

**Material Flow Analysis of wood fuel in small urban areas:
The case of Tsumeb, Namibia**

by
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DECLARATION

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March, 2012

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ABSTRACT

The current ways in which the human population continues to utilise natural resources in order to satisfy their lifestyle remains unsustainable. One such activity is the use of biomass resources mainly for cooking, heating and boiling water which sustains an estimated 2.4 billion people living in developing countries. Biomass not only is the fourth largest energy source after coal, oil and natural gas, but it is currently the largest renewable energy option and yet it has received minimal attention especially from current energy debates in developing countries. Literature shows cases of cities that remain 'uncertain' of their development agendas (regarding energy). The uncertainty is a result of most cities relying heavily on fossil fuel which is in most cases imported which minimises the possibilities of cities to come up with sustainable energy projects. As cities continue to grow the supply of this unsustainable energy puts cities in an uncertain position regarding the future energy sources of their cities. There are cities that have now realised the importance of understanding the flow of wood fuels in order to put in measures that can help manage the resource better. Most of them use a GIS-based tool, Wood fuel Integrated Supply Demand Overview Mapping Model (WISDOM) which was developed to analyse the wood fuel supply and demand spatial patterns. Tsumeb is currently also moving in an 'uncertain' direction especially when it comes to the energy needs of the town characterised by high electricity tariffs, increased population leading to clearing of land, high unemployment rate and distorted priorities (of the municipality).

The Material Flow Analysis (MFA) of wood fuels in Tsumeb is highly dominated by the informal sector. It remains unregulated and no attempt has been made to determine the household energy flow. This study is the first attempt to determine the flow of this very important household energy resource used more especially in winter. The survey revealed that firewood is used to prepare one to two meals a day especially in the townships where the households opt to consume one meal a day. Some consumers collect their own firewood and often have to purchase wood fuels to meet their individual needs. The wood fuel retailers that were surveyed in the study obtain their wood fuels from local commercial farmers and use charcoal produced both in Namibia and South African. The commercial farmers also form part of the informal sector as they supply some of the informal suppliers and consumers. Some informal suppliers resort to open forests located far from their homes, putting a lot of strain on the transport mechanisms. In order to ensure a sustainable supply of household energy in Tsumeb, it is inevitable that a new paradigm is needed in the current planning and development process of the town.

Therefore for an effective implementation of policies aimed at developing wood fuels, local conditions as well as the local wood fuel flows must be understood, grassroots initiatives need to be built and community participation should be encouraged in order to get a collective approach to issues that concerns and threatens their livelihoods.

OPSOMMING

Die wyse waarop die mensdom natuurlike hulpbronne aanwend om aan die eise van hul leefstyl te voldoen, bly onvolhoubaar. Een sodanige aktiwiteit is die gebruik van biomassahulpbronne, hoofsaaklik vir kosvoorbereiding en ruimte- en waterverhitting. Biomassahulpbronne onderhou 'n geraamde 2,4 miljard inwoners van ontwikkelende lande. Dit is nie net die grootste energiebron naas steenkool, olie en aardgas nie, maar is ook tans die belowendste bron van hernubare energie. Tog ontvang dit weinig aandag.

Hoewel literatuur steeds merendeels oor gevalle handel wat 'onseker' is oor hul ontwikkelingsagendas, is daar tóg diegene wat uiteindelik besef hoe belangrik dit is om die vloei van houtbrandstof te begryp ten einde maatreëls te tref om dié hulpbron beter te bestuur. Die meeste van hierdie lande gebruik 'n GIS-gebaseerde instrument, naamlik die WISDOM-model ("Wood-fuel Integrated Supply Demand Overview Mapping"), wat ontwikkel is om die ruimtelike patrone van houtbrandstofvraag en -aanbod te ontleed.

Die Namibiese stad Tsumeb is een van die 'onsekeres', veral wat sy energiebehoefte betref, en word gekenmerk deur hoë elektrisiteitstariewe, 'n groeiende bevolking wat al hoe meer ontbossing tot gevolg het, hoë werkloosheidsyfers en verwronge prioriteite. Die materiaalvloeiontleding wat in hierdie studie met betrekking tot die houtbrandstof in Tsumeb onderneem is, word in 'n groot mate deur die informele sektor oorheers. Hoewel die gebruik van houtbrandstof steeds ongereguleerd is, is geen poging tot dusver aangewend om die vloei van dié uiters belangrike huishoudelike energiebron, wat veral in die wintermaande gebruik word, te bepaal nie. Die opname het getoon dat brandhout gebruik word om een tot twee maaltye per dag te berei, veral in die townships waar die huishoudings meestal een keer per dag eet. Party verbruikers maak hulle eie brandhout bymekaar, maar moet steeds bykomende hout koop om in ál hulle behoeftes te voorsien. Die houtbrandstofhandelaars wat aan die opname deelgeneem het, bekom hul houtbrandstof van plaaslike kommersiële boere en van Namibiese sowel as Suid-Afrikaanse houtskoolverskaffers. Die kommersiële boere maak ook deel uit van die informele sektor, aangesien hulle sommige informele verskaffers en verbruikers van brandstof voorsien. Van die informele verskaffers wend hulle tot die plaaslike oop woud wat ver van hulle huise geleë is, en plaas sodoende heelwat druk op vervoerstelsels.

Die enigste manier waarop Tsumeb sy huidige energie-onsekerheid te bowe kan kom, is deur 'n nuwe benadering tot houtbrandstof in te stel. Om beleid met betrekking tot die ontwikkeling van houtbrandstof doeltreffend toe te pas, moet plaaslike omstandighede sowel

as die plaaslike vloei van houtbrandstof dus beter begryp word; moet inisiatiewe op voetsoolvlak tot stand gebring word, en moet gemeenskapsdeelname aangemoedig word. Sodoende sal die mense van Tsumeb – huishoudings, owerhede én ondernemings – gesamentlik kan reageer op kwessies wat hul bestaan beïnvloed en bedreig.

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List of acronyms

CEO	Chief Executive Officer
DRFN	Desert Research Foundation of Namibia
EJ	Exajoules
IEA	International Energy Agency
FAO	Food and Agriculture Organisation of the United Nations
GHG	Green House Gases
J	Joule
Kg	Kilogram
Km	Kilometres
KWh	Kilowatt hour
LPG	Liquid Petroleum Gas
LCA	Life Cycle Analysis
MET	Ministry of Environment and Tourism
MFA	Material Flow Analysis
MJ	Mega Joule
MME	Ministry of Mines and Energy
MW	Mega Watt
MWh	Mega Watt Hour
NamPower	Namibian Power Cooperation
NAPCOD	The National Programme to Combat Desertification
OGEMP	Off-grid Energisation Mater Plan
REEECAP	Renewable Energy and Energy Efficiency Capacity building programme
REEEI	Renewable Energy and Energy Efficiency Institute
SD	Sustainable Development
UN-HABITAT	United Nations Human Settlement Programme

DEFINING THE KEY TERMS

The various terms that might occur repeatedly in this thesis are defined below.

Biomass - It is a renewable energy resource, it includes all the water as well as land based vegetation and trees and waste biomass such as municipal solid wastes (Balat & Ayar, 2005)

Charcoal - Converted from wood through the process of pyrolysis which involves the slow heating of wood in the absence of oxygen (de Miranda *et al.*, 2010: 2).

Firewood - Is used directly after harvesting and does not undergo any conversion (de Miranda *et al.*, 2010: 2).

Fuelwood - Include the free gathering of wood in various forms such as scrap wood, wood Wastes from construction sites, woodcraft, lumber yards, landfill or garbage sites including non woody biomass (FAO,1993: 14)

Material Flow Analysis - “Systematic assessment of the flows and stocks of materials within a system defined in space and time” Brunner and Rechberger (2004) in Zumbuehl (2006: 16). It involves the harvesting of wood from the tree until it reaches the end user (FAO, 1996).

Primary fuelwood - Any woody biomass fuel that originates directly from felled trees (FAO, 1993: 14).

Wood fuel - Wood fuel in this thesis denotes both fuel wood otherwise known as “firewood” and charcoal (de Miranda *et al.*, 2010).

Wood fuel flows - The FAO (1996: II) defines wood fuel flows as the mechanisms in which the wood that has been harvested from a tree reaches the consumers as a fuel (FAO, 1996: ii).

CHAPTER 1: Introduction and Background

1.1 Introduction

This chapter describes the background of the research. The chapter also provides reasons why this research needed to be carried out. The various objectives of the research as well as the questions that were explored in order to achieve those objectives are also introduced. The chapter closes with a schematic representation of how the thesis is structured.

This research attempted to establish the wood fuel flow trends in the town of Tsumeb in Namibia by using the Material Flow Analysis (MFA) approach. The mechanisms of how wood fuels flow can be quite complex and can vary based on the season, source or origin which will in turn determine the quality of the wood fuel. The distribution systems of moving wood from the source to the end user may differ from very simple to elaborated systems. For example wood that has been collected for sale may have intermediaries compared to wood collected for own use. The more intermediaries there are the more difficult it becomes to trace the flow of wood fuels as many changes can be made along the way (FAO,1996: 9). It is much more difficult to quantify the amount of non forest wood fuels removed, especially where relatively small quantities are involved compared to the removal of larger quantities where permits are required (FAO,1996: 10).

In order to thoroughly understand these mechanisms various things need to be studied and understood. These include: wood fuel sources (by establishing whether the wood fuel comes from forest or non-forest areas), harvesting, transporting, trade, markets and identifying the various stakeholders involved (FAO, 1996: ii). Therefore for an effective implementation of policies aimed at developing wood fuels, local conditions as well as the local wood fuel flows must be understood (FAO, 1996: ii).

There are several aspects of wood fuels which the researcher finds extremely fascinating:

1. Wood fuels are often informal and unregulated although the majority of the people are dependent on it for their livelihoods (Chambwera, 2004: 3).
2. Unlike other forms of energy (fossil fuels) wood fuels are unique in that their localised markets are different from one town to another (FAO, 1996: ii).
3. The increasing scarcity of this important source of energy has become a major concern, especially in developing countries. The scarcity is believed to be as a result

of the increase in human population, market, policy failures¹ and demand outstripping sustainable supply. The increasing influx of people into urban areas places a great strain on the local authorities as they have to provide basic urban services such as housing, energy, water and sanitation, as well as ensure environmental sustainability. A majority of these people usually do not have enough money to own decent² housing and often inhabit the informal settlements of the town. Although wood fuel remains the most affordable energy option for the majority of urban dwellers in developing countries, the current spatial patterns of biomass demand and supply are not well understood, which has prevented appropriate design of national strategies for sustainable biomass energy use and exploitation (Drigo & Salbitano, 2008: ix; Kgathi *et al.*, 1997: 1; Zulu, 2009).

It is almost impossible to come across a household that does not have an outside fire place in Tsumeb. This scene is more prominent during the winter evenings. Shackelton *et al.* (2004) conducted a wood fuel study in South Africa and confirmed that most electrified urban households seldom use electricity for cooking. They added that the use of electricity mainly depends on the income levels of the households, as well as the availability and cost of the alternative fuels. Electrified households also tend to continue using wood fuel, not only because of its affordability or that it is freely available, but sometimes also due to cultural reasons³. According to Daurella & Foster (2009: 5) only about 3 to 4 % of the households uses electricity for cooking in Sub-Saharan Africa. According to the Atlas of Poverty for Namibia that was published in 2011, about 25% of the Namibian population used electricity for cooking in 2001, with Oshikoto region (where Tsumeb is located) making up 9% of the total figure (Central Bureau of Statistics, 2011: 36). Wood fuel has also become a very important fall-back resource once funds to purchase electricity and conventional fossil fuels (such as gas and paraffin) start to diminish (Shackelton *et al.*, 2004: 1,5).

¹ Shackleton *et al.* (2004: 13) argue that the management of wood fuel resources has failed because the various roles and rights of local authority and traditional authority were not clarified. Therefore, in order to manage wood fuel resources sustainably, there is a need to identify the various responsibilities and roles of all the stakeholders' involved (Shackleton *et al.*, 2004: 13).

² House of an acceptable standard and quality.

³ There seem to be a belief that food prepared using wood fuels tastes and smells better than those cooked using modern fossil fuels. Also, in some cultures, there is the belief that a fire wards off bad spirits.

Wood fuels especially the use of firewood, is perceived as primitive and inferior compared to the so called 'modern' fossil fuels, which most often compel consumers to be at the mercy of international demand and supply forces which they have no control over. Wood fuel use is also viewed as a rural area phenomenon thus data on the use of wood fuel in urban areas is often not available or not properly documented (Foley, 1985: 256).

The management of material flows is only recently receiving adequate investigation. This is mainly driven by the realisation that a constant supply for the growing wood demand calls for change towards a more efficient use and the conservation of natural resources, including energy. (Guy and Marvin, 1996; in Guy & Marvin, 2001: 22). The same authors argue that the interrelationships between production and consumption brought about by the changing social dynamics in the urban areas need to be understood. Guy and Marvin (2001: 23) also identified two conventional approaches to materials flowing through cities, which are centred on two views. The first one is the production-focused image, with intervention and analysis focused on physical place. The second one is the consumption-focused image, which gives attention to the social shaping of environmental choice (Guy & Marvin, 2001: 23). According to Masera *et al.* (2006) 60 % of the world's biomass is used solely for energy. It is important to note that 80% of this biomass is used for energy needs of the developing countries, accounting for 15% of the primary energy consumption (Masera *et al.*, 2006). The estimates of the International Energy Agency (IEA) show that about 2.4 billion people living in developing countries are fully dependent on wood fuel for cooking, heating and boiling water. Biomass energy accounts for almost 10 % of the approximately 500 Exa joules (EJ)⁴ of primary energy consumed globally. It is further reported that more than two thirds of this biomass energy is used for cooking and heating more especially in developing countries. The remainder is consumed in industrialized countries for industrial applications within the heat power and road transportation sectors as well as for the heating purposes of the private sector (WEC, 2004). The global potential of sustainable biomass for energy report also showed that in 2006, biomass was not only the fourth largest energy source after coal, oil and natural gas, but it is currently the largest renewable energy option (Ladanai *et al.*, 2009: 1-10; Balat & Ayar, 2005). This comparison is depicted in Figure 1.1 below.

⁴ 1 Exajoule = 1.0E+18 Joules

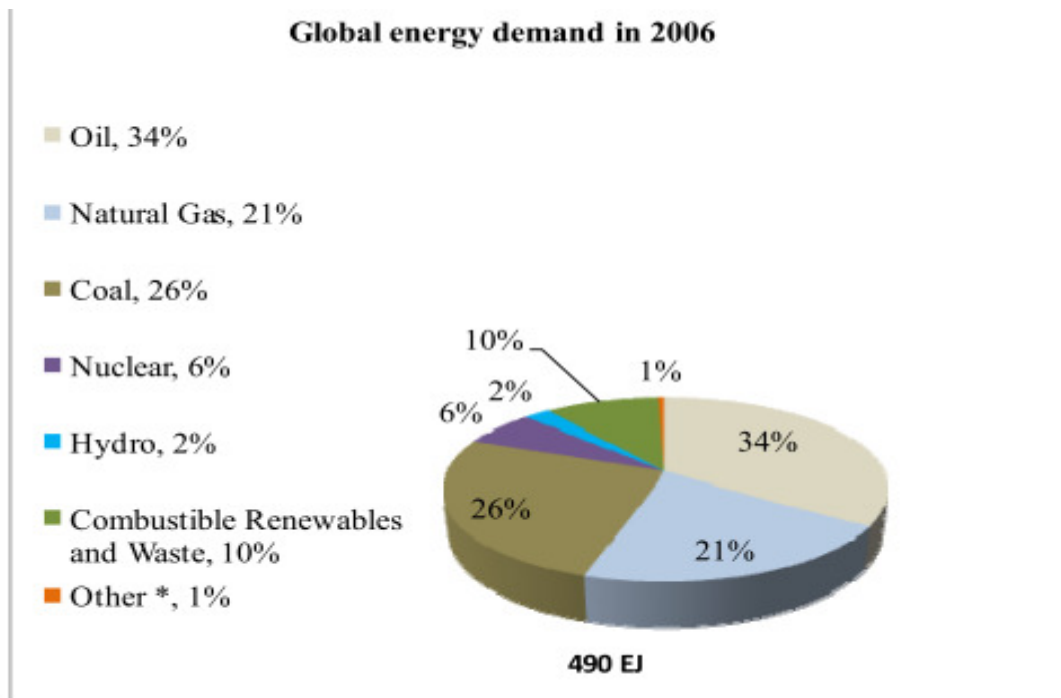


Figure 1.1 Global energy demands in 2006 (IEA,2008)

1.2 The development of the research topic

The interest in renewable energy started when the researcher completed the Bachelor of Science Degree in Environmental Science. It was after this degree that she became an intern at an environmental consulting company. She was required to assist in searching for literature on sustainable energy solutions and came to realise that the use of wood fuels continues to dominate a majority of households particularly in Africa even though modern energy sources (from fossil fuels) received more priority. This important primary energy resource also remained to a greater extent informal and unregulated, while its needs continued to increase and markets in urban centres continued to thrive. The interest endured when she became a Project Officer at the Renewable Energy and Energy Efficiency Institute (REEEI). It was at this institute that more literature on renewable and sustainable energy solutions specifically for Namibia was accessed and understood. She also had an opportunity to fire a 6KWe System Johannson⁵ wood gasifier demo unit which used wood blocks to generate electricity.

⁵ South African Manufacturer



Figure 1.2 6KWe System Johansson wood gasifier demo unit

The same institute allowed her to participate in the National Biomass Symposium. This symposium gathered stakeholders who had an interest in the sustainable use of wood fuels and identified how the Namibian biomass conservation strategy can be attained. The symposium toured the participants to various bush encroached areas and visited charcoal and briquettes producers as well as wood efficient stoves manufacturers. It was through this tour that the researcher was convinced that energy challenges still continue to have the most serious impacts on poorer communities.

It is evident that more than half of the population in Tsumeb rely on wood fuels particularly the use of fire wood for cooking and heating. This important energy source continues to receive minimum attention despite the fact that the majority of the population is dependent on it. The researcher also thought that there is a great opportunity for the use of the invader bush within the town of Tsumeb to solve the biomass scarcity problem. Therefore the initial research topic was the use of Multi Criteria Decision Analysis (MCDA) to analyse the implication of introducing small scale wood gasification plants in bush encroached areas of Namibia to generate electricity. The Government of Namibia places a lot of emphasis on rural electrification. The researcher is of the opinion that national, regional and local developmental agendas should be in line with one another. Given the policy position of the government of promoting electrification, it helps to understand what the community view as important: do they prefer to have electricity, firewood or both?

After several brainstorming sessions with the supervisor it was agreed that the most immediate need for energy was mainly for cooking and heating. Escalating energy costs also meant that the use of wood fuels will continue to increase. It is for this reason that the researcher together with the supervisor decided to refine the research topic and rather carry out a Material Flow Analysis of wood fuels in the town in order to help quantify the wood fuel

use and explore the whole value chain and ascertain what measures are in place to ensure that the biomass resource is being used sustainably.

1.3 Rationale of the study

The following reasons motivate the importance of this research:

- There is evidence that wood fuels constitute a major energy source in the town of Tsumeb especially for domestic purposes.
- Most wood fuel studies have given little consideration to the effect of urban wood fuel demand and supply. Previously the use of wood fuels has been regarded as a rural option; this has in most cases discouraged the studies focusing on the commercial organisation of the wood fuel industry in urban areas as well as the role of wood fuel in the development process.
- Very little information is known on the exact contribution of wood fuel to the total energy use in the town. The results of the study will form a good basis for preliminary discussions and assist decision makers (local authority) to make meaningful future interventions.
- Urban areas are supplied with "modern" fuels from fossil fuels, which are not environmentally friendly and often expensive.
- The use of wood fuels has been regarded as one of the fundamental causes of deforestation without looking at the situation holistically, such as considering the clearing of land for housing (urban sprawl and developmental purposes) and agricultural production.
- Tsumeb falls within the high density invader bush area of Namibia (de Kerk, 2004: xii). There is a growing need for wood fuel in the town and the resource that can meet that need is readily available and being viewed as a nuisance because it took over grazing land.
- Tsumeb is one of the very few towns with abundant water resources, fertile and available land (Tsumeb Municipality, 2008). Tsumeb being in the region with high densities of invader bush in the country, means that it is affected by the unsustainable invader bush control methods that pose major threats to the environment and the lowering of its water resource (DRFN, 2007 and de Klerk, 2004: xii).
- The majority of the population in Tsumeb reside in the township which is made up of both the formal and informal settlements. Most of these people fall in the low income household bracket and mostly use wood fuel as their primary source of energy.

- The mushrooming informal settlement residents use wood fuel as a predominant source of energy.
- The electricity tariff in Tsumeb is the second highest in the country at N\$/kWh⁶ 1.63. (2011 tariff) In terms of affordability this makes wood fuel cheaper, given the future escalating electricity prices from fossil fuels⁷.
- There is very little emphasis being placed on the sustainable utilisation of wood fuels in urban areas.

1.4 Research problem statement

Energy is a fundamental aspect of development and forms the central part of social, environmental and economic challenges. Globally most governments are now looking at locally available renewable and alternative energy options (FAO, 1993). This is due to the increasing fossil fuel prices, climate change and the need for energy security. A majority of the residents in Tsumeb rely heavily on the use of wood fuel for their energy needs. While this forms an important part of the total energy used in the town, its distribution channels have not been studied nor well understood. This however poses threats to the surrounding environment and does not allow for appropriate planning and sustainable management of the biomass resources which sustain the majority of the residents.

1.5 Research objectives and questions

According to Mouton (2001: 55) an appropriate research design is one that is able to best answer the formulated research questions (Mouton, 2001:55). In order to satisfy the objectives that were set out, the following research question in table 1.1 has been formulated:

⁶ A kWh describes how much power is being used over an hour (Yorwoods, 2008).

⁷ The Electricity control board of Namibia (ECB) is responsible for regulating electricity tariffs in the country. The end user electricity cost mainly comprises of the generation cost, transmission cost, distribution costs from the Central Red (CENORED) plus a local authority surcharge (tax from the local authority to allow them to cross subsidise their other services due to a lack / little fund from central government) (von Seydlitz, 2008: 25, 31).

Table 1.1 Reserch objectives and questions

Research objectives	Research Questions
1. Understand the energy market in Tsumeb (electricity, gas and the use of wood fuels)	What is the primary energy supply and demand situation in Tsumeb?
2. Build an understanding of the current wood fuel flow in the town of Tsumeb	Who are the role players in the biomass and biomass derivatives value chain ?
3. Identify how the wood fuel channels can be optimised to serve all the stakeholders better by utilising the MFA framework?	How can the wood value fuel chain be optimised?
4. Identify the opportunities that exist in order to create a market for the excess biomass material from the invader bush in the surrounding areas	What market opportunities exist in order to utilise the excess invader bush?
5. Assess measures that will lead to the formulation of sustainable wood fuel strategies in the town of Tsumeb	What strategies can be adopted to create a sustainable wood fuel flow in an urban and peri-urban environment?

1.6 Importance of the research problems

Wood fuel is a cross-cutting issue; it cuts through sectors such as energy, agriculture and forestry. Its complex nature has left wood fuel issues unattended mainly due to the involvement of multiple players. The study provides the local authority with a clear picture of the Material Flow Analysis (MFA) of wood fuels in the town. This will allow them to manage the biomass resource properly in order to support the wood fuel dependent residents of the

town. The study also raises awareness amongst the consumers, as well as the suppliers, of the importance of biomass conservation and the efficient use of biomass. It further brings to the scene the various stakeholders who were not only previously neglected or unknown but who might play very important roles in the use and planning of wood fuels in the town. The preliminary discussions that might be initiated as a result of this study will meet government developmental agendas half way by contributing to the aims and objectives of the government decentralisation policy.

1.7 Literature review

The research approach included a comprehensive literature review in order to establish what has been done and identified the various strategies that have been employed. The literature showed both the current existing trends and also gave insight on wood fuel use. The literature review attempted to provide an overview of the status of wood fuel flows and their impacts in the future. This section will provide the context for the research and help develop the arguments that will follow later on.

The literature analysis started off with broad readings of work done along the lines of wood fuel flows in urban areas as well as other sources with a bearing on the research topic and refined the search as the researcher went along to yield more precise and specific work. The researcher also used bibliographies of the documents that were reviewed in order to locate more relevant documents. According to Huysamen (1994), the first step to identifying the relevant literature for a particular subject is to list down keywords under which the research to be taken will be classified in the library search catalogue and internet search engines (Huysamen, 1994:190). The different keywords used during this study are listed in Table 1.2 below.

