IMPACT OF JOINT FOREST MANAGEMENT ON FOREST RESOURCE BASE AND LIVELIHOODS OF COMMUNITIES IN AMANI NATURE RESERVE, MUHEZA DISTRICT, TANZANIA

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN THE MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF THE SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2007ABSTRACT

Joint Forest Management (JFM) is an institutional arrangement considered to be a proper way forward for alleviating forest degradation. However, since the inception of JFM in Amani Nature Reserve (ANR), its impacts to the forest resource base and livelihoods of surrounding communities is not clearly known. Therefore the study assesses the impacts of JFM on both forest resource base and livelihoods of the local communities around ANR. Forest inventory was carried out by laying out 30 sample plots systematically. In the plots, diameter at breast height and heights of all the trees were measured, recorded and tree species were identified. Livelihood attributes were collected using a questionnaire, checklist for key informants and a number of PRA techniques. To assess impact, both inventory and livelihoods data were compared between 2001 and 2005. Microsoft Excel Software was used to analyse quantitative data for various forest parameters. Data collected during PRA were analyzed with the help of the local community. Content and structural-functional analyses were applied to analyse socio-economic qualitative data. Statistical Package for Social Sciences (SPSS) was used to analyse the socio economic quantitative data. Logistic regression analysis model was developed to identify socio-economic factors influencing participation of local communities surrounding ANR in JFM. The study found that 3043 ± 360 (SE) stems per hectare were obtained in 2005 compared to 1762 ± 225(SE)) of 2001 indicating significant increase ($t = 3.09$; $p=0.004$) though, dominated by small diameter class of 2.5-10cm. The basal area and wood volume decreased suggesting that there was tree cutting in ANR. Species diversity indices increased from 3.271 to 3.379 between 2001 and 2005 indicating that the forest is still facing human disturbance. Training sessions in JFM, tree planting, income shared from forest under JFM and engagement of household in economic groups significantly ($p<0.05$) increased the odds of participation of local communities by factors of 17.986, 45.894, 10.658 and 7.671 respectively. Household income and improved housing standards significantly ($p<0.05$) influenced JFM performance. Poor monitoring capability as an indicator of weaknesses in governance contributed to JFM to have negative impact on basal area and wood. The study observed a positive impact on livelihoods. The study among other things recommended improvement of in governance by ensuring transparency and clear responsibilities of Village Natural Resources Committees.

DECLARATION

I, Mwanaidi Said Kijazi, hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work, and has not been submitted for a degree award at any other University.

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DEDICATION

This Thesis is dedicated to my late parents Said and Asha, my brothers Charles and Adam who not only tirelessly endured to lay down the foundation of my education but also devoted much of moral support and financial resources to pay for my education.

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LIST OF ABBREVIATIONS AND SYMBOLS

ANR	Amani Nature Reserve
CBFM	Community Based Forest Management
DBH	Diameter at Breast Height
df	Degree of freedom
H’	Shannon Wiener Index
FBD	Forest and Beekeeping Division
G (m^2/ha)	Basal Area (square meter per hectare)
JFM	Joint Forest Management
ID	Index of Dominance
IVI	Important Value Index
MNRT	Ministry of Natural Resources and Tourism
NGOs	Non-Government Organizations
NS/ha	Number of Stems per hectare
PRA	Participatory Rural Appraisal
Spp	Species
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
TShs	Tanzania Shillings
V (m^3/ha)	Volume (cubic meter per hectare)
VFMA	Village Forest Management Area
VNRC	Village Natural Resources Committee
WCED	World Commission on Environment and Development
US$	US Dollar

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Transfer of power from centre to periphery, with a concomitant giving up authority and responsibilities to local communities is emphasized by Wily (1998). In Tanzania this concept marked the evolution of the concept of Participatory Forest Management (PFM). Forests on the general lands (formerly known as public land) have been under constant pressure for conversion to other competing land uses such as agriculture, livestock grazing, settlements and industrial development and repeated forest fires because of unclear ownership, absence of security of tenure and formal user rights (URT, 2001). The current rate of deforestation in Tanzania is said to be 91 200 ha per annum (URT, 2001) and is attributed to population pressure, poverty, market and policy failures and inadequate local institutional arrangements. The government capacity to protect forests based on the policing model of management has progressively proved inadequate. To readdress the situation therefore, Participatory Forest Management (PFM) is thought to be the option for saving the forest resources. Transition from centralized forest resource management to Participatory Forest Management can be measured by the local level control over socio-economic benefits and revenue flows from natural resources (Alcorn *et al.*, 2002).

Participatory Forest Management involves two concepts namely, Joint Forest Management (JFM) and Community-Based Forest Management (CBFM). JFM means involvement of local communities or non-governmental organisations in the management and conservation of forests and forestland with appropriate user rights as incentives (URT, 1998). In JFM, the government (Central or Local Government) is the owner but shares duty and benefits with local communities while in CBFM local communities are both owners and duty bearers (i.e. owners, users and managers) (Wily, 1998).

According to Lawrence and Green (2000) the term PFM is used as an umbrella term to include “shared forest management”, joint forest management”, “collaborative forest management” and “community forest management”. Willy (2002) outlines various typologies of PFM in Africa as follows:

i. *Consigned management* where the community has all operational powers apart from ultimate authority (e.g. as being promoted in Gambia, India and Tanzania in National Forest Reserves (e.g. Urumwa forest, Shume-Magamba and Amani Nature Reserve)
ii. *Community based forest management,* where jurisdiction is fully devolved and sometimes including ownership of the estate (e.g. as found in The Gambia, Malawi, Tanzania (e.g. Duru-Haitemba, Mgori, Mpanga, Mfundia, Angai forests in Tanzania), Lesotho, Namibia, South Africa and Uganda)
iii. *Contractual partnership* where community roles are more substantial but still inequitable (e.g. Cameroon, Ethiopia, Nigeria, Madagascar, Sudan, Niger, Mali and Guinea)
iv. *Consultative* (e.g. as expressed in the Forest-Farmer Commissions in Ivory Coast or the Forest Committees in Ghana)

The Forest Policy of Tanzania (URT, 1998) states clearly about the need to involve; organizations, agencies, private sectors and local communities in the management of forests and ensure equitable sharing of benefits amongst them in accordance with "approved management plans". However, the involvement of local communities in the management of forest resources has been passive because there was no legal backing in the existing forest legislation till when the new Act No. 14 of 2002 (URT, 2002b) supporting the policy was enacted.

1.2 Problem statement and study justification

Experiences in Tanzania show that centralized "top-down" conservation is only effective with large expenditures on enforcement. Kajembe and Mgoo (1999) argued that in the wake of declining budgets and the retrenchment of workers, following the Structural Adjustment Programs of 1980s, the government's capacity to protect forests based on the policing model of management has progressively deteriorated. This situation made it inevitable for the revision of the Tanzania forest policy in 1998 and Forest Act in 2002. Since then local communities are now legally encouraged to co-manage forest reserves with the government through special agreements. Under right conditions, such as appropriate legal framework and incentive structures, local communities are likely to become most effective managers and this would be cost effective. According to Willy (2002) and Kajembe *et al.* (2004a), one of the government forest reserves currently under JFM is the Amani Nature Reserve (ANR), which was established in 1997.

Joint Forest Management is an institutional arrangement considered to be a proper way forward for alleviating forest degradation (URT, 2001). However it was not clearly established as to what extent the forest resource base in Amani Nature Reserve has improved since the inception of JFM. Also the contribution of the forests to the livelihoods of the poor and marginalized people is not satisfactorily established. Therefore the aim of this study was to determine whether JFM had desired impact on resource base and livelihoods of communities surrounding Amani Nature Reserve.

1.3 Study objectives

1.3.1 Overall objective

The overall objective of the study was to assess impacts of Joint Forest Management on forest resource base and livelihoods of local communities around Amani Nature Reserve.

1.3.2 Specific objectives

Specific objectives of this study were to:

assess the impact of JFM on forest stocking and tree species diversity in ANR
identify socio-economic factors influencing participation of local communities surrounding ANR in JFM
assess the impact of JFM on livelihoods of local communities surrounding ANR

1.4 Conceptual framework

Figure 1 shows that Amani Nature Reserve is a state owned forest reserve managed under JFM arrangements where there is interaction between adjacent local communities and Amani Nature Reserve forest resource base. The interaction affects forest stocking, tree species diversity and livelihoods. JFM is expected to improve sustainable forest management of ANR and livelihoods of local communities living adjacent to the forest resource.

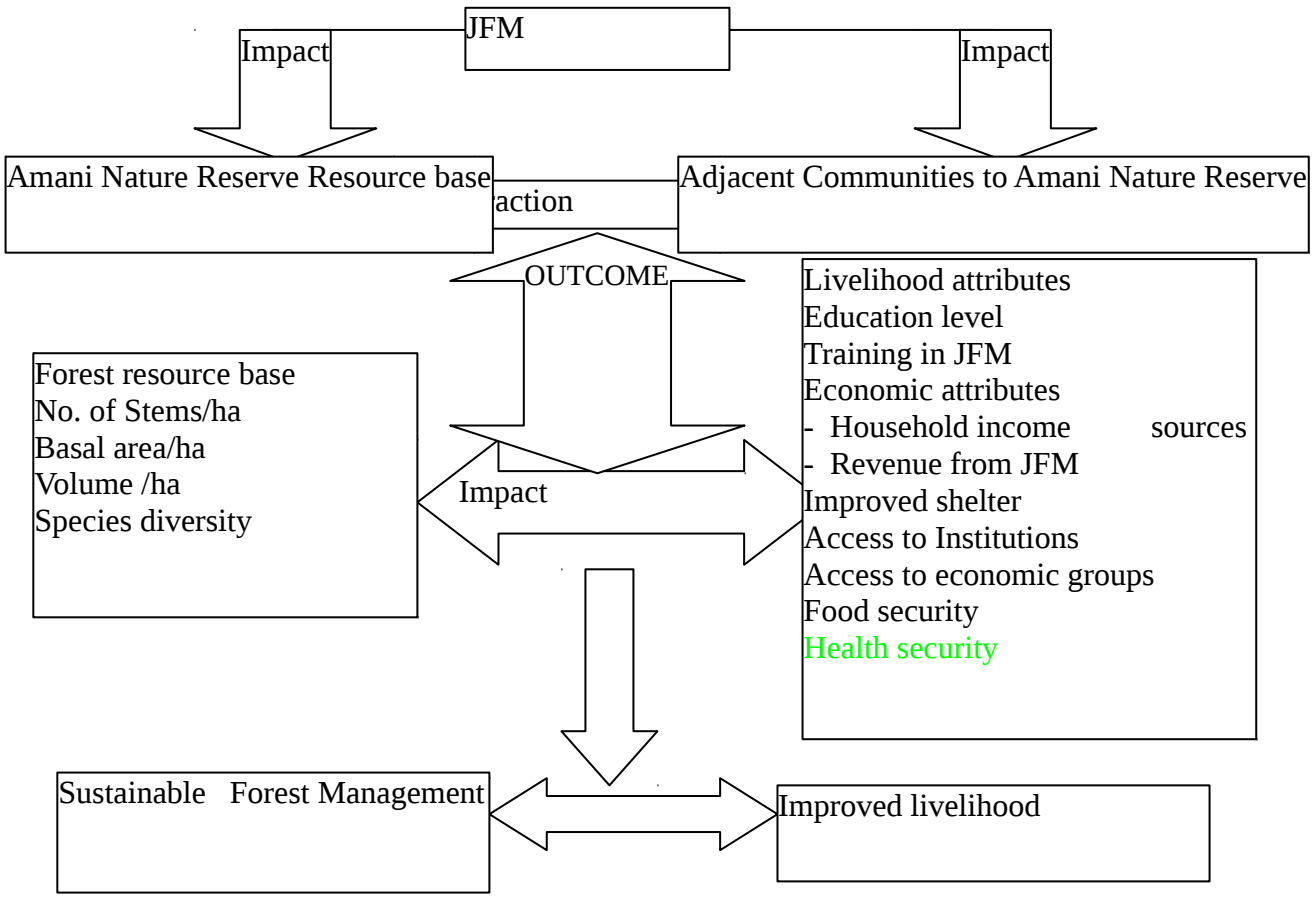

Figure 1: Conceptual framework underlying the study

1.5 Hypotheses tested

Ho: Joint Forest Management has no significance impact on forest resource base and livelihoods of the adjacent communities.

Hi: Joint Forest Management has significance impact on forest resource base and livelihoods of the adjacent communities.

1.6 Research questions

i. What are the impact of JFM on forest stocking and tree species diversity in ANR?
ii. What are the socio-economic factors affecting participation of local communities surrounding ANR in JFM?
iii. What is the impact of JFM on livelihoods of local communities surrounding ANR?

1.7 Limitations

Several limitations were encountered during the study. These included among others:

i. The livelihood data were based on memory specifically the data before JFM. It was difficult for respondents to recall and thus more time was consumed in responding to issues. This problem was resolved using additional information obtained from key informants and actual field observations.

ii. Difficulty in GPS reading caused by closed forest. However a directional compass and tape measure were of great importance for measuring directional and distance respectively.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sustainable forest management and biodiversity

Forestry provides forest products and services (e.g. watershed protection and carbon sequestration). Thus increasing denudation of forests has begun to pose severe challenges to their sustainability. Sustainable forest management is defined as the process of managing forests to achieve one or more clearly specified objectives of management with regards to production and protection of continuous flow of desired forest products and services, without undue reduction of their inherent values and future productivity (Higman *et al*. (1999) and without undue undesirable effects on the physical and social environments (FAO, 1999). Therefore sustainability subsumes productivity (growth) and equity (World Bank, 1992). Sustainable forest management therefore involves the achievement of multiple management objectives including economic, social, environmental and cultural benefits, for the country and particularly for the local communities. Local communities in developing countries have legitimate aspirations for an improved quality of life and any renewable resource such as forest; need to be exploited provided the rate of use ensures sustainability by maintaining regeneration and natural growth (WCED, 1987). Ecological sustainability is the major concern since it is believed to take care of livelihood sustenance of forest dependent communities. Livelihood sustenance should relate to sustainable harvest of forest products that ensure negligible impact on structure and dynamics of the plant population (Mallik, 2000) therefore enhance biodiversity.

Tanzania prides itself for having outstanding biodiversity due to diverse ecosystems, topography and climate. It is one of the fourteen biodiversity hot spot countries in the world (URT, 1997). The need to exploit this rich biodiversity sustainably is recognized. This situation places a responsibility for undertaking biodiversity actions that meet both the competing requirements of the present and legitimate claims of future generation

Biological diversity or more commonly used shorthand of biodiversity which is the term used to describe the total variety of living organisms on our planet, the communities/ecosystems and ecological processes of which they are a part. Biodiversity is conveniently classified and measured from three different angles: genetic diversity, species diversity and ecosystem diversity (Stuart and Adams, 1990; Rykowski, 2002).

- Genetic diversity refers to the variety of genetic information that forms the basis for natural selection and a measure of the variability both within and between species.
- Species diversity refers to measures of the total numbers of the species within a

given area, and can be considered either in terms of species richness or taxonomic uniqueness.

- Ecosystem diversity relates to the variety of different habitats within which species occur. Ecosystem therefore is composed of complex, interdependent groups of species. Forest ecosystem diversity is a function of site diversity (Rykowski, 2002). The author further argued that at the ecosystem level, description of forest communities such as structure, species occurrence, crown density, mixtures and quality classes is an important knowledge of the site.

The relationship between genetic, species and ecosystem diversity is complex and for the purpose of this study, tree species diversity indices like Important Value Index, Shannon-wiener index and Index of dominance were determined.

2.2 Policy, institutional change and governance

In Tanzania, Forest policy of 1998 encourages and reward active participation of communities and local institutions in sustainable forest management. JFM is one of the institutional arrangements of implementing forest policy. JFM is fundamentally based on devolution of responsibilities, rights and authority from the state to local communities and bodies designated for forest management (Mallik, 2000). In India for example, JFM is one of the formal institutional models between the public administration and local user groups identified having legitimacy and potential to enhance rural livelihoods (Baumann and Farrington, 2003).

Institutions are referred as the rules of the game in a society, stable, valued, recurring patterns of behaviour and include procedures that shape how people act, their status or legitimacy (Brinkerhoff and Goldsmith, 1992). Ostrom (1992) defined rules and constraints as prescriptions commonly known and used by a set of participants to order repetitive, interdependent relationships. Prescriptions refer to actions required, prohibited or permitted. In consequence they structure incentives in human exchange, whether politically, socially or economically. It is however important to point out that there are confusions regarding the difference between institutions and organizations. Many analysts in the field of “new institutional economics”, “new economic history” and “public choice

theory" view institutions as rules. However Ostrom (1992) distinguished between institutions and organizations that, organizations are visible and measurable (consists of human beings), while rules in use by organizations consists of common knowledge which people have in their heads or those that are written down on paper. Therefore a great diversity of institutions do exists that can be classified on the basis of various criteria though institutions with cultural and political backgrounds are most pronounced.
Mallik (2000) urged that beside strong, self-regulating institutions and community organizations that results into effective and transparent mechanisms on ensuring equitable sharing and conflict resolutions, training and capacity building to local communities are very important. Experience in India revealed that moves towards decentralization can be explained as the experience-induced outcome of failed centralised management over natural resources and evidence of worsening poverty–environment linkages (Baumann and Farrington, 2003). In this context JFM is expected to improve poverty – environment linkages through empowerment of local institutions. This is because many villagers complains normally rise from lack of transparency in financial use by their village governments an indicator of weak governance. Nurse and Kabamba (1999) lamented that cost and benefit sharing, motivation and incentives (incentive package) have been claimed by local communities as the most important issues in the successful implementation of rural forest programmes, or participatory forestry management. Musoko (2007) identified some characteristics of good governance that are; participation, accountability, transparency and efficiency.

Governance refers to transformation in patterns and processes of governing (Murdoch and Marsden, 1998). Stoker (1997), cited by Murdoch and Marsden (1998) defined the concept of governance as wider and directs attention to the distribution of power both internally and externally to the state and that focuses on interdependent of governmental and non-governmental forces in meeting economic and social challenges. The author urged further that governance concerns with how the challenge of collective action is met and the issues

and tension associated with this shift in the pattern of governing.

In JFM, collective action is very important instead of working in isolation since not all constraints can be solved by one person or single institution. A key issue in JFM is team work spirit as those working on JFM must not try and do everything on their own (White and Mustalahti, 2005). There is a great need of inviting others to undertake some of responsibilities jointly. This situation would not be possible unless there is recognition of various institutions having a stake on the resource and good governance that can welcome others. Williamson (2003) commented that communities are not stable and socially cohesive a situation resulting into no guarantee that decisions made by communities that will necessarily accord with the interest of biodiversity conservation unless effective institutions at all levels are functioning. Stoker (1997) cited by Murdoch and Marsden (1998) identified five major prepositions, which present different aspects of governance for consideration. First governance recognises the capacity to get things done which does not rest on the power of government or use its authority.

Government has to see governance as ability to use new tools to steer and guide. However Murdoch and Marsden (1998) argued that the role of a government is seen as one of identifying stakeholders and then developing the relevant opportunities and linkages for the stakeholders to act though does not guarantee the success of governance. The author continued to argue by saying that all kinds of tensions and difficulties among partners and between different institutions may well cause governance failure. Joint Forest management is expected to reduce tensions among stakeholders through building partnership in the management of forest resource base. Joint Forest Management enables development and signing of management agreements among central government, specialised executive agencies, private sector and or local governments as appropriate in each case, and local communities living adjacent to the forests (URT, 1998).

