ASSESSING THE SPATIAL-TEMPORAL EFFECT OF CHARCOAL EXTRACTION ON PUBLIC WOODLANDS: A PARTICIPATORY APPROACH IN GWATA-UJEMBE, MOROGORO, TANZANIA

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Assessing the spatial-temporal effect of charcoal extraction on public woodlands: A participatory approach in Gwata-Ujembe, Morogoro, Tanzania

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Abstract

The increased demand for charcoal in urban areas has led to degradation of forests and woodlands resources. This has made charcoal extraction to remain a serious problem to areas such as Gwata village, Morogoro district in Tanzania. The aim of this research is to assess the spatial-temporal effects of charcoal extraction on the woodlands in Gwata village. Data collection involved use of participatory rural appraisal techniques such as community meetings, interviews, focus group discussions. Participatory mapping facilitated collection of data on spatial distribution of charcoal kilns through transect walk. Stakeholder analysis was based on attributes of various stakeholders categorizing them into three groups: the conservation (law enforcers), extraction and land owners. Conflicts were evident during enforcement of forest conservation laws against charcoal extractors' interests. Remote sensing techniques such as image classification and post-classification comparison techniques were applied in mapping and analysis of land cover types and land cover change (2000 - 2007). Socio-economic survey reveals that, charcoal is a major source of income (80%) and employment (20%) in the study area. Results of land cover changes and spatial-temporal aspect of charcoal extraction show that there was an increase in open woodlands at a rate of 0.75 % per year. Closed woodland declined at rate of 0.05% per year and riparian woodland showed a decrease at rate of 2.23% per year. The annual decline in all land cover was 2.52%. Old charcoal kiln points were spatially concentrated in open woodlands to the West and North-west parts of the study area, an indication of previous charcoal extraction activities. New charcoal kiln points were concentrated to the Western part of the study area indicating the availability of preferred tree species for charcoal extraction. The increase in open woodlands and the decline in the riparian and closed woodlands in this area are therefore linked with charcoal extraction activities. The governing stakeholders play major roles in mitigating extraction activities but their role is overridden by the demand for charcoal. Reduced price in cooking fuel and low electricity tariffs for urban dwellers is likely to slow down charcoal dependence. Alternative livelihood strategies are also recommended to local people in Gwata village. Capacity building for the local communities on law enforcement is likely to create awareness on provisions in the existing forest laws. These recommendations are crucial at the spatial scale investigated; taking these into account may lead to sustainable conservation of miombo woodlands.

Key words: Spatial-temporal, charcoal extraction, miombo woodlands, degradation, stakeholder analysis, law enforcement.

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CBFM:	Community Based Forest Management
CHAPOSA:	Charcoal Potential in Southern Africa
DALDO :	District Agricultural and Livestock Development Officer
DC:	District Commissioner
DED:	District Executive Director
DFO:	District Forest Officer
GIS:	Geographic Information System
GPS:	Global Positioning System
NGOs:	Non Governmental Organization
NRM:	Natural Resources Management
MLC:	Maximum Likelihood Classifier
SI:	Sampling intensity
SUA:	Sokoine University of Agriculture
USD:	United States of America Dollar
VEO:	Village Executive Officer

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1. INTRODUCTION

1.1. Background information

Miombo woodland is an informal term used to describe African woodlands found in central, southern and eastern countries. Miombo woodland is dominated by Brachystegia and Julbernadia species (Campbell, 2007; Frost, 1996). These woodlands form the dominant part of the Zambezian phytochorological region, covering an area of 2.7 million km2 and supporting local livelihood of about 40 million people (Campbell, 2007; 1996; Nhantumbo and Kowero, 2001). Miombo woodland extends from Tanzania and southern Zaire in the north to Zimbabwe in the south, and across the continent from Angola, through Zambia to Malawi and Mozambique (Nhantumbo and Kowero, 2001).

In Tanzania, miombo is the most extensive and important woodland vegetation type covering 90% out of 33.5 million hectares of forest and woodlands (Mugasha, 2004; URT, 1998). The country holds 57% of forest which falls under public lands (43% in protected areas), in which most of it is miombo (Mugasha, 2004). It spans from the central-western part of the country, eastern to southern part of the country (Mugasha, 2004). Miombo woodlands extend to 1600 m (m.a.s.l.), and are favourable in areas receiving 1200 mm of rainfall annually.

Miombo woodlands posses unique environmental and biodiversity values, and serves as the chief source of woodfuel, provide economic benefits and subsistence to the local livelihoods and potentially used in spirituals and culturally values (Abdallah and Sauer, 2007; Campbell, 2007; Chidumayo and Kwibisa, 2003; Luoga, 2000). They contain large values in the form of timber and catchment (Malimbwi *et al.*, 2000) as well as non-timber products (Abbot, 1997). Moreover, miombo woodland areas are also potentially used for shifting agriculture (Abdallah and Sauer, 2007; Mangora, 2005; Monela and Abdallah, 2007).

The potential of miombo woodlands as a source of cooking energy has been well reviewed across Sub-Saharan Africa's. Most urban and rural people depend on miombo woodlands as a source charcoal and wood fuel respectively (Herd, 2007). For example, in Mozambique, about 70-80% of the urban population depend upon wood fuel; with an estimated annual wood fuel consumption of 16 million m3, out of this miombo woodlands accounts for 85% of total household energy requirements (Sitoe and Ribeiro 1995, cited in Campbell, 2007; Campbell, 1996). In Zambia, dependence of miombo woodlands as fuel wood is estimated to be 80% of the total country cooking energy consumption (The Stockholm Environment Institute (SEI), (2000) cited in Campbell, 2007). Its availability coupled with its cheap price and low labour cost (requirement) has probably made it a growing business (Luoga *et al.*, 2000; URT, 1998). Several factors are attributed to charcoal utilization in large cities. It is the most preferred source of cooking energy due to its caloric value and high caloric values as well as its taste food (Malimbwi, 2005; Mugasha, 2004; van Beukering *et al.*, 2007).

In Tanzanian, miombo woodlands is considered as the largest source for fuel wood for most of people's daily life and is used by all income levels (Malimbwi, 2005; Mugasha, 2004) It is estimated that wood fuel consumes around 90% of all energy consumed in the country (Iddi and Hakan, 1998; Luoga, 2000), out of that 60-70% of annual consumption is for firewood and the rest is accounted by charcoal. However, recent reports, see Mugasha (2004), indicates that, the country household charcoal consumption have been estimated at 100 tons per year.

Fuel wood is probably the most important forest produce which greatly contributes to economy of rural livelihoods (Makundi and Okiting'ati, 1995). In Mozambique, charcoal making accounts for more than 60% of the rural economy (Pereira 2001, cited in Campbell, 2007; Herd, 2007). In Tanzania charcoal production have a significant contribution to welfare of rural households and is considered as a last resort for income earning for rural households (Luoga *et al.*, 2000; URT, 1998). For example, 70% of cash incomes of most of villagers in central Tanzania come from charcoal production (Monela, 2004). It is reported that charcoal sellers in town earn more revenue than those selling charcoal at the production sites (Luoga *et al.*, 2000). Charcoal is a venture that is gaining importance as a part time job to supplement the income of the marginalized rural farmers. The incentives from the already existing markets in cities and towns encourage charcoal production as a full-time income generating activity (Monela and Abdallah, 2007).

Charcoal making in Tanzania is increasingly becoming a growing business in rural and urban areas. The existence of large markets is fuelling this. For example, currently, the price of one bag of charcoal (of 30kgs) in Morogoro town is valued at Tshs 12,000 while in Dar es Salaam, this is more than Tshs 30,000 (Monela and Abdallah, 2007). Still the existing prices are lower as compared to other source of cooking energy such as electricity and gas. This in one way or another, contributes to the increased charcoal demand in cities which in turn leads to depletion of woodland stocks.

Besides its biodiversity values and potential support to the local livelihoods, miombo is continually facing degradation resulting from anthropogenic activities. Anthropogenic activities such as, shifting cultivation (Abbot, 1997), charcoal and timber extraction, livestock grazing, settlements, and wild fires modify the ecological stability and its future viability (Chidumayo and Kwibisa, 2003). In Zambia, charcoal extraction has contributed greatly to deforestation (Chidumayo and Kwibisa, 2003). Zimbabwe and Malawi have been facing the same; the forests are shrinking at alarmingly rate as a result of human activities (Abbot, 1997; Chambwera and Folmer, 2007). The forest and woodlands in Botswana has been shrinking as a result of agriculture conversion and removal of other forest produce such as timber, poles and fuel wood extraction (Hiemstra-van der Horst and Hovorka, 2002). Tanzania has been losing an estimated 400000 hectares of forest (Kaale, 2005; URT, 1998), as a result of anthropogenic activities including shifting agriculture, timber logging and fuelwood extraction and wild fire incidences (Abdallah and Sauer, 2007; CHAPOSA, 2001; Iddi and Hakan, 1998; Kaale, 2005; Luoga, 2000; Luoga, 2002; Malimbwi *et al.*; Malimbwi *et al.*, 2004; Monela and Abdallah, 2007; Zahabu, 2001)

1.2. Spatial-temporal assessment

In the field of natural resources monitoring, the term "spatial-temporal" is frequently used. Spatial-temporal assessment of a particular phenomenon refers to the evaluation of the dynamic change of that phenomenon by taking into account time and space dimensions. In the framework of integrated management and environmental policy formulation, spatial-temporal assessment offers possibilities for a better understanding of dynamic evolution of landscape. With regard to forest cover change, these possibilities are serving as evaluation and decision making tools for policy makers. With the current development in remote sensing, spatial-temporal assessment techniques were enhanced. Indeed, remote sensing offers possibilities of capturing continuously the evolution of landscape and provides therefore, tools for land cover change detection within a given area in either static or dynamic time.

1.3. Problem statement and justification

The Tanzania energy policy of 1997 stresses development and use of indigenous energy sources such as bio-energy, coal, natural gas and hydropower (URT, 1998). However, the majority of people in Tanzania like in most developing countries cannot afford other type of energy sources rather than wood energy (i.e. firewood and charcoal). As such wood energy is left as the single source of cooking energy in the household. This has attributed to increased charcoal demand in big cities (Iddi and Hakan, 1998; Mwampamba, 2007).

In the year 2006 the government of Tanzania imposed a ban on the production and transportation of charcoal to cities. The reason being that if charcoal could not be moved to the cities the end users would seek for the alternative source of cooking energy thus mitigating charcoal production. The ban was later removed after people complained to the government about lack of affordable alternatives while prices of charcoal increase. This indicates that majority of people living in urban areas have no alternative of cooking energy the situation which continues to increase the demand of charcoal.

According to the present economic forces the majority of urban population in Tanzania will continue to depend on charcoal for a long time to come (URT, 1998). The increase in demand for charcoal remains a serious problem to many areas where charcoal is extracted and due to the anticipated steady increase in human population (at an annual rate of increase of 2.8%), it is expected that actual consumption of charcoal will continue to rise to a greater extent (Mugasha, 2004). This can exert pressure on the natural forests from where most of the charcoal is obtained. Commercial fuel wood extraction such as charcoal production requires large volume of wood, which in turn depletes tree stocks resulting into various forms of woodland degradation and conversion of tree species (Malimbwi *et al.*, 2000).

Currently, the study area (Gwata village) is facing degradation and depletion of forest and woodland resources. The village woodland falls under public land regime (open access forest areas) and is governed by regulations under Forest Act of 2002 and by-laws established by both central and local government. However, due to lack of proper management from the local government they are subjected to different threats, such as excessive tree cutting for charcoal extraction (mainly supplying to nearby cities such as Dar es Salaam and Morogoro), conversion to shifting cultivation and frequent

forests fires. In order to reverse the impact of these human activities, the forest and woodland resources need proper management such as community participation in resource conservation so that they may be used for future generations. Evidence exist that community participation has a significance role in improving woodland management and it can contribute to the sustainability of forest and woodland resources (Iddi, 2002). The summary of the problem and processes involved in this research is described below under DPSIR frame work (Driving force, Pressure, State Impact, and Response).

The DPSIR was used in this study as a method to analyze the research problem in the study area (See figure 1-1).

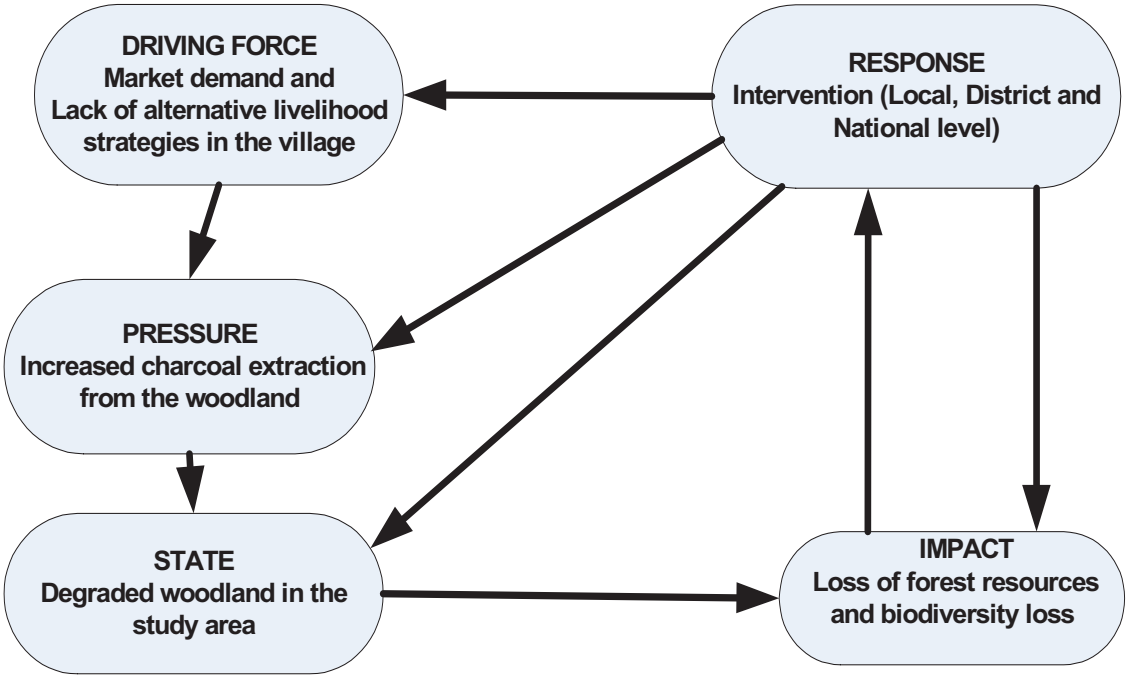

Figure 1-1: DPSIR framework
(Adapted and modified by Author of this report: Source: MULINO-DSS Tutorial http://siti.feem.it/mulino/softwa/tutorial.pdf).

Increased market demand of charcoal in cities and charcoal being the main source of income to rural households in the study area has increased demand of wood from the woodland resources. Further more, lack of alternative supporting alternatives for the local people to meet their daily needs is potential driving force (Driving force).This has fuelled extraction of woodland resources particularly charcoal which is gaining high demand in the nearby cities of Morogoro and Dar es Salaam (Pressure).Woodland resources in the study area are subjected to degradation when confronted with such human activities (State). Existence of such situation can lead to loss of forest resources and loss of biodiversity (Impact). These needs to be intervened by local or district level as well as National level at large (Response) which always works on the root cause of the problem.

The interventions can be promotion of the participation of local communities in forest management through benefit and responsibility sharing as an effective strategy towards sustainable forestry management. The introduction of cheaper alternative energy sources to urban communities will reduce high dependence on charcoal thus decreasing degradation of woodlands.

Inefficient law enforcement by the authority concerned is one of the reasons that accelerate the destruction of forests and woodlands from local communities. Sustainability of these forest and woodlands depends on good management plans which involve communities for sustainable conservation. Existence of woodlands in common property regimes has resulted to increased pressure on charcoal extraction which in turn depletes forest and woodland resources. Common property regime refer to a property rights arrangement in which a group of resource users share rights and duties towards a resource (Matose and Wily, 1996). In natural resources management, the regime has problems which may contribute to unsustainable utilization of forest resources in the study area. For example, one of the problems is its exclusion where it is difficult to control access by potential users because of the physical nature of the woodland resources although they can be protected. Subtractability is another problem where there is always difficulty on exploitation of resources by one user this affects other user capabilities to do the same. Charcoal extraction activities in the study area have been causing environment effects at unknown scale. For these reasons, it is apparently important to assess the spatial-temporal effects of charcoal extraction on the public woodlands. Findings of this study are anticipated to contribute to for sustainable management of the woodlands through full participation of local community around the study area.

1.3.1. Main objectives

The main objective of the research is to assess the spatial-temporal effects of charcoal extraction on the public woodlands.

1.3.2. Specific objectives and research questions

Specific objectives and research questions for the main objective are shown in table 1-1.

Table 1-1: Specific objectives and research questions

Specific objectives	Research questions
1. To assess the stakeholders involved in charcoal extraction in public woodland	1. Who are the stakeholders involved in charcoal extraction in the public woodland? 2. What are their interests (positive or negative) 3. What is their influence (power)? 4. Are there conflicts of interests and what is the scale of the conflicts?
2. To describe the legal regulations governing charcoal production and stakeholders perceptions	1.How are the regulations reinforced? 2. What are the perceptions of the stakeholders on the legal regulations surrounding charcoal production?
3. To determine the positive and negative impacts of charcoal extraction in the study area	1. What are socio-economic benefits the communities getting from charcoal making in the study area? 2. What are the effects of charcoal extraction on environment in the study area? 3. What tree species are mostly preferred for charcoal production?
4. To assess landcover change and map areas used for charcoal extraction (past and currently)	1. How charcoal extraction activities are spatially distributed in the study area? 2. Why charcoal extractors have been moving from one production site to other? 3. What is the rate of change of the land cover from 2000 to 2007 in the study area?