Table 1.2 key words used in the literature search engines

Subject	Key words
Sustainable use of wood fuels	Wood fuels, fire wood, charcoal, briquettes, urban energy use, urban energy policies, energy in Namibia
Material Flow Analysis (MFA)	MFA of wood fuel, MFA of wood fuel in urban areas, energy and urban areas, household energy
Unsustainable use of wood fuels	Inequality, poverty, informal settlements, fossil fuels,

1.8 Limitations of the study

It was not possible to survey all the households within the town due to the time constraints to complete the thesis. Therefore a sample was drawn from the total population which was believed to be a true representation of the total population.

Very few suppliers showed interest in the study. This observation was made when the researcher realised that some of the suppliers would continuously send her back to collect the questionnaire at a postponed date and would attempt to rush in completing the questionnaire once they have realised that the researcher has again pitched to collect the questionnaire. It is also assumed that confidentiality issues especially when it comes to their main suppliers (specifically fire wood suppliers in unlabelled bags) might have been a factor. This made it difficult for the researcher to follow up the supply chain. Rushing to complete the questionnaire could result in providing information that is not thought through and might be estimates which are far from the exact information. Although the researcher is originally from Tsumeb and understood the social dynamics in the town, MFA is a rather more complex and dynamic study which requires a thorough understanding of the entire system within a limited time frame. Although the time allocated to study this system was limited valuable relationships were established with the relevant stakeholders who had insights and information thus fast tracking the learning process.

1.9 The outline of the remainder of the thesis

Figure 1.3 below summarises the scope of the study and the outline of the remainder of this document.

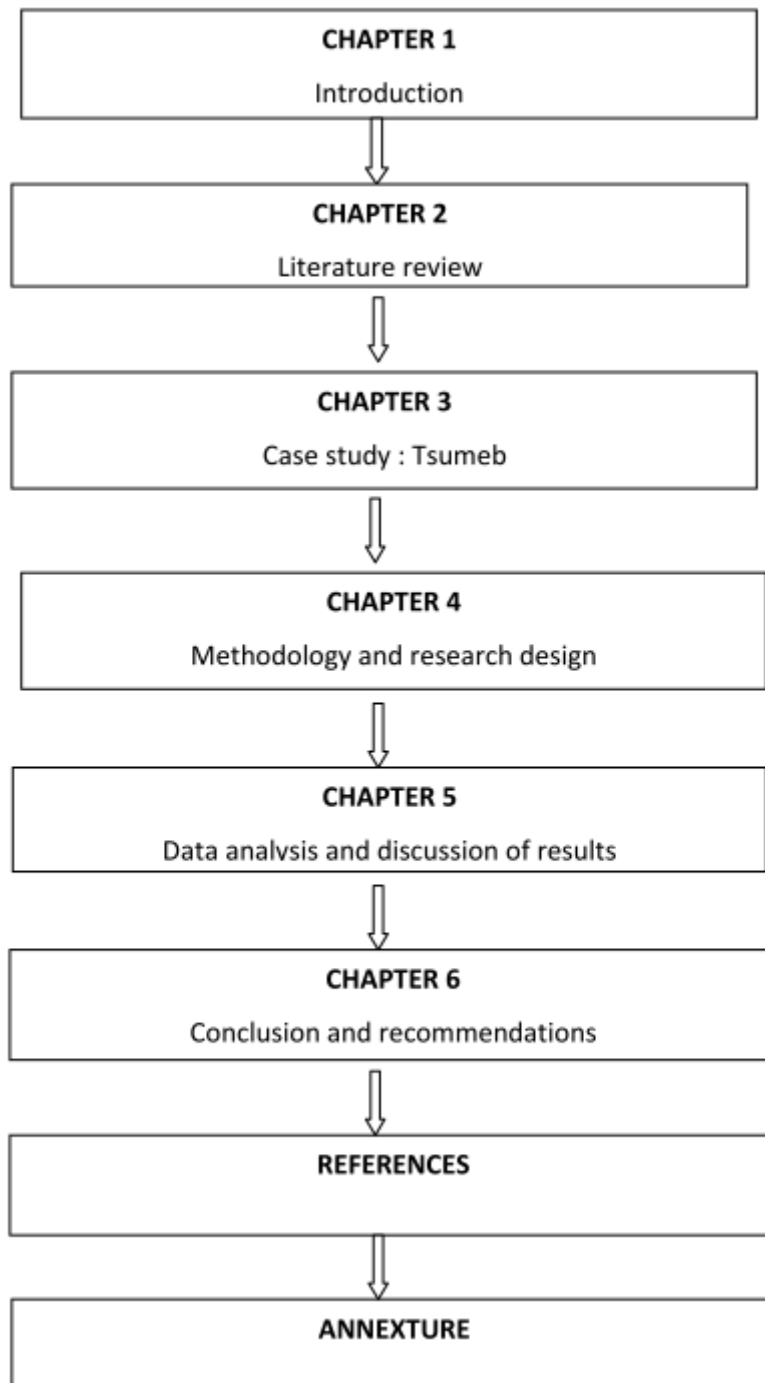


Figure 1.3 Schematic Outline of the thesis

Chapter 2: Literature review

The reviewed literature is presented in this chapter. The chapter starts off with the Sustainable Development (SD) discourse. It looks at the rates of urbanisation in Africa and Namibia in particular. The importance of wood fuels as a primary source of energy is highlighted. Household energy demand and fuel switching is also discussed. Two arguments linking wood fuel and deforestation are identified and discussed. Material Flow Analysis is introduced. Its strengths and limitations are explored. Possible solutions to wood fuel challenges are discussed in order to formulate sustainable wood fuel management strategies. Current sustainable wood fuel management options being employed will round up the chapter. A theoretical framework was developed from the reviewed literature and formed a basis of the argument that will be developed in chapter five and six.

Chapter 3 Case study: Tsumeb

Chapter 3 gives a brief background of the Namibian energy situation. It further outlines the current energy and biomass policy and legal frameworks in place. The chapter also gives an overview of Tsumeb and some of the municipality activities relevant to the subject. The first objective (Understand the energy market in Tsumeb) of the research is addressed in this chapter. It is addressed by briefly looking at the primary energy in Tsumeb, in order to understand the overall energy supply and demand situation and establish how wood fuels fit in.

Chapter 4: Methodology and Research design

This chapter explains the research methodology in more detail. The method that was used to establish the sample for the research is also explained. The research instruments used to generate data for the research includes questionnaires and open-ended / semi-structured questionnaires for both the consumers and suppliers of wood fuel. The procedure that was used to generate the data will be explained in more detail.

Chapter 5: Data analysis and discussion of results

This chapter will present the results of the survey that was carried out during the study. This chapter responds to four out of five research objectives. In response to research objectives 2 (Build an understanding of the current wood fuel flow in the town of Tsumeb) and objective 3 (Identify the opportunities that exist in order to create a market for the excess biomass material from the invader bush in the surrounding areas), a detailed wood fuel flow of Tsumeb will be presented based on the responses from the wood fuel suppliers and the consumers. It is from this flow that a foundation for making recommendations in Chapter 6 will be built. Responses to research objective four (Identify how the wood fuel channels can

be optimised to serve all the stakeholders better by utilising the MFA framework) will also be discussed. Research objective 5 (assess measures that will lead to the formulation of sustainable wood fuel strategies in the town of Tsumeb) will close off the discussion of results.

Chapter 6: Conclusion and recommendations

The final chapter will reintroduce the research objectives and study questions as outlined in chapter one in order to ensure that the objectives have been achieved. The chapter will further coherently link the various aspects of the thesis in order to come up with a round up conclusion and conclude by revisiting the research findings and outline the various recommendations.

CHAPTER 2: Literature review

2.1 Introduction

According to the World Energy Council (WEC), over two-thirds of the world's electricity continues to be derived from fossil fuels. The use of renewable energy has been picking up very slowly, the bulk of renewable energy is made up of hydropower and this is expected to remain so for the next decades with an increase of 60%. Biomass energy also contributes immensely to the global renewable energy mix followed by wind, geothermal and solar energy as depicted in figure 2.2. Natural gas on the other hand is expected to add to the generation, coal is still the major source of energy when it comes to electricity generation. (WEC, 2005: 42) Figure 2.1 below shows the world's electricity generation by fuel.

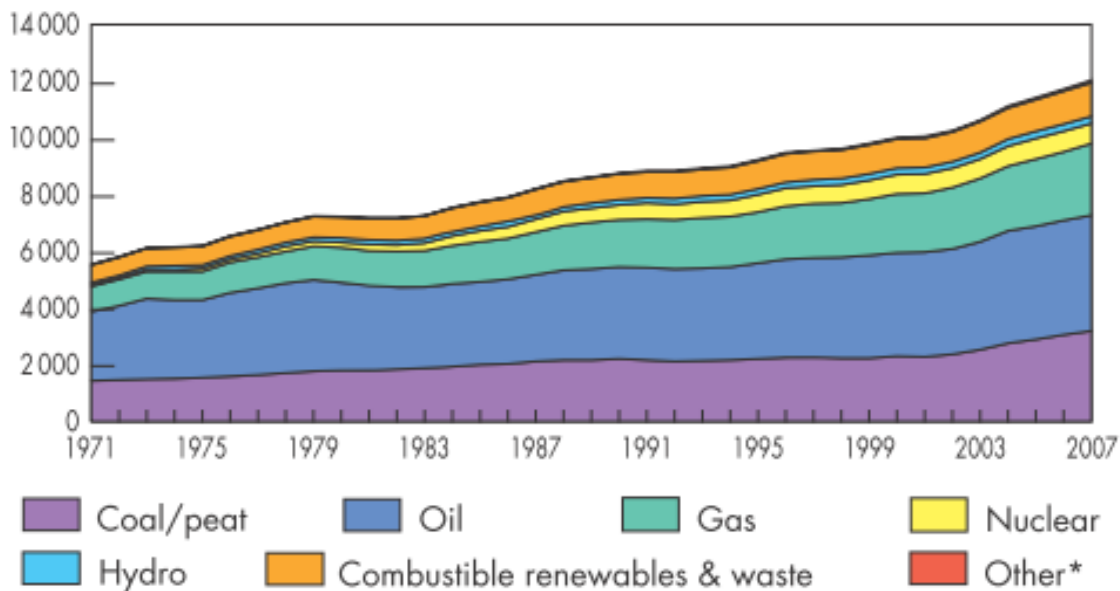


Figure 2.1 World total primary energy supply by fuel (Mtoe) (Source: EIA,2006: 6)

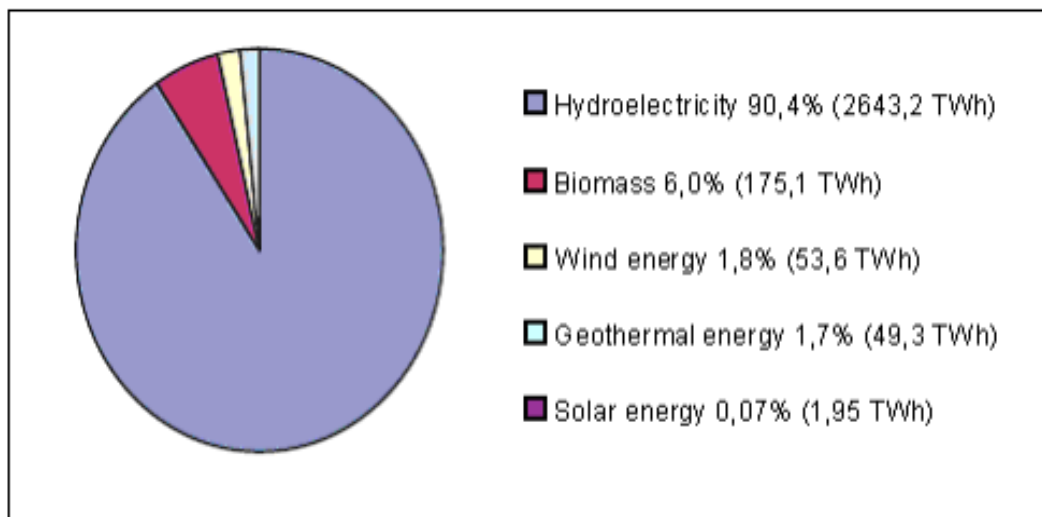


Figure 2.2 The world production of renewable energy in 2001 (Source: IEA, 2004)

The WEC (2005) shows that in most countries especially the developed nations, vegetable oil crops are mainly used as feedstock to produce liquid biofuels. Currently, the global biomass supply is about 50 EJ which makes up about 10% of the global annual primary energy consumption constituting mainly of traditional biomass which is used mainly for cooking and heating. The estimated global primary energy needs by 2050 will be in the range of between 600 to 1000 EJ, compared to approximately 500 EJ in 2008 (WEC, 2005: 360).

Looking at the various scenarios that have been forecast for the penetration of low carbon energy sources, the future need for bio energy is estimated to be up to 250 EJ/yr. The WEC, argues that “these projections fall well within the sustainable supply potential estimate” (WEC, 2005: 360). Therefore between a quarter and a third of the future global energy mix can be contributed sustainably through the use of biomass. A majority of people living in developing countries uses wood fuel as a primary source of energy (Foley, 1985: 253; Abbot & Jimmy, 1998; WEC, 2004: 250), this finding has been confirmed by the position paper on biomass for the ACP-EU Energy facility, which showed that biomass remains the oldest as well as the most common source of energy today in Africa, Caribbean as well as the Pacific countries. Africa is known to be the world’s largest biomass energy consumer through the use of firewood, agricultural residues, animal wastes (Hosier & Milukas, 1992).

About 61% of the world’s total wood that is removed is used mainly for energy. Only about 24.7% of the wood produced in developed countries is used for energy, wood used for

energy in developing countries reaches about 83%. In Africa the wood-fuels percentage of the total wood consumption is 91%, while in Asia it is 82% and in Latin America 69% (WEC, 2004: 252). Looking at the worldwide level only about two-fifths of the existing biomass potential is used and in most areas of the world the current biomass use is below the available potential, with Asia's current use exceeding the available potential (Parikka, 2003). Table 2.1 shows the percentage of the population of a given country that uses biomass for cooking in Sub-Saharan countries in 2004.

Table 2.1 The percentage of the total population using biomass for cooking in 2004 in Sub-Saharan Africa (Source: World Energy Outlook,2006)

Region	% total population (million in brackets)	% rural population (million in brackets)	% urban population (million in brackets)
Sub-Saharan Africa	76 (575)	93 (413)	58 (162)
North Africa	3 (4)	6 (4)	0.2 (0.2)
India	69 (740)	87 (663)	25 (77)
China	37 (480)	55 (428)	10 (52)
Indonesia	72 (156)	95 (110)	45 (46)
Rest of Asia	65 (489)	93 (455)	35 (92)
Brazil	13 (23)	53(16)	5 (8)
Rest of Latin America	23 (60)	62 (59)	9 (25)
Total	52 (2,528)	83 (2,147)	23 (461)

In developing countries, 80% of the biomass that is harvested is used for energy, accounting for 15% of the primary energy consumption. 70% of all the biomass in the world is used in the residential sector, while 14% is used in industry and 11% is transformed into electricity, heat or another energy carrier such as liquid fuel or biogas (Masera *et al.*, 2006).

Estimates by the International Energy Agency (IEA) shows that about 2.4 billion people living in developing countries are fully dependent on wood fuel for cooking, heating and boiling water. Figure 2.3 below shows the global trends in wood fuel consumption.

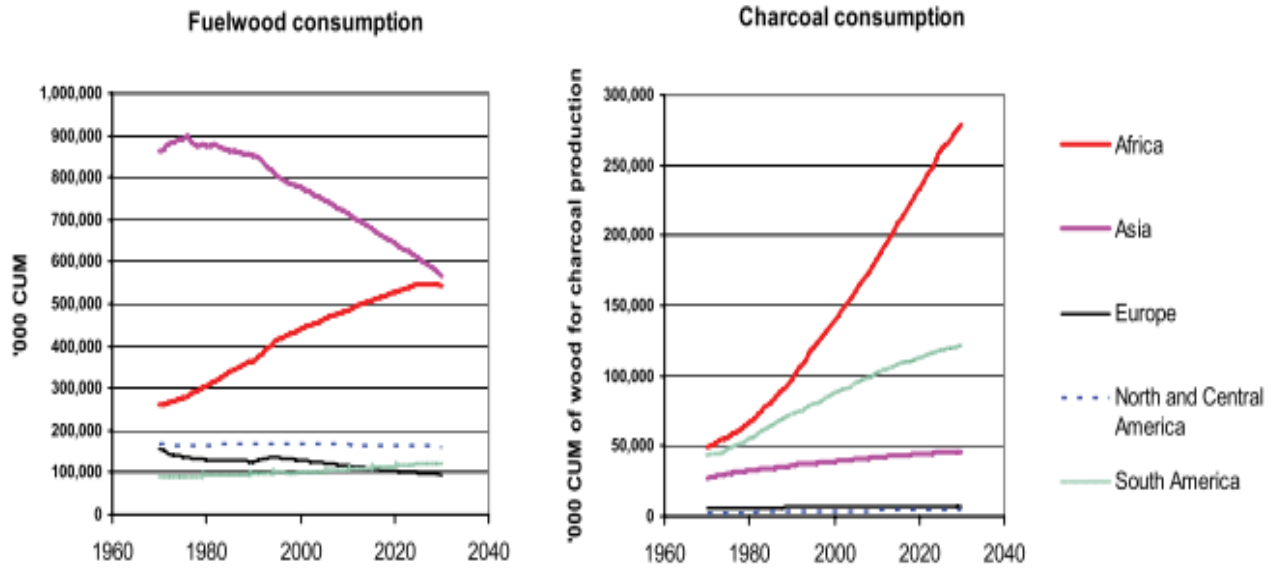


Figure 2.3 Global fuelwood and charcoal consumption by region 1970 –2030 (Source: FAO,2001a)

Although there is a decrease in the use of fuelwood in all the regions, Africa seems to be the only continent where the use of fuelwood is on the increase and the demand is expected to increase until 2025. There is a marked increase in the use of charcoal in all the regions, with Africa and Latin America topping the list. A pronounced shift from fuelwood to charcoal is being observed in Africa. The growth in charcoal demand in Africa is primarily as a result of urbanisation and this demand is expected to double in 2030 (WEC, 2004: 250).

There is a marked increase (see Figure 2.4 below) in the consumption levels and expected trends of fuelwood and wood used for charcoal in African subregions. The tropical subregions: East Sahelian, West Moist, Tropical southern and Central African countries has the highest charcoal consumption levels.

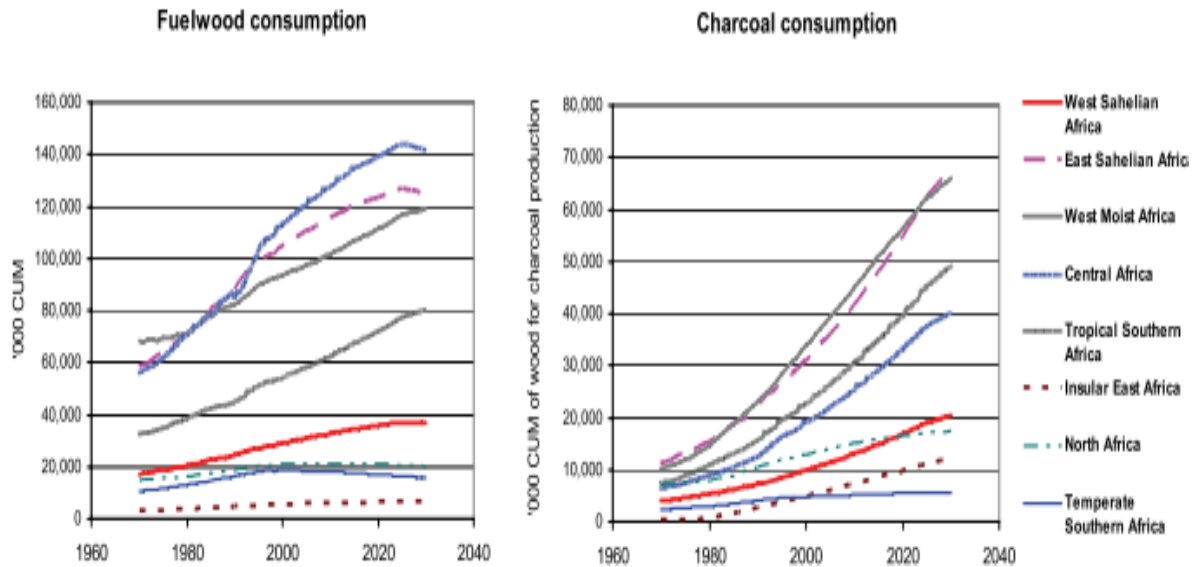


Figure 2.4 African wood fuel and charcoal consumption by subregion, 1970-2030
(Source: FAO,2001a)

In urban areas, consumers not only purchase their wood fuel from the suppliers but they also collect a considerable amount themselves (FAO, 1996:4). If the source of collection is close to the consumer especially in the urban area, most of the collected wood might end up in the wood fuel markets of the urban area (FAO, 1996: 11). According to van der Plas & Abdel-Hamid (2005), most African urban households purchase most of their wood fuels, this is because most of them are at work and do not have time to collect their wood fuel and often a lunch meal is not prepared. The most important meal in urban areas seems to be supper (van der Plas & Abdel-Hamid, 2005).

While firewood has become one of the most important sources of energy especially for the poor, it is also being depleted rapidly. One of the questions that have become increasingly important over the years is how the energy needs of so many people who are dependent on this valuable energy source will be met. It is unfortunate that there has been very little consideration dedicated to biomass energy in national policies and investment given the fact that it is a major economic sector today offering great opportunities for development.

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2.2 Sustainable development

Sustainable methods that would contribute to the optimization of wood fuel flows are still strongly linked to the current Sustainable Development (SD) discourse. It is evident that the current pressures placed on nature and paths taken to move towards 'development' have led to the major challenges facing the world today. In order to gain an understanding of why the world continues to witness unsustainable growth, which brings with it environmental degradation and increased poverty, it helps to briefly detour and revisit the two contexts in which the SD concept emerged from.

The first context is the realization of what happened in the 1970s, when the Western countries - now the 'developed' nations - came to realise that their continued patterns of production and consumption compromised on the safety, health, clean and diverse environment (Hattingh, 2001: 4). The second context involved a series of United Nations Conferences with a strict focus on environment and development. A number of reports emerged from these conferences including amongst them the famous '*Our Common Future*' (also known as the Brundtland Report) which coined the definition of SD (Hattingh, 2001: 4). The second context mainly "called for development (in particular of the poor) within the physical limits of the ecological systems of the earth sustaining it" (Hattingh, 2001: 4).

The World Commission for Environment and Development (WCED) defined Sustainable Development (SD) as development 'that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987).

Hattingh (2001: 2) quotes from Jacobs (1999: 22) that "sustainability or sustainable development are empty concepts, too vague or ill defined to be of any use in practical decision-making and real life policy implementation". Maybe it is the vagueness of this critical term that has led to the dubious assumptions which has continued to stimulate and accelerate the exploitation of nature due to its broad and open interpretation (Hattingh, 2001: 2; Sachs, 1999: 28-29; Mebratu, 1998: 494 and (Gallopín, 2003: 7).

Hattingh (2001: 2,5) and Sneddon et al (2006) are of the opinion that the current definition of SD has adopted a rather 'anthropocentric' approach, meaning that nature is only valuable as long as it is able to provide humans with resources and sees environmental problems as management problems. Is SD about conserving nature for the benefit of humans only? This in his opinion 'has gravitated towards a minimalist understanding to SD' and has "pretty much left the world as it is" (Hattingh, 2001: 2,5 and 26). Sachs (1999: 28) adds that any kind of development that will involve more people and use less nature would be an ideal way out of the current unsustainable development dilemma. While the world continues to experience an unequal distribution of resources (Sneddon et al, 2006) poverty remains an inescapable integral part of this division. It is the poor that will unfortunately suffer the most from environmental degradation (which will include amongst others, soil erosion, water shortages and weather patterns interruptions).

Observing the long and visible unsustainable patterns of growth, it is inevitable that a new paradigm is needed to define SD. The issues at the core of sustainability are economic, environmental and social aspects (WEC, 2004: 252). At this juncture, it seems appropriate to re-evaluate the current development practices. The literature shows that economic development so far has been the major drive for development, this has been evident from countries which during their initial stages of socio-economic development placed more weight on their economies compared to the well being of the environment that helped them generate such economies (Sneddon et al, 2006; Sachs, 1999 and Bartelmus, 1994: 5). The world capitalist system remains the driver of massive material flows and continues to lead intense production based economies (Gallopín, 2003). The environment therefore acts as a sink to absorb all the wastes that have been generated from these processes (Mebratu, 1998). While the environment continues to act as a sink, it seems as if there is going to be more need for sinks than for resources (Sachs, 1999: 32).

