SOCIO-ECONOMICS OF CHARCOAL EXTRA-TION IN TANZANIA: A CASE OF EASTERN PART OF TANZANIA.

By

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Abstract

A socio-economic study was conducted in 1999 in the eastern part of Tanzania covering woodlands in charcoal potential areas of Kitulangalo,Mbwewe and Bana which lie in the miombo woodlands. The purpose of the study was to assess socio-economic factors related to charcoal extraction in the study area. Data were collected by a household survey using structured questionnaire, interviews, focussed discussions and participant observation. Results show that there have been substantial immigration of people into charcoal potential areas in search for employment by engaging in charcoal extraction. Most of these people are from distant ethnic groups who have been retrenched in urban centres and in consequence have decided to settle in these areas. Even indigenous inhabitants who have been stricken by poverty and thus have low income and limited access to alternative energy sources have been forced to find refuge in charcoal extraction for employment and income. Thus poverty seems to be the prominent factor compelling people to engage in charcoal extraction. Most of the charcoal is locally and extracted by traditional often inefficient earth-kilns using simple implements and household labour. Urban –based charcoal dealers are the main buyers and sometimes employ local people to produce charcoal for them for sale in urban centres. There is a lucrative charcoal trade between producers and urban traders rendering the often regarded minor forest product a source of livelihood and income to many people. The huge number of preferred species available in the area and many producers has made the price of charcoal relatively low to the disadvantage of producers. There is also an apparent undervaluation of charcoal hence its relative cheaper price, coupled with availability and reliable supply charcoal has been rendered a more affordable source of energy. It is concluded that with the burgeoning population, demand for charcoal will continue to rise under conditions of declining income. These factors will compel more people to extract more charcoal from dwindling woodlands. Thus as more people will engage in charcoal extraction for sale, strains on the woodlands will rise and result in further depletion of the resource base due to increasing deforestation. Intervention measures to improve efficiency in charcoal extraction are crucial. Also sustainable forest management practices involving communities need to be introduced. Furthermore affordable alternative energy sources need to be solicited.

1 INTRODUCTION

1.1 Background

In Tanzania forests cover about 33.55 million hectares of forests and woodlands (Hurskainen, 1996). These are highly valuable as a source of timber and catchment services (URT 1998). These forests also have unique environmental and biodiversity values, and make available a wide range of products for subsistence use. The most important use of wood in Tanzania is for fuel and about 95% of the country's energy supply is met by fuelwood (Iddi & Hakan 1997). Miombo woodlands which constitute about 90% of the total area of forests in Tanzania are the chief source for firewood and charcoal in Tanzania. Woodland trees produce a heavier and more concentrated fuel than most fast growing softwood species and trees from tropical rain forests. (Gauslaa 1988). Apart from fuelwood extraction; wildfire, shifting cultivation and selective harvesting of trees for different purposes are some of the potential activities taking place in the miombo woodlands.

There is high fuelwood consumption in Tanzania attributed by low per capita income and limited investment in alternative energy supplies. Households consume about 97% of wood energy in SADC region mostly for cooking, heating and cottage industries while industrial sector is the second to household sector (SADC Energy Sector 1993). Most of the industrial wood energy is consumed by small-scale industries which include food processing industries and service sectors such as brewing, fish smoking, salt production, baking, restaurants, schools, hospitals and food vending; agro-processing industries such as tobacco curing, tea drying and beeswax processing; and production of building materials such as burnt bricks, lime, smiths, foundries, pottery and ceramics. These industries and domestic activities which rely upon wood energy provide employment and income for rural people particularly during off-season in agricultural production (Monela & Kihiyo 1999).