1.3.3. General Research Approach

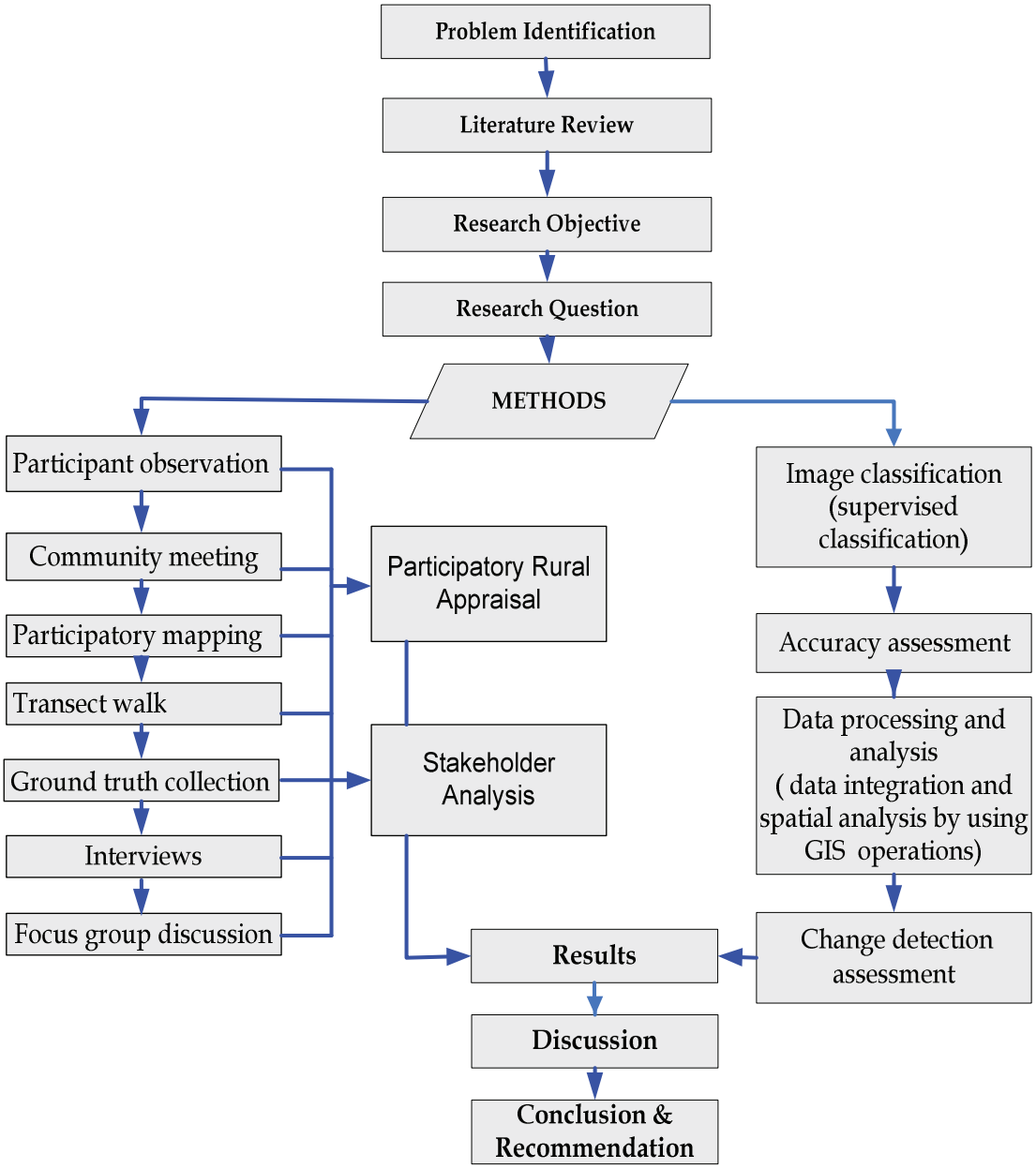

Figure 1-2: Research process flow chart

2. CONCEPTS AND PRACTICES USED

2.1. Participatory forest management in Tanzania

Many countries in eastern and southern Africa had accepted shortcomings in their policies for forest management and are now implementing new national forest policies and forest acts. These changes amount to a significant wave of reform, particularly in Tanzania, Kenya, Zambia, Mozambique, South Africa, Malawi, and Lesotho have been implementing new forest acts since 1998 (Wily, 2000). The new policies provide opportunity for the involvement of local communities who live within or adjacent to natural forests in determining the sustainability of the forest resources. Communities around these forest are generally poor and their livelihoods mainly depends on forests, predominantly woodland, dominated by the miombo for their substitute to agricultural or pastoral livelihood (Wily and Mbaya, 2001).

The forest resources need sustainable management for the benefit of the present and future generations. For a long time, forests in Tanzania have been managed without full participation of the local people and other relevant stakeholders living around the forest resources. Most forests in Tanzania have been managed under state ownership regimes where planning and management of forest resources were conducted by the central government in a top down approach without involvement of local communities, this have lead to enormous pressure on forests leading to degradation (Luoga *et al.*, 2005). Following the new forest policy of 1998, the central government has been gradually pulling itself from direct management of forest resources thus emphasizing on communities to establish Joint Forest Management (JFM). The aim is to empower the local people living adjacent to forests to be the custodian of the forest resources; this appears to be the best effective and cheaper way to manage forest resources.

According to Luoga et al. (2005) Participatory Forest Management (PFM) or Community Forest Management (CFM) are basically common property regimes which entails Joint Forest Management (JFM))and Community Based Forest Management (CBFM). The latter being more decentralized the power is transferred to the grassroots level, as it involves both user and ownership rights over the resource. Efforts have been made by the government to ensure sustainable management of forest resources by introducing Participatory forest management (PFM) which was included in forest laws (Forest Act of 2002) as it provides a clear legal basis for communities to own, manage or co-manage forests under a wide range of conditions. The strategy is aimed at improving rural livelihoods and therefore reducing poverty while at the same time protecting the environment in a sustainable manner. The introduction of Participatory Forest Management (PFM) was stimulated by both international and local factors. At the international level, treaties and accords such as the Tropical Forest Action Plan (TFAP) developed and approved the government of Tanzania in 1989 and agenda 21 framework (Initiated in Rio-de-Janeiro in 1992), aimed to reduce forest degradation through the involvement of all stakeholders at local level.

Joint Forest Management (JFM) was introduced in 1998 aiming at improving conditions of forest reserves and livelihood of the adjacent communities, one of which being the Handeni hill forest reserve in north eastern Tanzania. Joint Forest Management encourages forest adjacent communities to play a role in forest management through forest protection and patrol. In return for these efforts, they receive a range of tangible benefits, such as rights to harvest forest products, share revenue from forest harvesting, retain fines as well as confiscated materials/produce, use local water sources and so on(URT, 2006). It considers communities as rightful beneficiaries, logical source of authority and management. The assessment undertaken by the Forestry and Beekeeping Division revealed that Participatory Forest Management (PFM) was operating or being established in many parts of the country of which over 1800 out of 10,000 villages are currently practicing Participatory Forest Management (PFM) and over 2,060,608 ha are under Community Forest Management (CBFM) while a total of 1,612,246 ha are under Joint Forest Management (URT, 2006).

Joint Forest Management (JFM) is a collaborative management approach, which divides forest management responsibility and returns between the forest owner (usually central or local government but also in rarer cases, the private sector) and forest adjacent communities. It takes place on land reserved for forest management such as national forest reserves (for catchment, mangrove or production purposes) and local government forest reserves or private forest reserves. Joint Forest Management allows communities to sign Joint Forest Management agreements with government and other forest owners.

Under Community Based Forest Management (CBFM), villagers take full ownership and management responsibility for an area of forest within their jurisdiction and it is "declared" by village and district government as a village land forest reserve. Following this legal transfer of rights and responsibilities to village government, villagers gain the right to harvest timber and forest products, collect and retain forest royalties, undertake patrols (including arresting and fining offenders) and are exempted from regulations regarding harvesting of "reserved tree" species, and are not obliged to share their royalties with either central or local government. The Community Based Forest Management (CBFM) takes place in forests on "village land" (land which has been surveyed and registered under the provisions of the village land act (1999) and managed by the village council).

Forest and woodland in Tanzania are managed under different regimes, forest reserves are under central government jurisdiction (the Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism) and unreserved forest operating under the responsibility of local government (District councils). National Forest Policy (1998) clearly states the need to bring unreserved forests, such as those that form part of village lands under the jurisdiction of local communities and sets up a construct of village forest reserves as a primary vehicle for this. In respect of other categories of forest reserve (central and local government forest reserves), the policy opens the way for adjacent communities to become co-managers through joint management agreements.

Effective implementation of Participatory Forest Management (PFM) programs will stimulate conservation efforts in public woodlands hence reducing loss of hectares of forests being lost every year through anthropogenic activities. However, the public woodlands are the most affected due to lack of efficient management, and its nature as common pool resources regime. The government should emphasize on educating the communities surround the woodland to participate in conservation of the woodland resources. Participation of local people and other stakeholders in managing and

conservation of forest resources can help to improve environmental sustainability, and thus contribute to poverty alleviation if is to be implemented efficiently (Luoga *et al.*, 2005).

2.2. Public woodlands

Public land in Tanzania is a complex category as a result of its diverse meanings. Land law designates all land in Tanzania as public land, The more common meaning of 'public land' is an administrative, not legal, it embraces a range of tenure systems in that it covers all land not owned under statutory titles, and not within reserves.
According to Willy (1998), all lands which fall beyond the guidance of individual village settlements fall by default to the guardianship of District Councils. However, public land is categorized in two types, village lands and district lands where unreserved natural forest falls mainly within the last category hence the common naming of unreserved forest as public land forests. Public woodlands are "open access" characterized with insecure land tenure, shifting cultivation, harvesting for wood fuel, poles and timber, and heavy pressure for conversion to other competing land uses, such as agriculture, livestock grazing, settlements, industrial development in addition to wild fires (URT, 1998).

In Tanzania, forest and woodlands covers 33.5 million hectares out of this 13,000,000 hectares falls under the public lands (Malimbwi and Zahabu 2008). The rate of deforestation and forest degradation is estimated at between 130,000 to 500,000 hectares per annum and mostly impacted in the public land forests (Malimbwi and Zahabu 2008). Practically, the management of forests on public lands is almost non-existent. Due to lack of efficient management by the government, the forests on public lands are considered as open access that means there are no security of tenure or formal user rights and no incentive for systematic and sustainable forest management.

2.3. Charcoal production process

Charcoal can be produced from wood, coconut shell or crop residue in a process called carbonization. Carbonization is the method of burning wood or biomass in the absence of air after which it breaks down into liquids, gases and charcoal. During the charcoal production process in the kiln, water, combustible gases, methanol, acetic acids and tars are driven off, and when the temperature is high enough pyrolysis begins (the breaking down of wood under high temperature in the absence of air). At the end of pyrolysis what remains is the carbonized wood or charcoal.
The process of charcoal extraction involves wood cutting, kiln construction, carbonization and finally unloading charcoal from the kiln. In Tanzania, there are a variety of kiln designs used to make charcoal. The earth kiln is the most commonly method used for charcoal extraction (Zahabu, 2001). There are two types of earth kilns, the earth pit kiln and the earth mound kiln. An earth pit kiln is constructed by digging a small pit in the ground. Then the wood is placed in the pit and lit from the bottom, after which the pit is first covered with green leaves or metal sheets and then with earth to prevent complete burning of the wood.

In most parts of Tanzania, charcoal is produced in earth mound kilns (Figure 2-1) made by covering a pile of logs with earth igniting the kiln and allowing carbonization under limited air supply (CHAPOSA, 2002; Malimbwi, 2005; Monela *et al.*, 1993). With earth mound kiln the process of charcoal making takes about thirty seven days while unloading the charcoal kiln takes about four days (Zahabu, 2001).

Regarding trees, charcoal maker appears to practice a kind of selective cutting based on species preference and sizes. This is in principle the least destructive form as it allows young trees to grow. However due to inadequate management skills young trees are also cut down and used as kiln construction materials resulting in destruction of regenerants. Clear felling of forest land (for establishment of farms) is another source of trees for charcoal making, no selection of trees is being done. During charcoal making process not all wood is converted into charcoal only 30-40% of the wood is actually converted to charcoal, the rest is released into the atmosphere as gases (Mugo and Ong, 2006).

Efficiencies in charcoal production vary considerably, but generally, the process is characterized by low efficiency (on weight-by-weight basis) and low productivity. The variations in charcoal efficiencies depends not only on the type of kiln used, but also on the type of wood, its moisture content, density and diameter as well as the experience of the charcoal maker and even climatic conditions. According to Malimbwi and Zahabu (2008) experience from CHAPOSA (2002) shows that kiln efficiencies in Tanzania ranges from 11 to 30% ,while in Zambia 20-28%, and in Mozambique 14-20%.

Wood for charcoal kilns

Mound kiln in preparation

Figure 2-1: Construction of earth mound kiln at Gwata Ujembe village (October 2008)

2.3.1. Charcoal trade and distribution

The charcoal trade in Tanzania is primarily the informal sector. The informal sector as opposed to the formal sector includes those economic activities that do not show up in official statistics. Most of charcoal traders are not officially recorded because traders or dealers do not follow the regulations governing charcoal production. There is no significant warehousing; all stocks produced are promptly consumed. Abundant evidence of the charcoal trade is visible throughout from the production sites, along the roads and to the centre of towns and cities.

Generally charcoal traders buy their charcoal from charcoal producers at the production sites and then transport to towns or cities where they sell to their charcoal vendors or directly to consumers who buy charcoal in large quantities. Charcoal selling is done mainly in urban areas where charcoal dealers sell their charcoal either to charcoal vendors or directly to consumers who buy charcoal in large quantities. Charcoal vendors who are spread all over the urban areas then sell the charcoal to final consumers usually in small quantities.

Charcoal selling sites are both located at the source in the rural areas from where charcoal production takes place and along the road as well as at various localities in the urban area. In most cases charcoal is stored in open space and very few vendors are using reliable storage sheds and small rooms adjacent to their homes for storing few bags.

2.4. Charcoal transport

Almost all charcoal produced in rural areas is transported to the main Tanzanian cities by either trucks or bicycles. According to Malimbwi and Zahabu (2008), charcoal transporters are officially categorized at check points mainly in two groups: the commercial dealers who use vehicles to transport more than ten bags; and non commercial transporters who use vehicles to transport less than ten bags for home consumption. Although bicycles account for quite a small percentage of the charcoal transported, they are in common use among rural and semi-urban households.

It is clear that charcoal transportation to market places in towns and cities becomes a more complicated operation during the rainy season due to poor roads. The complications are brought about by the fact that charcoal first has to be collected from the actual production site, brought out of the forest and then transported in the town or city. During the rain season the transporters are unwilling to ferry charcoal because of the high likelihood of getting stuck and stranded or the risk of breakdown of their vehicles (Hibajene and Ellegård, 1994). Under this situation the cost of maintaining vehicles increases, leading to the inevitable increase of transportation costs. The technique used by charcoal dealers to reduce transport costs is by convincing charcoal producers to cluster in the same geographic areas such that charcoal can be collected from fewer points or produce in larger quantities in order to minimize the dealers' transport cost and, consequently, maximize their selling opportunities (CHAPOSA, 2002).

2.5. Licensing charcoal trading

In order to operate the charcoal business charcoal traders have to acquire a registration form from the District Forest Office, this is according to Forest act of (2002). The registration is obtained at the beginning of every financial year at a total cost of Tshs 55,000 including an application fee of Tshs 5000. The registration has to be renewed annually. However, given the informal structure of the business and the lack of enforcement from the government side, very few traders actually buy registration and if they do they tend not to renew it due to the high transaction costs. Other fees need to be paid by charcoal traders include:

- Fees to the Central Government (Tshs 1,200 per bag of 28 Kg)

- Fees to the District Council 5% of charcoal selling price at charcoal site (Tshs 2,000 to 400 per bag of 28 kg) and
- Fees paid to the Village Government (Tshs 500 per bag of 28 kg)

The fee for charcoal differs from one district to another district and between village governments due to differences in by-laws

3. STUDY AREA

3.1. Location of the study area

Gwata Ujembe village is located in Mikese ward, Mikese Division in Morogoro Rural district. The village is situated at about 50 km east of Morogoro town towards Dar es Salaam. Morogoro town is about 200 km west of Dar es Salaam. The predominant feature in this area is the Kitulangalo hill which is about 800 m above sea level (m.a.s.l) situated at 06041'S and 37057'E.