2.3 Livelihoods

Livelihoods include activities done by people to make a living. A livelihood comprises capabilities, assets and activities required for a means of living (Carney *et al*., 1999). A livelihood is sustainable when it can cope with and recover from stress and shocks and maintaining or enhancing its capabilities and assets both now and in the future, while not undermining the natural resource base (Gottret and White, 2001).

Rural livelihoods have three broad options to be improved including natural resources, non-natural resource based activities and migration to other agricultural areas or urban areas (Carney, 1998; Ellis, 1998). The authors argued that most people in rural areas obtain their means of livelihoods from surrounding environment. Livelihoods impacts can be measured through livelihoods indicators (TANGO International, 2004). The author reviewed livelihoods indicators used by FAO (1999) and NGOs and came out with indicators like food, shelter, economic attributes, education, gender status, health, community participation and access to institutions.

Joint Forest Management is an institutional arrangement that can affect these indicators since it aims at enhancement of natural resources, building local institutional capacity and sustaining livelihoods through equitable and productive natural resources management. This shift in policy is a recognition that sustainable resource management can never be independent of sustainability of collective human institutions that frame resource governance, and that local users are often the ones with the greatest stakes in sustainability of resources and institutions (Ostrom 1992).

A Framework for livelihoods analysis by Ellis (2000) consists of assets that their access is modified by social relations, institutions and organizations present in the context of trends and shocks that all together results into livelihood strategies. The strategies can be composed by natural based or non-natural resource based activities that can effect

livelihood security and environmental sustainability. Assets consist of natural, physical, human, financial and social capitals while, social relations consist of gender, class, age and ethnicity (Ellis, 2000).

The role of natural resources in local livelihood is complex. In the context of the rural poor in India, wage labour in natural resources management programmes is part of the stepping-stone to other non-local activities like natural resource surplus enhancement (Baumann and Farrington, 2003). A fundamental feature of assets as capital is that they exist as stocks (e.g. land or trees) giving rise to a flow of output, or they are brought into being when surplus is generated that enabling investments in future productive capacity (Ellis, 2000).

Policy choices in a range of areas such as employment, enterprise development, social protection, rural infrastructure and agriculture, have major impacts on rural livelihoods. In turn, the outcomes of such policies are affected by choice preferences and constraints of the poor. Thus effective policy-making requires an understanding of three livelihood issues that include dynamics of livelihood change, diversification of livelihoods and issues of exclusion and access to livelihood options and resources. According to Gosalamang *et al*. (2004) the households' endowments include labour, land and forests. These endowments can be affected by change in institutional arrangements. In Mt Elgon, the change in institutional arrangements resulted into constraint to people's livelihoods by affecting their subsistence, income generation and socio-cultural needs that they fulfilled from the forest reserve prior to the change in the management (Gosalamang *et al*., (2004).

2.4 Incentive for joint forest management

An incentive refers to anything that incites, motivate or influence forest stakeholders to practice sustainable forest management (Kajembe *et al.*, 2004a). The authors discussed various categories of incentives that a stakeholder may receive such as; money, training, study tours, devolution of power to villagers, planning and decision making in forest management. Dubois (1999) argued that JFM to function as an incentive, access and use rights must provide more tangible economic benefits to the local communities. Ranthore and Jain (2005) had this to say benefit sharing act as a motivating factor for people's

participation and for sustaining peoples interest in forest protection; for creation of stake for local people for effective conservation; a token appreciation for the people's efforts in conservation; a matter of recognition of people's contribution; realizing the basic psychology of "people care when they share". The author emphasized that structured mechanism of benefit sharing creates stake for the people for participation and therefore is a must for sustaining peoples' interest in forest management. The provision of incentives is a policy tool which is often applied to various sectors which temporarily need to be boosted (Kajembe *et al*., 2004a). Forest Policy of 1998 state clearly about incentive tools for Joint Forest Management that enable participation of all stakeholders in forest management. These include joint management agreements with appropriate user rights between the central government, specialised executive agencies, private sector and organised local communities living adjacent to the forests.

Some of the non-destructive income generating activities in the jointly managed forest reserves could include controlled harvesting of dead logs (old age and windfalls), beekeeping, promotion of ecotourism and collecting water fees. Revenues from all these activities should be equitably distributed among the stakeholders (Kajembe *et al.*, 2004a). In Tamilnadu, JFM activities are done to create immediate interest of the people to participate in the project activities include capacity building and competence development of the villagers through training in various themes (Ranthore and Jain 2005).

2.5 Participation of local communities in joint forest management

The participation of local communities and other stakeholders in managing forests can help to improve forest productivity, sustain livelihoods, increase environmental sustainability, and make rules governing forest access more enforceable. Introducing participatory management depends on government commitment and requires time and resources to develop consensus among stakeholders, establish new institutional arrangements, decentralize finance and administration, ensure appropriate rules and incentives for local involvement, and build organizational capacity at the local level (World Bank, 2005).

Key differences between centralized forest policies and participatory forest management are that the former are oriented to a single-use objective (such as timber production or policing a conservation site) and the rights of local users are limited to low-value secondary products and temporary concessions. In contrast, participatory forest management is based on a broader valuation of forest resources, taking into account the multiple values of forests and the social and economic needs of local forest users (World Bank, 2005). Access and use rights to forests as well as conflicts arising among competing users are locally defined and managed. The structure of incentives and the choice of technologies are geared towards environmental sustainability over long term. However

Wolmer and Ashley (2003) reported that despite of a policy of community partnership in forest management in Mozambique, field work in Derre Forest Reserve showed very little evidence of communities actually participating in co-management. Therefore, participation evolves endogenously within the socio-economic and cultural framework and is a long term process (Ranthore and Jain, 2005).

Socio-economic factors refer to economic, social and institutional patterns and their linkages that compose the context of development (Huisinga, 1997). Social and economic factors at various levels of social systems form an environment where people interact through roles and relationships and consequently influencing participation. Factors influencing participation as identified by Ashyby *et al*. (1989) include age, gender, ethnicity, level of wealth, community awareness about the programme, leadership influence, extension contacts, incentives, and traditional participatory practices.

2.6 Impact of joint forest management on forest resource and livelihoods

Impact is defined as strong influence towards certain initiative. The concept of impact is far broader as it includes both positive and negative consequences whether foreseen and expected or not. Joint Forest Management has positive impacts on forest resources (Khare *et al*, 2000). On the other hand JFM facilitate the use of other stakeholders who have a stake on the resource in management of forest resources and these include Non Governmental Organization (NGOs). Involvement of NGOs to facilitate Community Based Natural Resource Management (CBNRM) process and the private sector through partnership agreements has shown the potential to bring about economic development in remote rural areas and the promotion of sustainable utilization of natural resources (Baumann and Farrington, 2003).

In Amani Nature Reserve 20% of revenue from ecotourism is being distributed to local communities (Kajembe *et al.*, 2004a). The authors also added that according to local people there is considerable improvement in local climate and forest conditions, the

production of tea and water yield have also increased since a complete ban of timber harvesting inside the Nature Reserve was instituted.

However Joint Forest Management has some negative impact to local livelihoods and forest resource base as well. In Amani Nature Reserve forest users (such as carpenters) are dissatisfied and other villagers complain about land shortage (Kajembe *et al.*, 2004a). The authors added that illegal mining in the forest done by newcomers with the help of few unfaithful young people in the villages has a negative impact. At Kwizu and Nkweshoo Forest Reserves illegal timber harvesting, land conflicts and over harvesting of firewood and fodder appeared to be contrary towards successful implementation of JFM strategies (Kajembe *et al.*, 2004a). Whiteman, (2003) added that if local people living in and around the forest do not receive share of the benefits from forest management and they believe that they have some rights over the resource they might attempt to exert negative impacts on the recourse.

CHAPTER THREE

3.0 STUDY AREA AND METHODOLOGY

3.1 Study area

3.1.1 Location

Amani Nature Reserve (ANR) is within the East Usambara mountain range with an area of 8360 ha. ANR was Gazetted on 9th May 1997, GN 152. The Nature Reserve was a result of combination of the following forest reserves: Amani Sigi Forest Reserve (1153.5 ha) gazetted in 1934, GN 43; Amani East Forest Reserve (122.2 ha) gazetted in 1955, GN 111; Amani West Forest Reserve (158.5 ha) gazetted in 1955, GN 196; Kwamsambia Forest Reserve (1822.8 ha) gazetted in 1954, GN 95; Kwamkoro Forest Reserve (2270.9 ha) gazetted in 1923, GN 99 and Mnyuzi Scarp Forest Reserve (672.9 ha) gazetted in 1958, GN 296.

ANR is bordering 18 villages namely; Mlesa, Shebomeza, Mbomole, Mikwinini, Ubiri, Kisiwani, Mashewa, Kimbo, Potwe-Ndondondo, Potwe mpirani, Shamba kapori, Mnyuzi, Kwamzindawa, Gereza, Kwagunda, Magunga, IBC Msasa and Mkwakwani. ANR falls within Muheza and Korogwe districts. Geographically the reserve is located at 38° 33 – 38° 50 East and 4° 45-5° 15 South. The study was concentrated in Mlesa forest management area where the inventory data were collected while the livelihoods data were collected in four villages namely; Mlesa, Shebomeza, Kisiwani and Potwe-Ndondondo (Fig. 2).

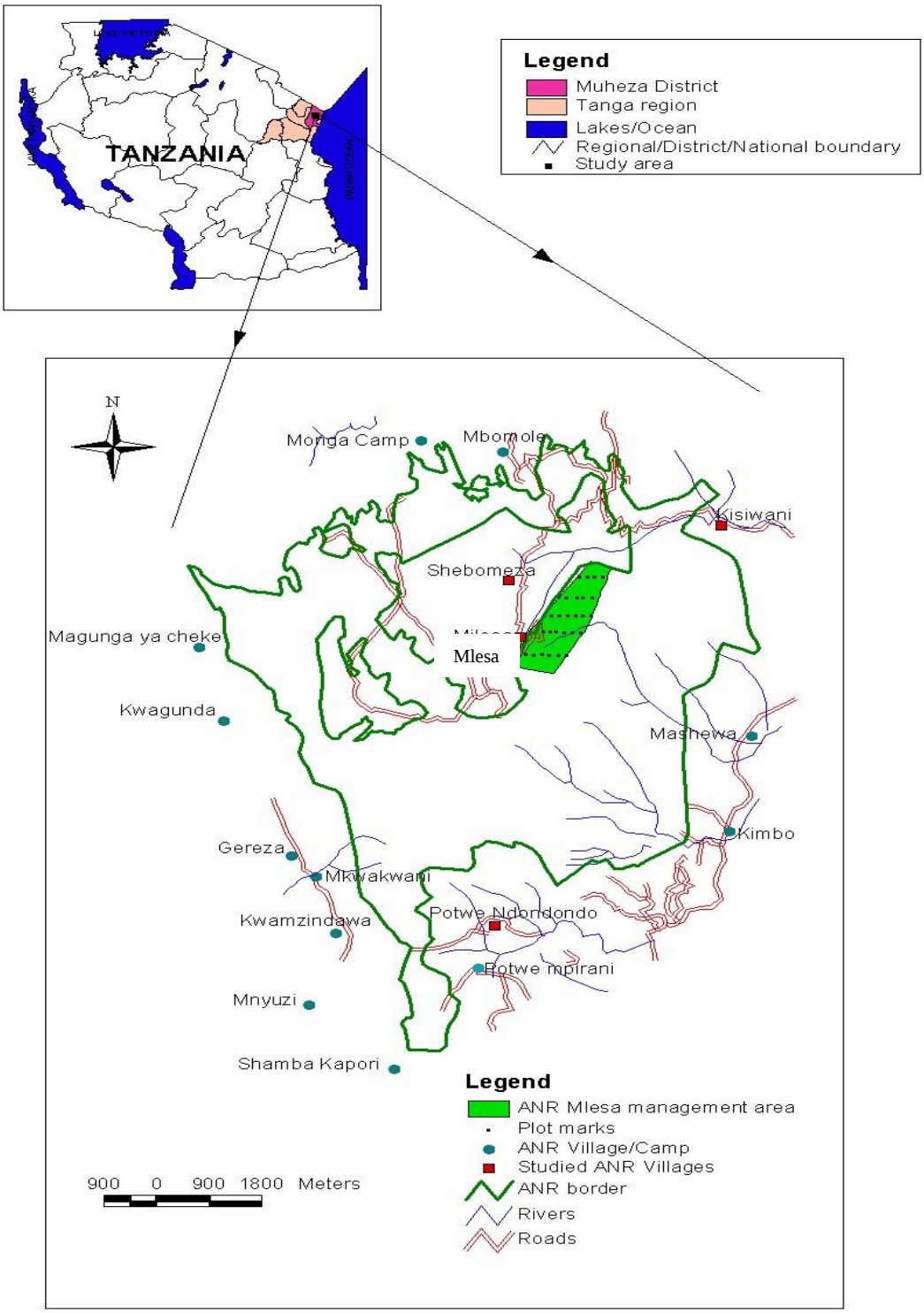

Figure 2: Location of Amani Nature Reserve in Tanga Region, Tanzania.

3.1.2 Climate and vegetation

The mean annual rainfall ranges between 1500mm and 2100mm with two peaks; the short rains (October – December) and long rains (Mid March-May). The mean annual

temperature at Amani is 20.6ºC but in the lowlands temperatures can be up to 25.6ºC or more. The altitude ranges from 250m in coastal plains to 1506m at the highest peak.

3.1.3 Vegetation

The study area is dominated by sub mountain rain forests. The vegetation is woody with luxuriant growth of trees reaching up to a height of 65m with stratified canopy. Main tree species found in the area include submontane species; *Allanblackia stuhlmanii Beilschemiedia kweo, Cephalosphaera usambarensis, Macaranga capensis, Newtonia buchanannii, Sorindeia usambarensis* and *Trichilia emetica.*

3.1.4 Livelihoods

Amani Nature Reserve offers the following products and services to the villagers: firewood, timber, medicinal plants, water, soil erosion protection, game meat, wild vegetables and fruits, and fresh air. Adjacent local communities are permitted to collect dead wood from the ANR for fuelwood twice a week. Crops cultivated include; cocoyams, banana, maize, beans, sweet and irish potatoes, cow peas and rice. Cash crops include sugarcane, spices such as cardamom, black paper, and cinnamon.

3.1.5 Population

The total population in villages around ANR is 27899 (13170 men and 14073 women) living in a total of 5792 households with annual growth rate of 1.8% (URT, 2002a). The main ethnic groups are Sambaa, Zigua and Bondei that comprise of 70.6%. Small ethnic groups of immigrants make 29.4% including Bena, Hehe, Ha, Pare and Pogoro.

3.1.6 Organizations available in the study area

Local organizations in villages surrounding ANR include; village governments, primary schools, churches and mosques, political parties and environmental committees. The traditional institutions found in the study area include traditional midwives, traditional healers and ritual leaders (Kajembe *et al*., 2003).

3.2 Methodology

3.2.1 Data collection

Two types of data were collected namely forest stand parameters and socio-economic data.

3.2.1.1 Forest inventory

The forest inventory data were collected through International Forestry Resources and Institutions (IFRI) Research program methodology. The IFRI methodology makes use of Forest Plot Form (IFRI Form P) as attached in Appendix 1. IFRI Form P recommends a minimum of 30 plots to be sampled in all natural forests in the size range of 0.5 to 200 hectares (Ostrom, 1999). Forest plots are key link between the social, institutional and forest resource data collected (Ostrom, 1999).

In order to compare and determine temporal changes Mlesa Forest management area was purposively selected because was sampled in 2001 by IFRI thus, the data was used as baseline data for comparing the results with the year 2005 data.

(i) Sampling design

A systematic sampling design was used as adopted by IFRI in year 2001. Five transect lines were laid out at an interval of 400m apart. Transects were laid out from Mlesa village, across the contours. Thirty plots were established in these transects at a distance of 100m apart and Figure 3 shows the layout of the plots in the sampled area

(ii) Sampling intensity, size and shape of the plots

Sampling intensity was adopted from the IFRI methodology (Ostrom, 1999) used in year 2001. Circular and concentric sample plots of 0.0314 ha each were established. The choice of circular plot was motivated by the fact that it has the advantage of reducing edge effect (Nduwamungu, 1996). The GPS recorder and the plot layout map were used to allocate the plots in the field. Once the centre of a plot was located, three concentric circles were marked (i.e. nested subplots of radii 1m, 3m and 10m).

Figure 4 shows the shape and size of the plots. In 1-metre radius subplot, data were

collected on all herbaceous ground cover and seedlings with diameter of less than 2.5cm. In the middle circle (3m radius), shrubs, and tree saplings were identified, their heights estimated and stems diameter at breast height (DBH) measured. Saplings were defined as young trees with a maximum stem diameter greater than 2.5cm, but less than 10cm diameter. Within the 10-meter radius plot, all trees with diameter at breast height (DBH) over 10cm were identified by species and their heights and DBHs measured and recorded (Appendix 1).