The Tanzania energy policy of 1997 still stress development and use of indigenous energy sources such as bio-energy, coal, natural gas and hydropower (URT, 1997). However, less than 2% of energy development budget is allocated to wood energy programs, and fuelwood is still regarded as minor forest product with little market value (TFAP 1989). Yet still, the vast majority of woodfuel consumers cannot afford the high investment costs associated with alternative commercial energy sources (Moyo *et al* 1993). Availability, reliability of supply and cheaper prices renders fuelwood more preferable than alternative sources of energy. Looking at the present economic forces, the majority of urban population in Tanzania will continue to depend on fuelwood for long time to come (URT 1998; Moyo *et al* 1993). Furthermore due to the anticipated steady increase in population (at an annual rate of increase of 2.8%) it is expected that actual consumption of firewood and charcoal will continue to rise to a greater extent. This will put strains on natural forests from where the Charcoal is obtained, possibly resulting in deforestation of the forest ecosystems.

Commercial fuelwood extraction such as charcoal production requires large volume of wood, which in turn depletes tree stocks causing deforestation. According to the 1990 FAO Forest Resources Assessment, deforestation is defined as a change of land use with the depletion of tree crown cover to less than 10 percent (Adger & Brown 1994). Little is known about the actual extent of deforestation due to urban charcoal use. Neither are the social and economic patterns, which determine the charcoal exploitation, or the policy options available to mitigate the problem. This has implications on the country regarding its ability to design and implement appropriate energy policies that can intervene in the charcoal sectors. This paper attempts to shed some light on these issues focussing on charcoal potential in Tanzania.

1.2 Objectives of the study

General objective:

To investigate charcoal extraction and the socio-economic aspects related to it in the woodlands of Tanzania.

Specific Objectives:

The specific objectives of this study are:

- To study communities and people involved in charcoal extraction
- To identify tree species preferred for charcoal and their availability
- To study socio-economic aspects that influence charcoal extraction
- To study tree tenure and involvement of local communities in forest management
- To assess the economic importance and value of charcoal for the communities and the country
- To propose possible interventions that can be carried out in order to sustain the supply of charcoal and to mitigate adverse effects of charcoal extraction.

Hypotheses

In the light of the objectives above the following hypotheses are going to be tested by this study:

- Due to increased demand for charcoal and employment, people migrate to charcoal potential areas..
- Low prices of charcoal compared to alternative sources of energy are due to under valuation of charcoal as one of the natural forest products.
- Tree cutting for charcoal depletes the woodlands from which charcoal is extracted.
- Extensive charcoal extraction is caused by prevailing pressure from social and economic factors.

2 MATERIALS AND METHODS

2.1 The study area

A socio-economic survey was done at Kitulangalo, Mbwewe and Bana areas. Ten villages were selected, 6 from Bana area and 2 each from Kitulangalo and Mbwewe areas. Kitulangalo area is located about 50 km East of Morogoro municipality towards Dar es Salaam along the Zambia - Tanzania Highway. Dar es Salaam is about 200 km East of Morogoro municipality. The predominant feature in this area is the Kitulangalo hill which is about 800 m above sea level situated at $06^0$41'S and $37^0$57'E and covered by woodlands. The Mbwewe area is on the sides of Segera – Chalinze highway, while Bana forest area comprises of villages surrounding the Bana Fuelwood Forest Project owned by Forest and Beekeeping Division of the Ministry of Natural Resources and Tourism.

The climate of the area is tropical, semiarid and sub-humid. The area is within the 700 mm to 1000 mm rainfall belt with wet season from October to May and dry season from June to October (Holmes 1995). The mean annual temperature is 24.3^0C while the annual minimum and maximum temperature are 180C and 30^0C respectively (Mugasha 1996). January is the hottest month while June is the coldest.

Most of the Bana Forest Reserve and public lands are covered with regrowth open Miombo woodlands with some scattered *Julbenadia globiflora, Brachystegia spp*. and *Pterocarpus*

rotundifolius reaching a height of 15-20m. However, most of trees are in an understorey, at 5-10m height composed of *Diplorhynchus candylocarpon, Combretum zeyheri, C. apiculatum* and others. The herbaceous layer is covered by dense *Themeda triandra* grass reaching a height of 1.5m. Grass fires are very common in Miombo areas and substantial woodlands are burnt annually.