The area comprises public (communal) lands with settlements, open woodlands and cultivated lands. Gwata village is bordered with Maseyu, Lubungo, Bwawani villages as well as the Kitulangalo Forest Reserve. The village is bisected by the Dar-es-Salaam–Morogoro highway which marks most of the southern boundary of the reserve and is the main transportation route for forest products to urban and commercial centre such as Dar-es-Salaam and Morogoro

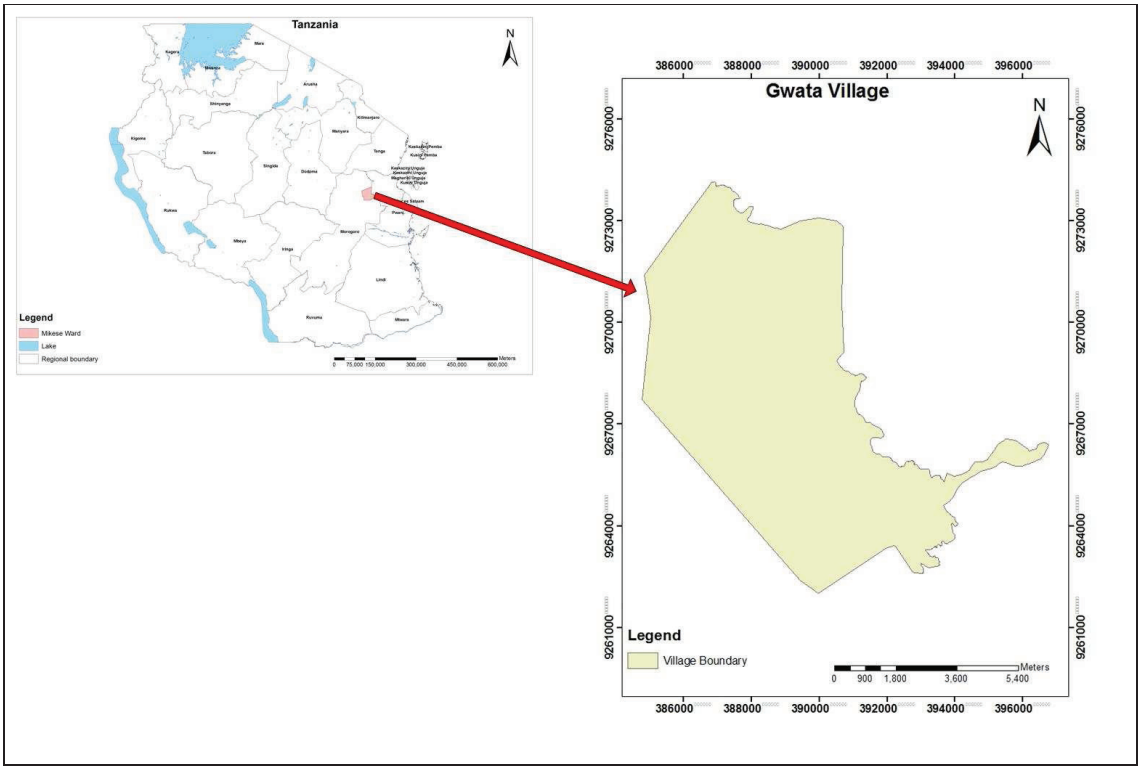

Figure 3-1: Location of the study area

3.2. Topography

The village land is mainly flat with gentle slopes and valleys (e.g. Sangasanga river valley) in few areas. The main flat areas are at residential part of Lukwambe, Gezaulole and CCM hamlets. Moreover, the village is at 686 meters above sea level (m.a.s.l).

3.3. Climate

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 The mean annual temperature is 24.30C while the annual minimum and maximum temperatures are 180C and 300C respectively (Mugasha 1996.) January is the hottest month while June is the coldest.

3.4. Vegetation

The village is dominated by open miombo woodlands with some scattered Julbernadia globiflora, Brachystegia boehmii and Pterocarpus rotundfolius. The most common smaller trees and shrubs are various species of Combretum, Diplorynchus condylocarpon and Dichrostachys cinerea.

3.5. Social economic characteristics

According to the census data (URT, 2002) the population of Gwata-Ujembe consisted of 1783 people, currently; the village population is 2037 people and 650 households. The growth rate per annum for Morogoro Rural District is 2.6%. The total village land is 6209 hectares covering forest reserve, public land and settlements. The main tribes of the village are Zigua and Kwere; other Tribes include Kami, Chaga, Bena, Luguru and Malila.

Livelihood activities of majority of the people in the village are natural resources based, such as farming and commercial charcoal production. The production of charcoal is either the primary source of incomes or a supplement to the mainstream agriculture. Cash and food crops are both grown in the study area, these are Maize, Sorghum and Millet and Simsim and Mangoes. Also there are some crops such as Peas, Pigeon peas, Groundnuts, Cassava, Coconut and Green pepper which are cultivated to supplement food.

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4. METHODS AND MATERIALS

4.1. Participatory Rural Appraisal (PRA)

Participatory Rural Appraisal (PRA) is a set of methods of action research. It utilizes a range of techniques, aiming at knowledge sharing between local people and outsiders in analyzing information, practicing critical self awareness taking responsibility and sharing the knowledge of life and conditions to plan and to act accordingly (Bhandari, 2003).

The popularity of this approach has come about in recent years after recognizing that traditional development strategies were adopting a top-down approach which did not consider empowering the local people using their indigenous knowledge in planning and analyzing their development programs (Binns *et al.*, 1997). The method has been applied in a wide variety of fields and in the case of this study it was used to offer a bottom-up approach for the PRA participants in identifying and locate their forest resources and charcoal extraction areas.

Under this method, different techniques such as participant observation, community meeting, participatory mapping, transect walks, land cover sampling, interviews and focus group discussion were employed as described below.

4.1.1. Participant observation

Participant observation is one of the most common techniques for qualitative data collection. The technique is commonly used by social science researchers to get insight information to the community being studied. The technique as the name implies ,is distinguished from other methods by the fact that the researcher accomplish this through observation alone or by both observing and participating to varying degrees, in the study community's daily activities. Participant observation always takes place in community locations where it is believed to have some relevance to the research questions (Kajembe, 1996). In natural resources perspectives, the technique enables the researcher to gain deep understanding on the local institutions and their capacity to manage natural resources and associated conflicts. Participant observation differs to other methods as the researcher approaches participants in their own environment rather than having the participants come to the researcher.

According to Casley (1988), the technique is of paramount importance in social science research as it relies on curiosity and willingness to learn from other people. In this study, the technique was used in identifying socio-related issues linked to charcoal extraction in the study area. Prior visit to the study area was made before the field work period. The purpose was to get familiar with the area and community being studied.

4.1.2. Community Meeting

Consultation with the village leadership in the village was done in order to invite and organize a community meeting. Thirty (30) participants including village government members, representatives from village environmental committee, charcoal extractors, and other stakeholders were involved. Participant's selection was based on identified qualities, such as involvement in village leadership (village executive officer, hamlet chairperson, and environmental committee), age groups, gender, and longevity in the area, livestock keepers, charcoal extractors, availability and willingness. The meeting was organized with the help of village chairman and village executive officer (VEO). The essence was to declare the purpose of the research and identification of stakeholders involved in charcoal extraction. Moreover, selection of participants for village sketch mapping and transect walk were done during the meeting.

4.1.3. Participatory Mapping

Participatory sketch mapping is a method for collating and plotting information on the occurrence, distribution, access and use of resources within the economic and cultural domain of a specific community. It is also a powerful tool that can help people in picturing their resource and features on a given base graphically manifesting the significance they attach to them. Sketch mapping can also catch the attention of participants to generate detailed information needed for good management decisions (Evans, 2006).

According to Minang (2003), participatory sketch mapping is a process in which local people make representations of their indigenous knowledge of space and use for analyzing issues. Participatory sketch mapping has been recognized as a management tool by involving local people in planning process of development programs (Ericson, 2006). During the community meeting, a village sketch map was drawn by the participants to indicate the geographical location of important features in the village, such as boundaries, settlements, natural resources, charcoal extraction sites and features like roads and rivers.

The researcher explained the purpose of mapping and the materials to be used. The sketch mapping activities began with a group discussion where the participants had chance to exchange ideas about their village sketch mapping. The participants decided first to draw a rough sketch on the ground and then selected representatives to draw directly on a paper while others looking on and giving suggestions (Figure 4-1 a. & b). After the drawing completed they discussed on which main features to be included, they agreed to include village boundaries, roads, bridge, rivers, forest reserve, and power line. After sketch mapping process participants were asked to identify their area and features on the sketch, this was important because the researcher wanted to know if they clearly understood the exercise. After the exercise was over, topographic map of the study area was used to compare the drawn features to see whether they were similar.

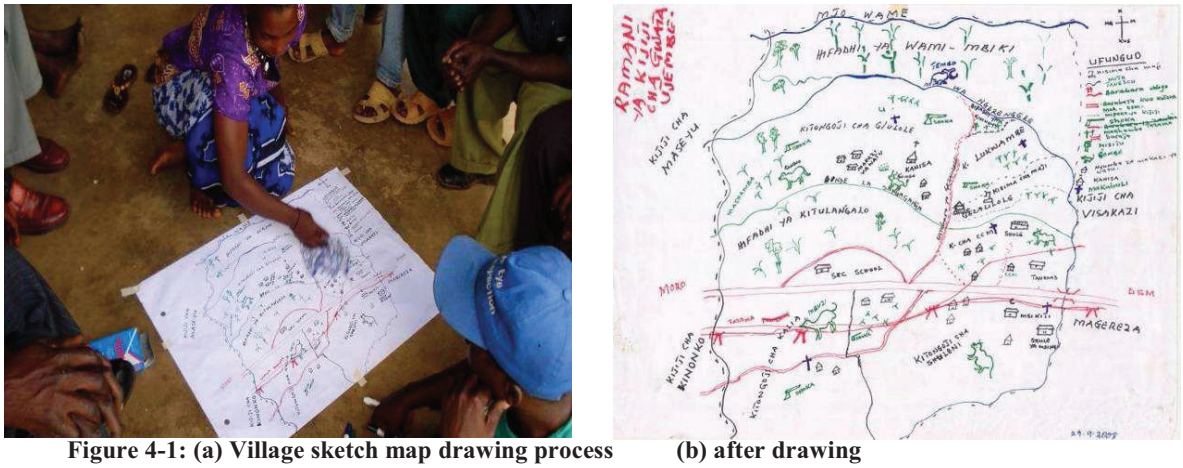


Figure 4-1: (a) Village sketch map drawing process (b) after drawing

4.1.4. Transect walk

Transect walk is a tool used to describe the location and distribution of resources, the landscape and main land uses. Basically, it involves systematically walking with local people through the area they use, observing, asking and listening (Waters-Bayer and Bayer, 1994). It further allow participants to identify constraints and opportunities with specific reference to ecosystems situated along transect. Fifteen (15) participants were selected for this exercise.

The purpose of transect walks were to verify the areas identified and mapped charcoal extraction sites, to locate and record kiln sites using GPS. A participatory search using local people knowledge was used to identify charcoal kilns. During the survey, 288 charcoal kilns points were recorded and categorized into new (1-2 years) and old (More than 2 years). Different observations were made using personal experience and questions on species preferred for charcoal extraction were asked to villagers.

4.1.5. Interviews

Structured interview was adopted in this research. The method is potentially used for quantitative data collection, provides uniform information and can easily be compared (Groenendijk, 2003). The interviews were conducted to the households in order to get general information on socio economic with emphasis on charcoal related issues. The sampling unit in this study was households. According to der Gier (2004) sample size should be at least 30 to 50; to ensure representatives of the population. Simple random sampling design was used to obtain the household to be sampled. The researcher used a calculator to generate the random numbers. This formula was used;

$S = R_{ni} \times N$

S= Selected sample from the population

R_{ni} = is the generated random number by the calculator

i =1, 2, 3 4, 5 ……..52

52 households were selected from the village register using number generated randomly.

4.1.6. Focus Group Discussion

Focus group discussion is an important technique used in researches as it enables a researcher to seek in-depth knowledge concerning sensitive issues and discuss topic of mutual interest with the participants (Schensul, 1999). In this study, focus group discussions centred on the identification of main issues related to charcoal extraction in the village. Checklists were used to guide focus group discussion with key informants. The discussions conducted were used to get detail of information and crosscheck the views expressed by the individual respondents. The participants for FGD in this study were selected among the stakeholders involved in charcoal extraction such as charcoal transporters, government officials at village and district level, charcoal traders, and labourers involved in charcoal loading. The group's size ranged from of 6-8 participants the number which is medium size and it was easy to handle.

4.2. Stakeholder Analysis

Ramirez (1999) defined stakeholder analysis as a methodology for gaining an understanding of a system and for assessing the impact of changes to that system, by means of identifying the key stakeholders and assessing their influence or power. Stakeholder analysis can be conducted in different ways, but before starting the process of identification it is suggested to define first the aspect of the system and problems under study. Without knowing the issues or problem or proposed intervention (Dougill *et al.*, 2006), stated that, it is impossible to know which stakeholders should be involved in identifying relevant issues.

McCall (2004) describe different ways of characterizing the group of actors in natural resources management situation as follows:

- Direct users vs. indirect (downstream) user's vs. non-users
- Active stakeholders (affect) vs. passive stakeholders (affected by)
- Scaled along a micro to macro continuum of stakeholders.
- Legitimate stakeholders vs. non-legitimate interests.
- Beneficiaries vs. non-beneficiaries

According to Grimble and Chan (1995) the key stakeholders in natural resources are the users and may equally include development practitioners, policy makers, planners and administrators in government, commercial bodies or non-governmental organizations (NGOs). In the context of natural resources, for example in Tanzania, as indicated in the National Forest Policy 1998 (URT, 1998), forest management draws a number of stakeholders with varying roles, responsibilities and interests. These can be grouped in two ways; first group includes those who consciously and directly manipulate the forests for their livelihood and economic returns. These include the private sector, parastatal and government forest authorities, local communities, and individuals at household level.

Another group covers those interested but not gaining direct returns and includes non-governmental organizations (NGOs), international financial institutions, donors and the international community. All these have major influences on policies, institutions and technology related to management of forests. Subsequently, their roles and responsibilities range from policy formulation to planning of

household level utilization of forest products including direct management, through planning, implementation and resources acquisition.

Stakeholder analysis can also be used to distinguish between conflicts and trade-offs in natural resources management. Grimble and Wellard (1998) described 'Conflicts' as the situations of competition and potential disagreement between two or more stakeholder over the use of one or more scarce resource. Such conflicts frequently originate from failure to operate in systems of common property management, under pressure from population growth, economic activity and sometimes invasion by outside interests.

4.2.1. The rationale of conducting stakeholder analysis

For this study, stakeholder analysis has been applied to understand the situation of charcoal extraction on public woodland. Understanding of stakeholder attributes can facilitate to reduce conflicts in sustainable utilization of natural resources in the study area (Grimble and Chan 1995).

4.2.2. The methodology used in Stakeholders analysis

The data on stakeholders involved in charcoal extraction were collected using different techniques such as community meeting, interviews; transect walks, focus group discussion and secondary data. In the community meeting stakeholders involved in charcoal extraction were identified by asking the participants in the meeting to make a list of stakeholders involved in charcoal extraction they know.
Secondary data and interviews for key informants were also used to provide information on stakeholders.
The following steps were followed in stakeholder analysis as described by Groenendijk and Dopheide (2003)

- Articulate the purpose of the analysis
- Identification and listing of stakeholders
- Assessment of stakeholders attributes: Different stakeholders attribute such as interest, influence and impact were investigated. Identification of conflicts between stakeholders was done in this step using various tools.
- Summarizing and reporting

4.2.3. Stakeholders categorization

In this research stakeholders involved in charcoal extraction were categorized based on their attributes (interests, influence, and impact) as described below. The reason of identification basing on the above attributes was to get a realistic picture of the range of stakeholders to understand their objectives, interactions and understand their conflicts related to utilization of forest resources. These attributes were defined in relation to this research as follows:

Interests: In this study it refers benefit or stakes of each stakeholder. Some stakeholders interests are more obvious than others. In this situation some stakeholders have an interest of getting benefits from forest utilization while others have interest on conservation purposes. Interest can be negative or positive.

Power: Is the extent to which stakeholders are able to persuade or coerce others into making decisions, and following certain courses of action. Stakeholders have different degrees of power to control decisions that have effects on achieving a particular objective. Other forms of power may be informal for example; personal connections with ruling politicians.

Impact: It refers to the ability to make positive/ negative changes of a particular state or situation. For example, stakeholders can have positive impact (tree planting) or negative (tree cutting) on resources such as forest.

Conflict: It is a disagreements and disputes over access to, control and use of, particular resources (e.g. forest).These conflicts may arise when people have different uses for resources such as forests, water, pastures and land, or want to manage them in different ways. Disagreements also arise when this interests and needs are incompatible or when the priorities of some user groups are not considered in the resource.

4.3. Land cover sampling

Prior to the fieldwork work 60 random sample coordinate points were generated in Excel spread sheet. During field work, Garmin GPS 12 XL unit was used for field navigation to locate the sample points. The observed points of landcover type were classified as Closed woodland (canopy cover > 40%), Open woodland (canopy cover 20% to 40 %) , farmland (areas used for agriculture), and bare (areas with vegetation cover is almost or entirely absent) following the classification system in Tanzania developed by (CHAPOSA, 2002)

4.4. Materials

4.4.1. Data

Primary data

- Charcoal kiln points data
- Land cover data

Secondary data

- Aster image of June 2007
- Landsat TM of July 2000
- A topographic map covering the study area (1: 50, 000).

4.4.2. Software

- ERDAS Imagine 9.1 was used to process the images while
- Arc GIS was used for the spatial analysis and map processing.
- SPSS 16.0 was used to process and analyze the socio-economic data.
- MS Excel was used for data analysis and graphics.
- MS Word, for word processing
- Visio, for making flow chart
- Endnote for world processing

4.4.3. Field equipment

- Garmin 12 XL hand-held Global Positioning System (GPS)
- Digital camera

4.5. Data Analysis

4.5.1. Socio-economic data

Statistical Package for Social Sciences (SPSS) computer program was used for data analysis. 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. Descriptive statistics were used and the results were presented using frequency tables. For qualitative data were analyzed by content analysis. These included information from the stakeholder conducted meetings, and sketch map drawn by villagers.

4.5.2. Image pre-processing

ASTER of June 2007 and Landsat of July 2000 images were obtained from ITC geo-database. The images were geo-referenced and re-projected to geographic coordinate (WGS 84, 37S) in ERDAS IMAGINE processing software. The effect of haze was also reduced using Erdas imagine haze reduction module. Since the two images were of different spatial resolutions, in our case there was the need to perform re-sampling since the two images were not of the same spatial resolution (Mertens and Lambin, 2000).Thus, there was the need to resample Aster image to the resolution of Landsat (30 x 30 meters). The nearest-neighbour technique was used to resample the ASTER image so that they are comparable in spatial resolution and the change detection could be done.

4.5.3. Image classification

A supervised classification was performed in ERDAS software version 9.1 using Maximum Likelihood Classifier (MLC).Though other classification methods are available, the choice of the MLC was based on its advantage expressed by Shrestha and Zinck (2001) that, it provides good results since it takes into account of the shape, size and orientation of a cluster.