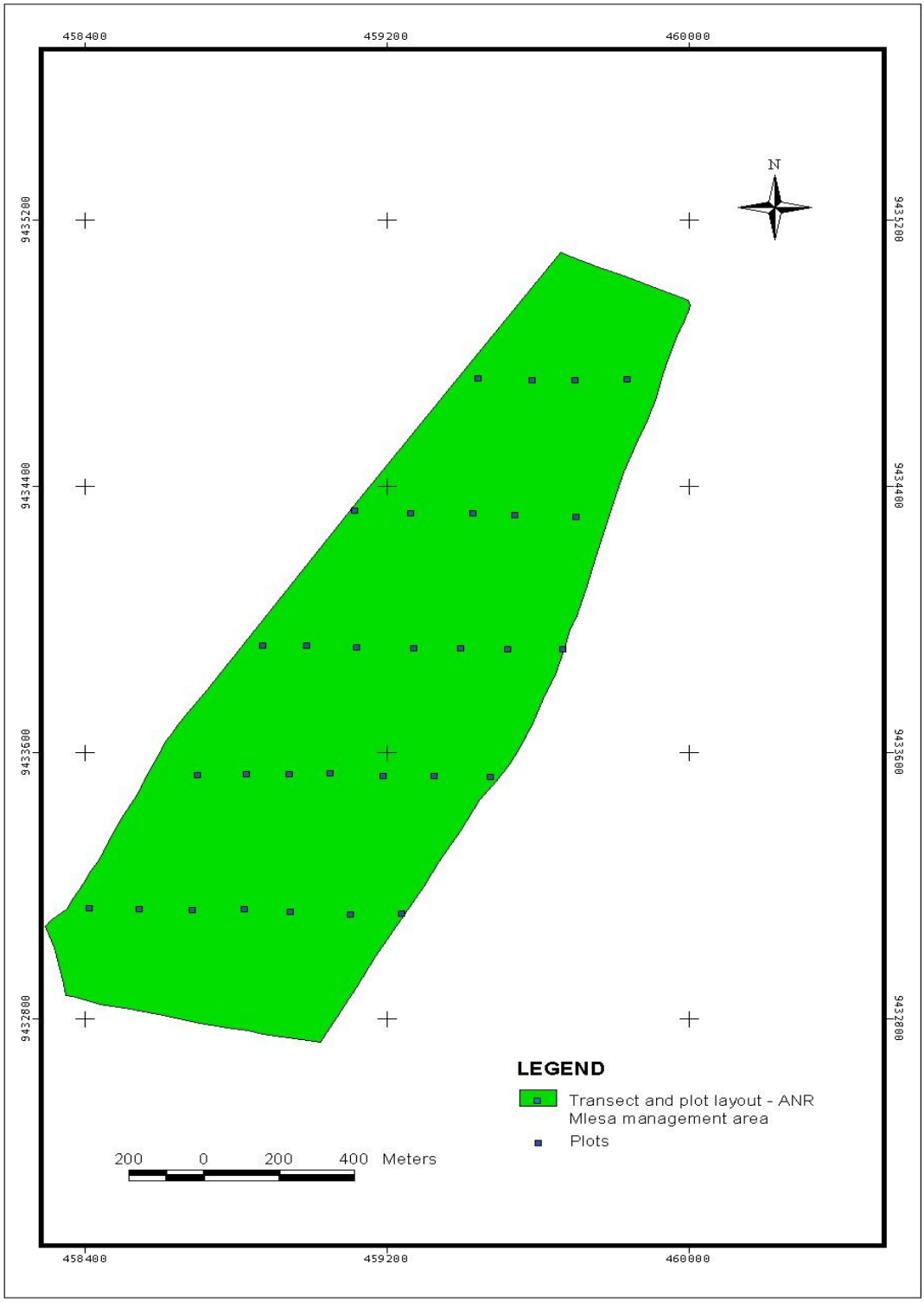

Figure 3: Layout of the transects and plots in Mlesa VFMA, ANR, Tanzania

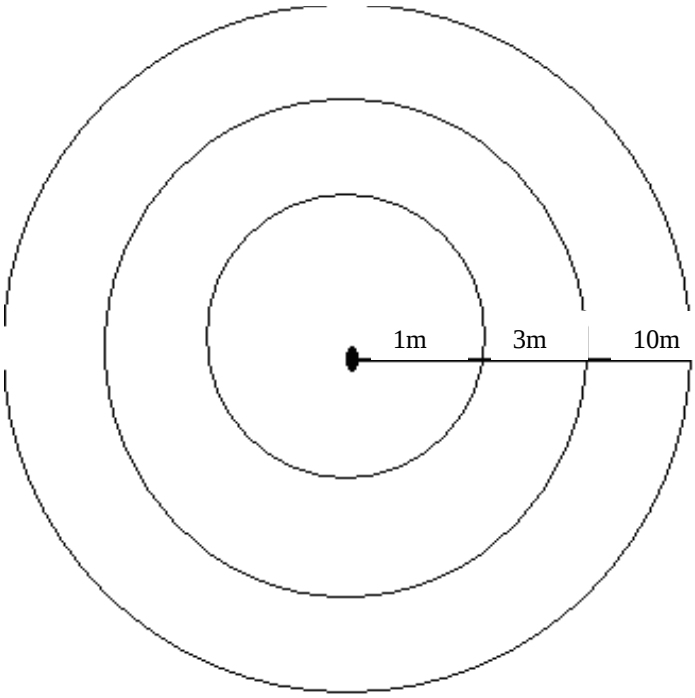

Figure 4: Shape and size of the plots used for data collection in Mlesa VFMA, ANR, Tanzania

The species identification was done using Shambaa, Bondei and Zigua dictionary by Sangai (1963) and Hamilton and Bensted-Smith (*eds*) (1989) with the help of a local botanist.

3.2.1.2 Socio-economic data

Multi-stage cluster sampling procedure was used to select the sampling units which were households. This procedure facilitated sampling from a large population whose members were not known and enabled selection of respondents from large population. Participatory Rural Appraisal (PRA) techniques, semi-structured interviews and structured questionnaire were employed to obtain the field data.

(i) Participatory Rural Appraisal (PRA)

PRA techniques are useful in valuation of resources and can allow local communities to apply their indigenous knowledge, experience and capacity to share information. PRA allows data analysis for developing practical options. PRA was carried out to familiarise the researcher with real environment of the research area. PRA techniques used included; focused group discussions, participatory resource mapping, participant observation, trend lines and venn diagrams (Appendix 2).

(ii) Participant observation

It is always essential to keep ones eye open when visiting a new area and to check what you are told against what you see (Mettrick, 1993). The method of participant observation was used to tie together the more discrete elements of data gathered by other methods. Participant observation method permitted specific elements to be examined within the context of the social system.

(iii) Focused group discussion

Checklists (Appendix 2) were used to guide focused discussions, which were undertaken with key informants. Key informants are not only members of the clientele, but are most often informed outsiders (Metrick, 1993) and are an individuals who are accessible, willing to talk and have a great depth of knowledge about issues in question. In this study key informants included herbalists, village leaders who were more knowledgeable of community issues, government and NGO officials.

(iv) Structured questionnaire

A principal strength of a sample survey is its capacity to yield detailed information at a household or individual level about a population whilst minimising investigative resource demand by gathering the information in a small sample (Ellis, 2000). A sample frame was the village register and the sampling unit for questionnaire survey was a household. A household is defined by TANGO International (2004) as a core analytical unit that defines regular roles, rights and responsibilities across gender and age. A household around Amani Nature Reserve consist of 5-7 members who perform their daily roles and

responsibility across gender and age and can be headed by a male or female (widow, divorcee). A sampling intensity of 5% was used for household interview as shown in Table 1. A random sample should at least constitute 5% of the total population to be a representative of that population (Boyd *et al*., 1981). Four villages namely Mlesa, Shebomeza, Kisiwani and Potwe ndondondo were purposively selected for the household interview (Fig. 2 and Table 1). Purposive selection allowed obtaining information where barriers like terrain can be one of factors that may not be addressed in random or systematic sampling.

Table 1: Distribution of respondents in the surveyed villages in ANR, Tanzania

Village	Total Population	Women above 18 years	Men above 18 years	Total number of households	Number of household sampled	Sampling intensity (%)
Mlesa	2233	522	625	518	26	5
Shebomeza	1872	376	383	329	17	5
Kisiwani	1464	783	681	315	16	5
Potwe Ndondondo	2975	1315	1170	509	26	5
Total	**8544**	**2996**	**2859**	**1671**	**85**	
Average	**2136**	**749**	**714.75**	**417.75**	**22**	

Source: URT, (2002a)

Also Mlesa and Shebomeza villages represented upland villages and also are enclaves where the villagers depend for forest products from the ANR for their livelihoods. Kisiwani village is situated just at the entrance gate of ANR that all eco-tourists to ANR could exert some impact to local communities while Potwe Ndondondo represented lowland villages and also was severely affected by ANR enlargement and thus local people

lost much of their farmlands.

The households were randomly selected from a village government register books for the questionnaire survey (after categorising the village household heads into age classes, gender, and wealth categories (Appendix 3). Pre-testing of questionnaires was conducted in 10 households in Mashewa village, which was not involved in the actual survey after which the minor modification were made.

3.2.1.3 Secondary data

Secondary data were obtained from books, journals, websites, IFRI data base and unpublished reports.

3.2.2 Data analysis

3.2.2.1 Inventory data

The Microsoft excel spreadsheet software was used to analyse the inventory data for the forest parameters. The parameters computed included number of stems per hectare (N), basal area per hectare (G-m^2/ha), and volume per hectare (V-m^3/ha). Species diversity indices were also computed. Since there was no existing model of diameter volume-relationship for Amani Nature Reserve, height of sampled trees was measured using optical instruments then the form factor of 0.5 was used for volume calculation. The form factor of 0.5 was used as an average for natural forest form factor that range between 0.4 and 0.6 (Phillip, 1983; Malimbwi, and Zahabu personal communication, 2005). Before the computation of stand parameters, a checklist of tree and shrub species was prepared (Appendix 4).

Computed parameters were separated into eight diameter classes as shown in Table 2 and Appendix 9) single tree volumes calculation was obtained through the following formula:

V = ghf…….……..(1)

Where;

V = volume estimation (m^3/ha)

g = basal area of the tree (m^2/ha)

h = height of the tree (m)

f = form factor (0.5); and

Basal area of the tree was obtained through the following formula;

g_i = $d^2/4$, ……..…….….(2)

g_i = basal area for ith tree inm^2

= pie (≈ 3.14)

d = diameter measured at breast height

Table 2: Diameter distribution into diameter classes for the trees sampled in ANR, Tanzania

Diameter class	DBH range (in cm)
1	2.5 -10
2	10.1-20
3	20.1-30
4	30.1-40
5	40.1-50
6	50.1-60
7	60.1-70
8	>70

Tables, histograms and pie charts were used to summarise the inventory data. Paired sample t-test was used to test if there was significant difference at $p<0.05$ significance level for stocking, basal area and volume obtained in this study and that of IFRI in 2001. Biodiversity indices calculated included Important Value Index (IVI), Shannon Wiener Index (H') and Index of dominance (ID).

(i) Important Value Index (IVI)

Important Value Index (IVI) shows the overall picture of ecological importance of a species with respect to the community structure. IVI is a composite index based on the summation of the percentage value of the relative frequency, relative density and relative dominance, and this value called IVI of the species presented in order of decreasing importance (Ambasht, 1998). It is calculated as follows (Ambasht, 1998):
Relative frequency + Relative density + Relative dominance = IVI…….(3)

$$\text{Relative frequency} = \frac{\text{No. of occurrence of the species}}{\text{No. of occurrences of all species}} \text{ x } 100 \text{ .....(i)}$$

$$\text{Relative density} = \frac{\text{No of individuals of the species in all plots}}{\text{No. of individual of all species in all plots}} x\,100\text{.....(ii)}$$

$$\text{Relative dominance} = \frac{\text{Total basal area of the species in all plots}}{\text{Total basal area of all species in all plots}} \text{ x } 100\text{.....(iii)}$$

(ii) Shannon-wiener index of diversity (H')

Shannon-wiener index of diversity (H') was used to determine tree species diversity. The Shannon-wiener index is the most widely used index of diversity, which combines species richness and evenness and also not affected by sample size. Krebs (1989), explained Shannon-Wiener Index of diversity as a measure of information content of a sample and since information content is a measure of uncertainty, the large the value of H', the greater the uncertainty. The index increases with the number of species in the community but in practice, for biological communities H' does not exceed 5.0. The Shannon-wiener function was calculated using the following formula (Kent and Coker, 1992):

$$H' = -\sum_{i=1}^{s} (P_i \log a\, P_i) \text{……...…..…... (4)}$$

Where;

H' = the Shannon-wiener index of diversity,

= the summation symbols,

s = the number of species,

P_i = the proportion of individuals or the abundance of the species in the sample,

$\log_a$ = the logarithm to base a (any base of a logarithm may be taken).

(iii) Index of dominance (ID)

The index of dominance is a measure of the distribution of individuals among the species in a community. This index of dominance is also called Simpson's Index of diversity and is equal to the probability of picking two organisms at random that are of different species (Krebs, 1989). The greater the value of dominance index, the lower is the species diversity in the community and vice versa. It was calculated as described by Misra (1989):

$$ID = \sum (ni/N)^2 \quad \ldots\ldots(5)$$

Where;

ID = the index of dominance

ni = the number of individuals of species i in the sample

N = the total number of individuals (all species) in the sample

$\sum$ = the summation symbol

3.2.2.2 Analysis of socio-economic data

(i) Qualitative data analysis

Data collected through PRA methods were analysed with help of participants and the results were communicated back to them. Content and Structural-functional Analysis techniques were employed to analyse qualitative information. Content analysis is a set of methods for analysing the symbolic content of any communication. Verbal discussion with key informants was broken down into smallest meaningful units of information.

Structural-Functional Analysis technique was used to explain the way social facts relate to each other in a social system and the manner in which they relate to the physical environment (Kajembe, 1994). This type of analysis helped the researcher to distinguish between obvious and latent functions. Obvious functions are those consequences that are 'intended and are recognised by actors in the system' (Katani, 1999), whereas latent functions are those consequences that are neither intended nor recognised (Kajembe, 1994).

(ii) Quantitative data analysis

Statistical Package for Social Science for Windows (SPSS 11.5) program was used for quantitative analysis for socio-economic data. The completed interview schedule was coded, cleaned and wherever possible data from open-ended responses were categorized and transformed to enable further analysis.

Descriptive and Inferential statistical analyses were carried out. Descriptive statistical analysis was done to explore the data for distribution of responses, central tendency and dispersion. Frequencies, histograms were used to summarise the data. In order to assess the impact of JFM on livelihoods of local communities surrounding ANR, two-tailed t-test, chi square test at 5% level of significance was used to test if there was a significant change on livelihoods of the adjacent communities as impacted by JFM between year 2001 and 2005. Analysis done under t-test and chi square test falls under inferential statistical analysis. According to Kajembe (1994), inferential statistical analysis helps in providing an idea about whether the patterns described in the sample are likely to apply to the population from which the sample was taken. H_0 was rejected where $P>0.05$. A chi-square test was used to test if there was a significant change on communities' participation in forest management activities between 2001-2005 and H_0 was rejected where $P>0.05$.

Hypothesis tested:

H_o: Joint Forest Management has no significance impact on biodiversity and livelihoods.

H_i: Joint Forest Management has significance impact on biodiversity and livelihoods

Logistic regression analysis was the inferential analysis technique used to identify socio-economic factors affecting participation of a household in Joint Forest Management. The binary dependent variable used was the participation of a household in JFM initiatives with value of one if response was 'yes' and zero if 'otherwise'.

Using regression coefficients (β), the prediction models were then developed and used for estimating the probability of participation or not of a household in JFM in the study area. The socio-economic factors (independent variables) considered to affect participation of household in Joint Forest Management in the study area include; age, education level, land size, benefit /income shared from JFM, awareness raising (training in JFM), tree planting, presence of local institutions and engagement in economic groups. The following prediction model was developed:

$$Yi = \frac{1}{1+e^{-(\beta_0 \beta_1 X_i)}} \quad \text{.....(6)}$$

Where:

Y_i = the ith observation value (score) of the dependent variable representing a linear combination of independent variables underlying participation of a household in JFM initiatives), which stand for a non – standardized logistic regression equation and was used for prediction purposes. Y_i is a binary variable with value of 1 if a household participate in JFM initiatives in the study area and 0 if otherwise The JFM initiatives tested in this study were the independent variables listed as X_i.

X_i = the independent variables (education, age, land size, benefit /income shared from JFM, training in JFM, tree planting, presence of local institutions and engagement in economic groups).

$\beta 0$ = Constant term of the model without the independent variables

β_1 = independent variable coefficients (β) showing the marginal effects (negative or positive) of the unit change in the independent variable and these were used in developing prediction equations on participation of household in JFM initiatives.

e = natural logarithm, approximately exp = 2.71828

Probability of an event not occurring was estimated as pro (no event) =1-pro (event)

For more than one independent variable the model can be written as adopted from Pampel (2000) follows;

$$Yi = \frac{1}{1+e^{-z}} \quad \text{.....(7)}$$

Where:

z = the combination of independent variables i.e.

$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots \beta_p X_p$

p = Total number of independent variable (p = 8)

From the above, the independent variables included in the models were

X_1 = Education level of a respondent. Increase in education level was assumed to increase participation of a household in JFM initiatives because educated people have more access to technical information that enable them to participate to new innovations compared to illiterate ones. Dummy variable with value 1 was assigned for formal education or 0 if otherwise. Education was assumed to have positive sign of the estimate β.

X_2 = Age of respondent in years. The age was assumed to have a positive sign of the estimate β. It was assumed that the increase in age of respondent increases the participation of JFM initiatives. This could be caused by increase in household needs and thus household head will participate in JFM initiatives so that can secure more options of livelihoods diversification.

X_3 = Farm size. It was assumed to have negative sign of the estimate β. This because when people have large farm land size means they have enough land for their undertaking and of course they fall in high category of wealthy that they don't need to participate in JFM activities.

X_4 = Sharing of benefit/income from JFM. It was assumed that revenue accrued by central government (ANR) from JFM sources can be shared directly with adjacent communities as recognition of their share in JFM. It was assumed to increase morale of households' participation in JFM. A dummy value of 1 for yes if the village receive income from JFM and 0 if otherwise. It was assumed to have a positive sign of the estimate β.

X_5 = Tree planting in farms. Asset is one indicator of livelihoods capability. In this case it was assumed that trees planted for income generation are assets to a household. Dummy value of 1 for household participating in tree planting and 0 if otherwise and was assumed to have a positive sign of the estimate β.

X_6 = Training in JFM. It was assumed that a household head that received

training would participate in JFM intervention compared to the one not trained. Human resource development is one factor that enhances livelihoods' development in a particular household. Dummy value of 1for a household head received training for JFM and 0 if otherwise and was assumed to have a positive sign of the estimate β.

X_7 = Access to institutions. Institutions and actions of local people greatly determine the success or failure of the nearby forest management schemes. Therefore it is assumed that a household that have an access to institution have also access to jurisdiction and sanctions as a result that household has an incentive to participation. Dummy value of 1 for a household having access to institutions and 0 if otherwise and was assumed to have a positive sign of the estimate β.

X_8 = Member of economic groups in the village. It was assumed that household heads who are members of economic groups have higher chance of improving socialization through more dialogue, increase household income and improve self confidence (personal and institutional). The dummy value of 1 for household head participating in economic group and 0 if other wise. The positive sign is expected for the β estimate.

The hypotheses tested were:-

(Ho): $\beta = 0$ implying that the regression coefficients are equal to zero and thus no effect on dependent variables (participation of household in JFM initiatives) and the independent variables (socio-economic factors);

against.

(Ha): $\beta \neq 0$ implying that the regression coefficients are not equal to zero and therefore there is either positive or negative effect between the dependent

(participation of household in JFM initiatives) and independent variables (socio-economic factors).

To test whether the regression coefficients is statistically significantly different from zero, the Wald statistic that asymptotically in large samples follows a Chi-Squared distribution (Gujarati, 1995; Norusis, 1990) was used. The Wald statistic is distributed as Chi-square with degree of freedom (df) equal to the number of constrained parameters (r). With single parameter, the Wald statistic is simply the square of the t-ratio. The odds ratios represented by Exp (β) from logistic regression analysis were used in explaining the likelihoods of participation of household in JFM or not.

To assess the goodness of fit of the regression model to the data, as suggested by Norusis (1990) and Pampel (2000) the model chi-square, the log likelihood ratio test denoted by -2LL and classification tables was used. By using the model Chi square test, significance level of the model was tested at 5% probability level. The magnitude of the -2LL value also determined the goodness of fit of the model to the given data set. The smaller the value of -2LL, the goodness of fit of the model, likewise the higher the overall percentage of classification the better the variables were explained by the model.

(iii) Interpretation of logistic regression results

It should be kept in mind that interpretation of parameters in logistic regression is not as straightforward and easy as it is the case with Ordinary Least Square (OLS) methods (Norusis, 1990; Pampel, 2000; Powers and Xie, 2000). For proper interpretation of logistic regression model results the researcher needed a careful look at:-

- The wald statistic to see whether the effect of a particular independent variable is statistically significant or not. The Wald statistic indicates non-zero values, implying that there are interaction between the dependent and independent variables. According to Norusis (1990) and Power and Xie (2000) non-zero values for the Wald statistics indicate presence of relationships between the explanatory variables.
- The sign of effect (β), to see whether the increase in the independent variable increased or decreased the probability of success (participation of household to JFM initiatives),
- The magnitudes of the similarity measured variables, to determine which of the independent variables seem to have a greater effect on participation in JFM initiatives.

