chain.

1.4. Research Hypotheses

The main hypothesis for this study is that:

H_0 = Costs and revenues are influenced by the actors in the charcoal value chain stages.

1.5. Practical Relevance

This research presents the economics of the charcoal value chain using a life cycle assessment method. In Lusaka alone, charcoal value chain employs about 500 000 actors from production to trade, but the challenge is that profits have only remained in the hands of a few actors. Therefore, this research is significant by assessing the economics efficiency along the charcoal value chain so as to break the information barriers relating to profit, margins, and finally the costs, revenues etc. at each value chain stage. While as in most settings, knowledge of the characteristics and role of other actors in the value chain – including middlemen, transporters, traders and retailers – is limited and largely based on anecdotal evidence. This research provides better information about the charcoal value chain; facilitate identifying opportunities for the more efficient organization of charcoal markets, producer cooperatives, and other institutions that enhance returns to value chain participants.

1.6. Brief Methodology

The study employed a life cycle assessment approach in assessing the economic feedbacks of the charcoal value chain of Lusaka District. The scope/goal of the LCA was to assess the economic efficiency of the value chain stage. The economic feedbacks were the inputs (capital and expenditure) and output (revenue, profits/losses) at each value chain stage. Focus group discussions were conducted for different actors along the value chain stages from the producers, to the traders. The study focused on charcoal coming from Chongwe district of the proximity of Lusaka markets. A stakeholder mapping was done to structure the charcoal value chain and actors.

Chapter Two: LITERATURE REVIEW

This chapter reviews the different literature about charcoal value chain narrowing to the energy sector, socio-economic development and poverty eradication. These include; the economics of charcoal with lessons from Southern African region, charcoal business and poverty alleviation, further a brief history of charcoal in Zambia, analysis of the charcoal value chain and market structure of the charcoal industry. Lastly, LCA as a supporting policy tool is studied from the different literature.

2.1. Overview of the charcoal sector

2.1.1. Energy, socio-economic development and poverty eradication

Charcoal is a prime source of energy in most African country, as well as a driving force of their economies with estimated annual growth rates of around 3.7 percent (Kammen and Lew, 2005). Charcoal is the solid residue derived from controlled combustion of a wide range of materials under conditions of limited supply of oxygen (Agbugba, 2013). Over the years, there has been a growth in the demand of wood energy in Zambia exacerbated by critical energy shortages resulting from droughts impacting heavily on electricity generation. Ultimately this is forcing the urban population to rely on charcoal as an alternative source of energy (GRZ, 2010). Surprisingly enough, policy makers pay little attention to the ways in which charcoal is produced and sold (Kammen and Lew, 2005). It is also clear today that the charcoal trade has continued to grow at a very fast rate thus increase in the number of key players along the value chain, especially women both in rural and urban areas, is a testament enough that the trade remains one of the most profitable ventures sustaining both rural and urban livelihoods. It is also important to note that though this trade has continued to play a salient role in the country's social-economic development, the charcoal industry is yet to be formally identified and utilized as potentially one of the biggest sectors that could be of huge significance to Zambia's revenue base.

For the city of Lusaka which holds the biggest market for charcoal and usually local traders are finding it profitable to sell charcoal in the capital city. For example a 50-kilogramme bag of charcoal fetching USD $2.5 or USD $3.5 in Nyimba (producing region) is sold at USD $8.0 and USD $15.0 in Lusaka. This trade has grown exponentially because people are making a living from it (CHAPOSA, 2003). Despite this, there has been little information documented about the

actual trade of charcoal and who is profiting from this industry because they whole industry has remained informal.

Charcoal production and marketing requires minimal financial and human resources as wood is mostly obtained for free from the woodlands. Therefore, the charcoal industry is a business of choice for the rural people as it contributes to their household income and provides food security, employment and similar poverty-related risks. Similarly, charcoal is for sale in almost all parts of Zambia, Malawi, Mozambique and Tanzania. At the national level, charcoal production contributes significantly to the respective GDPs of Zambia (3.7%), Malawi (3%) and Tanzania (2.3%) (GRZ, 2010). Charcoal production also contributes significantly to household incomes. In Zambia, surveys in Central, Copperbelt and Luapula provinces revealed trade in charcoal to be a major contributor to livelihood.

The charcoal trade offers income generation for small-scale retail businesses run mostly by women, who retail charcoal in urban areas and along road servitudes. For example in Mozambique, a study has shown that approximately USD 200 million per annum of charcoal is sold in urban areas, primarily for cooking (GRZ, 2010).An estimated 92 800 people in Malawi depend on charcoal, including 46 500 producers, 12 500 bicycle transporters, 300 'other' transporters and 33 500 traders (GRZ, 2010). This shows that the number of people engaged in the charcoal business is remarkable compared to other sectors. By example, the estimated number of charcoal producers in Kenya (ca. 200,000) is as high as the number of people working in the educational sector. Approximately 500,000 people engage in downstream-processing and trade (Kammen and Lew, 2005). Similar figures are reported by other countries (e.g. Malawi, Zambia and Niger). Such figures vividly underscore that promoting sustainable charcoal industries provides a first-rate means of poverty alleviation. Therefore, there is need to understand the value-chain of charcoal and to bring out the charcoal business from the shady realm of the informal sector and to harness its potential for sustainable development. But this should not only be limited to a comprehensive analysis of existing constraints, from ecological parameters but also to property/user rights to market access.

Investigating the sequence of charcoal production and marketing in all its facets including research and development, the regulatory framework, raw material supplies is a key to any systematic improvement. The Life Cycle Approach (LCA) provides a convenient means to this end, adding, as it were, knowledge, innovative insights and technology to each link. It also enables policy

makers to create favorable framework conditions which promote competitive enterprises, sustainable jobs and income for local people. Furthermore, it allows impact-oriented monitoring of initiated policy actions (Kammen and Lew, 2005).

2.2. Background of charcoal in Zambia

Charcoal producers in Zambia first came from Angola and introduced charcoal as a household energy source in the Copperbelt region of Zambia around 1947. In the year of 1962 the number households using charcoal had increased with the majority been Africans. This was strengthened by the government through the Forest Department by encouraging the use of charcoal instead of firewood in Lusaka town in central Zambia during the early 1960s (CHAPOSA, 2003). The consumption of charcoal in Lusaka city has steadily increased since then. Currently charcoal used in the town of Lusaka comes from distances as far as 300 – 400 km from the city. Production of charcoal in Chongwe district for the Lusaka urban market started in the early 1970s and has continued to today. According to CHAPOSA report (2003) charcoal transportation into Lusaka city as of 1992, was standing at 36% of the charcoal used in Lusaka came from Chongwe district but this had declined to 25% in 2000 but due to lack of further research there is higher probability of an increase in these figures.

Apparently land was only allocated to the producers for farming purposes, but many started charcoal production as a form of land clearing, and because of problems in the marketing of agricultural crops. This has led to charcoal producers to request for new or additional land from the headman and/or Chief to continue with charcoal production once trees on their current land are depleted and the majority were going to continue with charcoal production for the next 1-10 years (CHAPOSA, 2003).

Most producers would wait for traders from town to come and buy the charcoal but some travel to town or roadside to find buyers. The sale arrangements ranged from cash only to credit, cash and barter (exchange with clothes, foodstuffs, fertilizer etc.). The credit option was usually offered to buyers with a long business relationship with the producer. Some measures for ensuring that new traders buying charcoal on credit pay includes the trader leaving behind empty bags, producer accompanying trader to town to collect the money or know the place where the trader lives and sells charcoal, withholding a national registration card or a good recommendation from other producers. Even so, this risked the producers' and such traders are usually reported to other producers in the area and to the village headman so that they can be blacklisted. Although some

producers would be reluctant to report such defaulters to police because they feared getting in more serious trouble with government authorities, as they do not have licenses from the Forest Department (CHAPOSA, 2003).

2.3. Energy poverty in Zambia

According to Falcáo (2008) fuelwood and charcoal accounts for about 91% of Africa's energy needs for cooking and heating this constitutes of people in rural areas and peri-urban areas. This has led to the question of sustainability in many African countries thus need for other energy opportunities offered by other resources, including solar and wind energy. While the demand for woodfuel is rising due to the relatively high cost of electricity and petroleum-based fuels (e.g. paraffin) as well as the rapid human population growth, particularly in urban areas in Mozambique, Malawi, Tanzania and Zambia. Demand for wood fuel in the urban areas of developing countries is usually higher than in rural areas. One of the main reasons for this is inability of the households to have access to other fuels such as gas and fossil fuels in the energy mix of the urban areas (Falcáo, 2008).

Similarly, IAPRI (2016a) supports above claims, charcoal and firewood are a major household fuel for cooking and heating throughout the Miombo eco-region of which Zambia is part of. This fuelwood accounts for the highest percentage of the energy budgets among households in the Miombo eco-region countries. For example, in Zambia it accounts for 76% of the household energy budgets, 91% in Tanzania, and 85% in Mozambique. This fuelwood has been found to be important in Zambia due to the rising incomes among households that use electricity as an energy source. Even though there is still dependence on charcoal, with households using both charcoal and electricity, a reflection of fuel stacking behaviour among urban households.

Currently, there has been inadequate and erratic supply of hydro-electric power in Zambia making charcoal the main energy source among households. The resulting from low water levels in the major lake of Kariba dam has left the Government of the Republic of Zambia (GRZ) grappling with the problem of load shedding (IAPRI, 2016a). This has resulted in a kind of energy ladder of energy sources in the urban areas: from fuelwood at the bottom, through charcoal, kerosene and gas, to electricity at the top (Falcáo, 2008). As household income increases, people generally climb this ladder. Therefore, in rural areas charcoal is hardly used because of availability of free wood,

and while popular scenario is in urban areas because of higher income and other factors such as its lightness and non-smoking nature (Falcáo, 2008).

Despite this Zambia's electrification rate is standing at 22% (45% urban and 3% rural), this complements the tradition biomass which is the main source of energy and accounting for more than 70% of energy consumption within the 57% of urban populations depending on traditional biomass and while the 97% is for the rural areas (REN21, 2013). Biomass in the form of firewood is the mostly used mainly for cooking in rural areas and charcoal for urban usage. This has led to the development of the charcoal industry which employs about 500,000 individuals across the country along its supply chain, from producers, distributers to marketers (REN21, 2013).

2.4. Economics of charcoal

The current knowledge of the study shows that Zambian households in most urban areas where charcoal is used demand is driven by poverty and limited availability of affordable and cleaner energy alternatives. For example, in the city of Lusaka, about 85 percent of urban households use charcoal compared to 15 percent in rural areas, according to the Centre for International Forestry Research (CIFOR). Therefore, this study provides a baseline for assessing the economic efficiency along the charcoal value chain. This is also facilitated with country case studies in charcoal prominent regions such as Kenya, Uganda and Malawi.

i. Uganda

According to Khundi *et al.,* (2011) theorized for Uganda which faces a common slate of development challenges, including widespread poverty, low rates of labor absorption and stagnant agricultural growth, charcoal trade represents one of the largest domestic industries, although in many respects charcoal production is broadly representative of the environment-development challenge and the pressures facing mixed-use forests in developing regions, the charcoal sector has remained largely neglected by researchers and policymakers.

Nevertheless, this study and many other studies tend to focus on the environmental characteristics of charcoal production, and give little attention on the income-generating role of charcoal in rural areas. There is need for understanding how the charcoal industry operates rather than focusing on the environmental challenges posed. Therefore, the idea is to promote sustainable charcoal trade which will improve on the financial efficiency of the whole value chain.

Similarly, the author also argued that charcoal production is not the absolute source of income for the poorest because the charcoal share income increases with income from other sources. Even though the income for charcoal producers in Uganda can be as high as $122/year, this cannot be ignored completely at household level income gap. Therefore, in contrast to this paper, charcoal production is not contributing much to the national economy as much of the income is for household level and lack of formal marketing policies has made the sector to remain informal (Khundi *et al*, 2011).

ii. Malawi

According to Kamewa *et al* (2007) in a study to determine the scale, volume and economic value of the charcoal industry in Malawi, charcoal was found to be the most substantial pro-poor forest industry involving thousands of rural producers, bicycle transporters, and roadside or urban vendors. However, despite this importance, the industry's value is not well understood. While Kambewa *et al* (2007) supports this claim, that the charcoal industry is one of the largest in Malawi; if the product was exported, the annual foreign exchange income to the country would fall somewhere between that of tea (Malawi's 2nd-largest export after tobacco) and sugar (3rd-largest in 2006). According to this study, it was relevant determine the scale, volume and economic value of the charcoal industry in Malawi. This leads to the schools of thoughts that this research is trying to address which are the charcoal value chain structure with its actors, the cost structure and the profits and margins along the whole charcoal value chain. Similarly other factors come into play, for example in 2007 the Department of Forestry collaborated with the Malawi Defence Force to apprehend producers: prices went up and the traders profited more handsomely while the product supply was not noticeably constrained (Kambewa *et al* 2007) Even though there is little justification as to what the level charcoal contributes to the national economy through the value chain, the situation presented shows that were urban pro-poor households depend on charcoal, monthly expenditure on charcoal are more than that of electricity. However, there is little difference in charcoal expenditure between residential types. This simply shows that charcoal plays a major role in the economies of the suppliers in many urban areas. The author translates that the industry has an estimated value of about MK5.78 billion (roughly US $41.3 million or €30.4 million) for the four largest urban areas of Malawi which consume about 6.08 million standard bags per year.