Supervised classification convert the spectral data contained within remote sensing directly into thematic land cover information (Wilkie and Finn, 1996). To perform a supervised classification, the user identifies homogenous region within the image that represent unique known landscapes.These areas (training sets) are used statistically to generate spectral signatures (responses) characteristics of each landscape type. A digital classifier then compares the spectral signature of each pixel in the image to the training set signatures, thereby determining to which landscape type each pixel is most likely to belong. The image generated is, consequently a thematic land cover map of the area. During image classification, 35 points were used for accuracy assessment and for training set 25 points were used.

4.5.4. Accuracy assessment

In thematic mapping from remotely sensed data, the term accuracy is used typically to express the degree of ‘correctness’ of a map or classification (Foody, 2002). A good thematic map derived with a classification may be considered accurate if it provides an unbiased representation of the land cover of the region it portrays ,therefore, classification accuracy is typically taken to mean the degree to which the derived image classification agrees with reality (Foody, 2002). According to Lillesand and Kiefer (1994), the reliability of answers to some of the research questions depends on the accuracies of the

land cover maps which also depend on the quality of the ground truth samples collected from the field. The quality of a classified image is judged by its overall accuracy. The accuracy assessment was performed for Aster 2007 using 35 sample points to validate the classified map. The land cover classification for Landsat TM 2000 could not be validated due to lack of ground truth points for training set and accuracy assessment. Their validation was subjective

4.5.5. Change detection and spatial analysis of charcoal kilns points

Change detection is a technique used in remote sensing to observe the changes in a particular object of study between two or more time periods (Lu *et al.*, 2004). Change-detection is an important process for monitoring and managing natural resources because it provides quantitative analysis of the spatial distribution in the area of interest. Change detection may also reveal the spatial pattern of development in the area and this may be positive or negative and thus enable planners to modify strategies accordingly. More important, change detection can be used to identify areas where particular types of change should be encouraged or discouraged.

For land cover changes, a number of change detection techniques (image differencing, post-classification comparison, etc.) were reviewed by (Lu *et al.*, 2004). They identified post-classification comparison and image differencing as most common techniques used for change detection in practice. It was revealed that image differencing is simple and easy to interpret the results and recommended for forest defoliation and land-cover change. However the main disadvantage of the technique is the difficulty in determining a suitable threshold to identify change areas. A threshold is obtained based on complex statistical analysis. Also it does not provide a change matrix which indicates which cover has changed in what and where.

Post-classification comparison technique as suggested by Tardie and Congalton (2004) was used in this research to compare the classified images of (Landsat TM of 2000 and Aster 2007) and identify land-use/land cover changes. The reason of preferring the method was based on its capability to produce change matrix indicating which cover type has changed in what and where using matrix function. The analysis was done using ERDAS IMAGINE 9.1. The classified images were compared with each other using the same cover classes. The difference map was then generated using matrix ERDAS IMAGINE 9.1. Matrix dialog enables to create an output file that contains classes that indicate how the class values of the input files overlapped. Area for each class was calculated in ERDAS IMAGINE 9.1 to determine the percentage change.

For spatial analysis of charcoal kilns, old and new charcoal kilns were overlayed in Landsat 2000 and Aster 2007 images respectively and displayed in ARGIS 9.2. Sample option (Spatial analyst tool) was used to extract the land cover type where charcoal kilns point located. The extracted point data were exported to Excel 2003 for statistical analysis, where frequency and percentages of charcoal kilns were calculated in relation to location to cover type. A total of 128 and 160 charcoal kilns points were mapped as old and new kilns points respectively. Old charcoal kilns refers to any kilns which was assessed and/or reported to be more than two years, while new charcoal points were those less than two year

5. RESULTS

5.1. Stakeholders identification and analysis

The results show that twenty one (21) stakeholders were identified during stakeholders identification and analysis (see table 5-1).The identification were based on their interests in relation to woodland utilization and charcoal extraction. The list of stakeholders was summarised in thee groups: The first group include Central and Local Government at regional, district and village level, they were identified as stakeholders with interest in enforcement of laws at all levels (district and village), implementation of forest policy and sustainable conservation of forest resources. Fine and fees from charcoal is another interest of both governments in charcoal extraction. These fines are obtained from those who contravene forest regulations or from sales of confiscated charcoal during patrols. A local NGO (WAMI –MBIKI society) was identified to have the same interest of woodland conservation in the study area like the government. Its main objective in the study area is to protect woodlands form destruction activities to ensure the habitat of wild animals. The environmental conservation activities in the study area are supported by enforcement of forest laws and extension services such as awareness creation on environmental protection to the local communities

The second group were charcoal extractors in Gwata village and extractors from neighbouring villages were considered to have the same interest such as: charcoal product, market for charcoal, trees for charcoal making, and suitable soil for kiln construction. Charcoal traders and transporters were also included in this group. These were mainly buying and transporting charcoal from the production sites to Dar es Salaam city. Their main interest is charcoal and making profit

The third group were: Women, honey collectors and medicinal practitioners, Farmers, landowners, and livestock keepers. These have interest in firewood (branches/ dead wood), bark of trees and trees for beehives and pollination flowers, production of food and cash crops, water catchment and pasture land for livestock grazing. The detail information on stakeholdrs attributes (see appendix 8)

Table 5-1: List of stakeholder involved in charcoal extraction

No	Stakeholder
1	Charcoal extractors of Gwata village
2	Charcoal extractors of neighbouring villages
3	Women in the village
4	Medicinal practitioners
5	Honey collectors
6	Livestock keepers
7	Farmers
8	Land owners
9	Charcoal traders
10	Charcoal transporters
11	Regional Forest Catchment Officer
12	District Forest Officer
13	District Agricultural and Livestock Officer
14	District Commissioner
15	District Executive Director
16	Village Executive Officer
17	Ministry of Natural Resources and Tourism
18	Morogoro District Council
19	Central Government
20	Village Government
21	WAMI-MBIKI society (Local NGO)

5.1.1. Nature of conflicts in the study area

Different types of conflicts between stakeholders involved in charcoal extraction were identified in the study area. The main conflict was between the Government and charcoal extractors on enforcement of laws pertaining to illegal charcoal extraction. List of existing conflicts is on table 5-2.

Table 5-2: Conflict between stakeholders in relation to charcoal extraction

Stakeholder	**Type of conflict**
Regional catchment forest officer, District forest officer, Village executive officer Vs Charcoal extractors	Enforcement of laws governing charcoal extraction (Illegal charcoal extraction)
Central government, District council, Village government Vs Charcoal traders	Enforcement of laws governing charcoal trading - Trading charcoal without license /following regulations
Village government Vs Charcoal extractors	Environmental destruction through charcoal extraction activities conflict on fines (illegal charcoal extraction, fines)
Village government Vs Charcoal traders	Village by laws enforcement (Illegal charcoal trading)
Land owners Vs Charcoal extractors	Encroachment by charcoal extractors to make charcoal in their areas (Confiscation of illegal charcoal by land owner)
Livestock keepers Vs Charcoal extractors	Bush fires caused by charcoal extraction activities
Charcoal extractors Vs Charcoal extractors	Cutting trees already marked or identified by neighbour and Stealing charcoal from the neighbour kiln during the absence of one
Charcoal traders Vs Charcoal traders	Different prices offered to charcoal maker and mode of payment (advance money)

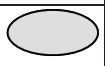
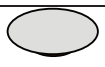
5.1.2. Conflict matrix

The relationships between different stakeholders in relation to charcoal extraction on the public woodland were investigated during the stakeholder analysis. A matrix was developed to show stakeholders conflicts and their extent (Figure 5-1).

Law enforcement was observed to be the main source of conflict between the District council, Forest officials, and Village government and charcoal extractors/traders. Charcoal extraction activities were observed to continue in the study area without any license issued from the government. According to the interview conducted to the households involved in charcoal extraction in the study area, about 83% of charcoal extractors reported existence of conflicts between charcoal extractors and the District council, village government and land owners.

The main conflict is on law enforcement on illegal charcoal extraction activities which contributes to woodland degradation. According to the discussions conducted to the District forest officials, it was observed that no licenses were issued to charcoal extractors due to ban from all forms of charcoal extraction by the regional authority. At the district level both the Forest Act of 2002 and the District council environmental by-laws are used to regulate illegal charcoal extraction activities. Forest patrols to extraction sites was also stated as the source of conflict especially when the government take stern measures such as taking the culprits to court or confiscation of illegal charcoal.

Encroachment to private wood lands by charcoal extractors was reported as another conflict in the study area. If charcoal extraction is not under agreement between the extractor and the land owner may require charcoal extractor to surrender all the charcoal to the land owner .This creates hate or misunderstands among the stakeholders. Other conflicts reported were minor like villagers and charcoal extractors and between landowners and livestock keepers were reported to be of small scale.

District council							
Village government							
Villagers							
Charcoal extractors							
Land owners							
Charcoal traders							
Livestock keepers							

	District council	Village government	Villagers	Charcoal extractors	Land owners	Charcoal traders	Livestock keepers

Figure 5-1: Conflict matrix between stakeholders

Note: The symbol  High conflict

 Low conflict

5.1.3. Legal regulations governing charcoal production

It was observed that charcoal production in Tanzania is regulated by different instruments such as, Forest Act of 2002, District by-laws and Village by-laws. The Forest Act of 2002 is established by the Ministry of natural resources and enacted by the National parliament of the Republic of Tanzania. The District by laws are established by the District council under the law of Local Government (District Council) No.7 of 1982 and passed by the Minister of Local government. The village by laws is established by the village and passed by the District council. Their main application is as follows:

(a) Forest Act of (2002): This is the main forest regulatory instrument for controlling forest activities in forest reserves and public lands.
(b) District Council Environmental by-laws: The by-laws are specifically for regulate environmental activities including charcoal extraction activities.
(c) Village environmental by laws: These by- laws are meant for regulating environmental conservation activities in the village.

5.1.4. Enforcement of regulations and stakeholder perceptions

Based on this study, it was identified that, the District Council is regulating the illegal charcoal extraction activities by enforcing the laws through the following activities;

- Awareness creation to stakeholders on the rules and regulations governing charcoal extraction.
- Establishment of district committees for monitoring forest harvest and trading of forest products
- Forest patrols by involving local communities
- Strengthening village environment committees for monitoring charcoal production
- Use of primary and district courts

5.1.5. Stakeholders perceptions on rules governing charcoal extraction

Different perceptions of stakeholders involved in charcoal extraction were observed during filed work as follows (see table 5-3 below).

Table 5-3: Stakeholders perceptions on rules governing charcoal extraction

Stakeholder	Perceptions
Charcoal extractors	Negative attitude against law enforcement It sounds these laws are not favouring their activities. For example, they claimed the fact that licensing processes complicated, high rates for registration.
Charcoal traders	Negative attitude on laws enforcement as they are against their will. These businessmen always aims at getting benefits ,however they also claim on high royalty rates for charcoal
Charcoal transporters	Restriction on transportation charcoal during the day times difficult. Moreover, the patrols are done by forest officials seems to limit their business schedules when hired to transport charcoal to the city.
Farmers /livestock keepers	In efficient laws enforcement to the woodlands in the village to regulate charcoal extraction.
Regional forest catchment officer	Regulations are good and have to be followed accordingly.
District forest officer	Good regulations , awareness creation to the people is important
Village executive officer	The fines are high in such away that people may be scared to extract charcoal without license

5.2. Impact of charcoal extraction

5.3. Socio-economic benefit of charcoal extraction

Results from present study shows that 80 % of respondent reported to realize charcoal as their source of income and 20 % considered it as a source of employment. The results show that, an average charcoal making household produce four kilns per year and one kiln produce an average of 30 bags of charcoal. Charcoal is sold at kiln site at Tshs. 8000/= per bag, and survey revealed that all charcoal is sold at the kiln sites.

5.3.1. Environmental effects of charcoal extraction

The study revealed that 70% of respondents reported decrease in woodland cover due to charcoal extraction and 30 % reported environmental degradation as a result of charcoal kilns left over. About 65% of the interviewed respondents said that currently the tree cover is thinner (bad state) than ten years ago due to charcoal extraction activities in the study area.

All these effects were reported to be caused by charcoal extraction.

5.3.2. Preferred tree species for charcoal making

Given the choice of species for charcoal production the most four preferred species in order of importance were mentioned by the respondents. These were; Julbernadia globiflora (Mhondolo) 48.3%, Tamarindus indica (Mkwaju) 28%. Brachstegia boehmii (Myombo) 22%, Acacia nigrescens (Mkambala) 17% and In reality charcoal makers are using a wider variety of species, apart from their top four preferred other species mentioned were, Combretum zeyheri (Mlama mwekundu), Combretum adonogonium (Mlama ngombe), Sclerocarya birrea (Mngongo), and Terminalia mollis (Mtanga).

5.3.3. Land use and cover change analysis

This section shows the results obtained after conducting change detection by comparing classifications of Landsat of 2000 and Aster 2007 images. Five main land cover types were defined for the purpose of this research. These included: Riparian woodland, closed woodland, open woodland, farmland, bare/settlements and unclassified/haze. Their description is shown in table 5- 5 below

Table 5-5: Description of landcover types

Land cover type	Description
Riparian woodland	A mixture of trees, shrubs and herbaceous vegetation around water bodies.
Closed woodland	These were areas with canopy cover more than 40 %. The stature of trees is in the range of 5m to 20m in height.
Open woodland	Tree stratum of small or medium sized vegetation with the height of more than 8 meters and percentage cover of 20% - 40% .The cover was mainly miombo species, Combretum, Terminalia and Acacia xanthophloea in some places.
Farmland	Area that are primarily used for agriculture.
Bare / settlements	This refers to dry open area where vegetation cover is almost or entirely absent. In the dry season, depending on the shape of the area, this could even be farmland that has been harvested or has not yet been planted with any crop. Settlements are also included.
Unclassified /Haze	The area in the image occupied with haze

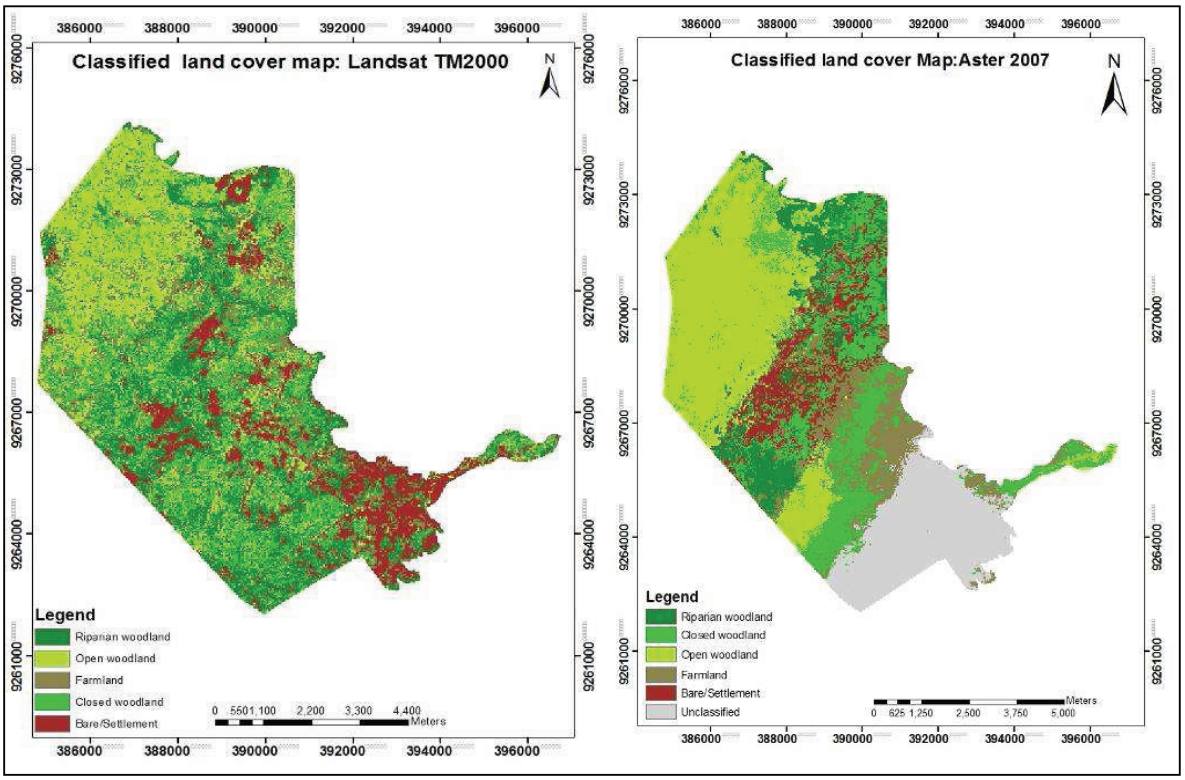


Figure 5-2: Classified images Landsat TM 2000 and Aster 2007

The above maps show the status of land cover types in the study area from the year 2000 and 2007. The dominant land cover type in the study area in 2000 was open woodland with patches of closed wood land and bear in the northern west part. In the landcover type of 2007, the northern part of the study area was dominated by open woodlands while the mid portion is dominated by closed and riparian woodland and bare areas. In the southern part of the image unfortunately the area was not classified as it was occupied with haze. An analysis of how much was changed within 7 years is presented below in table 5-6. The rate of change (per year) for each land cover type is as follows: Riparian woodland 138.7 ha (2.23%), Closed woodland 0.05 ha (3.39), Open woodland 46.38 ha (0.75 %), Farmland 22.35 ha (0.36%), Bare/Settlement 39.12 ha (0.63 %) and Unclassified/ Haze 0.00 (2.53%).The total change (decrease) in all land cover was 2.52% per year (excluding the unclassified).

