WOODFUEL CONSUMPTION IN SHINYANGA RURAL DISTRICT, TANZANIA

BY

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ABSTRACT

This study was conducted in Shinyanga Rural district, Tanzania to assess the woodfuel consumption at the household level. Specifically, its objectives were to identify woodfuel supply sources, species and uses as well as to determine the quantity of woodfuel consumed by households. Furthermore, factors influencing woodfuel consumption were also assessed. Data were collected through household's questionnaires, checklists, and participant observations. The Quantitative and qualitative data were analyzed using the Statistical Package for Social Sciences software tools. Findings showed that the natural forests and man made forests were the ideal supply sources of woodfuel. Results also revealed that about 65 tree species were recorded and botanically identified for woodfuel production. Woodfuel was found as major energy source for cooking in the study area. However, due to woodfuel scarcity, crop residues and cow dung are also used as options at households for cooking particularly during the dry and harvesting periods. Furthermore, the total amounts fuelwood and charcoal consumed by the households were estimated at 711 m^3 and 204 m^3 per year while, fuelwood and charcoal per capita consumption were estimated at 0.67 m^3 and 0.14 m^3 respectively. Moreover, results revealed that, household's family size and household's occupation significantly showed positive linear relationship with woodfuel consumption at ($p < 0.05$). Whilst, education level and wooodfuel collection time at ($p < 0.05$) had no significant relationship with the quantity of woodfuel consumed. Basically, it was observed that woodfuel supply situations among the surveyed households most were experiencing deficit. It is burden for the collectors and also it is unenvironmentally friendly since its collection involves cutting small trees and shrubs which are at regenerating stage for tree growth development. In order to ensure sustainable supply of woodfuel it is recommended that the use of improved cooking stoves, tree planting, encourage agroforestry farming system as well as community awareness rising on woodfuel scarcity implication to surroundings and livelihood of households, be promoted.

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DEDICATION

To GOD the Creator, JESUS the Savior and HOLY GHOST the Leader.

DECLARATION

I, Jonas Kasala Mangi, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for higher degree award in any other institution.

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The above declaration confirmed

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(1st Supervisor)

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ABBREVIATIONS AND ACRONYMS

AFREPREN	-	African Energy Policy Research Network
CBFM	-	Community Based Forest Management
DED	-	District Executive Director
EAAL	-	Energy Alternatives Africa Limited
ESMAP	-	Energy Sector Management Assistance Programme
FAO	-	Food and Agriculture Organization of the United Nations
FBD	-	Forestry and Beekeeping Division
H	-	Hour
IIED	-	International Institute of Environment and Development
IUCN	-	International Union for Conservation of Nature
JFM	-	Joint Forest Management
kg	-	Kilogram
m^3	-	Cubic meters
MAFS	-	Ministry of Agriculture and Food Security
MEM	-	Ministry of Energy and Minerals
MNRT	-	Ministry of Natural Resources and Tourism
NAFRAC	-	Natural Forest Resource Management and Agroforestry Center
NBS	-	National Bureau of Statistics
NWFPs	-	Non-Wood Forest Products
R & D	-	Research and Development
RWEDP	-	Regional Wood Development Programme
SADC	-	South African Development Community
SAPU	-	Strategic Analysis Planning Unit
SNAL	-	Sokoine National Agriculture Library
SPSS	-	Statistical Package for Social Science
TAFORI	-	Tanzania Forestry Research Institute
TANESCO	-	Tanzania Electric Supply Company Limited
TAS	-	Tanzanian shilling equivalent to 0.0008 USD
TaTEDO	-	Tanzania Traditional Energy Development Organization
UN	-	United Nations
UNCED	-	United Nations Conference on Environment and Development
UNDP	-	United Nations Development Programme
URT	-	United Republic of Tanzania
USD	-	United States Dollar
WB	-	World Bank
WRI	-	World Resources Institute

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Throughout the world, demand for woodfuel is increasing and the world's scene is changing rapidly. Rowe *et al*. (1992) estimated that nearly 3 billion people worldwide primarily depend on forests as their main energy source. The United Nations Conference on new and renewable source of energy in Nairobi reported that an approximately 2 billion people depend on woodfuel for domestic uses (Ishengoma and Nagoda, 1991), Wood energy sources are preferred to by most of people because the supply is more secure, available, affordable quantities in local markets and it requires no initial expensive investments in cooking stoves. Woodfuel generally collected from natural forests, bushes, established trees woodlot and farm lands at the margins of the fields and this will remain the priorities of the most consumers of rural and urban areas in developing countries (Soussan, 1998).

However, in the year 2005 global wood removal was over 3 billion m^3 of which 40 % was in the form of wood fuel (FAO, 2007). It was further reported by the author that woodfuel consumption shortages increased from 499 million m^3 to 661m^3 between the year 1990 and 2005 respectively in Africa. The most serious situation was identified in the arid zones South of Sahara where woodfuel deficit has been estimated at 95 million m^3 or 1.0^3 per inhabitant per year (FAO, 1996). Consequently, this has influenced wood over cutting so multiplying economic, environment and social ill effects. Promotion of environmental friendly forms of utilization of woodfuel without compromising forests should be considered locally and globally at large by creating awareness at households' level at both rural and urban areas.

Tanzania has about 33.5 million ha of forests and woodlands, which constitute 38% of its total area, while forest reserve constitutes about 13 million ha. (URT, 1998). About 90% of Tanzanian population depends on these forests and community livelihood to meet the growing demands and supply of products and services required such as wood as the supply sources, biodiversity values and environmental conservation (MNRT, 2001a). Enormous, woodfuel productivity in village levels, have been obtained from fast growing, short rotation species some of which have ability to produce coppice like *Eucalyptus spp, Senna siamea,* and other agroforestry species like *Lucaena spp* (Parrota and Agnoletti, 2007).

In Tanzania, biomass accounts for about 92% of woodfuel while, uses from different sources such as petroleum products account for about 7.2% and 0.8% for electricity (URT, 1998). On the other side Ishengoma *et al*. (1992) reported that annual woodfuel consumption per capita ranges from 2.1m^3 and 3.6m^3 in rural and urban areas, respectively. Furthermore, Ngaga *et al.* (2004) reported that woodfuel consumption remains the important dominant source of energy to the majority of households in Tanzania for the forecasted near future due to poverty and lack of alternative energy sources.

In countries like Ethiopia and even oil-rich ones like Nigeria in Africa and Nepal in Asia woodfuel constitute over 75% of energy by use (Eckholm *et al.,* 1996). On the other hand, in Sub Sahara Africa, bio energy accounts for an estimated 60% to 90% of the total energy use with the highest proportion being in the poorest countries and the household sectors. Sathaye and Meyers (1994) reported that there are also costs of obtaining fuelwood in terms of cash or time spent in gathering. According to Kaale (1995) woodfuel consumption pattern, supply, source and final use in East Africa countries constitute 71% in Kenya, 91% in Tanzania and 70% in Uganda. Moreover, it provides nearly 100 % of domestic use in rural areas and about 85% in urban areas.

Woodfuel impact assessment has been given little attention by planners in rural areas. The sector tends to concentrate more on industrial wood production rather than domestic fuelwood supplies. Also its impact assessment is relatively difficult because there is no management plans. However, the survival of forests and their continued contribution to livelihood depends on biodiversity conservation (Sjoholm, 1988). Also there has been little sustainable management of these natural forests, leading to continued degradation and deforestation thus bringing the forest cover down (Akitanda, 1991).

1.2 Problem Statement and Justification

Forest dependency patterns are not similar around the world where local communities depend on forests to meet a wide array of domestic needs mainly woodfuel for cooking and heating (Dudenhoefer, 2004). In developing countries woodfuel accounts for about 80% of energy consumed (Goudou, 2003; Mariara, 2003). This dependence is dictated by a wide variety of natural and exotic tree species used to supply the range of end products desired by household due to lack of other alternatives sources of energy.

In Tanzania, wood is the most important source of energy, where by about 95% of the households depend on it for home energy requirements particularly for cooking (Kigula, 1999). According to Mogaka *et al*. (2001) about 97% of energy consumed domestically is derived from natural forest. Woodfuel consumption per capita in Tanzania was reported to range between 2.1 and 3.6 m^3 (FAO, 1983). In semi arid areas of Tanzania including Shinyanga, forest products such as woodfuel had declined due to shifting cultivation, tree cutting for tobacco curing, illegal trees clear felling to eradicate birds and tse tse flies, overgrazing and forest encroachments. Consequently, the supply of wood raw materials become very uncertain and creates hardship for household sector in terms of cash and time spent for fuelwood collection (MNRT, 2001a).

Deforestation of natural woodland is a major environmental problem in Shinyanga region making it among the most deforested regions in Tanzania (Oduol *et al*., 2003). The key problems and driving forces of deforestation are the expansion of agricultural land, increased urban demand for charcoal and fuelwood consumption for tobacco curing and other processing industries such as bricks kilning, fish smoking and local brewing. Johnsen (1999) pointed out the social impacts of inadequate supply of household energy in Tanzania. For example the welfare effect of reduced woodfuel supply in rural areas is indicated by the time spent and distant walked for gathering fuelwood. This aspect needs a thorough evaluation on quantity of woodfuel consumption in the study area. This could institute sustainable use of woodfuel. However, there is no documentation on the quantity of woodfuel consumed by households in the study area.

Despite of woodfuel scarcity and its importance as the dominant energy source in Shinyanga rural district little has been done to assess the consumption at household level. Many efforts by government in terms of financial supports and studies have been directed to environmental conservation such as aforestation in Shinyanga region. For example the Hifadhi Ardhi Shinyanga (HASHI) programme currently is known as Natural Forest Resources and Agroforestry Centre (NAFRAC) aimed at aforestation programme and natural forest resources protection. Few studies for example MNRT (2001a) have addressed the way local communities perceive the natural forest resources and its utilization e.g. woodfuel for survival. Most studies according to Oduol *et al.* (2003) were directed on environmental degradation through unplanned agriculture, illegal tree cutting and afforestation and other conservation initiatives. But there is inadequate information on woodfeul consumption including its sources, and species used in the area under study. Moreover, data based on planning, demand and management of woodfuel supply and sustainable utilization is inadequately available and reliable. The study by MLNRT (1984) showed that women walked more than 10 km to the sources of woodfuel, to collect a head load of fuelwood estimated at between 18 kg and 30 kg. Depending on the family size, type of food cooked and species the head load could last one to two days. At a particular situation where there is a serious shortage of wood fuel supply, cooking is often supplemented with dry cow dung, agricultural crop residues such as maize cobs, cotton stalks, cassava sticks, rice husks and sisal dry leaves (World Bank, 1991).

Woodfuel shortages influence consumption of uncooked and reheated food giving critical problems to infants to digest it easily (Mnzava 1990). Furthermore, woodfuel scarcity is a symptom of wide spread rural poverty linked with aspects of survival, production and land management (Moyo *et al.,* 1991). Woodfuel is the major energy for the most rural and urban people, however, overexploitation of its sources will make it no longer a renewable form of energy and this calls for the need to pay serious attention on its sustainable utilization (URT, 2004).

Lack of economic options and increasing poverty are threatening the balance between woodfuel and livelihood needs, which make people, to harvest beyond allowable cut to meet immediate needs. According to NBS (2002) Shinyanga is among the least connected region to the National grid where 0.6% of populations only access electricity for lighting. Furthermore, the use electricity for cooking is less common at households in rural areas. This implies that electricity is for lighting with limitation its use for cooking. As the natural forest resources base continue to diminish, rural dwellers especially women and children will be forced to walk long distance for gathering fuelwood instead of doing other socio-economic activities for their livelihood development. It has been stated that woodfuel will continue to be a major energy source at household's level in the study area due to unavailability of alternative energy sources (NBS, 2002). This study provides information to fill the gap and comes up with suggestions on how to sustain the future woodfuel consumption in the study area. The information is useful to policy and decision markers for short and long-term energy development programmes in Shinyanga rural district and Tanzania as a whole.

1.3 Objectives

1.3.1 Overall objectives

To assess woodfuel consumption at household level in Shinyanga Rural District, Tanzania.

1.3.2 Specific objectives

(i) To determined the amount of woodfuel consumed by households in the study area,

(ii) To identify woodfuel sources in the study area,

(iii) To identify species used for woodfuel by households in the study area,

(iv) To assess uses of woodfuel at households in the study area,

(v) To assess factors influencing woodfuel consumption at households in the study area.

1.3.3 Research questions

(i) What quantity of woodfuel is consumed by households in the study area?

(ii) Where is woodfuel collected by the households in the study area?

(iii) Which species are used for woodfuel in the study area?

(iv) What are the uses of woodfuel at households in the study area?