2.2 Methods of data collection

This survey was aimed at collecting information concerned with socio-economic status of the people involved with charcoal extraction, tree species and size preferred for charcoal, cultural practices and their influence on forest regeneration and views of stakeholders on the potential of the woodland to supply charcoal. Structured questionnaire, and focused discussions with the help of check lists and participant observation were employed in this survey.

(i) Structured questionnaire

A mixture of both open and closed-ended questions was used. Pre-testing of the questionnaire was done in order to verify if questions could be understood and to chech if they address matters under investigation. The questionnaire is attached as Appendix 1. The sampling units in this study were households and stakeholders. A household is defined as a number of people living under the same roof and sharing meals. In each household, the head of household was interviewed. Pilot testing was done to a sample of four households involved in charcoal business selected at random. About 113 charcoal makers (50%) were selected and interviewed (Table 1)

The questionnaire aimed at collecting information about same variables from more than one person in order to end up with a data matrix that could be analyzed statistically.

Table 1 Distribution of the interviewed people from each site.

Site	Number of villages	Number of interviewed charcoal makers
Bana	6	60
Mbwewe	2	28
Kitulangalo	2	25
Total	10	113

(ii) Focused discussions

Checklists were used to guide focused discussion with key informants who are the stakeholders. These involved: regional, district, division and village forest officers; l village elders and religious leaders. These focussed discussions facilitated collection of secondary data about the study are and charcoal matters. They also facilitated cross-checking of information given by respondents . Sample checklists are shown in Appendix 2.

(iii) Participant observation

Participant observation is one among the techniques used by researchers on arriving to the village in order to overcome problems of orientation in the new community. In this technique researcher pretends to be part of the community being studied. In so doing the researcher

gains the confidence of the persons being studied, so that his/her presence does not interfere with the natural course of events. Thus respondents are made to provide the researcher with honest answers to questions and not hide important activities from the study. Curiosity and willingness to learn are the main tool in the new surrounding environment (Kajembe & Luoga 1996). Thus based on this technique, frequent visits accompanying charcoal makers were made. The visits aimed at observing and noting the condition of the woodlands and to monitor the charcoal extraction process.

2.3 Data analysis

Statistical Package for Social Sciences (SPSS) and Microsoft Excel computer programs were used. Quantitative data collected were summarized to ensure that they could be in the form suitable for addressing both the research questions and the method of analysis used. This was done while ensuring that original meanings of the statements made by respondents were maintained. The summarized data were then coded and used for subsequent statistical analysis whose results are presented in the subsequent chapters.

3 RESULTS AND DISCUSSION

3.1 Population pressure and its impact on woodlands in charcoal potential areas

More than 20 ethnic groups were found to exist in the study area, but the most important ones in terms of their population are shown in Table 2.

Table 2 Tribes found in the study area

Tribe	No. of respondents	Percentage
Zigua	31	27%
Zaramo	14	12%
Luguru	14	12%
Kwere	8	7%
Matumbi	6	5%
Ngindo and Nyasa	5	4%
Others	37	33%
Total		100%

Source: Field survey data, 1999.

Others, less important include Wasukuma, Wahehe, Wanyamwezi, Wapogoro, Washambaa, Wadoe, Wadigo, Wanyiramba, Wakaguru, Wandengereko, Wamwera, Wagogo, Wanyaturu and Wakami. These tribes originate from different parts of the country, and come to this area as immigrants for different reasons including agriculture, charcoal extraction and employment in sisal plantations. Miombo woodlands are known for their high potential to supply a variety of forest products and services to local communities who live within or around them (Monela *et al* 1993). Therefore the mounting population pressure in the study area due to immigrants is attributed to existence of the huge resource in the woodlands which has attracted charcoal extraction activities.