Further the charcoal industry provides significant employment in the various activities outlined above: it is estimated that 92,800 people owe their livelihoods to charcoal. This figure includes 46,500 producers, 12,500 bicycle transporters, 300 other transporters and 33,500 traders.

iii. Kenya

According to the Kenya Ministry of Energy, a total annual charcoal consumption in the country is estimated at 1.6 million tonnes, this generates an estimated annual market value of over KES32 billion (US$427m), almost equal to the KES35 billion (US$467m) from the tea industry. This translates to about a quarter of household income in Kenya spent on wood fuel, regarded as the poor person's energy source, since the alternative energy sources are beyond the means of most Kenyans. While according to this report the number of people engaged in the charcoal business is remarkable. An estimated figure of 200,000 people are directly employed in production and an estimated 500,000 others involved in transportation and vending of charcoal, who were in turn believed to be supporting 2.5 million dependants (KMoE, 2013).

In most case the industry is valued according to the average incomes generated from charcoal as KES 4,496 for producers, KES 11,298 for transporters and KES 7,503 for vendors. Therefore, the industry also contributes to government revenues through licenses and business permits. For instance, a fee of 20 shillings and 1800 per bag and per lorry load of charcoal respectively are being charged by the Kitui county council. Similarly, this shows potential government revenue standing at over KES 5.1 billion if sufficient efforts are invested in effective collection. The study indicates that if excess were charged on all the estimated 60 million bags of charcoal traded within the country, this would generate an additional KES. 1.8 billion to KES. 3.0 billion Annually (KMoE, 2013).

Along the value chain, the profits are disproportionately skewed in favor of the vendors and transporters, with the producers and the consumers getting the least margins. Revenue accruals and distribution vary significantly along the value chain with the vendor (wholesalers and retailers) controlling 41% of the market share, transporters 37% and producers (wood and charcoal) only 22%. A greater portion of the profits (63%) in the charcoal value chain goes to the vendors with the wood and charcoal producers enjoying only 24% of the total profit. Therefore, along the value chain, producers and consumers are the least beneficiaries in the chain due to lack of structures and ineffective implementation of the laws and policies, high levels of corruption, bribery.

2.5. Charcoal business and poverty alleviation

According to Ainembabazi *et al.* 2013, charcoal production provides a path out of poverty for rural households. Charcoal producers are better off than non-charcoal producers in terms of income. Most rural people are faced with a limited set of livelihood strategies and low stocks of productive assets, thus rely on natural resource extraction for sustenance, cash income and insurance against unforeseen events. Charcoal becomes attractive to rural house-holds because of availability of input resources and typically requires only unskilled labor and a modest set of purchased inputs to collect or process.

Despite the low economic value of charcoal resulting from market activities, it sometimes provides natural insurance against idiosyncratic shocks by acting as a safety net. Indeed, rural households dependent on charcoal are often found to be poor not just in terms of income, but also in terms of assets such as land, livestock and financial networks that might facilitate income growth. While Michel et al. 2006, states that the economics of household wood fuel demand in developing countries is that on the energy ladder, a progression to modern fuels is expected as income rises, implying that fuelwood is an inferior good. One general result emerging from this work was that income consistently turned out to be an important influence on the level of wood fuel use. Simply charcoal consumption decreases with increase in income, while urbanization increases charcoal consumption (Ainembabazi *et al*. 2013).

Further, external factors such as remoteness, poor infrastructure and limited market access also relegate the economics of charcoal trade. Additionally, because markets for charcoal is often thin and unpredictable, thereby undermining the investments in productive assets that generate rural development (Michel et al. 2006). Ainembabazi *et al.* 2013 concludes that income contributions from charcoal production are somewhat small at the low end of the income distribution, but grow larger as one moves toward the upper end of the income distribution.

Therefore, economic estimates of own-price elasticity of demand for charcoal in urban areas are inelastic, despite the greater availability of alternative fuels in cities. Charcoal production, selling, or trading represents a large part of the income for most people involved. For some it can be their main source for example the number of people involved in wood fuel selling in Zambia increased when crop incomes fell. Simply charcoal trade represents a safety net for majority of people (Ainembabazi et al. 2013).

2.6. Charcoal value chain analysis

2.6.1. Stakeholders along the Charcoal Value Chain

The charcoal value chain comprises of a number of stakeholders from where the tree grows to where charcoal is consumed. These different stakeholders participate in the value chain right from wood production, carbonization of the wood, packaging and transportation of the charcoal, retailing and distribution, and consumption (KMoE, 2013). As charcoal is gaining much recognition in major urban areas of sub-Saharan Africa, there are new and different actors along the value chain. For example, in Uganda's charcoal value chain according to Shively *et al.* (2010) identified five major value chain participants namely the producer, agent, transporter, trader, and retailer. Similarly, Kakuru, (2012), identified tree farmer/land owner and forest authorities at the local level in the wood production section, charcoal producers in harvesting and charcoal production, transporters and Traders (retail and wholesale) in the transport, distribution, retail and wholesale trade section and households and institutions in the consumption section (KMoE, 2013). Another scenario is in Malawi as reported by Kambewa, *et al* (2007) in a study of charcoal consumption, trade and production revealed several scenarios dependent on the route followed by charcoal from the producer to consumer. The first scenario was from producer to consumer, whereby a small-scale producer takes the charcoal directly to the consumer. The second scenario was from producer to buyer to consumer, where a buyer purchases the charcoal from the producer and takes it directly to consumers' homes. The third scenario was from producer to primary buyer to secondary buyer to consumer which was a more complex option in which there is both wholesale and retail markets. According to the authors, the last scenario was most common in Blantyre and Lilongwe where there were well-established wholesale markets, especially in high-density, shanty and unplanned areas (KMoE, 2013).

While for small countries like Rwanda with higher energy poverty and large population density, the charcoal value Chain is identified by five key actors in the wood production component of the charcoal value chain (CVC): wood producers, local authorities, National Forest Authority (NAFA) District Officer, financial services providers and research institutions (KMoE, 2013). Within the carbonization section of the CVC, the analysis found main stakeholders are charcoal producers, local authorities, middle men, financial services providers, communication enterprises and research institutions (KMoE, 2013). Detailed analysis of the CVC identified transporters, community police and middlemen as the key stakeholders in the transportation section. The

analysis also identified charcoal retailers, local authorities and landlords as main stakeholders in the retail and distribution section.

A clear structure and outline of different stakeholder based on the above and other reviews is presented in the chat below.

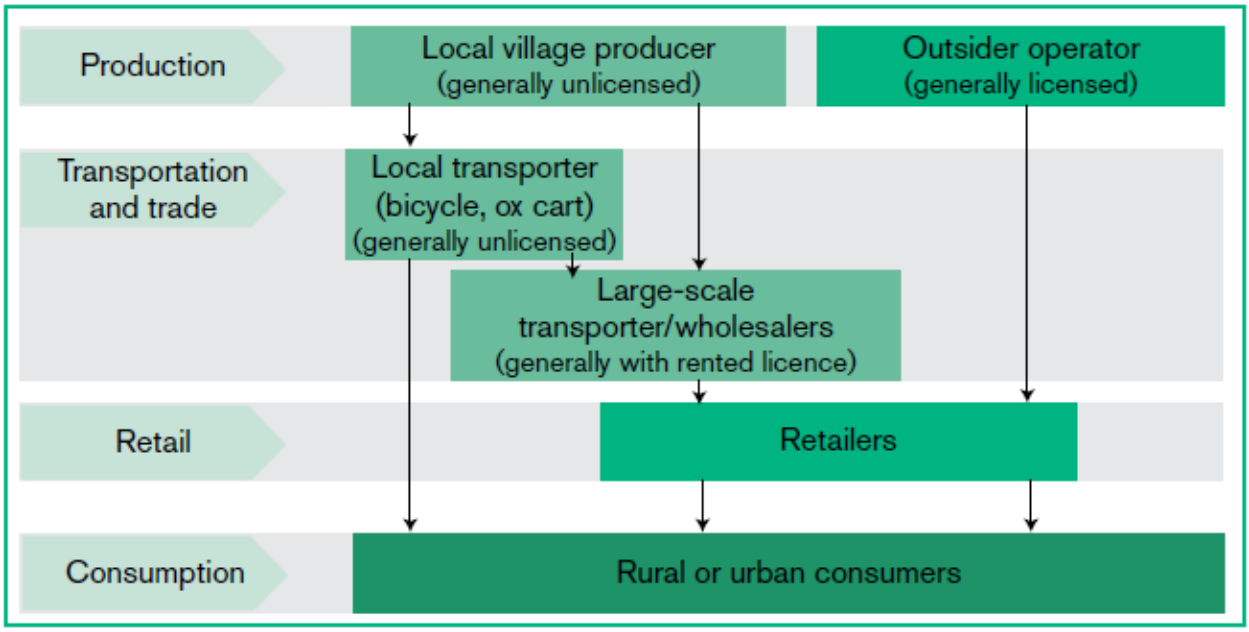


Figure 2.1: Structure and outline of different stakeholder

Source: Baumert et al, 2016

a. Charcoal production

Charcoal can be produced from wood and other biomass types in a process called carbonization. Carbonization is the method of burning wood or other biomass in the absence of air after which it breaks down into liquids, gases and charcoal. This wood is harvested from woodlands through clear felling, selective cutting or from purposely grown plantations. Preference and suitability of trees used varies with size, availability and accessibility of the tree species. The harvested wood is converted into charcoal in a batch-type process. When the process has ended, the kilns are opened or dug up and the charcoal is removed. The resulting charcoal resembles smaller, lighter pieces of blackened wood. These will have higher energy content by weight than fuelwood (Aridam, 2014). Charcoal producers are the main stakeholders within the carbonization sector of the charcoal value chain. As a result of the new charcoal regulations, most charcoal producers will need to organize themselves into groups or associations. For example, Kenya passed a law of charcoal producer group association (CPAs) with current figures estimated 150 CPAs registered countrywide.

Membership within the CPAs ranged from 30 to about 1000 members (KMoE, 2013). Cost associated with technology but the lower the costs of production means the conversion efficiency is very low.

According to Kambewa et al (2007) producer costs include cost of wood amounting paid to the ranch owners by the charcoal producer groups, the conservation fee payable to associations and labour. But in most situations the wood used to burn charcoal is either obtained freely from on-farm sources, or illegally from government sources. Overall charcoal production cost amount to an average of KES 100/bag. With the sales price of KES 250-350, the producers net income amounts to KES 150-350/bag (KMoE, 2013).

While for charcoal which at times is sold by the producers directly to consumers, usually along the highways and by the roadside in bags can attract a profit of 300%-400%. Here the total profit goes to the producer. Charcoal at this point is fairly cheap to the consumer as the cost of transportation is born by the consumer. However, where the producer sells to a retailer who then sells to the consumer by the roadside the profit drops to 250%-300% for the producer with the retailer 33%-112%, the producer market profit share drops from 100% to 48% with the retailer enjoying 52% of the market profit share. These sales are mostly illegal with the traders not acquiring the required documents. A part from the illegal status the production levels are difficult to monitor as individuals produce and sell independently and this can lead to high levels of degradation (KMoE, 2013).

b. Transportation

Like is the case for many other commodities, there are many different ways in which charcoal is being transported. Basically anything that moves can play a role: tractors, lorries, trucks, trains, bicycles, pushing carts, donkeys, head loads et cetera. The cost associated with the use of a certain type of transport also plays a major role in the possibility to forego detection of illegal charcoal also comes into play. For example, in Dar-es Salaam city border, charcoal transported by lorry is taxed, but charcoal transported by bicycle is not, as in the latter case it is assumed to be for private use. In general, the charcoal producer brings the charcoal in bags to the roadside from where it is transported by truck, other motorized vehicles or by bike to the urban centers (Arindam, 2014).

Charcoal transporters have received far less focused attention within the literature, there is a perception that they are an elite urban-based minority who earn higher revenues than other chain actors as they typically monopolies motorized transportation links and are politically connected.

Major cities in Africa are assumed as the most important charcoal consumption zones across Africa and a source of income for an unknown, but assumedly large number of people involved in the charcoal trade but little is known about the charcoal actors especially the transporters. This is major gap in the literature.

For example, in Kenya, charcoal transporters mostly buy charcoal from the producers at price ranging from KES 700-750 (US$ 7-7.50) per bag and sell to wholesalers or brokers at KES 1000/bag in Kajiado, KES 1100/bag in Kitengela and KES 1300 /per bag in Nairobi (US$ 10 - 10.1) respectively. The average costs per bag from the producer to wholesaler ranges from KES 972 to Nairobi, KES 930, Kitengela and KES 862/bag for Kajiado. This attracts a profit of KES 327, KES 135 and KES 170 per bag (US$ 1.5 average) respectively. However, during the ban, without permit, costs increase due to increased bribes to authorities mainly the police and the county council leading to a fall in profit per bag to KES 127, KES 107 and KES 113 per bag for Nairobi, Kajiado and Kitengela respectively. On average transporters handle about 3000 bags per months making between 2-3 trips to the market each 250 bags per trip (KMoE, 2013).

For a long time, charcoal trade in sub-Saharan Africa has been unregulated, and even with legal restrictions. For example, in Senegal Local charcoal traders were found to have retains of 3% of the charcoal market's net profits whereas 70% went to merchants. This is not different from a country Zambia even though less information has been documented with regards to profit returns along the charcoal value chain.

Therefore, this calls for improvement of the charcoal value chains. Although legality of the charcoal sector can increase corruption, exploitation and can cause voicelessness and powerlessness, particularly among poor and female value chain actors. Charcoal transporters play a very important role in the value chain, even though these actors are deemed to be the ones benefiting less has been documented.

Harriet *et al* in her study found that charcoal transporters benefit depends on the weekly number of trips multiplied by the number of bags per trip and the net per bag profit. However, charcoal transport is an easily targeted activity for law enforcers and penalties can be costly. The illegality and associated risks increase transporters' vulnerability to reduced income, which can subsequently have detrimental impacts on household food security, financial security, and access to education and healthcare.