The exp(β), to see how much a 1-unit increase in X_k changes the odds of success (this is because the odds of success is not the same as probability of success).

Finally, assess the results of different values of independent variables (X) and make mathematical calculations to see how a change in the value of a particular independent affects the probability of success (Appendix 6).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Impact of JFM on forest stocking and tree species diversity in ANR, Tanzania

4.1.1 Impact of JFM on tree stocking

4.1.1.1 Comparison of distribution of number of stems per hectare in 2001 and 2005

The results in Table 3 show that a total of 3043 ± 360 (SE) stems per hectare were found in 2005 compared to 1762 ±225(SE)) stems per hectare found by IFRI in 2001. The difference of stems per hectare for the two periods was statistically significant (t = 3.09; p=0.004).

Table 3: Comparison of stocking parameters in 2001 and 2005 in Mlesa VFMA, ANR, Tanzania

Stocking	Years		t-value	P(T<=t) two-tail
	2001	2005		
N	1762 ± 225(SE)	3043 ± 360 (SE)	3.09	0.004 **
G	46.118 ± 7.583(SE)	42.096 ± 4.973(SE)	0.41	0.688 ns
V	720.493 ± 135.849(SE)	530.337 ±87.883(SE)	1.07	0.292 ns

Source: IFRI data (2001) and own field data (2005)

N = Number of stems per hectare (N/ha), G = Basal area (m^2/ha), V = Volume (m^3/ha), SE = Standard error; ** = Significance at 0.05 level, and NS = Non-Significance at 0.05 level

Further more the number of stems per hectare per diameter classes was presented in Fig. 5 and Appendix 9. Both years 2001 and 2005 showed a reversed J – shaped trend of the diameter class distribution though year 2005 showed an increase in number of stems per hectare particularly in the first diameter classes compared to year 2001.

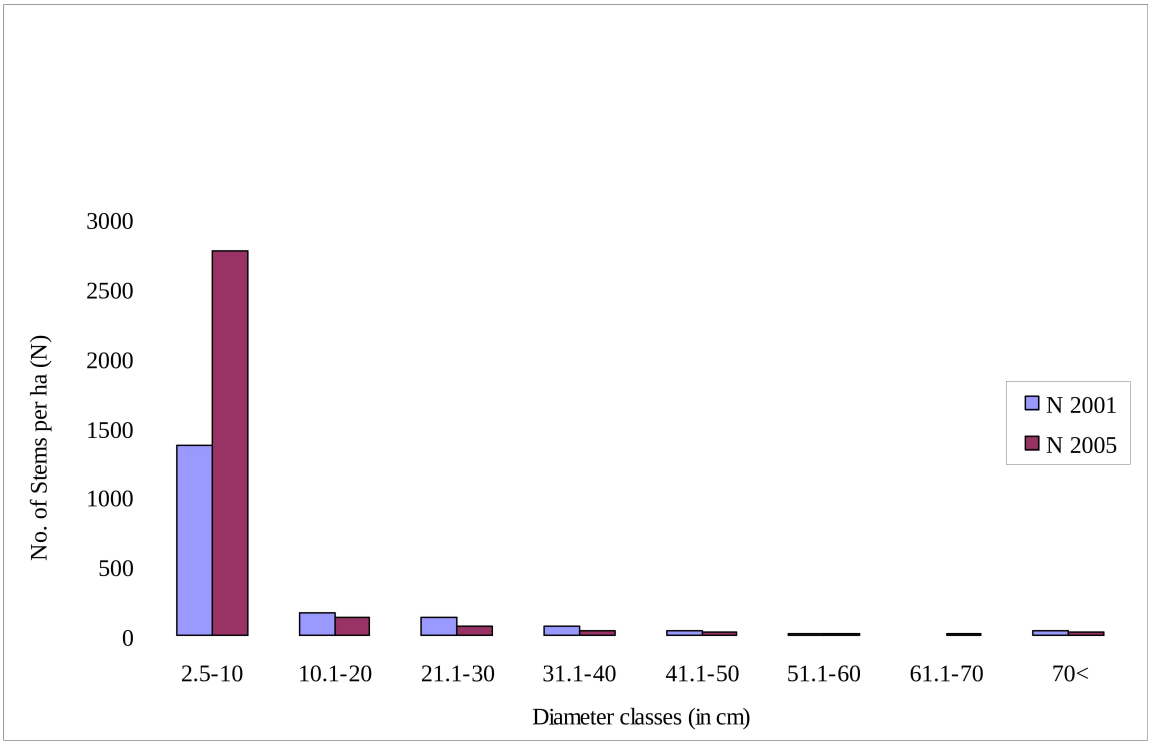

Figure 5: Comparison of number of stems per hectare between year 2001 and 2005 in Mlesa VFMA, ANR, Tanzania.

This is an indication of good regeneration and recruitment in the natural forest as reported by Phillip (1983). However Fig. 5 also shows a remarkable decrease in number of stems per hectare in diameter classes of three to eight in both periods of 2001 and 2005. The plausible reason could be over cutting of tree species with bigger diameter classes. The study suggests presence of human impact that involves opening of gaps that allow more small trees to grow.

Kajembe *et al.* (2004a) observed the same trend of significant increase in number of stems per hectare in montane forest in Kwizu Forest reserve observed in year 2003 as compared to year 2000. Kwizu Forest indicated substantial human impact that was contributed by institutional failure where abuse of rules was a common phenomenon that resulted into negative impact on the forest resource. In another study conducted by Njana (1998) in North Kisara-Mamiwa forest reserve which is within in the Eastern Arc Mountains 665 stems/ha were reported. Tangwa (2000) observed similar trend that most of number of

stems per hectare (98%) were below 20cm diameter at breast height an indicator of severe human impact on forest resource base.

4.1.1.2 Basal area and wood volume

The results in Table 3 shows mean basal areas of 42.096 ± 4.973 (SE) m^2 ha^{-1} in 2005 which is a bit lower compared to the basal area of 46.118 ± 7.583 (SE) m^2 ha^{-1} recorded in 2001. However, the difference is not statistically significant ($p>0.05$). Similarly, the wood volume obtained in 2005 is 530.337±87.883 (SE) m^3 ha^{-1} being a little bit lower than the wood volume of 720.493±135.849 (SE) m^3 ha^{-1} recorded in 2001. The difference is not statistically significant ($p>0.05$). The possible reason could be that though most tree species are abundant in the first two diameter classes (2.5 -10 and 10.1 – 20 cm) as shown in Appendix 9, still comprise of very small diameters that contribute to small basal area and consequently small wood volume as indicated in Fig. 6 and Fig. 7 respectively.

The study suggests that there was tree cutting going on in Mlesa Village Forest Management Area and therefore the forest resource possibly experiences negative human impact. From field observation, fresh cuts of trees of 10.1-20 cm dbh were observed likely for poles while old big diameter trees experienced gravity fall and are being used as firewood by the surrounding community. Similar trend was reported by Kajembe *et al.* (2004b) at Kwizu Forest Reserve where JFM strategy is operating. According to them slight lower basal area and wood volume was observed in 2003 compared to that observed in 2000. The authors concluded that decrease in basal area and volume in Kwizu Forest reserve suggested an institutional failure.

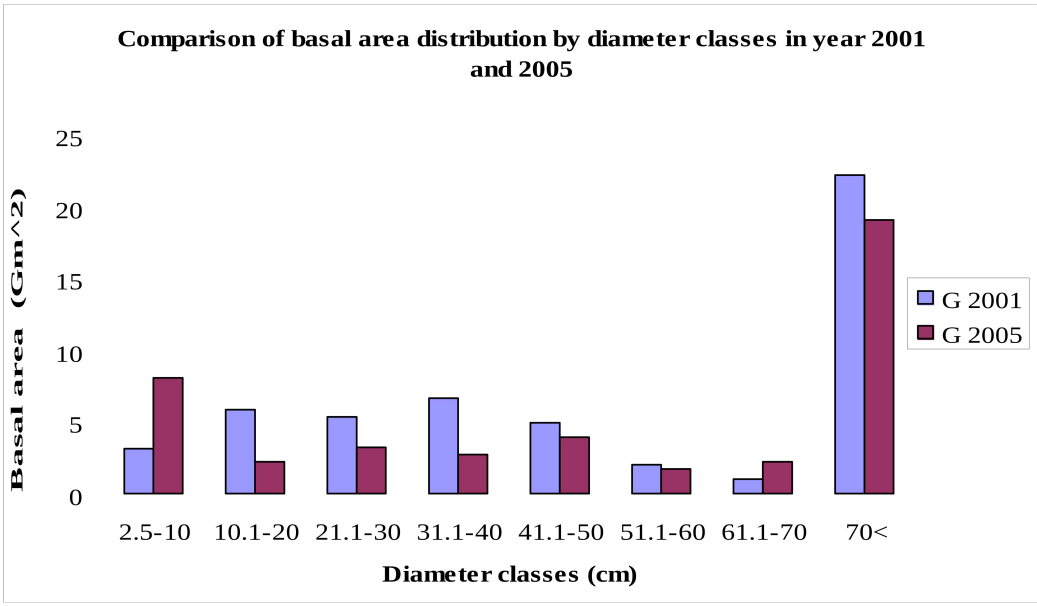

Figure 6: Comparison of basal area distribution between 2001 and 2005 in Mlesa VFMA, ANR, Tanzania.

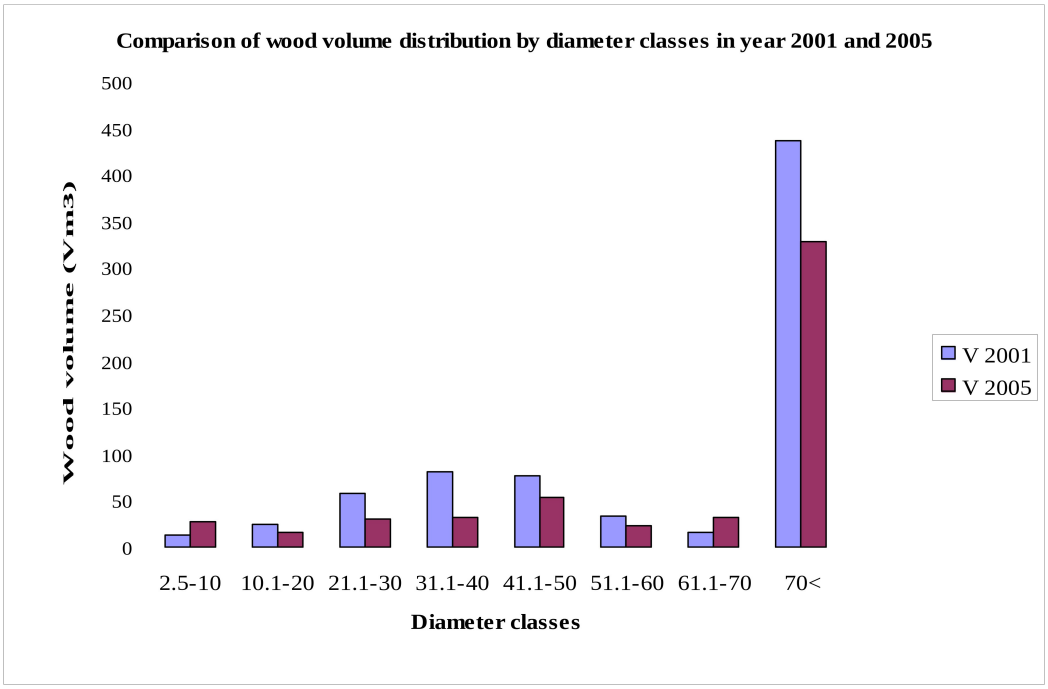

Figure 7: Comparison of wood volume distribution between 2001 and 2005 in Mlesa VFMA, ANR, Tanzania.

In general, the study found that there were increased number of stems per hectare, and a decrease of both basal area per hectare and wood volume per hectare suggests that there were tree felling which open gaps that encourage more stems per hectare in small diameter classes. Hence the null hypothesis is rejected in favour of the alternative hypothesis and concluded that JFM has negative impact on basal area and wood volume at ANR, Tanzania. These results were contrary to that observed in India by Khare *et al.* (2000) and Mohamed (2006). Khare *et al.* (2000) reported that in India Joint Forest Management have positive impacts on forest resources while Mohamed (2006) reported similar trend in Handeni Forest Reserve, Tanzania that Joint Forest Management showed positive impact on forest resource base. The plausible reason of the contrary results could be poor monitoring capability of forest resource base caused by ineffective co-ordination of created institution and thus the whole issue centred as weak governance.

4.1.2 Impact of JFM on tree diversity and richness

4.1.2.1 Important Value Index

Important value index (IVI) is presented in Appendix 8. Fig. 8 shows IVI for 11 species in order of magnitude in the order: *Allanblackia stuhlmanii*, *Sorindeia madascariensis*, *Mesogyne insignis*, *Maesopsis eminii*, *Cephalosphaera usambarensis* and *Isoberlinia schefferi* were species with highest important value index in relation to others implying that are abundant species in the study area.

Important Value Index (IVI) shows the overall picture of ecological importance of a species with respect to the community structure because is a composite index based on the summation of the percentage value of the relative frequency, relative density and relative dominance (Ambasht, 1998).

Figure 8: Important Value index for eleven species in Mlesa Village Forest Management Area – ANR, Tanzania.

4.1.2.2 Shannon-wiener Index of Diversity

The Shannon-wiener value (H') in this study was 3.379. This value was higher than 3.271 observed in 2001 (Appendix 8). The greater the value of Shannon-wiener index the higher the species diversity (Mbwambo *et al.*, 2004). These results suggest that there is high species diversity found in 2005 compared to 2001. The higher diversity of species observed in 2005 indicate high re-growth rate of the forest after disturbance. This was supported by fact that 74 tree and shrubs species were found in 2005 compared to 51 trees and shrubs observed by IFRI in 2001.

Causes of disturbance in the forest studied according to field observation were subsistence mining, pole cutting for household construction and gravitation fall experienced by old big trees that opens gaps that encourage recruitments. Normally the fallen trees are collected as firewood for household use. This was due to the fact that the forest area under study was the Village Forest Management Area (VFMA) in ANR where local uses are allowed. Selective harvesting open gaps thereby enhancing regeneration and subsequent increase of the Shannon-wiener index. Pole cutting was reported by Hamilton and Bensted-Smith (1989) to have a major influence on the forest that can alter the balance of species.

An increase in Shannon-wiener Index value was also observed by Mohamed (2006) in Handeni Hill Forest Reserve where JFM strategy is operating. The author observed a Shannon-wiener Index value of 3.103 and 3.389 for miombo woodland and semi-evergreen forest respectively in 2004, compared to H' value reported by Malimbwi and Mugasha (2002) of 2.425 and 2.657 for miombo woodland and semi-evergreen forest respectively. Therefore JFM at ANR has enhanced tree species diversity suggesting that the forest composition was changing as new species were recruited.

4.1.2.3 Index of dominance

The Index of dominance (ID) observed in 2005 was 0.051 which was slightly lower compared to 0.052 observed in 2001 (Appendix 8). These results imply that the probability of picking randomly two individuals belonging to the same species is slightly low (0.051) in 2005 compared to 2001 (0.052. Therefore these results suggest that there was relatively more heterogeneity in vegetation in 2005 compared to 2001. This slight difference in heterogeneity could be caused by some disturbances in the forest and recruitment of new species.

The Index of Dominance obtained in this study was more or less similar with that obtained in submontane forest in other studies. For example Munishi *et al.* (2004) obtained Index of Dominance value of 0.05 and 0.04 for Kisimagonja in West Usambara and Uluguru respectively. Therefore JFM had slightly influenced the forest to become heterogeneous with new species coming in.

4.2 Socio-economic factors affecting participation in JFM by local communities surrounding ANR

4.2.1 Training sessions in JFM

The results in Table 4 concerning training of villagers in JFM related issues show positive regression coefficient. These results imply that increase in training sessions on JFM related issues increase the odd ratio by a factor of 17.956. This indicates that increase in training sessions tend to induce attitude of change towards JFM. The increase of odds of participation in JFM initiatives was statistically significance (p=0.003).

The importance of capacity building to villagers and attitude change for both foresters and villagers was emphasized by Mallik (2000); TANGO International, (2004) and Ranthore and Jain, (2005). Training particularly capacity building and competence development of the villagers creates immediate interest of the people to participate in project activities (Ranthore and Jain, 2005). Kajembe *et al*. (2004b) emphasized that to ensure full participation in JFM schemes all stakeholders at community level need to be involved, educated and sensitised about their rights, responsibilities and expected returns. Mutual attitudinal change can result in mutual rapport building and trust building resulting in strong bondage of partnership that encourages more participation in JFM interventions.

Table 4: Socio-economic factors affecting participation in JFM by local communities surrounding ANR, Tanzania

Variables	β	S.E.	Wald	df	Sig.	Exp(β)
Education	.230	.840	.075	1	.785	1.258
Age	.047	.032	2.181	1	.140	1.048
Farm size	-.081	.103	.609	1	.435	.923
Training sessions in JFM	2.888	.968	8.905	1	.003**	17.956
Tree planting	3.826	1.094	12.239	1	.000***	45.894
Shared income from forests under JFM	2.366	.907	6.801	1	.009**	10.658
Access to local institutions	1.773	.991	3.200	1	.074	5.888
Engagement of households in economic groups	2.037	1.017	4.015	1	.045*	7.671

Constant	-10.297	2.792	13.600	1	.000	.000

-2LL = 49.958; Model chi-square = 64.77, $p<0.001$; Overall percentage of classification = 88.1%, Number of cases = 85, Exp(ß) = odds rations (probability of success/probability of failure), SE= standard error of the estimate, *Statistically significant at 0.05 level of significance, ns = statistically non significant at 0.05 level of significance, Sig = significance or P – values, e = 2.718, ß = regression coefficients which stand for the odds ratio of probability of success to the probability of failure and Wald statistics = $ß/(SE)^2$ according to (Norusis, 1990; Powers and Xie, 2000).

4.2.2 Tree planting after JFM

The results in Table 4 showed that tree planting has positive regression coefficient. This implies that increase in one household that planted tree increases the odd ratio of participation in JFM initiatives by a factor of 45.894. This means a household that is participating in tree planting tend to increase assets of the household. This is because those trees can be sold and a household can get income for household use. The increase of odds of participation of household in JFM initiatives with reference to tree planting was statistically significant ($p<0.0001$). JFM represents a fundamental shift from mere departmental tree planting to people centred approach (Ranthore and Jain, 2005) and farmers plant trees in their farms for variety of products and services (Anyonge and Roshetko 2003).

4.2.3 Shared income from forests under JFM

Results in Table 4 further show that income shared from forest under JFM has positive coefficient. This means that when one unit of income from JFM shared with local communities increase the odd ratio of participation in JFM by a factor of 10.658. This implies that local communities who are duty bearers need a clear benefit so that they can be motivated to participate in JFM initiatives. Furthermore the increase of odds for participation in JFM was statistically significant at ($p=0.009$). These results demonstrate that participation in JFM initiatives is a ‘give and take’ exercise.