3.2 Main economic activities

Like in most parts of Tanzania, the economy of people in the surveyed villages largely depend on subsistence agriculture. However, in this area charcoal making is important as well. Quantitatively, fuelwood is the major product from miombo woodlands (Temu, 1979). In the present study, about 67% of the respondents indicated that they were involved in agricultural activities and about 23% were doing charcoal business only (Fig. 1).

Out of the 74% involved in agriculture, 64% indicated that they are doing both agricultural activities and charcoal making. Other less important economic activities include pitsawing 2% small business 5% and about 11work under casual labour conditions.

Only 30% of the respondents indicated that their previous activities were both agriculture and charcoal extraction. This suggests that more people are now engaged in the charcoal extraction compared to the past. Like most Tanzanians, miombo inhabitants are forced by poverty to discount the future at a high rate while disregarding the ecological costs due to deforestation by switching from agriculture to intensive forests exploitation. Charcoal production in eastern Tanzania has been shown to contribute substantially to the economy of rural people (Monela *et al* 1993). Charcoal trade has been found to be a major source of employment and income to many rural and urban dwellers due to Structural Adjustment Programmes (Monela *et al* in press). In urban areas the market of charcoal exists because of financial constraints of acquiring alternative sources of energy (TFAP,1994).

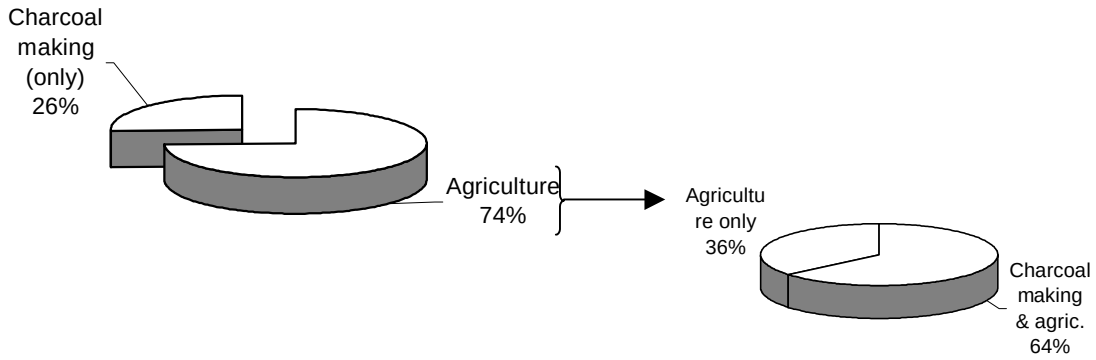

Figure 1 Main activities done by the respondents in the study area

In rural areas in which charcoal is produced, people use mostly firewood for their cooking energy requirements. The consumption of wood fuel (firewood and charcoal) is indicated against each village in Table 3. The amount of firewood consumed seems to exceed that of charcoal by far magnitude. Other studies have shown that, availability, reliability of supply and cheaper prices renders fuelwood more preferable than alternative sources of energy. However in Zimbabwe less demand for fuelwood is observed due to widespread urban electricity and cheap subsidized kerosene (Campbell and Mangono 1994).

Table 3 Household woodfuel consumption per year in the study villages

Village name	Firewood headload/ year	Charcoal bags/year
Kwangandu	182.8	0.5
Msangani	115.2	1.4
Karege	113.5	1.3
Zinga	179.3	3.0
Kongowe	149.2	12.0
Mbwewe	159.6	6.9
Buma	160.	5.
Yombo	172.0	22.7
Gwata	190.0	9.0
Maseyu	194.7	3.3
Total (Mean)	100.3	3.3

Source: Field survey data, 1999.