But, targeting just one actor in the value chain, rather than the cause of uncontrolled charcoal production, has limited the financial benefits of the entire value chain. This will lead to a reduction in charcoal transporting activity.

c. Trade

Charcoal supply takes largely place in the informal sector and corruption is rampant and systemic in many cases, leaving many charcoal producers vulnerable to unscrupulous trading practices and economic exploitation. Mostly, charcoal traders are often seen as the ones benefiting most in the charcoal supply chain. A common observation is that there is no equitable revenue sharing along the entire value chain. The majority of charcoal is sold to large- or small-scale transporters. Some large-scale transporters are also wholesalers. These wholesalers then pass the charcoal on to smaller-scale retailers and consumers (Aridam, 2014). The retailing of charcoal offers trade opportunities for many people, in particular women.

As for the wholesalers they buy charcoal from transporters and sell to retailers at KES 1500, 1200 and 1500 (US$ 12-15) per bag in Nairobi, Kajiado and Kitengela attracting a profit of KES200 (US$2) per bag (KMoE, 2013). While the retailers on the other hand sell to consumers (Households, institutions and commercial business at varied prices ranging from KES 1300-2800 (US$13-20)/ bag depending on the town and units of sale.

Similarly, roadside retailing is a common practice with the retailers buying charcoal directly from the producers and selling to the households, mainly passengers and vehicle owners along the road. The purchase price of charcoal from producers is at KES 700-750 (US$ 7-7.50) per bag. With a total average cost of KES 125 (US$ 1.25) per bag being cost of packaging bag, license from county council, transport, and bribe to police, the overall cost per bag increases to KES 875 (US$8.75). The sale price to households' ranges from KES 1000/bag to KES 2000/bag (US$10-20) when sales are done in 2Kg tins. This amounts to a total profit 14-129% or KES 10000-90000 (US$ 100-900) per month assuming a daily sale of 20 bags.

d. Consumption

For many urban poor, charcoal provides a reliable, convenient and accessible source of energy for cooking at a stable cost. The consumption levels of charcoal do not always differ much between poorer and richer end users; in terms of disposable income poorer households spent a much higher proportion than richer households (GRZ, 2010). In general, end users are satisfied with the use of

charcoal. Compared to the use of fuelwood, indoor levels of toxic air pollutants during use are much reduced. However, when charcoal is used for heating purposes, special care is needed to avoid exposure to dangerous carbon-monoxide emissions (Kammen and Lew, 2005).

2.7. Comparative Analysis of Regional Charcoal Production Systems and Value Chains

A literature review was conducted so as to make a comparison of charcoal production systems and charcoal value chains for Rwanda, Malawi and Uganda. Rwanda is reported to be one of the few countries with increasing forest cover, growing about 7% from 2000 to 2005 primarily due to large numbers of forest plantations. The country's charcoal production system is characterized by high timber and wood-fuel prices due to massive prior deforestation. Most of the charcoal is derived from trees planted on government, private or community land. Charcoal is no longer being produced from natural forests and the remaining rainforests are well conserved. There exists secure land tenure and improved market control and negotiation power of farmer's/ charcoal producers. Due to the rising income, there is improved social standing of farmers in rural society (NL Agency, 2011).

In Uganda, charcoal is produced mainly from woodlands which constitute roughly 3,975,000 hectares or 81 percent of Uganda's total forested area. Charcoal production is concentrated in central Uganda and parts of western and northern Uganda, with the main species utilized for production being; *Combretum; Terminalia; Albizia; Acacia; Allophylus* and *Grewia spp.* These woodlands are characterised by low rainfall and charcoal production is undertaken as a main activity by the locals or at times as a complement to land clearing which produces large volumes of raw material suitable for conversion to charcoal (Shively, *et al.*, 2010). Most of the charcoal produced in these areas is transported to Kampala city. There is lack of control at all levels in the value chain due to the weak capacities of the forest authorities (Kakuru, 2012).

In Malawi, 60% of the charcoal consumed in the major urban areas including Blantyre City, Lilongwe City, Mzuzu City and the Municipality of Zomba is mainly produced from Forest Reserves and National Parks. 40% comes from customary land and 2% of charcoal comes in from Mozambique. Also, charcoal making is altering the species composition of forests and production is done using traditional earth kilns which is wasteful and inefficient (Kambewa, *et al* 2007).

In all the three countries, the industry provides substantial employment for those involved in charcoal production, transportation and trade. In Rwanda, surveys in 2010 indicate the sector employs more than 300, 000 people in wood production, and 8,000 people in charcoal production,

with a further 200-300 people involved in its transportation (Blodgett, 2011). In Uganda, around 200,000 permanently earn money from charcoal ESD (2007). In Malawi, a study by Kambewa, *et al* (2007) estimated that 92,800 people owed their livelihoods to charcoal. This included 46,500 producers, 12,500 bicycle transporters, 300 other transporters and 33,500 traders.

In terms of revenue generated, there are significant variations in the three countries. The charcoal industry revenue accounts for about 0.5% of Malawi's GDP. The approximate value of the industry in the four largest urban areas of Malawi is roughly US $41.3 million, a figure that is slightly less than the value of Malawi's tea industry (Kambewa, *et al* 2007). In Rwanda, the industry contributes to between 1.1% and 5% of its GDP (Blodgett, 2011). Closer to Kenya, the industry's contribution to Uganda's GDP stood at Ushs 70 billion (Approximately USD 36,175,711-1 USD=1935) (Knöpfle, 2004).

Benefits are almost evenly distributed among stakeholders in the charcoal value chain in Malawi, with values accruing to producers ranging from 20% to 33% of retail price, transporters earning 20% to 25% of final value and retailers making the greatest profits of 25% to 33% of final selling price (Kambewa, *et al* 2007). A study analyzing the Profits and margins along Uganda's charcoal value chain (Shively *et al* 2010), reveals the greatest overall returns to participation in the charcoal value chain is among traders. Within the Rwandese value chain, wood production sector was valued at US$ 8.7 million, carbonization at US$ 17.5 million, transport sector at US$ 19.7 million and the retail and distribution at US$ 6.5 million (Blodgett, 2011).

2.8. Charcoal market structure

Charcoal production and distribution contributes towards the national balance of payments at the macro level as foreign exchange. For example, in Nigeria, the wood charcoal enterprise is one of the major components of the wood fuel industry and it is the main source of domestic fuel in urban areas, accounting for more than half of the domestic energy consumption (Agbugba et al, 2013).

There has been rising demand for charcoal in urban areas. According to Agbugba (2013) this urban demand led to the formation of markets for wood charcoal for both men and women. The men mostly involved in long distance trade in wood charcoal and firewood, whereas women are involved in small-scale wood charcoal trade. This situation is similar in most African countries in sub-Saharan Africa. Although there are disparities to such structures, for example in Zambia there has been influx of women in the charcoal trading from as far as 400km from the trading center but this also has led to specialization in the charcoal industry with most men trading charcoal on

bicycles and vans. In many instances poor urban women are said to pay higher prices for charcoal owing to its inefficient marketing (Agbugba, 2013). In rural areas, women and children walk long distances to produce, harvest and transport wood charcoal to their households.

Further Agbugba (2013) refined that the marketing system performs vital functions through the allocation of resources through the price system. But the price charcoal determines the income and economic welfare of wood charcoal business households which in turn influences investment and production decisions.

Wood charcoal market flows through four (4) major marketing channels represented diagrammatically in Figure below.

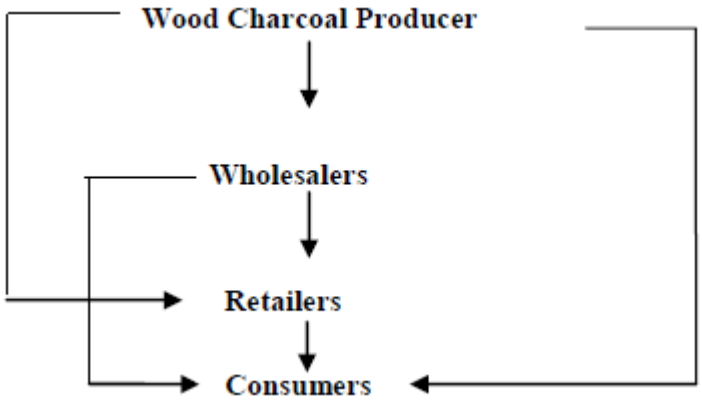


Figure 2.2: Shows the market structure for charcoal

Source: Agbugba (2013)

As shown in the above market flows, there are two intermediaries operating between the wood charcoal producer level and the consumer level these are namely wholesaler and retailer. In a different scenario for example as reported by Davison et al (2013), there are three intermediaries between charcoal producers and consumers, namely the transporter, wholesaler and retailer.

But because most researches (Agbugba, 2013, Davison et al, 2013, Sophia et al, 2016) have reported a two or three-way intermediary in the charcoal value chain, there has been recent development along the charcoal value chain with an increase in the number of actors. For example, the value chain structure as reported by Kambewa et al, (2007) the value chain has attracted a lot of actors such as middlemen. As shown in the figure below.

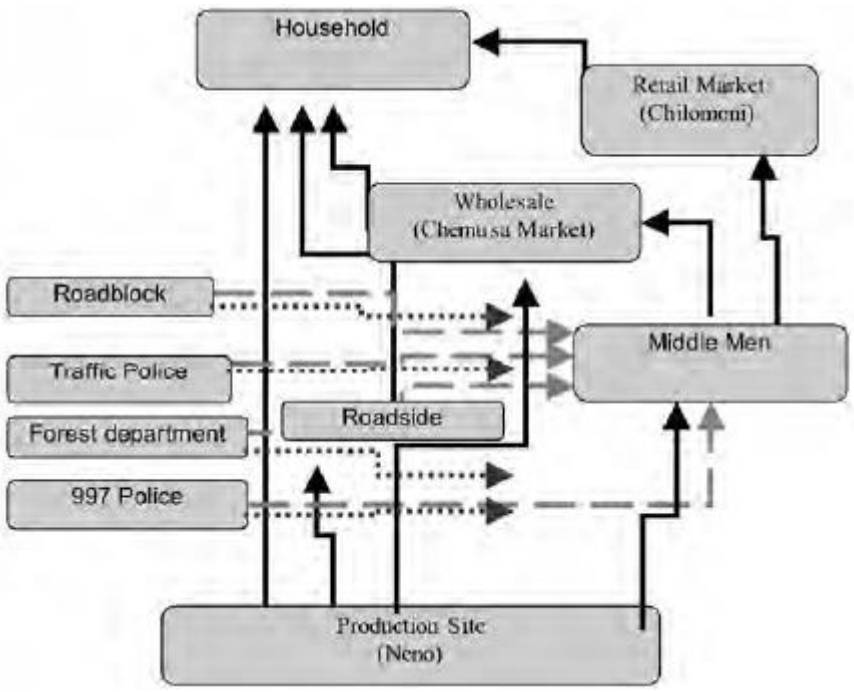


Figure 2.3: Shows the actors of the charcoal value chain

Source: Kambewa et al, 2007.

Similar results were found in Nigeria as reported by Agbugba (2013), three intermediaries and consumer of fuelwood of processed cassava products in Africa. He observed that the wholesale dealers buy from producers and sell to the retailers. While the retailer in turn sells to the consumer in small quantities. However, in some instances some small scale retail shops buy directly from producers. Also, large consumers like hotels buy directly from the producers or the wholesalers. In most cases there has been absence of wood charcoal association or union.

2.9. Background of Life Cycle Assessment

Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) are defined as tools used to assess the cradle-to-grave analysis of the environmental and economic consequences of using products or providing services (Sheehan et al, 1998). LCA is an analytical tool used to comprehensively quantify (within the limits of available data) and interpret the flows to and from the environment. While according to the US Environmental Protection Agency, LCA is a technique to assess the environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). Performing economic LCA on charcoal value chain would let us know which components are incurring more cost. Further, these costs can include air

emissions, water effluents, solid waste, toxicity, and the consumption/depletion of energy and other resources, over the entire life cycle of a product or process, commonly referred to as "cradle-to-grave." LCAs can include production and extraction of raw materials, intermediate products manufacturing, transportation, distribution, use, and a final "end-of-life" stage, which often includes multiple parallel paths such as recycling, incineration, or land filling (Sheehan et al, 1998).

In most cases performing an LCA involves two main steps: Step one which is the *Inventory*, here the material, financial costs and energy inputs and out puts from a life cycle are calculated and tabulated; and while step two involves the *Interpretation*, which describes the implications to decision makers that may be gleaned from an analysis of the inventory data. The methodology of LCA analysis can be standardized and its practitioners and users commonly accept these standardized approaches. Approaches to the interpretation step are much more varied depending on the goal/scope of the LCA.

In the most straightforward and transparent approach to LCA interpretation, the LCA results may be used to help identify and prioritize opportunities for inefficiencies such higher financial costs, pollution prevention or increases in material and energy efficiency for processes within the life cycle. A particular advantage of LCA applied in this way is its comprehensiveness. LCAs help detect the shifting of environmental, financial and social burdens from one life cycle stage to another (e.g., lower energy consumption during use, achieved at the cost of much higher manufacturing energy consumption), or from one medium to another (e.g., lower air emissions at the cost of increased solid waste).

When the resulting number of flows calculated during an LCA analysis exceeds 100, subsets of the flows are sometimes consolidated or aggregated into stages, such as production or transportation, to facilitate interpretation, especially when two or more products or processes are being compared using LCA (Sheehan et al, 1998).