(v) What are the factors influencing woodfuel consumption at households in the study area?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Global Overview of Woodfuel Consumption

Woodfuel consists of fuelwood and charcoal and it is the most important fuel for the bulk of the world's population. It is a renewable form of energy, which can be produced within the country by utilizing local resources (FAO, 2009). Globally forests are estimated to cover 4 billion ha, covering about 30% of the world's land area (Maini, 1993). Forest resources have an important role in contributing to the overall social and economic livelihood of the people in rural and urban areas through the goods and services they provide. However, the contribution of forests and tree products to social and economic livelihood and environmental conservation can only be achieved when the resources are managed and utilized in a sustainable manner (Nilsson, 1992; Maini, 1993).

Nearly 3 billion people worldwide depend on wood primarily from natural forests as their main source of household energy. By 1990s woodfuel as a major energy source accounted for 90% of energy consumed for cooking and heating at households in the world (FAO, 1996). Likewise, the world lost 3% of its forest area, with an average decrease of some 2% per year in 1999 to 2005 (FAO, 2007). Changes in forests are largely an outcome of multitude of actors such as farmers, producers and collectors. These driving forces are grouped broadly as policy and institutional, demographic, economic, social and technological (FAO, 2002).

In developing countries forest products including charcoal and fuelwood are major sources of income for many rural poor people and play a major role in household food security through creation of employments (Monela *et al.*, 2000; Mariara, 2003; Hamza *et al.*, 2004;

Luoga *et al.,* 2005). In Zambia for example the per capita income from charcoal production was five times the per capita income from agriculture production (CHAPOSA, 2002). Ngaga *et al*. (2004) observed that more than 75% of rural households in the villages surrounding Kitulangalo forest reserve in Morogoro, Tanzania depended on charcoal as the first or second source of income after agriculture.

It has been stated by FAO (1998) that there would be woodfuel deficit of 1-billion m^3 in the world where 500 million m^3 of woodfuel deficit will be found in Africa, about 140 m^3 in Latin America and 60 million m^3 in other countries.

2.2 The Situation of Woodfuel in Africa

The estimated forest area for Africa in 2005 was 635 million ha accounting for about 16% of the total global forest area. Africa also had more than 400 million ha of other woodland forests with scattered trees. Data on the extent and growing stock of other wooded land are weak, but the extent continues to decline (FAO, 2001).

According to FAO (2006), woodfuel provide more than 14% of the world's total primary energy. However, in developing countries the dependence on such fuel is much greater providing 33% of the total energy, while in some sub regions of Africa as much as 80% of energy is derived from biomass. The supply sources of woodfuel include: natural fallow land around villages, bushes, shrubs, farmland trees, woodlots, plantation and agricultural crop residues. Africa's wood production increased from 340 million m^3 in 1989 to 699 million m^3 in 2000. About 91% of all wood were used as fuel, which is a major household energy source (FAO, 2006). Woodfuel consumption in Africa reached 623 million m^3 in 1994, the highest consumption per capita of any continent (Emrich, 2000; WRI, 2003). Africa is also the leading in intensive use of woodfuel in per capita, with an average annual per capita of 0.89 m^3 per year, implying that the continent has the highest per capita woodfuel consumption compared to other continents like Asia where only 0.3 m^3 is consumed per year (FAO, 2001).

Forests in Africa confront a number of problems including decline in forest cover, loss of biological diversity and variety of unsustainable uses that cast uncertainty on the future flow of goods and services. Shifting cultivation for example was responsible for 70% of deforestation in Africa by 1980s (FAO, 1982). Woodfuel scarcity is also claimed to be associated with other socio-economic and environmental problems which include land degradation, economic hardships, lowering of living standards and decline of agricultural crop production (Lipper, 2000). These problems lead to poverty and its solution is to enhance sustainable management of natural forest resources (Moyo *et al.,* 1993., Kaale, 1994 and Levang *et al*., 2005). Sustainable management and development of natural forest as the sources of woodfuel supply in Africa requires urgent attention. This is because of great influence of demographic pressures and other human impacts, which have caused massive degradation and deforestation of the forest resources.

Biomass energy uses in Eastern and Southern Africa is important in many and medium scale industries for example brick manufacture, lime production, fish smoking, tobacco curing, beer brewing, coffee and tea drying. Despite of their use, many industries operate in rural and urban areas where information on this important biomass energy consumption is inadequate (Warmer, 2000). In Zambia, for example charcoal is the most important household fuel for about 83% of urban households. Charcoal productions form an important Zambian industry, providing employment to a large number of people (World Bank /ESMAP, 1990; Hibajene and Ellegard, 1994). Similarly, in Tanzania more than 75%

of urban residents are reported to use charcoal, although a few afford to use other form of fuels (Monela *et al*., 1993).

The majority of Eastern and Southern Africa's population rely on wood energy from forests and woodlands. Miombo woodland is estimated to account for about 92% of the total energy in Tanzania. In Namibia for example, over 85% of population rely on wood based energy compared to 90% in Malawi, 70% in Zambia and 80% in Mozambique (Mogaka *et al.*, 2001). A study by Hassan *et al*. (2002) found that more than 90% of rural households in Swaziland collect fuelwood for domestic use. Most of studies Grundy and Cruz (2001) and FAO (2003) had showed various factors which contributed to households' woodfuel consumption in Africa including households' family size and the nature of locality where humid forests dwellers are expected to consume much compared to arid zone.

2.3 Energy Patterns in Tanzania

Energy patterns in the context of this study refer to how different fuels function in performing different works at a particular locality. The commonly known ones are woodfuel (i.e. firewood and charcoal), agricultural crop residues, solar, wind and geothermal as well as electricity and coal (MNRT, 2001a). Potentially these patterns of energy are used in production both in rural and urban areas of Tanzania. According to MAFS (2005) households use fuelwood as primary energy source which is supplemented with crop residues for cooking in rural areas, complemented with kerosene for lighting. Charcoal is the main fuel for cooking at households in urban areas complemented either with electricity or kerosene for lighting.

2.3.1 Woodfuel

Tanzania has about 946 000 km^2 land area whereas forests and woodlands cover about 50%, of which closed high natural forests cover 1.7% and the remaining area is miombo woodland (MNRT, 2001a). About 90% of populations in Tanzania depend on these forests for supply sources of woodfuel. Apart from energy supply, forests play multiple roles in the rural life of the majority of Tanzanian especially women and other social groups in relation to food security, household subsistence as well in the local and global environmental and biodiversity conservation.

Other sources of fuelwoods in rural areas of Tanzania are trees in farmlands and small-scale homestead tree woodlots. Agricultural crop residues and animal wastes are supplemented as biomass energy where woodfuel is at an acute scarcity (Kaale, 1995). According to MNRT (2001a) biomass based fuels accounted for about 90%, while petroleum and electricity about 8% and 1% respectively the least ones are solar, wind and biogas accounted for only less than 1%. Further, it was reported that oil and electricity are mainly commercial purpose while; woodfuel is mainly for cooking at households in rural and urban areas. It is also forecasted that woodfuel will continue to be the major source of energy to majority of people in Tanzania for the foreseeable future (MNRT, 2001a).

The annual fuelwood consumption per capita in Tanzania is estimated at 2.0 m^3 for cooking and heating while 0.1 m^3 is for non-domestic consumption such as fish smoking, tea drying, tobacco curing, salt production, brick kilning bread baking, pottery and lime processing MNRT (2001b). In Mwanza and Shinyanga regions as reported by Kaale (1994) wood fuel consumption per capita ranged between 0.43 m^3 with no or very little forests and 1.5 m^3 at sites with plenty of forests, bushes and shrubs. In addition, the current need stands at between 50 and 55 million m^3, however, it has also been pointed out that in 2020 with unchanged annual population growth rate of 3%, the woodfuel consumption is forecasted to be between 78 and 85 million m^3 (Kusekwa *et al*., 2004).

Cooking is the major consumer of woodfuel in Tanzania (MNRT, 2001a). This is also true for African continent where 90% of the population uses woodfuel for cooking (Bembridge and Tarton, 1990). To meet future woodfuel demand, conservation and proper management of existing natural forests, intensive tree planting and increased end use efficiency of fuelwood have been identified as the major strategies for solving the fuelwood shortage. In addition, the professional awareness problem must be spread to the decision makers and the general public campaigns to raise awareness must be intensified (Kaale, 1985).

2.3.2 Agricultural crop residues

Woodfuel is the major energy source in most rural and urban areas of Tanzania mainly for cooking (MNRT, 2001a). However, recently due to its scarcity is supplemented by crop residues particularly during the dry and harvesting periods. Crop residues could differ from one place to place but generally include maize cobs and rice husks, cotton remnants, sorghum and cassava sticks (MNRT, 2001a). According to Kafumu (2000) commonly used agricultural crop residue as sources of energy in Tanzania include: cotton stalks, maize cobs, coconut shells, sugar residues (bagasse and molasses), cashew nuts residues, rice and coffee husks normally used in rural areas where there is shortage of woodfuel. Some studies including FAO (1998) in developing countries reported that crop productions provide a wide range of materials capable of burning. For example in West Africa, sorghum stalks are used for cooking and great variety of crop residues are used in villages, including rice stems and hulls of groundnuts. In Asia continent particularly in India with serious wood shortages, agricultural crop residues and animal wastes accounted for about 34% and 24% of the total energy consumption respectively (FAO, 1998). Generally crop residues are regarded as low grade fuels which require greater fire management when cooking but have other important uses notably as fodder and manure. However, planners often seem to have limited scope for energy planning intervention to utilize crop residues effectively (Spears, 1986). Crop and animal forms of energy are gradually becoming significant to the energy base due to high rate of depletion of woodfuel in rural areas in developing countries (Hartmet, 1976). Likewise, similar observations were reported by Mnzava (1990) in Tanzania.

2.4 Commercial Energy

2.4 1 Electricity

Tanzania possesses large reservoirs of water, coal and natural gas and therefore has the capacity for significant expansion of the power industry, but patterns of household energy consumption vary from one area to another within a country. They also vary with season and depend on availability of local resources and alternative energy (Mbendi Profile, 2003; RWEDP, 2003).

About 80% of Tanzania population lives in rural areas of which accessibility to electricity is estimated at about 1% compared to 12% in urban areas where by its cost per kilowatt are quite high with smaller capacity units (MEM, 2003). In addition, the initial costs for establishment and running cost are relatively expensive which makes the customers avoid using it for cooking. For such a situation electricity seem not to be used as substitute energy for saving the environment including reducing woodfuel consumption. In adequate supply of energy restricts socio economic activities, growth and adversely affects the quality of life. Thus energy future requirements will continue to grow with increase in living standards, industrialization and a host of other socio economic factors (TaTEDO, 2001; Sawe, 2005).

2.4.2 Coal

Coal is a solid combustible mineral substance containing essentially of carbon with small amount of Hydrogen, Oxygen, Nitrogen and Sulphur. A high-grade coal contains 70% and 80% of energy per unit weight of oil. The use of coal as an energy source in Tanzania is still low and limited compared to the existing reserves. Few industries such as that of cement, textiles, and paper are using it (Kusekwa *et al.,* 2004). The authors pointed out that it produces a high grade smokeless fuel, but it is non renewable, expensive interms of production as well as transportation and hazardous to human health. Also, mining activities to exploit coal might have negative impact on the land by creating problems of soil erosion, unless remedial work is undertaken, which may also be expensive. Above all coal exploitation probably is affected with limited technology since in the developed countries with advanced technology are using it effectively.

2.5 Impact of Woodfuel Consumption to Natural Forests

Fuelwood scarcity in developing countries dictates high purchase price, consequently make natural forest resources to be overexploited consequently causing deforestation (Kaale, 1994). As woodfuel shortages deepen, changes are likely to occur including consuming some economic valuable tree species e.g. *Dalbergia melanoxylon*, *Brachystegia speciformis*, medicinal and fruit plants. Also, it destructs trees like *Acacia senegal* which produce gum Arabic or trees maintained along stream banks which protect water sources and cultural value trees regardless of its sustainability. Likewise, other materials of economic values such as cow dung and crop residues are also diverted to fuel use instead of being used as fertilizer in crop production (Kaale, 1983). According to CFAN (2005) woodfuel demand, threaten the land, through soil deterioration, water base, and consequently degrade the environment. Generally wood fuel scarcity is the sign of a wide spread rural poverty linked with more fundamental aspects of survival, production and land management

In all this situations, according to Warmer (2000), woodfuel crisis threatens development potentials e.g. incidences on nutritional and health of the people who consume uncooked food and protection from cold, disproportionate amount of time and money diverted to woodfuel expenses. The problems could be resolved by restoring and protecting a productive environment (Warmer, 2000).