Developed countries placed economic growth first on their priority list and very little environmental concerns have been integrated in the economic sector although they remain an "essential postulate" of SD. Sneddon et al (2006) further argue that there are numerous strategic plans that are developed to implement and monitor SD at both national and local levels, but the downfall of such plans is the lack of consolidation (Sneddon et al, 2006). Therefore, improvement in the quality of life should be done within the carrying capacity of the ecosystem that sustains them, thereby making environmental and social sustainability equally important (Sneddon et al, 2006).

One of the vital steps to take will be to build grassroots initiatives and encourage community participation for a collective approach to issues that concerns and threatens their livelihoods. Equally important will be to build an understanding of how both the local and global dimensions interact as well as the consideration of spatial and temporal horizons to ensure that the needs for intra-generational⁸ and inter generational⁹ equity are considered (Gallopín, 2003: 7).

2.3 Urbanisation

In 2008 more than half of the world's population which amounts to about 3.3 billion people was living in urban areas. If the current urbanisation trends in Africa and Asia persist, almost half of the population in Africa will be living in urban areas comes 2050 (UN-Habitat, 2008: 10). According to the UN-Habitat, Africa has the highest urbanisation rates in the whole world with 3.3 % per annum¹⁰ (between 2000 – 2005), more than half the urban population will have no access to electricity. (UN-Habitat, 2008: 17). These increases will place considerable pressures on the local systems that provide goods and services to the urban areas (Hosier & Milukas, 1992). Wood fuel flows in urban areas are particularly interesting in this context because they show the trade off that exists between environmental degradation and basic human needs. It is this increase in urban population that has led to an increase in the demand for wood fuels (Hosier & Milukas, 1992). This demand led to a growing wood fuel market, while these markets continue to grow, they are still not properly understood. Recently these markets have become interesting due to two reasons:

1. The rural areas supply wood fuels to meet the ever increasing urban wood fuel demand. This demand may exacerbate pressures for environmental degradation and deforestation (Hosier & Milukas, 1992).
2. Urban growth in developing countries is continuing rapidly (Hosier & Milukas, 1992 & UN-Habitat, 2008: 15).

⁸ The reduced use of resources by the current generation (Gallopín, 2003: 20) by ensuring that resources are distributed equally (Hattingh, 2001: 7).

⁹ Ensuring that the current generation does not compromise on the needs of the future generations (Gallopín, 2003: 20 and Hattingh, 2001: 7).

¹⁰ Some of the factors that are contributing to the high Urbanisation rate in Africa includes; the increasing economic growth in the cities, war and conflicts, droughts and famine amongst others (UN-Habitat,2008: 18).

2.3.1 Urban environment

Urban areas have large ecological footprints. Ecological footprint is defined as an “area of productive land and aquatic ecosystems required to produce the resources used, and to assimilate the wastes produced, by a defined population at a specified material standard of living, wherever that land may be located” (UNEP,2002: 243). It is important to note that worsening environmental conditions can have serious effects on human health and welfare especially for the poor. Within their vicinities cities have different impacts such as the conversion of agricultural or forest land for urban uses and infrastructure development, reclaiming wetlands and excavation of sand, gravel and building materials amongst others. The use of biomass as a source of energy also causes indoor and outdoor air pollution. Cities are characterised with high levles of energy use (especially the use of fossil fuels and electricity) and increasing levels of consumption and waste production. According to the International Energy gency (IEA) cities consumed over two thirds of the world’s energy accounting for more than 70% of the global Carbon dioxide (CO₂) (IEA, 2008: 180).

The health risks of using wood fuels particularly indoors or in enclosed kitchens especially during rainy seasons have been a major concern. Some of the health risks associated with the use of wood fuels includes respiratory diseases and eye irritations amongst others. Therefore improved non-polluting energy efficient stoves should be developed.

Once the amount of new biomass growth balances with the biomass used for energy, the bioenergy produced is carbon dioxide "neutral", so that the use of biomass for energy does not increase carbon dioxide emissions and does not contribute to global climate change. It is important to note that some of the stoves used in the homes of developing countries have low efficiencies (about 15%), with almost 10% of the energy from the wood lost due to incomplete combustion (WHO,2000: 13).

Cities hold promise for sustainable development because of their ability to support a large number of people while limiting their per capita impact on the natural environment. Environmental impacts can be reduced through good urban planning. Even densely populated settlemts has the potential to reduce the need for land conversion, provide opportunities for energy savings and ensure that recycling is more cost effective (UNEP, 2002: 245 and UN-Habitat, 2008). The first step towards dealing with urbanisation issues will be for national governments to incorporate a clear urban component in their policies (UNEP, 2002: 245).

2.3.2 Urban electrification

Some challenges and issues related to the electrification of slums include;

1. Policy issues

The electrification of slums is often not mainstreamed into national policies and programmes and does not receive the same support as rural electrification programmes. The ambivalence of politicians to informal settlements stems from the fear that providing infrastructural investments in slum areas will legitimise their existence. There is still limited policy development that will help address affordable tariffs to vulnerable and fuel poor consumers (UNHABITAT, 2009: 7).

2. Programme design issues

One main challenge of programme designs in informal settlements is the upfront investment cost bearing in mind the risks associated with informal electrification programmes. The uncertainty of electrifying informal settlements as long term investments or transitional measures pending resolution of long term statuses of informal settlements also remains a challenge (UNHABITAT, 2009: 7).

3. Data issues

Unreliable data on the rates of legal and illegal connectivity in informal settlements is another challenge hindering the formation of reasonable data bases for policy development and programme design purposes (UNHABITAT, 2009: 8).

Affordability is undoubtedly one of the major problems for poor households to benefit from electricity access, the urban poor are most likely not to have access to electricity due to their inability to afford such services. Many of them are burdened with high arrears and may even face electricity cut-offs, leading to the common illegal re-connections and the use of alternative energy sources such as wood and paraffin. The use of pre-paid meters is also common amongst households. Most of the households however do not understand the information printed on their receipt (Malzbender, 2005: 14).

2.3.3 Urban governance

Most of the urban environmental problems are not caused by urbanisation alone but are as a result of poor management, planning and missing coherent urban policies. In order to secure environmental sustainable development the fundamentals of governance have to be

participatory, democratic and pluralistic (UNEP,2002: 246). Some of the activities that can improve urban governance includes: promoting participatory processes, developing effective partnerships with all stakeholders in the society, securing greater effective empowerment of the local government and reorganization unresponsive organisations and bureaucratic structures. The first step in developing a local environmental agenda will be to assess the local environmental situation. This information will be useful in city planning. One major challenge about urbanisation is to learn to live with it and use its benefits and negative impacts in a more manageable manner (UNEP,2002, 246-428).

2.4 Household fuel switching and energy efficiency

One of the dynamics taking place at household levels in urban areas is that of fuel switching. Some of the underlying factors influencing energy demand include the price of the energy source and the appliance it will fuel; household income; fuel availability and cultural preferences. This consumption generally follows what is referred to as the “energy ladder” (Schlag *et al*, 2008 in Daurella & Foster, 2009). This is a transition from cheaper and less efficient fuels towards fuels with intermediate prices and progress towards so called quality, expensive and more convenient types of energy. Wood fuels are mostly being switched for kerosene, Liquid Petroleum Gas (LPG) or electricity. It seems the most primitive fuels tend to be seen as being ‘dirty’ and less efficient, thus ends up at the bottom of the ladder, while mostly expensive non renewable fuel types are viewed cleaner and more efficient and ends up at the top of the ladder. This concept argues that wood fuel switching mainly occurs once household incomes increase (Daurella & Foster, 2009: 4; Ouedraogo, 2005 and Foley, 1985: 253). If the decision to switch fuels is driven by financial reasons, then the use of fuel efficient stoves will be ideal, however if the move is based on non-financial reasons then a different set of mechanisms will be needed¹¹ (Clancy, 2006).

¹¹ This mechanisms might include the reassessment of the current distribution systems or even opting for low-cost conversion equipment (Clancy, 2006).

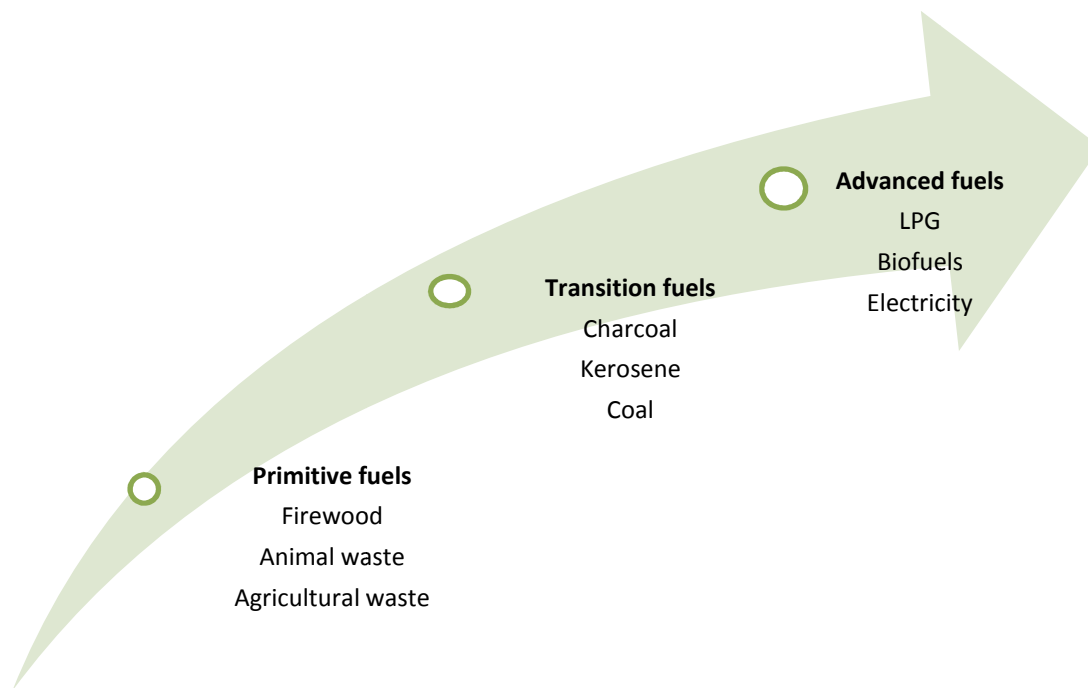


Figure 2.5 The energy ladder (Source: Schlag et al, 2008 in Daurella and Foster, 2009).

Other studies argue that it is more accurate to refer to the energy ladder as an ‘energy stack’ since it is quite common for households to use more than one fuel type (Daurella & Foster, 2009).

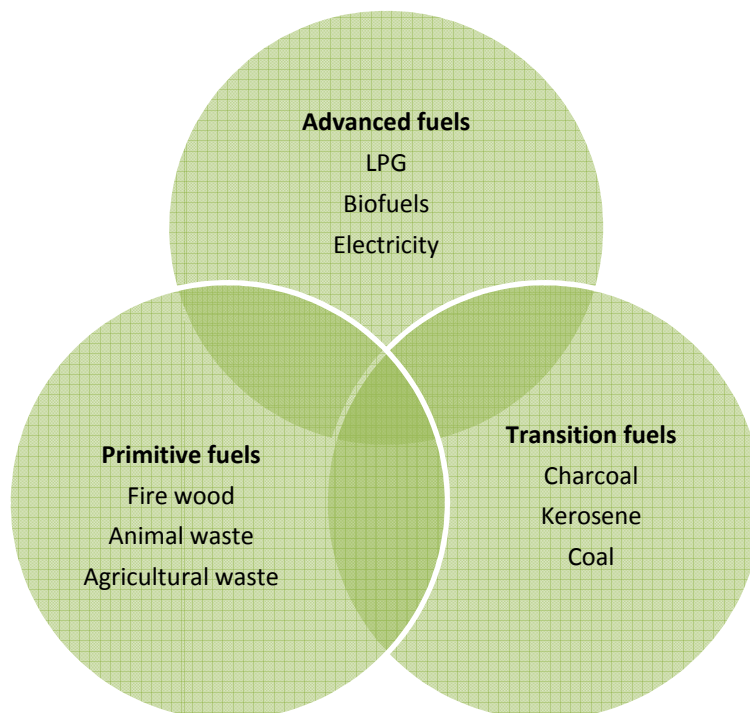


Figure 2.6 The energy stack (Source: Schlag et al, 2008 in Daurella & Foster, 2009)

Other factors that contribute to household fuel switching other than income include increased availability and access to so-called modern fuels, changes in urban lifestyles as well as settlement patterns which will make modern fuels more attractive in most cases this fuel sources are viewed to be cleaner than wood fuels (FAO, 1993: 19). Poverty remains one of the barriers towards the transition to so called modern fuels (WHO, 2000: 9). An increase in the price of alternatives like LPG gas and kerosene means that more people are now relying on biomass fuels. On average fuel collection takes up about one to two hours per day, with woman being more at risk of Indoor Air Pollution (IAP) (WHO, 2000: 12). There is currently a growing and visible recognition of the close inter-relationship between energy and poverty. According to WHO (2000: 14), evidence show that the cost of using the so called 'fossil fuels' is not as high as it is being perceived, it is poverty that prevents people from taking advantage of those fuels. The poor usually find it difficult to invest money up-front to get the appliances that they need for using kerosene, gas or even electricity let alone buy the fuel in sufficient quantities to benefit from low unit prices (WHO, 2000: 14). Figure 2.7 continues to give an overview of health and development issues that are linked to the use of household energy in the developing countries (WHO, 2000: 14).

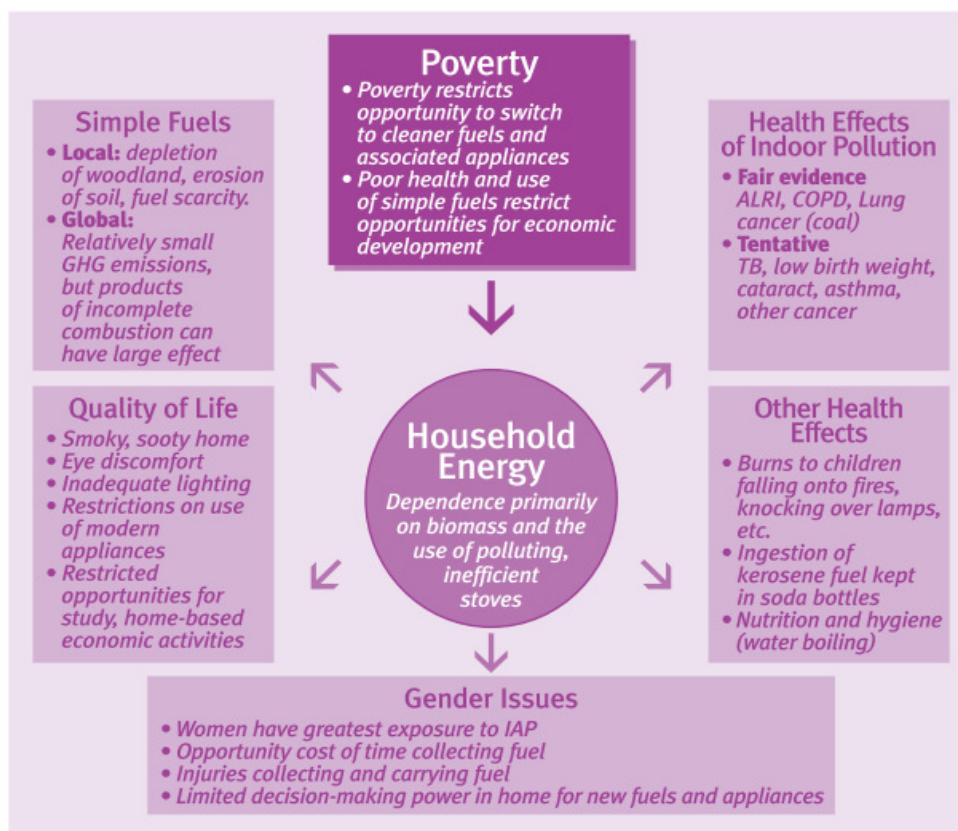


Figure 2.7 Brief overview of health and development issues linked to the use of household energy in developing countries (WHO,2000: 14).

The FAO continues to add that the extent of fuel switching in a particular urban area is also determined by the size of the town as well as the level of economic development of that particular country. Another reason for fuel switching is the scarcity of the fuel resources. As wood fuel become scarce, households would resort to lower quality fuels such as twigs, sticks, agricultural wastes/ residues and animal dung (Deweese, 1989). While this situation can be country specific it could also be due to the increased scarcity of wood in various regions, either due to over harvesting, or due to population increase.

The wood fuel demand in the residential sector of urban areas will be affected by the rate and extent to which households will be switching to conventional fuel sources (FAO, 1993: 19). Based on this, it is clear that cities in countries with relatively low incomes continue to be heavily dependent on wood fuels (Stevenson, 1989; Cline-Cole *et al.*, 1990a; Hosier & Bernstein, 1992 in FAO, 1993: 19).

Most urban dwellers are likely to switch from wood to charcoal (Arnold, Kohlin, & Persson, 2005 and (WEC, 2004: 251). According to a study that was conducted in N'Djamena (Chad), there is a small difference in the purchasing price of wood fuel and charcoal (van der Plas & Abdel-Hamid, 2005). People switch over from firewood to charcoal mainly because of the cleaner characteristics of charcoal compared to firewood. Charcoal is safer to use and it is easier to store, unlike the heavy and bulkier firewood and it is seen to be a modern fuel (van der Plas & Abdel-Hamid, 2005). Charcoal production, like in the case of Namibia, is likely to boom on private abundant farm land and is, in most cases, very expensive compared to wood. According to the position paper on biomass for the ACP-EU Energy facility, the current energy transition coupled with the increase of the population in urban areas also involves an increase in the use of charcoal. While developing scenarios for the future become important, it is also important to ensure that the current inefficient use of the charcoal chain is improved. The end use efficiency is quite low across all traditional fuels; therefore the use of energy efficient equipment is encouraged. The position paper on biomass for the ACP-EU Energy facility shows that about 80 to 90 per cent of the residential energy needs of most low-income households are met through the use of traditional biomass mainly fuel wood and / or charcoal.

A commentator on India wrote that “the more affluent sections of society always prefer cleaner and more convenient cooking fuels to wood. The poor know that there is a hierarchy of cooking fuels and they view changes from fuel wood to charcoal to kerosene to electricity or gas as steps in the improvement of the quality of their lives”(Foley, 1985: 255).

While the poor know the hierarchy of cooking fuels, many might not be able to go up that hierarchy, even so the middle income groups and the poor still use wood fuels as a source of energy intermittently and even as a fall back resource when they are unable to afford the conventional fuels (Shackleton, *et al.*, 2004: 5). Wood fuel has also become a very important fall back resource once funds to purchase electricity and alternative energy sources start to diminish (Shackleton *et al.*, 2004:5). The transition from wood fuel in urban areas will be highly determined by the trends that will show the real incomes as well as the various affordable alternatives (Chambwera, 2004:2).

2.5 Different wood fuel assessment tools and theories

2.5.1 Gap Theory

There are currently two arguments pertaining to the relationship between wood fuel consumption and deforestation. The first argument was known as the "fuelwood gap theory" which was formulated in the 1970s and implied that the consumption of wood fuels has been unsustainable. The "gap" shows that wood fuel demand is larger than the sustainable supply, therefore deforestation and forest degradation are as a result of firewood harvesting (Top *et al.*, 2003).

When the fuelwood gap theory was proposed there was inadequate data on the origins of fuelwood and it was assumed that fuelwood originated mainly from the forests. Over the years more and more information on the origins of fuelwood started to emerge; it is now known that about 60% of fuelwood comes from non-forest sources (FAO, 1999).

The second argument states that wood fuel consumption is not necessarily linked to deforestation. Wood fuel problems are localized and complex within regions, and collectively do not amount to a wood fuel crisis. Proponents of this argument believe that the "gap theory" has exaggerated the scale of the wood fuel problem (Top *et al.*, 2003; Dewees, 1989 and WWF, 1992). There have been only few estimates of the available biomass resources and its sustainable productivity and many studies have also ignored the spatial variation of wood fuel consumption in relation to forest availability in each region (Top *et al.*, 2003). Masera *et al.* (2006) adds that in order to successfully assess the current patterns of wood fuel use and production as well as draw up strategies on how to sustainably manage this resource, a holistic approach is needed, taking into consideration the spatial patterns of wood fuel supply and demand (Masera *et al.*, 2006). The wood consumption study that was done in Botswana revealed that the removal of biomass material for agricultural purposes

was the main contributor to deforestation and not necessarily the collection of wood fuel (Kgathi *et al.*, 1997: 4). The future levels of the wood fuel gap are not easy to determine. Wood fuel consumption tends to decrease as scarcity increases and this makes it difficult to forecast the levels of wood fuel consumption accurately (Kgathi *et al.*, 1997: 15).

According to Dewees (1989), the consumption of wood fuels is related to the economic costs involved and the supply options. In section 2.4 Hosier & Milukas (1992) argued that increased urban populations have led to an increased demand for wood fuels eventually leading to growing wood fuel markets (Hosier & Milukas, 1992). While population growth is always identified as one of the contributors to the increasing demand of wood fuel, Dewees (1989) argued that wood fuel is not a static variable, it cannot be extrapolated using population growth rates (Dewees, 1989).

2.5.2 Wood Fuel Integrated Supply Demand Overview Mapping Model (WISDOM)

WISDOM is a GIS-based tool which was developed to analyse the wood fuel supply and demand spatial patterns, this is achieved through the gathering of scattered information (Maser *et al.*, 2006). WISDOM has been used in various cities such as Dar-es-Salaam, Arusha-Moshi, Kampala and Khartoum amongst others. WISDOM studies revealed that supply zones extend further away from urban areas and wood fuels travel long distance to reach the consumers in urban areas (Drigo & Salbitan, 2008). Traditionally fuel wood use was known to be the main contributor to environmental degradation and deforestation, unfortunately the situation is more complex than this. The harvesting of fuel wood alone is not the only contributor, other factors like the clearing of land for the increasing population and the right to resources and raw materials that is needed to sustain the livelihoods of the urban dwellers (Drigo & Salbitano, 2008). According to Zulu (2009) some of the other misleading facts of the gap theory are the increase of fuel wood deficits as a result of the linear wood fuel gap theory that is based on the population, without considering the various household fuel substitutions as well as the demand management responses to scarcity (Zulu, 2009). Not all regions are likely to face wood fuel scarcity, the supply and demand of wood fuels are complex and most often site specific (Maser *et al.*, 2006).

2.5.3 Material Flow Analysis (MFA)

MFA is one of the simplest and general methods of analysing systems as well as the environmental impacts (Meinzinger, 2010: 35). As depicted in Figure 3.1, MFA includes all the sources where the materials are coming from, the pathways it travels and the

intermediate and final sinks (Giljum, 2003: 27). The aim of MFA is to follow and quantify the flow of materials within a defined situation over a given period of time. It defines the flow of materials being used and transformed in the system in a specific geographic area and at a certain period of time (By Brunner and Rechberger, 2004 in Meininger, 2010: 35). MFA is based on the law of thermodynamics and uses quantitative methods to establish the flows of materials and energy through the economy. It is a combination of both the input (including extractions and imports) and output (including consumptions, exports, accumulation and wastes) of materials and economic information. MFA also looks at hidden flows, where materials have been extracted but never made it to the final consumption or use of the products (The Sustainable Scale Project, 2003). In order to determine the economic information, material throughput is required. The various environmental impacts brought about by the flow of the materials are also evaluated. MFA is important for effective planning and management of natural resources, it also helps to identify any existing gaps and the relevant policy interventions to be taken (FAO, 1996: 3).

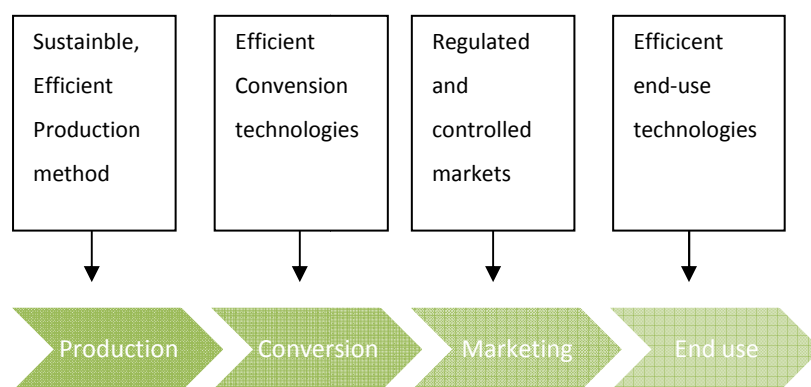


Figure 2.8 Holistic analysis of the entire value chain for effective planning (Source: GTZ, 2010: 22)

It is important to understand that wood fuel flows are complex and site specific. Sustainable wood energy systems remains the most important issue on the agenda for a majority of policy makers especially the community planners in developing and developed countries (WEC, 2004: 52). Measures that aim at improving the wood fuel supply chain assumes that (Energypedia, 2011):

- There is a considerable amount of wood fuel that can be produced sustainably.
- Suitable technologies that will be able to assist the transition exist / can be introduced.