Finally, because the results of an LCA are influenced by a significant number of assumptions and uncertainties, the interpretation phase should include some sensitivity analyses to assess the robustness of the baseline results and conclusions. Sensitivities can also highlight potentially influential assumptions, methodological choices, future scenarios, and uncertainties (Sheehan et al, 1998).

2.10. Policy implications

In most sub-Saharan countries the charcoal sector yields three interesting observations: despite the first priority given to charcoal as a single-most important energy source for millions of urban dwellers in the country and is used by all tiers of society ranging from the poorest to the upper-class, it seems to be neglected in a political fashion, without much priority or urgency (Sander,et al, 2013). Taken under a coherent policy framework, will make all policies governing the charcoal sector to be compatible and mutually supportive along the entire charcoal value chain and across the key sectors, including forestry and energy. Such policy framework would bring about economic sustainability and an equitable distribution of benefits among different actors along the value chain. For example, the World Bank policy of 2009 provided a coherent policy framework governing charcoal production, trade and use despite been neglected in many African countries. This has made the charcoal sector remain highly informal and unregulated.

Secondly, many governments are losing estimated revenue of US$ 100 million per year due to foregone taxes and licensing fees from charcoal production and trade. Despite the charcoal sector being one of the biggest business sectors in these countries, with an estimated value of US$ 650 million annually. For example in Tanzania, Dar es Salaam valued at US$ 350, compared to US$ 700 million of foreign direct investment in Tanzania in 2010) (Sander,et al, 2013) . Therefore, charcoal contributes little to the national accounts budget relative to its significance for the national economy.

Thirdly, charcoal production is frequently considered responsible for causing significant change in forest ecosystems leading to the degradation of forest land, especially around the rapidly expanding urban areas. As urban areas expand in development, this combination with charcoal production leads to permanent deforestation in some areas of the country.

The major policy challenges are lack of systematic initiatives that make the charcoal sector more environmentally and economically sustainable. For example, of such initiative was a two-week charcoal ban in January 2006 in Tanzania. This ban was imposed by the Minister for Natural Resources and Tourism was to reduce rapid deforestation. This policy was ineffective since there are no other alternatives to charcoal for most urban consumers considering that other fuels were being more expensive and the cheaper firewood widely unavailable. The production continued during the ban, albeit under more difficult conditions (Sander,et al, 2013). This ban led corruption and collusion, further increased prices of charcoal for consumers. Similarly, the ban led to an

increase in the paying-off of law enforcement staff at checkpoints and corruption in other control mechanisms.

Therefore, the policy implications of understanding these drivers can provide important insights into viable entry points for strategic engagement with charcoal sector stakeholders. This will help in identifying the deal makers and breakers thus bringing along the reform processes for making the charcoal sector more environmentally and economically sustainable. However, without a formal policy analysis and documentation, these assumed drivers remain nothing but mere speculation and are inadequate to be incorporated in a committed dialogue on reform policy design and implementation. Analyzing and documenting the political economy of the charcoal sector in a structured approach using validated methodologies can, thus, add significant value to existing technical analysis. Such reforms should be designed to allow the integration of charcoal into the overall economy as a formal economic activity.

Chapter Three: METHODOLOGY FOR THE STUDY

3.1. Description of the study areas

For this study area, Chongwe district in Lusaka Province was selected as the proximal charcoal supplying region for Lusaka District. The district was created in 1995 by splitting the former Lusaka Rural district into two separate districts: Chongwe and Kafue. The district covers 11259 km2 between latitudes 15° and 15°45' S, and longitudes 28°30' and 29°30' E. This is an area on the edge of the escarpment into the Luangwa valley, east of Chongwe town and northeast of Chongwe River. It extends south into the Lower Zambezi national park, and north over the Lusemfwa river. Chongwe district supplied about 36% of the charcoal consumed in Lusaka city during 1992(CHAPOSA, 2001). It is therefore a significant source of charcoal for Lusaka.

The other sources of charcoal for Lusaka were Kabwe Rural and Mumbwa districts in Central Province. Charcoal production in Chongwe has been the focus of a number of studies in the past, including those by Chidumayo & Chidumayo (1984), World Bank/UNDP (1990), Natural Resources Institute & Oxford Forestry Institute (1995), Kalumiana *et al*. (1998). In addition, forest surveys and ecological studies have been previously conducted in the Chongwe area, including the establishment of permanent woodland plots for monitoring soil and woodland productivity (CHAPOSA, 2001).

All the charcoal in the Chongwe study area is made in earth kilns built by covering a stack of logs with soil clumps dug around the kiln site. Trees are cut at about knee or waist height with hand axes and boles and branches cross-cut into 1-2 m long billets that are stacked to make a kiln. The kiln is ignited and carbonization takes a number of days, or even weeks for large kilns, after which the kiln is broken, the charcoal separated from the soil, cooled and bagged before transportation to the market. The average cut plot in one of the previous production areas was 0.173±0.06 ha (mean ±1S.E) and uncut trees contained 7% of the pre-cut biomass. The majority (92%) of uncut trees were small (dbh< 10.0 cm) (CHAPOSA, 2001). The large uncut trees belonged to *Erythrophleum africanum*, *Albizia antunesiana*, *Burkea africana* and *Pericopsis angolensis* which are either too hard to cut or make charcoal with poor burning qualities.

Charcoal producers therefore appear to practice a kind of selective cutting based on size and species. The mean charcoal conversion efficiency in 65 earth kilns assessed using three different data sources (see section 2.1), ranged from 25 to 28% with no significant differences among the three data sources ($F = 0.67$, d.f. = 2, 62, $p = 0.52$). The overall mean ±1S.E. conversion rate was

26.7±1.5% which is a relatively high conversion efficiency given that the carbon content of wood in miombo woodland is about 45% (CHAPOSA, 2001).

However, this also means that where conversion efficiencies are less than 25%, potential exists for improving the efficiency of the earth kiln technology, especially through better kiln management (Hibajene & Kalumiana 1994).

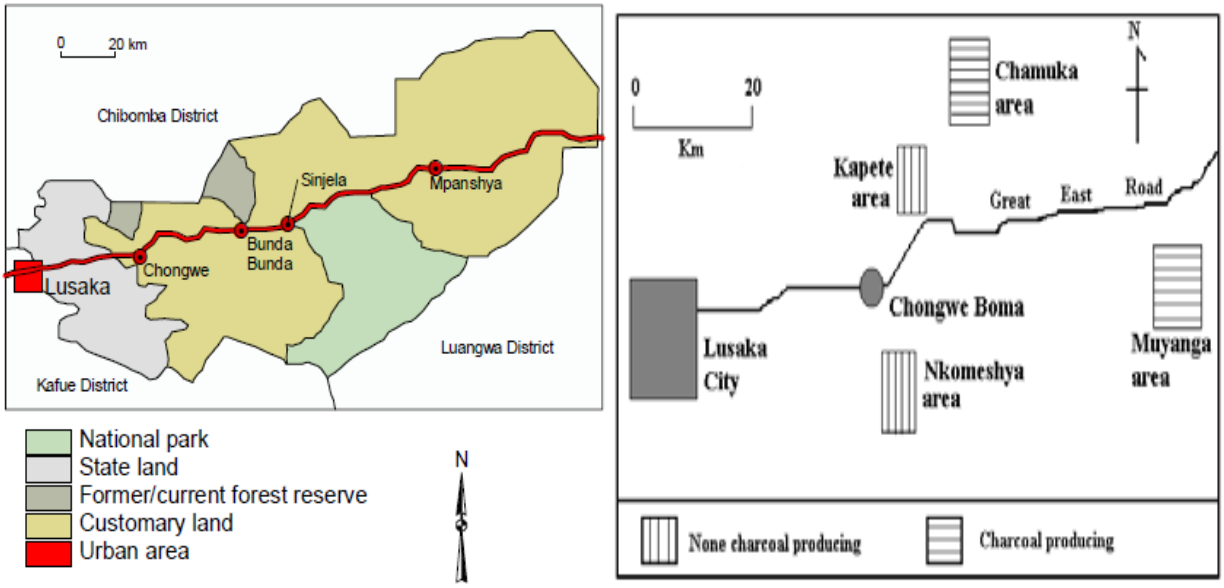


Figure 3.4: Shows the map of the study area

Source: (CHAPOSA, 2001)

3.2. Life Cycle Assessment Methodology

A leading tool for assessing environmental performance is life cycle assessment (LCA), is an internationally-recognized approach that evaluates the relative potential environmental and human health impacts of products and services throughout their life cycle, beginning with raw material extraction and including all aspects of transportation, production, use, and end-of-life treatment (Afrane, 2012). Among other uses, LCA can identify opportunities to improve the economic performance of products, inform decision-making, and support marketing, communication, and educational efforts. In this research standard LCA was used to explore the economic feedbacks in the charcoal value chain. This was done by carrying out an inventory on the expenditures, incomes, profits and losses along the charcoal value chain.

An LCA generally contains four main phases which are displayed in Figure below:

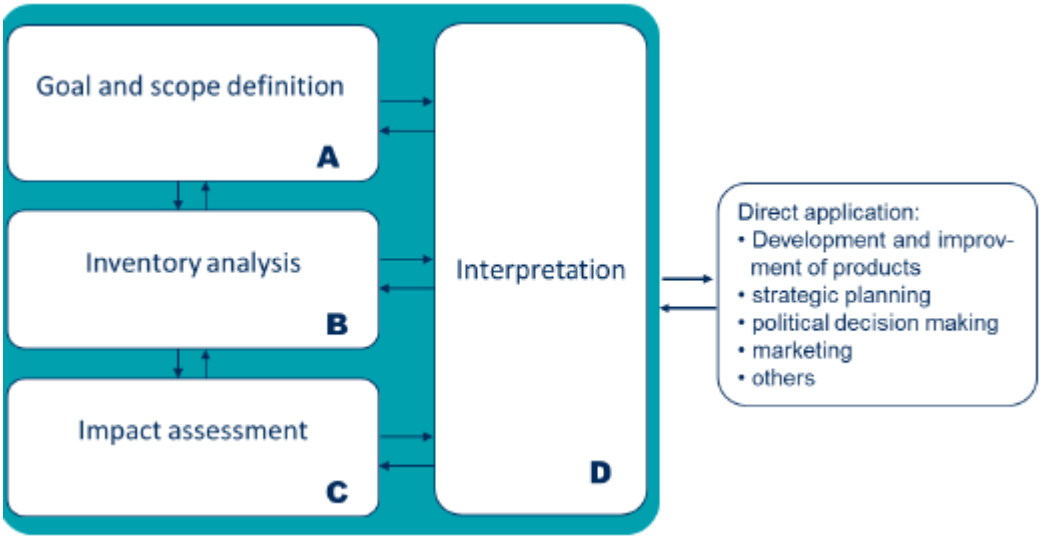


Figure 3.5: Shows the phases of an LCA

Source: Quantis, 2014

In this research, LCA was used to estimate the full life-cycle cost (LCC) on the economic feasibility of charcoal value chain in Zambia. The LCA stages included production, transportation and trade (wholesale and retail) of charcoal from Chongwe district to the proximity market of Lusaka. This product value chain provided insight into the input and output of financial resources at each value chain stage and the resulting economic costs of each scenario.

The life-cycle costs were calculated by summing financial costs of charcoal at each stage of the value chain by taking into consideration the expenditure, income, price of charcoal, profits or losses.

3.2.1. Goal and Scope

The cumulative economics costs of charcoal production from woodlands in Chongwe districts from traditional earth mound kilns are estimated using process-based LCA in Microsoft Excel. The goal of the charcoal economic LCA was to quantify economic flows associated with the charcoal value chain. The study does not detail into the economic analysis but it is limited to the economic efficiency such as expenditure and revenue. While the economic feedbacks refer to the profits and loses which determine the sustainability of the charcoal business and these are as a result of capital costs, investment returns, and the operating cost (Holm-Nielsenae et al, 2009).

3.2.2. System Boundaries

The system boundary for this study is only limited to the general components of the charcoal value chain from production, transportation and trade. The method of charcoal production and collection was dependent on the feedstock which was wood derived from the forests and woodlands. The study does not take into consideration the costs of wood production as there was no information regarding in the production area. Once the charcoal was produced it was transported to the markets by different modes of transport where it was reduced in quantity through retailing. Even though their different channels by which charcoal reached the retailer or consumer, this study only evaluated the general links of charcoal supply. The figure below shows the LCA scheme for charcoal that was developed during the research. Other authors (Chidumayo, Gumbo et al, Jagger et al) have a different value chain scheme from producer, transporter, trader and consumer.