3.3 Labour for charcoal extraction

Charcoal is usually extracted form the public lands owned by local governments. All interviewed respondents said charcoal business was important economic activity in the study areas. About 65% of the respondent indicated that there are special months in which charcoal making is done and the remaining 35% indicated that they do it throughout the year. This can be attributed by the fact that some people, a large percent of the villagers are engaged in charcoal business to supplement farm income from agriculture which is the their major economic activity. Hence during farming seasons they shifts to farming. About 32% of respondents while about 32% indicated to use only household labour and only 1% indicated to use hired labour in charcoal extraction.

The number of days used for wood cutting, kiln preparation, combination and unloading is shown in table 4 against each village.

Table 4 Number of days used in charcoal production activities for a standard earth kiln operated in the study area by households.

Village name	Days for wood cutting	Days for Kiln preparation	Carbonization period	Unloading
Kwangandu	7.2	6.6	10	5
Msangani	12.6	7	15	3
Karege	9.5	6.	11.7	4
Zinga	18.5	8.5	14.5	7
Kongowe	16.5	12.25	16	3.6
Mbwewe	5.3	7	16.3	4
Buma	14.3	10.3	13.2	2.6
Yombo	18.12	12.4	15	4
Gwata	17.2	11.3	15.0	5.2
Maseyu	9.4	9.3	14.3	3.3
Mean	13	9.6	14	4

Source: Field survey data, 1999.

Table 4 shows the mean number of days spent for each charcoal making step. While 13, 10 and 14 days are spent for wood cutting , kiln preparation and carbonization respectively unloading the charcoal kiln takes only about 4 days. The average working days per month is 20 days while the average working hours per day is 7hrs.

3.3.1 Tree species preferred for charcoal extraction

Particular tree species are favoured for charcoal production due to dense and hard charcoal they produce, Julbernadia globiflora, Brachystegia boehmii, Tamarindus indica, Acacia nigresces, Acacia gerrardii, Combretum adenogonium, Combretum molle, Combretum zeyheri, Combretum collinum, Diospyros kirkii, Xeroderris stuhrmanii , Mimusops kummel, Albizia harvey, Acacia goetzei subsp. Goetzei and Lonchocarpus capassa. About 95% of interviewed charcoal makers do select suitable tree species for charcoal and that those preferred tree species for charcoal are no longer available at shorter distances from the village and road sides. People who have no species preference are those intending to make charcoal as a consequence of clearing the woodland for agriculture. These results are in line with previous studies. Best trees for charcoal along the Dar es Salaam highway have been cleared up to 30 km from the road (Monela et al., 1993). Monela et al (in press) mentioned the best highly preferred tree species for charcoal in miombo woodland areas of Tanzania as Brachystegia boehmii, Combretum spps, Julbernardia globiflora, Acacia nigrescens and Tamarindus indica. Nduwamungu (1996) estimated an average of 12 stems per ha with dbh greater than 20 cm of preferred species removed annually in miombo woodlands of Kitulangalo SUA Training Forest Reserve. Most of these trees cut were intended for charcoal production and were mainly individuals of Julbernardia, Combretum and Brachystegia species.

3.3.2 Amount of charcoal produced

Charcoal extraction activities in the study area generally started in 1980s. Charcoal is produced mainly for two reasons, for sale with the aim of generating household income and to a limited extent for home consumption. Table 6 indicates the amount of charcoal produced against each village. The amount produced for home use is essentially what is left after sale and usually is very minimal.

Table 5 Household charcoal production per year in the study area

Village name	Firewood head-load/Year	Charcoal bags/Year
Kwangandu	0.5	22
Msangani	0.3	20.0
Karege	0.4	80.0
Zinga	0.5	25.0
Kongowe	0.5	25.0
Mbwewe	0.7	33.7
Buma	3.0	40.5
Yombo	5.2	21.0
Gwata	-	56.2
Maseyu	-	30.7
Total (Mean)	11.5	354

Source: Field survey data, 1999.

