Population Dynamics and Sustainable Forest Conservation: A Case Study of the West Matogoro Catchment Area in Songea, Tanzania.

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DECLARATION

Submitted in fulfilment / partial fulfilment of the requirements for the degree of PHD, in the Graduate Programme in Development Studies , University of KwaZulu-Natal, Durban, South Africa.

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. It is being submitted for the degree of PHD in Development Studies in the Faculty of Humanities, Development and Social Science, University of KwaZulu-Natal, Durban, South Africa. None of the present work has been submitted previously for any degree or examination in any other University.

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10th February 2010

Date

DEDICATION

This research work is dedicated to my beloved wife Mrs. Neema Reuben Haule

and

My beloved parents, i.e. my father Mr. John Joseph Haule and my Mother Mrs. Engeltrauda Cosmas Haule

Your inspirations, perseverance and love have finally born fruits that will be beneficial and exemplary for our future generations. Be blessed to see more of our future achievements.

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LIST OF ACRONYMS

AAAS- American Association of Advancement of Science

AGCI- The Aspen Global Changes Institute

GIS - Geographical Information Systems

IIASA-International Institute of Applied Systems Analysis

IRA – Institute of Resource Assessment (T)

MKUKUTA- Mkakati wa Kuondoa Umasikini Tanzania (Tanzania National Poverty Alleviation Strategy)

NASA- National Aeronautics and Space Administration

NEMC- National Environmental Management Council (T)

NEP-National Environmental Policy (T)

NFP- National Forestry Policy (T)

NLP- National Land Policy (T)

NWP- National Water Policy (T)

PDE – Population, Development and Environment

TANRIC-Tanzania Natural Resources Information Centre

TERI - TATA Environmental Research Institute

UNCED – United Nations Commission on Environment and Development (UN)

UNCSD- United Nations Commission on Sustainable Development (UN)

WCED – World Commission on Environment and Development (UN)

WCFSD world Commission on Forestry and Sustainable Development (UN)

WMCA – West Matogoro Catchment Area

WMCF - West Matogoro Catchment Forest

WRI- World Resources Institute

WWF –World Wide Fund for Nature

GLOSSARY

The following are terms and concepts used in the thesis.

Aforestation is the replacement of lost forest cover by planting or seeding in an area of non-forestland. It is taken to mean all those activities that involve tree planting.

Appropriate Technologies refers to kind of technology which is appreciably simple, cheap, and accessible and that can be adopted.

Biodiversity is the totality of the complexity of coexistence of a wide variety of living organisms and their complex interdependence.

Buffer zone refers to the forested land area in the fringes of the village boundaries and bordering the protected forest area. It is meant for use by the local population. It is the transition zone between village land and the forest reserve.

Catchment Area is an area of land that collects water, which drains to the lowest point in the area that could be a lake, a dam, or the sea. It is the area covered by catchment forests characterized by a multiplicity of small streams and rivers.

Catchment Forests constitute both terrestrial and aquatic plants that grow at watershed areas. They are located on hilly or mountain slope areas. Their conservation is crucial for protection of rivers and for rain formation.

Catchment Value refers to the ability of the *catchment area* to sustain sources of water that ooze from springs which originate from it. The more the quantity and quality of water a *catchment area* produces, the higher is its *catchment value*.

Deforestation is the process of reduction of forest cover and tree density for various causes. It refers to the removal of forest stands by cutting and burning to provide land for agricultural purposes, residential or industrial building sites, roads, etc., or by harvesting the trees for obtaining building materials or fuel.

Environmental Degradation refers to the decreasing natural status of the earth's surface. It is a broad term, which includes *deforestation, pollution, soil erosion* etc.

Forest is "an ecosystem with a minimum of 10% crown cover of tree or bamboo, covering an area of not less than 0.5 hectare; with the minimum tree height of 0.5 metre; associated with natural soil conditions and not subject to agricultural practices" (FAO, 2000). For the purpose of the thesis, vegetation that has a number of trees and grass lands, not put under cultivation or not colonized by other human activities will be classified as a forest.

Forest Conservation includes all efforts geared towards protecting natural vegetation. It includes measures that create an alternative to the use of natural forest resources, like tree planting in areas where natural vegetation was destroyed; and protecting the natural forests from human activities, and replacing lost vegetation cover.