CHAPTER THREE

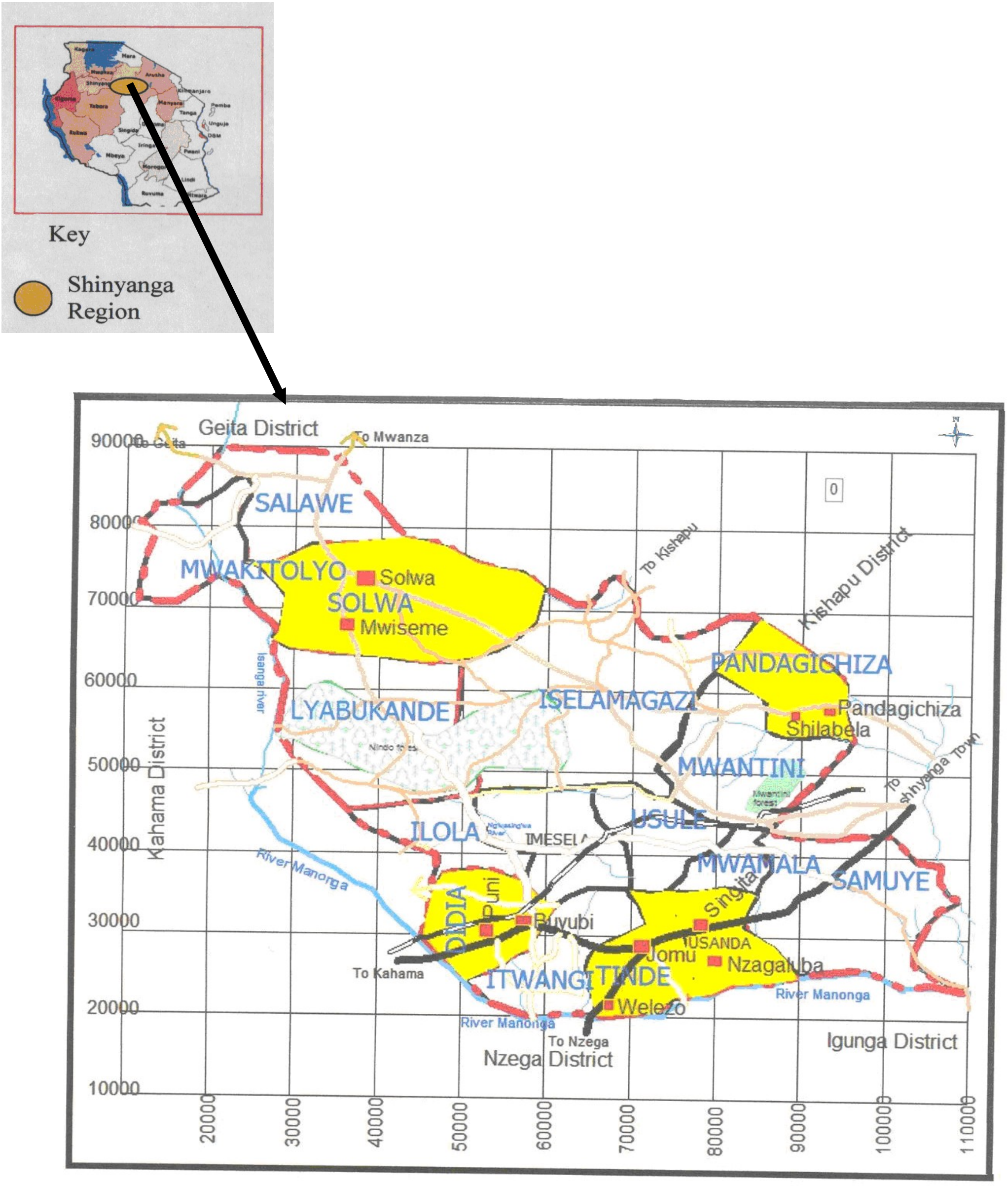
3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location and administration

The study was conducted in Shinyanga Rural District in Shinyanga Region, Tanzania. The District lies between Latitudes 3^0 20′ and 3^0 95′ South, and Longitudes 31^0 31' and 33^0 30′ North of Greenwich. It is bordered by Geita and Misungwi districts in the North, Shinyanga urban and Kishapu in the East,Geita and Kahama in the West, Nzega and Igunga in the South. The District covers an area of 3646 km^2 where by 656 km^2 is for agricultural, about 656.2 km^2 is a free-range land for livestock grazing and about 10.21 km^2 is degraded land and rocks. Settlement and forest reserves cover about 182 and 72.9 km^2 respectively (NBS, 2002). Administratively the District consists of three divisions, which include Samuye, Nindo and Itwangi, with 16 wards and 107 villages (Fig. 1). According to NBS (2002) population and households of the study area was estimated at 335 887 and 45 517 respectively and households family size consisted of an average of 5.6 persons.

The study area was purposely selected simply because it is in arid zone area facing with a number of challenges including: high population growth and deforestation through shifting cultivation, charcoal production, encroachments and firewood gathering by cutting wood tree species. Consequently, woodfuel consumption seems to be scarce and expensive in terms of cash and time involved at gathering.



LEGEND

- Wards study Area
- Villeges study Area
- Forest Land

Roads

Figure 1: Map of Shinyanga Rural District Showing the Study Area

3.1.2 Climate, topography and soil

Flat and gently undulating plains covered with low and sparse vegetation characterize the study area. The area lies at an attitude ranging between 1045 and 1400 meters above sea level. It has tropical type of climate with clearly distinguished rain and dry seasons. Generally it receives inadequate rainfall which starts in October or November and ends in May. The amount of rainfall ranges between 450 and 990 mm per annum, whilst its mean temperature varies between 20 ^{0}C and 26 ^{0}C (NBS, 2002). The soil is poorly sandy loam, black clay and flat depressed *mbug*a characterized with blackish clay soil good for cotton production, very sticky and swelling when wet and shrinks and cracks when dries. Based on poor land management system, deforestation and overgrazing, the land is subjected to erosion, severe floods and land degradation with shortages of water and food (URT, 2004).

3.1.3 Vegetation

In early 1920s Shinyanga was extensively forested with *Acacia* and miombo species and forest products and services were available (Malcolm, 1953). By 1970s the area was under severe ecological strain with severe land degradation caused partly by conflicting policies such as tsetse fly eradication programme, expansion of cotton production for foreign markets, villagization programme and by tradition of overstocking which resulted in overgrazing (Barrow *et al.*, 1998). Consequently, these activities have negative impact on forests. It involved clear felling of trees and hence forests were threatened and valuable species of economic importance had became overexploited particularly of miombo like *Brachystegia speciformis, Dalbergia melanoxylon* and *Afzelia quanzensis.* To date the vegetation in the study area is composed of shrubs with thorns and usually deciduous mixed with grass for livestock feeding. According to Holmes (1995) other wooded grassland vegetation mixed with *Acacia bussei, Acacia mellifera, Acacia senegal, Acacia tortilis, Adansonia digitata, Delonix elata* and *Terminalia speciosa* are found in the study area.

3.1.4 Social economic activities

The main ethnic group of the study area is the Wasukuma whose major occupation is farming and livestock keeping. Shinyanga rural area is under semi-arid geographical location zone in Tanzania, experiences drought, hunger, fodder shortages, scarce rainfall with severe soil erosion (NBS, 2002). Under such conditions the community in the study area practices cultivation of crops tolerant in the arid zone areas. Among these crops include cereal types such as millet, sorghum and maize. Other crops include cassava, sweat potatoes and leguminous crops. These subsistence food crops sometimes are sold as cash crops for household's income generation. To some extent, cotton is also cultivated as a cash crop in the study area (NBS, 2002).

3.2 Sampling Procedures and Data Collection

3.2.1 Sampling design

Multistage sampling design was used to obtain a representative sample in which there was successive selection of smaller group's stage wise within the population, resulting into sample individual households as sampling units. Lists of households in the respective villages were regarded as a sampling frame. The sampled households were obtained by simple random selection from village register. The study was conducted in two phases: the first phase being preliminary survey prior to the main household's woodfuel survey for pilot testing questionnaires and checklist for households and other key informants. This was crucial to enable the researcher to check the relevance and comprehensiveness of the data collection in gathering the required information. This also assisted in modifying some questions, which were used in the main field work. The second phase was the main survey where questionnaires were administered to respondents at households.

3.2.2 Sample size

The study area consisted of three divisions namely Nindo, Samuye and Itwangi. These three divisions have a total of 16 wards and 107 villages. Among the 16 wards, five wards namely: Solwa, Pandagichiza, Busanda, Tinde and Didia were selected based on geographical and administration location, closeness to woodfuel sources and for small town centers. Ten villages were selected from five wards, two from each ward (Table 1). The numbers of households as sampling units were selected randomly from their respective village registers without replacement. The sample size of the households sampled from each village was 5% of the total village household's population as recommended by Boyd *et al*. (1981) to represent the entire population (Table 1).

Table 1: Households survey sampling intensity

Division	Ward	Village	Number of households	Percent
Nindo	Solwa	Mwiseme	15	7
		Solwa	25	12
	Pandagichiza	Shilabela	24	11
		Pandagichiza	19	9
Samuye	Busanda	Singita	29	14
		Nzagaluba	11	5
Itwangi	Didia	Buyubi	12	6
		Puni	14	7
	Tinde	Welezo	15	7
		Jomu	50	23
Total			**214**	**100**

3.2.3 Data collection methods

Two categories of data, which included primary and secondary, were collected. Primary data at households' level were collected through questionnaire survey (Appendix 1) and field observations. The questionnaires were designed based on specific objectives. On the other hand the key informants were interviewed using a checklist (Appendix 2).

Secondary data on woodfuel consumption were obtained from journals, books, records from Regional and District Forestry Department offices and from other information centers such as Sokoine National Agriculture Library (SNAL). Additional information was obtained from relevant energy offices including Ministry of Natural Resources and Tourism, Ministry of Energy and Minerals, Dar es Salaam, Tanzania and Tanzania Forestry Research Institute (TAFORI) and NAFRAC Offices in Shinyanga. The information obtained was used to supplement primary data obtained from the study area.

3.2.3.1 Questionnaire survey

Questionnaire survey involved the household's sampled respondents. A household was taken as the unit of analysis because it is where all decision about the woodfuel consumption status such as sources of supply, demand, availability or shortages, other alternatives energy use available as well as its implications to households socio-economic and its forest resources and measures are primarily reported and taken (Opole, 1995).

Questionnaire forms (Appendix 1) were designed for each sampling unit, which included the household and key informants. The questions set permitted acquisition of both quantitative and qualitative data in the form of open and closed ended questions. In open ended questions, respondents and informants were left free to avoid yes or no answers and encouraged maximum discussion and the closed questions alternative answers were provided.

During household survey different information were recorded mainly on the quantity of woodfuel consumed daily, weekly, monthly and yearly in bundles (firewood) and bags (charcoal) in Kilogram (kg). The equivalent conversion formula from kg to cubic meters (m^3) was based on Holmes (1995). Other information included the woodfuel supply sources, their use, the available species used for woodfuel, and factors which influence the utilization of the woodfuel in the study area as well as households socio economic characteristics. The questionnaire was interpreted in *Kiswahili* and before interview the respondents were given a brief introduction by the interpreter in *Kiswahli* or in local language directly. Explicit explanation helped the respondents to understand the study while responding to the questions on woodfuel consumption. Furthermore, apart from woodfuel consumption survey in the study area, other fuels were assessed and these included: electricity, solar, biogas, kerosene, agricultural crop residues and cow dung. Its aim was to detect their uses in terms of cooking so as to rank them.

Ranking was employed as a useful tool of assessing the dominant fuel patterns used at households by listing them as first, second, third and so on, where by the least rank was assigned to the lowest fuel pattern consumed at households and vise versa. According to (Owen and Jones, 1994) ranking methods are simply used to identify the most fuel used in the community so that it could be an indicator for decision making assessment tool for forestry institutions and energy planners for management planning for sustainable supply and utilization at a particular locality.

3.2.3.2 Participant observation

This method was used to observe respondents social, cultural, economic activities, and the general status of woodfuel sources, supply and utilization and respondents response on afforestation programme as well as environmental conservation. Based on Gvares (1998) observations can be made without disturbing relevant collected data and if done properly they can provide reasonable accurate data. Since such observations are made on the physical existing status under the area of the study, the observer can only report the existing situation and not why it occurred. Accoding to Kajembe and Wiersum (1998) in participant observation often the observer forms part of the situation being studied.

3.3 Data Analysis

3.3.1 Quantitative and qualitative data

Data collected through structured questionnaire was coded to facilitate data entry in the computer. Both quantitative and qualitative data analysis was done by using the Statistical Package for Social Science (SPSS) software tools from which tables, frequencies, and percentages were generated. The Multiple Regression Model was employed to test the relationship between woodfuel consumption m^3 and independent variables which included: family size, education level, time spent in fuelwood gathering and occupation of respondents.