Influence of socio-economic factors on amount of charcoal produced for sale show no strong correlation (Table 6). This may be attributed by the fact that factors determining amount of charcoal to be produced are in combination, poverty being the major driving force.

Table 6 Influence of some socio-economic factors on amount of charcoal produced.

X_i	Y_i	t
	$R^2 = 0.043$	
	b*	
Age	0.058*	0.411
Education level	1.47 (ns)	1.054
Sex	-0.008*	-0.72
Ethnic group	0.31 (ns)	0.268
Number of wives	-0.156*	-1.352

Key:
R^2 = Coefficient of determination
Xi = Independent variables
* = Indicates significant at 0.05 probability level
ns = Not significant
b* = beta weight
Yi = Dependent variable (charcoal produced for sale bags/month)

3.3.3 Kiln types and production

The main types of earth kilns used are rectangular and circular in shape. Usually charcoal is produced in earth mould kilns made by covering a pile of logs with earth, igniting the kiln and allowing carbonization under limited air supply. About 95% of the respondents used rectangular kilns and the rest used either rectangular alone or the combination of both rectangular and circular. Kiln production, based on the amount of trees used in a kiln is indicated against each village in Table 7. There is an average of 9 trees felled to produce about 29 bags (i.e. 1tree to 3 bags of charcoal ratio) of charcoal with large numbers of trees in Kitulangalo area compared to other parts of the study. This indicates that smaller trees are cut for charcoal in Kitulangalo area probably because there are noticeable signs of over exploitation.

Table 7 Household kiln production in the study area.

Village name	No of trees	Charcoal bags
Kwangandu	8	20
Msangani	4	25
Karege	4	44
Zinga	3	10
Kongowe	7	35
Mbwewe	6	51
Buma	4	18
Yombo	13	22
Gwata	26	35
Maseyu	18	34
Mean	9	29

Source: Field survey data, 1999.

3.3.4 Charcoal Market places

Through the survey, respondents indicated that production of charcoal is done without prior contracts with charcoal dealers. About 85% of respondents indicated that they did not need a contract before they could engage in charcoal extraction for sale. Important market places (entries) for charcoal were at the production site, and in the village. However the survey indicates that the most important place in which charcoal is sold is at the production site, where dealers from Dar es Salaam and other urban centres come to collect charcoal bags for their business. About 63% of respondents indicated that they sale at production site, 12% sale at road side, 2% within the village. Only 4% sale their Charcoal in Dar es Salaam while about 9% use a combination of all the places mentioned above. The survey results further indicate that more than 95% of the customers come from outside the villages where charcoal is extracted. Thus while most extraction is done locally, buyers are mainly outsiders..

3.3.5 Charcoal transportation and Cost of primary delivery

The main transport means were found to be by headloads, carts, vehicle and bicycles. Charcoal makers usually gather their charcoal bags into piles by carrying them as headloads at the kiln site where wholesale buyers come to s buy the charcoal and transport it to urban centres. Carts and bicycles are used to transport charcoal to the roadside and village centres. Transport either from kiln site, road side and village centres to urban centres is by means of vehicles. However survey results indicate that, the most important means of transport are the head load, bicycle and vehicles. More than 75% of respondents indicated that they use bicycles, more than 20% use headloads, about 10% use vehicles and only 5% use carts. The use of either type of transport means is dictated by availability and cost involved.

3.3.6 Charcoal Prices

Charcoal prices vary with selling sites. Different selling points have different prices based on accessibility and means of transport used. Table 8 indicates charcoal prices at different sites. The price of charcoal is about Tshs. 1,500/=, Tshs. 1,400/= and Tshs 1000/= at roadside, village centre and kiln site respectively. The apparent variation is due to profit margin added to cover cost of transport.

Table 8 Charcoal producer prices at different selling sites in the study area (T.Shs.).