Table 5-6: Change in Land cover (ha and %) and rate of change (ha and % /year) from 2000-2007

	Year: 2000		Year: 2007		Rate of change	
Landcover	Area(ha)	Percentage	Area(ha)	Percentage	Area(ha/year)	Percentage/year
Riparian woodland	1518.39	24.45	547.56	8.82	-138.69	2.23
Closed woodland	1239.66	19.96	1215.9	19.58	-3.39	0.05
Open woodland	1639.66	26.31	1958.22	31.54	46.38	0.75
Farmland	976.5	15.73	820.08	13.21	-22.35	0.36
Bare/ Settlement	841.32	13.55	567.45	9.14	-39.12	0.63
Unclassified/Haze	0	0	1100.25	17.12	0	2.53
Total	6209.46	100	6209.46	100		2.52

5.4. Accuracy assessment

The overall accuracy obtained for classified Aster 2007 image was 74.29 %. This result was accepted for the purpose of this study, given that the maximum likelihood (0.74) is approaching 1 (considered as 100% true).

Table 5-4: Accuracy assessment

Class Name	Reference Totals Classified Totals	Classified Totals	Number Correct	Producer Accuracy	User Accuracy
Riparian woodland	7	4	4	57.14%	100.00%
Closed woodland	6	7	5	83.33%	71.43%
Open woodland	12	15	12	100.00%	80.00%
Farmland	6	2	2	33.33%	100.00%
Bare/Settlement	3	5	2	66.67%	40.00%
Unclassified	0	0	0	-	-
Totals	35	35	26		
Overall Classification Accuracy = 74.29%					

5.5. Change map

Changes from one cover type 2000 to 2007 are shown in (figure 5-3). The sequential increases in the major land cover were as follows: Riparian woodland, by 5.31% (330 ha), Closed woodland 15.27 % (948 ha) Open woodland by 16.11% (1001 ha), Farmland 10.76% (668 ha), Bare/Settlement 8% (497ha). The major areas of forests cover change occurred in open woodland (see appendix 4). The portion of the land cover change map which was covered with haze was named as unclassified. This area accounted for 1100 hectares. The spatial distribution of land cover change shows much of the woodland in the North West part of the study area is changed to open woodland. The unchanged landcover accounted for 26.83% (1666 ha) and is dominant to the northern west part of the study area.

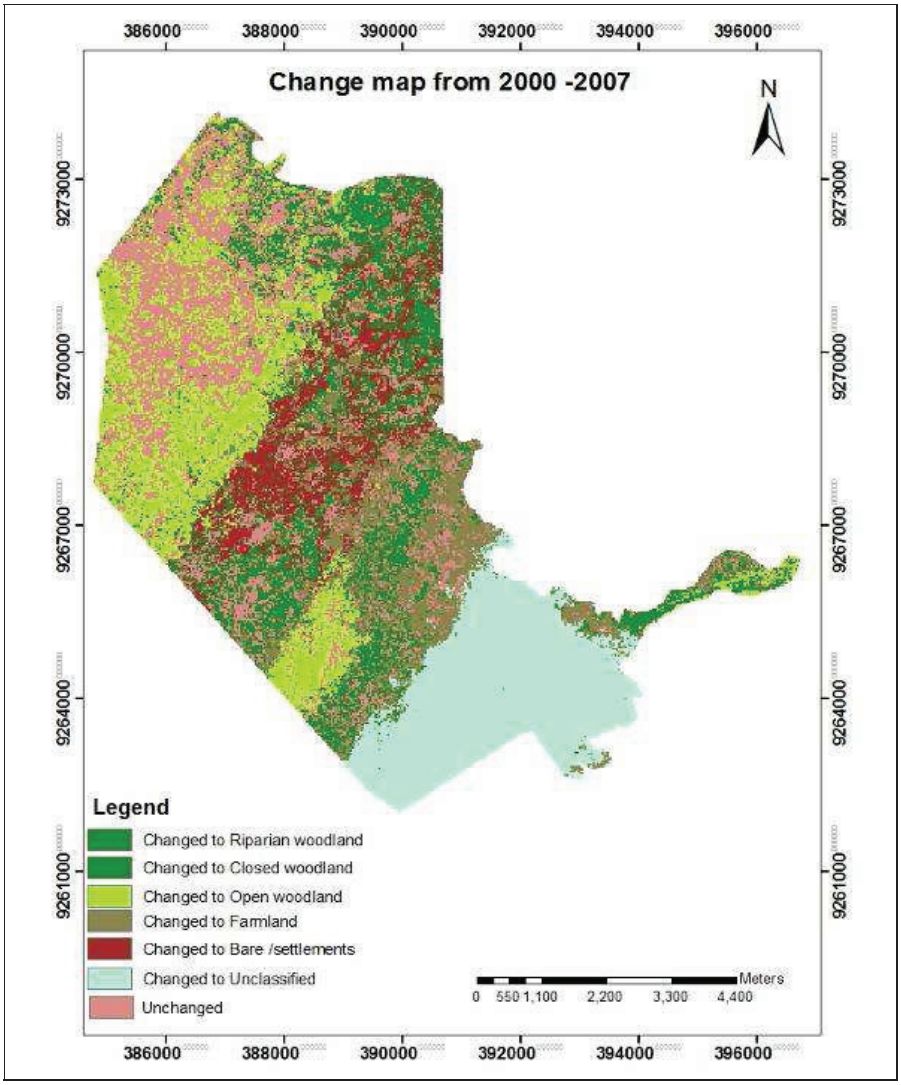


Figure 5-3: Land cover change map

5.6 Change in spatial distribution of charcoal extraction in the study area

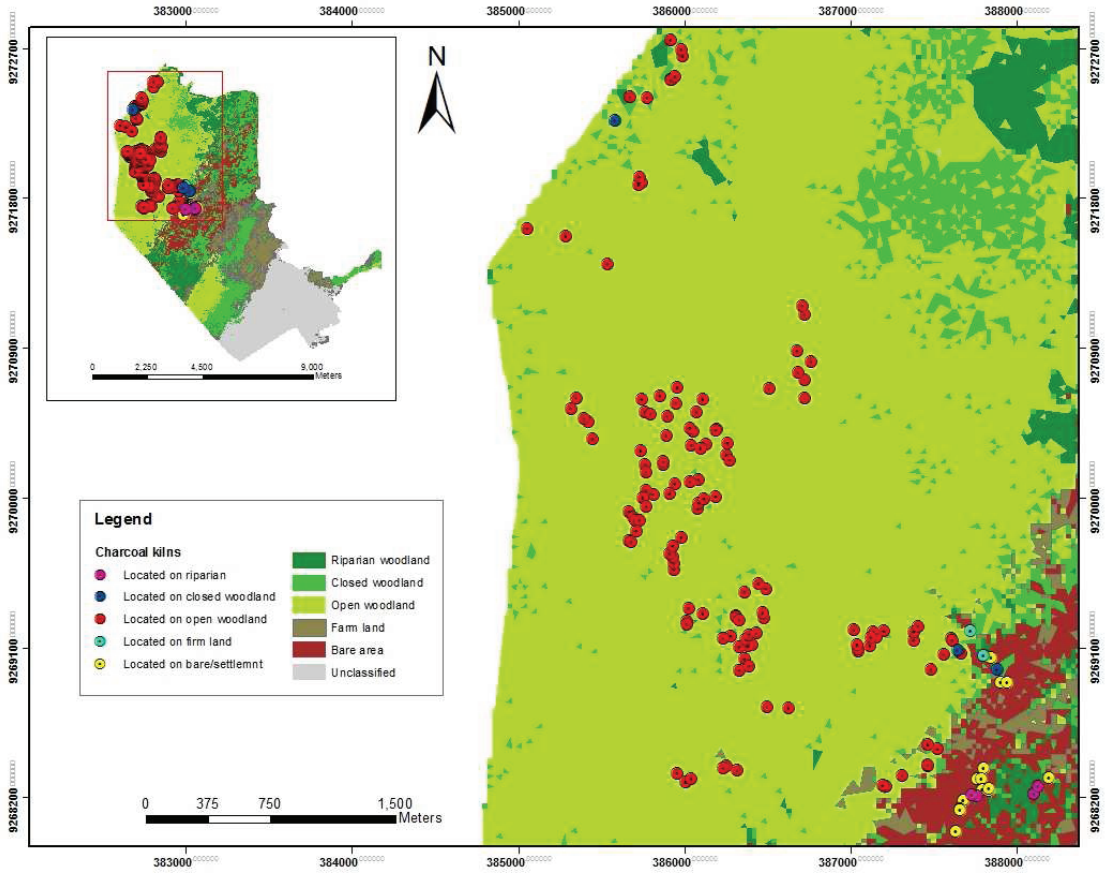


Figure 5-4: Spatial distribution of charcoal kilns from 2007- 2008

The results shows that, the extraction of charcoal in the study area is concentrated in the Central North-west part of the village in Lukwambe and Gezaulole hamlets (see figure 5-4)

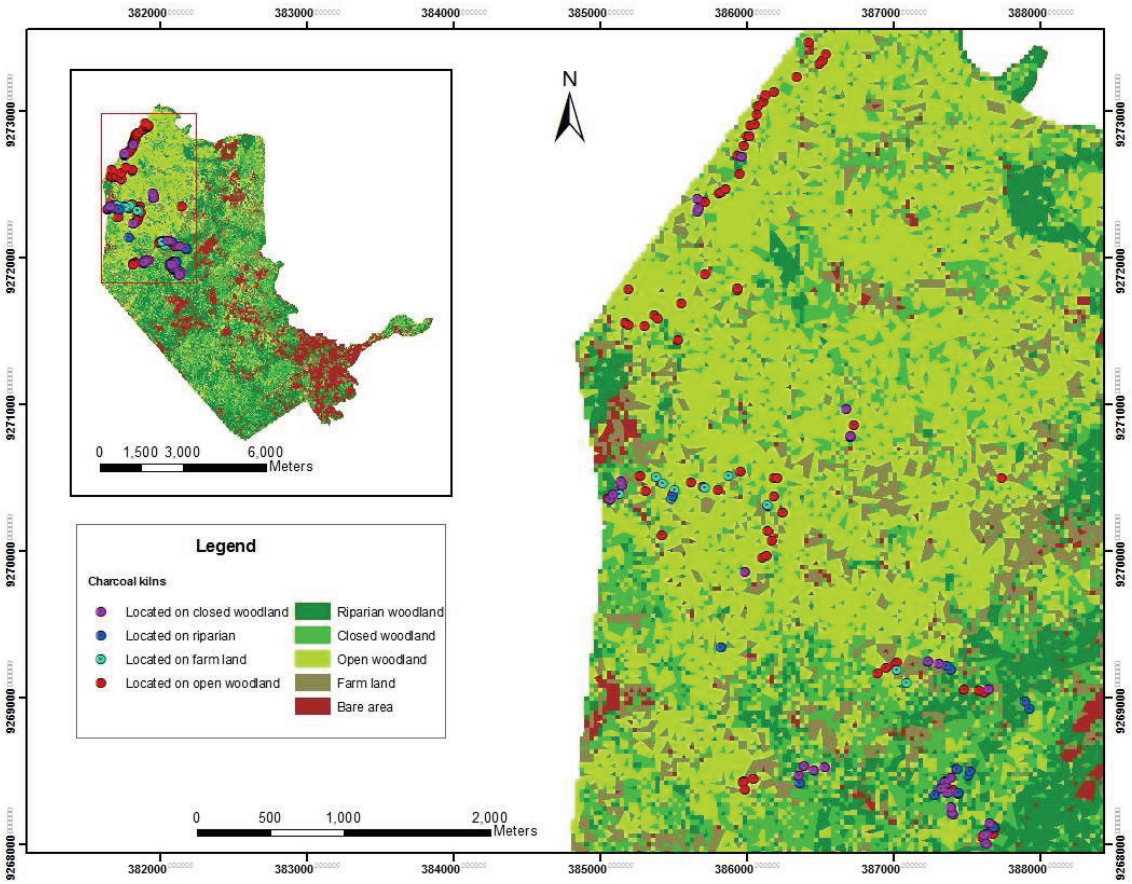


Figure 5-5: Spatial distribution of charcoal kilns before 2007

Spatial distribution of charcoal was investigated in different land cover types for 2000 (see figure 5-5) and 2007 (figure 5-4). A total of 128 and 160 charcoal kilns points were mapped as old and new kilns points respectively. Old charcoal kilns refers to any kilns which was assessed and/or reported to be more than two years, while new charcoal points were those less than two years.

Results shows that, in open woodlands charcoal kilns has increased between the two period of time (51% - 83%), while charcoal kilns in other landcover types have been decreasing with time as illustrated in Figure 5-6. For example, riparian woodlands occupied 17% and 3% between 2000 and 2007 respectively which indicates reduction of 14 %. Charcoal kilns gradually decreased from 33% in 2000 to about 5% in 2007 for closed woodlands indicating reduction of 28% (see figure 5-6). Likewise, farm land has decreased by 12% between the time intervals. Close to settlement 8% of kilns were recorded in 2007.

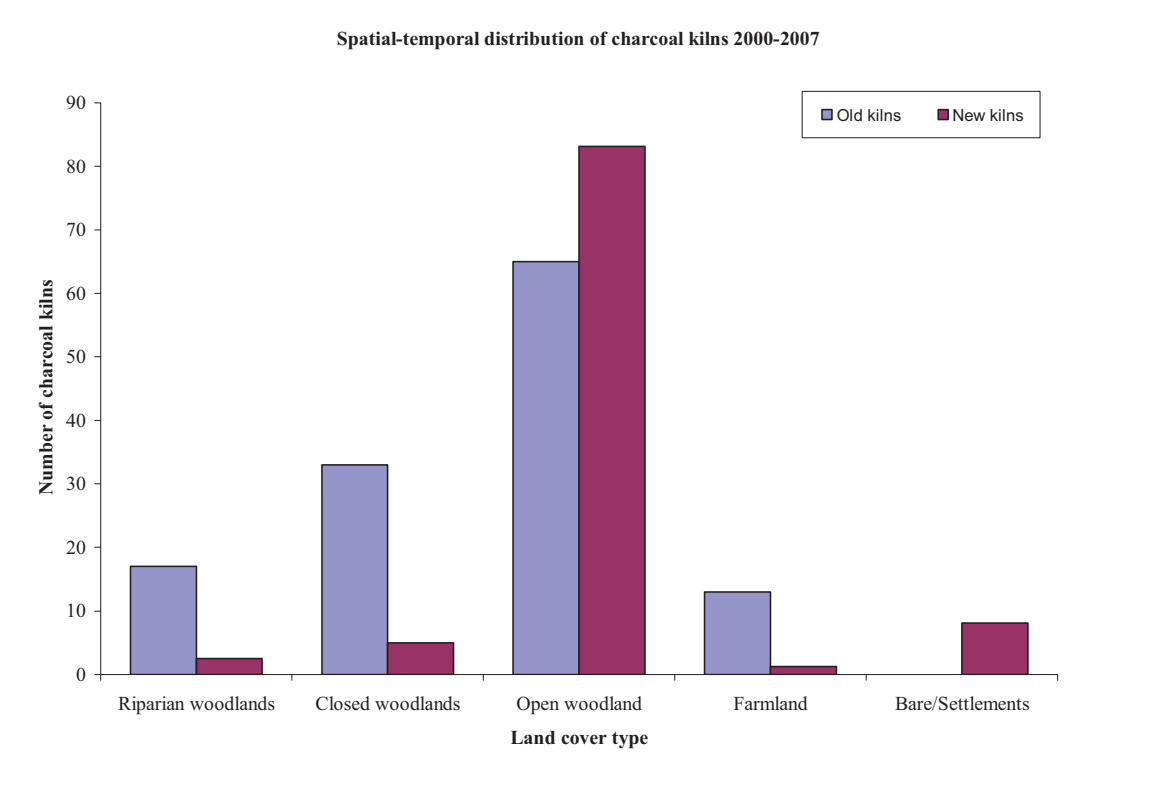


Figure 5-6: Spatial -temporal distribution of charcoal kilns 2000-2007

5.6. Reasons for moving from one production site to another

The result shows that, about 70 % of the respondents reported the main reason for shifting from one place to another was attributed to species availability. Soil type accounted for 23% as the second reason for shifting from one point to another as charcoal extractors preferred moist clay soil. Availability of kiln construction materials (3.3%) and accessibility (3.3%) were not reported as the main reason.

6. DISCUSSION

6.1. Stakeholders involved in charcoal extraction

Results show that stakeholders in this study are of three categories depending on their interest in charcoal extraction. The group concerned with woodland conservation includes: the central government, local government, village government and NGOs. The extraction group includes: charcoal extractors, transporters and traders, while the third group includes: landowners, farmers, medicinal practitioners and honey collectors. This result is in agreement with other studies which realized that forest management in Tanzania involve a number of stakeholders with varying roles, responsibilities and interests (URT, 1998). In this study, the first group's interest is to ensure forests and woodlands are protected in a sustainable way and have very high influence and positive impact on the woodland protection. This is achieved by using different combination of approaches include law enforcement. Charcoal extractors, traders and transporters play a major role in forest destruction through over exploitation of forest resources. This situation is influenced by weak enforcement of forest laws in the study area. Their influence on charcoal production is very high and has negative impact on the woodlands through tree cutting. It was observed that lack of alternative livelihood strategies in the village is the reason of local people's involvement in charcoal extraction and they depend on charcoal as their main source of income. Charcoal traders have high influence on charcoal extraction because they have power in terms of income as they do business. Land owners were identified as stakeholders since they play a major role in protection of the woodland from encroachment by charcoal extractors. Some woodland areas in the study area are managed by landowners where they restrict extraction of charcoal.

The relationships between different stakeholders in relation to charcoal extraction on the public woodland were investigated during the stakeholder analysis. It was observed that there are existing conflicts between stakeholders due to different interests among stakeholders on the utilization of forest resources. Law enforcement is the main source of conflict between the government officials and charcoal extractors and traders in the study area. These conflicts are fundamental in the field of natural resource management, particularly where there is increasing resource scarcity and where common property resources are concerned (Grimble and Wellard, 1998).

6.2. Regulations enforcement

Exploitation of forest products such as charcoal from the woodland in Tanzania is regulated through permits and licenses. The sole authority responsible for this relies on the Director of forest department (URT, 1998). It was observed that in the study area charcoal extraction is conducted in the general woodlands which are under the private and communal owned land, and some parts managed by village government. The existence of different ownership regimes, poor enforcement of laws and regulation has resulted into over exploitation of these woodlands. In some places the woodlands have been depleted to the extent that are now standing disjointed (fragments) in the degraded landscape within the study area.