- Provided that replacement keeps up with harvesting, Green House Gases (GHG) will be reduced since the use of biomass as a renewable resource will have minimal impacts on the environment.
- The use of biomass will create opportunities to enhance economic benefits such as value addition and the creation of jobs.

There are various methods used in wood fuel flow studies, these mainly depend on the various circumstances the researcher is faced with (FAO, 1993: 91). Understanding household energy use patterns is a critical aspect of any commercial wood fuel flow study. Briefly looking at the relation between MFA and Life Cycle Assessment (LCA), once MFA has been established LCA can be determined, therefore one can say that the LCA is an impact assessment of the MFA. LCA strives towards completeness while MFA aims at ensuring transparency and manageability. LCA determines the various environmental impacts of goods as well as services based on its life cycle¹². It does this by using structured methodologies which are internationally standardised (Meininger, 2010: 36).

LCA is a very useful instrument for companies. It is used to support business strategies; it is also used for system analysis and assists the companies in strategic planning (Meininger, 2010: 37). However, the LCA tool has several drawbacks. A LCA requires large amounts of data and once the results of the study are available, they have to be aggregated into impact categories; this process leads to a loss of information. An LCA uses standardised conditions, therefore any dynamic development process like change in land use in urban areas, is not easily incorporated into the LCA process, because the LCA assessments are limited within the boundaries of the system that is being studied. The focus of LCA is on specific goods and services, while MFA focuses on countries, regions as well as sectors (Meininger, 2010: 37).

2.6 Energy content derived from wood fuels

Before the energy that has been derived from the wood fuel is presented it is important to understand the processes that take place when wood burns. According to Slusher (1985) there are three things that occur when wood burns (Slusher, 1985).

1. As the wood burns the water in the wood is removed through evaporation.

¹² A life cycle starts from the extraction of raw materials, the manufacturing, distribution, use and the final disposal of such goods, this process is also known as cradle to grave (Meininger, 2010:36).

2. The wood breaks down to form charcoal, gas and volatile liquids while forming carbon dioxide and water as end products.
3. As the charcoal continues to burn, carbon dioxide is converted to carbon monoxide

The term heat value refers to the amount of heat that is available in the fuel (KJ/Kg). It is mostly a heat function of the chemical composition of the fuel¹³ (Ciolkoz, 2010: 1). Different types of wood have various heating values depending on its density as well as its moisture content, wood with 20 % moisture content has a calorific value¹⁴ of 16 MJ/Kg. High moisture content reduces the heat produced by the wood fuel (Slusher, 1985: 1) apart from the moisture content the composition of wood fuels also determines its performance (Ciolkoz, 2010: 3). Some of these compositional properties include ash content, susceptibility to slagging and fouling and percent volatiles¹⁵ (Slusher, 1985: 2). It is preferred that wood is dried up to at least 20% moisture level (Slusher, 1985: 2). This is preferable because it burns more readily and also provides more useful heat per unit mass (Ciolkoz, 2010: 1).

2.7 Developing sustainable wood energy systems

Although the use of wood fuels in most instances remains unregulated, it is important to recognise that wood energy will continue to dominate a number of households for years to come as poverty levels continues to increase in the developing countries resulting in the increased use of wood fuels by a majority of households. This dominance therefore presents problems and opportunities, therefore developing sustainable wood fuel strategies will help alleviate some of the negative impacts caused by the unsustainable use of wood fuels and make the most of the opportunities (FAO,1993;UNEP,2003 and UN-Habitat, 2008).

2.7.1 The improvement of traditional uses of wood fuels

The use of wood fuels will continue to dominate a majority of households in the foreseeable future. Therefore the key areas of sustainable wood energy development will be to improve the traditional use of wood fuels especially at household levels. This development will

¹³ The climate as well as the soil type in which the fuel is grown also determine the heat content of the fuel (Ciolkoz, 2010: 2).

¹⁴ The usable energy content of wood fuels is referred to as its Net calorific value (NCV)

¹⁵ Refers to the percentage of the fuel that is able to turn into gas once it is heated to a high temperature (Ciolkoz, 2010: 2).

consider both the conservation of biomass energy; ensure that the use of wood fuels is clean, efficient, convenient and economical. The design of energy efficient stoves should adopt a decentralised approach and be inclusive of the cooking practice, economic, social and cultural circumstances of the targeted groups; this will stimulate the grassroots initiatives and create jobs for the locals (FAO,1993 and Drigo & Salbitano,2008)

2.7.2 Improve wood fuel flows and markets

In order to ensure that there is a steady supply of sustainably produced wood fuels, wood fuel flow systems in urban areas need to be improved, this includes inter-alia the marketing, transportation, distribution, harvesting , processing and stock piling. In order to improve wood fuel flows and expand wood fuel markets, it is important to prove the sustainability of their production and once that has been done to eventually make the business operations legitimate (Drigo & Salbitano, 2008 and FAO, 1993).

2.7.3 Promoting sustainable wood fuels production

Supporting initiatives that are aimed at implementing sustainable tree production and management especially in non-forest areas. The planting of more trees also provides a viable land management option for land that has been neglected (Chmbwera, 2004 and FAO, 1995).

2.8 Conclusion

It is clear that the current methods in which wood fuel are used remains unsustainable. Given that two thirds of the world's electricity is derived from fossil fuels followed by coal, oil, gas, nuclear and small portion from renewable energy mainly hydro power. The predicted scenarios show that biomass is able to contribute to the global energy mix sustainably (WEC, 2005: 360). It is evident that, what previously seemed to be a rural area phenomenon has become an urban area burden (FAO, 1996: 4). New innovative policy/programme initiatives should address the challenge of allowing the end users to recognise the importance of energy efficiency which is the first step in addressing the problems that stem from urban energy use. It is the energy suppliers that make supply-side investments decisions and the builders and appliance manufacturers are usually the once that most often determine the efficiency of their products although none of them pay the energy bills. The next chapter introduces the case study area of Tsumeb. The background gives an understanding of the situation in the town and possible challenges hindering the sustainable utilisation of wood fuels.

CHAPTER 3: Case study: Tsumeb

3.1 Introduction

Chapter 3 gives a brief background of the Namibian biomass resource and energy system. It also covers the appropriate wood fuel policies and regulatory frameworks in Namibia. It covers in particular the requirements needed to obtain permits for harvesting, marketing and transporting wood fuels. This chapter brings to the scene some of the immense opportunities that exist in the town of Tsumeb that can help alleviate the problems of firewood scarcity and help in ensuring that the wood fuel flows operate smoothly and efficiently.

3.2 The Namibian energy context

Namibia covers an area of about 824 000 km² and has a population of about 1.8 million people (Barnes *et al.*, 2010: 159). 33 % of this population lives in urban areas and 9 % live in smaller emerging urban areas such as villages and settlement areas (Muller & Mitlin, 2007: 426). Namibia's total annual per capita energy consumption was about 7.5 MWh in 2007 and produced a Gross Domestic Product (GDP) of about N\$52 billion equating to N\$26,000 per person.

Namibia imports all its liquid and gaseous fossil fuels from South Africa. The total installed generation capacity in mid 2008 was about 387 MW, with a peak demand exceeding 500 MW. Namibia imports about 50% of the country's electricity, with a bulk of it being supplied by ESKOM in South Africa and the rest from ZESCO in Zambia and ZESA in Zimbabwe (Emcon, 2008: 2).

Namibia has well developed transmission and distribution systems which stretch over about 16,000 Km, table 3.1 below shows NamPower's generating capacity.

Table 3.1 Nampower's generating facilities (Source: NamPower, 2011)

Name of station	Type	Installed capacity (MW)	Commission date
Ruacana	Hydropower	240	1978
Van-Eck	Coal-fired	120	Unit 1& 2: 1972 Unit 3&4: 1974/9
Paratus	Diesel	24	1976
Anixas	Diesel	22.5	Inaugurated November 2011

Only about one-third of the population has access to the electricity grid¹⁶. In 2007 the urban areas consumed about one-half of the country's total electricity consumption (about 3.5 TWh). This left out about 100,000 households which are still not connected to the national grid¹⁷.

Figure 3.1 below clearly depicts the various energy sources making up Namibia's energy mix. Biomass used for energy contributed 9% to the total energy consumption in the country with 5304000 GJ. The Contribution of solar energy is still extremely low with a contribution of 8240 GJ (REEEI, 2008: 10).

¹⁶ With over 70% of the urban and 15% rural households connected (von Oertzen, 2008: 3).

¹⁷ This figure includes many informal settlement residents around urban areas (von Oertzen, 2008: 3).

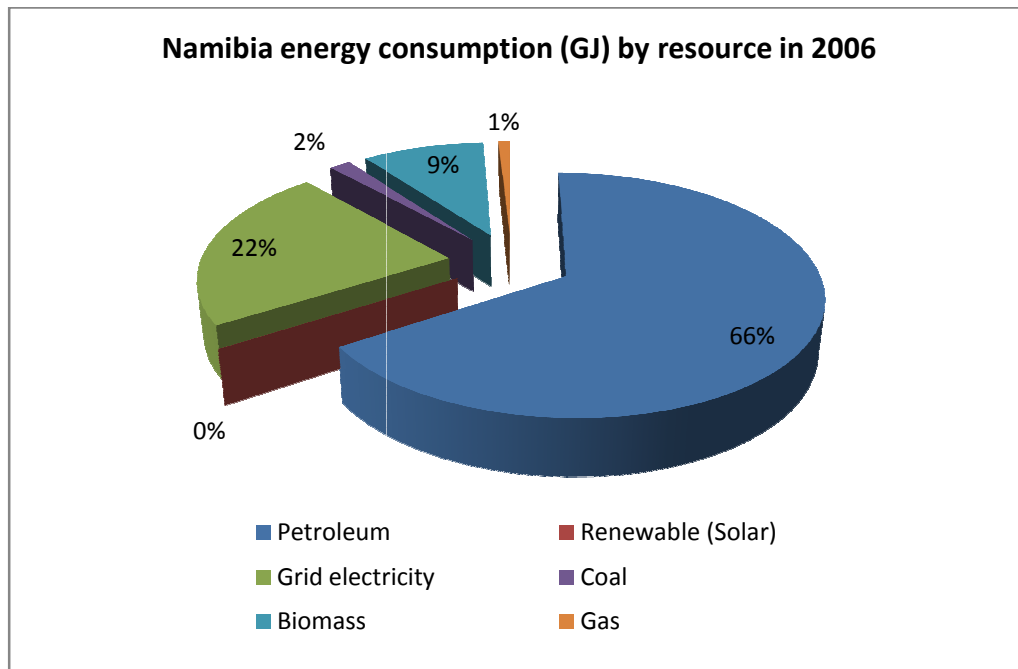


Figure 3.1 Namibia energy consumption by resource in 2006 (REEEI, 2008: 10).

Like other African countries, Namibians also relies heavily on wood fuels as a source of energy (DRFN, 2007). Figure 3.2 below show the various energy sources that are being used in the Namibian households. The 2001 Population and Housing Census figures shows that approximately 213,000 households that are using wood fuel in Namibia are in the seven northern regions of the country (DRFN, 2007: 2). It is estimated that the daily consumption of fire wood in each of this households is about 8 kg (DRFN, 2007: 2). According to the statistics of the National Planning Commission (NPC), these households make up 59.6% of the population which is mainly dominated by the poor households (NPC, 2008: 27). *The Wood fuels Review and Assessment: Namibia Country Report* conducted by the Ministry of Environment and Tourism (MET) in 2000, estimated that subsistence consumption of fire wood was 520 00 tons/year (MET, 2000).

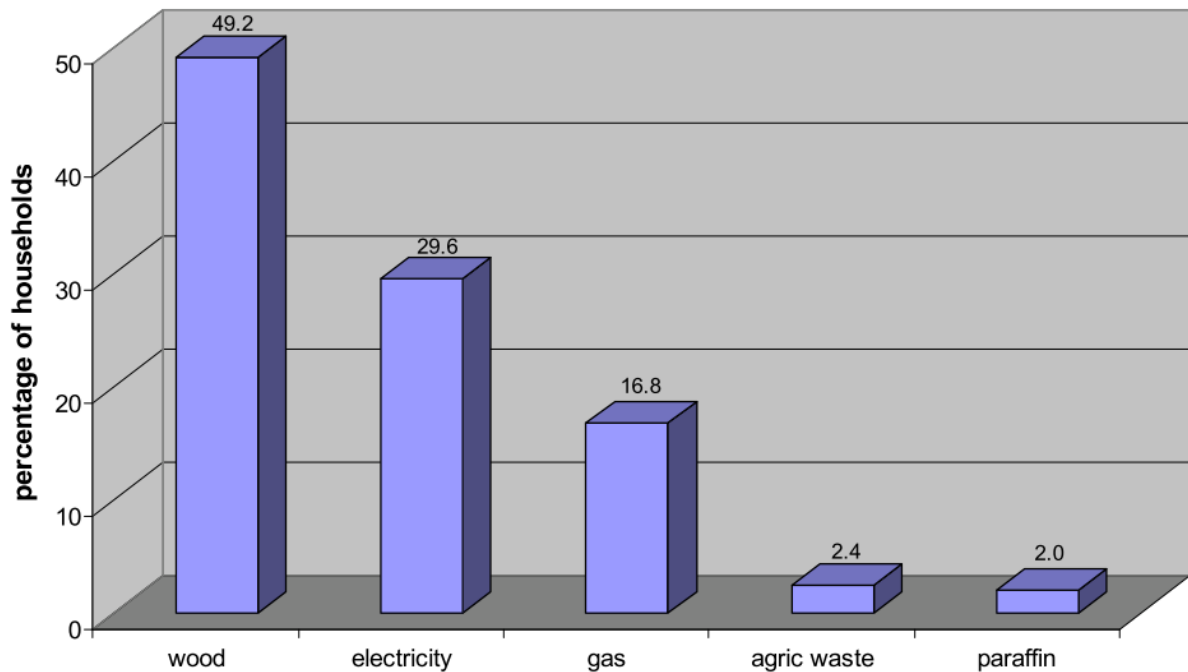


Figure 3.2 principal cooking fuels of Namibian households (Source: DFRN, 2007)

The preliminary economic asset and flow account of Namibia's forest resources study that was conducted in 2004 showed that Namibia has an estimated woody resource of 90758693 tons with a value of about N\$ 19 billion in 2004 (Barnes *et al.*, 2010: 166,173). About 5.8 tons per year of wood fuel was estimated to be the available sustainable resource for harvesting. The remainder included 0.9 tons per year for pole and 0.06 tons per year for saw timber. The similar study shows that the Oshikoto region, the region in which Tsumeb is located, has a total forest biomass volume of about 15622.3 tons and of this 843.6 tons per year is the estimated sustainable harvest of wood fuel, poles and saw timber from the total stock, with regards to what is physically utilisable (Barnes *et al.*, 2010: 166).

One topic currently on top of the Namibian energy agenda is the manufacturing of charcoal. This industry has been thriving in the last ten years and is mainly targeting the leisure sectors of Europe and South Africa (Diekmann & Muduva, 2010: 1). The industry started as an innovative by-product of clearing the problematic invader bush, where about 50,000 to 60,000 tonnes of charcoal is produced per year. It was estimated to be worth about N\$75 to 100 million in 2004 alone and this figure continues to grow (Diekmann & Muduva, 2010: 1). About 26 million hectares in Namibia is reported to be infested with this invader bush, its density varies from one area to another and the average yield is estimated to be between 13 and 18 tonnes per hectare (Honsbein & Joubert, 2009: 23). While bush encroachment is a problem in some areas, 62% of the Namibian population is suffering from a shortage of wood, which is considered a primary source of fuel (DRFN, 2007). These high densities of

invader bush has led to the loss of about N\$700 million every year (de Kerk, 2004: xii &). With such high losses the livelihoods of 65,000 households within the communal areas, as well as 6,283 commercial farmers, including their employees has been affected. Apart from it having serious impacts on livelihoods, bush encroachment is also considered a threat to biodiversity, affects underground water tables and water-use efficiency (de Kerk, 2004: xii). In 2004, a preliminary economic asset and flow account of Namibia's forest resources in all the thirteen regions was conducted for the Environmental Economic Unit under the Ministry of Environment and Tourism. This study focused directly on the direct use values¹⁸ of the natural resources. This included the harvesting of fuel wood mainly for consumption in rural areas and sales in urban areas, harvesting of poles used in the construction of houses and fencing and the harvesting of Non Timber Forest Products (NTFPs)¹⁹ and the production of charcoal which is currently a booming industry in Namibia, mainly on private land²⁰. The study omitted the use of woodlands and savannas as it is believed that they are best suited in separate accounts (Barne *et al.*, 2010: 160).

A very important aspect that needs to be addressed urgently is the exclusion of these natural resources from the national accounts; this is because these resources have not been accounted for as "assets" (Barnes *et al.*, 2010:160). The preliminary forest accounts deal exclusively with direct use values, which are derived from the direct use of the resources such as in the production of tangible goods with market value. National accounts has only been incorporating man-made or owned assets, although they realise prohibits sound planning for sustainable development (Barnes *et al.*, 2010: 160).

¹⁸ Direct use values comes from the direct use of natural resources which are manufactured into goods with a market value (Barnes *et al.*,2010:160).

¹⁹ NTFPs include plant products that are used for craft production, edible plant products, plant products used for cosmetics and medicine as well as grass that is used for thatching (Barnes *et al.*, 2010:160).

²⁰Charcoal production was however excluded from this study due to a lack of data.

The asset and flow accounts are developed based on the standardised methods for natural resource accounting, the Integrated Environmental and Economic Accounting/Integrated Environmental and Economic Accounting (IEEA) manual which has been developed by the United Nations. This manual complemented the conventional, internationally adopted system of national accounts. It is important to note that resources that are not exploitable, either for legal or economic reasons have a zero value. This study only valued on that portion of the natural stock that could realistically be brought into viable production in the future (Barnes *et al.*, 2010: 4).

Apart from establishing the standing volumes of woody biomass resources in the various regions of the country, a survey was conducted to understand the use of the resources, volumes harvested and consumed, sales and prices involved and the levels of incomes generated from these resources that is used for household livelihoods. Both urban and rural suppliers of these resources were also surveyed. While this study gives an idea of the current flow account of Namibia's forest resources, it is still based on a lot of assumptions due to a lack of forest data in Namibia. This therefore necessitates the need to generate primary forest data in the country to ensure accurate studies which will allow appropriate future planning (Barnes *et al.*, 2010).

3.2.1 Policy and regulation framework in Namibia

1. The White Paper on Energy Policy of 1998

The Ministry of Mines and Energy (MME) is in the process of having the White Paper on Energy Policy of 1998 reviewed. The policy's goals are centred on: effective governance, security of supply, social upliftment, investment and growth, economic competitiveness and efficiency, as well as sustainability. Namibia's energy white paper also has a dominant focus on electricity and modern commercial fuels. The policy not only realises that the majority of Namibians depend on wood fuel for cooking, but also realises that the biomass resource is being over-exploited; thus threatening the environment. The energy use patterns in urban areas are also not clearly understood (MME, 1998: 13) although these areas are becoming centres of high population densities (MME, 1998: V).

The Namibian Renewable Energy Macro Economic Study that was conducted in 2008 has identified the absence of a policy option in Namibia that is able to satisfy policy criteria which has been identified in the White Paper on Energy Policy. The report argued that while some options tend to be economically efficient, they do not seem to maximise the use of renewable energy resources. Other options are cheap and unfortunately do not guarantee

security of supply, while those options that are able to maximise the use of renewable energy turn out to be extremely expensive (von Seydlitz et al, 2008: 18). von Oertzen (2008: 11-12) added that while the update of the White Paper on Energy Policy is long overdue, it needs to consider all the indigenous renewable energy options and also consider emerging regional as well as international energy sector constraints and opportunities (von Oertzen, 2008: 11-12).

Local solutions can only be built by identifying what options will work and possibly why. Although this might seem easy, it is important to realise that any intervention that will operate in the absence or in contradiction with the set policies is doomed to fail (Soussan et al, 1992). For policies to effectively assist local communities, it has to achieve the following goals:

1. It must allow local ownership of the resource base, this move will start the management of local resources (Soussan *et al*, 1992).
2. The policy should ensure that both economic and political environments are created in order to allow local solutions to flourish, (in most instances the external policy environment does not consider the local initiatives) this is a very crucial aspect if wood fuels are to be managed sustainably (Soussan *et al*, 1992).
3. Any wood fuel policy should be able to provide external support which will be able to provide input when there is any form of local level needs lacking (Soussan *et al*, 1992).

2. The Forestry Act, 2001

In Namibia, the Forest Act, 2001 (No.12 of 2001) as amended by Act No 13 of 2005 is the document that is guiding the use of biomass in the country. Anyone that needs to harvest, transport, market and export forest resources has to be in a possession of a permit obtainable from the Directorate of forestry offices within the Ministry of Agriculture, water and forestry (Diekmann & Muduva, 2010: 14). This Act has not been fully implemented yet, especially in the Namibian Charcoal industry where regular inspections are supposed to be carried out as stipulated in the Act. Also, the illegal collections of biomass resources without official permits especially for own use is still evident (Diekmann & Muduva, 2010: 14).

Harvesting permit

Government officials will conduct an inspection on the farm where the application for a permit is coming from. The inspection assures that there is indeed biomass resource is

available to all the harvesting of the given quantities. This permit is valid for 6 months and cost N\$15 (MAWF, 2010).

Marketing permit

Although all the procedures relating to the completion of the form are similar to those of the harvesting permit. The only additional information needed is the place of markets as well as the origin of forest produce (MAWF, 2010). Therefore the marketing permit is only granted once the harvesting permit has been issued. The marketing permit is valid for 6 months at a cost of N\$15 (MAWF, 2010).

Transport permits (commercial or own use)

In order to get a transport permit, the name of the transporting agent or registration number of the vehicle that will be transporting forest resources will be required. These two permits are valid for 14 days with a payable fee of N\$15 (MAWF, 2010).

Export permit (commercial or own use)

The export commercial permit allows the applicant to export forest produce to other countries. Two certificates are needed to accompany the forest produce; a fumigation certificate obtainable from the destination country (mainly the Department of Water and Forestry) and a phytosanitary certificate which is obtained from the Department of Veterinary Services within the Ministry of Agriculture in Windhoek (MAWF, 2010). These requirements apply to the export for own use as well, although the import permits can be issued at the border post. The export for commercial and own use permit is valid for 7 days and the weight of the produce by commercial applicant determines the fee to be paid. The first ten tons are charged at N\$5 per ton and all other additional tons are charged at N\$2 per ton. The export for own use permit is charged N\$5 (MAWF, 2010).

3. Namibian draft Bush Encroachment Management Policy

Namibia currently has a draft Bush Encroachment Management Policy. This policy was prepared with the support of the Ministry of Environment and Tourism (MET). It is however sad that the initial idea to submit this policy to cabinet in 2005 never materialised (Diekmann & Muduva, 2010: 16).

3.3 Overview of Tsumeb

The town of Tsumeb is situated in the Oshikoto region, which is one of Namibia's thirteen regions. The town has a sub tropical climate, with mean maximum temperatures of about 29.7°C and mean minimum temperature of 14.4°C. The average rainfall is 555mm per

annum (Municipality, 2002). According to the 2001 Namibia Population and Housing Census, Tsumeb had a population of 13 108 people (NPC, 2003: 3). Tsumeb like any other town is also experiencing an inflow of rural-urban migrants and this brings along with it social development challenges such as the ever increasing high levels of unemployment, increased poverty and an increase in housing shortage (Municipality, 2002). During the drafting of its strategic plan for 2009 – 2013, the Tsumeb municipality recorded an increase in the population of about 22 500 people residing in Tsumeb and its surrounding areas, with a total of about 16 000 people residing in the town itself (Tsumeb Municipality, 2008). The copper mine in Tsumeb is the major employer in the town followed by the informal market (called Tulongeni Pamwe translated “let us work together” in the local language) providing a living for about 234 families (Municipality, 2002). Tsumeb is one of the very few local governments that provides its own water to its residence, while this seems to be an impressive move, the electricity tariffs in the town are unfortunately the second highest in the country at N\$/kWh 1.63. The mining activities that are taking place in the town present major pollution threats to the underground water source as well as contamination of much of the town land making most of the available virgin land as well as serviced land unsuitable for normal residential and business purposes (Tsumeb Municipality, 2002).



Figure 3.3 Aerial view of Tsumeb 19°15' Southern latitude and 17°42' Eastern longitude

There is very little community involvement in municipal activities. Thus the stakeholder participation in planning and development in the town is still a major challenge. Tsumeb, like any other town has complexities of wood fuel flows and the human settlements that often are not visible to the naked eye. Wood fuel consumption in the town is currently high; not only at household level, but also because of its use at the informal market that has become the source of income for the majority of the residents. The Tsumeb municipality clearly points out the importance of “inclusiveness” as one of its core values in order to ensure community participation in all municipality affairs. The feeling gathered from some community members, however, shows that this value is still far from reach as community members are in most cases not involved in crucial decision making processes.