The multiple regressions model applied was based on Mendenhall (1989) formulae's follow:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \ldots + b_nx_n + er$$

Where:

a = constant

er = error

Y = woodfuel consumption as dependent variable (m^3)

b_1 to bn = regression coefficients

x_1 = average size family members at households,

x_2 = level of education

X_3 = occupation

x_4 = time spent for collection (h)

The regression was tested at 5% level of probability. The model was preferred because it offers full explanation to the dependent variables since very few phenomenons are the product of a single cause and the effect of the particular independent variable (Mendenhall, 1989). Other studies for example Pallant (2006) showed that the regression coefficients (independents variables as the function of dependent variables) are used to assess the goodness of fit of linear relationship in the multiple linear regressions, where the higher the coefficient of determination (R^2) measured in percentage are the better the precision. The species were identified and recorded during survey were classified using the vernacular language of the *Wasukuma* during the household's survey. The names of species classified vernacularly were related to the list of botanical classification based on Mbuya *et al.* (1994) (Appendix 3).

3.3.2 Woodfuel consumption estimation

The amount of woodfuel consumed at household level in the study area was estimated by measuring fuelwood head loads and charcoal in big bags, tins and small plastic bags in kilograms (kg) using a spring balance. The quantities of fuelwood loaded on oxen-carts were measured by tape measure and estimated in kilogram (kg). The conversion factor from kg to m^3 by Zahabu (2000) revealed that 5.37 m^3 is equivalent 1800 kg (36 bags) of charcoal. However, Holmes (1995) found that 6 m^3 of round wood equivalents produce 1 metric tone of charcoal; while 1 m^3 of round wood was equivalent to 725 kg of fuelwood. In this study (Holmes, 1995) estimates were adopted because conversion of charcoal to round wood was developed based on wood from degraded areas same as the study area.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter represents results and discussion of the study in various forms summarized in percentages within tables. These results reflect on the total of 214 sampled households in the study area. Presentations of results were also based on specific objectives and research questions. Discussion follows immediately to interpret the trend shown by results.

4.2 Influence of Respondents Characteristics

4.2.1 Sex

A total of 214 respondents were interviewed in the study area where 58% (124) were female and 42% (90) were male. The distribution by sex in surveyed villages of the study area is indicated in Table 2.

Table 2: Percentage distribution of sex of respondents in the study area

Name of villages	Female	Male	Total
Mwiseme	53(8)	47(7)	100 (15)
Solwa	64(16)	36(9)	100 (25)
Shilabela	42(10)	58(14)	100 (24)
Pandagichiza	68(13)	32(6)	100 (19)
Singita	76(22)	24(7)	100 (29)
Nzagaluba	63(7)	36(4)	100 (11)
Buyubi	50(6)	50(6)	100 (12)
Puni	50(7)	50(7)	100 (14)
Welezo	53(8)	47(7)	100 (15)
Jomu	54(27)	46(23)	100 (50)
Total	**58(124)**	**42(90)**	**100 (214)**

Note: Numbers in the parentheses are frequencies

The number sampled of women is relatively higher than men due to the fact that, women have profound influence in the role them playing daily in fuelwood collection, utilization, its availability harvesting techniques and forest protection techniques. Generally, women are said to be more active in utilizing woodfuel compared to male counterparts, and Katani (1999) found that women are often extensively involved in several forests based livelihood activities such as collection of fuelwood.

Women, through their individual skills, knowledge and experience are thought to provide relevant information about the most tree species for woodfuel, the amount of woodfuel consumed at households, woodfuel sources, uses and factors affecting its consumption, gathering problems and options suggested for sufficient utilization at sustainable manner (Baguant, *et al.*, 1992). According to Sunderland *et al*. (2004) women often spend much of their time on livelihood and health related issues including woodfuel gathering, cooking and family caring at households. FAO (2005) reported that trees and forests are multifunctional for women, whereas men tend to concentrate on commercial activities such as timber and other goods for income generation, women think of source of fuel, fodder and food.

It is customary in most African societies to find women are the collectors, managers and user of woodfuel at households. Moreover, women and children are the most vulnerable groups in terms of energy scarcity and adverse environmental impacts associated with energy production and use (World Energy Council, 1999 and ESMAP, 2003).

Reddy *et al*. (1997) pointed out that women have practical interest in the burning properties of different woodfuel tree species, heat management and fuel-saving techniques. Importantly, women influence the direct and indirect energy consumption patterns of their households. This behaviour is in line with the knowledge of females on woodfuel utilization properties observed in the study area. Women revealed better burning wood with high heat intensity and relatively smokeless tree species.

4.2.2 Household size

About 53% of respondents in surveyed villages had 4-7 members in their households followed by 26% who had more than 8 members and only 21% had less than 3 members in their households (Table 3).

Table 3: Percentage distribution size of households in surveyed villages of the study area

Name of the village	Family size (%)		
	< 3 persons	4-7 persons	8 > persons
Mwiseme	13 (2)	40 (6)	47 (7)
Solwa	16 (4)	72 (18)	12 (3)
Shilabela	17 (4)	54 (13)	29 (7)
Pandagichiza	5 (1)	37 (7)	58 (11)
Singita	28 (8)	52 (15)	21 (6)
Nzagaluba	18 (2)	27 (3)	55 (6)
Buyubi	33 (4)	50 (6)	17 (2)
Puni	7 (1)	79 (11)	14 (2)
Welezo	20 (3)	60 (9)	20 (3)
Jomu	30 (15)	52(26)	18 (9)
Total	**21 (44)**	**53 (114)**	**26 (56)**

Note: Numbers in parentheses are frequencies

According to (URT, 2002) the estimated average members at household level were 2.4 in the study area. However, results from this study revealed that the average size per household was 5.2. This indicated that there is an increase in average members at household level of the study area. This could be attributed by various factors including polygamy system and early marriage. It was noted in the study area that bearing many children serving as labour force at the households was worth wise and prestige. However, the increase household's size might increase demand of forest wood products including woodfuel exerting pressure on gazzetted forests through encroachment, for charcoal production and firewood gathering. Consequently, this could alter the pattern of the forest resource use, and hence accelerate deforestation and forest degradation.

According to Mariara (2003) in Kenya larger families at households in rural areas are likely to be poorer because they fail to produce enough to meet individual basic needs like woodfuel. Hence, the size of the family might be also the determinant of the per capita collection and utilization of woodfuel.

4.2.3 Education level

The results indicated about 58% of respondents in the study area to had attained primary education, while 35% had informal education and only 7% had attended secondary education (Table 4).

Table 4: Education levels of respondents in surveyed villages of the study area

Village	**Education level (%)**		
	Informal	**Primary**	**Secondary**
Jomu	32 (16)	64 (32)	4 (2)
Welezo	33 (5)	53 (8)	13 (2)
Puni	43 (6)	57 (8)	Nr
Buyubi	67 (8)	33 (4)	Nr
Nzagaluba	Nr	100(11)	Nr
Singita	38 (11)	38 (11)	24 (7)
Pandagichiza	37 (7)	63 (12)	n r
Shilabela	46 (11)	54 (13)	Nr
Solwa	24 (6)	68 (17)	8 (2)
Mwiseme	33 (5)	53 (8)	13 (2)
Total	**35(75)**	**58(124)**	**7(15)**

Note: Numbers in parentheses are frequencies, nr = no response

The study revealed that most of respondents had attained primary education implying that they are able to write and read as their illiterate level is not very low. According to FAO (2005) education normally has an influence on natural forest resources management and utilization including tree planting for present and future generation and environmental conservation. During informal conversation with elder respondents with informal education it was noted that communities had traditional ways of conserving forests through insitu conservation in *ngitili* for fodder and other forest goods including fuelwood. Katani (1999) pointed out that people should be educated through awareness creation, positive attitudes, values and motivation for better management of natural forest resources in sustainable manner. This should also be emphasized to the people in the study area.

4.2.4 Occupation

Results revealed that farming was the main households' occupation in the study area accounting for about 92%, while civil servants and others accounted only for 4% each (Table 5).

Table 5: Percentage distribution of occupation of the respondents of the study area

Village	Farmers	Civil servants	Others
Jomu	94 (47)	Nr	6 (3)
Welezo	93 (14)	(1) 7	Nr
Puni	100 (14)	Nr	Nr
Buyubi	83 (10)	(1) 8	8 (1)
Nzagaluba	82 (9)	Nr	18 (2)
Singita	76 (22)	21 (6)	3 (1)
Pandagichiza	100 (19)	Nr	Nr
Shilabela	100 (24)	Nr	Nr
Solwa	92 (23)	Nr	8 (2)
Mwiseme	93(14)	1(7)	Nr
Total	**92(196)**	**4(9)**	**4(9)**

Note: Numbers in parentheses are frequencies, nr = no response

Results from the study area seem to be not so much different to what URT (2002) reported where by about 91% of population in Shinyanga rural district were farmers, while the other sectors e.g. government civil servants and others accounting only for about 9%. This implies that more land for agricultural practices might be required for subsistence and cash crops, making forest resources under pressure of depletion in the study area and hence woodfuel shortages. For example, overexploitation and illegal charcoal production mainly for income generation purposes was reported to increase gradually in forest reserves of Tanzania (URT, 1999). Proper management of land use system and practices such as agroforestry seems to be appropriate options for land improvement and for meeting the immediate and the long term forest products demand e.g. woodfuel consumption for communities in the study area.

4.2.5 Age

The results showed that most respondents were in age group of between 36 to 59 years (49%) while about 41% were aged less than 35 years old and only 10 % were in age group of 60 years and above (Table 6).

Table 6: Percentage distribution of age of respondents in the study area

Village	**Age of respondents (N)**		
	< 35 years	**36 – 59 years**	**> 60 years**
Mwiseme	40 (6)	60 (9)	Nr
Solwa	56 (14)	40 (10)	4 (1)
Shilabela	42 (10)	54 (13)	4 (1)
Pandagichiza	53 (10)	37 (7)	11 (2)
Singita	24 (7)	59 (17)	17 (5)
Nzagaluba	55 (6)	27 (3)	18 (2)
Buyubi	42 (5)	50 (6)	8 (1)
Puni	36 (5)	50 (7)	14 (2)
Welezo	53 (8)	33 (5)	13 (2)
Jomu	32 (16)	56 (28)	12 (6)
Total	**41 (87)**	**49 (105)**	**10 (22)**

Note: Numbers in parentheses are frequencies, nr = no response

Results showed that the ages from 36 to 59 were regarded as the most active working group in the study area, implying availability of active labour to be involved in overexploitation of forest and its products, through encroachment for charcoal production to meet the basic human needs. Forest products such as charcoal as well as firewood were noted to be commercial products for income earning by the respondents in the study area. This group should be sensitized on the importance of conserving natural forest resources and participation in Afforestation programmes be encouraged to ensure sustainable woodfuel supply.

Makwaia (2003) reported that the age of individuals plays an important role in application of indigenous knowledge and innovations, which could have either negative or positive impact to forest resources conservation, Afforestation, deforestation, and encroachment of restricted forests. Other studies for example URT (1999) in Shinyanga argued that youth aged between 15 to 44 years depend on agriculture and its related activities as their main employment opportunity for their livelihood sustaining. Similarly, TAFORI (2004) reported that middle age class dominance was common phenomenon for Shinyanga and Tabora regions. This implied that, labour resources in most households' families were sufficient for farm activities, collection of fuelwood, deforestation and charcoal burning for income generation.

4.3 Woodfuel Sources

4.3.1 Collection sites

Results revealed that 34% of the respondents depended on buying woodfuel as a means of supply, while 32% depended on more than one source, 16 % collected from public forest land and only 9% collected from small woodlots. Other sources were "*insitu*" forests (*ngitili*) which accounted for only 5% (Table 7).

Table 7: Percentage distribution of sources of woodfuel supply in the study area

Village	**Sources of woodfuel (N)**					
	Buying	**Access land**	**Woodlot**	**Insitu –forest**	**Begging**	**Combination**
Mwiseme	33 (5)	7 (1)	7 (1)	13 (2)	6 (1)	33 (5)
Solwa	60 (15)	Nr	8 (2)	4 (1)	4 (1)	24 (6)
Shilabela	17 (4)	38 (9)	4 (1)	8 (2)	4 (1)	29 (7)
Pandagichiza	11 (2)	5 (1)	11 (2)	21 (4)	16 (3)	37 (7)
Singita	21 (6)	41 (12)	14 (4)	Nr	nr	24 (7)
Nzagaluba	Nr	18 (2)	18 (2)	Nr	nr	64 (7)
Buyubi	8 (1)	17 (2)	17 (2)	Nr	nr	58 (7)
Puni	7 (1)	14 (2)	29 (4)	Nr	14 (2)	36 (5)
Welezo	47 (7)	13 (2)	nr	7 (1)	nr	33 (9)
Jomu	66 (33)	8 (4)	nr	Nr	nr	26 (13)
Total	**34 (74)**	**16 (35)**	**9 (18)**	**5 (10)**	**4 (8)**	**32 (69)**

Note: Numbers in parentheses are frequencies, nr = no response

Results indicate about 66% and 60% of respondents who live at small town centers of Jomu and Solwa depended on buying woodfuel. Normally they use charcoal from Nzega or

Igunga districts of Tabora region and sometimes from Kahama or Bukombe districts of Shinyanga region. Overall results indicate that almost each household in villages of the study area buy woodfuel except Nzagaluba village, which is situated closer to Busanda hill forest where the respondents claimed to have free access for woodfuel collection by cutting green trees. Woodfuel, collection by cutting the green wood implies the shortage of fuelwood and not only this means the young growth development species are consumed but also some economic important species e.g. *Dalbergia melanoxylon*, fruit trees and some medicinal plants might be harvested. If these forests have no proper management plan, they could be subjected to deforestation. In order to ensure the continued supply of forest products at sustainable manner the Community Based Forest Management approach should be emphasized in the study area. However, it was noted that households collected fuelwood from their own woodlots and insitu forests. Given that planted trees as the source of woodfuel are the medium to long term investment, therefore species selection is a key for choosing fast growing species that can be harvested within few years e.g. *Luceana spp.*

According to Van Beukering *et al.* (2007) in developing countries for many decades woodfuel has been abundant and collection taken for granted almost around their homesteads. Recently woodfuel has relatively no longer being a free commodity but rather as a commercial product in terms of its price which is gradually rising and increased distance walked in collection.