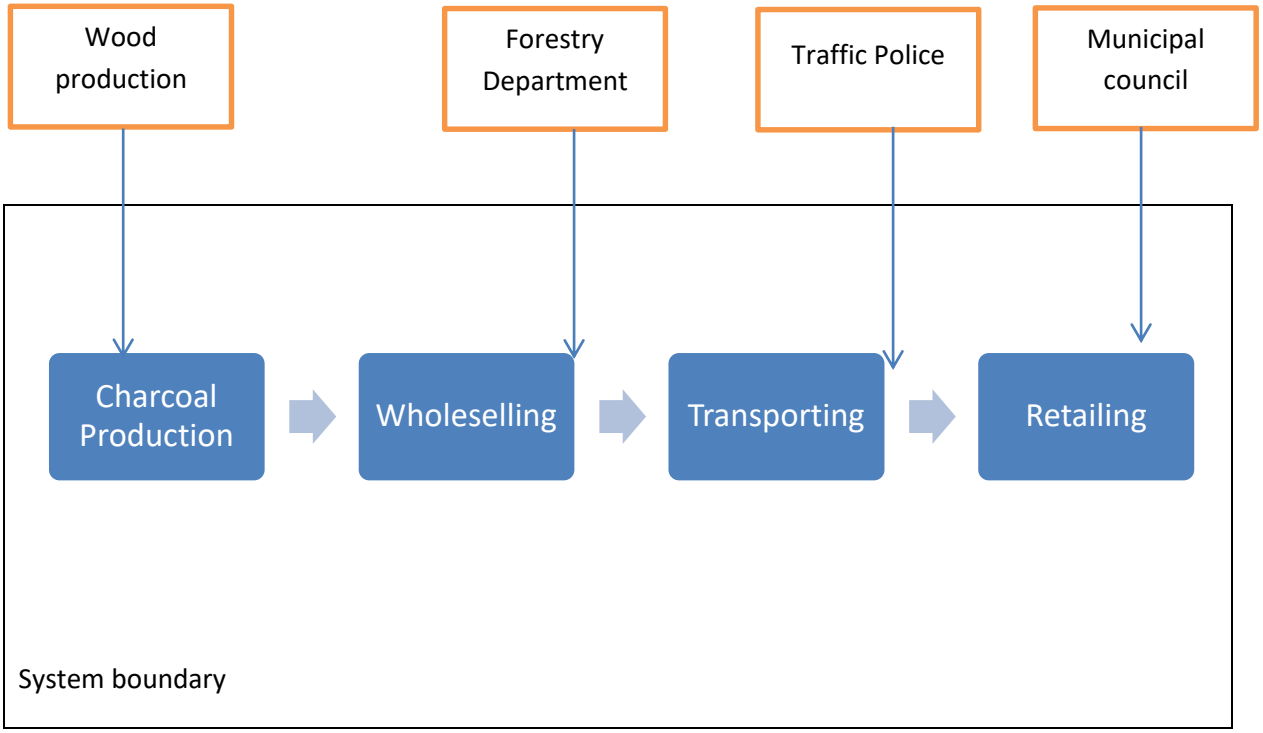


Figure 3.6: shows the system boundary of the charcoal value chain

Source: Field survey, 2017

3.2.3. Functional unit

The function units for this study are based on the standard units of a 90kg bag of charcoal. It does not take into considerations on the actual masses of the charcoal bag because the mass of charcoal depends on the wood density used during production. Most charcoal in Chongwe district is packaged in what is termed as standard bags which are the 90kg empty bags. For this study functional unit of 100 by 90 kilograms bags of charcoal were taken into account for the LCA. Other functional units include the Zambia Kwacha Currency (ZMK) used for the economic flows.

3.2.4. Life cycle inventory data collection

The inventory considers data on the primary costs of charcoal production, transportation, marketing (wholesale and retailing). The expenditure, income and profits come from the charcoal value at each value chain stage. Gross revenues are determined by the market prices of charcoal at each level in the chain (Roland and Dania, 199).

The sources of data are grouped into the four unit operations that make up the charcoal value chain namely; production, transportation, wholesaling and retailing. Further a stakeholder mapping activity was conducted to identify the actors along the charcoal value chain.

Production: Quantitative data on input-output flows (amount of money required and corresponding costs of producing charcoal produced was obtained from the producer. Further, the total costs, price of commodity and revenue generated was obtained at this stage. Data obtained

Transportation: Transportation costs and pricing mechanism for charcoal transportation from Chongwe to Lusaka was obtained from the transporters. Further data on types of transports used and prices charged was collected from the transporters.

Wholesalers and Retailers: Data was collected on charcoal capital, expenditures, income and profits from different retailers such as household, roadside and market based charcoal traders. Data consist of income and profit, prices, and quantities of the goods handled by these different actors. Additional information was collected on participant demographics, social capital.

3.2.5. Impact assessment

The potential economic impacts associated with the inventory data were determined based on the economic flows along the charcoal value chain. The methodology value chain analysis conducted

to understand sequence of related business activities from production to consumption of charcoal, and the functions of the operators and supporters in the chain. This analysis helped 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 (Ndengwa, 2015). The assessment consisted of 50 respondents in the proportion 10 producers, 10 transporters, 10 wholesale traders, 10 retailers and 10 stakeholders. These were gathered from different trading sections within and between Lusaka and Chongwe district so as to increase on the diversity of information. Households charcoal traders were purposively selected based on their proximity to the market places and random selection was applied on producers, transporter and traders.

3.2.6. Interpretation of Results

The results of the LCA inventory was analyzed using excel based LCA model and related financial dimensions for this study includes the total cost, income, profits e.g. initial costs, on-going cost, annualized capital cost, operating cost, revenues (price obtained per quantity, profits and Rate of Investment return) of charcoal at different stages of the value chain, these were calculated using Microsoft Excel.

Chapter Four: RESULTS AND DISCUSSION

This chapter presents the results of the study on Life Cycle Assessment on the economic feedbacks of the charcoal value chain in Lusaka District. The economic feedbacks for this study are limited to the parameters of capital, expenditure, revenue and profit/losses of the charcoal. The study was conducted by looking at the financial input and outputs at each stage of the charcoal value chain. The value chain stages were limited to the production, transportation, wholesaling and retailing in the charcoal value chain. A value chain structure of the charcoal value chain is presented based on the field survey and the economic flows representing the economic feedbacks are illustrated.

4.1. Characterizing the Value Chain of Charcoal in Lusaka District

4.1.1. Participants in the Charcoal Value Chain

Table 4.1: The social characteristics of the respondents

	Producer	Agent	Transporter	wholesalers	Retailer	All
Gender (% of females)	5	10	6	10	15	46
Age	37	29	32	35	33	33
Education	1	3	3	5	3	3
N	10	5	5	20	10	50

According to the findings of the study as in Table 4.1, the characteristics of the respondents in the charcoal value chain are based on gender, age and levels of education. It was found that men dominate the charcoal business along the value chain. There are very low levels of female (46%) participation in the producer (5%) and transporter (6%) categories. The average age was fairly uniform across groups of charcoal value chain participants. It was found that producers (37 years old) and traders (35 years old) respondents were the oldest whilst agents (29 years old) are the youngest. For the levels of education which was the number of years spent in school, the producers had the lowest number of years spent in school with primary education level. Traders as a group had a higher average level of education having attained secondary education. Primary education for retailers may indicate disadvantages when bargaining, due to limited access and ability to process market information, but higher education for traders may not mean that one will necessary succeed in the charcoal industry (Shivel *et al*., 2014). Therefore, five major roles for value chain

participants were identified: producer, agent, transporter, trader, and retailer. The identification of these roles was based upon a scoping exercise involving key informant interviews conducted in Lusaka prior 2017. Further the primary and secondary roles of participants along the value chain were assessed.

4.1.2. Charcoal producer costs and profits

Table 4.2: Estimated charcoal producer costs and profit for 2017

Estimated Financial Costs		
Total labor costs per average clamp producing 100, 90 Kg bags	**ZMK Per production**	**ZMK/bag 100 bags,90kg**
Felling	30	120
Cross-cutting	40	160
Haulage to clamp	10	300
Building clamp	40	120
Maintaining harvesting	800	800
Total labor	1500	1500
Equipment and tools	200	200
Total labor and other expenses	1700	1700
Price of charcoal on site	35	3500
Profit	1800	1800

Most studies have focused their attention away from estimating the earnings from charcoal production (Hibajene and Kalumiana 2003; Siedel, 2008; Pereira *et. al*., 2001; Herd, 2007, Malimbwi, *et. al*., 2005; Mulombwa, 1998). While in this study an attempt is made - to estimate the cost of charcoal in for various actors in the year 2017 for Lusaka District. Table 4.2 shows the producer costs, the profit margin in this study is derived as the residue between the estimated production costs and the wholesale trading price.

From Table 4.2 it can be seen that producers never paid production and conveyance fees and sold their produce at either ZMK 35 per bag made 51% profit per bag of charcoal sold. From an economic point of view, the producers seek to maximize profits by avoiding production and conveyance fees and also reduces operation costs, without this many producers would have stopped production. These are realistic assumptions because the majority of producers in Chongwe District do not pay stumpage fee and a situation relating to charcoal production in Zambia

currently. Under normal circumstances a producer is supposed to pay production fee of ZMK 27 per bag and conveyance fee ZMK 13 per bag to the Forestry Department which translates to roughly ZMK 450 per 10 bags which translates to ZMK 45 per bag of charcoal.

Note: (USD exchange rate as of June 2017 was US$1 = ZMK 8.7 to 9.0).

4.1.3. Charcoal Wholesaler costs and profits

Table 4.3: Charcoal Wholesaler costs and profits

Estimated Financial Costs	**2017**	
Total costs per 100, standard bags	**ZMK Per trip**	**ZMK/bag 100 bags,90kg**
Ropes	45	540
Empty bags	4	400
Paper defense (bribes)	400	400
Market fee	300	300
Packing in bags	700	700
Loading	1000	1000
Offloading	1100	1100
Transportation	40	4000
Production & conveyance fee	45	4500
Others	250	250
Total expenses	13130	13190
Capital cost for charcoal	35	3500
Total cost	16590	16690
Income after resale	200	20000
Profit	3310	3310

Similarly, an attempt was made to estimate wholesaler' costs and profit margin as shown in Table 4.3. This analysis showed that wholesalers require higher capital and thus incur higher costs; therefore, this results in low profit margins. The charcoal transport cost to market, without including the cost from production site to roadside, was 20 % retail price. The exclusion of this component of the transport cost is because most producers sell the charcoal at the production site and are not engaged in retail trade. Transport costs are based on June 2017 and July 2017 transport survey (ZMK 40 per bag of charcoal on all Lusaka roads), Off-loading and loading charges assume a ratio to retail price of 0-15% of market price. Market price of charcoal for a 90 kg as found to ZMK 200 in the month of June 2017and July 2017 for Lusaka city.

From the calculations, the wholesaler makes a small profit of close to 20% of the selling price. Bribes are also prominent in charcoal transportation to the market, the traders call them paper defense. The license also known as a production and conveyance costing about ZMK 45 per bag this license is valid only for two weeks. Therefore, to avoid the costs of acquiring another license it was noted that the traders have to pay the officers at the check point a sum ranging between ZMK 300 to ZMK 500 depending on the number of checkpoints passed. Similarly, Jagger and Shivel (2014) report that bribes were mostly paid by the wholesaler and transporters along the charcoal value chain. Therefore, it was further noted that in most instances charcoal has to be transported at night to avoid detection by the officers and also transporters have to use routes in the bushes to avoid passing through the checkpoints. Purchasing of charcoal from production sites is only done once in a month and the journey takes three days, therefore the trader has to spend roughly about ZMK 250 on food and other amenities. While at the production site the trader purchases charcoal at ZMK 35 per 90kg bag, further incurs costs of stacking the charcoal into empty bags ZMK 700 and loading into transport at ZMK 1100. Therefore, these results are supported by the findings of Roland and Dania (1999) who found that wholesalers made less profits compared to wholesalers who owned their own transport. Therefore, revenues in the charcoal value chain are skewed towards the transporter.

4.1.4. Charcoal retail costs and profits

Table 4.4: Charcoal costs and profits for a retailer

Category of retailer	Cost Items ZMK	Income/profit ZMK
Household based Repackaged in plastics	Charcoal= 150 Empty bags= 5	Charcoal = 170 Profit = 15- 20 per bag
Wheelbarrow	Charcoal=140 Hiring = 15	Charcoal = 200 Profit = 60 - 80
Bicycles	Charcoal= 150 Bicycle cost = 50	Charcoal = 200 Profit = 30 -50
Market based	Charcoal = 150 Market fee= 5 day	Charcoal = 170 Profit = 20 - 30

The results in the Table 4.4 above show the costs and profits for different categories of retailers for charcoal in Lusaka. The study identified four types of retailer categories namely the household, market, wheelbarrow and bicycle retailers. According Roland and Dania (1999) retail traders buy charcoal in the market from wholesalers and sell it outside on the market periphery or elsewhere in the city in smaller quantities. Their typical clients are probably persons who dispose over little money and are unable to pay one sack of charcoal at a time. From the focus group interviews conducted with the household and market retailers of charcoal, it was discovered that these types of retailers make minimal profits 13 to 15% the cost of charcoal. Therefore, to minimize further costs charcoal is repackaged in smaller units and sold ZMK 2, ZMK 5 and ZMK 10 depending on the economic status of the urban areas. Similarly, retailers avoid selling charcoal in bags as it yields less profit because it has to compete with the actual retail price from wholesalers. Roland and Dania (1999) also found that charcoal is traded in bins or small piles by retailers. Sacks, bins and heaps are basic units of volume and prices are per sack, bin or heap and difficult to manipulate.

Another group of retailers are the migrant retailers selling charcoal door to door in residential areas. These use bicycles or modified wheelbarrows these are also referred to

agents as they purchase charcoal from retailers and wholesalers and deliver it to the known customers such as restaurants and homesteads (SEE APENDIX II). Compared to the stationed retailers, these agents make slightly higher profits of about 30 %. The migrant retailers for example those using wheelbarrows will sometimes repackage the charcoal bag after dividing into two components, they later fill the middle section of the charcoal bag with fine grains and top and bottom section with coarse grains of charcoal. The success of this effort depends on the possibilities to reduce costs, raise unit revenues by manipulating the volume/price relation, and, last but not least, by the turnover (Roland and Dania, 1999). This many customers have seen it as an act of theft, because from one bag of charcoal they produce two bags which contain sometimes charcoal dust or stones just to fill up the bag and encourage people to buy when the bag appears full.