Forest Regeneration is the act of renewing tree cover by leaving young trees to naturally grow again after the previous stands or forest was removed. It includes natural regeneration and practices of enrichment planting, reduced grazing of forested savannas and changes in tree genetics or tree species.

Gender roles refer to the customary division of labour and specialization that is based on one's sex. It is a social construction.

Geographic Information Systems (GIS) is the scientific technique used for analyzing the deforestation and other environmental phenomena through remote sensing techniques.

Household is defined as a group of persons (or one person) who make common provisions for food, shelter, and other essentials for living.

Intensive farming systems refers to those farming systems that make use of more external farm inputs like industrial fertilizers, hybrid seeds, pesticides, etc. It is known for repeated use of the same piece of land over a long time.

Key Actors refer to people who actively participate in activities that contribute to deforestation and/or forest conservation. In this case, they are classified by their age-groups, sex categories and specific livelihood or economic activities they perform.

Migration refers to the permanent mobility of people from one area to another. In this context it constitutes movements from one village to another and/or from a village to town (s) and stay at the destination for one year and above.

Mixed Cropping is the farming system whereby more than one crop is planted within the same plot. It is a coping strategy used especially when land is scarce and fertilizers are unavailable or expensive.

Participatory Conservation Methods include those methods of protecting the forest which takes into account local people's knowledge, skills and experiences. Participation includes involvement in planning, decision making, implementation, monitoring and evaluation of development programmes (FAO, 1982).

Population Composition is taken to mean the proportionate presence of people of different sex in a population. Sex ratio determines the proportions of males and females in a population.

Population Dynamics refers to population change brought about by births, deaths and migration. Variations in terms of proportionate existence of people of the different age groups, sex composition and are their total number are outcomes of *births*, *deaths* and *migration.*

Population Structure is the basic characteristic of the population explained basing on different age groups within a population.

Protected Areas/Forests are forest reserves, i.e. legally protected areas that are inaccessible to the local population. In such areas human activities are strictly prohibited by law.

River basin is the area that is drained by many tributaries of rivers. The basin constitutes a part of the catchment area which may constitute many rivers, each of which has its own basin.

River Discharge refers to the total amount of water passing by a particular section along the river channel *per* unit time. It is measured in cubic metres *per* second (*cusecs*). Maximum and minimum readings of the *flows* are recorded at gauging stations.

River regime refers to that seasonal variation of water levels in a river in a year.

Specie extinction refers to the total disappearance of plant and/or animal species from the entirety of *biodiversity*. It consequently results from *biodiversity erosion* mainly caused by *habitat loss* resulting from human activities and/or natural processes.

Sustainable Development refers to that development which meets the needs of the present without compromising the ability of future generations to meet their own needs (UNCED, 1992). Any effort that brings about long term positive impact to enhance forest cover status is considered part of sustainable conservation.

West Matogoro Catchment Area refers to the land area covered by the West Matogoro Mountains and it includes the Matogoro Forest Reserve and the surrounding villages in the proximity of not more that 10 km from the forest reserve *fringes* covering 155.2 km^2.

Village is defined as a rural settlement of not less than 1,250 people or a minimum of 250 households. It has to have enough resources to provide the necessary services like education, health and other infrastructure like roads for the local population (URT, 2002).

Matogoro Forest Reserve is the legally protected forest located within, and the constituent part of, the WMCA. The area is out of bounds for the *local communities*.

ABSTRACT

For decades linkages between population, development and environment have been related to population growth which refers to the increase of population size without consideration of its internal dynamics, i.e. sex composition and age structure. It was the prime aim of the thesis to establish whether changes in population structure and age structure have any impact on the environmental changes, catchment forest in particular and the extended effects on *catchment value* and micro climatic change.

Basing on the available quantitative data from the household survey and the qualitative data based on PRA discussions, it became apparent that both sex composition and age structure significantly influenced household members' involvement in activities related to both deforestation and those linked to conservation. A remarkable variation was noted in terms of involvement of males and females in specific activities that led to deforestation such as expansion of farms and firewood collecting. Males dealt with cutting of trees for firewood while females collected firewood from those trees cut by males. Male dominance was also clearly observed in conservation-related activities, particularly in tree planting.