In most cases natural forests, woodlands, plantation, woodlots or trees on farm are the main woodfuel energy supply sources in Tanzania (MNRT, 2001a). Other woodfuels in Tanzania are collected from logging residues and sawmill. In Tanzania of all wood harvested, about 90 % is from natural forests, which are poorly managed and stocked (Kafumu, 2000). However, results are different from Kafumu (2000) probably due to the fact that most of natural forests which are the major supply of woodfuel as the source of energy for cooking in the study area have been depleted due to higher pressure in use.

4.3.2 Type of woodfuel collected

About 61% of respondents in the study area were found to collect woodfuel by cutting green wood while about 35% depend on both green cutting and dry fuelwood collection while only 4% of respondents collected the dry wood (Table 8). This implies that forests have been depleted through anthropogenic activities such as shifting cultivation, overgrazing, charcoal production and poor land use management system.

Table 8: Percentage distribution of type of fuelwood collected in the study area

Name of the village	**Types**		
	Dry	**Green wood**	**Both (green and dry)**
Mwiseme	Nr	67 (10)	33 (5)
Solwa	Nr	32 (8)	68(17)
Shilabela	5 (1)	79 (19)	16(4)
Pandagichiza	Nr	89 (17)	11(2)
Singita	Nr	79 (23)	21(6)
Nzagaluba	18 (2)	82 (9)	Nr
Buyubi	17 (2)	83 (10)	Nr
Pun	Nr	86 (12)	14(2)
Welezo	Nr	49 (7)	51(8)
Jomu	2 (1)	30 (15)	68(34)
Total	**4 (6)**	**61 (131)**	**35(77)**

Note: Numbers in parentheses are frequencies, nr = no response

The study indicated that only 4 villages: Nzagaluba (18%), Buyubi (17%), Shilabela and Jomu only accounting for 5% and 2% collected dry fuelwood, from their own natural "*insitu*" forests ("*ngitili*") and from woodlots around homesteads, general public land and illegally from Mwantini forest reserve.

The study results revealed that the majority of respondents of the study area collected fuelwood by cutting green trees. Due to shortages of trees in the study area any species seem to be consumed regardless of its characteristics. For example some *Acacia spp* with thorns e.g. *Acacia polycantha* and irritating latex poison fluid of *Euphorbia tirrucalli* were noted to be used as fuelwood.

Other studies for example by Malimbwi *et al.* (2005) reported that unpreferred woodfuel tree species such as *Acacia polycantha* and *Sterculia africana* with thorns were regarded to be a limiting factors for collection. However, FAO (1984) reported that consumption of *Euphorbia tirrucalli* as source of energy for cooking indicates fuelwood scarcity in a particular locality. Cooking by *Euphorbia tirrucalli* as a source of fuel had not preferred due to its effect on human health including eyes allergic reactions and respiratory diseases. It is advised that cooking at good ventilation kitchens can minimizes the susceptible risk effects of the exposure of inhaling smoke from such species.

4.3.3 Fuelwood collectors

Results showed that women were the major fuelwood collectors in the study area accounting for 57%, followed by women and children (26%) while children only accounted for 23% and men and women together accounted for only 8% (Table 9).

Table 9: Percentage distribution of fuelwood collectors and non collectors

Village	Fuelwood collectors (N)				Non Collectors
	Women Alone	Women and Children	Children alone	Women and Men	Buyers
Mwiseme	33 (5)	27 (4)	nr	7 (1)	33 (5)
Solwa	8 (2)	12 (3)	4 (1)	16 (4)	60 (15)
Shilabela	42 (10)	42 (10)	nr	4 (1)	12 (3)
Pandagichiza	84 (16)	5 (1)	nr	5 (1)	5 (1)
Singita	21 (6)	38 (11)	3 (1)	10 (3)	27 (8)
Nzagaluba	36 (4)	36 (4)	9 (1)	9 (1)	9 (1)

Buyubi	58 (7)	17 (2)	nr	16 (2)	8 (1)
Puni	43 (6)	50 (7)	7 (1)	Nr	Nr
Welezo	7 (1)	27 (4)	7 (1)	13 (2)	47 (7)
Jomu	Nr	20 (10)	2 (1)	2 (1)	74 (37)
Total	**57 (27)**	**26 (57)**	**23 (6)**	**9 (16)**	**35 (77)**

Note: Numbers in parentheses are frequencies, nr = no response

Results obtained conform to FAO (1984) who reported that fuelwood collection is mostly a women task helped by children. The dominance of women in the collection of fuelwood normally for consumption at the households calls for the need to ensure proper planning, policy and management of natural forest resources and its energy development for households at sustainable manner in the study area. This could be accomplished by women forming groups dealing with micro projects related to environmental conservation including raising seedling in nurseries and tree planting as well as woodfuel efficient cook stove making.

Makonda (1997) reported similar observations where in Geita district women were found to be more active in fuel wood collection. Lema (2003) in Morogoro Rural District, Tanzania and Clarke *et al.* (1996) in Zimbabwe reported that more than 80% of women were involved in fuelwood collection. According to Katani (1999) gender affects division of labour within a specific social group and has profound influence in roles that men, women and children play in household’s activities including management, conservation and utilization of forest resources.

4.3.4 Fuelwood collection distance

Results revealed that the distance walked by local communities in collecting a head load of fuelwood was at an average of 5 km. However, at a particular instance it was noted that fuelwood collection was estimated at 21 km by oxen cart transportation taking almost 2 days. It is indicated however, that most of the households in the study area as per 55%

response walk less than three kilometers (< 3 km). The shortest distance walked (< 3 km) for gathering fuelwood was found at Solwa village followed by Jomu and Welezo (60%) each, Nzagaluba 55%, and the least was Pandagichiza 37% (Table 10).

Table 10: Percentage distribution of on walking distance (km) for collection of fuel wood

Village	**Distance walked (N)**		
	< 3 km	**4-6 km**	**> 7 km**
Solwa	84 (21)	(2) 8	8 (2)
Shilabela	54 (13)	(10) 42	4 (1)
Pandagichiza	37 (7)	(11) 58	5 (1)
Nzagaluba	55 (6)	(5) 46	nr
Buyubi	42 (5)	(7) 58	nr
Puni	50 (7)	(7) 50	nr
Welezo	60 (9)	(6) 40	nr
Jomu	60 (30)	(15) 30	10 (5)
Total	**55 (118)**	**40 (85)**	**5 (1)**

Note: Numbers in parentheses are frequencies, nr = no response

Results are different from what MNRT (2001a) reported where women in rural Tanzania are reported to walk 4 to 8 km to collect firewood three times a week, spending 4 to 5 h each time, to carry home an estimated fuelwood head load of 15 kg. Not only is this very labour intensive, but also set women at risk of danger from animal bites, burns, cuts, falls, backache, exhaustion, as well as violence and sexual assault (Ezzati and Kammen, 2002; Wickramasinghe, 2003).

The study also found that some of the households in surveyed villages walked further distance for gathering fuelwood ranging from 4 to 6 km accounting for 40% of the respondents in the study area. The longer distances walked to sources of fuelwood suggests the scarcity of woodfuel. Consequently, the study has noted that there was an increased use of agricultural crop of residues as the supplement supply sources of energy through use of dry maize stalks and cobs, millet stalks, cotton remnant sticks, sisal dry leaves and cow dung (*ndelya*), which was collected around homesteads. These forms of energy are mostly limited for use during the dry season only after crops have been harvested to supplement woodfuel.

Similarly in some rural areas of Zimbwabwe, households had shifted to use biomass fuels like cow dung, agricultural crops residues and herbs found around the homesteads and fields and hence lower distance costs of collecting fuelwood (Grundy *et al.*, 1993). According to Chidumayo (1991) cow dung, crop residues are gradually becoming significant energy sources due to the high rate of depletion of forests biomass and its forest products. The increased use of cow dung and crop residues as a fuel may reduce soil fertility while the overexploitation of common woodland resources may jeopardize the availability of fodder and construction materials.

According to Malimbwi *et al.* (2005) the availability of woodfuel in rural and urban areas is increasingly becoming difficult because of increase in distance from its sources. In many instances, the simplest way to measure the availability of woodfuel is to estimate distance walked to collect it (Digernes, 1979). As the distance increases, not only the quantity change, but the sexually defined roles dictating the responsibility for gathering also change.

4.4 Fuel Combinations and Use Patterns

Results indicated that fuelwood and kerosene were fuel patterns most found to be consumed at households accounting for 32%, followed by fuelwood + charcoal + kerosene with about 21%. On the other hand, fuelwood + crop residues + Kerosene accounted for about 20%

and the least one were (fuelwood + charcoal + electricity + kerosene) and (fuelwood + electricity + kerosene only by 1% each (Table 11).

Table 11: Fuel Combinations and use patterns recorded and ranked in the study area

Types	% Response	Ranking
Fuelwood + Kerosene	32 (69)	1
Fuelwood +Charcoal + Kerosene	21(45)	2
Fuelwood +crop residues +Kerosene	20(43)	3
Charcoal + Kerosene	13(29)	4
Fuelwood + crop residues + Cowdung + Kerosene	6(12)	5
Fuelwood + crop residues + Charcoal + Kerosene	4(8)	6
Fuelwood + Charcoal + Solar + Kerosene	2(4)	7
Fuelwood + Charcoal + Electricity + Kerosene	1(2)	8
Fuelwood + Electricity + Kerosene	1(2)	9
Total	**100(214)**	

Note: Numbers in parentheses are frequencies

The combination of fuelwood and kerosene seem to be preferred by the majority of respondents in the study area for cooking and lighting probably due to being cheapest and easily available. According to Anderson and Fishwick (1984) social economic factors do influences the energy use patterns by households which include: purchasing power of households, the availability and reliability of the fuel supplies, its prices, family size and cooking habits. These could be among of the reasons for the results obtained from this study.

4.5 Woodfuel Use

About 76% of households in the study area rely on fuelwood as their primary source of energy for cooking compared to charcoal which accounted only for 24%. In Puni village for example fuelwood for cooking accounted 100%, followed by Singita (90%) and the least village was Solwa (60%) (Table 12).

Table 12: Percentage distribution of woodfuel (fuelwood and charcoal) used in village

Villages	Fuelwood	Charcoal
Mwiseme	87 (13)	20 (3)
Solwa	60 (15)	48 (12)
Shilabela	79 (19)	13(3)
Pandagichiza	79 (15)	5 (1)
Singita	90 (26)	21(6)
Nzagaluba	64 (7)	Nr
Buyubi	83 (10)	17 (2)
Puni	100 (14)	14 (2)
Welezo	80 (12)	53 (8)
Jomu	64 (32)	76 (38)
Total	**76 (163)**	**24 (51)**

Note: Numbers in parentheses are frequencies, nr = no response

Other researchers from other countries for example Mogaka *et al.* (2001) reported that 85% of the population in Namibia, 90% in Malawi, 70% in Zambia and 80% in Mozambique to depend on wood as sources of energy for home consumption. Results of the study area seem to be different as indicated that almost 100% of respondents depend on woodfuel for home consumption activities mainly for cooking. This could be due to lack of alternative energy sources in the study area. However, in countries like Zambia other available sources of fuel are used to substitute woodfuel consumption as principle source of energy for cooking. These fuels could be either coal or electricity. Similar studies in Eastern Africa by EAAL (2003) found that biomass (woodfuel and agricultural waste) in Kenya is the predominant energy source and contributes about 78% of the total biomass sources of energy demand for domestic consumption. A study conducted by Hassan *et al.* (2002) in some rural households' areas of Swaziland found that more than 90% of the total population use woodfuel as the major source of energy for cooking. This is also true for

African continent including Tanzania where 90% of its population is reported to use woodfuel for cooking (Bembridge and Tarlton, 1990).