Apart from the regimes, high demand of charcoal in urban areas and lack of alternative livelihood strategies also contributes much to accelerate charcoal extraction in Gwata village. Findings from the study revealed that about 56% of the households interviewed reported to depend on charcoal extraction as their main source of income. Our claim on economic contribution of charcoal are supported by Monela et al. (2000), who reported that charcoal production contribute to the incomes of rural people in eastern parts of Tanzania

The present study it was identified existence of non licensed charcoal extractors in the surveyed area. This claim hold true as no license was issued by the forest office to charcoal extractors due to ban from all forms of charcoal extraction by the regional authority This was in accordance to the government ban on charcoal in 2006. This was during a transition period to assess status of forest products and to established new regulations to control the production of charcoal. However, up to now, the ban still holds within Morogoro region. This might attribute to the observed charcoal extraction as even those who are full willingly to apply for charcoal licence and permit do not have access to such services.
The regulation requires districts to establish forest harvesting committees for regulating harvesting of forest products including charcoal. The committee is chaired by the District commissioner and the secretary is the District Development Director. The function of these committees is to approve applications from villages for harvesting of forest products. Permits from these committees depends on recommendations from concerned villages, however, this still not applicable due to the above mentioned reasons.

At the district level both the Forest Act of 2002 and the District council environmental by-laws are used to regulate forest products, including charcoal extraction activities. The enforcement of Forest Act of 2002 in relation to charcoal extraction is according to the following sections;
Section no 85: related to offences in relation to trees not in forest reserves where a person without license or permit fells or cut a tree in public lands or his farm if found guilty is liable to pay fine not less than Tshs 50, 000 and not exceeding to Tshs 1,000,000 or imprisonment or both fine and imprisonment.
Section no 88: related to offences to unlawful taking possession or receiving of forest produce, this section refers to any body in possession of forest products which is not lawful obtained if found guilty is liable to fine not exceeding to Tshs 1000,000 or imprisonment of two years or both fine and imprisonment.

Section no 89: offences related to trading in forest produce if a person is found without permit driving a vehicle or any machine carrying forest produce obtained without license or sells or buys or stocks forest produce if convicted is liable to a fine not less than Tshs 200,000 and not exceeding to Tshs 1000,000 or imprisonment of two years or both fine and imprisonment.

The district by-law is implemented according to section number ten (10) sub section a, b and c referring on charcoal production, transportation and trading in the district. Section c refers to penalty given for a person found guilty to any offence is liable to pay a fine not less than Tshs 50000 or imprisonment of six months jail.

Based on this study, it was identified that, despite of continuing of illegal charcoal in the study area law enforcement are employed to arrest the situation. The district controls these illegal activities through the following;

- Awareness creation to stakeholders on the rules and regulations governing charcoal extraction, people are educated through village assembly meetings.
- Establishment of district committees for controlling harvest and trading of forest products.
- Forest patrols to extraction areas by involving local communities
- Strengthening village environment committees by conducting seminars
- Use of primary and district courts to deal with issues on illegal charcoal extraction.

However, Gwata village has established the environmental bylaws but up to now it's not function because have not approved by the Morogoro district council The delays of approval of village by laws from the district council is one among the contributing factors to weaken law enforcement thus creating a room for villagers to involve in charcoal extraction. Other factors such as lack of resources and staff to support the district forest office for enforcement of laws contribute to accelerate illegal charcoal extraction. (Pers.comm from Morogoro District Forest Officer)

6.3. Perceptions of stakeholders on the legal regulations

The study confirmed that charcoal extractors and traders have a negative attitude against law enforcement as they operate their business without license. Discussions conducted with different stakeholders revealed that the current laws (new regulations) are a bit tough than the previous one. In the past the penalties for forest offences were small compared to the present economic realities, people afforded to pay fines whenever they found guilty on forest offences. For example, the penalty for the first offence for anybody not adhered to forest laws was Tshs. 5000 or six months prison term. Fine for the second offence was Tshs. 12,000 or 12 months prison term. (Exchange rate at mid-2001: 1 USD = Tshs. 900). If the offence is further repeated, both fine and prison term can be concurrently imposed (CHAPOSA, 2002). Currently, penalties have increased tremendously up to a range from Tshs 50,000 to Tshs 1,000,000 or six months jail for the first offence and Tshs 200000 to Tshs 1000000 for the second offence or two years imprisonment.

However, the perceptions of government officials were positively to the laws that they suit according to the offences .They also pointed out that in order to implement these regulations there should be an aid to make them to detect charcoal offences, this may be the government to encourage the key informers by providing rewards if they facilitate or help in conviction of offenders. According to Christy (2007) awards to key informants is practiced in the Democratic Republic of Congo (DRC) where key informants and forest officials whose task is to enforce law are entitled to rewards. These incentives could be important for improvement of the efficiency in enforcement of charcoal regulations because most of the extraction activities are in remote areas where it is not easy to detect or identify.

6.4. Impact of charcoal extraction in the study area

6.4.1. Socio-economic benefits to the community from charcoal making

Based on results from this study, majority of charcoal extractors benefit from charcoal extraction as a source of income whereas the same activity is considered as a source of employment as highlighted by 20 % of our respondents. These results are in line with the study conducted by CHAPOSA(2002) and Monela et al, (2000) where they reported charcoal as among the main factors contributing substantially to the economy of rural people in eastern Tanzania. Results from present study shows that about 37 % of interviewed charcoal extractors produce 4 kilns per year and one kiln can produce an average of 30 bags of charcoal. The results are similar to the findings reported by Abdallah and Monela (2007), that in Tabora one kiln can produce an average of 20 to 30 charcoal bags. Assuming charcoal is produced in four cycles per year and each cycle produces one kiln of an average of 30 bags per kiln, by this conversion 120 bags of charcoal are produced per year by one extractor. Charcoal is sold at kiln site at Tshs. 8,000/= per bag, thus household realizes an income of Tshs 960,000/= per year equivalent to USD 872 per year (Exchange rate 1 USD = Tshs. 1200) from the sale of charcoal. The average income for charcoal sales per month is Tshs 80, 000 the amount which is almost similar to the minimum salary rates paid currently to government workers. the household income from charcoal per year have been changing, for example, in 1992 in eastern Tanzania was USD 176 (Monela *et al.*, 1993),in 1996 it was USD 445 (Monela *et al.*, 1993), while in 2002 it was USD 645 (CHAPOSA, 2002).

The household income from charcoal in the study area is higher compared to the past incomes reported in Tanzania. This profit margin is probably the reason for 57% of the interviewed households being involved in charcoal extraction as their main source of income. The obtained income may be attractive enough even to other households to join the business, and thus resulting to more degradation of the woodland. However the existing and large market for charcoal in Dar es salaam city may be another attraction for the involvement of large number of households in charcoal extraction

6.4.2. Environmental effect of charcoal extraction

Charcoal extraction sites are increasing from settlements to woodlands due to search of preferred tree species for charcoal production. About 93% of interviewed charcoal extractors reported that the distance from where they were previously extracting charcoal has been increasing at fast rate. Furthermore, preferred species was reported to be a reason which makes charcoal extractors move from one kiln site to another, creating therefore a room for empty holes/pits. Charcoal extractors who did not move are usually using any available tree species without any choice. Depletion of tree species in the woodlands results in environmental degradation to areas where charcoal kilns were left open. Therefore, spatial-temporal movements of charcoal extractors are implying woodland cover fragmentation

6.4.3. Preferred and used tree species for charcoal making

About 100 % of the interviewed charcoal makers do select suitable tree species for charcoal making. Based on the study results, the first four preferred tree specie are: - Julbernadia globiflora, Combretum zeyheri, Brachstegia boehmii and Tamarindus indica. Julbernadia globiflora were the most used because of its availability and easy to cut when preparing small logs. About 59% of the interviewed charcoal extractor they preferred these species due to high calorific value and do not break easily during transportation.

According to study which was done by (CHAPOSA, 2002; Malimbwi, R.E and Zahabu, E., 2008; Zahabu, 2001) also indicate that, particular species are preferred for production of charcoal due to high calorific value and which do not break easily during transportation. Charcoal with high calorific value attracts market and hence more income to charcoal makers.

In reality charcoal makers were using a wider variety of species, apart from their top four preferred other species mentioned were, Combretum adonogonium, Sclerocarya birrea, Acacia nigrensis and Terminalia mollis.

However, it was observed that those preferred tree species for charcoal making are no longer available at shorter distance from the village; the distance has been increasing every now resulting to scarcity of preferred tree species. The depletion of tree species with increase in distance is an indicator of over exploitation of woodland which has been occurring in the study area. The results are being supported by CHAPOSA (2002),who reported that it is common to observe charcoal production areas been increasing overtime due to depletion of nearby charcoal sources. For example in 1970's the distance from Dares salaam to charcoal sources was around 50 km but in 1990's increased up to 200 km The same pattern was observed in Dakar Senegal where the supply of charcoal was coming from a distance of over 300 km .

The present species reported do differ form the preferred species reported by CHAPOSA (2002). The difference in preference might be attributed to the fact that charcoal activities are spatial-temporal, they change with time. This means that a species was preferred by 5 years back is no longer available within a vicinity of far distance, thus extractors change the preference to other species

6.5. Land cover mapping

Land cover mapping was done to assess the land change for 2000 and 2007. An overall accuracy of 74.29% was obtained. This accuracy is acceptable in land cover classification (de Leeuw, 2008). Additionally, thresholds for accuracy depends on the purpose of classification and the particular classes you are working with (Foody, 2002). Based on the classified landcover, the lower accuracy below the threshold proposed by Campbell (2002) can be due to indifferences between the field samples and the date when the image was acquired. The Aster image was acquired in June 2007, and the field data were collected in October 2008. It is apparent that the difference of 15 months could have contributed to this accuracy. However, the classified land cover map served its purpose as the woodland classes were classified above and/or close to the proposed threshold.

There was a remarkable decrease in riparian woodlands over the seven years. Riparian woodlands decreased from 1518.39 ha to 547.59 ha, accounting for an annual loss of 2.23%. This loss of riparian woodlands can be explained by the fact that the area has large mixed trees which are targeted by charcoal extractors to meet the market demand. Regeneration of the cut trees accounts for the 330ha gained in this class over the seven years. Other studies have shown miombo woodlands regenerate faster when confronted by human activities such as fire and tree cutting (Luoga, 2004), and the presence of large trees attracts charcoal extractors, as normally they are look for trees from which they can maximize their profit (Mugasha, 1996.).

A very slight change was observed in the closed woodlands. The woodlands (closed) shrinked at a rate of 0.05% per annum within the temporal scale of seven years. This small change can be attributed to the fact that, most of the closed woodland areas belong to either the village forest reserve and/or government forest such as SUA Training Forest Reserve which they are well protected woodlands compared to other type of woodlands in the study area (Malimbwi, 2001). Being protected areas, the small reduction can also be attributed to encroachers. We can infer that the slow reduction of woodlands at the observed rate would not affect the closed woodlands. However, there was gain of 948 ha for the period of seven years. The gain is linked to regeneration of cut trees by charcoal extractors. There was also decrease in farmland areas in the past seven years; again this decrease is believed to be caused by extraction of some trees for charcoal making after depletion of available tree species in the other woodlands. Not only this, but also people they have been opening up areas for agriculture, although agriculture has been decreased for the past five years as reported in the socio-economic survey in the present study. Bare areas decreased at a rate of 0.63% per annum, the decline is likely due to the impact of district tree planting campaign around homesteads. Regeneration of trees is another reason for the decline of bare areas.

There has been an increased area of open woodlands for the span of 7 years. Open woodlands gained an annual increment of 0.75 %. By 2000 open woodlands had 1633.59 ha and by 2007 it had covered 1958.22 ha. Increment of open woodlands can be explained by several factors. For example, reduction in riparian and closed woodlands might have contributed to increased area covered by open woodlands. Open woodland within the study area are covered by species which have high regeneration rate. It is well known that, miombo woodlands recover at a faster rate when confronted with human disturbances such as frequent wild fires caused by farming activities or wild honey collectors (Luoga, 2004).The results are supported by CHAPOSA (2002) who found that, charcoal activities occurred much in relatively open woodlands, and fuelled regeneration of miombo woodlands through coppicing. Therefore there can be a link between increase in open woodland and charcoal extraction activities.

6.6. Spatial distribution of charcoal kiln points in the study area

Figure: 5-4 and 5-5 shows spatial distribution of charcoal points in 2007 and 2000. Results show that charcoal extraction is concentrated in the North West part of the study area. The concentration of charcoal kilns on that area can be explained by the fact that the area is away from the village, thus it is relatively safer for illegal charcoal extractors to charcoaling without being easily noticed by village authority and forest officers. This is supported by previous study in Kitulangalo that an increased distance from roads is associated with much more charcoal and other forms of illegal activities (CHAPOSA, 2002; Malimbwi, 2005).

Decreased number of kilns points in riparian woodland, closed woodlands and farmland in 2007 can be associated with the decrease in number of preferred species for charcoal extraction. Another possible reason is due to the fact that some portion of these areas belongs to private land owners. This led to decreased extraction on these areas because owners are very strict to encroachers. Increased number of kilns in open woodlands in 2007 is due to increased number of preferred species in these types of woodlands. After restriction from owners of private woodlands charcoal extractors moved to open woodlands. The increased in number can also be supported by the fact that miombo woodlands tend to regenerate fast following human related disturbance such as fire and logging (Luoga, 2004). The other reason is the fact that the open area belongs to village land which refers to open access regime (Zahabu, 2001). Also, the area covered by open woodland is relatively large as compared to other areas thus we expect high number of human related disturbances activities. Interestingly, by 2007 some charcoal activities were also done in close to settlement area, particularly for those people who are having woodlands in closer to their home and/or farms. Other reasons for the observed spatial distribution could also be attributed to reasons such as availability of kilns construction materials and supporting soil type. These reasons have been also mentioned by previous study (Monela, 2004; Zahabu, 2001)

6.7. Reasons for moving from one production site to another

Analysis of factors responsible for shifting from one production area to another was assessed. The main driving force for this was availability of species preferred for charcoal extraction. The same was reported by Zahabu (2001) who reported that charcoal extractors are driven by species availability. Species availability driven demand has been also reported by (Monela *et al.*, 1999). Soil type also plays an important role in contributing shifting of charcoal activities from place to place. Charcoal extractors search for moist clay soil which is easy for them to prepare charcoal kilns.

In summary, the present study has provided important information and can potentially applied to seek for sustainable management of woodlands. The role of stakeholders, mainly primary stakeholder should not be ignored when seeking protection of woodland and forest resources. Primary stakeholders are the one which are closer the resource. Denying access to these resources wouldn't be a case so long as they don't have alternative livelihood strategies or if they are not full engaged in managing these resources. Local (District) and Central governments should work in conjunction with local people to manage these resources. The government on the other hand should look for an alternative to lower tariffs for cooking fuels and electricity. This might reduce people dependence on charcoal which has been a destructive activity within the study area and somewhere in the country.

Regulation enforcement seems a problem, laws and by-laws exist but the present study provided evidence of weak implementation of these laws. The inefficient implementation of these laws gives the local people (charcoal extractors in particular) an opportunity to use woodland and forest products. Land cover has been converted from one type to another within the time frame the present study looked at. Most of landcover types have shrinked due to different human related activities, particularly charcoal extraction. It has been witnessed that in 2007 some charcoal kilns were in farmland or closer to human settlement. Shift of charcoal kilns from one point to another have some detrimental effects to the environmental like degradation. For example, empty charcoal kilns are left unfilled.

The approach of CBFM ties well with the other strategies suggested by CHAPOSA (2002) in charcoal production areas: promotion of sustainable charcoal production, price adjustments, and adoption of efficient charcoal production technologies. For it to work in an effective way the whole village land has to be put in a proper land use management plan with proper mapping and detailed use categories. This will facilitate better use of the still remaining general land within the village that is outside village forest reserves. The Ruvu fuel project is collaborative whereby the government has apportioned degraded forest land to villagers who plant trees for fuel wood under the guidance of the government since late 1990s. The project seems to be successful. On the other hand something should be done on the charcoal consumption side. The suggested strategies of provision of direct energy subsidies, promotion of fuel substitution, and adoption of energy efficient technologies should be given enough thought for their possible adoption.

6.8. Limitations of the study

The main limitations of this study were:
Ground data for 2008 was used with a 2007 satellite image since the available 2008 image was occupied with clouds. Haze effect to a satellite image of 2007 used in this study was another limitation. A mismatch of these datasets is the likely factor for the low accuracy.

7. CONCLUSION

This chapter covers conclusions of the study in line with research objectives. Based on the results findings, the research has answered the questions

The research has successfully assessed the spatial-temporal effects of charcoal extraction on public woodlands. This was achieved through participatory approaches and land cover analysis. Participatory approach enabled this research to obtain information on the effects of charcoal extraction on public woodland. This approach facilitated analysis of stakeholders on their identification, perception on legal regulations and their socio economic benefits from charcoal extraction. Change detection analysis revealed evident decreases in riparian and closed woodland that were more than the gain per year, while open woodlands maintained an increase of their coverage. Methodology adopted in this research has played an important role to achieve the main objectives.

Specific Objective 1: **To identify the stakeholders involved in charcoal extraction in the public woodland**

This study was able to identify twenty one (21) stakeholders in the study area based on their interest, influence and impacts as well as existing conflicts of interest on the resource at stake. These stakeholders were further summarized and grouped into three sub categories. Among the identified stakeholders, central and local government have high influence on protection of the woodlands, while charcoal extractors, traders and transporters contribute to depletion of the woodland resources. For land owners and other stakeholders in the same category, they are seen to have less impact on the woodland. The scale of conflict of interest between the stakeholders is thus seen to be high.