Sex and/or gender issues were noted to play a vital role in livelihood activities because sex differences and inequalities constitute social systems with consequences on environment changes. Individual's age also influenced one's involvement in livelihood activities. This based on biological capability for performing certain tasks and the socially assignment of duties and responsibilities, i.e. age-based division of labour and specialization which is part of culture. It is therefore imperative for demographic knowledge to be taken into account in the analysis of environmental changes. Gender based division of labour and specialization was the basis for differential involvement of household members in livelihood/development activities.

It is argued that unless the *key actors* in deforestation and conservation are identified basing in the demographic characteristics no sustainable conservation may be attained. Even in the event of urging for participatory or joint forest management, like vast literature points out, a need to focus and target the *key actors*, by their demographic characteristics, becomes an indispensable and important aspect for attaining sustainable conservation.

Poverty conditions that prevail in most developing countries, that limit availability of funds for broad-based extension service, would ensure its effective utilization of little financial resources available through adoption of a more focussed or targeted conservation strategy. Such scientifically planned extension interventions accrue from and are directed towards the identified environmentally significant population segments rather than the entire population. This is the essence of effectiveness and sustainability of conservation efforts based on demographic analysis of the *in situ* population.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

The growth of human population has generally been associated with environmental degradation that includes deforestation (WCFSD, 1999; UNFPA, 2001; Aggrawal, Netanyahu and Romano, 2001). A plethora of literature shows that rapid population growth and the consequent expansion of human activities are related to unprecedented deforestation experienced in various parts of the world. Deforestation and other forms of environmental degradation are generally classified as anthropogenic in origin, with agriculture being repeatedly mentioned as the most significant proximate cause of deforestation (UNCED, 1994; UNFPA, 2001; Geist and Lambin, 2001).

The State of the World Forests observed expansion of agricultural land in 75% of countries while it declined in 25% and stagnated in 5%. Where agricultural land increased, forest cover decreased and *vice versa*. However, in most countries, forest cover decrease was noted mainly through farm expansion (FAO, 2003; Hunter, 2001).

The rapid rate of world population growth, estimated to reach 8.9 billion by 2050, was thought to adversely impact on both environment and population (UN, 1998). Despite the observed general decline in fertility, world population, especially in developing countries, is bound to increase mainly due to *population momentum,* caused by the presence of a large proportion of people aged below 15 (Mostert *et al.,* 1998; UNFPA, 2001; UNFPA, 2007).

Tanzania, the focus of this study, experienced high levels of infant and child mortality that threatened family existence, possibly influencing fertility decline. High levels of education were exhibited by the countries with low fertility levels, with all the girls of relevant age groups enrolling for primary schools, while 20 to 40 % of them were in secondary schools. However this was not the case in Tanzania (World Bank, 1991). One realizes high potential for further growth of population under conditions of low literacy (Mbonile and Kivelia, 2007).

The Food and Agricultural Organization (FAO) statistics indicate that between 1980 and 1995, about 200 million hectares of the forest were cleared in developing countries mainly for agriculture. Reforestation, gradual re-growth, and plantation forest compensated only about 20 million hectares, thus marking a net loss of about 180 million hectares of forest cover. FAO defines a forest as "an ecosystem with a minimum of 10% crown cover of tree or bamboo, covering an area of not less than 0.5 hectares; with the minimum tree height of 0.5 metre; associated with natural soil conditions and not subject to agricultural practices" (FAO, 2002:5). Trends in deforestation, particularly in Africa, have surpassed human initiatives to replenish the loss (FAO, 2000; FAO, 2003).

The World Commission on Forestry and Sustainable Development (WCFSD) report indicates that about 14 million hectares of forests were cleared annually, with the remaining forests deteriorating in terms of their quality and quantity. The Commission noted that 25 countries had totally depleted their forests, 18 countries lost over 95% of their forests, 11 others lost 90% of their forests (WCFSD, 1999). Population growth was cited to be the main responsible factor for deforestation. Forest statistics indicate the pathetic state of forest that call for immediate intervention to minimize the threat to survival of humankind.

The significance of forests to humankind includes carbon dioxide recycling, protection of water sources, conservation of biodiversity (*flora* and *fauna*), temperature moderating, rainfall formation and the provision of various forest products i.e. timber, fuel wood and the like. All these 'nature services' got negatively affected by deforestation (Myres, 1990; WCFSD, 1999; Laurence, 1999; UNFPA, 2007).