Wood energy remains the most significant source of energy for the majority in rural and urban areas to date and for the near future at the most households in developing countries (FAO, 2005). This could be due to poverty and lack of affordable alternatives energy sources. According to Trossero (2002) a few numbers of households have access to electricity, biogas, solar and oils (e.g. kerosene) to mention a few in the developing countries. The author also argued that declining supply of woodfuel coupled with inability of the majority of households to afford commercial fuels will exacerbate poverty, forest or land degradation, deforestation, and eventually desertification if allowed to continue. Tree planting could be appropriate measure for production woodfuel and conseving the environment in the study area.

Charcoal is another source of energy found to be consumed in the study area though for commercial purposes to generate income. Generally it was noted that charcoal consumption as the source of energy was sold mainly at small town centers of Jomu, Singita and Solwa in the study area. Government employees, food venders and other business men were mentioned to be the major customers of charcoal, and sometimes transported from nearby districts of Nzega (Tabora region), Kahama and Bukombe (Shinyanga region). Other factors including transportation cost incurred had made the charcoal price to be relatively higher, implying that consumption of charcoal at town centre’s depend on people with relatively high income level. Planting trees should be a continuous process at the degraded areas of Shilabela, Tinde, Busanda, Solwa and Welezo. Also enrichment planting at Mwantini Forest Reserve, Tinde and Busanda hills in the study area should also be taken into consideration. The approaches to be adopted are through community participation either through Joint Forest Management or Communty Based Forest Management (MNRT, 2001a). This will ensure woodfuel energy source supply and forest resources conservation.

4.6 Species Used for Woodfuel

A total of 65 species used as fuelwood were recorded and botanically identified. Ten species were found to be the most frequently used for woodfuel in the study area as extracted from (Appendix 3) and illustrated in Table 13 below.

Table 13: Percentage distribution of the most frequently used trees for woodfuel production

Local name	Botanical name	Frequency
Msubata	*Diospyros fischeri*	91
Mpogolo	*Albizia amara*	45
Msana	*Combretum zeyheri*	42
Mkoma	*Grewia bicolor*	41
Mgobeko	*Combretum longispicatum*	40
Mtundulu	*Dicrostachys cinerea*	33
Mtundu	*Brachystegia speciformis*	30
Mngu	*Acacia ploycantha*	30
Mgembe	*Dalbergia melanoxylon*	28
Mlucina	*leucaena leucocephala*	27
Mgunga	*Acacia tortilis*	26

Most of the species used for fuelwood production were indigenous except *Leucaena leucocephala* which was introduced as an agroforestry species. Difference species were also noted that had some peculiar favored features which make them to be preferred in the study area. These features included relative thin bark with less moisture content, densely, relatively smokeless, odorless, and relatively slow burning with less ash production and easy for splitting. *Dalbergia melanoxylon* and *Grewia bicolor* are dense, slow burning, and less smoke. Likewise, *Grewia platyclada* and *Albizia petassiana* are preferred due to its thin bark and less moisture content so could be used immediate after felled down.

However, due to fuelwood scarcity it was noted that almost all species could to be consumed as fuelwood regardless of its low quality in terms of fuel value (e.g. *Commiphora africana* and *Diospyros fischeri*), longer time involved in drying, weak flame, much ash and sparks producing as well as smoke emitted. Grundy *et al*. (1993) in Zimbabwe observed *Julbernardia globiflora, Colophosperum mopane and Brachystegia boehmii* as preferable tree species for woodfuel consumption. The author pinpointed out various tree species preferred characteristics including species which produce woodfuel with high recovery percentage, dense, slow burning, relatively smokeless, less moisture content and less subjected to insect boles and fungi when stored but also does not break easily during transportation.

This study also revealed that species like *Euphorbia tirrucalli* are used as fuelwood just for the matter of inconvenience due to scarcity. The species are claimed to have weak flame producing, low dense and emits smoke which could have effect on human health and by entering into eyes they cause irritation. It was also observed that to offset some of the associated effects *Euphorbia tirrucalli* was sometimes debarked, so as to hasten the dryness conditions and provide better combustion.

4.7 Households Woodfuel Consumption

4.7.1 Fuelwood

The total amount of fuelwood consumed by households in the study area was found to be 711 m^3 per year which is equivalent to 515 388 kg (Table 14). The per capital fuelwood consumption per head at the household level was estimated at 0.67 m^3 (481 kg per year). On the other hand fuelwood consumption per capita at household was estimated at 3.45 m^3 (2502 kg of fuelwood / household) in the study area.

Table 14: Per capita fuelwood consumption at households in surveyed villages

villages	Quantity per year		per capita /head		Per capita / Household	
	(m^3)	Kg	(m^3)	(kg)	(m^3)	(kg)
Jomu	125	90 480	0.48	346	2.50	1800
Singita	101	73 080	0.67	482	3.43	2506
Shilabela	96	69 948	0.77	560	4.00	2912
Pandagichiza	86	62 640	0.87	631	4.52	3281
Solwa	65	46 980	0.50	355	2.60	1846
Mwiseme	56	40 716	0.72	520	3.74	2704
Welezo	48	35 496	0.62	451	3.22	2345
Puni	49	35 496	0.66	480	3.43	2496
Buyubi	46	33 408	0.72	520	3.74	2704
Nzagaluba	37	27 144	0.64	467	3.33	2428
Total	**711**	**515 388**	**6.65**	**4812**	**34.51**	**25 022**
Average	**71**	**51 539**	**0.67**	**481**	**3.45**	**2502**

The per capita fuelwood consumption in the study area could probably be influenced by household’s size of an average of 5.2 as revealed during at household’s survey in the study area. It could also be due to the geographical location of the surveyed villages. This implies that households living near the natural forests have free access to forests, bush and shrubs or hills thus consume relatively larger amount of fuelwood than those living near degraded land or with less species e.g. villages of Pandagichiza and Shilabela seem to have higher per capita fuelwood consumption per head / year which accounted for 0.87 m^3 and 0.77 m^3 situated near Mwantini forest reserve. On the other hand villages like Solwa, Welezo and Nzagaluba seem to have low per capita fuelwood consumption probably due to the fact that they are situated in areas with relatively less trees, bushes and shrubs.

According to MNRT (2001b) the average household fuel consumption in Mwanza was estimated at about 398 kg / month relatively greater than what was observed by this study area (118 kg / month). The variation in results could be due to such factors as long distance walked or time spent to collect a head load of fuelwood in the study area. It could also be due to access to other biomass fuel sources that are locally available and consumed for cooking like crop residue (cassava and cotton dry remnant sticks, maize cobs and its stalks, millet stalks, rice husks, dry sisal leaves and cow dung). The other factor could due to the large family size of 5.2 persons per households in the study area which demand more fuelwood for different purposes.

4.7.2 Charcoal

Charcoal consumption at households of the study area was estimated at 204 m^3 per year which is equivalent to 34 068 kg of charcoal (Table 15). The per capita per person charcoal consumption was estimated at 0.14 m^3 in the study area. The charcoal consumption seem to be influenced by household size, the food venders (*mama lishe*), restaurants and meat fries for income generation as evidenced by charcoal consumption per household estimated at 2.6 kg, per day.

Table 15: Per capita charcoal consumption at households in surveyed villages

Villages	**Quantity per year**		**Per capita / head**		**Per capita / household**	
	m^3	**kg**	**m3**	**kg**	**m3**	**kg**
Jomu	96	16000	0.37	62	1.93	323
Singita	11	1753	0.07	12	0.36	63
Shilabela	4	638	0.03	6	0.16	32
Pandagichiza	5	879	0.05	9	0.26	47
Solwa	48	8000	0.37	61	1.92	317
Mwiseme	12	2080	0.15	27	0.78	141
Welezo	14	2400	0.18	31	0.94	161
Puni	3	473	0.04	6	0.21	32
Buyubi	5	874	0.08	14	0.42	73
Nzagaluba	6	958	0.09	16	0.47	83
Total	**204**	**34068**	**1.43**	**244**	**7.45**	**127**
Average	**20.4**	**3407**	**0.14**	**24.4**	**0.75**	**2** **127**

MNRTa (2001) reported around 85% of the total urban population in Tanzania (7.3 million people) are using charcoal as their main source of domestic energy. Charcoal is also widely used by food vendor, restaurants and other government institutions like hospital, schools, prisons and armed forces. MNRT (2001a) indicated that the average annual charcoal consumption per family in some areas of Tanzania is around 1080 kg at the rate of 3 bags of about 30 kg each per month. According to Chidumayo (2004) about 76% of Zambian populations depend on charcoal as source of energy for cooking. On the other hand the charcoal production and consumption will continue rising in Zambia as forecasted to range between 0.7 m^3 to 1.2 m^3 per capita per person per year the year 1990 to 2010 respectively (Campbell *et al*., 1996).

MNRT (2001b) pointed out that charcoal in small town centers of the study area and Shinyanga urban as the major charcoal consumers has increased deforestation mainly Mwantini, Buyange and Nindo forest reserves and access general forest lands of the study area. On the other hand this could be due to lack of affordable alternatives sources of energy. Hence introduction of improved energy efficient stoves in the study area in the development programme by energy related sectors should not be neglected.

4.7.3 End user woodfuel prices

Results showed that on average fuelwood costed about TAS 17 625 192 at households in the study area, as indicated by the per capita fuelwood cost per head per year which was estimated at TAS 16 893 (equivalent to 463 kg of fuelwood or 21 head loads). Similarly, per capita fuelwood costs per household per year were estimated at TAS 87 845 (Table 16). It was observed that fuelwood has become a commercial product not only in town centers but also in rural areas. For example an average bundle of a head load of fuelwood weighed about 22 kg and 2.6 m^3 for oxen-cart (*tela la ngombe*) purchased at a range from TAS 500 to 1000 and TAS 5 000 to15 000 respectively.

In addition, during the rain season fuelwood price was a bit higher compared to the dry season due to the fact that most of the people pay attention on agricultural farming related activities than in woodfuel production and supply.

Table 16: Fuelwood end users prices in the study area

Villages	Quantity (kg)	Prices (TAS)	Fuelwood per capita / TAS	Fuelwood per capita /household / TAS
Mwiseme	40 716	1 384 344	17 748	92 290
Solwa	46 980	1 597 320	12 287	63 892
Shilabela	69 948	2 378 232	19 026	98 935
Singita	73 080	2 484 720	16 455	85 566
Nzagaluba	27 144	922 896	17 413	90 548
Buyubi	33 408	1 135 872	18 030	93 756
Puni	35 496	1 206 864	19 157	99 616
Pandagichiza	62 640	2 129 760	21 513	111 868
Welezo	35 496	1 206 864	15 473	80 460
Jomu	90 480	3 076 320	11 832	61 523
Total	**515 388**	**17 625 192**	**168 934**	**878 454**
Average	**51 539**	**1 762 519**	**16 893**	**87 845**

According to Baguant *et al.* (1992) in Lesotho, fuelwood has been depleted from their supply sources and with no other reliable source of energy available, bringing in the issue of categorization of wood as a traditional fuel. To date, fuelwood in Lesotho is mainly a commercial fuel in terms of cash and long distance walked for watching and fuelwood gathering. In the study area this situation could be offset by emphasizing afforestation and natural forests conservation programmes.

Apart from fuelwood being the major source of energy in the study area, results also showed that charcoal was the dominant source of energy in the small town centers of Jomu and Solwa. It was revealed that, households spent an average of about TAS 8 091 150 for purchasing about 34 068 kg of charcoal (852 bags of charcoal) per year. Further it was found that the per capita charcoal cost per head per year was estimated at TAS 23 270 based on the 269 estimated population who use charcoal for cooking. On the other hand its per capita charcoal cost per household per year was estimated at TAS 121 010 (Table 17).

Table 17: Charcoal end user prices in the study area

Villages	Quantity (kg) per year	Prices (TAS) Per year	Charcoal per capita / TAS	Charcoal per capita / household / TAS
Mwiseme	2080	494 000	44 909	233 527
Solwa	8002	1 900 475	36 548	190 050
Shilabela	640	152 000	5846	30 399
Pandagichiza	880	209 000	9952	51 750
Singita	1760	418 000	6147	31 964
Nzagaluba	960	228 000	14 250	74 100
Buyubi	880	209 000	9952	51 750
Puni	480	114 000	10 364	53 893
Welezo	3658	868 775	54 298	282 400
Jomu	16 003	3 800 713	40 433	210 252
Total	**34 068**	**8 091 150**	**232 669**	**1 210 085**
Average	**3407**	**809 115**	**23 270**	**121 009**

The common measurements for charcoal were bags / sacks, tins and small plastic bags known as "*Rambo*". The study found that the average bag of charcoal weighed at 40 kg costed between TAS 6000 and TAS 13 000 while a tin of charcoal weighed about 8 kg costed about TAS 1400 and TAS 350 for a small plastic bag.