Specific objective 2: **To describe the legal regulations governing charcoal production and stakeholders' perceptions.**

Three regulations pertaining to charcoal extraction were identified in the study area. These regulations were Forest Act (2002), Morogoro district council by-laws and Gwata-Ujembe village by-laws. The identified by-laws are implemented in different ways to intervene illegal extraction of charcoal and other woodland resources. Laws involve use of primary and district courts to fine illegal charcoal extractors. The continued illegal charcoal extraction activities in the study area is a manifested of poorly enforced forest laws by the concerned authorities. Positive and negative perceptions on the rules governing charcoal production were identified. Enforcing authorities perceive the established forest regulations positively and find them suitable to regulate charcoal extraction, while extractors, traders and transporters perceive these regulations negatively.

Specific Objective 3: **To determine the impacts of charcoal extraction in the study area**

Findings from the study revealed that, 80% of charcoal extractors depend on charcoal extraction as the source of income and 20% as employment. Effects of charcoal extraction on the environment include: depletion of woodland and forest resources where charcoal making is intensified and, environmental degradation through abandoned charcoal kilns and charcoal wastes. All these were attributed to charcoal extraction activities in the area. Four species were identified as most preferred for charcoal extraction.

Specific objective 4: **To assess land cover change, identify and map areas used for charcoal extraction**

Assessment of land cover changes (2000 – 2007) showed an increase in the area covered by open woodlands in all years while a decrease was evident in the rest of land cover. The total change in all land cover is 2.52% per year. The increase in open woodlands is associated with decrease in other classes. Land cover changes were found to originate from charcoal extraction activities. Additionally, depletion of preferred tree species for charcoal extraction increased with increase in distance from the road and settlements. The spatial-temporal distribution of charcoal extraction areas revealed that, most of charcoal kilns are concentrated on the north-west part of the study area in open woodland. Spatially, charcoal extraction activities change from year to year. The different reasons for such change have been reported as availability of preferred tree species and availability of materials used for charcoal extraction. Moist clay soil is also preferred for making charcoal kilns and this contributes to influence on the spatial distribution of charcoal extraction activities.

8. RECOMMENDATION

The following recommendations are put in place for Gwata-Ujembe village, local and central government.

- Charcoal demands originate from big cities near the study area; there is need for urban dwellers to minimize wood energy consumption rates through development of alternative source of energy. For example, use of kerosene stoves or charcoal improved stoves and reduction in fuel and electricity tariffs. If these can be followed, it is likely woodland degradation due to charcoal extraction will decrease.
- There is need for capacity building (training) for local communities on existing forest law enforcement and sustainable management of woodland resources in the study area. This is based on general observations from both interviews and focused discussions with village leaders that local communities lacked knowledge on law enforcement
- Facilitate local people on protecting woodlands and forest resources by providing and/or encouraging tree planting. This would contribute to protect the environment.
- Involvement, enhancement and/or establishment of community based forest management projects. This will built a sense of participatory in natural resources management and reduce the idea of considering public woodlands and forests as common access regimes.
- Increasing awareness to the public on role played by woodlands and forest in supporting the environment from which human people depends upon.
- Charcoaling is currently banned in Morogoro district, even if allowed; extractors should have to look for better charcoal making methods. Poor charcoal making methods leads to kiln inefficiency, thus more trees are used for production of certain amount of charcoal which could be produced by few trees.
- Alternative livelihood strategies are recommended for the local communities in Gwata – Ujembe village, this could reduce dependency on woodland as source of livelihood.

9. REFERENCES

Abbot, P., Lowore, J., Werren, M. (1997). Models for the estimation of single tree volume in four Miombo woodland types. Forest Ecology and Management **97**(1): 25-37.

Abdallah, J. M. and Monela, G. G. (2007). Overview of Miombo Woodlands in Tanzania. MITMIOMBO Project Workshop. SUA Morogoro, Tanzania. **50**.

Abdallah, J. M. and Sauer, J. (2007). Forest Diversity, tobacco production and resource management in Tanzania. Forest Policy and Economics **9**(5): 421-439.

Bhandari, B. B. (2003). Participatory Rural Appraisal.

Binns, T., Hill, T. and Nel, E. (1997). Learning from the people Participatory rural appraisal, geography and rural development in the 'new'South Africa. Applied Geography **17**(1): 1-9.

Campbell, B. M. (1996). The Miombo in Transition: Woodlands and Welfare in Africa, Center for International Forestry Research.

Campbell, B. M., Angelsen, A., Cunningham, A., Katerere, Y., Sitoe, A., Wunder, S. (2007). Miombo woodlands–opportunities and barriers to sustainable forest management.

Campbell, J. B. (2002). Introduction to Remote Sensing London, Taylor & Francis.

Casley, D. J. a. K., K (1988). The collection, Analysis and Use of Monitoring and Evaluation Data.

Chambwera, M. and Folmer, H. (2007). Fuel switching in Harare: An almost ideal demand system approach. Energy policy **35**(4): 2538-2548.

CHAPOSA (2001). Charcoal Potential in Southern Africa. Forest Policy and Economics.

CHAPOSA (2002). Charcoal Potential in Southern Africa. INCO_DEV: International cooperation with developing countries (1998-2002)
Forest Policy and Economics.

Chidumayo, E. N. and Kwibisa, L. (2003). Effects of deforestation on grass biomass and soil nutrient status in miombo woodland, Zambia. Agriculture, Ecosystems and Environment **96**(1-3): 97-105.

Christy, L. C. (2007). Forest Law and Sustainable Development: Addressing Contemporary Challenges Through Legal Reform, World Bank Publications.

de Leeuw, J. (2008). Kappa, Lecture handout. Enschede, International Institute for Geoinformation Science and Earth Observation (ITC).

der Gier, A. (2004). Sampling Concepts and how to handle them. Enschede, : Lecture Handout, International Institute for Geo Information Science and Earth Sciece and Earth Observation.

Dougill, A. J., Fraser, E. D. G., Holden, J., Hubacek, K., Prell, C., Reed, M. S., Stagl, S. and Stringer, L. C. (2006). Learning from Doing Participatory Rural Research: Lessons from the Peak District National Park. Journal of Agricultural Economics **57**(2): 259-275.

Ericson, J. A. (2006). A participatory approach to conservation in the Calakmul Biosphere Reserve, Campeche, Mexico. Landscape and Urban Planning **74**(3-4): 242-266.

Evans, K., Wil de Jong, Peter Cronkleton, Douglas Sheil, Tim Lynam, Trikurnianti Kusumanto, Carol J. Pierce Colfer (2006). Guide to Participatory Tools for Forest Communities. Bogor Barat, Center for International Forestry Research (CIFOR).

Foody, G. M. (2002). Status of land cover classification accuracy assessment. Remote Sensing of Environment **80**(1): 185-201.

Frost, P. (1996). The ecology of miombo woodlands. The miombo in transition: Woodlands and welfare in Africa. In: Campbell, B., (Ed.), Center for International Forestry Research, Bagor, pp.11-57.

Grimble, R. and Wellard, K. (1998). Stakeholder Methodologies in Natural Resource Management. Socio-economic Methodologies. Best Practice Guidelines. Chatham.

Grimble , R. J. and Chan , M.-K. (1995). Stakeholders analysis for natural resources

Groenendijk, E. M. C. and Dopheide, E. J. M. (2003). Planning and management tools, The International Institute for Geo- Information Science and Earth Observation (ITC) The Netherlands.

Herd, A. (2007). Exploring the Socio-economic role of charcoal and the potential for sustainable charcoal production in the Chicale Regulado, Mozambique Edinburgh, U.K, University of Edinburgh. **MSc:** 76.

Hibajene, S. H. and Ellegård, A. (1994). Charcoal transportation and distribution: a study of the Lusaka market. Energy, Environment and Development Series **33**.

Hiemstra-van der Horst, G. and Hovorka, A. J. (2002). Reassessing the "energy ladder": Household energy use in Maun, Botswana. Energy policy **In Press, Corrected Proof**.

Iddi, S. (2002). Community participation in forest management in the United Republic of Tanzania.

Iddi, S. and Hakan, S. (1998). Managing Natural Forests at the village level. Reacting ultimate Development goal. A paper presented in 2nd Forestry Research Workshop. Sokoine University of Agriculture Olmotonyi Training Forest Arusha, Tanzania.

Kaale, B. K. (2005). Baseline Study on Biomass Energy Conservation in Tanzania. SADC Programme for Biomass Energy Conservation (ProBEC). Tanzania, Ministry of Energy and Minerals**:** pp. 41.

Kajembe, G. C. L., E.J (1996). Socio-economic aspects of tree farming in Njombe district.

Lillesand, T. M. and Kiefer, R. W. (1994). Remote Sensing and Image Interpretation, New York, Wiley & Sons.

Lu, D., Mausel, P., Brondi´zio, E. and .., a. M. E. (2004). Change detection techniques. 25(12): 2365 – 2407.

Luoga, E. J., Kajembe, G. C. and B.S, M. (2005). Impact of Joint Forest Management on Handeni Hill Forest Reserve andAdjacent Communities in Tanga, Tanzania.

Luoga, E. J., Witkowski, E. T. F. and Balkwill, K. (2000). Economics of charcoal production in miombo woodlands of eastern Tanzania: some hidden costs associated with commercialization of the resources. Ecological Economics **35**(2): 243-257.

Luoga, E. J., Witkowski, E. T. F., Balkwill, K. (2000). Economics of charcoal production in miombo woodlands of eastern Tanzania: some hidden costs associated with commercialization of the resources. Ecological Economics **35**(2): 243-257.

Luoga, E. J., Witkowski, E. T. F., Balkwill, Kevin (2002). Harvested and standing wood stocks in protected and communal miombo woodlands of eastern Tanzania. Forest Ecology and Management **164**(1-3): 15-30.

Luoga, E. J., Witkowski, E. T. F., Balkwill, Kevin (2004). Regeneration by coppicing (resprouting) of miombo (African savanna) trees in relation to land use. Forest Ecology and Management **189**(1-3): 23-35.

Makundi, W. R. and Okiting'ati, A. (1995). Carbon flows and economic evaluation of mitigation options in Tanzania's forest sector. Biomass and Bioenergy **8**(5): 381-393.

Malimbwi, E. R., Zahabu, E., Gc, K. and Luoga, E. J. Contribution of Charcoal Extraction to Deforestation: Experience from CHAPOSA Research Project.

Malimbwi, R. E., and Mugasha, A.G. (2001). Inventory Report of Kitulangalo Forest in Morogoro, Tanzania. Consultant report to the Forest and Beekeeping Division, Dar es Salaam.

Malimbwi, R. E., Misana, S., Monela, G. C., Jambiya, G. and Zahabu, E. (2000). Impact of Charcoal Extraction to the Forest Resources of Tanzania. The case of Kitulangalo area, Tanzania.

Malimbwi, R. E. and Zahabu, E. (2008). Woodlands and charcoal trade :The case of Dar es salaam city. Forest utilisation in miombo woodlands. Iringa, Tanzania.

Malimbwi, R. E., Zahabu, E., Monela, G. C. & Misana, S., Jambiya, G. C., Mchome, B. (2005). Charcoal potential of Miombo woodlands at Kitulangalo, Tanzania. Journal of Tropical Forest Science **18 (1)**(121-126).

Malimbwi, R. E. A. L., E.J., Zahabu, E., GC, K. and Luoga, E. J. (2004). Contribution of Charcoal Extraction to Deforestation: Experience from CHAPOSA Research Project.

Mangora, M. M. (2005). Ecological impact of tobacco farming in miombo woodlands of Urambo District, Tanzania. African Journal of Ecology **43**(4): 385-391.

Matose, F. and Wily, L. (1996). Institutional arrangements governing the use and management of miombo woodlands. The miombo in transition: Woodlands and welfare in Africa: 195-219.

McCall, M. K. (2004). "Can participatory GIS strengthen local level spatial planning"? : Suggestions for better practice .2004 : Presented at GISDECO proceedings of the 7th international conference on GIS for developing countries . 10-May 2004, Universities Technology Malaysia, Johor Malasia 19 p. GISDECO. Malaysia.

Mertens, B. and Lambin, E. F. (2000). Land-Cover-Change Trajectories in Southern Cameroon. Annals of the Association of American Geographers **90**(3): 467-494.

Minang, P. A. (2003). Assessing Participatory Geographic Information Systems for Community Forestry Planning in Cameroon: A Local Governance Perspective, International Institute for Geo-Information Science and Earth Observation.

Monela, G. C. and Abdallah, J. M. (2007). Principle Socio-Economic Issues in Utilization of Miombo Woodlands in Tanzania. Proceedings of the First MITMIOMBO Project Workshop. Morogoro, Tanzania, Finnish Forest Research Institute 50: 115-122.

Monela, G. C., Kowero, G. K. and ARS & Kajembe, G. (2000). Household Livelihood Strategies in the Miombo Woodlands of Tanzania: Emerging Trends. Tanzania Journal of Forestry and Nature Conservation **73**: 17-33.

Monela, G. C., O'Kting'ati, A. and Kiwele, P. M. (1993). Socio-economic aspects of charcoal consumption and environmental consequences along the Dar es Salaam-Morogoro highway, Tanzania. Forest Ecology and Management **58**(3): 249-258.

Monela, G. C., Zahabu, E., Malimbwi, R., Jambiya, G. and Misana, S. (1999). Socio-economics of Charcoal Extraction in Tanzania: A Case of Eastern Part of Tanzania, CHAPOSA, Stockholm Environmentalt Institute, Stockholm, Sweden. 13pp.

Monela, G. C. Z., E, Malimbwi, R.E, Jambiya, G. and Misana, S. (2004). Socio-economics of charcoal extraction in Tanzania: A case of Kitulangalo, Tanzania.

Mugasha, A. G. (1996.). Silviculture in Tropical natural Forests with special reference to Tanzania.

Mugasha, A. G., Chamshama, S. A. O., Gerald, V. V. K. (2004). Indicators and Tools for Restoration and Sustainable Management of Forests in East Africa.

Mugo, F. and Ong, C. (2006). Lessons from eastern Africa's unsustainable charcoal business.

Mwampamba, T. H. (2007). Has the woodfuel crisis returned? Urban charcoal consumption in Tanzania and its implications to present and future forest availability. Energy policy **35**(8): 4221-4234.

Nhantumbo, I. and Kowero, G. (2001). A goal programming model for planning management of Miombo woodlands. Modelling methods for policy analysis in miombo woodlands. Occasional Paper**:** 5-15.

Ramirez, R. (1999). Stakeholder analysis and conflict management. Cultivating Peace: Conflict and Collaboration in Natural Resource Management: 101-126.

Schensul, J. J. (1999). Enhanced Ethnographic Methods: Audiovisual Techniques, Focused Group Interviews, and Elicitation Techniques, Rowman Altamira.

Shrestha, D. P. and Zinck, J. A. (2001). Land use classification in mountainous areas: integration of image processing, digital elevation data and field knowledge (application to Nepal). International Journal of Applied Earth Observations and Geoinformation **3**(1): 78-85.

Tardie, P. S. and Congalton, R. G. (2004). A change-detection analysis: using remotely sensed data to assess the progression of development in Essex County, Massachusetts from 1990 to 2001.

URT (2006). Participatory Forest Management: Facts and Figures.

URT (2002). Population and Housing Census, Ministry of Lands and Housing, Dares salaam Tanzania.

URT (1998). Tanzania Forest Policy. Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism, Dar es Salaam.

van Beukering, P., Kahyarara, G., Massey, E., di Prima, S., Hess, S., Makundi, V. and van der Leeuw, K. (2007). Optimization of the Charcoal Chain in Tanzania, PREM Working Paper 07/03. .

Waters-Bayer, A. and Bayer, W. (1994). Planning with pastoralists: PRA and more. A review of methods focused on Africa. Eschborn: GTZ, OE. **422:** 153.

Wilkie, D. S. and Finn, J. T. (1996). Remote Sensing Imagery for Natural Resources Monitoring: A Guide for First-Time Users, Columbia University Press.

Wily, L. (1998). The legal and the political in modern common property management: Re-making communal property in Sub-Saharan Africa with special reference to forest commons in Tanzania.

Wily, L. A. (2000). Forest law in eastern and southern Africa: moving towards a community-based forest future? UNASYLVA-FAO-: 19-26.

Wily, L. A. and Mbaya, S. (2001). Forest management and democracy in East and Southern Africa: lessons from Tanzania, IIED, International Institute for Environment and Development.

Zahabu, E. (2001). Impact of charcoal extraction on the miombo woodlands: The case of Kitulangalo area, Tanzania. Morogoro, Tanzania, Sokoine University of Agriculture. **MSc thesis:** pp 74.

10. APPENDICES

Appendix 1: House hold questionnaire

HOUSEHOLD QUESTIONNAIRE FORM: FIELDWORK AT GWATA-UJEMBE VILLAGE

Date……
District name……
Division……....
Ward……
Village……Sub-village……..
Name of head of household……..