The growing demand for food that necessitates agricultural expansion is generally termed as the main cause of deforestation and *biodiversity* loss (Myres, 1990; Bongaarts, 1996; Geist and Lambin, 2001; UN, 2002). Unsound agricultural practices are blamed for loss of top soil due to accelerated erosion, over exploitation of water sources, and pollution of water and the soil caused by fertilizers and pesticides. For example Participatory Rural Appraisal (PRA) conducted in West Matogoro Catchment Area (WMCA) in 2005 revealed similar results in respect to the impact of population growth on natural vegetation. For future environmental certainty, slow population growth, through use of effective means to reduce human fertility was considered essential (Bongaarts, 1994; FAO, 2003).

Increase in the population density in the WMCA resulted into the expansion of the proportion of the cultivated land, the cropping frequency and crop yield. However, expansion of land under cultivation basically depended on the existence and availability of the potential arable land. Possibility for intensification of farming stands as a means to mitigate the problem of shortage of cultivable land (Scherr *et al.,* 2004). Acquisition of appropriate farm technology that enhances productivity at low and affordable cost, an aspect partly influenced by the level of farmers' income and the applicable national policies was vital for realization of ample on-farm production.

The need to conserve natural forests and biodiversity were observed to set-off legal limits to farmers from accessing some potential agricultural land areas within their vicinity (WCFSD, 1999; Madulu, 2001b; Scherr *et al.*, 2004). A study by Haule (1998) in *Peri*-Urban Songea revealed that shortage of money for buying fertilizers and availability of vast areas for farmland were among factors that limited intensification of farming in the *peri*-urban areas of Songea Municipality. Urbanization led to the concentration of larger populations in small land areas, thus rising population pressure on the land resources. This demanded for more *intensive farming* methods than *extensive farming* (Haule, 1998)[1].

Since population growth raised demand for food and forest products whose realization lead to deforestation, it is implicit arguing that no sustainable conservation can be achieved devoid of understanding PDE relationship in the area. The United Nations Conference on Environment and Development (UNCED) urge for interdisciplinary, location-specific research on the relationship between population, development and environment, whose findings would guarantee sustainability of conservation efforts (UNCED, 1992; FAO, 2003; UN, 2002). More detailed examination of the linkages between population, development and environment is necessary in fostering sustainable conservation.

1.2 Statement of the Problem

Population of WMCA has been growing through time. However, little is known about occurrence of changes in its age structure and sex composition. Furthermore, it is not known whether changes in age structure and sex composition, if any, are related to deforestation and conservation of the catchment area in terms of intensity and variations over time. The interactive causal relationship between rapid population growth, development and the unprecedented rate of deforestation experienced in Tanzania lack a detailed analysis in terms of the *key actors*, trends, degree of destruction and its spatial distribution.

Population of Songea, like that of elsewhere, is not homogeneous. It consists of people of different age, sex and levels of education. The population members were socially assigned different productive and reproductive roles, thus experienced different interface with the environment. The differential involvement, in various activities, was the likely and a logical reason for differential contribution to deforestation. A detailed demographic explanation of how the population of WMCA influenced the forest cover changes needs to be documented.

The main assertion of this thesis is that age structure and sex composition have important implications in influencing the pace and/or extent of deforestation. This underlines the fact that population does not come into interface with the forest as a 'single unit' but in its disaggregated manner (Orians and Skumanik, 1997; Sanderson *et al.*, 2002). We urge for the need for a clear explanation on how people of different age groups and sex categories contribute to deforestation. This enables to identify the right target group in causing deforestation a precondition for formulation of more effective forest extension packages, planning the intervention strategy and its timing. This would focus conservation efforts by identifying its *key actors* and targeting them in conservation.

[1] Masters degree dissertation (M.A. Development Studies) of University of Dar es Salaam in 1998

We have as well noted a knowledge gap about the existing inter-relationship between trends in population growth and changes in the environment over time; therefore using it in the analysis and documentation. Population growth, a determinant of population size, has traditionally been considered to be only one of the contributing factors to deforestation (Sanderson *et al.*, 2002; Liu *et al.*, 2000; Hunter, 2001).

1.3 Research Objectives

1.3.1 Aim

The main purpose of the thesis was to investigate and establish the existing relationship between population size, structure, composition and deforestation in the West Matogoro Catchment Area and their interactive impact.