According to Malimbwi *et al.* (2007) low income households have the tendency of buying charcoal in retail scale (small plastic bags or tins) on daily basis while those from high income tend to buy larger amount at least a bag which last longer. Also it was reported that on average a household use a tin of about 1 kg of charcoal sold at TAS 600 to prepare one hot meal, two times a day. On the other hand the respondents earning with relatively high income level (e.g. government civil servants on monthly pay basis) used one bag of charcoal per month costing about TAS 9500.

4.8 Fuelwood Scarcity and Mitigation Options

4.8.1 woodfuel scarcity

Results revealed that population growth is among the most factors which cause the woodfuel scarcity as per 20% of the respondents, followed by 19% who didn't have comments and the rest of responses are as shown in Table 18.

Table 18: Causes of woodfuel scarcity in the study area

Village	Wood fuel scarcity causes factors (%)					
	Population Growth	**High living Expenses**	**Over exploitation**	**Shifting cultivation**	**Charcoal production**	**No Comment**
Mwiseme	20 (3)	7 (1)	7 (1)	27 (4)	13 (2)	27(4)
Solwa	8 (2)	16 (4.)	24 (6)	24 (6)	nr	28 (7)
Shilabela	8 (2)	25 (6)	33 (8)	13 (3)	17 (4)	4 (1)
Pandagichiza	16 (3)	16 (3)	21 (4)	26 (5)	16 (3)	5 (1)
Singita	14 (4)	14 (4)	3 (1)	24 (7)	21 (6)	24 (7)
Nzagaluba	9 (1)	9 (1)	36 (4)	27 (3)	18 (2)	Nr
Puni	43 (6)	Nr	14 (2)	7 (1)	14 (2)	21 (3)
Welezo	33 (5)	20 (3)	2 0 (3)	Nr	13 (2)	13 (2)
Jomu	24 (12)	28(14)	6 (3)	6 (3)	12 (6)	24 (12)
Total	**20 (42)**	**17(36)**	**16 (34)**	**16 (34)**	**13 (28)**	**19 (40)**

Note: Numbers in parentheses are frequencies, nr = no response

Ecologically the study area is situated within the semi arid zone area of Tanzania characterized by shortage of fuel mainly due to deforestation. Population growth has been pointed out to be a critical factor which directly or indirectly affects natural forests and its resources use by altering its patterns in a particular area (MNRT, 2001a). Furthermore, according to FAO (2001) population growth and increased per capita woodfuel consumption was forecasted to increase by 34% between the years 2000 to 2010. Without doubt, fuelwood overcutting can multiply economic, environment and social ills and cause forest loss. However, United Nations (2008) argue that global population growth and increasing energy demand per capita are threaten the forest resources including woodfuel consumption that cannot be sustained using current energy systems. Further efforts are therefore needed to improve energy efficiency and move towards a cleaner fossil fuel technologies in the transition towards sustainable development (United Nations, 2008).

About 19% respondents did not respond on the factors causing woodfuel scarcity in the study area. The majority of respondents were observed to manage their natural insitu conservation (*ngitili*), woodlots and live near hills with bushes and shrubs thus seem to have no problems with woodfuel scarcity since they access free to collect woodfuel. This could be the reason for the respondents were didn't have comments. Moreover, some of respondents argued that woodfuel like charcoal were not a problem. It was pointed out that poverty e.g. financial constraints and employment opportunities were the most problems facing them rather than wooodfuel. On the other hand it could be either due to ignorance of the respondents or the Forest Policy was not correctly interpreted to the community by extension staff. Other studies like FAO (2006) reported that almost 1.2 billion people in rural and urban areas in developing countries live in extreme poverty which is caused by high levels of unemployment which limits people's ability to acquire income for purchasing basic need goods including woodfuel as the principle fuel for cooking. Indeed, the failures in Forest, afforestation and conservation programmes are due to lack of participation or long term sustainability, physical and weak logistical support and lack of conceptual model combined with difficulties in a way that is measurable (Barrow, 1996).

Charcoal productions in the study area were mostly carried out by the respondents of Jomu, Nzagaluba, Singita who live around Tinde and Busanda forest hills. Normally its production was for commercial purposes mainly for income generation. The production of charcoal in the study area is operated with no sustainable management plan at the existing shrubs, bushes, hills, and general access forest land and forest reserves. However, it was observed that some villages like Shilabela and Pandagichiza depend on Mwantini Forest Reserve for charcoal production through encroachments. Consequently, the valuable indigenous tree species for charcoal production have been relatively depleted leading to forest resources degradation. Recently charcoal has been observed brought nearby districts of Nzega and Kahama in Tabora and Shinyanga regions, Tanzania. This has resulted in charcoal end users price to be relatively expensive in the study area.

4.8.2 Woodffuel mitigation options

About 45% of the 214 respondents suggested the need of tree planting particularly of fast growing multipurpose tree species as an immediate option to mitigate woodfuel scarcity in the study area (Table 19). The rest of the responses are as shown in Table 19.

Table 19: Percentage distribution of views on woodfuel scarcity mitigation options

Village	Tree Planting	Law enforcing	Woodfuel awareness	Forest conser vation	Seedling Distri bution	Alter Natives	No comments
Mwiseme	53 (8)	13 (2)	nr	7 (1)	4 (1)	7 (1)	13 (2)
Solwa	56(11)	4 (1)	8(2)	71	4 (1)	4 (1)	16 (4)
Shilabela	46(11)	8 (2)	4(1)	21(5)	13 (3)	Nr	4 (1)
Pandagichiza	63(12)	nr	nr	16 (3)	11 (2)	Nr	5 (1)
Singita	38(11)	nr	7(2)	7 (2)	14 (4)	3 (1)	28 (8)
Nzagaluba	82(9	nr	9(1)	9 (1)	Nr	Nr	Nr
Buyubi	25(3	8 (1)	17(2)	8 (1)	8 (1)	Nr	33 (4)
Puni	64(9	nr	nr	nr	14 (2)	Nr	21 (3)
Welezo	40(6	7 (1)	7(1)	7 (1)	Nr	7 (1)	13 (2)
Jomu	26(13	10 (5)	18(9)	2 (1)	2 (1)	10 (5)	37 (17)
Total	**45(96)**	**12 (6)**	**8(18)**	**8 (16)**	**7 (14)**	**4 (8)**	**17 (37)**

Note: Numbers in parentheses are frequencies, nr = no response

Tree planting seem to be a significant step towards production of woodfuel in the short and long term planning in the study area. FAO (2005) reported that education has influence on tree planting not only for woodfuel production but also for other tangible and intangible basic human needs for their livelihoods. The successful of tree planting in the study area could rely on provision of education on the importance of trees in terms of its products for community livelihood and conservation. The government sensitization efforts through its policies, National tree planting campaign for future generation in the study area and the country as a whole should continue.

Tree planting efforts however, have been faced with many difficulties, including water scarcity due to droughts, termites and pest infestation and high temperature (MNRT, 2001a). According to FAO (1984), in order for the community tree planting to be promoted and developed into fully self reliant, people need guidance, supervision and resources. However, it was observed that future afforestation efforts in the study area might face the problems of land scarcity due to population growth and normally the priority of best land to be allocated for agricultural related activities rather than planting trees. Therefore, education is needed to change the local people attitude which hinder afforestation programme in the study area. There is also a need to strengthen extension services and awareness creation in proper land use management system and forest management so as to ensure sustainable woodfuel supply in the study area.

According to FAO (2009) due to woodfuel scarcity in most developing countries, the focus must be on promoting improved wood energy saving stoves that are cost effective and culturally accepted. The improved energy technologies could reduce the time and trips incurred by poor women for collection of fuelwood, reducing heat loss, increase combustion efficiency and significantly reduce indoor air pollution and hence ensure efficient fuelwood use (Kaale, 2005).

Through experience it was noted in the study area that the existing National Forest Act and Policy have proved unsuccessful in environmental and natural forest resources protection due to its weakness implementation of policy by decision makers, forestry managers and staffs, and other stakeholders. The law enforcement in most cases seem to base upon restriction rather than community participation in planning, implementing and safeguarding forest public land and forest reserves. This situation is creating bad relationship between the community and forestry staffs, and is a source of illegal harvesting of forest products and overexploitation in the study area (MNRT, 2001a; Usivuori, 2002).

This situation could be rectified by involvement of the local people participation in sustainable management of forest resources of the situation (Raintree and Hoskins, 1990). To ensure effective participation process modalities have to be established for cost and benefit sharing between the forest owners and the relevant stakeholders (URT, 1998).

4.9 Factors Influencing Woodfuel Consumption

Results indicated that woodfuel consumption by households in the study area have been influenced with its availability as accounted by about 34% of the respondents, followed with 22% of respondents who mentioned inadequate alternative energy sources. The rest of the responses are as shown in Table 20.

Table 20: Factors influencing woodfuel consumption

Village	**Factors influencing woodfuel consumption (%)**				
	Available	**Renewable**	**Affordable**	**Cheap**	**Inadequate alternative energy sources**
Mwiseme	60(9)	Nr	7(1)	27(4)	7(1)
Solwa	32(8)	8(2)	8(2)	20(5)	32 (8)
Shilabela	25(6)	4(1)	17(4)	21 (5)	33 (8)
Pandagichiza	47(9)	5 (1)	26 (5)	16(3)	5 (1)
Singita	35(10)	7(2)	24 (7)	17(5)	17 (5)
Nzagaluba	27 (3)	9 (1)	18(2)	27(3)	18 (2)
Buyubi	50 (6)	Nr	25(3)	Nr	25 (3)
Puni	36 (5)	21 (3)	(3) 21	14(2)	7 (1)
Welezo	(4) 27	7 (1)	(3) 20	13(2)	33 (5)
Jomu	26 (13)	6 (3)	18(9)	24(12)	24(13)
Total	**34 (73)**	**7 (14)**	**18 (39)**	**19 (41)**	**22 (47)**

Note: Numbers in parentheses are frequencies, nr = no response

Historically in the study area before and after independence the area was covered with plenty of vegetation where by other areas were declared and gazette as Central and Local authority forest reserves aimed for production and environmental conservation. This is a typical a example showing that forests and its products including woodfuel were available and collections were taken for granted as a free access commodity within the vicinity areas. The availability of woodfuel has the implication on per capita consumption to be increasing as well as the user tend to consume forest products including woodfuel unsustainable consequently they have threaten the land through degradation and deforestation. Results revealed that woodfuel availability is relatively site specific for example in the surveyed villages like Mwiseme where as accounted for 60% and Buyubi about 50% while the least was Welezo only for about 4% indicating the acute shortages of woodfuel consequently making it a commercial commodity with the increase in price. To some extent this makes force some households to use cow dung and crop residues to supplement woodfuel for cooking.

Woodfuel as a traditional form of energy can only be termed as a renewable energy source if is protected and used at sustainable manner. In the study area it was found that woodfuel is the dominating energy consumed at the households in the study area. It was also observed that around their homesteads respondents planted among many species which sprout or produce coppices when cut to enhance the continuity of getting forest goods including woodfuel as a renewable source of energy.

Results from regression analysis showed that independent variable factors: household's size and occupation showed positive significant while education level and time involved in woodfuel gathering showed negative significant ($p< 0.05$). Moreover, adjusted R^2 – value of 0.729 was obtained indicating that the model explained about correlation linearity between woodfuel consumption and its indepent variables. According to Tabachnick and Fidell (2001) the higher the R^2 value the more the fitted well the data (Appendix 4).

4.9.1 Household family size

There was a significant and positive relationship between woodfuel consumption and the family size in the study area ($p < 0.05$, $\alpha = 0.139$). The positive correlation implies that the households with more people often tend to use more woodfuel. However, according to Kaale (1994) an additional household member leads to decrease in per capita consumption of woodfuel due to the fact that larger household' sizes seem to utilize their resources to a greater extent than smaller family sizes. Similar studies in rural Kenya by Arnold (1980) and by Fleurets (1978) in Tanzania reported that large family size consumes more woodfuel than small ones. This was due to the size of pots and quantity of food cooked and is analogous to economies of scale in household production. Hence, per capita woodfuel consumption decreases as household size increases. This implies that large households are not only more efficient users of woodfuel than smaller ones, but also in a smaller proportion of household's perspectives, it is more advantageous to maintain a large household than a small one.

4.9.2 Occupation

Multiple regression analysis showed that occupation had positive and significant relationship to household woodfuel consumption ($p < 0.05$; $\alpha = 0.195$) (Appendix 4). Generally, most of the respondents were found to be farmers who practice shifting cultivation farming often in the natural forests, bushes and shrubs clear felling. It was observed that the cleared trees are collected and converted into woodfuel for cooking. This implies that the larger the land cleared by farmers the easiness of availability of woodfuel to collect and hence signifies increase in woodfuel consumption in the study area. Historical background of Shinyanga and Mwanza regions in Tanzania points out underlying wood fuel scarcity to be due to cleared forests to eradicate tsetse flies and for mechanized cotton production (Barrow *et al*., 1998).