Village name	Kiln (shs/bag)	Roadside (shs/bag)	Village (shs/bag)
Kwangadu	720	1150	960
Mgangani	1075	1500	1800
Kerege	1465	1500	1500
Zinga	1065	-	1700
Kongowe	1140	1875	1500
Mbwewe	1060	1475	1150
Buma	1020	-	1200
Yombo	1185	1500	1500
Gwata	1055	1500	-
Maseyu	1125	1500	-
Mean	1091	1500	1414

Source: Field survey data, 1999.

For different reasons, charcoal producers have been moving from one production site to another. Some reasons which were found as compelling factors include scarcity of kiln con-

struction materials, scarcity of preferred tree species and to avoid soil destruction which later on will be used for crop production.

The survey results also indicate that there has been an increase in distance over the last 10 years, in search of better charcoal making site. The search for this has been attributed to charcoal making activities opening forests/woodlands for agricultural activities and timber production.

3.3.7 Involvement of local communities in forest management (weak tenure rights)

Survey results indicate that the natural forests present in the study area were managed by the government (Government Forest Reserves) and District Councils through village governments. However, the combination of community and government forest management were found to exist in some villages like Kongowe and Kitulangalo areas. About 58% of the respondents indicated that the forest condition was generally good. The main products from the forest include fuel wood, charcoal and building poles.

It is important that charcoal business be regulated due to its importance and its impact to the forests and the environment in general. Woodland regulating measures mentioned to be in force includes:- permit payment (12%), restriction of endangered species utilization (45%) and allow harvest of only large trees (35%).

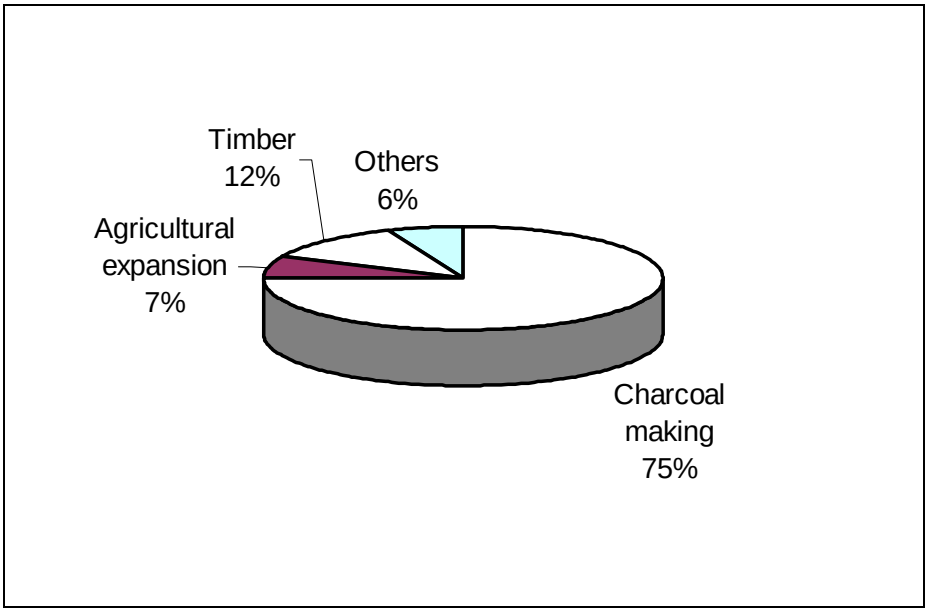

Figure 2 Activities contributing to woodland degradation in the study area.