3.4 Description of the residential areas

The main residential areas in Tsumeb are; Mein plaas, town and the township. The township is further divided into Nomtsoub, the informal settlement and Soweto. The research focused on all of the residential areas. Table 3.2 below gives brief descriptions of the various residential areas in order to get an idea of the energy use and affordability of the various energy sources.

Table 3.2 Description of residential areas in Tsumeb

Residential area	Description
Mein Plaas	Situated on the outskirts of town. Has the least population size compared to other residential areas. The community is made up of mainly low income households, with a high population of unskilled labourers. The area is much closer to the biomass resource compared to other residential areas.
Town	The town dwellers comprise of educated, skilled and semiskilled members of the community and fall between middle to high income households.
Nomtsoub	The majority of the population resides in the township. Nomtsoub comprise of low to high income households and generally covers the entire township, but for the purpose of the study is further split up into the informal settlement and Soweto. Nomtsoub has a combination of educated, skilled, semiskilled and unskilled members of the community. There are open land on the outskirts of Nomtsoub with some biomass resource.
Soweto	Most crowded residential areas in Tsumeb, comprising of low to middle income households. Back yard shack and illegal power connection is common there. Soweto has a higher population of unskilled labourers in the town and has a high number of sheebens operated on the household premises.
Informal settlement	Has been the major contributor of urban sprawl. It is made up of Unelectrified households mainly depending on wood and paraffin. High number of unskilled labourers with a majority of people involved in small businesses (mainly at the informal market). Vast amount of land has been cleared around the informal settlement area due to urban sprawl.

It is not easy to classify the various residential areas especially those people residing in the township as they fall under various categories from rich, middle and low income groups. The National Planning Commission (NPC) of Namibia produced a report on the review of poverty and inequality in Namibia. Figure 3.4 below is extracted from that report and illustrates the poverty shares by region during 2003/2004. As it has been mentioned earlier in this chapter,

the town of Tsumeb falls within the Oshikoto region. This region is the third largest region with high levels of incidences of poverty after the Kavango and Ohangwena regions (NPC,2008: 11).

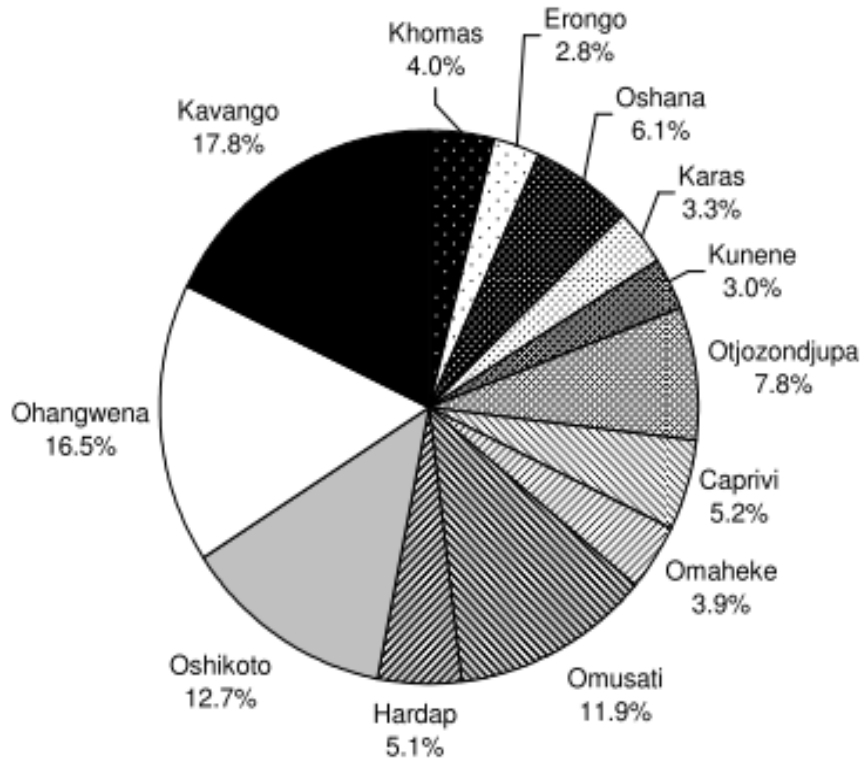


Figure 3.4 Poverty shares by regions in Namibia during 2003/2004 (Source: NPC, 2008: 11)

Table 3.3 below shows the average size of households by region. Poor households have more people living in them compared to non-poor households. According to table 3.3 the average household size in Namibia is 4.9 persons with 4.2 on average in urban areas and 5.4 in rural areas. The average household size of poor households is 6.7 compared to 4.2 for non-poor households. Severely poor households has average household size of 7.2 (NPC,2008: 12).

Table 3.3 Average size of households by region in Namibia 2003/2004 (Source: NPC,2008: 12)

	Severely poor	Poor	Non-poor	Total
Caprivi	6.4	5.9	4.1	4.6
Erongo	5.7	5.0	3.4	3.6
Hardap	5.8	5.5	3.6	4.2
Karas	6.9	6.0	3.5	4.0
Kavango	7.7	7.3	5.3	6.4
Khomas	5.7	5.2	3.9	4.0
Kunene	8.6	7.4	3.8	4.6
Ohangwena	8.4	7.8	5.0	6.3
Omaheke	6.5	5.8	3.5	4.2
Omusati	7.0	7.1	5.1	5.7
Oshana	7.2	7.0	5.0	5.4
Oshikoto	7.0	6.5	4.6	5.4
Otjozondjupa	6.8	6.1	3.7	4.3
Namibia	7.2	6.7	4.2	4.9
Urban	6.5	6.0	4.0	4.2
Rural	7.3	6.9	4.5	5.4

According to Niikondo (2010: 1) not all people living in informal settlements are poor. He explained that some city migrants feel like transient residents and thus do not see the need to invest in proper housing as “their hearts and spirits remain in rural areas” (Niikondo, 2010: 1). Some urban dwellers put up structures (shacks) as temporary domiciles since they eventually return back to their places of origin after pension (Niikondo, 2010: 1).

Niikondo gives a summary of some factors that contribute to the development of more shacks than formal housing by immigrants in the cities (Niikondo, 2010: 3).

- Lack of entitlement rights
- Lack of capital for housing investment
- The need to accumulate remittances to invest in their places of origin (communal areas)
- Cheaper standard of living in shacks as opposed to formalised housing
- No thorough understanding of the urban lifestyle

Apart from the housing options, the researcher assumes that these factors might also play an important role in choosing the type of energy source to use. Understanding the background of the town complements the method that will be carried out for the study. The next chapter will outline the research design and methodology that was followed to ensure that the study objectives were achieved.

3.5 Conclusion

Namibia imports most of its electricity from South Africa and other countries in the region. Namibia will have to concentrate on alternative power generation projects if it is to meet the ever increase demand for electricity. Namibia currently has a White paper on Energy Policy of 1998 which has remained dormant for the past 13 years. Attempts are underway to have it reviewed. It will only have an impact if it will consider the indigenous renewable energy options and provide a platform to resolve constrains within the energy sector which has over the years prohibited viable energy projects. Tsumeb has favourable climatic conditions for afforestation projects which will guarantee future biomass resources for the community. The lack of the community involvement in the municipal activities and decision making process poses a major threat to the town's development process especially when it comes to the conservation and sustainable utilisation of the biomass resource.

CHAPTER 4: Research design and methodology

4.1 Introduction

This Chapter will illustrate the methods that were used to carry out the study. These methods satisfied the set objectives as outlined in Chapter one. The chapter will also justify the various methods that were used during the study which lead to the findings that will be presented in chapter five. Since this thesis focuses on the Material Flow Analysis (MFA) of wood fuels, this chapter will also look at the strengths and limitations of using MFA and also outline how each objective was achieved. Due to the complexities of Wood fuel flows a number of stakeholders had to be interviewed, these include the wood fuel consumers and suppliers, the research generated both qualitative and quantitative information.

4.2 Research design

The chosen research design was aimed at achieving the research objectives as outlined below.

1. Understand the energy market in Tsumeb
2. Build an understanding of the current wood fuel flow in the town of Tsumeb
3. Identify the opportunities that exists in order to create a market for the excess biomass material from the invader bush in the surrounding areas
4. Identify how the wood fuel channels can be optimised to serve all the stakeholders better by utilising the MFA framework?
5. Assess measures that will lead to the formulation of sustainable wood fuel strategies in the town of Tsumeb

4.2.1 Identifying the important offices in Tsumeb

1. The Tsumeb Municipality

Although the researcher is a resident of Tsumeb and has a fair understanding of the social dynamics of the town, she updated herself with the latest development in the town given the fact that she has not been in town for a while. The first step was to meet with the Chief Executive Officer (CEO) of the Tsumeb municipality. The CEO was able to give amongst others, a historical background of the town, energy usage in the town, various challenges the municipality is facing and the state of the biomass materials in and around the town. One very important document received from the CEO's office was the Strategic Plan

Development Initiative for 2009 – 2013. This document provided a good insight of the various activities of the town. The CEO also referred the researcher to meet with the town planners, unfortunately this meeting never materialised given multiple contact attempts to meet with them.

2. The Regional Councillor of Tsumeb constituency

The researcher also visited the regional councillor's office. This office is a decentralised arm of the government. The research required the researcher to engage with the community, firstly the researcher needed to report herself to that office in order to obtain permission to engage with the community. This office gave the researcher a letter (attached in annexure 1) that acknowledged her presence in the town to conduct the research and also urged members of the community to be cooperative during this exercise. Secondly, as part of the regional councillor's office duties, they sent out announcements to the radios and the local churches in the town informing them about the study and urged the community to feel free to render assistance and provide the researcher with the information she required to ensure successful completion of the research.

3. Ministry of Agriculture Water and Forestry (MAWF)

The local Ministry of Agriculture Water and Forestry (MAWF) office played a crucial part in identifying the farmers that sell fire wood and charcoal to the community of Tsumeb. One crucial document from this office was the Forest Act (12 of 2001) Amendment act 13 of 2005. Useful information on obtaining the harvesting, marketing and transport of biomass resources was also provided.

4.2.2 Overview of the wood fuel use over the past years: Senior citizen of the town

Over the years there has been a significant change in the vegetation and population size in Tsumeb. Urban sprawl is now clearly visible as the number of people in the town continues to grow and the re-opening of the copper mine has lead to the creation of more jobs. The researcher sought to understand this transition from a senior citizen who has been residing in Tsumeb for the past fifty years. She narrates these changes in the following chapter when the findings of the research will be discussed.

4.3 Literature review

Literature was reviewed in order to gather information on the different debates around wood fuel flows and Material Flow Analysis (MFA), sustainable wood fuel strategies and methods that are being used in MFA studies, examine the sampling and interview methods that are being used as well as the structuring of the questionnaires that were used during the interviews.

The strength of the study is that there is no knowledge of any MFA study conducted in Tsumeb before. In order to build an understanding of the current wood fuel flow in Tsumeb, primary data including quantitative and qualitative information was generated. This was also used to reinforce what has been gauged from the random and informal conversations with the various members of the community.

In order to reach research objective one (build an understanding of the current wood fuel flow in the town of Tsumeb), interviews with wood fuel suppliers and consumers were conducted. The results from the interviews established who the main suppliers of wood fuels are, how wood fuels are transported and identified the various markets that exist. Literature on MFA, survey sampling and formulating MFA questions for the questionnaires was also reviewed.

Once the MFA of wood fuels was established, research objective two (build an understanding of the current wood fuel flow in the town of Tsumeb) and research objective three (Identify the opportunities that exists in order to create a market for the excess biomass material from the invader bush in the surrounding areas) was achieved. In order for the wood fuel channels to be optimised the problems/challenges within the system had to be identified and the strongest links within the system needs to be strengthened. This understanding was assessed against the current wood fuel flows in the town, with the aim of promoting sustainability and gaining an understanding of the current gaps that exist in the wood fuel market and how they can be strengthened to create a thriving market for the excess invader bush in and around the town.

Extensive literature on sustainable wood fuel strategies was reviewed alongside with Namibia's policies, activities and regulatory framework on the use of biomass. It is this literature and the survey results that lead to the various recommendations as seen in the final chapter of the thesis.

4.4 Strengths of MFA

This thesis aims to establish the MFA of wood fuels in Tsumeb by conducting an analysis of the actual material as well as the energy flow that goes through an economy. The various human activities and environmental problems are easily identified and quantified, thereby allowing for appropriate planning on how to manage the responsive measures (The Sustainable Scale Project, 2003). MFA is able to detect problems in advance, thereby providing precautionary measures to be put in place. It is able to detect problems that are being transferred between regions and sectors and can be used at the various stages of economic activity (The Sustainable Scale Project, 2003 and Belevi, 2002: 1).

4.5 Limitations of MFA

There are several limitations and shortcomings of using MFA methods. Giljum (2003: 38) has identified two major shortcomings the first one is the aggregation of various qualities of MFA studies that leads to the development of aggregated indicators. The second shortcoming he has identified is the weak links that exist between MFA indicators and the environmental impacts (Giljum, 2003: 38).

Binder *et al.* (2009: 645) has identified the importance of having sufficient data available in order to improve MFA studies. They further added that there are various factors that determine the ability to implement MFA in the decision making processes. While implementation of MFA results at industry and manufacturing entities level seem to occur easily and quickly, it is much slower at government levels. One challenge faced at government level is the uncertainty of who is responsible for taking action, since the number of stakeholders involved at government level increase, there is an increase in data uncertainty and in most cases the goals of material management are not clearly defined, leading to the misinterpretation of MFA results (Allan, 2005; Binder, 2007 in Binder *et al.*, 2009).

An internationally standardized MFA procedure which can be used across various applications is still missing (Binder *et al.*, 2009: 645 and Giljum, 2003: 39). Another shortcoming is that although MFA can be useful in identifying potential options that will bring about change, it unfortunately does not offer solutions for implementation (Binder *et al.*, 2009: 645). Authors of various MFA studies did not take a step further to incorporate possible policy-related uses of MFA results and this should be a critical issue for future MFA

studies (Giljum, 2003: 39). In order to have effective policies and intervention strategies, a thorough understanding of wood fuel flows in the local context is important (FAO, 1996).

4.6 Developing a questionnaire for wood fuel consumers and suppliers

Two types of questionnaires were developed namely: for wood fuel consumers and wood fuel suppliers (questionnaires are attached in appendix 1 and 2). As previously indicated in section 3.3 the drafting of the questionnaires started with the review of literature on MFA. According to a report from the Food and Agriculture Organisation of the United Nations (FAO, 1996), also cited in Chapter one of this research, understanding wood fuel flows requires an identification of the characteristics of wood fuel sources. Some issues to consider includes; the origin of the wood fuel whether it comes from forest or non-forest area, methods of harvesting, how the wood fuel is transported, what the existing markets are and identifying the various stakeholders that are involved (FAO, 1996). These issues were also taken into consideration during the drafting of the two questionnaires that were used during the study. While studying the literature it was also realised that MFA studies are not standard and differ depending on the type of resource or material that is being studied. The questionnaires that were used were open-ended / semi-structured questionnaires.

The advantage of semi-structured questions over structured and unstructured questions is that it allows for already planned key questions to be answered and allows other issues not included in the questionnaire to be discussed. It also ensures that new lines of thinking are created and allows for a more relaxed style of talking that puts both the interviewer and interviewee at ease (Wickham, 1997: 148).

4.7 Establishing the survey

A good representative sample is ideal in order to be able to derive quantitative and qualitative estimates of the use of wood fuel by consumers. Usually the population to be sampled is so large that it becomes impossible to sample every member of the population, therefore most researchers only take a sample of the total population (Huysamen, 1994:37).

Table 4.1 Comparison of probability and non-probability samples (Huysamen, 1994: 37).

Probability samples	Non-probability samples
Examples	
Random samples, stratified samples, systematic samples, cluster samples	Accidental samples, purposive samples, quota samples, snowball samples
Advantages	
Once the sample results deviate, probability sampling is able to indicate the deviation probability from the corresponding population values. Sampling errors can be estimated easily It is frequently used due to convenience and economy	Less complicated More economical Can be useful in pilot studies
Disadvantages	
Expensive	Not possible to estimate sampling error

Probability sampling

According to Huysamen (1994), random sampling has been viewed as the appropriate sampling method. There are two types of random sampling methods mainly, simple and stratified random sampling method. By using random sampling technique, all members of the population to be sampled have an equal chance of being selected and sampling errors can be picked up easily. A random sample will require a sampling frame, which lists down the various elements of which the population is made off (Huysamen, 1994: 40).

Stratified random sampling focus on members of the community that are homogenous compared to the entire population (Huysamen, 1994: 40). It takes into account the diverse variations in the population. In the stratified random sampling, the various subgroups are identified and a random sample is drawn from all the various subpopulation identified (Huysamen, 1994:41). This method gives a representative sample of a population which

clearly distinguish the various subpopulations compared to the simple random sampling method (Huysamen, 1994: 41).

Stratified random sampling technique usually requires a smaller sample compared to simple random sampling technique to ensure that the various subpopulations are included in the sample (Huysamen, 1994: 41). Systematic and cluster sampling can be used together with simple or stratified random sampling or even in combination with each other. Although systematic sampling takes up less time and money, random sampling still yields more accurate results (Huysamen, 1994: 42). Cluster sampling may be done in more than one phase, which might not be representative of the entire population or of the various clusters. It saves time and money but can lead to biased samples, especially when there are clusters that are homogenous (Huysamen, 1994: 43).

Non-probability Sampling

In non-probability sampling there are some elements which might not stand a chance at all of being selected in the sample (Huysamen, 1994: 43). Accidental Samples are usually used as a last resort when all other options have failed. A purposive sample involves selecting participants for the sample through personal experiences or even through past research findings. It is important to bear in mind that various researchers might use different ways in identifying the sample, thus making it difficult to evaluate the extent to which this samples are true representatives of the entire population being sampled (Huysamen, 1994: 44).

Snowball samples identify certain individuals in the population who then identify other individuals within the same population to be included in the sample (Huysamen, 1994:44). To obtain satisfactory results, the sample to be selected should be made larger in the case where the total population is small. The variance of the variable also determines the sample size (Huysamen, 1994: 47-48). A larger sample is often recommended since some participants might not provide all the information required or decide to withdraw from the study or complete half of the study (Huysamen, 1994: 48).

This study used a combination of stratified random sampling and snowball sampling technique. Snowball sampling was inevitable in this study as more and more referrals were being made during the interview process especially when it came to identifying the different informal wood fuel suppliers. A total of six households were randomly selected from each of the five residential areas, meaning that a total of thirty households were selected. The residential areas include:

1. Soweto
2. The informal settlement
3. Nomtsoub
4. Mein plaas
5. Town (resident living in town)

While this proved to be an ideal sampling method for this study, a similar method was also employed during the preliminary economic asset and flow accounts study of Namibia’s forest resources conducted in 2010 (Barnes et al.,2010: 162) as well as the wood fuel flow study that was conducted in Cebu, Philippines in 1993 (FAO, 1993: 92).

4.8 Interviews

The interviews started with the “backwards linkage methodology” this means that the interviews first started with the wood fuel consumers. It was through interviewing wood fuel consumers that some of the wood fuel suppliers were identified and traced for interviews. It is important to note that wood fuel suppliers especially fire wood suppliers are not easy to trace especially in the informal sector which has proven to be the dominating sector in Tsumeb (more details will be discussed in the next chapter). Other wood fuel suppliers like the wholesalers, filling stations and retailers were easily noticeable.

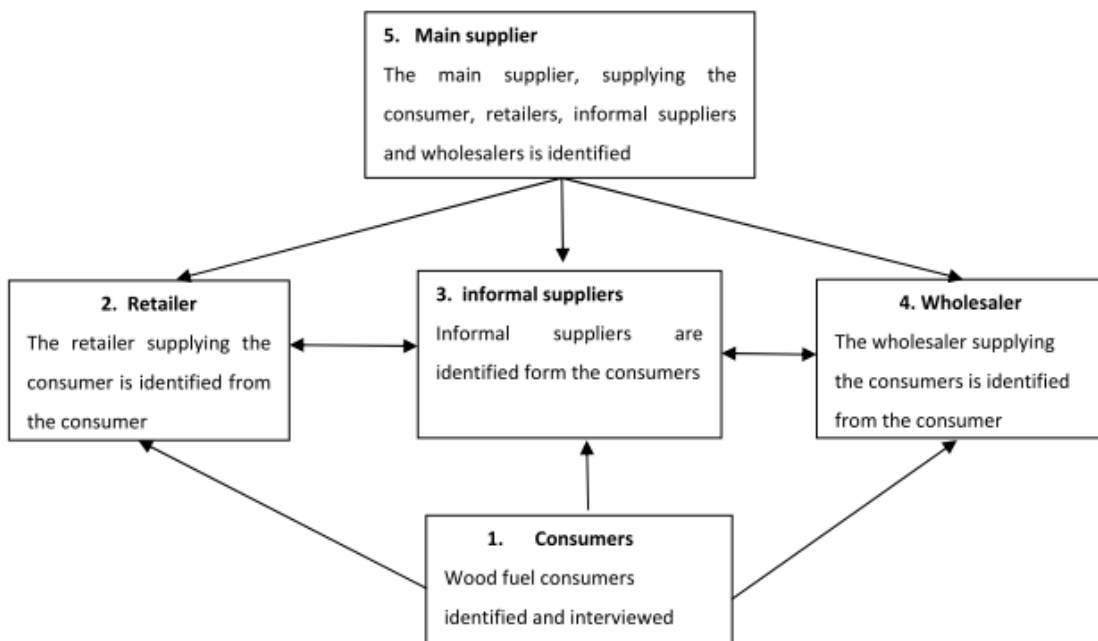


Figure 4.1 Schematic diagram of the backwards linkage methodology

Advantages of the backwards methodology compared to the standard methodology

1. The standard method usually takes a sample of participants from a population and when official licence records are to be used; a substantial number of the population might be left out of the pool to be sampled, since most of the participants in the trade sector are un-licensed. The backwards linkage methodology identifies the part time wood fuel suppliers who often remain dormant and not noticeable (Boberg, 1993: 476).
2. It is difficult to identify all the suppliers in the town and there is a lot of uncertainty with regards to the search especially in larger towns (Boberg, 1993: 476).
3. Statistically, there might be locations that might not be discovered through the standard method, this might led to the exclusion of some wood fuel traders from the survey sample. Thus the backwards methodology is reasonably certain as long as the information from the respondents is accurate (Boberg, 1993: 476).
4. Distances between all the nodes of the system are easy to measure thereby establishing the distance and channels the wood fuel goes through (Boberg, 1993: 476).

The consumer's group comprised of households, informal settlement wood fuel consumers (mainly food vendors), Institutions (Schools, pre schools, tertiary institutions) and organisations (mainly the copper mine). Most of the ambulant food vendors were traced during household interviews since they do the cooking and marketing of their food that they sell on the household premises. Some of the important items the researcher carried with her at all times included a note book (most of the information was captured by writing extensive notes), tape recorder (mainly used with focused groups), camera, permission letter from the Regional Councillor's office (the letter from the regional office eliminated any refusals for the participation in the survey), Stellenbosch University student card and standard weighing scale.

Interviews with consumers

Interviews were held with the household heads for about thirty minutes to an hour in languages spoken by the respondents. Most of the respondents either spoke English, Afrikaans, Oshiwambo, Otjiherero and Damara Nama. Although the questionnaires were in English the researcher was able to communicate with the respondents in all the above mentioned languages²¹, thus no translation of the questionnaire or translator was needed. In cases where household heads were absent, household member(s) with a clear

²¹ The researcher speaks and understands all the languages used in the interviews.

understanding of their household wood fuel consumption were interviewed instead. As showed in figure 4.1 above the backwards linkage methodology starts with the consumers of the wood fuel, therefore interviewing the consumer gave the researcher a clear indication of who their wood fuel suppliers were. In cases where there was no specific supplier (when they purchase their wood fuel from infrequent and random suppliers at a particular location) the location was recorded and a wood fuel seller at that specific location was picked at random. A wood fuel suppliers list was then compiled from these interviews. Other visible wood fuel suppliers like those with piles of fire wood displayed for sale in their yards and those selling along the roads and informal markets were also added on the list.

Interviews with focus groups

The researcher also accompanied a group of women and girls on one of their fire wood collecting days. With the permission of the group the interviews were recorded as it was not easy to capture notes with a constant simultaneous addition of information from the group members.