4.9.3 Household education level

Results showed that households education level had negative relationship with woodfuel consumption ($p < 0.05$; $\alpha = - 0.048$) (Appendix 4). This implies that the increase education level of the household's head of the study area seem to be corresponds to the decrease quantity of woodfuel consumption at the households. This could be supported by argument that they can adopt the use of efficiently woodfuel cooking stoves and sometimes for fast cooking food like breakfast, kerosene stove could be used as fast options, consequently, the less quantity of woodfuel to be consumed by households. Likewise, Abdallah *et al*. (2007) also reported that the increase in education level of a head of household leads to decrease in the amount of woodfuel to be consumed as revealed by this study. Furthermore, the increase the education level of the respondents tend to have ability to foresee and hence could reduce costs by minimization of family size by following family planning, implies less amount of woodfuel consumption at the households. This could be due to the fact that the formal educated households' respondents seem to adhere to the family planning programme to minimize the large household's sizes which have the influence on woodfuel consumption. The level education of household head is of great importance particularly in decision making and implementation of afforestation and environmental forest protection programmes in the study area, targeting to reduce pressure on existing forests as one approach to ensure proper management, and sustainable resource use. According to FAO (2003) reported that education level generally is a tool that can make people to manage forests and its resources including woodfuel at sustainable manner by providing necessary skills of establishement woodlots, maintain and the rationale for taking care of the environment.

4.9.4 Woodfuel collection time

Results indicated no significant relationship ($p < 0.05$, $\alpha = -0.237$) between the woodfuel consumption and time spent for collection (Appendix 4). Generally, consumption of woodfuel at households depends on its availability. The abundant the woodfuel the shorter the time spent in collection while the scarce the fuel wood, the longer the time could be spent in collection. Since household member collect wood but not necessarily plant, they only meet the cost associated with woodfuel gathering. The evidence from past researches indicate women and children take more time, collecting woodfuel, which was formerly readily available close to homesteads (Kaale, 1994, Malimbwi *et al.*, 2005). Also, Mnzava (1990) reported that in areas with woodfuel scarcity, up to 300 man days per annum are required per family for fuelwood collection, creating constraints to other development activities.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion the study has found that:

(i) Almost 100% of the households in surveyed villages use woodfuel (both fuelwood and charcoal) as the principle energy source for cooking. On the other hand agricultural crop residues and cow dung to some extent are used for cooking at some households during the harvesting period to as energy source indicating the woodfuel scarcity in the study area.

(ii) About 65 species were recorded and botanically identified for woodfuel consumption in the study area. The most 10 species frequently used for woodfuel were: *Diospyros fischeri*, *Albizia amara, Combretum longispicatum, Combretum zeyheri, Grewia bicolor, Dichostachys cinerea, Dalbergia melanoxylon, Leucaena leucocephala, Brachystegia speciformis* and *Acacia spp.*

(iii) The quantity of fuelwood consumed at households was estimated at 711m^3 per year whilst fuelwood consumption per capita was estimated at 0.67 m^3. While the amount of charcoal consumed was estimated 204m^3 per year relatively equivalent to per capita consumption of 0.14m^3.

(iv) Woodfuel consumption was influenced by many factors including the household's size which significantly indicated positive relationship to the quantity of woodfuel consumed.

(v) Population growth was viewed by a significant population of respondents as the cause of woodfuel scarcity in the study area.

5.2 Recommendations

From the study results, the following is recommended:

(i) Woodfuel consumption at households be sustainable and efficiently utilized by adoption of the use of improved cooking stoves technologies to reduce the quantity of woodfuel used. But they should be suited to the cultural and economic aspect needs of the communities, cost effective and sustainable to produces more energy using less wood.

(ii) Planting trees (fast growing, multipurpose exotic and indigenous tree species) and natural forest conservation programme should be emphasized so as to meet the immediate and the long term forest products needs of households.

(iii) There is a need to sensitize Local community participation at the village level as the bottom up approach, pay attention in gender balance in planning and decision making on planting activities, for natural resource protection and utilization to be effective and sustainable.

(iv) Agroforestry system practices are emphasized to farmers to meet their wood products demand around home vicinity and reduces burden to women and children who spend long walking distance for fuelwood gathering. This will in turn lead to conserving the land, provide fuelwood, fodder and foods through fruits and make agricultural crop production sustainable.

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APPENDICIES

Appendix 1: Household's head questionnaire on wood fuel consumption in Shinyanga Rural District

Questionnaire number ………………

Name of Researcher ………….…….

Date ………………………….……..

Name of household head ………………………………………………………….

Name of respondent ……………………………………………………...….

Sex …………..age …………Occupation ……………………………………….....

Division ……………Ward……………… Village ………………………………..

1. Number of members in household.

Age group (years)	Male	Female
< 18		
18 – 50		
> 50		

2. Level of education: Primary (   ) Secondary (   ) Adult education ( )

Non formal education (   ) others (specify) ……………………………...….

3. What type of fuel do you use for cooking or heating?

No	Energy type	Uses
1	Fuel wood	
2	Charcoal	
3	Electricity	
4	Kerosene	
5	Biogas	
6	Solar	
7	Crop residue	
8	Others (specify)	

5. Where do you collect wood fuel?

(a) Woodlot (   )

(b) On public natural forest land (   )

(c) In forest reserve (   )

(d) Others specify ( )

6. Is there any shortage of fuel you use?

Yes ( ) No ( ). If the answer is No, give reasons for these shortages?

………………………………………………………………………………………

7. How many meals are cooked a day? ( )

8. How much fuel do you use (per week/month)?

(a) Fuel wood ……………. bundles per week/month

(b) Charcoal …………… bags per week/month

(c) Kerosene ………….. Liters per week

(d) Don't know

9. How much do you pay (TAS)?

(a) Fuel wood per bundle TAS……………..

(b) Charcoal per bag TAS ……………

(c) Kerosene per liter TAS ……………

(d) Electricity bill TAS ……………

10. Which fuel do you feel is the most expensive?

………………………………………………………………………….

11. Do you collect dry fuel wood or cut green wood?

Dry fuel wood ( ) Green wood ( )

Why? ……………………………………………………………………………….

12. How many distance walked to supply sources for woodfuel collection? ....

13. How much time do you spend to collect a head load of fuel wood per trip per day?

……………………………………………………………………….………

14 How many trips per week? ……………………………………………......................

15. Do you feel wood fuel supply is a problem? Yes (   )   No (.)

If the answer is Yes, give reasons

……………………………………………………………………………………………

……………………………………………………………………………………………

16. What tree species are preferred for household wood fuel?

Scientific name	**Vernacular name**	**Family**

17. What factors influence the woodfuel utilization at the household level in the study area?

………………………………………………………………….

Appendix 2: Checklist of key informants

Check list No …………………....
Name of Researcher …………….
Date ……………………………

1. Name …………………………….
2. Occupation ………………………
3. Years of service ………………….

4. What kind of fuel is most available?
(i) ………………………………………………………….……….
(ii) ……………………………………………………….……………….
(iii) …………………………………………………………….……..…
(iv) …………………………………………………………….………

5. Where is wood fuel collected from?
(1) Woodlot ( )
(2) On public forest land ( )
(3) In forest reserve ( )
(4) Others (Specify) ……………………………………………………………….....

6. What are the uses of wood fuel?
………………………………………………………………………………………………

7. What factors influence the woodfuel utilization at the household level?
………………………………………………………………………………………………

8. What is the quantity wood fuel consumption in the household sector?
(a) Fuel wood per bundle ……………….. bundles per day/week/month
(b) Charcoal ……………………………...bags per day/week/month
(c) Kerosene ……………………………..liters per week/Month.
(d) I don/t know ( )

9. How do you assess consumption of fuel wood for past ten years?

(i) Increasing ( )

(ii) Decreasing ( )

(iii) Remaining constant ( )

(10) What tree species used for wood fuel consumption?

Scientific name	**Vernacular name**	**Family**

11 How many distance walked to supply sources for collection of woodfuel

(a) Less than 5 km ……………………………………………..............................

(b) Between 5 km and 10 km ……………………………….............................

(c) More than 20 km. ……………………………………….............................

Appendix 3: The botanically identified and recorded species used for woodfuel in Shinyanga Rural district

Scientific name	Vernacular name	Family
Diospyros fischeri	Msubata	Ebanaceae
Albizia amara	Mpogolo	Mimosaceae
Combretum zeyheri	Msana	Combretaceae
Grewia bicolor	Mkoma	Tiliacae
Combretum longispicatum	Mgobeko	Combretaceae
Dicrostachys cinerea	Mtundulu	Mimosaceae
Brachystegia speciformis	Myombo	Caesalpiniaceae
Acacia polycantha	Mugu	Mimosaceae
Dalbergia melanoxylon	Mgembe	Papilionaceae
Acacia tortilis	Mgunga	Mimosaceae
Leucaena leucocephala	Mlukina	Leguminaceae
Acacia nilotica	Mdubilo	Mimosaceae
Grewia platyclada	Mpelemese	Tiliacae
Senna siamea	Msongoma	Caesalpiniaceae
Acacia macrocantha	Mtangala	Mimosaceae
Acacia seyal	Mlula	Mimosaceae
Mangifera indica	Mnyembe	Anacardiaceae
Abrus precatorius	Msali	Fabaceae
Euphorbia tirrucalli	Mnala	Euphorbiaceae
Acacia senegal	Mgwata	Mimosaceae
Markamia abtusifolia	Mbaba	Bignoniaceae
Commiphora africana	Mponda	Burseraceae
Albizia lebeck	Mtanga	Mimosaceae
Combretum obovatum	Mlobashi	Combretaceae
Melia azedarach	Mboyo	Meleaceae
Lannea vulva	Mselya	Anacardiaceae
Tamarindus indica	Mushishi	Caesalpiniaceae
Anacardium occidentale	Mkorosho	Anacardiaceae
Chamaecrista abus	Msambilia	Fabaceae
Delonix regia	Mfulamboyanti	Caesalpiniaceae
Vitex doniana	Mpulu	Verbenaceae
Senna singuena	Mtungulu	Caesalpiniaceae
Ficus sycomorus	Mkuyu	Moraceae
Ormocerpus trichocarpum	Mlulambuli	Papilionaceae
Terminalia sericea	Mjimia	Combretaceae
Xeloderris stuhulmanii	Mjundu	Papilionaceae
Ximenia americana	Mtundwa	Olacaceae
Azadirachta indica	Muarubaini	Meleaceae
Zanthoxylum chalybetum	Mnungu	Rutaceae
Eucalyptus spp	Mkaratusi	Myritaceae
Friesodiclsia abovata	Msalasi	Annonoceae
Cassia abbreviata	Mlundalunda	Caesalpiniaceae
Acacia hockii	Mnyenyela	Mimosaceae

Strophanthus eminii	Msungululu	Apocynaceae
Gutaranegum spinosa	Mmochangoko	Rubiacea
Balanite aegyptiaca	Myuguyu	Balanitaceae
Combretum molle	Mlama	Combretaceae
Ziziphus mucronata	Mgugunu	Rhamaceae
Afzelia guinensis	Mkola	Caesalpiniaceae
Lannea schweinfurthii	Msayu	Anacardiaceae
Cissampolos pereira	Mkuluanti	Vitacea
Lannea humilis	Mtinje	Anacardiaceae
Lonchocarpum bussei	Mmale	Fabaceae
Scelerocarya birrea	Mng’ongo	Anacardiaceae
Syzigium cuminii	Mzambarau	Myritaceae
Vitex mombasae	Msungwi	Verbenaceae
Vernonia doniana	Mpungwambu	Verbenaceae
Zanha africana	Mkalya	Sapindaceae
Albizia petasiana	Mshishigulu	Mimosaceae
Borusus aethiopium	Mhama	Palmaceae
Cadaba farinosa	Mkaninigwe	Cappavidaceae
Cordia monoica	Msheni	Boraginaceae
Dalbergia nitidula	Mfifi	Fabaceae
Cathium burtii	Mgumbalu	Rubiaceae
Combretum adenogium	Mlunjaminzi	Combretaceae
Zanha africana	Mkalya	Sapindaceae

Appendix 4: Multiple Regression model analysis

Factors	**Standardized Coefficients**		
	Beta (α)	**t**	**Sig.**
(Constant)		0.154	0.878
Family size of the household	0.139	2.085	0.038*
Time spend for collection	- 0.237	3.562	0.000
Levels of education	- 0.048	0.746	0.026
Occupation	0.195	3.009	0.003*

$R^2 = 0.729$ $F=7.771$ $P < 0.05$

* = significant factors

Dependent Variable**:** Total fuelwood consumed per year in a household (m^3)