Benefit sharing encompasses a variety of measures aimed altering the distribution of the benefits from forest management among stakeholders (Whiteman, 2003). Kajembe *et al.* (2004a) reported that revenues from JFM activities should be equitably distributed among the stakeholders. Ranthore and Jain (2005) found that; benefit sharing act as a motivating factor for people’s participation and token appreciation for the people’s efforts in conservation. The author emphasized that structured mechanism of benefit sharing creates stake for the people’s participation and therefore is a must for sustaining the peoples’ interest in forest management. Nurse and Kabamba (1999) urged that cost and benefit

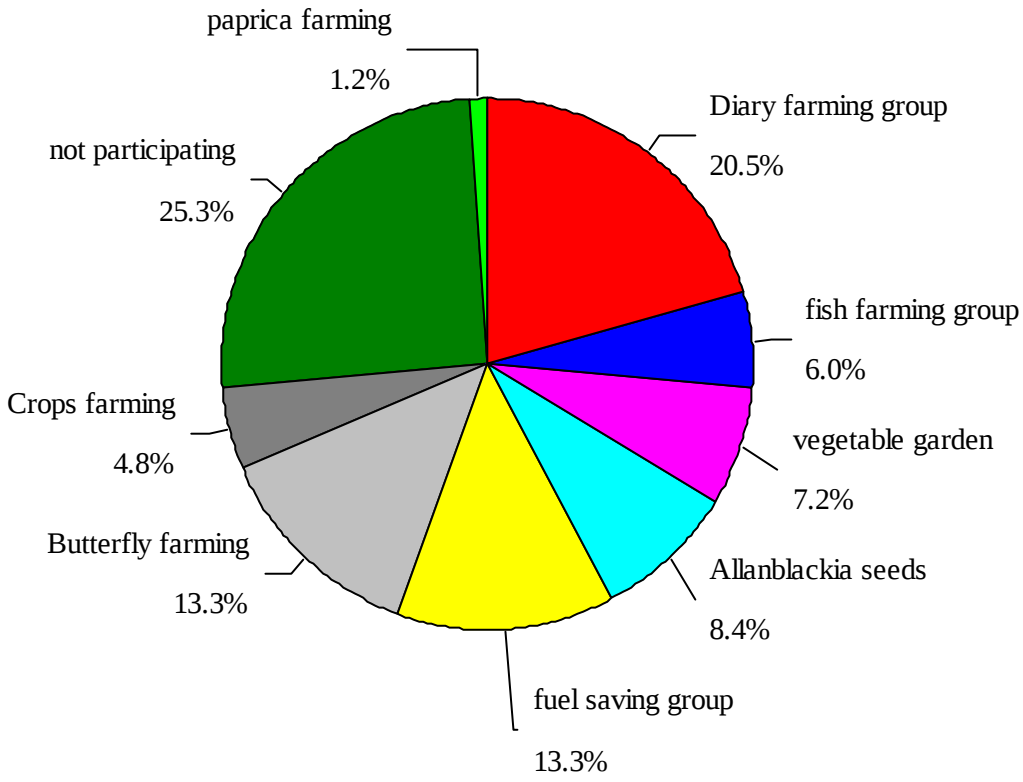

Figure 9: Various economic groups in villages surrounding ANR, Tanzania.

Nombo (1995) urged that in a group setting, people can share and exchange ideas so as to come to a common solution to particular problems, despite their individual differences. The author added that group approach provides farmers with either direct access to political power or political means of acquisition. Advantages of farmer groups were acknowledged by Ashby *et al.* (1989) that improve dialogue, efficiency of using resources and potential for improving linkages. Therefore engagement of households in economic groups enhances participation in JFM initiatives in the study area.

4.2.5 Education level

The results in Table 4 show that education has a positive regression coefficient. This implies that an increase in educational level of respondents increase the odd ratio on participation in JFM intervention by a factor 1.258. The plausible explanation of positive coefficient in education can be due to the fact that increase in the level of education increases the level of awareness of the community in forest resources management and hence willingness to participate in JFM initiatives. However, the increase of odds ratio of participation in JFM initiatives was not statistically significant ($p>0.05$).

Katani (1999) commented that an increase in education level increases the level of awareness and thereby creating positive attitudes. Mbwambo (2000) argued that education has a direct influence on people's participation in natural resources management and promote sustainable utilization of the natural resources.

4.2.6 Age of a respondent

Table 4 show that age of a respondent has positive regression coefficient. These results imply that an increase in age by one year increases the odds of participation of households in JFM initiatives by a factor of 1.048. The plausible explanation can be that, as age increases responsibilities in a household increases also, a situation that makes the household head to seek more livelihood options. JFM initiatives offer livelihoods options hence the household participates in these initiatives. However, the effect was not statistically significant ($p>0.05$). Age was also identified by Ashyby *et al.* (1989) as one of the factors influencing participation.

4.2.7 Farm size

Table 4 shows that farm size has a negative regression coefficient. This means increase in one unit (hectare) of farm size of a respondent decreases the odds of participation in JFM initiatives by a factor of 0.923. In most cases when people have large farm sizes it means they have enough land for farming. Further more in the study area wealth was associated with farm sizes this means that a household with large farm is relatively wealthier, thus does not need to participate in other initiatives like JFM. In general, in the study area farm sizes are small and some households are landless and thus survive through land borrowing. In the study area an average of 5.3 ± 0.496(SE) hectares (with minimum of zero and maximum of 25.0 hectares) were the farm sizes of households. This situation forces household members to participate in JFM initiatives so as they can learn how to diversify income sources. Small farm size also is a driving factor towards participation in agro-forestry. However, the effect was not statistically significance at ($p>0.05$). The so-called insecurity of land has major implications for management of biodiversity (FAO, 1999).

4.2.8 Access to local institutions

Table 4 showed that coefficient for access to local institution was positive. This implies that the increase in accessibility to local institutions increases the odds ratio of participating in JFM interventions by a factor of 5.888. These results can be explained by the fact that institutions structure incentives, whether politically, socially or economically and thus have potential to enhance participation in JFM initiatives. Furthermore, participation of local communities in managing forests can help to establish new institutional arrangements that improve forest productivity, sustain livelihoods, increase environmental sustainability, and make rules governing forest access more enforceable.

However, the increase in odds ratio of participation of JFM initiatives was not statistically significant ($p>0.05$). The insignificance of access to local institution could be caused by the passive role played by these institutions. In the study area for example, Village governments have no by-laws that could help in the implementation of the forest management agreements. Similarly, Village Natural Resources Committees (VNRC) in the study area have no clear responsibilities, an indicator of inadequate accountability a situation that may end up into frustrating these committees. Lack of accountability and absence of rule of the law are the major challenges that Africa faces (Musoko, 2007). Further more 100% of respondents were not aware as to whether the communities are presented into the Board Meeting of Amani Nature Reserve. The study found that there was inadequate devolution of responsibilities, rights and authority from the state to local communities. This situation was an indicator of lack of transparency, and hence weak governance.

Brinkerhoff and Goldsmith (1992) argued that institutions include procedures that shape how people act, their status or legitimacy. Strong, self-regulating institutions result into effective and transparent mechanisms on ensuring participation, equitable sharing and conflict resolutions (Mallik, 2000; Musoko 2007). A Framework for livelihoods analysis by Ellis (2000) consists of assets that their access is modified by social relations and institutions that all together results into livelihood strategies that encourage participation of local communities in development initiatives such as JFM.

In general, both t-test and Wald statistic tests indicate that training sessions in JFM, tree planting, shared income from forests under JFM and engagement of households in economic groups have significance influence ($p<0.05$) on the participation in JFM by local

communities surrounding ANR. In terms of goodness of fit, the logistic regression model (LRM) fitted well to the data 88.1%. This is shown by highly significance value of <0.001 for a constant (Table 4). The second support of fitness of the model to the data is the computed model Chi-square value of 64.77, which is significant at 0.05 probability level. Therefore, the model can be used for prediction of socio-economic factors influencing participation in JFM by local communities surrounding ANR by 69.4% confidence limits.

4.3 Impact of JFM on livelihoods of local communities surrounding ANR

4.3.1 Impact of JFM in household income

Mean income earned per household per month from JFM initiatives and its impact for the period of 2001-2005 are presented in Table 5. The major source of income after JFM intervention included tree and tree products including poles and tree seedlings, *Allanblackia* oil seeds, fish farming, butterfly farming, employment and selling of spice. Significantly ($p<0.05$) income was earned by local communities after JFM (Table 5).

4.3.1.1 Income from tree and tree products

Table 5 shows that mean income per household from sales of poles and tree seedlings was Tsh. 4242.16 ± 2110.48 (SE) per month. The Table shows further that households in Potwe Ndondondo village earned more income of 12467.95 ± 6583.86 (SE) from tree products and seedlings followed by Kisiwani, Mlesa and Shebomeza villages. The plausible explanation for Potwe Ndondondo village earning more income compared to other villages sampled was attributed by marketability of *Tectona grandis* poles compared to other species planted in the upland villages. Table 5 further shows that impact of increase of income per household per month from tree and tree products like seedlings was statistically significant ($t=2.156$, $p=0.034$).

The income earned for those households which planted trees tend to encourage more villagers to plant trees and 56.5% of respondents planted trees in their farms after JFM compared to 9.4% before JFM. The results showed that respondents planted trees after JFM were statistically significant at ($\chi^2=18.66$, $p=0.028$).

Table 5: Impact on mean household income per month from sales of products from JFM initiatives before 2001 and 2001-2005 in villages surrounding Amani Nature Reserve, Tanzania

Income sources under JFM	Period	Villages					t	p
		Mlesa n=26	Shebomeza n=17	Kisiwani n=16	Potwe Ndondondo n=26	Overal n= 85		
Tree and tree seedlings	Before JFM	0	0	62.5 (62.5)	1668.27 (1600)	522.06 (490.13)		
	After JFM	64.10 (64.10)	39.22 (39.22)	2130.21 (2080.73)	12467.95 (6583.86)	4242.16 (2110.48)	2.156	0.034
Allanblackia seeds	Before JFM	0	0	0	0	0		
	After JFM	1137.82 (648.90)	924.02 (392.63)	0	0	532.84 (218.11)	2.443	0.017
fish farming	Before JFM	0	0	0	25.64 (25.64)	7.84 (7.84)		
	After JFM	0	1073.53 (880.70)	0	368.59 (277.66)	327.45 (196.29)	1.629	0.107
Butterfly farming	Before JFM	0	0	0	0	0		
	After JFM	0	0	9578.13 (2750.79)	0	1802.94 (649.02)	2.778	0.007
Employ ment / Contract	Before JFM	2653.85 (1985.29)	0	0	0	811.76 (613.68)		
	After JFM	8430.77 (4037.55)	4882.35 (3388.87)	13208.33 (6408.68)	2692.31 (2692.31	6865.10 (2033.18)	3.075	0.003
Spices	Before JFM	0	0	0	0	0		
	After JFM	7629.01 (3894.27)	13425.49 (3539.25)	4030.21 (1264.95)	2673.08 (1051.04)	6594.95 (1482.52)	4.448	0.000
Overall average income per household per month contributed by JFM initiatives								3394.24
Average income/household/month						82797.65 (9968.30)		
% of overall mean Income from all JFM products /month per household								4.1%

Note: N-Statistic is out of 85 households from all four villages.
Figures outside parentheses represent mean income in Tshs while figures inside parentheses represent Standard error of the mean (SE)

Table 6 shows an overall mean of number of trees planted at household level before JFM was 403 ± 139.2(SE) and after JFM was 1048 ± 183.6(SE). Furthermore Table 6 shows that more trees were planted after JFM in Potwe Ndondondo (1489 ± 428.0(SE)) and Shebomeza (1182 ± 407.0(SE)) villages compared to Mlesa and Kisiwani villages. The number of trees planted before and after JFM were statistically significant (t= 4.585; p<0.001). These results could be influenced by indifferences in wealthy ranks among the respondents in the sampled villages.

The tree species planted in the study area were presented in Appendix 5 of which *Grevillea robusta* was the most planted species in the study area followed by *Cedrella ordorata* and *Tectona grandis*. Jordan (1995) argues that trees will continue to provide profits in the future as can be replanted and harvested again and again.

4.3.1.2 Income from selling of *Allanblackia stulhmanii* oil seeds

Table 5 also shows that other tree products sold in the area include *Allanblackia stulhmanii* seeds. The income per household per month from sales of *Allanblackia stulhmanii* oil seeds was Tshs 532.84 ± 218.11(SE).

Table 6: Number of trees planted per household in villages surrounding ANR, Tanzania

Number of trees planted	Villages				
	Mlesa n=26	Shebomeza n=17	Kisiwani n=16	Potwe Ndondondo n=26	All villages n= 85
Before JFM	247 (125.8)	513 (339.4)	363 (349.4)	512 (319.3)	403 (139.2)
After JFM	693 (197.5)	1182 (407.0)	765 (414.8)	1489 (428.0)	1048 (183.6)

t statistic = 4.585; p<0.001
Figures outside and inside the parentheses are mean and standard error of the mean (SE) respectively

This represents an average of 5.33 kgs of seeds sold per household per month at a price of Tshs100 per kg. In Mlesa and Shebomeza the villagers were involved in selling of *Allanblackia stulhmanii* oil seeds and earned Tshs1137.82 ± 648.90(SE) and 924.02 ± 392.63(SE) respectively per household per month. Table 5 further show that the impact of increase of income per household per month from selling *Allanblackia stulhmanii* oil seeds was statistically significant (t=2.443, p=0.017).

4.3.1.3 Income from butterfly farming

Table 5 shows that average income per household per month from butterfly farming was Tsh. 1802.94 ± 649.02(SE). Butterfly farming was not practised before JFM while after JFM 9.4% of respondents in the study area were engaged in butterfly farming and among the sampled villages, Kisiwani was the only village engaged in butterfly farming. The possible reason for butterfly farming carried out in Kisiwani village could be a result of other organizations such as Tanzania Forest Conservation Group (TFCG) taking responsibilities of modifying asset that enhances livelihoods without bringing detrimental effect to forest resource base. Table 5 further shows that increase of income per household per month from butterfly farming was statistically significant (t=2.778, p=0.007).

4.3.1.4 Income from employment

Table 5 further shows that household income after JFM was also contributed by employment with an average income per household per month being TShs. 6865.10 ± 2033.18 (SE). The average income per household per month earned from employment as shown in Table 5 was highest in Kisiwani village followed by Mlesa village with a mean income per household of TShs 13208.33 ± 6408.68 (SE) and TShs 8430.77± 4037.55(SE) respectively. Table 5 further shows that increase of income per household per month from employment was statistically significant (t=3.075, p=0.003).

The increased income from employment might be caused by ANR offering employment in ecotourism industry where tour guides are local people. Watchmen, hotel attendants are also local people.

4.3.1.5 Income from sales of spice

Table 5 shows that household income from sales of spice increased household income per month at an average of Tshs. 6594.95 ± 1482.52(SE). Spices in the study area include black pepper, cinnamon, cloves and cardamom. Shebomeza village earned the highest income per month per household followed by Mlesa village (Tshs13425.49 ± 3539.25(SE) and Tshs 7629.01 ± 3894.27(SE) respectively). The increase in household income per month was statistically significant at ($t=4.448$, $p<0.0001$).

4.3.1.6 Income from fish farming

Table 5 showed that sales from fish farming increased income at household level per month by a mean of TShs. 327.45 ± 196.29(SE). Households in Shebomeza village earned the highest income from fish sales after JFM followed by Potwe Ndondondo village while Mlesa and Kisiwani villages were not practising fish farming. However the increase in mean household income per month due to sales of fish was not statistically significant ($t=1.629$, $p>0.05$).

Other studies argue that an incentive to influence stakeholders to participate in sustainable forest management must provide more tangible economic benefits to the local communities (Dubois, 1999; Khare *et al.*, 2000 and Kajembe *et al.*, 2004a). It was also revealed that the money obtained from JFM initiatives was used for household development. These results are similar to those reported by Pandey (2005) where JFM influenced development of entrepreneurial skills among villagers. The considerable increase of income after JFM at a household level was a tangible economic gain and is a positive impact from JFM.

Table 5 further shows that income from JFM initiatives contributed to household income per month at an overall average of Tshs 3 394.24. The increase of income from JFM initiatives contributed to 4.1% of the total household income per month, which was Tshs.82 597.65 ± 9 968.309(SE) (US$ 67.7 ± 8.171(SE) in the study area. Other income sources not from JFM initiatives in the study area were from milk production, tea farming, cocoyam, sugarcane, coconuts, local brewing, carpentry, remittance, petty business, pig project, sewing, herbalist and poultry.

Masayanyika (1995), reported the average overall household income in the same study area to be TShs.436 000 (US$ 846.6) per year which was equivalent to TShs.36 333.33 (US$ 70.55) per household per month. The mean income per household per month in households surrounding ANR observed in this study was a bit lower compared to that reported by Masayanyika (1995). The plausible reason could be hindrance of commercial logging in Amani Division and the fall of cardamom harvest after stopping its cultivation in the forest. But the income per household per month was higher compared to minimum wage of Tanzania civil servant (Tshs.60 000/= (US$ 49.1)). However the average number of persons per household ranged from 5 to 7 (URT, 2002a) and therefore the income per person per day was between Tshs.550.64/= and Tshs.393.32/=. This amount is below one US dollar per day and therefore adjacent villagers are below poverty line.
The per capita income of a Tanzanian was estimated to be at about US$282, which was about Tshs 26 000 per month (Masayanyika (1995). This was an estimate of Tshs.866.67 per person per day which was also less than one US dollar per day.

JFM did not contribute to household income to reach the level of sustaining normal daily life. However, household income per month for adjacent communities around ANR was higher than in other areas such as Kibaoni, Kwabaya and Kwamasaka as reported by Mohamed (2006); Chome and Kwelikwiji as reported by Kingazi (2001) and O'kting'ati *et al.* (2000) respectively. The overall mean income per month per household from various sources was found to be Tshs. 43 288.68/= (US$ 35.48) in Kibaoni, Kwabaya and Kwamasaka villages surrounding Handeni Hill Forest Reserve that was under JFM initiatives (Mohamed, 2006). Kingazi (2001) reported average household gross income of Tshs. 35 929/= (US$ 37.85) per month in villages adjacent to Chome Forest Reserve, Same district, while O'Kting'ati *et al.* (2000) reported an average household income of Tshs. 37 743/= (US$41.9) per month in Kwelikwiji village, Nguru mountains.

4.3.2 Improvement of housing

Table 7 shows that 27.1% of respondents in the study area were using mud or burnt brick for construction of their houses after JFM. Table 7 also showed that 12.9% and 8.2% of respondents in Shebomeza and Potwe Ndondondo villages respectively improved their houses from wood to brick houses after JFM. The results in table 7 imply that respondents were shifting from wood houses to more modern ones and that improved housing is one of the indicators of sustainable livelihoods. Therefore through JFM, households managed to change from low standard houses to high ones (Plate 1).

Table 7: Response of improved housing from wood to brick houses in Village around ANR, Tanzania

		Villages						
JFM activity		Mlesa n = 26	Shebomeza n=17	Kisiwani n=16	Potwe Ndo ndondo n=26	All villages n = 85	Chi (X^2)	Proba bility
Brickmaking /construction	after JFM	3.5 (3)	12.9 (11)	2.4 (2)	8.2 (7)	27.1 (23)		
	Both before and after JFM	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	15.71	p=0.015
	Not using bricks	25.9 (22)	9.4 (8)	15.3 (13)	21.2 (18)	71.8 (61)		

Note: Numbers outside parentheses denotes percentages while numbers in parentheses denotes respondents; n=85

Amani Nature Reserve management constructed timber presses for mud brick making and provided them to villages. Households in form of

collective or working parties (‘*kiwili*’) can make one household’s bricks, shift to another household until every member of the working party have his own bricks.