4.1.5. Transportation of Charcoal

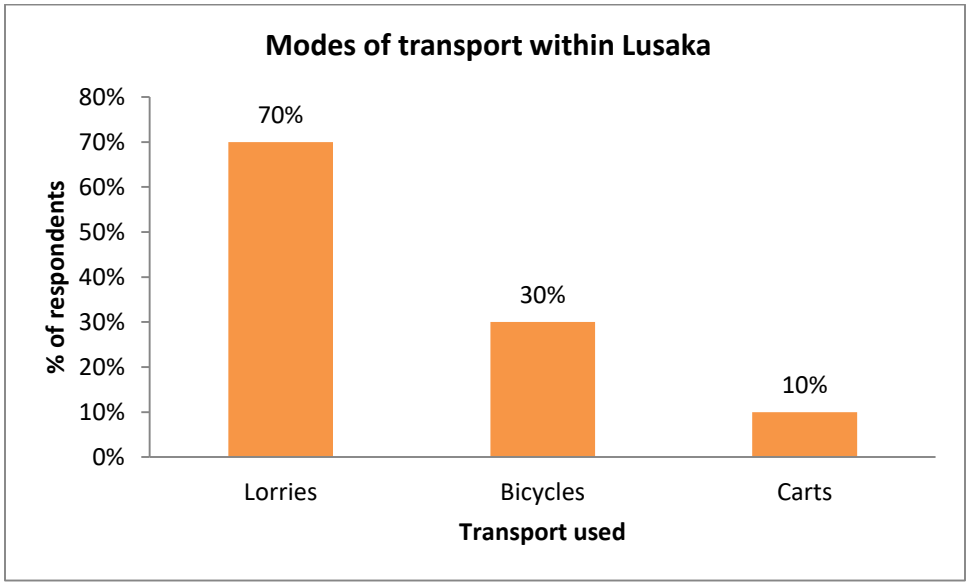


Figure 4.7: Percentage of different modes of charcoal transport in Lusaka district

A survey of charcoal transporters within Lusaka districts revealed that 30% Bicycles, 10% Carts, 70% Lorries and Canters were used for transporting charcoal. According to Harriet et al (2015) charcoal transporters, who supply charcoal are mainly attracted by fast cash-in hand, low capital requirements and the lack of alternative local employment opportunities. In addition, the study also found that 90% of the transporters interviewed were male and females only involved in transporting charcoal from production sites to where charcoal will

be ferried by canters and Lorries. Similarly, Harriet et al (2015) supports these finding that both men and women participate in charcoal transportation, yet transport methods are gendered (Table 4.1). Men, who typically transport charcoal on a bicycle, earn three times as much per week as those who carry charcoal on their heads, the main method used by women. However, bicycle users incur higher financial risk due to costs associated with confiscations and damage to bicycles.

4.1.6. Costs and profits of charcoal transporters

Table 4.5: Costs and profits of a charcoal transporter

Costs Item per Trip	Cost Charge ZMK
Fuel	600
Servicing / maintenance	500
Tax	500
Other	200
Total costs	1800
Income	4000
Profit	2200

For transportation to take place transporters have to secure movement permits from the Forestry Department. In most cases it is referred to as the conveyance and production fee normally paid by person contracting the transporter. While the study found that for each sack, charcoal transporters fee charge is normally per cord of 10 bags at ZMK 450 or ZMK 45 per bag. The policy only applies for anyone transporting a quantity of 10 and above number of charcoal bags. From the results of the study as shown in Table 4.5, the transporter transported makes about 64% profit and 37% goes into costs for the whole trip. Similarly, Roland and Dania (1999) found that transporters have to obtain a cutting and transport license from the provincial offices of the national forest service. Guards stop the vehicles loaded with charcoal at police checkpoints around Maputo to verify the license.

Within Lusaka district charcoal producers ferry the charcoal to designated collection points at their own cost, where they are loaded onto Lorries and personal vehicles for

transportation to urban centers. This is mostly near the main roads while some transporters pick up their charcoal from within the production area.

Bicycle transporters had the highest profits and there was a strong gender component, with women unable to participate in bicycle transportation. These gender disparities are not necessarily surprising, as gendered activities and roles are not uncommon in rural livelihoods (Ellis, 1999). It was estimated from the study that each Lorry transported an average of between 200 and 350 bags of charcoal twice weekly. In Lusaka district, transporters pay to the Municipal council about ZMK 20 per trip. The transporters were also forced to pay illegal taxes at police checkpoints along the highways. These illegal taxes vary from place to place, from **over** ZMK 300 to ZMK 500 as documented during the study. These unofficial payments accounted for 15% to 20% of the final value of a bag of charcoal.

4.2. Cost structure of charcoal in Lusaka District

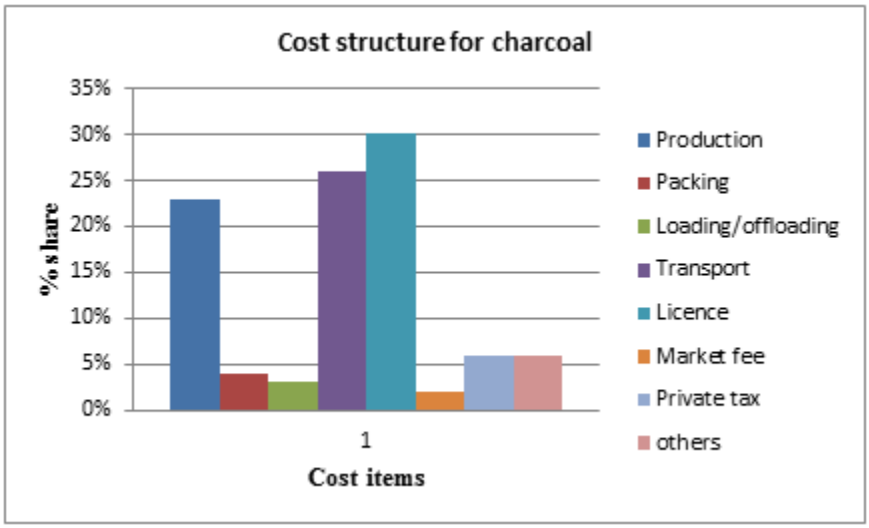


Figure 4.8: The cost structure for the charcoal value chain in Lusaka District

The sources of cost as charcoal moves from producer to consumer are production, packing, loading/offloading, transport, license, market, private tax and other fees. There were differences in the distances from production site to the urban area, and the mode of transport. Finally, there were different costs depending on the retail market at which the charcoal is sold. In this case the research focused on the costs structure for charcoal from Chongwe District of Lusaka Province.

Licenses paid to public officials were very high in Lusaka district, accounting for about 30% of the total cost. Although traders do not meet public officials every time they transport charcoal, it is likely that they factor the risk of having to pay bribes accounting for 6% into their prices, thereby making charcoal more expensive. Jagger (2014) also found that charcoal is a bulky commodity, suggesting that high-value inventories are large and difficult to hide from tax-collecting officials. However, gains from tax evasion for high value inventories suggest a potentially negative relationship between capital-at risk and tax payment.

The other major costs, as shown in Figures 4.8 are production 23%, transport 26%, and other costs 6%. Labour for packing does appear in the costs for Lusaka City, as in this market the producer charges for doing all the packing. These costs are justified, as they represent value being added, but the bribes add no value and simply result from charcoal being unlicensed product or Police officers demanding for money with claims that the vehicle is not road worth. The high incidence of bribe payment is often in tandem with payment of a tax or tariff. In developing countries where the routes for bulky commodities are limited to major transportation routes, the highest probability of extracting a bribe or a tax is from the traders and transporters that are moving large and high-value loads along well-established routes (Jagger, 2014, Olken and Barron, 2009).

Market fees are not levied uniformly even though they fetch 2% of the total cost. In some cases, traders pay daily market fees ranging from ZMK 2 to ZMK 5 per stall. In others, traders paid either ZMK 300 for the total consignment of charcoal brought into the market, plus the usual daily rate for subsequent days.

4.3. Charcoal value chain for Lusaka District

4.3.1. Finance structure of the charcoal value chain

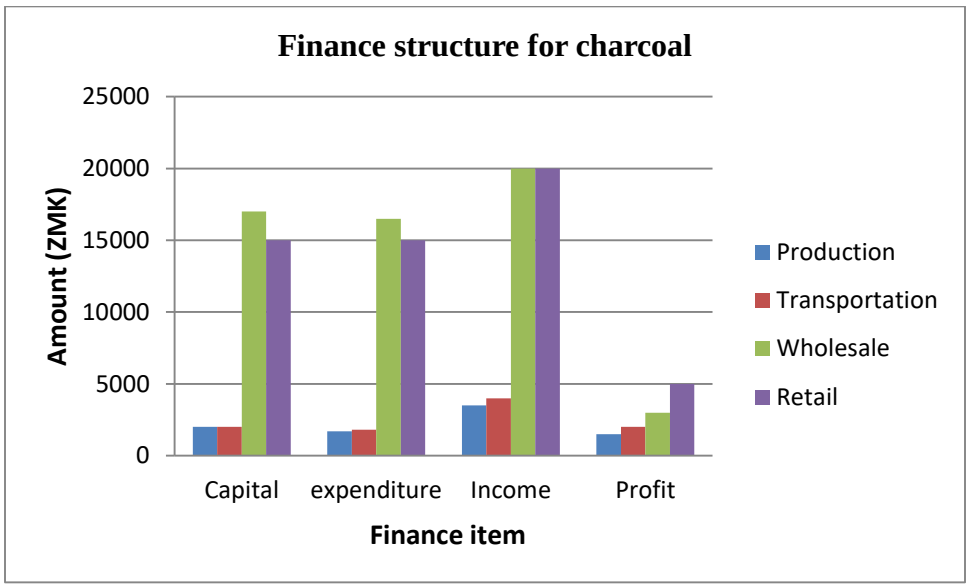


Figure 4.9: The finance structure of the charcoal value chain in Lusaka District

The results of the study in the Figure 4.9., above shows finance structure of the charcoal value chain in Lusaka district. The study focused on the capital, expenditure, income and profits along the charcoal value chain, this provided the economic feedback. From the results of the study, it was found that capital and expenditure was high for wholesaler and retailer and lowest for the producer and transporter. The expenditure for the wholesaler was high due to the production and conveyance fee paid to the Forestry Department, and bribes accounting for 30% and 3% respectively. Further the wholesaler incurred high capital costs due to the transportation fee which was 30% of the capital and other related costs of procurement of charcoal and delivering the charcoal to the retailer.

The profit margins were very for low for the producer and transporter costing 48% and 45% respectively, because the invested capital and expenditure were less than the actual returns after selling charcoal and this gave them higher profit margins. According to Roland and Dania (1999) the net revenue one obtains by participating in the commodity chain are the balance of costs and gross revenues and differences reflect one's individual economic capacities to economize costs and maximize revenues. At a deeper level, these differences refer not only to individual qualities, but also to structural characteristics. While for this

study the wholesaler and retailer required lot of capital and expenditure and thus the retailer had higher profits compared to the wholesaler. The retailer only paid market fees thus less expenditure. Similarly Shivey et al (2014) found overall profits and per-unit marketing margins along the value chain and depended on location, human and social capital, and asset ownership on observed economic returns and scale of activity.

4.3.2. Economic feedback in the charcoal value chain

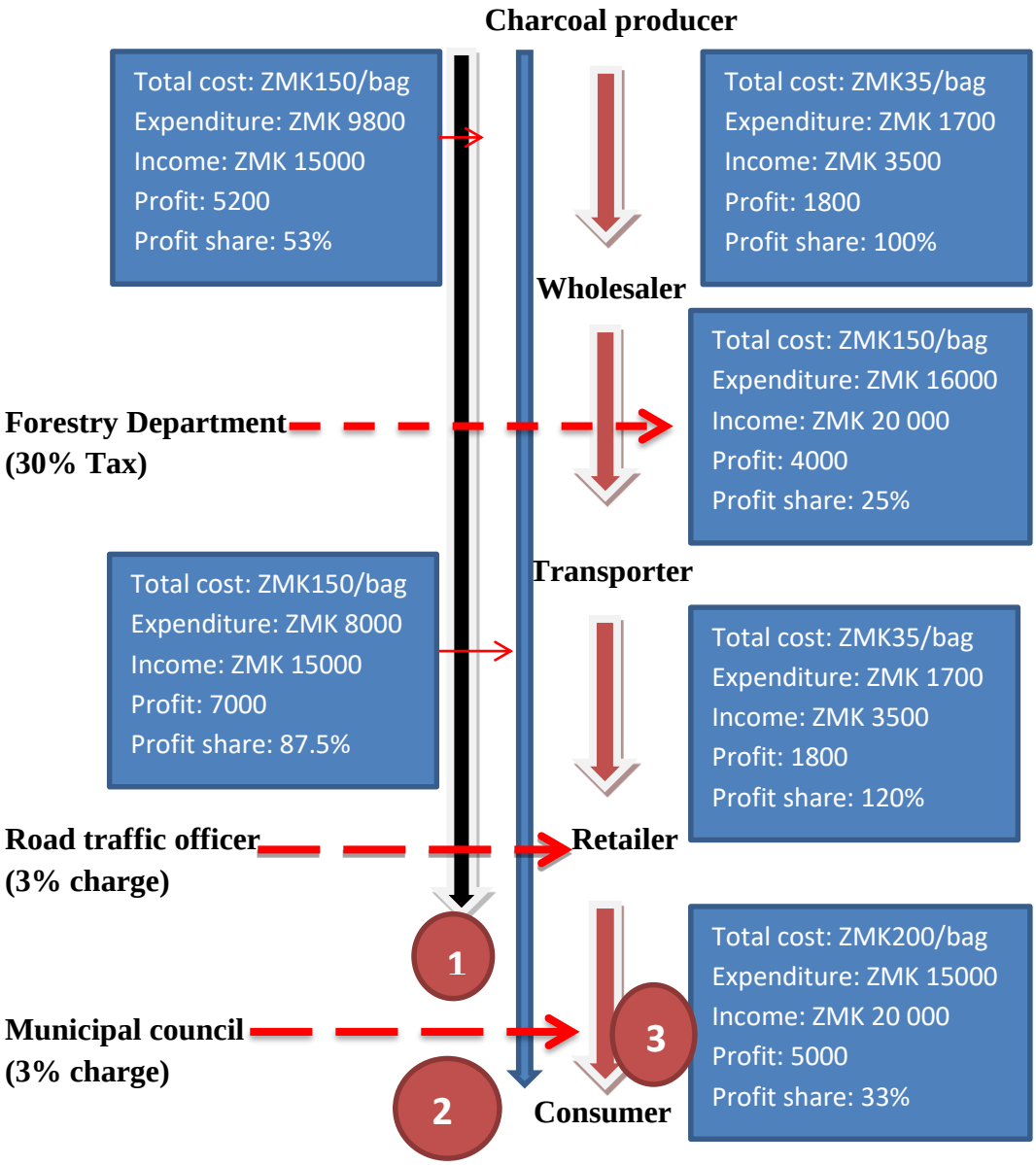


Figure 4.10: The economic feedbacks of the charcoal value chain in Lusaka district

The charcoal value chain of Lusaka district provides an important baseline for understanding the economic feedbacks at each stage of the value chain. From the results of the study in Figure 4.9.,

it emerged that there are different and sometimes complex channels through which charcoal moves from producers to consumers. According to Roland & Dania (1999) charcoal is mainly transporte from the production area to the urban consumers are carried out by a set of specialised economic actors. These actors constitute a commodity chain. Four different channels identified from the study are summarised with Figure 4.10. In the Chongwe – Lusaka supply chains there are a few constant players involved; namely producers, traders and consumers, but the mechanisms for flow of charcoal between players and locations can vary greatly, SEE APENDIX I (BCP, 2013).