PART 1: RESPONDENT GENERAL INFORMATION:

1. Gender of respondent: (a) Male (b) Female

1.1 Age of respondent
- (a) 18-35 years
- (b) 36-55 years
- (c) 56-75 years
- (d) 76 and above years

1.2 Are you the head of a household? YES / NO

1.3 Where you born in this village? YES / NO

1.4 Ethnicity/tribe of respondent: ……..

1.5 What is your education level?
- (a) No education
- (b) Informal education
- (c) Primary Education
- (d) Others

1.6 How many people live in your household?
- (a) 1-5 people
- (b) 6-10 people
- (c) 11 people and above

1.7 Respondent's main source of income in previous years (5 yrs back)
- (a) Farming/ Agriculture/Livestock
- (b) Micro economic activities
- (c) Salary/Wages
- (d) Beekeeping/Fishing
- (e) commercial/Charcoal selling
- (f) Others (specify)……..……

1.8 Respondent's main source of income (Currently)
- (a) Farming/ Agriculture/Livestock
- (b) Micro economic activities
- (c) Salary/Wages

(d) Beekeeping/Fishing
(e) commercial/Charcoal selling
(f) Others (specify)…….……

PART: 2 CHARCOAL EXTRACTION ACTIVITIES:-

1.1 Is there any forest around your village? (a) YES (b) NO
If YES, who owns or manages it?

Forest type	**ownership**
Government	
Community (village forest reserve)	
Public land	
Both	

1.2 How do you consider the present state of forest around the village?
(a) GOOD
(b) BAD If BAD why?
1.3 What was the state of the forest in your area like 10 years ago?
(a) GOOD
(b) BAD
1.4 Why was it better or worse? / How will it be in the future?
1.5 Are you involved in charcoal extraction?
1.6 Why are you interested in this business of charcoal?
1.7 What forces made you engage in charcoal extraction?
1.8 When did you start the charcoal extraction?
1.9 Are you working under contract production? No/ Yes
If yes who owns the business ……and where he/she stays……..
2.0 Are you allowed to extract charcoal were you want?
2.1 For what purpose do you produce charcoal?
2.2 Do you use charcoal for home consumption?
2.3. How many bags do you use per month?
2.4 Do you have a licence to make charcoal? YES/NO
2.5 How do you obtain such a licence?
2.6 Do you know the rules used to regulate the exploitation of woodlands for charcoal making and who makes them?

Regulation/rules	**Who make them**

2.7 What is the best tree species used for charcoal making and reason of preferring?
2.8 Do you always use these tree species?
2.9 Which parts of the trees do you use?
3.0 For how long have you been occupying the site?
3.1 For how long can you continue to be there?
3.2 Is there any change in tree species availability?
3.3 Where will you go next?
3.4 Where do you sell your charcoal and the current the market prices?

Name of market place	Price (T shs /bag, tin or can)
(i) Charcoal making site	
(ii) Road side	
(iii) Village	
(ii) Morogoro	
(iii) Dar es Salaam city	

3.5Who are your customers? .....

3.6 How many bags do you sell per day?

Number of bags	
0 -5	
10-20	
> 20	

3.7 How long does it take to sell your charcoal.....? days?

3.8 What makes you move from to the next charcoal making site?

3.9 Has the distance from the village to charcoal extraction site increased over the last ten years?

(a) YES

(b) NO If Yes, why?

4.0 Is charcoal making continuous thought the year or specific in the given season?

(a)YES

(b) NO If NO specify?

4.1 How long it takes you to burn your charcoal kiln?

Days used for wood cutting ……

Days for kiln preparation ……..

Days for combustion……

Days for unloading…….

4.2 Is your kiln burns well and produce high quality charcoal?

4.3. If not what is the reason?

4.4. How many kilns you can make……. a year?

4.5. Quantity of charcoal produced …… bags per kiln

4.6 Is charcoal scarce today than previous years? (a) YES (b) NO

If YES why?

4.7 Are there any conflicts within your charcoal extraction activities? (a)YES (b) NO

If YES of what nature?

4.8 What are the effects of charcoal extraction to the environment in this village?

4.9 What are the difficulties you face at the moment for extraction charcoal?

5.0 Was it easier 10 years back? How will it be in the future?

Appendix 2: Focus group discussion checklist

1. Types and extent of forest/ woodlands in the study area
2. What are the threats to woodlands in the study area
3. Is charcoal extraction allowed in this village?
4. Who are the main actors involved in charcoal extraction /business and their trends
5. Trends in charcoal prices (What are the prices at different sites)
6. How are the regulations on charcoal extraction perceived by the communities?
7. Attitude towards community in participatory forest management
8. What are the effects of charcoal extraction to the woodlands in the study area?

9. Conflicts between stakeholders involved in charcoal extraction
10. What are the main economic activities in the study area

Appendix 3: Change matrix

Landsat 2000	Aster 2007	Class name	Area (ha)
1	1	Unchanged	217.71
1	2	Riparian to Closed woodland	295.29
1	3	Riparian to Open woodland	252.99
1	4	Riparian to Farmland	223.65
1	5	Riparian to Bare/Settlements	171.81
1	6	Riparian to Unclassified	356.94
2	1	Closed to Riparian	104.40
2	2	Unchanged	267.66
2	3	Closed woodland to Open woodland	383.49
2	4	Closed woodland to Farmland	166.95
2	5	Closed woodland to Bare/Settlements	128.70
2	6	Closed woodland to Unclassified	188.46
3	1	Open woodland to Riparian	103.41
3	2	Open woodland to Closed woodland	287.73
3	3	Unchanged	957.60
3	4	Open woodland to Farmland	112.77
3	5	Open woodland to Bare settlements	101.07
3	6	Open woodland to Unclassified	71.01
4	1	Farmland to Riparian	62.37
4	2	Farmland to Closed woodland	204.21
4	3	Farmland to Open woodland	305.37
4	4	Unchanged	152.10
4	5	Farmland to Bare/Settlements	95.13
4	6	Farmland to Unclassified	157.32
5	1	Bare/ Settlements to Riparian	59.67
5	2	Bare/ Settlements to Closed woodland	161.01
5	3	Bare/Settlements to Open woodland	58.77
5	4	Bare/Settlements to Farmland	164.61
5	5	Unchanged	70.74
5	6	Bare/Settlements to Unclassified	326.52

Appendix 4: Summary-Land cover change (Matrix) during 2000-2007

SN	Class name	Area Change (ha)	Percentage (%)
1	Changed to Riparian woodland	330	5.31
2	Changed to Closed woodland	948	15.27
3	Changed to Open woodland	1001	16.11
4	Changed to Farmland	668	10.76
5	Changed to Bare /settlements	497	8
6	Unclassified	1100	17.72
7	Unchanged	1666	26.83
	Total	**6209**	**100**

Appendix 5: Land cover sample points

Land cover sample points			
ID	**EASTINGS**	**NORTHINGS**	**REMARKS**
1	389258	9265681	Open woodlands
2	390845	9264447	Open woodlands
3	387231	9273514	Open woodlands
4	385981	9266853	Open woodlands
5	389323	9263962	Closed woodlands
6	386259	9272453	Open woodlands
7	385946	9267962	Open woodlands
8	392693	9263345	Open woodlands
9	387720	9272241	Open woodlands
10	386023	9269399	Open woodlands
11	388788	9268712	Farm lands
12	388973	9272198	Open woodlands
13	386081	9268773	Riparian woodlands
14	386860	9266665	Open woodlands
15	390043	9265414	Open woodlands
16	386013	9269785	Open woodlands
17	390336	9269286	Open woodlands
18	386740	9270495	Open woodlands
19	387420	9273059	Open woodlands
20	388820	9271532	Riparian woodlands
21	386301	9268014	Open woodlands
22	390023	9264984	Open woodlands
23	388747	9268016	Open woodlands
24	395260	9266005	Closed woodlands
25	389322	9272274	Riparian woodlands
26	385802	9270882	Farm lands
27	390371	9270343	Open woodlands
28	390775	9268094	Closed woodlands
29	388758	9271916	Riparian woodlands
30	385546	9270298	Open woodlands
31	385272	9270272	Open woodlands
32	386927	9268464	Open woodlands
33	386919	9268154	Open woodlands
34	387430	9268587	Open woodlands
35	387281	9268328	Open woodlands
36	388748	9267538	Farm lands
37	388472	9266992	Farm lands
38	389834	9266695	bare
39	390659	9266628	Open woodlands
40	390568	9266297	Open woodlands
41	390802	9265744	Closed woodlands
42	391033	9265830	Open woodlands
43	391129	9265224	Closed woodlands
44	391458	9265266	Open woodlands
45	392386	9265222	Farm lands
46	392669	9264805	Farm lands
47	390513	9268485	Riparian woodlands
48	391427	9266803	Riparian woodlands
49	391156	9266240	Riparian woodlands
50	393362	9265159	Riparian woodlands
51	393394	9264124	Bare lands
52	393326	9264739	Bare lands
53	392154	9264525	Bare lands
54	391562	9264964	Bare lands
55	391432	9264457	Closed woodlands

56	390387	9264356	Closed woodlands
57	390134	9266232	Closed woodlands
58	389531	9268324	Closed woodlands
59	390027	9268976	Closed woodlands
60	386952	9272817	Open woodlands

Appendix 6: Location of new charcoal kilns points

No	Eastings	Northings	No	Eastings	Northings	No	Eastings	Northings	No	Eastings	Northings
1	388107	9268220	41	387730	9269202	81	386282	9269168	121	386118	9270589
2	388135	9268269	42	387610	9269153	82	386238	9269155	122	386198	9270411
3	388201	9268315	43	387615	9269143	83	386030	9269336	123	386195	9270405
4	387804	9268375	44	387650	9269083	84	386019	9269257	124	386266	9270325
5	387764	9268310	45	387668	9269068	85	386020	9269241	125	386260	9270255
6	387789	9268311	46	387568	9269060	86	385943	9269566	126	386275	9270222
7	387796	9268244	47	387486	9268967	87	385941	9269604	127	386138	9270319
8	387837	9268240	48	387383	9269141	88	385935	9269646	128	386102	9270294
9	387839	9268252	49	387389	9269195	89	385916	9269664	129	385958	9270569
10	387763	9268208	50	387414	9269226	90	385937	9269708	130	385962	9270661
11	387737	9268213	51	387203	9269200	91	385990	9269761	131	385858	9270609
12	387680	9268180	52	387159	9269159	92	386083	9269933	132	385748	9270595
13	387664	9268131	53	387143	9269194	93	386090	9269967	133	385772	9270518
14	387666	9268125	54	387123	9269110	94	386123	9269992	134	385802	9270500
15	387636	9267999	55	387126	9269163	95	386191	9270004	135	385903	9270491
16	387469	9268392	56	387049	9269078	96	386093	9270111	136	385453	9270353
17	387469	9268398	57	387050	9269088	97	386041	9270095	137	385427	9270455
18	387531	9268495	58	387046	9269120	98	385951	9270082	138	385402	9270478
19	387472	9268515	59	387027	9269210	99	385918	9270024	139	385325	9270533
20	387316	9268331	60	386324	9268361	100	385818	9270018	140	385359	9270598
21	387218	9268264	61	386256	9268389	101	385775	9270044	141	384825	9271740
22	387201	9268274	62	386241	9268377	102	385757	9269998	142	385295	9271571
23	386635	9268739	63	385963	9268346	103	385777	9269948	143	385544	9271407
24	386368	9269032	64	386016	9268290	104	385673	9269917	144	385263	9271942

25	386336	9268961	65	386046	9268313	105	385701	9269886	145	385244	9271929
26	386116	9269305	66	386391	9268990	106	385714	9269863	146	385248	9271974
27	386515	9270654	67	386416	9269115	107	385736	9269866	147	385073	9272301
28	386729	9270596	68	386387	9269108	108	385718	9269799	148	385073	9272301
29	386732	9270705	69	386333	9269104	109	385670	9269743	149	385104	9272318
30	386692	9270756	70	386374	9269147	110	385687	9269734	150	385191	9272461
31	386767	9270815	71	386395	9269172	111	385743	9270284	151	385298	9272450
32	386685	9270884	72	386437	9269187	112	385772	9270201	152	385444	9272561
33	386728	9271101	73	386486	9269281	113	385778	9270153	153	385438	9272564
34	386714	9271150	74	386479	9269309	114	385877	9270201	154	385463	9272581
35	386505	9268743	75	386498	9269450	115	385881	9270219	155	385507	9272705
36	387911	9268889	76	386450	9269483	116	385896	9270372	156	385503	9272741
37	387948	9268890	77	386365	9269432	117	386043	9270312	157	385438	9272804
38	387888	9268969	78	386317	9269291	118	386056	9270397	158	385929	9273274
39	387853	9269039	79	386317	9269285	119	386040	9270421	159	386117	9273484
40	387806	9269054	80	386334	9269267	120	386079	9270513	160	385944	9273475

Appendix 7: Location of old charcoal kilns points

No	Eastings	Northings	No	Eastings	Northings	No	Eastings	Northings	No	Eastings	Northings
1	387664	9268144	33	387935	9268922	65	386219	9270499	97	385675	9272402
2	387678	9268129	34	387907	9268972	66	386195	9270370	98	385720	9272378
3	387697	9268117	35	387658	9269054	67	386252	9270262	99	385822	9272438
4	387700	9268108	36	387630	9269037	68	386159	9270306	100	385831	9272449
5	387684	9268072	37	387594	9269050	69	386153	9270312	101	385860	9272472
6	387645	9268070	38	387490	9269053	70	385966	9270545	102	385960	9272572
7	387630	9268060	39	387400	9269188	71	385887	9270515	103	385974	9272693
8	387615	9268046	40	387371	9269217	72	385815	9270419	104	385941	9272694
9	387646	9268001	41	387320	9269234	73	385725	9270429	105	385987	9272761
10	387413	9268201	42	387246	9269248	74	385706	9270442	106	386011	9272833

11	387408	9268216	43	387102	9269100	75	385631	9270469	107	386027	9272827
12	387404	9268252	44	387035	9269192	76	385516	9270418	108	386027	9272827
13	387455	9268342	45	387021	9269220	77	385499	9270386	109	386029	9272902
14	387451	9268351	46	387033	9269239	78	385500	9270373	110	386062	9272908
15	387522	9268466	47	386961	9269207	79	385494	9270357	111	386074	9272974
16	387536	9268497	48	386903	9269170	80	385434	9270462	112	386082	9273034
17	387446	9268512	49	386541	9268530	81	385393	9270506	113	386122	9273066
18	387440	9268511	50	386463	9268507	82	385281	9270514	114	386134	9273110
19	387400	9268455	51	386403	9268536	83	385316	9270412	115	386194	9273135
20	387369	9268429	52	386367	9268470	84	385178	9271560	116	386346	9273235
21	387362	9268428	53	386370	9268413	85	385200	9271542	117	386500	9273321
22	387359	9268425	54	386052	9268447	86	385308	9271532	118	386523	9273348
23	387368	9268386	55	385989	9268434	87	385381	9271610	119	386545	9273388
24	387413	9268375	56	385982	9268423	88	385403	9271584	120	386427	9273473
25	387394	9268354	57	385995	9268373	89	385543	9271443	121	385430	9270107
26	387381	9268351	58	385835	9269342	90	385565	9271688	122	387749	9270499
27	387331	9268379	59	385999	9269861	91	385947	9271779	123	385060	9270355
28	387293	9268333	60	386113	9269953	92	385943	9271796	124	385077	9270351
29	386714	9270779	61	386145	9269972	93	385726	9271886	125	385100	9270387
30	386714	9270787	62	386176	9270075	94	385200	9271785	126	385141	9270390
31	386741	9270858	63	386151	9270135	95	385669	9272316	127	385158	9270448
32	386687	9270966	64	386196	9270495	96	385676	9272339	128	385152	9270475

Appendix 8: Stakeholder attributes table

No	Stakeholder	Interests	Influence		Impact on woodland
			Charcoal extraction	Woodland protection	Positive/Negative
1	Charcoal extractors of Gwata village	- Firewood trees -Suitable soil for kiln construction - Market	+ +	– –	– –
2	Charcoal extractor of neighbouring villages	- Firewood trees - Suitable soil for kiln construction. - Market	+ +	– –	– –
3	Women	- Firewood	–	–	–
4	Medicinal practitioners	- Medicinal herbs - Bark of trees	–	–	–
5	Honey collectors	- Trees for beehives - Trees for pollination flowers - Beehives	–	–	– –
6	Livestock keepers	- Pasture land - Grass	–	–	–
7	Farmers	- Farm land - Production of food and cash crops - Water	–	–	– –
8	Land owners	- Woodland conservation	–	+	+ +
9	Charcoal traders	- Charcoal	+ +	– –	– –
10	Charcoal transporters	- Business -Charcoal	+ +	– –	–
11	Regional Forest officer (RFO)	- Law enforcement and policy implementation (fines) - Sustainable utilization of forest resources - Conservation of woodland resources - Climate regulation - Catchment river / rainfall	– –	+ +	+ +
12	District forest officer (DFO)	- Law enforcement and policy implementation (fines) - Sustainable charcoal extraction - Forest protection	–	+ +	+ +

13	District Agricultural and Livestock officer (DALDO)	-Climate regulation/rainfall - Water catchment/river	_	+ +	+ +
14	District Commissioner (DC)	- Woodland conservation - Political support - Forest resources conservation	- -	+ +	+ +
15	District Executive Director (DED)	- Forest resources conservation - Enforcement of District by-laws	_	+ +	+ +
16	Village Executive Officer (VEO)	- Enforcement of village by-laws (fines) -Woodland conservation	-	+ +	+ +
17	Ministry of Natural Resources and Tourism (MNRT)	- Establishment of forest policy - Implementation of National forest policy	_	+	+
18	District council (DC)	Fees for charcoal traders Law enforcement	_	+ +	+ +
19	Central government	Fees for charcoal traders	_	+ +	+ +
20	Village government	Fees for charcoal traders	_	+ +	+
21	WAMI-MBIKI society (Local NGO)	- Conservation of the woodlands resource - Sustainable livelihoods	_	+ +	+

INTERPRETATION OF SYMBOLS

++ Very high (Positive) + High (Positive) -- Very low (Negative) - Low (Negative)

Appendix 9: Summary of stakeholders according to their influence and impact on woodland resources

Stakeholder	**Influence and impact**
DALDO, DC, DED, VEO, DFO, District council, Village government, and WAMI MBIKI. Regional forest catchment officer, Ministry of natural resources and tourism.	Very high influence/ Positive impact on the woodlands High impact
Charcoal extractors, charcoal traders and charcoal transporters	Very high influence on charcoal extraction, and very high negative impact on the woodlands (cutting trees)
Land owner, farmers, medicinal practitioners and honey collectors.	Very low influence on charcoal extraction, and low negative impact on woodlands

Appendix 10: Field work pictures at Gwata- Ujembe village (October 2008)

1. Participants of transect work

2. Open woodland

3. Old charcoal kiln located in farmland

4. Household interview

5. Charcoal packing ready for sale

6. Preferred tree specie for charcoal making