Plate 1: A newly constructed brick house at Chemka in Shebomeza village, around ANR, Tanzania

These results imply that there was initiative at household level of improving their housing standards which is a requirement of sustainable livelihoods. This was the positive impact of JFM on livelihoods of local communities around ANR. The increase in household constructed with bricks

as influenced by JFM initiatives was also observed in villages surrounding Handeni Hill Forest Reserve by Mohamed (2006).

4.3.3 Reduced women's workload and time lost from firewood collection

The study also revealed that women's workload and time lost for collection of firewood was reduced through construction and use of energy saving stoves. The results in Table 8 showed that 38.8% of respondents use fuel saving stoves in the study area. Table 8 also shows that before JFM there was no body using energy saving stoves in the sampled villages but after JFM Mlesa and Potwe Ndondondo villages have 11.8% each of respondents constructed and used the energy saving stoves followed by Shebomeza (9.4%) and Kisiwani (5.9%) villages.

Table 8: Response of distribution of fuel saving stoves in villages surrounding ANR, Tanzania

		Villages						
Alternative	period	Mlesa n = 26	Shebomeza n=17	Kisiwani n=16	Potwe Ndondondo n=26	Total Ndon = 85	Chi(X^2)	Probability
Fuel saving stoves	before JFM	0.0 (0)	0.0(0)	0.0 (0)	0.0 (0)	0.0 (0)		
	after JFM	11.8 (10)	9.4 (8)	5.9 (5)	11.8 (10)	38.8 (33)	0.29	p=0.961
	Before and after JFM	0.0 (0)	0.0(0)	0.0 (0)	0.0 (0)	0.0 (0)		
	no	18.8 (16)	12.9 (11)	11.8 (10)	17.6(15)	61 (52)		

Note: Numbers outside parentheses denotes percentages while numbers in parentheses denotes respondents; n=85

However the use of energy fuel stoves was not statistically significant ($\chi^2 = 0.29$, p=0.961).

The plausible reason of indirect relationship between JFM and construction and use of energy saving stoves could be attributed by Amani Nature

Reserve management engaged in training of villagers in constructing and use of the stoves. Other factors that influence the spread of energy saving stoves as revealed from PRA were reduction of fuel wood head loads used per week from 5-6 to 2 – 3 for a family size of 4-7 people in a household. Women in Amani acknowledged a big saving in firewood of 50-70% when they use the energy saving stoves (White and Mustalahti, 2005). These results imply that women's workloads through collection of firewood were minimized and that time saved can be used in other productive activities. Also the sanitation of the kitchen has improved because of less smoke spreading around the house. Properly dried fuel-wood and well-designed, well built and well used improved stoves with chimneys and hoods reduce kitchen pollution substantially (Smith, 2006). In addition women use these stove to maintain warmth of the food for the members of the family (Plate 2).

Plate 2: Energy saving stoves at Shebomeza village, Amani, Tanzania.

Similar trend of increased number of households using energy saving stoves were observed by Mohamed (2006) in Vibaoni, Kwamasaka and Kwabaya villages around Handeni Hill Forest Reserve, Tanzania. In another study Lalika (2006) reported an increase in the use of energy saving stoves by 50% of household in Kungwe village in Uluguru Mountains, Tanzania. Simith (2006) argued that improved stoves may have social (e.g. time-saving), ecological (e.g. tree-conserving) and economic (e.g. fuel- saving) benefits.

4.3.4 Food security

Table 9 shows that, communities adjacent to ANR depend on maize, cassava, beans, banana, cocoyams, rice and sweet potatoes for food and cash. Selling food crops for cash is caused by insufficient cash crop production in the study area. However, crop production does not fulfil demand for household food and income. Purchasing of food in the study area is a common phenomenon that only 20% of the households are food sufficient. Four percent of households supplement food by buying almost the whole year, 31% of household buy half of their food in year, and 43.5% supplement a quarter of food needed for their households.

Table 9: Main food crops cultivated by local communities surrounding ANR Tanzania

Crop	Villages				All a Villages n=85
	Mlesa n=26	Shebomeza n=17	Kisiwani n=16	Potwe Ndondondo n=26	
Maize	21.7 (26)	21.6 (17)	18.4 (16)	21.8 (26)	21.0 (86)
Cassava	20.8 (25)	21.6 (17)	18.4 (16)	21.0 (25)	20.5 (84)
Beans	6.7 (8)	17.0 (13)	18.4 (16)	20.2 (24)	15.2 (62)
Banana	20.8 (25)	18.2 (14)	18.4 (16)	16.0 (19)	18.3 (75)
Coco yams	16.7 (20)	11.4 (8)	9.2 (9)	5.0 (6)	10.8 (44)
Rice	4.2 (5)	4.5 (3)	1.3 (1)	12.6 (15)	6.1 (25)

Sweet potatoes	9.2 (11)	3.4 (2)	13.2 (12)	3.4 (4)	7.1(29)

Note: Numbers not in parentheses denotes percentages while numbers in parentheses denotes respondents; n=85

These results suggest that households in the study area are suffering from food insecurity. Food insecurity in the household surrounding Handeni Hill Forest Reserve which was under JFM strategy was reported by Mohamed (2006). Reasons of food insecurity in the households are presented in Fig.10. Figure 10 shows that unfavourable weather condition, vermin, small farm size, unfertile soil, poor farming methods and lack of improved seeds were the major reasons of insufficient harvest that leads to food insecurity in the study area. This situation can be adjusted by improving farming methods in the agricultural sector as well as integrations of JFM initiatives in the study area.

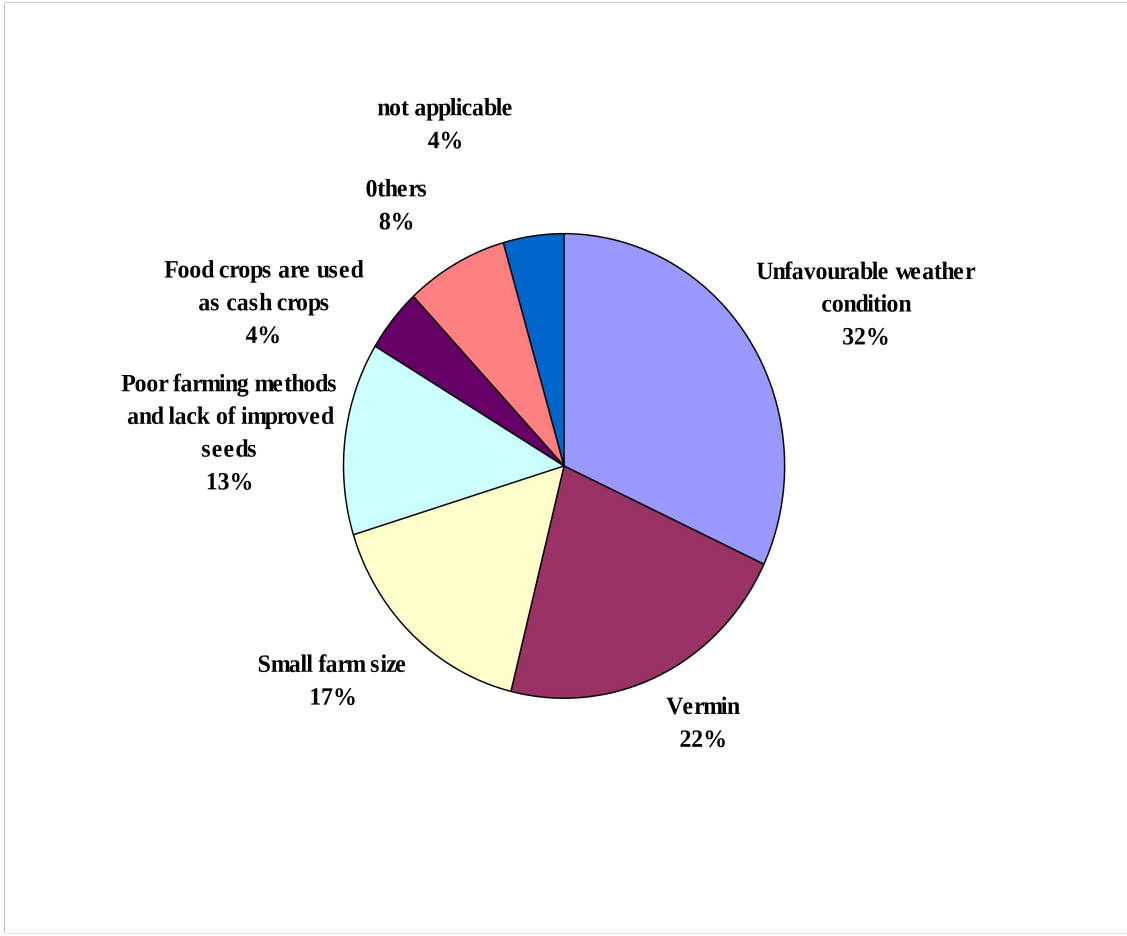

Figure 10: Reasons of food insecurity in villages surrounding ANR, Tanzania.

Medicinal plants are also accessed for curing different diseases. 72.9% of respondents use medicinal plants to cure their members of the family.

Appendix 7 show medicinal plants collected for household use. The reason of using medicinal plants could be attributed to the walking distance to reach the dispensaries while medicinal plants are available at their vicinity and one can get cured and continue with the household production activities.

According to Nyange (2001) traditional medicines help to keep labour force healthy during agricultural seasons, thus ensuring high productivity. Therefore it can be concluded that by using medicinal plants from ANR, local communities secure their health.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study showed an increased number of stems per hectare; decreased basal area and wood volume per hectare suggesting that tree felling was still going on in Mlesa Village Forest Management Area. Furthermore diversity indices seemed to be influenced by JFM. The increase in Shannon-wiener index and Index of Dominance suggests that the forest was becoming more heterogeneous. Therefore the study concluded that poor monitoring capability as an indicator of weaknesses in governance contributed to JFM to have possibly negative impact on basal area and wood volume in Mlesa Village Forest Management Area, in ANR.

The study also identified a number of socio-economic factors influencing participation in JFM by local communities around ANR. These include training session in JFM, tree planting, shared income from forests under JFM, and engagement of households in economic groups.

JFM initiatives showed positive impacts on livelihoods specifically in increase of average household income, improved housing standards and reduced women's' workloads through time saving in collection of firewood. However JFM initiatives had not reduced food insecurity possibly due to inadequate improved farming methods in the study area.

5.2 Recommendations

Based on the findings and conclusion of the study, the following recommendations are pertinent for improving the positive impact of JFM on forest resource base and livelihoods of local communities surrounding ANR.

5.2.1 The need to improve governance

There is a need of improving governance in the management of forest resource base in ANR through improved transparency, clear responsibilities for Village Natural resources Committees and favourable environment that welcome JFM actors to take their responsibilities. This can act as incentives in checking inadequacy of devolution of responsibilities, rights and authority from the state to local communities. Consequently this can enhance efficiency in monitoring and thus may reduce the negative impact on forest resource base.

5.2.2 Consideration to socio-economic factors that influences participation in JFM

Policy makers need to take into consideration socio-economic factors that influence participation of local communities in Joint Forest Management The consideration of these factors may lead into improved governance and may contribute into better livelihood strategies.

5.2.3 The importance of improving and diversification of income sources

More sources of Joint Forest Management based income need to be secured. Contemporary sources of income need to be intensified. Furthermore Joint Forest Management initiatives in Amani Nature Reserve should be used to ensure food security by improving farming methods.

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APPENDICES

Appendix 1: Inventory data - forest plot data form

B. GROUND COVER AND SEEDLING INFORMATION

What are the different ground cover plant species in the plot? To obtain the name of all species, he field researcher may ask the resident of the village the local names(s) of the species and cross-check the local name with the botanical name.

Starting at the centre of the plot, create a circle with a 1-meter radius. For each wood seedling species in this area, identify the species name and count the number of stems or woody climbers with stem diameters less than 2.5 centimeters or a height less than one meter: For herbaceous plant species, estimate the percentage of groundcover for all herbaceous plant species and write in one number for this estimation. If possible, collect a sample of each unknown species.

	Name of species		Is the species a woody seedling or a herbaceous plant? Write "S" for seedling or "H" for herbaceous plant	What percent of the 1-metr circle does this species cover?	If the species is a woody seedling, how many seedling are there
What is the family name of this plant species?	Botanical	Local			

C. SHRUB, SAPLING, PALM AND WOODY/HERBACEOUS CLIMBER INFORMATION

Record the local and botanical names of each shrub, sapling, palm, and woody/herbaceous climber found in the circle of 3-meter radius. Record maximum diameter and height in metric units

Starting at the centre of the plot, create a circle with a 3-meter radius. For each sapling, shrub, palm and/or herbaceous climber species in this area, answer the questions below. Remember that a sampling is defined as a young tree with a stem diameter great than 2.5 centimetres but less than 10 centimetre

	Name of species		Is this a shrub, sapling, palm, or	Maximum stem diameter of the	Estimated height of the shrub or
What is the	Botanical	Local			

family name of this plant species?				climber? Write “B” for shrub, “P” for sampling, “W” for woody climber	shrub, sampling or woody climber (centimetres) (But not climbers)

D. TREE, PALM, AND WOODY CLIMBER INFORMATION

Record the local and botanical names of each tree, palm, and woody climber found in the circle of 10-meter radius. For each tree, record its DBH and height in metric units.

Starting at the centre of the plot, create a circle with a 10-meter radius. For each tree species in the area answer the questions below. Remember to record only those trees with a DBH greater than or equal to 10 centimetres. If possible, collect a sample of each species.

	Name of species		Is this a tree, palm, or a woody climber? Write “T” for tree, “M” for palm, or “C” for woody climber	DBH of the tree (centimetres) (But not climbers)	Estimated height of the tree or palm (Meters (but no climbers)
What is the family name of this plant species?	Botanical	Local			

Appendix 2: Checklist for key informant survey

A: Regional Natural Resources Office-Secretariat

Themes:

1. Institutional setup and future plan on management of natural resources in the region
2. Capacity building on forest management at district level
3. Coordination and collaboration NGOs and projects working at district
4. Regional support on JFM for central and local government forests
5. Link/coordination between regional and district forest offices
6. Comments on JFM and parallel structures of local and central governments, and regional administration on forestry matters.

B: Regional and district catchment forest offices

1. Past and current management strategies and their differences
2. Existing forest management problems and success
3. Weakness and strength of JFM and its impact to sustainability of forests
4. Cost and benefit sharing mechanism between government and communities
5. Sustainability of income generating sources and alternative use of forest resources
6. Improvement in forest and society since JFM. Difference: before and after JFM
7. Comments and future prospects

C: DISTRICT FOREST AND NATURAL RESOURCES OFFICE (DFO AND DNRO) –MUHEZA DISTRICT

1. Collaboration between District Catchment Forest Office (DCFO) and DFO/DNRO
2. Programs related to PFM (CBFM and JFM) in local and central government forests
3. Poverty alleviation/forest programs and related NGOs/Projects. Current situation and its sustainability.
4. Comments on JFM and three parallel structures on natural resources management

D: VILLAGE GOVERNMENTS AND VILLAGE NATURAL RESOURCES COMMITTEES (VNRC) AND WOMENS' GROUPS

1. Situation in forest and society before and after JFM
2. Initiatives and activities on JFM
3. Does community participate in the management activities of the reserve? What are these management activities
4. Overlap of activities and confusion among many programs at village
5. Cost and benefit on JFM
6. Strength weaknesses of VNRC in protection and conservation of ANR
7. Strength and weakness of village bylaws as compared to policing Forest Act
8. Strength and weakness forest management agreements between government and villages
9. What about income generating activities as one of the component of JFM
10. Land availability
11. Fire occurrences, illegal acts, encroachment in forest reserve

12 Capacity building on forest management and how women are involved. Situation compared before and after JFM

12 Comments on JFM

E; Local tour guide

1. How many tourists do you receive for a year and what is their fee

2001, ……. Fee ……

2002, ……. Fee …….

2003, …… Fee ……

2004, …… Fee ……

2005 …… … Fee ……..

2. Is the frequency of eco-tourist enough to employ you in a year? What can you comment

F; VILLAGE REPRESENTATIVES IN ADVISORY BOARD

What can you comment on local empowerment on decision making on management of biodiversity in general.

Can you comment on how conflict resolution between local communities and Amani Nature Reserve are tackled?

G; HERBALISTS

1. How many patients do you receive in a work Before JFM and JFM
2. Where do you get your species for curing your patients before JFM and after JFM
3. Can you list

Appendix 3: Household questionnaire

Questions headings to be included in the questionnaires

BASIC INFORMATION

1) Date …….. 2) Household ID/No. ……

3) Name of the household head/Respondent ……

4) Gender: Female …. Male …….

5) Age …… 6) Ethnicity/Tribe …… 7) Wealthy rank ……..

8) Education level (i) Primary education (ii) Secondary (iii) Above secondary education

9) Village name …….. 10) Ward ……

11) Division …… 12) District ……

SECTION A: FOOD, NUTRITIONAL AND HEALTHY SECURITY

1.0 **Staple food**

1.1 What is the staple food of your family?

1- Maize 2- Cassava 3- Beans 4- Banana 5 Cocoyam

6- Others (specify) _____

1.2 Do you supplement staple food by buying every year ……What about year 2005/2006 ……

If you bought, how much? 1- Most 2- Half 3- Little

1.3 What are the reasons for not satisfying staple food for your household use

……,……..,……..,……..

……,……,……..,……..,…….

2.0 Access to forest resources/products for a living in a household

2.1 Is your household have access to forest products: Yes/No

2.2 If Yes which among the following

Type of forest products	Local Name	Uses	Before JFM	After JFM
Vegetables				
Firewood				

Wild fruits				
Wild nuts				
Medicine				
Mushroom				
Ropes				
Building poles				
Wild meat				
Timber				
Others (Specify)				

2.3 Is there any effort of making alternatives of the products obtained in the forest reserve outside the forest reserve? Before JFM: Yes/No; After JFM: Yes/No

2.4 If yes mention them

Alternative efforts	Before JFM	After JFM

NB: Alternative efforts can be tree planting for building poles, firewood production, brick making, fuel saving stoves construction and using, vegetable gardens and others

2.5 Do you use medicinal plants to cure some members of your family when is sick: Before JFM: Yes/No; After JFM

2.6 If yes can you list local name of the medicinal plants and their cure

Serial No.	Medicinal plants (Local name)	Parts use	Disease it cures
1			
2			
3			
4			
5			
6			

2.7 What is your general comment/observation on availability of forest products before JFM and AFTER JFM?

……

……

SECTION B: ECONOMIC SECURITY (HOUSEHOLD ASSETS AND INCOME STREAMS)

3.0 Livelihoods assets

3.1 Is there any difference between your construction material for your house before JFM and after JFM: Yes/No

3.2 Dou you posses land: Yes/No What size is your farm ……..

3.3 How do you acquire land

Land acquisition	**Before JFM**	**After JFM**
Inheritance		
Borrowed		
Purchased		

3.4 What other assets do you posses for your economic security

Before JFM ……. After JFM ……

4.0 Household income streams/sources

4.1 Diversification of income sources in your household

Income sources	Earnings per year	Before JFM	After JFM
Cultivation of Cash crops (list them)			
Selling tree products			
Selling nursery seedling			
Fish farming			
Butterfly farming			
Selling *Allanblackia* seeds			
Beekeeping			
Poultry keeping			
Zero grazing for Milk production)			
Employed			
Spice cultivation			

Selling vegetables			
Trees planted			

4.2 Do your household or village get any revenue accrued from ecoutourism before JFM: Yes/No

After JFM: Yes/No

4.3 Do your village get any revenue accrued from ecoutourism before JFM: Yes/No;

After JFM: Yes/No

4.4 Do you plant trees for your household use: Before JFM :Yes/No; After JFM: Yes/No

4.5 If yes list the name of the trees planted and expected end use

Serial No	Name of species	Intended uses

5.0 Human resource capital (Access to training opportunities)

5.1 Is your household members participated in any of the farmers' training opportunities below:

Training opportunities	Before JFM	After JFM
Seminars		
Study tours		
Meetings		
Workshop		
Cinema/Video shows		
Seedling raising		
Energy saving stoves construction		
Contour construction		
Others (Specify)		

5.2 What can you comments on capacity/awareness of you household and villagers in general on management of forest resources in general if you compare the situation before JFM and after JFM?