Interviews with suppliers

All the first identified suppliers from the consumers were interviewed. It was through these suppliers that the next node of the wood fuel path was established. This method led to the identification of multiple wood fuel suppliers and this completed the back tracking of the wood fuel path purchased by the original end user. This method was also able to define the spatial and temporal nodes. Both full-time and part time wood fuel traders were interviewed, whether they operate from the open-markets, along the public roads, form homes and even supermarkets.

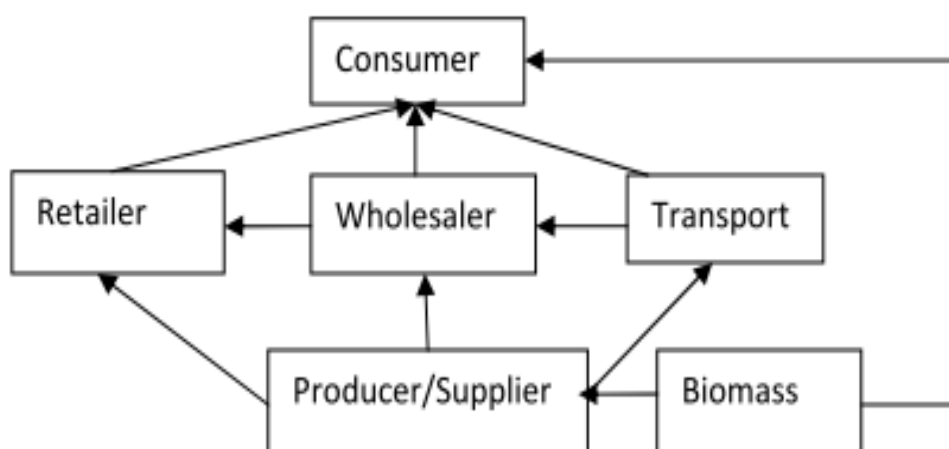


Figure 4.2 Wood fuel supply system (Boberg, 1993:476), modified.

This wood fuel supply system formed a very important part in linking suppliers to their actual suppliers. The entire Tsumeb wood fuel system will be presented in the next chapter. Table 4.2 below shows the formal wood fuel suppliers in Tsumeb.

Table 4.2 Formal wood fuel suppliers in Tsumeb

Retailer	Category
General dealers	Shoprite
	Pick n Pay
	Spar
	Lisboua
Filling station	Engen Le Platz
	Engen Wimpy

Only five out of eight retailers in Tsumeb are involved in the trading of wood fuels²². It was interesting to note however that there are no shops in the township that sells wood fuels (particularly fire wood) despite the fact that they are consumed there in high volumes. Only one retailer (Shoprite) out of all the retailers interviewed did not sell briquettes at the time of the study. The researcher tried as far as possible to ensure that she orally conducted the interviews instead of having telephonic interviews or even leaving the questionnaires with the suppliers and collecting them at a later stage once the suppliers have completed the questionnaire. The reason for this was to eliminate any chances of respondents misinterpreting the questions and also created an opportunity to get other valuable additional information that might not be addressed in the questionnaire. All the interviews that were conducted were done either with the manager or assistant manager of the respective shops at their business premises. Similarly, all the questionnaires that were submitted for completion were submitted to the managers.

Unfortunately, only two suppliers out of the six suppliers agreed to have oral interviews with the researcher. Table 4.3 below show the various suppliers that were surveyed for the study.

²² Note: Wood fuels in this thesis include fire wood, charcoal, briquettes and any biomass material (such as twigs) that is used as a source of energy. The twigs are mainly sourced by the consumers themselves and do not form part of the formal system.

Table 4.3 Formal wood fuel suppliers in Tsumeb

Number	Retailer name	Person interviewed/person who completed questionnaire	Interview/collect questionnaire	Date of interview
1	Model Pick n Pay	Manager	Interview	17 May 2011
2	Engen Le Platz service station	Assistant manager	Interview	17 May 2011
3.	Lisboua	Manager	Questionnaire collected	24 May 2011
4.	Shoprite	Assistant manager	Questionnaire collected	28 May 2011
5.	Wimpy Engen service station	Manager	Questionnaire collected	2 June 2011
6.	Spar	Manager	Questionnaire collected	7 June 2011

4.9 Observation

Observation is also a very critical aspect of research. It helps to glean information that could not be gathered from literature or the questionnaire. As mentioned before the researcher accompanied a group of women and girls on one of their wood collecting days and occasionally visited the unfenced landfill site. This area has become a hang out spot for some of the community members. The wood based waste collected for the purpose of cooking will be discussed further in the next chapter.

4.10 Data analysis

Qualitative and quantitative data was generated. The qualitative data will be very useful in establishing the trends which is a very critical aspect of this research. Graphs will be used to clearly show the results of the study. Microsoft Excel spreadsheets can be used for simpler MFA studies although there are other software that have been designed for MFA studies such as, Substance Flow Analysis (STAN), ORWARE, which was developed in Sweden and is used in MFA of waste management and URWARE used for water management as well as SIMBOX which is quite flexible and allows for a better degree of adaptation for the user (Meininger, 2010: 36).

CHAPTER 5: Data analysis and discussion of results

5.1 Introduction

This Chapter will discuss the findings of the study. These findings include results from the interviews that were conducted with the wood fuel consumers and suppliers. These findings attempted to answer the research objectives²³ which will be presented again in this chapter.

The MFA framework will assess the wood fuel flows as well as all the material stock within the system taking into account the location as well as time (FAO, 1996). Once the flow is understood the weak links within the system become visible and measures will be introduced to establish how to best optimise the wood fuel value chain. As observed in Chapter One all the interview questions were structured in a way that will help achieve the set objectives. Each objective will be reintroduced and clarity on how the objective was achieved will be given. This chapter will also draw back to chapter 2 (Literature review) to see the relations of the research findings with what has been said in the literature.

The discussion of the results starts off with a story by a senior citizen in the Town of Tsumeb. She compares the current wood fuel availability to those of the past years. Her story is narrated in Box A. This overview leads to the presentation and discussions of the research findings. As part of the research objective one, the researcher wanted to understand the overall energy market in Tsumeb in order to really establish whether wood fuels do play a significant role in the household energy mix. The researcher first draws this picture before dwelling in the results from the survey. The findings are summarised into a

²³ Research objectives:

1. Understand the energy market in Tsumeb
2. Build an understanding of the current wood fuel flow in the town of Tsumeb
3. Identify the opportunities that exists in order to create a market for the excess biomass material from the invader bush in the surrounding areas
4. Identify how the wood fuel channels can be optimised to serve all the stakeholders better by utilising the MFA framework?
5. Assess measures that will lead to the formulation of sustainable wood fuel strategies in the town of Tsumeb

Material Flow Analysis (MFA) which includes both the wood fuel suppliers and consumers. The actual stock and energy quantities sold are presented in separate tables due to the two subsystems (formal and informal suppliers). The chapter closes off with concluding remarks of the findings.

BOX A

Mrs Anna Shikongo moved to Tsumeb in 1971. She has been a resident of Soweto for the past 40 years. She has been living in a shack behind a family member's house for about seven years before she eventually became a house owner in the same neighbourhood. Mrs Shikongo clearly remembers how easy and quickly it was to collect firewood for cooking. Firewood sales were not at all profitable since firewood was very close and all the firewood she used was self collected. She walked about 15 minutes to collect good quality firewood and would occasionally return to collect more depending on what was being prepared and more especially during the rainy season. She prepared food whenever there was a need to prepare and did not trouble herself with the availability of firewood. Whenever there was any kind of celebration she would make a traditional beer "*omalovu*". Preparing this beer requires lot of firewood as the mixture of water; sugar and sorghum flour had to be boiled for some time before the pulpy sorghum is sieved out. She remembers how one day to her surprise the forest where she collected firewood was cleared, it remained empty for about two years.

"What type of leader makes such decisions; did they clear the land with no definite plan in mind? They starved us of that good quality wood for two years! But we had options to move to another location close by."

Firewood slowly started becoming scarce as the town kept expanding which resulted in the clearing of more and more land. The distance travelled to collect firewood became longer and took up most of her time to do other household chores. While previously she could collect firewood twice a day due to the short distance she travelled, she now can only do one trip. She remembers how the bush density made it difficult to walk through and even see her other colleagues she collects firewood with. No trees were planted to replace the harvested ones. This is because there was no community forest as there didn't seem to be the need. If the house did not have firewood in the olden days people assumed there was no food in the house. This portrayed a sign of weakness of the man to provide for his family. Soon firewood became scarce and vendors started seeing a niche. She still collects her own firewood and it takes her about four to five hours. In order to save firewood, one meal is prepared early in the morning and is consumed throughout the whole day (one diet). She explained the need to soak food substances that would require more firewood for cooking as another conservation measure. Asked about energy efficiency and whether she would consider using energy efficient stoves to save firewood she replies... "It is difficult to change from my traditional way of preparing food for my family, but with time I might not have a choice. *I never knew that firewood scarcity would change my lifestyle, even the food I eat*"

5.2 Analysis of the wood fuel flow in Tsumeb

Before the wood fuel flow analysis is presented, the overall energy market was assessed. This was done in order to establish what the primary demand and supply situations are in Tsumeb. It was observed that the Tsumeb energy mix consist of electricity, gas, paraffin and the use of wood fuels mainly firewood and charcoal. The major cooking fuels are gas and firewood. Paraffin mainly dominates households in the informal settlement where it is used for lighting and cooking especially during rainy seasons. The use of firewood in Tsumeb dominates the entire energy mix and supply zones include the nearby peri-urban areas and the local forests. The electricity is being managed by the local Regional Energy Distributor (RED) and the local AFROX depot is the main supplier of gas in the town. As for the paraffin and wood fuels they are all purchased either from the suppliers (retailers) or informal suppliers (especially firewood).

In an attempt to respond to research objective two: *Build an understanding of the current wood fuel flow in the town of Tsumeb, the Material Flow Analysis (MFA) of wood fuel in Tsumeb is presented in figure 5.4. The flow shows that consumers use firewood and charcoal and no use of briquettes has been recorded although they are on the shelves of the suppliers.*



Figure 5.1 The manufacturing of bush blocks also known as briquettes in Otjiwarongo 180 km from Tsumeb (Source: DRFN, 2007).

The Researcher also realised that the consumers tend to use the term 'briquettes' interchangeably. Some of the consumer's are of the opinion that briquettes only apply to the

bush blocks manufactured at Cheetah Conservation Fund (CCF), while others consumers are of the opinion that it applies to both bush blocks and charcoal. In order to ensure that the right information was provided the researcher always made sure she got the proper understanding of the term from the consumer. The researcher's interpretation of the term briquette, is any block of compressed coal, charcoal, sawdust or wood chips used for fuel.

Although the production of charcoal uses bigger branches greater than a certain diameter, small twigs (just like in the production of bush blocks/briquettes) are now cut up and crushed into pulp which is moulded into briquette shapes and prepared in charcoal as shown in figure 5.2 below. The briquettes/ bush blocks on the supplier's shelves are manufactured at the Cheetah Conservation Fund (CCF) 180 km outside Tsumeb.



Figure 5.2 Namibian charcoal

The consumers obtain their firewood from the open forest land, landfill site and through land clearing activities although it does not happen often. Purchasing wood fuels is another option. Charcoal and firewood has been reported to be the main wood fuel purchased from the suppliers. They either purchase from the six wood fuel suppliers in the town, from informal suppliers or from the commercial farmers who also form part of the formal suppliers as they supply the six formal suppliers. There is also evidence that the consumers also make use of all the supply methods available depending on the need, quality, price and season.

5.2.1 Wood fuel suppliers

The wood fuel suppliers in Tsumeb as mentioned before are divided into two categories mainly the informal and formal suppliers. There are some formal suppliers (mainly commercial farmers supplying the six retailers) who also form part of the informal sector by supplying consumers directly. These commercial farmers obtain all their biomass resources for firewood and charcoal from their private land. The study recognises three local commercial farmers who are supplying the formal sector with firewood. These are: MJJ²⁴, Mr. O.J. Britz and Mr Swartz. Some of the consumers that were interviewed for the study confirmed that they order charcoal and firewood straight from the local producer. It was unfortunately not possible to interview the local charcoal producer. Although the production of charcoal is less efficient compared to fire wood, it is more efficient to transport which makes it a good option for the suppliers since transport is a major component to the total cost.

Informal suppliers on the other hand consist mainly of un-regulated suppliers who either harvest their firewood from the open forest land, purchase from commercial farmers in bulk and sell to consumers in bundles or they act as middle men between the commercial farmers and the consumers by selling on their behalf. Figure 5.3 below show pictures of informal wood fuel suppliers who collect their own wood and sell directly to wood fuel consumers. There are full time informal suppliers whose main job is to sell firewood at all times, seasonal suppliers only sells depending on the season especially during rainy seasons and part time suppliers sell firewood when there is a great demand and suppliers are not meeting up to the demand such as during month end or the copper festival time.

²⁴ No meaning to the abbreviation was given by the supplier. The only information provided was that it is a local supplier who sells fire wood and charcoal.



Figure 5.3 Informal wood fuel suppliers

The town of Tsumeb is known for its annual Copper festival celebration which is held towards the end of September²⁵. This is the time of the year when lots of wood fuels particularly charcoal and firewood are being used in the town and suppliers capitalise on this opportunity by increasing their stock in order to make more profit. Most of these suppliers have other formal or informal jobs and mainly do this as a form of earning extra income because they see that there is a demand or they are able to get firewood easily and often has more than they need and opt to sell some of it. No hidden flows (where materials that have been extracted never made it to the final consumption) have been reported in this study. The study also did not pick up any link between the informal suppliers and the retailers. The main suppliers interviewed did not show any sign of harvesting from the open community forest except from their private farms.

The supplies are mostly transported using private cars (bakkies), bicycles, wheelbarrow and head loading. The quantities involved are often smaller compared to those supplied by the formal sector. It was not possible to exhaust all the suppliers in this sector; this research interviewed ten informal suppliers comprising of fulltime, part time, seasonal and commercial farmers. The informal sector is being operated almost everywhere in town. Some of these places includes: the informal market (A stall rental fee is payable per month), trader's place of residence, door to door sales and along the roads. While it is possible to tell the origin of

²⁵ The copper festival aims at creating a platform for entrepreneurs where they can showcase their products and services and to attract people into the town with the aim of stimulating business activities and income generation.

most products from the labels it was not easy to track the origins of wood fuels especially firewood. Most of the firewood in the retailers was enclosed in unlabelled bags.

All the informal suppliers interviewed only sell firewood. It was also important to note that there are no retailers or ordinary grocery stores in the township that sell wood fuels let alone fire wood which is used by the majority of residents in the township. Taking into consideration the number of informal suppliers including itinerant suppliers and the piles of fire wood in the various neighbourhoods for sale, it is clear that the wood fuel system in Tsumeb falls largely within the informal sector.

No Namibian charcoal was seen on the shelves of the suppliers during the time of the study apart from the foreign Potrade and Safari charcoal from South Africa, although the suppliers assured the researcher that Namibian charcoal does form part of the wood fuel stock. The use of coal in the Tsumeb Copper mine is also not reflected in the flow because it does not form part of the Namibian supplier consumer chain. The coal being used in the Tsumeb copper smelter is imported mainly from South Africa. Apart from the households and informal market sellers, no institutions or organisations was reported to be using wood fuels.

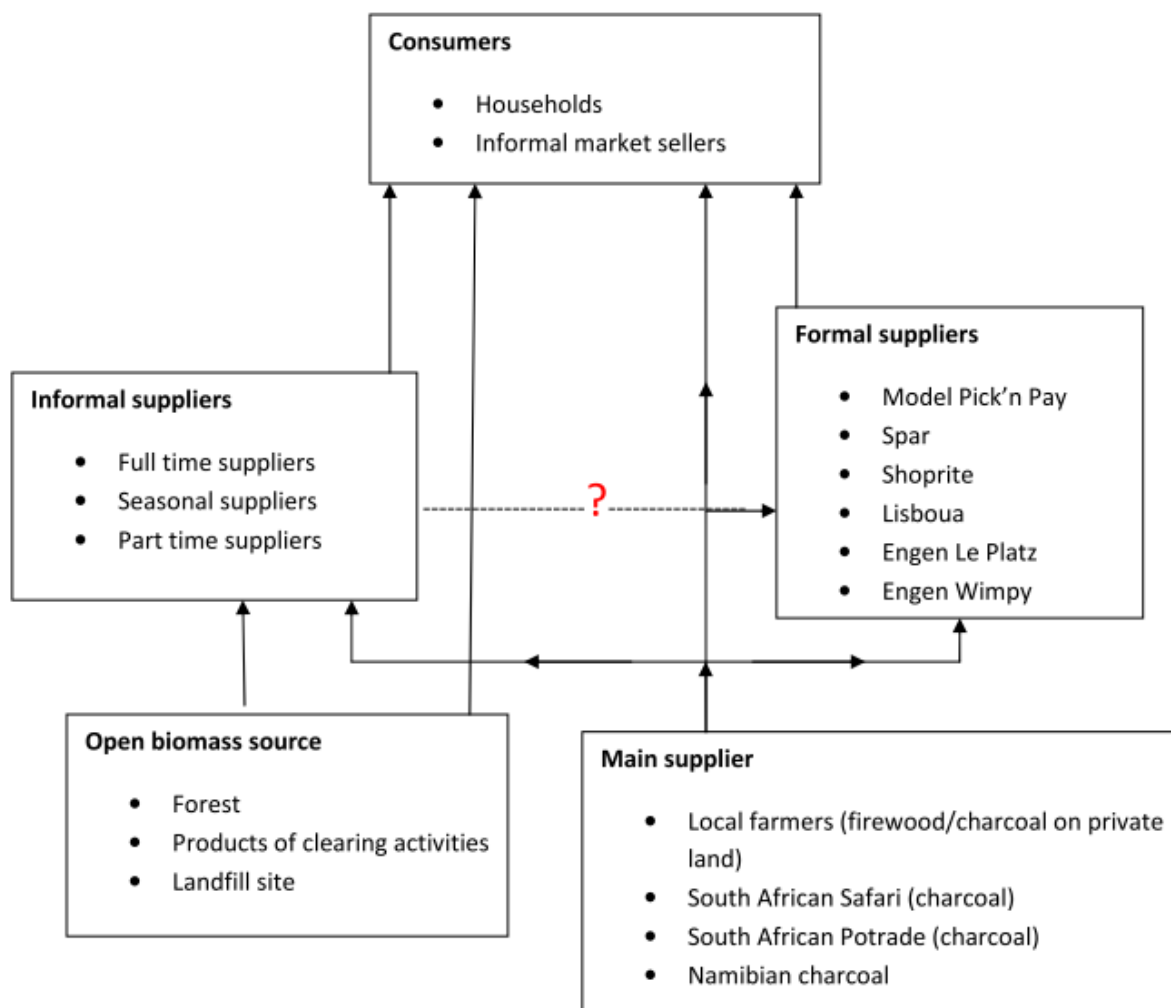


Figure 5.4 Wood fuel flows in Tsumeb

According to the survey, retailers do not order the same amount of wood fuels. Each retailer orders their wood fuel depending on the demand²⁶ and season. The survey showed that there is more wood being used in winter compared to summer. This is mainly because most of the consumers use wood to heat up their water during the winter season. The water is heated either using the open fire or the traditional donkey.

It seems the location in which the retailer is located also plays a role in the wood fuel sale. The following quote emerged during the interview with one of the retail Managers.

²⁶ The area in which the retailer is situated also plays a major role in selecting the type of wood fuels to be sold. Most of the retailers in the city center capitalise on charcoal as it is the most preferred wood fuel type.

“.....Although we are here to serve all our consumers, I have come to realise that I have more charcoal consumers than firewood consumers I order twice as much charcoal compared to firewood. It is maybe because the business is located in the city centre which is inhabited by residents with a braai culture”

Figure 5.5 below shows how often wood fuels are used in the households surveyed in Tsumeb. Most of the households use firewood to cook one meal which will either be consumed throughout the whole day (meaning the family will have to rely on one diet per day) or consumed at supper time. Some consumers use firewood or charcoal during weekends only. The ‘depend’ option on the graph is highest amongst the town dwellers unlike other residential areas where wood fuel is used for preparing one to two meals a day. The depend category comprises things like;

- When there is a need for a barbeque
- Depending on the type of meal to be prepared (especially high energy consuming food products)
- In the case of power failure/ lack of electricity or in an attempt to save electricity
- As a fall back resource when electricity unit has ran out.

Most of the food stuff that requires less energy to cook is prepared using Liquid Petroleum Gas (LPG), paraffin (informal settlements) and electricity, while food products requiring more energy to cook are prepared outside using firewood.

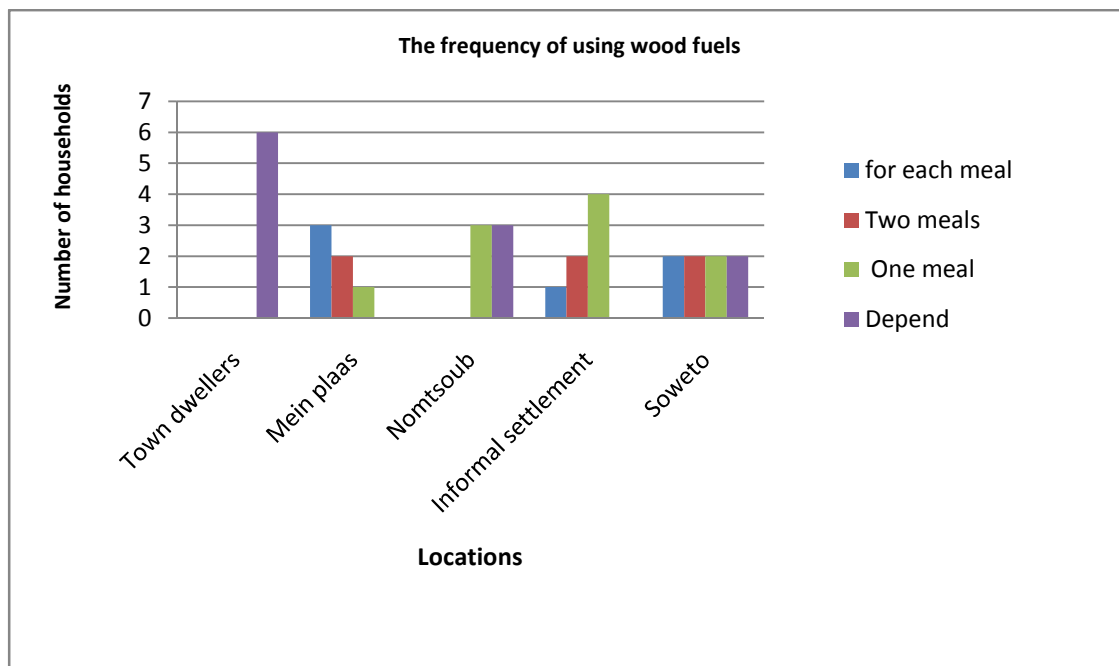


Figure 5.5 The frequency of using wood fuels in the Tsumeb households

5.2.2 Wood fuel consumers

In order to come up with viable recommendations and sustainable wood fuel energy strategies, it is important to know the population size being serviced with the wood fuel. A total of six households were interviewed in each of the five residential areas, which translate into 30 households (containing a total of 178 people). Figure 5.6 below shows that Mein plaas on the outskirts of the town has households containing larger families which are highly dependent on fire wood as their main source of energy, also in their favour is the available abundant biomass resource compared to other residential areas.