First there are three direct channels for charcoal supplying. The first channell (1) involves the movement of charcoal from producer to wholesaler. In this movement the inputs for the producer are lower than the outputs. Production costs are extremely minor (note the opportunity cost of labour is not included). Producers do not suffer financial production constraints, meaning there should not be financial barriers to changing production systems and habits (BCP, 2013). Therefore the enxpenditure is lower than the income, money is recycled back into the chain for for inputs. Therefore is a positive economic feedback at production with a profit share above 100%. Simillarly is the transporter who in this chain gets a profit share of 120%. The producer and the transporter have low economic costs because they do not pay tax to the local authories such as Forestry Department and Municipal Council.

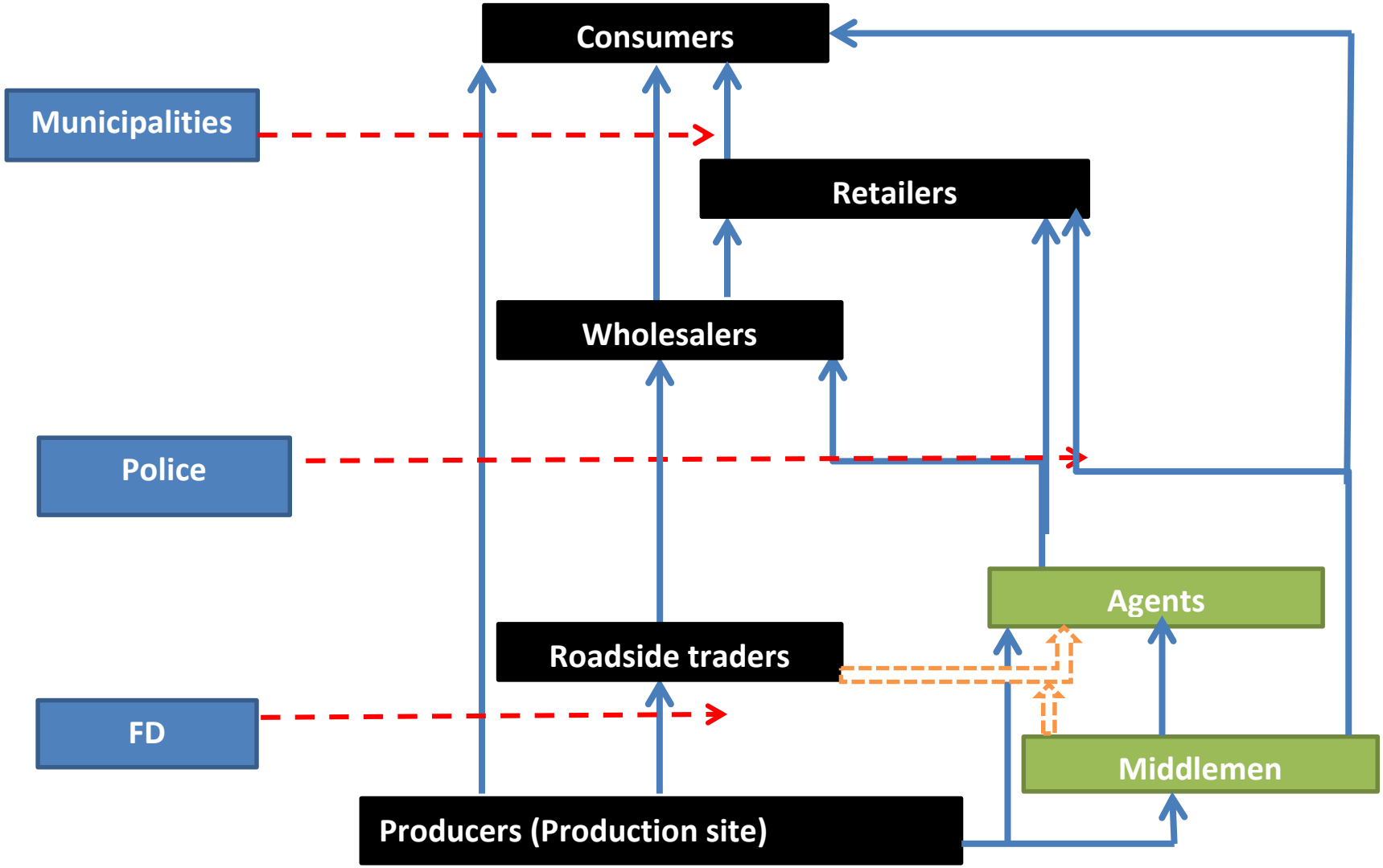
The other economic feedback loop is for the wholesaler and retailer who struggle to minimize the negative feedbacks. Although the desired chain if from producer to retailer, there are limitations of capital for transport. Therefore the most common supply chain is 3. Here, a trader (wholesaler) buys directly from a series of producers and then transports the charcoal back to Lusaka for sale. According the report by ESDA (2005) main customers sourcing charcoal directly from producers include charcoal vendors, households, food business, other business and social institutions. The study found that the wholesaler incurs the highest econonmic costs with a smaller proift share of 25% compared to the retailer with 33% profit share. This coupled with other costs the wholesaler needs higher initial capital for charcoal trade. The wholesaler had to meet the costs of paying tax to Forest Department (FD) about 30%, Municipal 3% levy and Police checkpoints 3% bribes. Thererfore the economic feedbacks for the chain and stage where considered to be negative due to the higher inputs and lower outputs. In many instances the wholesaler and retailer exhusted the returns from the sales of charcoal which left them with no capital to recycle back into the system.

This for instance the charcoal sales were found to be very slow and competitive such that prices were flactuating and stocks were sold at desparate prices. This coupled with the other shocks of povert the money from charcoal sales was diveretd to meet the daily household needs such as school fees for children, food, bills etc. Therefore the 25% and 33% profit shares were insufficient for the wholesaler and retailer respectively due to the higher capital demand. At the end of sale of each stock it was found that the wholesaler was lacking capital to recycle back in the business, this made charcoal business non lucrative for the wholesaler and retailer.

Other economic feedbacks are the indirect channels when the producer channel ends to the retailer or consumer stage with a profit share of about 53% and 85% respectively. Through such channels the inputs are minimized through avoidance of market levy. In most cases they offer door to door delivery of charcoal. Here the producer becomes the retailer thus minimizes the costs of the wholesaler and maximizes them through the benefits of the transporter and retailer.Therefore the study found that there were positive economic feedbacks in the feedback loops of the producer and transporter stages (Piotr, 2004, Bonan, 2008).

4.4. Key Actors along the charcoal value chain

Figure 4.11: Key players along the charcoal value chain in Lusaka District



The charcoal sector in Zambia still follows the unformalised structure of supply. Charcoal represents an important source of energy for many households and this has attracted a lot of key players in the supply chain. For the city of Lusaka, charcoal is delivered to the households by a number of key players such as producers, wholesalers, transporters, agents, middlemen and retailers. Therefore through these key actors charcoal finds its way into the peri and urban areas of Lusaka. According to the results of the study in Figure 4.5, there three types of actors along the charcaol value chain of Lusaka district name the Local Authorities, direct value chain players and indirect value chain players. The Local authority ihcludes the Forestry Department (FD), Police (road blocks) and Municipal council. These regulate the flow of charcoal to the city of Lusaka and they also play a role in delivering the charcoal to the consumer through inpusion of unlicensed charcoal and later auctioning.

The direct key players are the charcoal producers, roadside traders, wholesalers and retailers. These are involved directly in the charcoal supply chain by delivering the charcoal to the consumer whilst encountering the regulation authoirty. Finally the indirect players such as middlemen and agents these include private vehicles, bycicles, ox-carts etc smuggling charcoal into the city of Lusaka. Through these channels they avoid paying taxes to the local authorities. The middlemen and agents only supply a small number of charcoal to avoid detections but they face bribes on police checkpoints.

Chapter Five: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The following conclusions were derived from the findings, which were based on the objectives of this study:

1. There were three links of charcoal supply with different actors, such as the charcoal producers, roadside wholesalers, transporters, market wholesalers, retailers (market, household, mobile), agents, middlemen and institutions/govt departments. The number of actors in the charcoal value chain is increasing with new actors coming into play. Despite this there was lack of gender representation along the value chain with men dominating and only 30% of female participated in the producer and transporter categories.
2. It was also found that there is lack of business skills among the lower actors of the chain (i.e., charcoal producers) indicated by the way charcoal is priced and how charcoal production costs are estimated in the case of charcoal producers. For example, it was found that charcoal producers tend to overlook labour costs (ZMK 45 per day) especially if labour are provided by family members. This resulted in the prices of wood feedstock and charcoal at the production point to be lower than would otherwise be expected if all costs were taken into account. Therefore, a charcoal producer producing 100 by 90kg bags had an expenditure of about ZMK 1700, sold the bags of charcoal at a price of ZMK 35 and made a profit of 51% per bag.
3. The transporter had a higher profit margin as he was hired to transport charcoal from Chongwe to Lusaka. The expenditure was on fuel, road levy to the municipal, toll gate fees, and food which amounted to ZMK 1800 per trip. In return the transporter was charging ZMK 42 per bag of charcoal and for 100 bags he was getting ZMK 4200. This translated into 120% profit margin. In the case of bribing the road traffic officers, the charges where paid by the trader who hired the transporter.
4. The wholesaler had the highest expenditure resulting from paying production and conveyance and transport fee about 33% of the final value of charcoal. Similarly, the wholesaler paid bribes at Police checkpoints and also market fee which cost roughly 3% of the final value of charcoal. Further the wholesaler requires higher capital cost for procuring the charcoal. Despite this the final value of charcoal was very low with unstable market prices

and agents who manipulated the wholesalers. Therefore, the wholesaler was making a profit of 20% and this resulted in many traders to avoid taxes so as to increase profit value.

5. Similarly, the retailer was found to be making a profit of 13 to 15% of the cost of charcoal. Four types of retailer categories where identified namely household, market, wheelbarrow and bicycle retailers. Compared to the stationed retailers, mobile agents made slightly higher profits of about 30 % from the resale of charcoal.
6. The cost structure for charcoal as charcoal moves from producer to consumer is production, packing, loading/offloading, transport, license, market, private tax and other fees. Licenses paid to public officials were very high in Lusaka district, accounted for about 30% of the total cost, while bribes accounting for 6%, production 23%, transport 26%, and other costs 6%.
7. The finance structure for the charcoal value chain includes expenditure, income and profits. The capital and expenditure was high for wholesaler and retailer and lowest for the producer and transporter. The wholesaler was paying production and conveyance fee about 30% paid to the Forestry Department, and transport fee and bribes accounting for 30% and 3% respectively. Therefore, the retailer only paid market fees thus less expenditure.
8. The inputs for the producer are lower than the outputs and this gave a positive economic feedback at production with a profit share above 100%. The transporter had profit share of 120%. Thererefore the money this money was routed back into the system as capital for charcoal. The other economic feedback loop is for the wholesaler and retailer who struggle to minimize the negative feedbacks. The wholesaler incurs the highest econonmic costs with a smaller proift share of 25% compared to the retailer with 33% profit share. Therefore the study found that there were positive economic feedbacks in the feedback loops of the producer and transporter stages.