5.3 What is your recommendation on capacity building for the future of your household and the village in general.

SECTION C: INSTITUTIONS

5.1.1.1.1.1.1 **Access to institutions and organization**

6.1 Are there institutions present in your village that regulate or rather involve in natural resources management/protection: Yes/No

6.2 If yes, mention them

Name of Institution present before JFM	Name of Institution present after JFM	Responsibilities / regulating what?

Institutional issues can be local norms, traditions or belief (that regulate resource use e.g. not using a certain species, retaining some species in farms), by-laws, Management Agreement, fining system, court cases,

Which organizations are presents in your village

Before JFM	After JFM	Responsible for / regulating what?

6.4 Can you mention the representatives of local communities in the Advisory Board

6.5 Are there any effective groups present in your village: Yes/No

Before JFM	After JFM	Responsibilities

6.0 Household participation in JFM and village community activities

7.1 Are there any community activities before JFM; Yes/No After JFM; Yes/No
7.2 If yes mention them

Community activities before JFM	Community activities after JFM	

*The activity can be 1-Patrol; 2-Forest boundary-clearing, 3-Planting, 4-Weeding, 5-Resurveying; 6-Gaps restoration, 7-Harvesting, 8-Fire breaks construction, 9-Fire fighting, 10-Fining, 11-Court cases,

7.3 Is your household participating in community activities related to JFM: Yes/No

7.4 If yes mention them

7.5 What do you recommend about institutional arrangements currently operation now

Appendix 4: Check list - species and codes

Code number	Family	*Species*	Local name
1	Simaroubaceae	*Quassia undulata*	Banko

2	Araliaceae	*Polyscias fulva*	Fumbati
3	Chrysobalanaceae	*Maranthes geotzeniana*	Fuzu, Mng'anga/ Ng'anga
4	Monimiaceae	*Xymalos monospora*	Mzikoziko/Kidimudimu
5	Flacourtiaceae	*Dasylepis integra*	Kigwandi
6	Apocianaceae	*Funtumia africana*	Kiimboti
7	Guttiferae	*Horungana madagascariensis*	Mkuntu
8	Sapotaceae	*Chrysophyllum perpulchrum*	Kuti
9	Melianthaceae	*Bersoma abysinica*	Mbamba
10	Fabaceae	*Isoberlinia schefferi*	Mbarika/mtoa magasa
11	Euphorbiaceae	*Suregada lizoxyla*	Mdimu-mwitu
12	Lauraceae	*Beilchimiedia kweo*	Mfimbo
13	Rhamnaeae	*Maesopsis emimi*	Mhesi
14	Icacinaceae	*Alsodeiopsis schumanii*	Mkaranga-mwitu, Mozambeyu
15	Annonaceae	*Uvariodend usambarense*	Mkenene
16	Euphorbiaceae	*Drypetes gerrardii*	Mkokoko-dume, Kihambie
17	Cecropiaceae	*Myrianthus holstii*	Mkonde
18	Alangiaceae	*Alangium chinense*	Mkondogogo
19	Moraceae	*Mesogyne insignis*	Mkuhe
20	Euphorbiaceae	*Macaranga capensis*	Mkumba
21	Combretaceae	*Terminalia zambesiaca*	Mkurungo
22	Moraceae	*Ficus sur*	Mkuyu
23	Anacardiaceae	*Sorindeia madagascariensis*	Mkwingwina
24	Anacardiaceae	*Placodiscus amaniensis*	Mkwingwina-dume
25	Rosaceae	*Magnistipula butayei*	Mlawia
26	Guttiferae	*Garcinia volkensii*	Mndee-mzize
27		*Newtonia buchanannii*	Mnyasa
28	Sapotaceae	*Synsepalum cerasiferum*	Mohoyo
29	Loganiaceae	*Anthocleista grandiflera*	Mpumu
30	Rhizophoraceae	*Anisophyllea obtusifolia*	Msala, Msaa-mti

31	Guttiferae	*Allanblackia stuhlmanii*	Msambu
32	Lauraceae/Olacaceae	*Strombosia scheffleri*	Msangana, Sangana
33	Fabaceae	*Schefflerodendron usambarense*	Msase
34	Fabaceae	*Albizia gummifera*	Mshai
35	Myrtaceae	*Syzigium guineense*	Mshihwi
36	Myristicaceae	*Cephalosphaera usambarancis*	Mtambara
37	Annonaceae	*Green wayodendron suaveolens*	Muaka / Mwaka
38	Apocynaceae	*Tabernae montana pachysiphon*	Muambe, Mbeewe
39	Euphorbiaceae	*Antidesma membrenaceum*	Muindi, Mlindi
40	Chrysobalanaceae	*Parinani excelsa*	Muua / Muula
41	Sterculiaceae	*Cola greenwayi*	Muungu
42	Sapindaceae	*Chytranthus obliguinervis*	Mzenga-madii
43	Sapindaceae	*Blighia unijugata*	Mzinda -nguwe
44	Fabaceae	*Englerodendron usambarense*	Mzumba / Mzumba
45	Annonaceae	*Annickia kummeriae*	Ng'waka
46	Annonaceae	*Uvariodendron oligocarpum*	Ng'wati
47	Rubiaceae	*Rytigynia schumannii*	Ntwavuha
48	Rubiaceae	*Tricalisia myrtifolia*	saani, uhako wa ngoto
49	Rubiaceae	*Aoranthe penduliflora*	Samaka
50	Euphorbiaceae	*Alchomea hirtella*	Zasa
51		*Seuriparum serarifen*	
52			Kibandu
53	Celastraceae	*Salacia lenmbachii var. usambarensis*	Kimungwe
54	Papilionaceae	*Dalbergia lactea*	Kowa
55		*Cyathea usambarensis*	Long`e
56		*Cremaspora triflora*	Mbonyati
57	Rutaceae	*Toddalia asiatica*	Mdongonyezi
58	Papilionaceae	*Milletia dura*	Mhafa

59			Mkamia
60		*Grewia spp*	Mkole
61			Mkunse
62		*Terminalia spp*	Mkuzu
63		*Terminalia kilimandscharica*	Mnkwanga
64		*Phenix spp*	Msaa
65	Sapotaceae	*Pachystella msolo*	Msambia
66	Sapotaceae	*Malacantha alnifolia*	Msambia long`we
67	Simaroubaceae	*Pseudobersama mossambicensis*	Msiwa
68		*Dracaena usambarensis*	Ng'weng'we
69	Burseraceae	*Commiphora africana*	Mnyakwa
70		*Polyalthia oliveri*	Mzonozono
71		*Trichili emetica*	Mngoimazi
72	Rubiaceae	*Tarenna nigrescens*	Mshaghashachoe
73		*Celtis soyauxii*	Mzughu
74	Myrsinaceae	*Maesa lanceolata*	Mdami

Appendix 5: Tree species planted by local communities around ANR, Tanzania

Species	Village name				Total
	Mlesa	Shebo meza	Kisiwanido	Potwe ndondon	Total
Grevillea robusta and Cedrella ordorata	8.2 (7)	12.9 (11)	2.4 (2)	2.4 (2)	25.9 (22)
Grevillea robusta and Tectona grandis	0.0 (0)	0.0 (0)	1.2 (1)	1.2 (1)	2.4 (2)
Grevillea robusta	8.2 (7)	5.9 (5)	1.2 (1)	0.0 (0)	15.3 (13)
Grevillea robusta,Cedrella ordorata,Tectona grandis & Mvule	0.0 (0)	0.0(0)	0.0 (0)	4.7 (4)	4.7 (4)
Tectona grandis	0.0 (0)	0.0 (0)	1.2 (1)	8.2 (7)	9.4 (8)
Cedrella ordorata	2.4 (2)	0.0 (0)	2.4 (2)	2.4 (2)	7.1 (6)
Grevillea and Terminalia	3.5 (3)	0.0 (0)	0.0 (0)	0.0 (0)	3.5 (3)
Tectona grandis and Cedrella ordarata	0.0 (0)	0.0 (0)	4.7 (4)	10.6 (9)	15.3 (13)
Cedrella and Gliricidium spp	0.0 (0)	0.0 (0)	1.2 (1)	0.0 (0)	1.2 (1)
Cedrella ordarata and Terminalia	8.2 (7)	3.5 (3)	3.5 (3)	0.0 (0)	15.3 (13)

Figures in parenthesis indicate number of households (Total N = 85), not in parenthesis denote percent (Total respondent that planted tree = 100%)

Appendix 6: Mathematical Calculations for Quantifying Development of surrounding communities.

Given the regression coefficient in Tables 4 (This volume page 47), the standard logistic regression equation was developed for prediction purposes. However, the variables that were not statistically significant were removed from the prediction model, as they have no significant contribution on changes in odds of the dependent variable (participation in JFM by local communities surrounding ANR). The removal of insignificant variables from the prediction model is based on Pampel (2000), who provided as cut-off value for a variable significance probability (p) of 0.05 and argued that a variable should be entered in the prediction model only if its significance level is less than 0.05 and removed from the prediction model if its significance level is greater than 0.05.

The variables not included in the new prediction equation were age, education level, farm size, access to local institution, (Table 4. The general functional form of prediction model used for predicting participation in JFM by local communities surrounding ANR is shown below.

$z = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+ \beta_4X_4$

Where: β_0 = Constant = -10.297, X_1 = Training sessions in JFM, X_2 = Tree planting, X_3 = Shared income from forests under JFM, X_4 = Engagement of households in economic groups (Table 4). By substitution method, we have the equation below:

z = -10.297+ 2.888 (=Training sessions in JFM) + 3.826 (=Tree planting) + 2.366 (=Shared income from forests under JFM) + 2.037 (=Engagement

of households in economic groups).

When the above prediction model (equation 5) is applied:

$z = -10.297 + 2.888 + 3.826 + 2.366 + 2.037 = 0.82$

Substituting z = 0.82 in equation (6) below, the probability of occurrence of participation in JFM by local communities surrounding ANR can be obtained as follows:

$$\text{Prob (Participation of household in JFM)} = \text{Prob (Event)} = \frac{1}{(1+e^{-z})}$$

Where:

z = 0.82

e = natural logarithm equal to 2.718.

$$\text{Prob (Occurrence of participation of household in JFM)} = \text{Prob (Event)} = \frac{1}{(1+2.718^{-0.82}} = 0.694 \text{ (} 69.4\%)$$

Therefore, the probability of occurrence of participation in JFM by local communities surrounding ANR due to training sessions in JFM, tree planting, shared income from forests under JFM and engagement of households in economic groups 69.4%). This implies that participation in JFM by local communities surrounding ANR is likely to occur due to availability of training sessions in JFM, tree planting, shared income from forests under JFM and engagement of households in economic groups. According to Norusis (1990) and Pampel (2000) the probability of success or failure

of any event to be 0.5 (i.e. 50%) and that an event is likely to occur if probability its probability is greater than 50% (Norusis, 1990; Pampel, 2000). In this case, participation in JFM by local communities surrounding ANR is likely to occur (69.4% >50%). as there more training sessions in JFM, tree planting, shared income from forests under JFM and engagement of households in economic groups in a give local community.

On the other hand, the probability of participation is not likely to occur can be obtained as follows:

$$\text{Prob (No participation of household in JFM)} = \text{Prob (No Event)} = 1 - \frac{1}{(1+e^{-z})}$$

Through substitution, the probability of no participation is (1– Prob (success/participation). This gives 1 – 69.4%)= 0.306 0r 30.6%, which implies that occurrence of participation can be predicted provided that the training sessions in JFM, tree planting, shared income from forests under JFM and engagement of households in economic groups in a given local community are facilitated in the village. Therefore it is possible to quantify the factors influencing participation in JFM by local communities surrounding ANR by using Logistic Regression Model (LRM) as opposed to Ordinary Least Square (OLS) approach.

Appendix 7: **Name of medicinal plants used as mentioned by respondents in ANR, Tanzania**

Botanic name and local name	Percent of respondents
Coleus kilimandschari (Mzughwa)	12.6 (22)
Ocimum suave (Mzumbasha)	12.6 (22)
Microglossa densiflora (Muuka)	8.0 (14)
Hyptis pectnata (Hozandoghoi)	8.0 (14)
Anthocleista zambesiaca (Mpumu)	8.0 (14)
Dialopsis africana (Mnkwanga)	8.0 (14)
Terminalia kilimandscharica (Mkuungo)	7.4 (13)
Deinbollia borbonica (Mbwakabwaka/Mtamba	6.9 (12)
Crassocephalum bojeri (Eza)	5.7(10)
Vernonia iodocalyx (Mhasha)	5.7 (10)
Toddalia asiatica (Mdongonyezi)	5.1 (9)
Clausena anisata (Mjavikai)	3.4 (6)

Piper capense (Ng'oko)	2.3 (4)
Cissus intergrifolia (Shaghampa)	1.7 (3)
Citrus aurantium (Mshuza)	1.1 (2)
Culcasia scandens (Kiandama)	1.1 (2)
Abrus precatorius (Ufyambo)	1.1 (2)
Olyra latifolia (Ufiha)	1.1 (2)
Vernonia colorata (Hashaanda)	1.1 (2)
Cynometra sp. Salacia lehmbrachii va. us	0.6 (1)
Dodonaea viscosa (Mzutwe)	0.6 (1)
Ugooto	0.6 (1)
Artemisia afra (Fivi)	0.6 (1)
Spilanthes mauritiana (Mtango)	0.6 (1)
Adenia cissampeloides (Ghoe)	0.6 (1)
Melothria microsperma (Fuiza)	0.6 (1)
Acalypha fruticosa (Msagati kizumba)	0.6 (1)
Dombeya cincinnata (Mkiika)	0.6 (1)
Mlingolingo	0.6 (1)

Note: Figures in parenthesis indicate number of households (Total N = 175 due to effect of multiple response), not in parenthesis denote percent (Total respondent = 100%)

Appendix 8: Biodiversity indices – IVI, ID and Shannon-wiener 2005

Spp code	*Species*	Local name	N	G	V	Spp FREQ.	IVI	PiLNPi	Pi^2
31	*Allanblackia stuhlmanii*	Msambu	143	6.999	107.838	34	27.636	-0.220	0.008
23	*Sorindeia madagascariensis*	Mkwingwina	374	1.529	8.242	59	27.581	-0.219	0.008
19	*Mesogyne insignis*	Mkuhe	441	1.497	7.024	40	25.976	-0.212	0.007
13	*Maesopsis emimi*	Mhesi	71	4.938	63.033	56	24.818	-0.206	0.007
36	*Cephalosphaera usambarancis*	Mtambara	187	2.923	42.163	35	19.879	-0.180	0.004
10	*Isoberlinia schefferi*	Mbarika/mtoa magasa	139	4.202	72.981	20	18.276	-0.170	0.004
50	*Alchomea hirtella*	Zasa	277	0.682	2.701	28	16.279	-0.158	0.003
46	*Uvariodendron oligocarpum*	Ng'wati	149	1.121	11.180	29	13.250	-0.138	0.002
3	*Maranthes geotzeniana*	Fuzu, Mng'anga/ Ng'anga	6	3.653	68.226	6	9.834	-0.112	0.001
20	*Macaranga capensis*	Mkumba	116	0.775	5.651	18	9.182	-0.107	0.001
32	*Strombosia scheffleri*	Msangana, Sangana	75	1.726	10.884	10	8.451	-0.101	0.001
1	*Quassia undulata*	Banko	8	1.569	25.134	10	5.879	-0.077	0.000
29	*Anthocleista grandiflera*	Mpumu	65	0.990	11.460	5	5.443	-0.073	0.000
27	*Newtonia buchanannii*	Mnyasa	62	0.666	9.462	8	5.181	-0.070	0.000
53		Kimungwe	51	0.809	10.614	8	5.153	-0.070	0.000
56	*Cremaspora triflora*	Mbonyati	94	0.090	0.176	8	4.918	-0.067	0.000
44	*Englerodendron usambarense*	Mzumba / Mkwe	64	0.282	1.623	10	4.757	-0.066	0.000
28	*Synsepalum cerasiferum*	Mohoyo	7	0.507	5.339	13	3.981	-0.057	0.000
25	*Magnistipula butayei*	Mlawia	3	1.379	20.490	3	3.883	-0.056	0.000
17	*Myrianthus holstii*	Mkonde	22	0.360	3.046	11	3.745	-0.055	0.000
43	*Blighia unijugata*	Mzinda -nguwe	60	0.201	1.249	6	3.640	-0.054	0.000
38	*Tabernae montana pachysiphon*	Muambe, Mbeewe	29	0.535	6.038	7	3.576	-0.053	0.000
40	*Parinani excelsa*	Muua / Muula	48	0.191	0.623	5	3.029	-0.046	0.000
21	*Terminalia zambesiaca*	Mkurungo	2	1.096	12.180	2	2.996	-0.046	0.000
45	*Annickia kummeriae*	Ng'waka	27	0.383	3.657	5	2.760	-0.043	0.000
64	*Phenix spp*	Msaa	50	0.201	2.066	3	2.728	-0.043	0.000