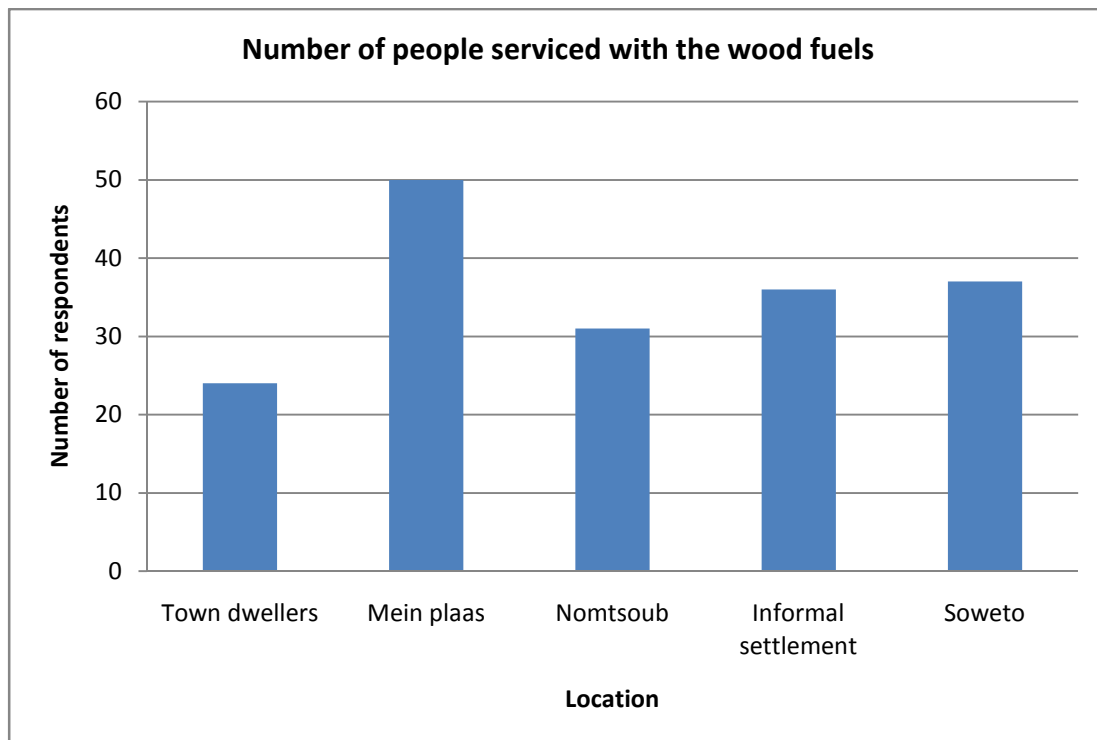


Figure 5.6 Number of people serviced with the wood fuels

The major factor driving the extensive use of wood fuels especially fire wood is the high electricity tariffs in Tsumeb and the expansion of the unelectrified informal settlement. Firewood is mainly used for cooking and heating water especially during winter while charcoal is mainly used for barbeques. According to the consumers most of the cooking is done using open fire, electricity²⁷ or Liquid Petroleum Gas (LPG).

²⁷ It is surprise to know that at such high electricity tariffs, some consumers still alternate between firewood and electiricty for cooking.

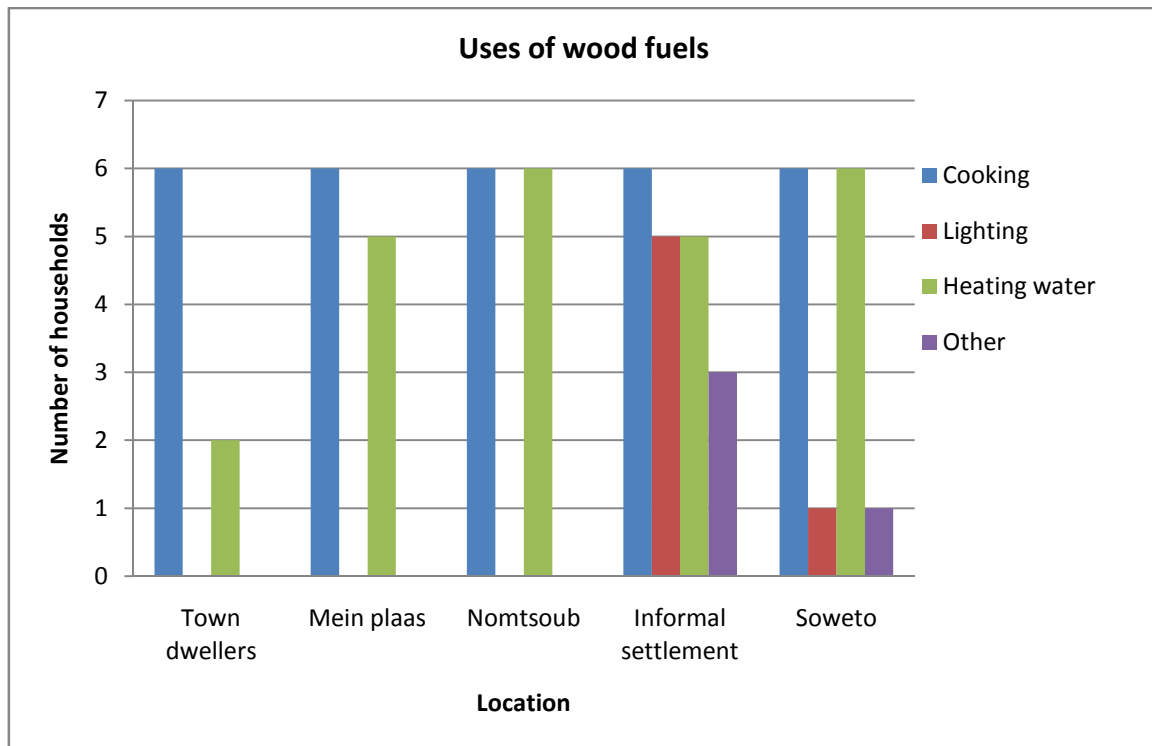


Figure 5.7 Various uses of wood fuels

The survey revealed that wood fuels especially firewood is mainly used for cooking and heating water in all the residential areas. A small percentage of town dwellers use firewood to heat up water, this is because most of their houses are equipped with electrical water geysers. Other areas surveyed use firewood to heat up their water either on open fire or using the 'donkey'. A small percentage of informal settlement residents as well as residents in Soweto use firewood for lighting and coal from firewood in their irons for ironing (represented by 'other' on the graph above).

Mein plaas residents find it easier to use fire wood although they have electricity in their houses; this is because they are situated on the outskirts of town and very close to the forest where fire wood is still in abundance. Figure 5.8 below shows the different wood fuel types that are used in the five areas surveyed.

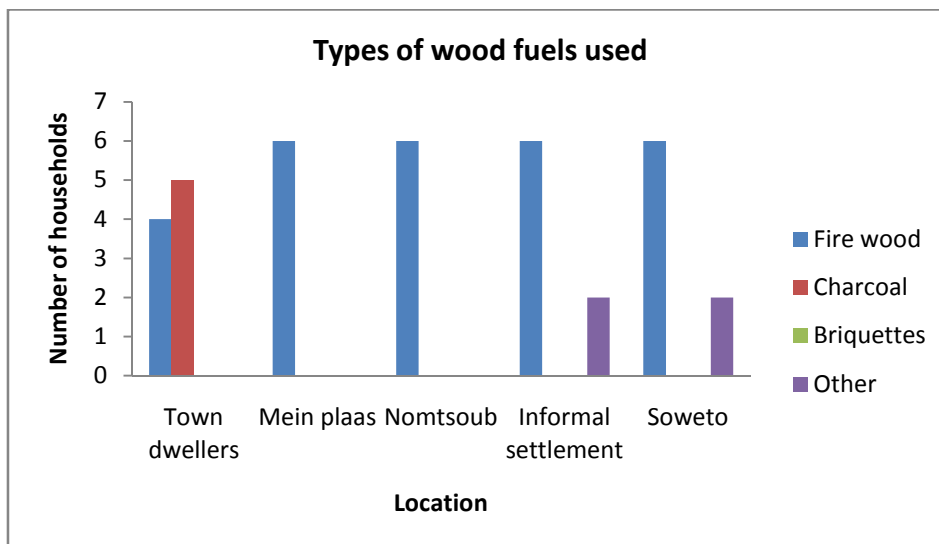


Figure 5.8 Different types of wood fuels used in Tsumeb

Most of the town dwellers interviewed for the study seem to be using more charcoal compared to fire wood. These people usually have superior houses and are financially well off compared to the other members of society. The black community also does not seem to have a braai culture compared to the white and coloured community. It was also interesting to note that charcoal is most often preferred for braai because some of the consumers has realised that smoke from some of the firewood used for braai causes stomach irritations once the braai is consumed, one such species is the Tamboti tree (*Spirostachys africana*).

It was unfortunately not easy to trace consumers that use bush blocks from the Cheetah Conservation Fund (CCF). The researcher then approached the bush blocks/briquettes suppliers who actually clarified that the bush blocks/briquettes sell very slowly compared to charcoal briquettes and fire wood. One of the possible explanations could be that some of the bush blocks/briquettes at the filling stations might be purchased by travellers or passer-by's since Tsumeb is a major gateway to northern Namibia. It also seem as if the consumers do not exactly know what bush blocks/ briquettes really are and see them more as a heating fuel.

There are households specifically in the informal settlement and in Soweto that use dry seed pods and dried Marula fruits (*Sclerocarya Birrea*) that were used in the brewing of the alcoholic drink (ombike), this is represented by 'other' on the graph above.

Consumers that are using firewood now travel longer distances to obtain good quality firewood, it is the scarcity of good quality firewood in the vicinity that has led to the thriving informal firewood market. They travel long distances and often do not have transport to

carry their supplies. The researcher spent some time observing the collection habits of residents at the unfenced landfill site, she observed that most of the old wooden furniture was being disassembled to be used as firewood. A typical wood bundle assembled at the landfill site consists of planks, twigs, branches, hardboards and wood pieces. Wood is often harvested dry although sometimes wet wood is also harvested and allow to dry at their premises or in the forest and collected later.

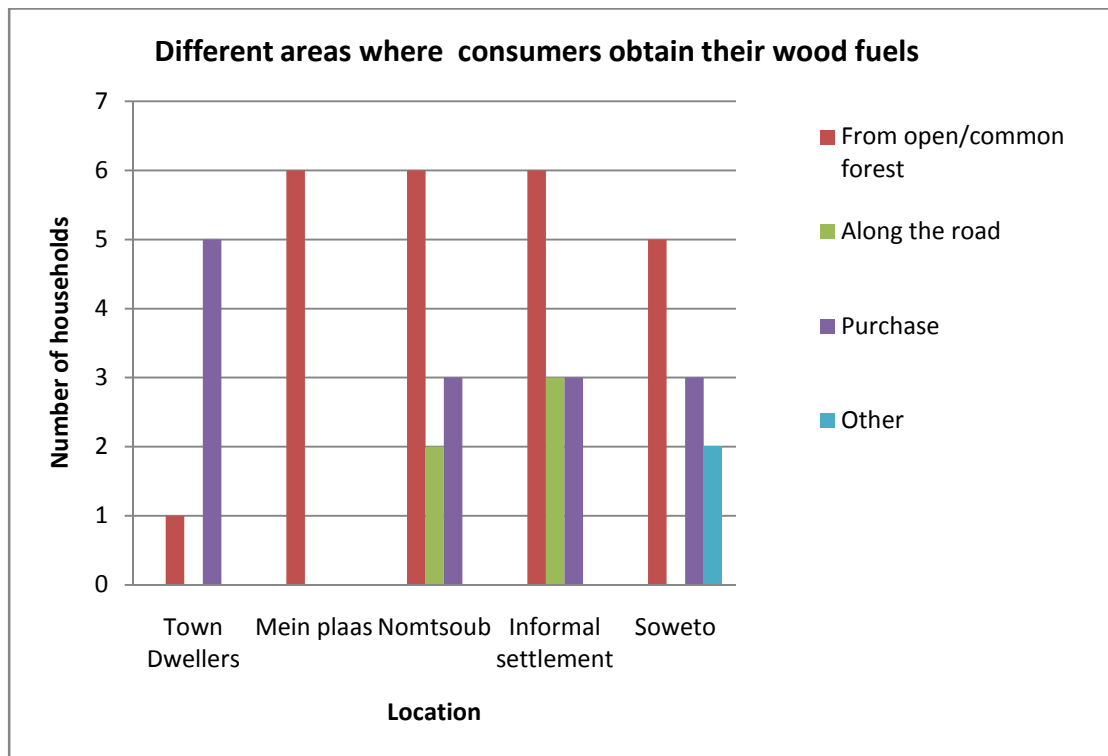


Figure 5.9 Areas where consumers obtain their wood fuels

The researcher also accompanied a group of woman who collect their firewood in the forest on the outskirts of town. They walk about 5 kilometres (Km) to the forest and collect bundles of wood ranging from about 20 kilograms (Kg) to about 40Kg. This specific group of woman carried the firewood they collected on their heads, although there are some that use bicycles and wheelbarrow.



Figure 5.10 Wood fuel consumers collecting their own firewood

5.3 Translating wood quantities into energy values

In order to understand the amount of energy derived from the wood fuels sold, the calorific value as well as the wood fuel quantities was calculated. The heating value of any fuel is the energy that is released per unit mass of the fuel when the fuel is completely burned. The condition on the water molecules in the final combustion product determines the heating value of a fuel, whether it will have a Higher Heating Value (HHV)²⁸ or Lower Heating Value (LHV)²⁹(Sokhansanj,2011).

The calorific value given in most of the literature is approximate, this is because most of the substances (such as wood, charcoal, coal and petroleum products) that are listed in the literature are not well defined (National Physical Laboratory , 2011). The survey results show that consumers usually harvest their wood dry from the forest. The calorific value used is 15 MJ/Kg at 15% moisture content. There are cases however where wet trees are chopped down and branches are left to dry before harvesting.

²⁸ HHV refers to the condition in which the water condenses out of the combustion products (also referred to as the gross heating value) (Sokhansanj,2011).

²⁹ LHV refers to the condition in which water in the final combustion products remains as vapour (also referred to as the net heating value) (Sokhansanj,2011).

5.3.1 Amount of energy sold in the formal sector

Table 5.1 below shows that the different wood fuel retailers interviewed sold a total of about 3908940 MJ of wood fuels (firewood, charcoal and briquettes) per month at the time of the study. Firewood contributed the most to this figure with 3161600 MJ per month amongst.

Table 5.1 Amount of wood fuel energy sold by the formal sector per week and monthly basis

Wood fuel type	Mass	Bags	Total
Total amount of fire wood sold	95 kg	520	95 x 520 = 49400 kg
Heat energy (MJ) per week	Calorific value x quantity 16 MJ/Kg x 49400 KG =790400 MJ		
Heat energy (MJ) per month ³⁰	Calorific value x quantity 49400 kg x 4 weeks = 197600 kg 16 MJ/Kg x 197600 KG = 3161600 MJ		
Total amount of charcoal sold	25 Kg	200	25 kg x 200 = 5000 kg
Heat energy (MJ) per week	Calorific value x quantity 32.245 MJ/KG x 5000 KG =16122.781 MJ		
Heat energy (MJ) per month ³¹	Calorific value x quantity 5000 kg x 4 weeks = 20 000 KG 32.245 MJ/KG x 20 000 KG = 644900 MJ		
Total amount of briquettes sold	13 kg	100	13 kg x 100 =1300 kg
Heat energy (MJ) per week	Calorific value x quantity 19.7 MJ/KG x 1300 KG = 25610 MJ		
Heat energy (MJ) per month ³²	Calorific value x quantity 1300 KG x 4 weeks = 5200 KG 19.7 MJ/KG x 5200 KG = 102440 MJ		
TOTAL WOOD FUEL ENERGY SOLD	3161600 MJ + 644900 MJ + 102440 MJ = 3908940 MJ		

³⁰ Calorific value of firewood is about 16 MJ/KG with 15% moisture (NPL, 2011).

³¹ The calorific value of charcoal is about 32.245 MJ/KG (HEDON, 2010)

³² The calorific value of briquettes is about 19.7 MJ/KG (Bioenergy international , 2007)

5.3.2 Amount of energy sold in the informal sector

Table 5.2 below shows in more detail the quantities of fire wood sold, the frequency of harvesting and the amount of energy derived from firewood per month in the informal sector. Most of the informal suppliers did not have the exact figure and only provided estimates due to the absence of proper accounting systems; the informal suppliers sold an estimated 93920 MJ of firewood.

Table 5.2 Informal firewood suppliers interviewed

Informal wood fuel Supplier	Type of supplier	How frequent do you harvest	Quantities harvested
1	Commercial farmer	Twice a week	About 50 bags. 5 Kg each 250 kg of fire wood per day 500 kg in total
2	Commercial farmer	Once a week	About 100 bags 10kg each 1000 kg of fire wood per day
3	Seasonal supplier	Depend on farmer availability	About 40 bundles 20 kg each 800 kg of fire wood
4	Seasonal supplier	Harvest once a month for month end sales	About 70 bundles 20 kg each 1400 kg of fire wood
5	Seasonal supplier	Based on demand	About 500 kg of fire wood
6	Seasonal supplier	Depends how fast the wood is sold out	About 300 kg of fire wood
7	Full time supplier	Three times a week	About 5 bundles 30 Kg each 150 kg of fire wood About 450 kg for three days
8	Full time supplier	Twice a week over the weekend	About 500 kg of fire wood
9	Full time supplier	Twice a week	About 300 kg of fire wood
10	Full time supplier	Twice to three times a week	About 120 kg of fire wood
Total			5870 kg of fire wood per month (5.87 tonnes)
Heat energy (MJ)			Calorific value x quantities 16 MJ/Kg x 5870 Kg = 93920 MJ

5.3.3 Concluding remarks on the research findings

The survey revealed that wood fuels especially firewood is mainly used for cooking and heating water. It is not easy to get good quality firewood within the town of Tsumeb, most of it is found on the outskirts of town. Wood fuel consumers that collect their own firewood travel on average about 5 kilometres (Km). They collect bundles of wood weighing between 20 to 40 kilograms (Kg). Apart from the open forest land, consumers also collect their firewood from landfill site and land clearing activity sites. Most of the households use firewood every day to prepare one to two meals and more of it is used during winter for heating water. The major factor driving the extensive use of wood fuels especially fire wood is the high electricity tariffs in Tsumeb and urban sprawl leading to the expansion of the informal settlement. In terms of consumer consumption, the formal market is catering that very well compared to the informal market as they most often has available stock compared to the informal sector.

The bush blocks (also referred to as briquettes) are manufactured at the Cheetah Conservation Fund (CCF), which is about 180 Km outside Tsumeb. The bulk of the informal sector supplies are locally extracted and the bulk of the formal sector supplies are imported from outside the local region.

The formal sector mainly obtain its wood fuel (charcoal and firewood) supplies from the commercial farms outside the town of Tsumeb and imports some of its charcoal from South African suppliers. As it was previously shown in table 5.1, the wood fuel retailers sold a total of about 3908940 MJ of wood fuels per month comprising of 3161600 MJ of firewood, 644900 MJ of charcoal and 102440 MJ of briquettes compared to 93920 MJ sold by the informal sector. The formal sector sold more wood fuels compared to the informal sector. This is because the formal suppliers order wood fuels in bulk which are delivered to their business premises. They often has more than one wood fuel supplier and often has mechanisms in place to ensure their stock is refilled once it is sold out. Informal wood fuel suppliers often sell wood fuels in smaller quantities because the wood fuel is getting scarce and further away and often struggle to transport their firewood.

The overall energy content sold by the formal sector is higher compared to the informal sector, this is because the formal sector has more diversity in the wood fuels being they sell (firewood, charcoal and briquettes) as opposed to the just selling firewood as it is the case with the informal suppliers.

5.4 Wood fuel selling prices

A significant difference in the prices of wood fuels between the different suppliers has been observed. One of the suppliers gave a reason for this that their selling price is based on the quality of the product, availability and the different wood fuel suppliers (Including the informal wood suppliers and wood fuel retailers) supplying to them. It is however cheaper to buy wood fuels in bulk as opposed to buying in smaller quantities. Filling stations have higher wood fuel prices compared to other suppliers, this is because they are expensive to run since they operate on a 24 hours basis.

The wood fuel prices vary amongst the different suppliers, with even more noticeable difference amongst the informal suppliers.

5.5 Market opportunities identified through the MFA

In an attempt to answer research objective three: Identify the various opportunities that exist in order to create a market for the excess biomass material from the invader bush in the surrounding area.

5.5.1 Use of invader bush around the town

As already mentioned in Chapter 3, Tsumeb has a sub tropical climate, with an average rainfall of 555mm per annum (Tsumeb Municipality, 2002). Bush encroachment remains a major challenge for the commercial farms around Tsumeb. The current situation is that there are Tsumeb residents requiring firewood while commercial farmers outside the town sit on the problematic encroacher bush taking over their grazing land. It is not known how many of these farmers see the opportunity that exists to supply residents with the fire wood and reduce pressure on the local biomass resource. What is known is that the charcoal industry has become lucrative and commercial farmers want to capitalise this market by using their invader bush. Emerging bush-to-electricity project in Namibia has also raised interest amongst commercial farmers to supply their invader bush.

It is worth exploring the opportunities of harvesting in rural areas or from commercial farms instead of depending more on the already stressed and depleted biomass resource in and

around the town. There exists an opportunity for the farmers and local informal suppliers to come to an agreement to harvest firewood for consumption in the town.

5.5.2 Giving opportunities to locals to supply wood fuels

Informal wood fuel suppliers need to be given a chance to penetrate the local wood fuel supply market as well in order to boost the local economy. The establishment of formalised local wood fuel markets will bring more order in the system and make it easy to monitor. It is worth exploring the possibilities of formalising the informal suppliers to supply the local retailers. This will lead to regulation and control issues of harvesting that the supplier has to comply with and this process is often viewed cumbersome. It was still not clear whether indeed Namibian charcoal is being sold in the surveyed retailers. It is important to boost the local economy by making sure that the consumers embrace their local products.

5.5.3 Market for already existing township businesses

The survey also showed that none of the existing registered businesses in the township are selling wood fuels although they form part of the energy needs of the majority of households there. It was discovered that they assume that the informal wood fuel suppliers has flooded the market and it will not be profitable. The argument therefore is, while informal suppliers has flooded the market especially in the township they clearly still do not meet the demand since firewood scarcity still occurs occasionally. There is a great opportunity that exists for township business to supply consumers with wood fuels and save them the time and money they use to go to retailers far from their homes

5.5.4 Energy efficiency

The use of energy efficient stoves is one important move towards biomass energy conservation. There is a market for locals to design and manufacture energy efficient stoves and boilers and create jobs for themselves.



Figure 5.11 Energy efficient stove and the manufacturing of energy efficient stove in Ovitoto, central Namibia

5.6 Optimisation of the wood fuel flow using MFA framework

In an attempt to answer research objective 4: *Identify how the wood fuel channel can be optimised to better serve both the supplier and consumer*

Now that the MFA of the wood fuel has been established, the wood fuel flow in Tsumeb can be designed/arranged to operate smoothly and efficiently as possible. Some of the areas that need to be strengthened to ensure a smooth and effective flow of wood fuels include:

- Introducing the proof of origin for wood fuel from suppliers, this will help in identifying the original source of the wood fuel and allow for regular monitoring in those areas. Introducing standardised and improved quality wood fuels in order to control the harvesting of wood fuels
- Level the playing field by allowing equal access to biomass resources. By ensuring that when there are regulations put in place that they apply to everyone.
- Introduce energy efficiency measures by streamlining wood fuel products with consumption technologies. Energy efficiency is a very important aspect when it comes to energy use. In order to obtain maximum heat from the wood fuel, energy efficient equipment should be used. Each wood fuel burning equipment whether it is a water heater ('donkey'), furnaces or open fire differs based on their designs as well as their constructions. The open fire is the most inefficient method of using wood fuels; its open nature means that most of the heat escapes (Slusher, 1985: 1).

Local energy efficient equipment initiatives such as stoves and water heaters taking into consideration the local conditions will in turn also lead to the creation of more employment opportunities.

- Harmonise harvesting with consumption patterns in order to allow the forests to regenerate (allow the forest to grow again in order to yield good quality wood fuels).
- There is a great need to raise awareness amongst the consumers and suppliers of the need to conserve and sustainably utilise the biomass resource in the town. Therefore local ownership of the resource base is important to kick start the management of local resources (Soussan *et al*, 1992).

As indicated in figure 5.4 above there is no link between the informal suppliers and the retailers. During the interviews with the various retailers, it was clear that quality of wood fuels, consistency of wood fuel quality and constant supply plays a major role in selecting their suppliers. It is still assumed that these criteria can only be fulfilled by already established suppliers (often out of town)

Measures that will lead to the formulation of sustainable wood fuel strategies in the town of Tsumeb (objective five)

After obtaining the MFA results the aim is to recommend authorities to consider wood fuels when they are busy with their development planning. Table 5.1 and 5.2 quantifies the amount of wood fuels sold and harvested by the formal and informal suppliers and will help in the decision making process

The long term municipal land use activities with a focus on environmental management by ensuring that priorities are not skewed towards the protection of the water resources only from which its income is generated but that all environmental problems including prioritising the contaminated town lands through the mining activities. Municipal consideration to explore acquisition of nearby farmland due to the growing population will have severe impacts on the MFA of wood fuels and will also introduce new aspects to the flow. Consumers and informal suppliers might be required to travel longer distance putting a lot of strain on how the firewood will be transported.

The other issue is that of cost as travelling expenses might be factored into the actual selling price to the already financially challenged consumers due to a high unemployment rate. This thesis is not against urban sprawl or any development activities, but rather argues that these issues need to be addressed holistically. Any institutional framework influences how it evolves. Energy is a cross cutting issue amongst various sectors, in Namibia it is shared between the Ministry of Mines and Energy, Ministry of Environment and Tourism and the

Ministry of Agriculture Water and Forestry. It is this collaborative effort which in the researcher's opinion has led to the down fall of properly managing this important resource. The municipality and all other stakeholders should align themselves along those values in order to sustainably tackle the issues of sustainable harvesting amongst others.