5.2. Recommendation

Based on the findings and the conclusions drawn, the following recommendations are made:

1. There is need for formalization of the charcoal business through implementation of the charcoal market rules and price control in market places. Furthermore, there is need for decentralization of the Forestry department with a separate section dealing with charcoal activities through monitoring and capacity building.
2. As a result of this, management in the local authorities should consider forming charcoal value chain cooperatives for training in business skills for sustainable business activities and profits maximization. This will also improve gender participation along the value chain and further help in poverty alleviation.
3. There is need for the Forestry Department to increase the validity period of the trading license to a year and limiting the number of bags produced. This will reduce on corruption by Forest officers on the check points. Furthermore, elimination of corruption which forms a significant proportion of the costs will result in lower final prices.
4. Non-Governmental Organisation (NGOs) should help charcoal traders through training so that they can adopt a business model approach to charcoal production and trade: The government should consider making charcoal production legal and formal business.
5. There is need for different stakeholders to fully implement the Charcoal Regulations to eliminate subtleties in the various permutations of the identified value chains that make it difficult for example for producers to negotiate for higher prices for their charcoal.
6. Through the formalization of the charcoal sector the government can collect enough tax. Regulating the charcoal sector well could enhance revenue collection for every bag of charcoal passing the checkpoint and not only limiting it to traders.
7. Lastly, there is great potential for a study to determine the extent of charcoal movement in and out of the country. This will account for charcoal imports and exports and boost the Zambian.

BIBLIOGRAPHY

[1] Kammen D.M. and Lew D.J. (2005), *Review of Technologies for the Production and Use of Charcoal.* Renewable and Appropriate Energy Laboratory Report. University of California, Berkeley, *USA,*

[2] GRZ (2010). *Zambia quick start initiative. Collaborative programme on reducing emissions from deforestation and forest degradation in developing countries.* Zambia National Joint Programme Document. Lusaka, Zambia.

[3] CHAPOSA (2002). *Charcoal Potential in Southern Africa,* Final Report. Stockholm Environment Institute (SEI), Energy and Development Group. Stockholm, Sweden

[4] Emmanuel N. Chidumayo, Davison J. Gumbo (2013). The environmental impacts of charcoal production in tropical ecosystems of the world: A synthesis. *Energy for Sustainable Development 17:86–94*

[5] Arindam Kumar Basu (2014). *Policy options for sustainable charcoal*, World Future Council.

[**6] Smith, H., Eigenbrod, F., Hudson, M., Kafumbata, D., Schreckenberg, K. (2015).** *The impact of informal forest product trade on economic outcomes:* A case study of charcoal transporters in Zomba, Malawi. Paper for XIV World Forestry Congress, Durban, South Africa.

[7] Kaplinsky, R. and M. Morris. (2001). *A handbook for value chain analysis.* Ottawa, Canada: International Development Research Centre.

[8] Kaplinsky, R. 2000.*Spreading the gains from globalization: what can be learned from value chain analysis*. IDS Working Paper Nol. 110. London, UK: Institute of Development Studies.

[9] Girard, P. 2002. Charcoal production and use in Africa: what future? *Unasylva* 53(211): 30-34.

[**10] Falcáo, M. P. (2008).** *Charcoal Production and Use in Mozambique, Malawi, Tanzania, and Zambia: Historical Overview, Present Situation, and Outlook.* Retrieved from https://energypedia.info/images/b/bb/EN

[12] IAPRI. (2016a). *The socio-economics of charcoal production and trade and its implications for forest ecosystems in the prevailing load shedding in Zambia.* Unpublished IAPRI Survey Report.

[13] Renewable Energy Agency (REN21) (2013). *Renewables Readiness Assessment:* Zambia.

[14] Agbugba, Ikechi Kelechi1 & Ajuruchukwu Obi1, 2013. Market Structure, Price Formation and Price Transmission for Wood Charcoal in Southeastern Nigeria. *Journal of Agricultural Science;* Vol. 5, No. 10; 2013.Canadian Center of Science and Education

[15] Baumert, Sophia, et al. "Charcoal supply chains from Mabalane to Maputo: Who benefits?." *Energy for Sustainable Development* 33 (2016): 129-138.

[16] Afrane, George, and Augustine Ntiamoah."Analysis of the life-cycle costs and environmental impacts of cooking fuels used in Ghana." *Applied energy* 98 (2012): 301-306.

[17] Sheehan J. Camobreco V. , Duffield J. , Graboski M. , Shapouri H. (1998) *Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus* (Natl. Renewable Energy Lab, Golden, CO)NREL Publ. No. SR-580-24089

[18] Sander, Klas, Clemens Gros, and Christian Peter. "Enabling reforms: analyzing the political economy of the charcoal sector in Tanzania." *Energy for Sustainable Development* 17.2 (2013): 116-126.

[19] CHAPOSA (2001). *Charcoal potential in southern Africa*—final report for Zambia. Stockholm, Sweden: Stockholm Environment Institute.

[20] Ribot, Jesse C. (1998). Theorizing Access: Forest Profits along Senegal's Charcoal Commodity Chain. *Development and Change 29. 2: 307-341*

[21] Quantis (2014). Transforming Tanzania's Charcoal Sector: *Life Cycle Assessment Component.* Zurich, Switzerland.

[22] Holm-Nielsenae J.B., T.Al Seadib. P.Oleskowicz-Popielc. (2009). The future of anaerobic digestion and biogas utilization. *Bioresource Technology* 100: 22, 5478-5484 https://doi.org/10.1016/j.biortech.2008.12.046

[23] Piotr. G., (2004). *Economic Feedback.* Economic web institute. http://economicswebinstitute.org/glossary/feedback.htm : Accessed 10/08/2017

[24] Bonan, G. B. (2008). Forests and climate change: forcings, feedbacks, and the climate benefits of forests. *Science* 320 (5882): 1444–1449. Crossref

[25] Ribot, J. C. (1998). Theorizing access: forest profits along Senegal's charcoal commodity chain. *Development and Change*, 29(2), 307–341. Crossref

[26] Smith, W. (2005). Mapping access to benefits in Cameroon using commodity chain analysis: a case study of Azobe timber. In *Managing the Commons: Markets, Commodity Chains and Certification* eds. L. Merino and J. Robson. Palo Alto, CA: The Christiansen Fund.

[27] Shively, G., Jagger, P., Sserunkuuma, D., Arinaitwe, A., & Chibwana, C. (2010). Profits and margins along Uganda's charcoal value chain. *International Forestry Review*, *12*(3), 270-283. DOI: 10.1505/ifor.12.3.270

[28] Jagger P., & Shively G., (2014): Taxes and Bribes in Uganda, *The Journal of Development Studies*, DOI: 10.1080/00220388.2014.947278

[29] Roland B., & Dania M. , (1999). The charcoal commodity chain in Maputo: access and sustainability. Southern African Forestry Journal- No. 185

[30] Harriet E. S., Felix E., Dalitso K., Malcolm D. Hudson & Kate S., (2015): Criminals by necessity: the risky life of charcoal transporters in Malawi, Forests, Trees and Livelihoods. DOI: 10.1080/14728028.2015.1062808

[31] Ellis F. (1999). Rural livelihood diversity in developing countries: evidence and policy implications. London: Overseas Development Institute (ODI).

[32] BioCarbon Partners (BCP). (2013). *Can commercial solutions make charcoal in Africa sustainable?* Business Innovation Facility, Zambia.

[33] Hibajene, S.B. and Kalumiana, (2003). Manual for Charcoal Production in Earth Kilns in Zambia.

[34] Hibajene, S.H., Chidumayo, E.N. and Ellegard, Anders, (1993). The Zambia Charcoal Industry. Inventory of Wood Used in Charcoal Production in Zambia. Available: http://www.worldwildlife.org/bsp/publications/africa/inventory_wood/inventory.html#Wood .

[35] Seidel A. (2008). Charcoal in Africa Importance, Problems and Possible Solution Strategies. GTZ Household Energy Programme. Eschborn. Germany;

[36] Van Beukering, P., G. Kahyarara, E. Massey, S. di Prima, S. Hess, V. Makundi, and K. van der Leeuw. (2007). Optimization of the Charcoal Chain in Tanzania. Poverty Reduction and Environment Management (PREM) Programme. Institute for Environmental Studies, Amsterdam, The Netherlands.

[37] Malimbiwi, R.E., Zahabu, E., Monela, G.C., Misana, S., Jambiya, G.C and Mchome, B. (2005). Charcoal Potential of Miombo Woodlands at Kitulangalo, Tanzania, *Journal of Tropical Science*, 17(2): 197-210;

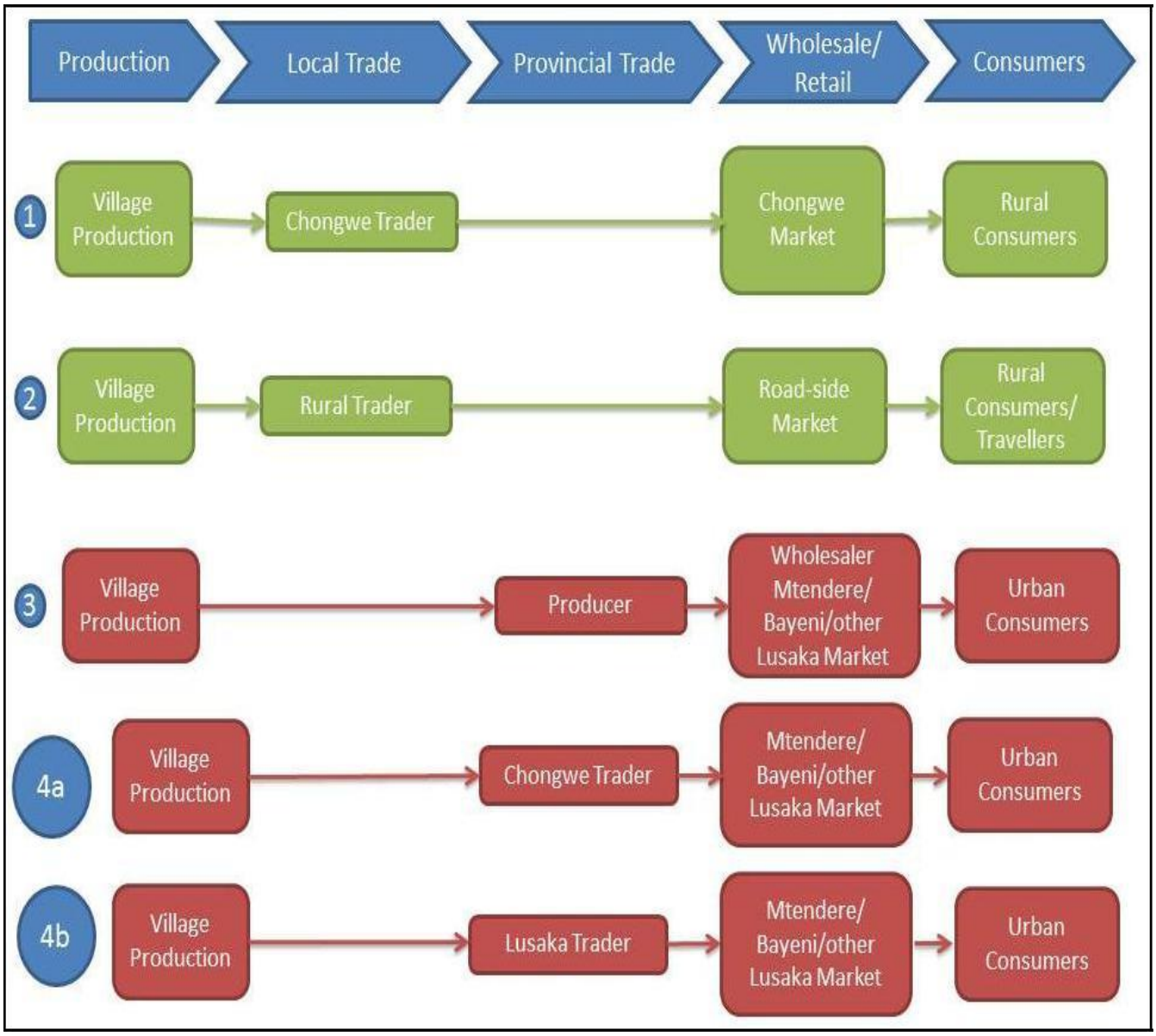
[38] Gumbo, D.J., Moombe, K.B., Kandulu, M.M., and Kabwe, G., (2012). The Dynamics of Charcoal and Indigenous Timber Trade in Zambia*: A Scoping Study in the Eastern, Northern and North-western Provinces of the Country.*

[39] Mulombwa, (1998). Woodfuel review and assessment in Zambia. Data Collection and Analysis for Sustainable Forest Management in ACP Countries - Linking National and International Efforts

[40] Mwitwa, J., Makano, A. (2011). *Charcoal Production, Demand and Supply in Eastern Province and Peri-urban Areas of Lusaka*, USAID Report.

[41] Holm-Nielsenae J.B., T. Al Seadib. P. Oleskowicz-Popielc. (2009). The future of anaerobic digestion and biogas utilization. *Bioresource Technology* 100: 22, 5478-5484 https://doi.org/10.1016/j.biortech.2008.12.046

APENDIX I


Production
Local Trade
Provincial Trade
Wholesale/ Retail
Consumers
1
Village Production
Chongwe Trader
Chongwe Market
Rural Consumers
2
Village Production
Rural Trader
Road-side Market
Rural Consumers/ Travellers
3
Village Production
Producer
Wholesaler Mtendere/ Bayeni/other Lusaka Market
Urban Consumers
4a
Village Production
Chongwe Trader
Mtendere/ Bayeni/other Lusaka Market
Urban Consumers
4b
Village Production
Lusaka Trader
Mtendere/ Bayeni/other Lusaka Market
Urban Consumers

APENDIX II

Wheelbarrow for transporting Charcoal

Photo caption: Kamwala Market Lusaka, 2017

Bicycle transport for Charcoal

Photo caption: Chongwe, 2017

Photo caption: Chongwe, 2017

Lorry transporting Charcoal to Lusaka

Photo caption: Great East Road, 2017