3.3.8 Fragility of forest area and its regeneration potential.

About 67% of respondents indicated that charcoal is scarce today than 10 years ago. Tree cover was also found to be worse today than 10 years back whereby about 82% of respondent confirm this fact. The reasons attributed to this problem are indicated below in table 6. Charcoal making is by far the most destructive factor to the environment. While about 15% of the respondents in Kitulangalo and Mbwewe area use previously charcoal extracted areas for agriculture; 75% of the charcoal makers in these areas do not turn the woodland to farms after charcoal making. Instead the practice give room to woodland regeneration as open forest which is left to encourage regeneration. Miombo species regenerate largely through coppice regrowth and root suckers rather than seeds (Robertson 1984 in Campbell 1996). Chidumayo

(1988), observed that stumps of almost all Miombo woodland trees have the ability to produce sucker shoots. Though also seeds of majority of Miombo trees and shrubs germinate immediately after dispersal when there is enough moisture, tree density in regrowth Miombo woodland decreases with time due to moisture and heat stress. The majority of seedlings of Miombo trees experience a prolonged period of successive shoot die-back during their development phase in order to cater for these stresses. Shoot die-back is caused by water stress and/or fire during the dry season. Also with the case of suckers and coppice fire can either slow or accelerate growth. If a destructive fire occurs before dominant shoots attain a safe height to escape mortality, the process of sucker shoot domination reverts to the initial stage and stumps respond by producing an equal or larger number of replacement shoots (Chidumayo 1988). However inter-specific resistance to these environmental factors varies with species.

4 CONCLUSIONS AND RECOMMENDATIONS

The study has demonstrated that charcoal extraction in the woodlands is one among most important economic activities providing employment and income to many households both in rural and urban centres. The high number of species preferred for charcoal extraction which are found in the study area is a clear indication of the available high potential for charcoal extraction. The study has shown that rural communities rely on charcoal extraction to save economic, social, political and cultural purposes which extend to urban centres. It has also shown that there is strong link between charcoal extraction and ecological balance of the woodland resource. Poverty expressed by low income seems to be a compelling factor for a decision to engage in charcoal extraction. This is often exacerbated by absence of reliable alternative employment. However, the apparent poverty is a response to increases in human population as well as a complex of factors related to policy and market failures as well as macro-economic factors most of which act with apparent synergistic effects and interconnectedness.

Empirical evidence from the study highlights the complexity of factors concerning charcoal extraction and its links to income, employment and environmental degradation. The study takes the premise that like poverty, charcoal extraction is an inevitable consequence of social and economic factors strongly influenced by prevailing market and policy environments. Local availability, reliability of supply and relatively cheaper prices compared with alternative energy sources have rendered charcoal demand progressively rising in the wake of the burgeoning population. These factors have also made charcoal the most preferred and affordable energy source. One main consequence has been depletion of the woodlands and the accompanying need for intervention measures to foster sustainability of charcoal supply as well as the resource base. Improving charcoal extraction methods, introduction of affordable energy-saving stoves and cheaper alternative energy sources are some of the necessary measures to reduce high dependence on charcoal and firewood. These measures should take place concurrently with involvement of local communities in forest management through benefit and responsibility sharing in order to facilitate sustainable management practices in the woodlands. This strategy should also embrace improvement of agriculture which is the main economic activity. This would create reliable alternative employment opportunities in rural areas and relieve the need for employment solely though charcoal extraction. Improving income coupled with social and institutional strengthening are essential preconditions to facilitate mobilization of resources and labour to overcome capital and technology limitations in energy supply.

Thus in the long term, a costly and painstaking process of adopting improved technologies which require capital investment are unavoidable. However, in a short and intermediate term, removal of institutional impediments and use of low capital intensive methods must be given priority in extraction and utilization of charcoal as a source of energy. Efficient marketing services for charcoal and other forest products, producer price incentives and tax incentives are crucial measures that could have positive externalities on ecological protection. Producer price incentives would improve charcoal extraction methods by increasing possibilities for raising capital through own savings if producer prices could rise and alternative employment made available. In the short term, capital has potential to play a crucial role in acquisition of improved charcoal extraction implements and possibilities for hiring labour. In the long term, however, it can facilitate adoption of labour-saving power technologies. Therefore, generally, a careful and equitable economic policy based on an understanding of the incentive structure of rural households are required to foster more sustainable ways of charcoal extraction.

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