Implement monitoring and regulation programmes that will ensures that the harvesting of biomass resources is still in line with what is required. Another initiative that will add value to the biomass resource of the town is the introduction of the afforestation initiatives for the community in order to start community forests, which will increase supply.

5.7 Conclusion

The wood fuel flow of Tsumeb in its current state is unsustainable. According to the survey, the key drivers towards the use of wood fuels in Tsumeb are high electricity prices, available biomass resource although longer distances have to be travelled, and the lack of electricity particularly in the informal settlement. The harvesting of firewood in the town is taking place with no regulation and monitoring despite the various government biomass permit requirements and regulations. The wood fuel flow in Tsumeb is also unsustainable in the sense that no afforestation initiatives are being implemented, It was interesting to observe that the use of electricity given its high tariff forms part of the cooking fuel in the town. Although there are certain food substances that are soaked in order to save firewood, the use of open fire to prepare the food is still not efficient. The increase in the population size of Tsumeb calls for an urgent assessment of the biomass resource and strategies that need to be implemented to ensure that human activities in the quest to satisfy their energy needs does not destroy the environment.

There is a lack of control and monitoring from the relevant agencies responsible in the town of Tsumeb. The land use activities need to be defined properly in order to initiate the programmes that will lead to the sustainable utilisation of biomass. The survey clearly showed that cities can no longer be treated as distinct spaces that are not connected to other regions surrounding them. The linkages between the rural and urban areas as well as between cities have created new opportunities that rely on connectivity to allow the flow of people and resources from one area to another (UN-Habitat, 2008). The next and final chapter will round up the thesis with the main findings of the research and readdress the study questions.

CHAPTER 6: Conclusion and recommendations

6.1 Conclusion

The Material Flow Analysis (MFA) of wood fuels in Tsumeb has identified some areas that require strengthening in order to ensure sustainable local wood fuel supply. Some of the measures that need to be taken answer the research objectives as they were earlier presented in Chapter One. Table 6.1 below presents the research objectives and research questions again to ensure that the objectives of the study have been achieved.

Table 6.1 Research objectives and questions

Research objectives	Research Questions
1. Understand the energy market in Tsumeb	What is the primary energy supply and demand situation in Tsumeb?
2. Build an understanding of the current wood fuel flow in the town of Tsumeb	Who are the role players in the biomass and biomass derivatives value chain ?
3. Identify how the wood fuel channels can be optimised to serve all the stakeholders better by utilising the MFA framework?	How can the wood value fuel chain be optimised?
4. Identify the opportunities that exists in order to create a market for the excess biomass material from the invader bush in the surrounding areas	What market opportunities exist in order to utilise the excess invader bush?
5. Assess measures that will lead to the formulation of sustainable wood fuel strategies in the town of Tsumeb	What strategies can be adopted to create a sustainable wood fuel flow in an urban and peri-urban environment?

The survey showed that firewood constitutes a major part in the Tsumeb energy mix. A total of six households were interviewed in each of the five residential areas that were surveyed which translate to 30 households (containing a total of 178 people who are all serviced with the wood fuel). It is in most instances used in combination with other energy sources mainly

electricity and gas. A large part of the firewood used in the town is mainly harvested locally from the open forest. A small portion is supplied by the commercial farmers. It is very expensive to cook using electricity especially at the household level due to the high electricity tariffs which have made consumers find alternative cooking fuels. The survey also revealed that the wood fuel market in Tsumeb falls largely within the informal sector. Suppliers source their wood fuel supplies either from the forest or from other suppliers and supply to the consumers. The available invader bush in the surrounding areas of Tsumeb is still being underutilised while consumers and suppliers continue to harvest the open forest in the town unsustainably.

In order to optimise the use of wood fuels in Tsumeb, the wood fuel flow needs to be understood to ensure that every node in the chain is addressed. The process of handling wood fuels permits needs to be controlled and made more efficient to ensure that suppliers and consumers operate within the law.

As mentioned in Chapter 2, the wood fuel 'gap theory' is one of the arguments pertaining to the relationship between wood fuel consumption and deforestation. The 'gap theory' argues that the consumption of wood fuels has been unsustainable because the wood fuel demand is larger than the sustainable supply, therefore deforestation and forest degradation are as a result of firewood harvesting (Top *et al.*, 2003). Although the thesis did not concentrate fully on the 'gap theory' based on its definition, the research found that forests are not only harvested for the purpose of getting firewood but also for developmental activities (thus harvesting from landfill and from areas where clearing took place) as well as demand for more land due to increasing urban population.

The researcher agrees with Masera *et al.* (2006) that in order to successfully assess the current patterns of wood fuel use and production as well as draw up strategies on how to sustainably manage this resource, a holistic approach is needed, taking into consideration the spatial patterns of wood fuel supply and demand. Chapter two also introduced the "energy ladder" concept which refers to the transition from cheaper and less efficient fuels towards fuels with intermediate prices and progress towards so called quality, expensive and more convenient types of energy. Although this study revealed some cases of households moving up the "energy ladder", the so called primitive fuel types are not completely abandoned when transitioning up the energy ladder. Households use multiple fuel types depending on various situations such as affordability, season and availability.

6.2 Limitations and areas of future research

This thesis was not able to cover all the complex issues of wood fuel flow in Tsumeb due to time constraints. It is however believed that it has identified some of the aspects that are salient to the process of transition in Tsumeb. Some of the issues that were not addressed in the thesis and which could have provided a deeper insight to the findings include;

- The lack of information about the use of wood fuel in Tsumeb meant that the study depended on a lot on estimates especially information derived from informal suppliers and some consumers.
- More insight on how urban sprawl has affected the overall wood fuel flow, apart from transporting wood fuels and the added distance.
- The monitoring of wood fuels being transported into the town of Tsumeb from other towns.
- The willingness for consumers to use wood efficient stoves in order to conserve the biomass resource.

6.3 Recommendations

- A combination of Material Flow Analysis (MFA) and WISDOM will give a better insight into the wood fuel flow of Tsumeb as it will involve more relevant stakeholders and go into greater depth. This thesis is just a pointer towards the transition process; it lays out some key areas that have over the years remained visible or ignored yet so important in the transition process towards the sustainable utilisation of the biomass resource.
- A detailed study on the overall energy mix of Tsumeb is needed in order to understand the exact pressure being placed on the environment.
- Additional information is required to show the environmental issues linked to the pattern of wood fuel use in Tsumeb.
- The research also came to realise that most of the urban environmental problems we face are a result of poor management, inadequate planning methods and a lack of coherent urban policies. The local authority needs to clearly state its land use activities in order to allow the community to take up projects that will lead to the sustainable utilisation of the biomass resource.

- The local Ministry of Agriculture Water and Forestry must work with the community and propose appropriate interventions and set out concrete actions that need to be carried out in order to ensure that the resource is used sustainably.
- Afforestation programmes need to be initiated and managed by the communities themselves

6.4 Concluding reflections on the research

The findings of the research are summarised below;

A total of six households were randomly selected from each of the five residential areas surveyed (Soweto, Mein Plaas, Nomtsoub, Town and the informal settlement). Meaning that a total of thirty households comprising of 178 people were selected. Considering this households out of the total population size of about 16 000 people, quite a large number of people are being serviced with wood fuels in Tsumeb. The local wood fuel shortages in particular the shortage of firewood is due to the early unsustainable harvesting methods employed by the residents. There is however still an adequate supply on commercial farms and on the outskirts of town. This areas where previously very far to travel and there was no need to go further to the outskirts when good quality firewood was still available close by. Wood fuels especially firewood is mainly used for cooking and heating water (More especially in winter). Consumers either purchase their wood fuels from retailers, commercial farmers or collect their own firewood, travelling on average 5 kilometres (Km) and carrying wood bundles on their heads weighing between 20 to 40 kilograms (Kg). The bulk of the formal sector supplies are imported from outside the local region. The formal sector sold a total of about 3908940 MJ of wood fuels per month comprising of 3161600 MJ of firewood, 644900 MJ of charcoal and 102440 MJ of briquettes compared to the 93920 MJ sold by the informal sector.

The thesis does not aim to stop the use of wood fuels in the town, nor does it want to bring in control measures that will make people lose their jobs. What the thesis aims to do is to understand the system. The thesis wants to look at both the strong and weak links in the system and identify measures that will allow the community to continue using the wood fuels sustainably for the sake of their children and the environment. Most of the urban environmental problems we face are a result of poor management, inadequate planning methods and a lack of coherent urban policies. It also means that no early detection of biomass depletion and strategies has been put in place to ensure a suitable utilisation of such resource. It is hoped that the developed MFA of the wood fuel flow in Tsumeb will help readers understand how and under what conditions wood fuel flow from the source to the consumers. This understanding is important in identifying policy gaps that exist and hopefully start conversations that will lead to the transition towards suitable and sustainable wood fuel use.

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APPENDICES

Appendix 1: Wood fuel survey questionnaire for consumers

Questionnaire number:

Wood fuel survey questionnaire for consumers

Dear Respondent

My name is Lydia Mlunga, and I am currently in the process of completing my final year postgraduate education (Masters of Philosophy) in Sustainable Development Planning and Management: Renewable & Sustainable Energy Studies programme at Stellenbosch University in South Africa. As part of the programme, I am required to complete a thesis, which is titled, **Material Flow Analysis of wood fuel in urban areas: The case of Tsumeb, Namibia.** In order to complete my thesis successfully, I kindly request that you correctly and honestly complete the following questionnaire; I assure you that you will remain anonymous and your response will be treated with absolute confidentiality.

If you have any questions, comments, suggestions or want to discuss the questionnaire further, do not hesitate to contact me on my mobile number: 081 277 4870 or email me at shekupe@webmail.co.za or lydia.mlunga@gmail.com

Thank you for your time and assistance.

Lydia Mlunga

1. Why do you use wood fuel? (kindly tick all appropriate options, rank in order of importance)

Lack of electricity

Electricity is expensive

Abundant wood fuels

Wood fuels are cheaper

Other

Please specify

.....

2. Which of the wood fuel type(s) below do you use?

Fire wood

Charcoal

Briquettes

Dried Fruits

Other

Please

specify.....

3. What do you use that wood fuel for?

Cooking

Lighting

Both

Other

Please

specify.....

4. How many people reside in your house (How many people are serviced with the wood fuel)?

.....

.....

.....

5. Where do you obtain your wood fuel from?

From self planted trees

From open/common forest

Along the road

Purchase

Other Please
specify.....

6. What is the distance travelled to obtain the wood fuel

.....
.....
.....

7. How do you harvest your wood fuel?

Using harvesting equipment (e.g axe) Please specify.....

Harvesting by hand

Other Please
specify.....

8. If you harvest your own wood fuel, do you obtain permission for harvesting?

Yes Please specify from
who.....

No Please specify
why.....

9. How is the wood fuel stored?

Chopped wet and left to dry

Stored in bags dry

Left in the open

Other
specify.....

Please

10. Where do you purchase your wood fuel from?

Informal Market
specify.....

Please

Supermarket / Retailer
.....

Please specify

Regular supplier(s)
specify.....

Please

Random suppliers
specify.....

Please

Other
specify.....

Please

11. How far is the place of purchase from your residence ?

.....
.....
.....

12. What are the wood fuels selling prices against quantities? (e.g N\$ per kg or number of pieces/ load)

.....
.....
.....

13. How often do you use the wood fuel?

Everyday : Specify number of occasion

for each meal (three meals)

Two meals

One meal

Depend
specify.....

Please

14. How is the wood fuel transported?

By car (truck, pick up bakkies etc)

Head Loading

Wheelbarrow

Bicycle

Other

specify.....

Please

15. How much wood fuel do you use per day (kg)?

.....
.....
.....

16. What is the daily summer wood fuel consumption?

.....
.....
.....

17. What is the daily winter wood fuel consumption?

.....
.....
.....

18. Type of wood burning system used

Stove
one.....

Please specify which

Open fire

“Donkey” (water heating)

Other
specify.....

Please

19. In what form do you collect /purchase your wood fuel

Dead form (dry)

As a by- product of other activities

(Clearing of land for agriculture, housing and developmental activities etc)

Collected / purchased wet and left to dry

Other Please specify

.....
.....

20. Has there been any fuel- switching history in your household (e.g switching from wood fuel to conventional fuel sources like kerosene, Liquid Petroleum Gas, Electricity etc...)?

.....
.....
.....

21. Kindly indicate the switching option(s)

.....
.....

22. What are the reasons for fuel switching?

.....
.....

23. Do you plan to continue using wood fuels in the next two/three/four/five years to come? Indicate reason for both yes and no options.

.....
.....

24. Would you like to stop using wood fuels?

Yes

No

25. Kindly indicate reason for your option above

.....
.....

26. Have you notices any changes or fluctuations in the price of wood fuels during the past year? Kindly indicate

.....
.....
.....

27. Without taking cost and availability into consideration, which fuel do you think is best for cooking and why

.....
.....

28. Any other additional information

.....
.....
.....

-----End of questionnaire-----

Appendix 2: Wood fuel survey questionnaire for suppliers

Dear Respondent

My name is Lydia Mlunga, and I am currently in the process of completing my final year postgraduate education (MPhil) in Sustainable Development Planning and Management: Renewable & Sustainable Energy Studies programme at Stellenbosch University in South Africa. As part of the programme, I am required to complete a thesis, which is titled, **Material Flow Analysis of wood fuel in urban areas: The case of Tsumeb, Namibia**. In order to complete my thesis successfully, I kindly request that you correctly and honestly complete the following questionnaire; I assure you that you will remain anonymous and your response will be treated with absolute confidentiality.

If you have any questions, comments, suggestions or want to discuss the questionnaire further, do not hesitate to contact me on my mobile number: 081 277 4870 or email me at shekupe@webmail.co.za or lydia.mlunga@gmail.com

Thank you for your time and assistance.

Lydia Mlunga

1. Is there still biomass resource available for wood fuel sales in Tsumeb?

Yes

No

Please motivate

.....
.....
.....

2. What type of woodfuel do you sell?

Fire wood

Charcoal

Briquettes

Both

Other
specify.....

Please

3. What are the selling prices of woodfuel

.....
.....
.....

4. Do you own a registered business?

Yes

No

5. Where do you obtain your woodfuel?

From self planted trees

From open/common forest

Along the road

Purchase from other suppliers

Partnership with farmer(s)

Other
specify.....

Please

6. If you purchase from other suppliers how does the wood fuel reach to you (eg they deliver to you, you collect yourself etc)

.....
.....
.....

Who is responsible for the transport costs?

.....
.....
.....

7. How frequently are supplies delivered and what are the usual quantities delivered?

.....
.....
.....

8. If you are in partnership with the farmer(s) to obtain your woodfuel

Who are/is the farmer(s).

.....
.....
.....

Where are they located

.....
.....
.....

What are the arrangements for harvesting

.....
.....
.....

9. How do you harvest your woodfuel?

Using harvesting equipment (e.g axe) Please specify.....

Harvesting by hand

Other Please specify.....

10. Who harvest the wood fuel

Yourself

Employees

Other

Please Specify.....

11. How often do you harvest?

.....
.....
.....

12. How is the woodfuel stored?

Chopped and left to dry

Using bags

Left in the open

Other

specify.....

Please

13. How is the wood fuel transported?

By car (truck, pick up bakkies etc)

Head Loading

Wheelbarrow

Bicycle

Other

Please specify

14. How often do you transport the wood fuel?

.....
.....
.....

15. Do you have a woodfuel harvesting permit?

Yes

From where.....

No Why.....

16. Do you have a woodfuel transporting permit?

Yes From where.....

No Why.....

17. Do you have a woodfuel selling permit?

Yes From where.....

No Why.....

18. Who are your clients?

Everyone

Supermarkets

Informal market sellers

Institutions Which ones.....

19. How do you reach you clients?

They collect themselves

Pick up points

Deliver to them

Others
specify.....

Please

20. What are the existing wood fuel markets in the town?

.....
.....
.....

21. Do you experience wood fuel seasonality sales? Kindly elaborate

.....
.....
.....

22. What are some of the wood fuel purchasing patterns you experience

.....
.....
.....

23. Do you use any particular terminology to distinguish between the different types and size of wood fuel bundles, sacks , charcoal etc..? kindly elaborate.

.....
.....
.....

24. Have you realised any changes in the quality of wood fuel over the years (during the different seasons) ? Kindly elaborate

.....
.....
.....

25. What percentage of charcoal sacks ends up as fines?

.....
.....
.....

26. Are there any uses for these fines?

.....
.....
.....

27. How intense is the competition amongst wood fuel traders / suppliers?

.....
.....
.....

28. What are some of the issues that can affect the future of wood fuel sales and supply?

.....
.....
.....

29. Any other additional information

.....
.....
.....

-----End of questionnaire-----

Appendix 3: Example of a completed wood fuel consumer questionnaire

2

1. Why do you use wood fuel? (kindly tick all appropriate options, rank in order of importance)

Lack of electricity

Electricity is expensive

Abundant wood fuels

Wood fuels are cheaper

Other Please specify

2. Which of the wood fuel type(s) below do you use?

Fire wood

Charcoal

Briquettes

Dried Fruits

Other Please specify

2

3. What do you use that wood fuel for?

Cooking

Lighting

Both

Other

Please specify.....

4. How many people reside in your house (How many people are serviced with the wood fuel)?

4 people

5. Where do you obtain your wood fuel from?

From self planted trees

From open/common forest

Along the road

Purchase

Other

Please specify..... *Purchased from retailer*

6. What is the distance travelled to obtain the wood fuel

WITHIN 5 KILOMETERS FROM RESIDENCE

7. How do you harvest your wood fuel?

Using harvesting equipment (e.g axe) Please specify.....

Harvesting by hand

Other Please specify.....

8. If you harvest your own wood fuel, do you obtain permission for harvesting?

Yes Please specify from who.....

No Please specify why.....

9. How is the wood fuel stored?

Chopped wet and left to dry

Stored in bags dry

Left in the open

Other Please specify Only DRY WOOD HARVESTED

10. Where do you purchase your wood fuel from?

- Informal Market Please specify INDIVIDUALS SELLING WOOD
- Supermarket / Retailer Please specify AVAILABLE IN SHOPS
- Regular supplier(s) Please specify BOTH SUPERMARKET AND INFORMAL MARKET
- Random suppliers Please specify.....
- Other Please specify.....

11. How far is the place of purchase from your residence ?

WITHIN 3 km

12. What are the wood fuels selling prices against quantities? (e.g N\$ per kg or number of pieces/ load)

4 PIECES @ N\$ 20-00

13. How often do you use the wood fuel?

Everyday : Specify number of occasion

for each meal (three meals)

Two meals

One meal

Depend Please specify BARBE QUI

14. How is the wood fuel transported?

- By car (truck, pick up bakkies etc)
- Head Loading
- Wheelbarrow
- Bicycle
- Other Please specify.....

15. How much wood fuel do you use per day (kg)?

2 KG PER WEEK

16. What is the daily summer wood fuel consumption?

4 PIECES PER WEEK

17. What is the daily winter wood fuel consumption?

2-6 KG

18. Type of wood burning system used

- Stove Please specify which one.....
- Open fire

"Donkey" (water heating)

Other Please specify.....

19. In what form do you collect /purchase your wood fuel

Dead form (dry)

As a by- product of other activities

(Clearing of land for agriculture, housing and developmental activities etc)

Collected / purchased wet and left to dry

Other Please specify

Bought as dry wood

20. Has there been any fuel- switching history in your household (e.g switching from wood fuel to conventional fuel sources like kerosene, Liquid Petroleum Gas, Electricity etc...)?

FROM WOOD FUEL TO ELECTRICITY. IT WAS AFFORDABLE TO MY HOUSEHOLD.

21. Kindly indicate the switching option(s)

Simply from wood fuel to electricity

22. What are the reasons for fuel switching?

Simply BECAUSE I CAN AFFORD IT.

23. Do you plan to continue using wood fuels in the next two/three/four/five years to come? Indicate reason for both yes and no options.

YES! FOR BARBECUE EACH WEEKEND,
MEANING FOUR TIMES PER MONTH.

24. Would you like to stop using wood fuels?

Yes

No

25. Kindly indicate reason for your option above

ITS PART OF MY CULTURE. I GREW
UP AND IS USED TO WOOD FUELS.

26. Have you notices any changes or fluctuations in the price of wood fuels during the past year? Kindly indicate

NO! PRICES REMAIN STABLE AND DO
NOT FLUCTUATE ON RANDOM

27. Without taking cost and availability into consideration, which fuel do you think is best for cooking and why

WOOD FUELS. BECAUSE THE HEAT IS NOT
EXTREME LIKE ELECTRICITY AND THEREFORE
RETAINS CERTAIN VITAMINS IN FOOD STUFFS.

28. Any other additional information

N.A.

-----End of questionnaire-----

Appendix 4: Example of a completed wood fuel supplier questionnaire

1. Is there still biomass resource available for wood fuel sales in Tsumeb?

Yes

No

Please motivate

Tsumeb is surrounded by open
spaces/trees

2. What type of woodfuel do you sell?

Fire wood

Charcoal

Briquettes

Both

Other Please specify.....

3. What are the selling prices of woodfuel

N\$ 16.00

4. Do you own a registered business?

Yes

No

5. Where do you obtain your woodfuel?

From self planted trees

From open/common forest

Along the road

Purchase from other suppliers

Partnership with farmer(s)

Other Please specify.....

6. If you purchase from other suppliers how does the wood fuel reach to you (eg they deliver to you, you collect yourself etc)

They deliver to us
.....
.....
.....

7. Who is responsible for the transport costs?

Supplier
.....
.....

8. How frequently are supplies delivered and what are the usual quantities delivered?

40 bags supplied weekly

9. If you in partnership with the farmer(s) to obtain your woodfuel

Who are/is the farmer(s).

O.J. Britz

Where are they located

What are the arrangements for harvesting

He delivers wood in 10kg and we supply the packets in which it comes

10. How do you harvest your woodfuel?

Using harvesting equipment (e.g axe) Please specify.....

Harvesting by hand

Other Please specify.....

11. Who harvest the wood fuel

Yourself

Employees

Other Please Specify..... Supplier.....

12. How often do you harvest?

N/A.....
.....
.....

13. How is the woodfuel stored?

Chopped and left to dry

Using bags

Left in the open

Other Please specify.....

14. How is the wood fuel transported?

By car (truck, pick up bakkies etc)

Head Loading

Wheelbarrow

Bicycle
Other Please specify

15. How often do you transport the wood fuel?

Weekly
.....
.....
.....

16. Do you have a woodfuel harvesting permit?

Yes From where.....

No Why.....

17. Do you have a woodfuel transporting permit?

Yes From where.....

No Why.....

18. Do you have a woodfuel selling permit?

Yes From where.....

No Why.....

19. Who are your clients?

- Everyone
- Supermarkets
- Informal market sellers
- Institutions Which ones.....

20. How do you reach you clients?

- They collect themselves
- Pick up points
- Deliver to them
- Others Please specify Call from shop.

21. What are the existing wood fuel markets in the town?

.....
.....
.....

22. Do you experience wood fuel seasonality sales? Kindly elaborate

Yes - Winters you sell the most wood
and in the warmer seasons less
.....
.....

23. What are some of the wood fuel purchasing patterns you experience

.....
.....
.....

24. Do you use any particular terminology to distinguish between the different types and size of wood fuel bundles, sacks, charcoal etc.? kindly elaborate.

We only sell 10kg Wood
Charcoal - 10kg
Briquettes - 4kg

25. Have you realised any changes in the quality of wood fuel over the years (during the different seasons)? Kindly elaborate

No

26. What percentage of charcoal sacks ends up as fines?

—

27. Are there any uses for these fines?

—

28. How intense is the competition amongst wood fuel traders / suppliers?

N/A

29. What are some of the issues that can affect the future of wood fuel sales and supply?

If there are no trees/bushes
.....
.....
.....

30. Any other additional information

.....
.....
.....
.....

-----End of questionnaire-----

Appendix 5: Letter from the town council



OSHIKOTO REGIONAL COUNCIL



TSUMEB CONSTITUENCY

Tel: +264 (0)67 220073 / 220701
Fax: +264 (0)67 220071
Cell: +264 (0) 81

P.O. Box 1116
TSUMEB

Enquiries: Ms. Shipanga

10 May 2011

To Whom It May Concern:

This letter serves to confirm that **Ms. Lydia Shekupe Mlunga, ID: 83120110027** is a final year student doing **Masters Studies in Sustainable Development Planning & Management**.

Lydia intends to conduct a research on the usage of firewood in our town, as part of her study. Her presence in Tsumeb Constituency/Town is known by this office as she reported herself at this office before he goes in the community.

This Office is therefore requesting individual/community to please feel free to render assistance to this student, by providing the information she requires.

Thank you for your assistance.

Sincerely,



HON. LEBBIUS TANGENI TOBIAS
REGIONAL COUNCILLOR
TSUMEB CONSTITUENCY