41	*Cola greenwayi*	Muungu	36	0.128	0.839	4	2.295	-0.037	0.000
66		Msambia long`we	14	0.345	4.000	4	2.048	-0.034	0.000
68	*Dracaena usambarensis*	Ng'weng'we	35	0.083	0.112	3	1.959	-0.033	0.000
73		Mzughu	13	0.317	2.810	4	1.948	-0.033	0.000
7	*Horungana madagascariensis*	Mkuntu	26	0.088	0.580	4	1.846	-0.031	0.000
12	*Beilchimiedia kweo*	Mfimbo	2	0.442	6.103	3	1.683	-0.029	0.000
8	*Chrysophyllum perpulchrum*	Kuti	25	0.101	0.540	3	1.644	-0.029	0.000
2	*Polyscias fulva*	Fumbati	25	0.231	1.413	1	1.548	-0.027	0.000
26	*Garcinia volkensii*	Mndee-mzize	5	0.149	0.988	5	1.507	-0.027	0.000
67		Msiwa	25	0.107	0.291	2	1.460	-0.026	0.000
65	*Pachystella msolo*	Msambia	1	0.431	3.879	2	1.425	-0.025	0.000
52		Kibandu	24	0.086	0.195	2	1.377	-0.025	0.000
15	*Uvariodend usambarense*	Mkenene	24	0.045	0.061	2	1.281	-0.023	0.000
63		Mnkwanga	12	0.016	0.109	4	1.217	-0.022	0.000
16	*Drypetes gerrardii*	Mkokoko-dume, Kihambie	14	0.050	0.208	3	1.170	-0.022	0.000
18	*Alangium chinense*	Mkondogogo	2	0.302	2.781	2	1.162	-0.022	0.000
71	*Trichili emetica*	Mngoimazi	16	0.178	1.514	1	1.140	-0.021	0.000
72		Mshaghashachoe	13	0.092	0.547	1	0.836	-0.016	0.000
57		Mdongonyezi	12	0.093	0.278	1	0.803	-0.016	0.000
69		Mnyakwa	12	0.075	0.113	1	0.762	-0.015	0.000
37	*Green wayodendron suaveolens*	Muaka / Mwaka	2	0.117	0.921	2	0.734	-0.015	0.000
59		Mkamia	12	0.059	0.148	1	0.726	-0.015	0.000
61		Mkunse	12	0.037	0.055	1	0.674	-0.014	0.000
62		Mkuzu	12	0.037	0.055	1	0.674	-0.014	0.000
6	*Funtumia africana*	Kiimboti	12	0.024	0.075	1	0.644	-0.013	0.000
22	*Ficus sur*	Mkuyu	12	0.021	0.032	1	0.638	-0.013	0.000
54		Kowa	12	0.015	0.022	1	0.623	-0.013	0.000
70		Mzonozono	12	0.015	0.033	1	0.623	-0.013	0.000
55		Long`e	12	0.008	0.008	1	0.608	-0.013	0.000
58	*Milletia dura (Papil.)*	Mhafa	2	0.031	0.185	2	0.537	-0.011	0.000

60		Mkole	2	0.083	0.663	1	0.459	-0.010	0.000
4	*Xymalos monospora*	Mzikoziko/Kidimudimu	1	0.075	0.675	1	0.406	-0.009	0.000
30	*Anisophyllea obtusifolia*	Msala, Msaa-mti	1	0.063	0.501	1	0.377	-0.008	0.000
74		Mdami	1	0.044	0.328	1	0.333	-0.008	0.000
			3012	43.289	544.143	507	300	-3.379	0.051

Cont: Biodiversity indices – IVI, ID and Shannon-wiener 2001 Appendix

Species	Local name	N	G	V	SPP FREQ	IVI	Pi^2	PiLNPi (H')
Maesopsis emimi	Mhesi	82	5.173	77.589	66	30.559	0.010	-0.233
Sorindeia madagascariensis	Mkwingwina	273	2.897	19.822	39	30.202	0.010	-0.231
Alchomea hirtella	Zasa	295	0.597	1.820	25	23.564	0.006	-0.200
Mesogyne insignis	Mkuhe	233	0.414	1.350	27	20.226	0.005	-0.182
Allanblackia stuhlmanii	Msambu	74	4.379	71.254	29	19.656	0.004	-0.179
Green wayodendron suaveolens	Muaka / Mwaka	83	1.932	23.714	38	17.550	0.003	-0.166
Cephalosphaera usambarancis	Mtambara	45	4.242	71.990	22	16.099	0.003	-0.157
Beilchimiedia kweo	Mfimbo	26	6.474	110.909	4	15.088	0.003	-0.150
Parinani excelsa	Muua / Muula	17	4.368	83.441	6	10.959	0.001	-0.121
Chrysophyllum perpulchrum	Kuti	56	1.630	28.594	12	9.175	0.001	-0.107
Isoberlinia schefferi	Mbarika/mtoa magasa	6	3.199	58.983	6	8.070	0.001	-0.097
Alsodeiopsis schumanii	Mkaranga-mwitu, Mozambeyu	86	0.234	0.816	10	7.627	0.001	-0.093
Xymalos monospora	Mzikoziko/Kidimudimu	4	3.234	3.406	2	7.060	0.001	-0.088
Maranthes geotzeniana	Fuzu, Mng'anga/ Ng'anga	7	2.462	47.410	7	6.924	0.001	-0.087
Macaranga capensis	Mkumba	54	0.424	2.483	10	6.211	0.000	-0.080
Englerodendron usambarense	Mzumba / Mkwe	42	0.614	7.159	10	5.929	0.000	-0.078
Drypetes gerrardii	Mkokoko-dume, Kihambie	43	0.446	5.242	10	5.658	0.000	-0.075
Myrianthus holstii	Mkonde	21	0.947	10.128	10	5.448	0.000	-0.073
Dasylepis integra	Kigwandi	60	0.096	0.215	7	5.206	0.000	-0.070
Quassia undulata	Banko	10	1.188	18.529	9	5.024	0.000	-0.068
Newtonia buchanannii	Mnyasa	3	1.724	34.298	3	4.279	0.000	-0.061

Synsepalum cerasiferum	Mohoyo	27	0.563	11.453	6	4.034	0.000	-0.058
Uvariodend usambarense	Mkenene	18	0.596	4.699	7	3.861	0.000	-0.056
Tabernae montana pachysiphon	Muambe, Mbeewe	36	0.101	0.443	4	3.186	0.000	-0.048
Syzigium guineense	Mshihwi	26	0.318	3.129	4	3.015	0.000	-0.046
Anisophyllea obtusifolia	Msala, Msaa-mti	16	0.389	4.619	5	2.856	0.000	-0.044
Magnistipula butayei	Mlawia	25	0.197	1.276	3	2.478	0.000	-0.040
Cola greenwayi	Muungu	24	0.025	0.068	2	1.840	0.000	-0.031
Anthocleista grandiflera	Mpumu	3	0.407	7.770	3	1.697	0.000	-0.029
Strombosia scheffleri	Msangana, Sangana	13	0.216	3.016	2	1.619	0.000	-0.028
Schefflerodendron usambarense	Msase	3	0.293	5.985	3	1.473	0.000	-0.026
Albizia gummifera	Mshai	3	0.181	3.230	3	1.253	0.000	-0.023
Funtumia africana	Kiimboti	3	0.093	1.165	3	1.081	0.000	-0.020
Annickia kummeriae	Ng'waka	12	0.093	0.463	1	1.077	0.000	-0.020
Placodiscus amaniensis	Mkwingwina-dume	12	0.049	0.099	1	0.993	0.000	-0.019
Suregada lizoxyla	Mdimu-mwitu	12	0.024	0.084	1	0.943	0.000	-0.018
Ficus sur	Mkuyu	12	0.017	0.034	1	0.929	0.000	-0.018
Chytranthus obliguinervis	Mzenga-madii	12	0.016	0.023	1	0.926	0.000	-0.018
Antidesma membrenaceum	Muindi, Mlindi	12	0.008	0.013	1	0.912	0.000	-0.018
Terminalia zambesiaca	Mkurungo	1	0.208	3.648	1	0.708	0.000	-0.014
Seuriparum serarifen		1	0.203	3.040	1	0.697	0.000	-0.014
Horungana madagascariensis	Mkuntu	2	0.047	0.501	2	0.690	0.000	-0.014
Polyscias fulva	Fumbati	1	0.133	2.001	1	0.561	0.000	-0.012
Uvariodendron oligocarpum	Ng'wati	1	0.040	0.444	1	0.379	0.000	-0.008
Alangium chinense	Mkondogogo	1	0.020	0.109	1	0.338	0.000	-0.008
Blighia unijugata	Mzinda -nguwe	1	0.018	0.108	1	0.335	0.000	-0.008
Bersoma abysinica	Mbamba	1	0.015	0.091	1	0.329	0.000	-0.007
Garcinia volkensii	Mndee-mzize	1	0.010	0.062	1	0.320	0.000	-0.007
Aoranthe penduliflora	Samaka	1	0.010	0.067	1	0.320	0.000	-0.007
Rytigynia schumannii	Ntwavuha	1	0.010	0.076	1	0.319	0.000	-0.007
Tricalisia myrtifolia	saani, uhako wa ngoto	1	0.009	0.056	1	0.318	0.000	-0.007

		1800	**50.985**	**736.925**	**416**	**300.000**	**0.052**	**-3.271**

Appendix 9: Diameter distribution per DBH – classes for year 2005 and year 2001

	DBH CLASS 1				DBH CLASS 2			DBH CLASS 3			DBH CLASS 4			DBH CLASS 5			DBH CLASS 6			DBH CLASS 7			DBH CLASS 8			TOTAL	
Spp code	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
1				1	0.034	0.510	1	0.067	0.735	3	0.309	2.676	1	0.185	2.220				1	0.390	5.851	1	0.584	13.142	8.493	1.569	25.134
2	24	0.134	0.449				1	0.096	0.964																24.652	0.231	1.413
3				2	0.064	0.630																4	3.590	67.596	6.369	3.653	68.226
4							1	0.075	0.675																1.062	0.075	0.675
6	12	0.024	0.075																						11.795	0.024	0.075
7	24	0.039	0.093																2	0.049	0.487				25.714	0.088	0.580
8	24	0.089	0.510	1	0.012	0.030																			24.652	0.101	0.540
10	130	0.350	1.114	4	0.062	0.478	2	0.114	1.419							1	0.252	3.153				2	3.424	66.818	139.302	4.202	72.981
12							1	0.070	0.522													1	0.372	5.581	2.123	0.442	6.103
13	12	0.006	0.009	20	0.358	3.014	19	0.853	8.981	7	0.783	10.068	8	1.231	16.039	2	0.460	6.901				2	1.247	18.022	71.243	4.938	63.033
15	24	0.045	0.061																						23.590	0.045	0.061
16	12	0.011	0.023	2	0.039	0.185																			13.918	0.050	0.208
17	12	0.009	0.012	4	0.072	0.471	6	0.279	2.562																22.411	0.360	3.046
18				1	0.020	0.098										1	0.282	2.683							2.123	0.302	2.781
19	436	1.220	3.010	2	0.022	0.051				1	0.112	1.675	1	0.143	2.286										440.670	1.497	7.024
20	106	0.427	2.396	6	0.089	0.783	2	0.112	0.833				1	0.147	1.639										115.711	0.775	5.651
21																						2	1.096	12.180	2.123	1.096	12.180
22	12	0.021	0.032																						11.795	0.021	0.032
23	342	0.775	1.813	27	0.469	3.420	4	0.195	1.575	1	0.090	1.435													373.909	1.529	8.242
25				1	0.014	0.106	1	0.014	0.118													1	1.351	20.267	3.185	1.379	20.490
26				4	0.073	0.455				1	0.076	0.532													5.308	0.149	0.988
27	59	0.070	0.146				1	0.036	0.393							1	0.256	3.583	1	0.305	5.341				62.161	0.666	9.462
28				4	0.080	0.554	1	0.034	0.236				1	0.149	1.865	1	0.244	2.684							7.431	0.507	5.339
29	60	0.184	0.724	1	0.009	0.023	2	0.080	0.823	1	0.102	1.277										1	0.615	8.613	65.346	0.990	11.460
30							1	0.063	0.501																1.062	0.063	0.501
31	118	0.402	1.247	7	0.108	0.801				3	0.286	2.546	5	0.998	15.153	1	0.259	3.621	3	1.127	16.611	5	3.820	67.859	143.430	6.999	107.838

32	71	1.399	5.985	2	0.042	0.280							2	0.285	4.619										75.018	1.726	10.884
36	165	0.483	1.845	11	0.161	1.106	4	0.234	2.111	2	0.340	5.165	3	0.510	7.277							2	1.195	24.659	187.426	2.923	42.163
37							2	0.117	0.921																2.123	0.117	0.921
38	24	0.046	0.122	4	0.080	0.400																1	0.409	5.515	28.898	0.535	6.038
40	47	0.170	0.475	1	0.021	0.148																			48.243	0.191	0.623
41	35	0.054	0.168				1	0.075	0.671																36.447	0.128	0.839
43	59	0.118	0.504							1	0.083	0.745													60.038	0.201	1.249
44	60	0.093	0.238	1	0.020	0.122	3	0.169	1.263																64.284	0.282	1.623
45	24	0.070	0.421				1	0.041	0.352				2	0.272	2.884										26.775	0.383	3.657
46	130	0.134	0.275	8	0.139	1.102	4	0.232	2.696	5	0.432	4.642	1	0.183	2.465										148.856	1.121	11.180
50	271	0.596	2.108	4	0.038	0.164	1	0.048	0.429																276.598	0.682	2.701
52	24	0.086	0.195																						23.590	0.086	0.195
53	47	0.100	0.510	2	0.027	0.094	1	0.067	0.167													1	0.615	9.843	51.427	0.809	10.614
54	12	0.015	0.022																						11.795	0.015	0.022
55	12	0.008	0.008																						11.795	0.008	0.008
56	94	0.090	0.176																						94.362	0.090	0.176
57	12	0.093	0.278																						11.795	0.093	0.278
58				2	0.031	0.185																			2.123	0.031	0.185
59	12	0.059	0.148																						11.795	0.059	0.148
60	1	0.041	0.332				1	0.041	0.332																2.123	0.083	0.663
61	12	0.037	0.055																						11.795	0.037	0.055
62	12	0.037	0.055																						11.795	0.037	0.055
63	12	0.016	0.109																						11.795	0.016	0.109
64	47	0.032	0.053	1	0.010	0.073	1	0.065	0.817	1	0.094	1.123													50.366	0.201	2.066
65																						1	0.431	3.879	1.062	0.431	3.879
66	12	0.006	0.009				1	0.039	0.389													1	0.300	3.602	13.918	0.345	4.000
67	24	0.098	0.239	1	0.009	0.052																			24.652	0.107	0.291
68	35	0.083	0.112																						35.386	0.083	0.112
69	12	0.075	0.113																						11.795	0.075	0.113
70	12	0.015	0.033																						11.795	0.015	0.033

71	12	0.059	0.385	3	0.073	0.635	1	0.045	0.494															16.042	0.178	1.514
72	12	0.059	0.385	1	0.032	0.162																		12.857	0.092	0.547
73	12	0.006	0.009															1	0.311	2.801				12.857	0.317	2.810
74							1	0.044	0.328															1.062	0.044	0.328
	2716	7.984	27.082	132	2.208	16.133	68	3.302	31.305	28	2.707	31.884	27	4.104	56.447	7	1.753	22.624	8	2.182	31.091	27	19.048	327.576	3012.267	43.289	544.143

Cont. Diameter distribution per DBH – classes for year 2001

spp code		DBH CLASS 1			DBH CLASS 2			DBH CLASS 3			DBH CLASS 4			DBH CLASS 5			DBH CLASS 6			DBH CLASS 7			DBH CLASS 8			TOTAL	
	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
1				3	0.059	0.530	3	0.156	1.894	1	0.116	2.030	1	0.142	1.564							1	0.715	12.511	10	1.188	18.529
2										1	0.133	2.001													1	0.133	2.001
3										3	0.319	3.848				1	0.248	4.334				3	1.895	39.229	7	2.462	47.410
4				3	3.185	3.185	1	0.049	0.222																4	3.234	3.406
5	59	0.084	0.155	1	0.012	0.060																			60	0.096	0.215
6				2	0.043	0.365	1	0.050	0.801																3	0.093	1.165
7				1	0.010	0.045	1	0.036	0.455																2	0.047	0.501
8	47	0.062	0.199	4	0.081	0.739	1	0.035	0.389	1	0.127	2.219										2	1.325	25.048	56	1.630	28.594
9				1	0.015	0.091																			1	0.015	0.091
10				2	0.061	0.783	1	0.046	0.599				1	0.166	2.073				1	0.352	4.051	1	2.574	51.477	6	3.199	58.983
11				12	0.024	0.084																			12	0.024	0.084
12							1	0.053	0.067	12	1.135	1.759				1	0.213	2.552				12	5.073	106.532	26	6.474	110.909
13	12	0.016	0.057	22	0.496	4.893	19	0.966	14.940	18	1.812	27.413	10	1.401	23.062							1	0.482	7.224	82	5.173	77.589
14	83	0.196	0.635	3	0.038	0.181																			86	0.234	0.816
15				17	0.442	4.491							1	0.154	0.208										18	0.596	4.699
16	35	0.035	0.096	2	0.039	0.323	4	0.242	3.197	1	0.130	1.626													43	0.446	5.242
17	12	0.011	0.017	1	0.025	0.202	5	0.288	2.657	1	0.102	1.021				2	0.521	6.231							21	0.947	10.128
18				1	0.020	0.109																			1	0.020	0.109
19	224	0.324	0.867	8	0.090	0.483																			233	0.414	1.350

20	47	0.351	1.891	6	0.073	0.592																		54	0.424	2.483
21													1	0.208	3.648									1	0.208	3.648
22	12	0.017	0.034																					12	0.017	0.034
23	177	0.317	1.233	32	0.477	2.821	64	2.102	15.767															273	2.897	19.822
24	12	0.049	0.099																					12	0.049	0.099
25	24	0.185	1.204	1	0.012	0.072																		25	0.197	1.276
26				1	0.010	0.062																		1	0.010	0.062
27										1	0.088	2.202	1	0.154	2.467							1	1.481	29.630	3	1.724	34.298
28	24	0.026	0.073	1	0.012	0.090	1	0.038	0.340													1	0.487	10.950	27	0.563	11.453
29										2	0.195	1.922				1	0.213	5.847						3	0.407	7.770
30	12	0.021	0.043	1	0.013	0.117				2	0.220	3.112	1	0.135	1.347									16	0.389	4.619
31	47	0.209	1.204	10	0.181	1.413	3	0.153	1.871	5	0.571	8.263	3	0.606	10.272	1	0.271	4.334	1	0.352	6.165	3	2.035	37.733	74	4.379	71.254
32	12	0.084	0.627							1	0.133	2.389												13	0.216	3.016
33				1	0.012	0.008	1	0.073	0.871				1	0.208	5.107									3	0.293	5.985
34				2	0.034	0.362							1	0.147	2.868									3	0.181	3.230
35	24	0.100	0.617				1	0.062	0.715				1	0.156	1.798									26	0.318	3.129
36	24	0.020	0.028	2	0.038	0.176	1	0.037	0.412	7	0.773	9.910	4	0.804	13.720	2	0.520	9.444	1	0.310	5.429	3	1.739	32.871	45	4.242	71.990
37	47	0.096	0.281	13	0.260	1.908	16	0.777	9.968	6	0.591	8.639	1	0.208	2.918										83	1.932	23.714
38	35	0.091	0.379	1	0.011	0.064																			36	0.101	0.443
39	12	0.008	0.013																						12	0.008	0.013
40	12	0.023	0.069	1	0.018	0.107																4	4.327	83.265	17	4.368	83.441
41	24	0.025	0.068																						24	0.025	0.068
42	12	0.016	0.023																						12	0.016	0.023
43				1	0.018	0.108																			1	0.018	0.108
44	35	0.039	0.061	1	0.023	0.182	2	0.143	1.969	2	0.202	2.134	1	0.208	2.814										42	0.614	7.159
45	12	0.093	0.463																						12	0.093	0.463
46				1	0.040	0.444																			1	0.040	0.444
47				1	0.010	0.076																			1	0.010	0.076
48	1	0.009	0.056																						1	0.009	0.056
49				1	0.010	0.067																			1	0.010	0.067

50	295	0.597	1.820																					295	0.597	1.820
51													1	0.203	3.040									1	0.203	3.040
Total	1369	3.105	12.312	163	5.893	25.231	127	5.308	57.133	66	6.646	80.489	30	4.902	76.906	8	1.984	32.742	3	1.015	15.645	33	22.132	436.468	1800	50.985	736.925