1.3.2 Objectives

The specific objectives of the study were to:

(i) Analyze the demographic characteristics of the population living in WMCA in terms of size, sex composition and age structure.

(ii) Assess population trends and changes in the environment over the periods from 1978, 1988, 2002 and 2005.

(iii) Examine the impact of differentials in age, sex and level of education on catchment forest destruction and conservation.

(iv) Evaluate the existing interaction between population, development and deforestation.

1.4 Research Questions

In order to realize the aim and objectives, the thesis addressed the main and subsidiary research questions as outlined below.

1.4.1 The Main Research Question

What is the nature of the relationship between population, development and deforestation in the WMCA for the period between 1978 and 2005?

1.4.2 Subsidiary Research Questions:

(i) How people of different age groups, sex categories and level of education contribute to deforestation and forest conservation?

(ii) To what extent is population affected by deforestation and *vice versa*?

(iii) How are development and population-related changes associated with deforestation?

(iv) How changes in population size, over time, have impacted on the vegetation cover of the WMCA.

1.5 Significance of the Study

This thesis is a multidisciplinary and location-specific study, with the potential for generation of more precise findings essential for practical application for forest conservation in WMCA and elsewhere. The findings are significant in enhancing effective community participation strategies and methods in forest conservation. The thesis developed and made use of the unique and specific method of linking population, development and deforestation that was more practical for a specific spatial location, therefore critical in formulating appropriate solutions to the ailing deforestation problem.

The study findings produced inputs vital for the planning of more effective conservation activities. The findings keep focus on selection of forest extension packages, extension service methods and the timing of interventions. Since WMCA was observed of being highly affected by deforestation, attributed to the bourgeoning human activities, the understanding on how population is linked to deforestation, which undergirds the thesis, was considered essential and necessary for development of sustainable conservation practices. Understanding the population characteristics and how they are related to environmentally significant behaviours remains basic in the Population, Development and Environment (PDE) analysis.

Findings of the thesis, if put into practical application may be directly used in conserving the source areas of the three major rivers, i.e. *Ruvuma, Ndongosi* and *Luhira*; and many small rivers whose existence is threatened like *Kapela* and *Makupe Streams*. Utilization of the findings will enhance conservation of *biodiversity* and ensure better life among local communities. Integrated Water Resources Management which includes river basin management is of prime significance for sustainable water management (UNFPA &TERI, 2001; Dungumaro and Madulu, 2003). Literature indicates that human-induced environmental changes have been faster and covering larger areas, therefore prompting the need to understand such processes for improvement of conservation activities (FAO, 2003; UNFPA, 2001; Delacote, 2007).

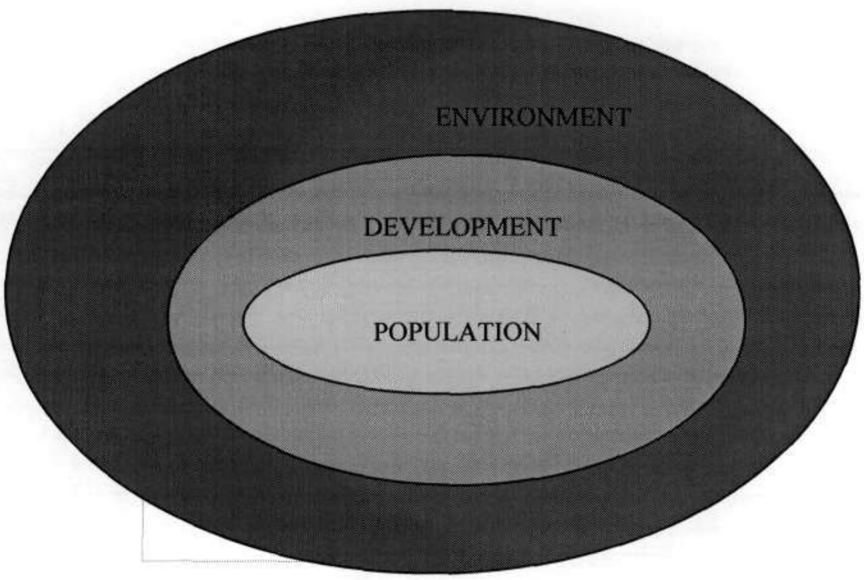
A generalized typology on linkages between demographic characteristics and the environment should be put in place; however specific typologies more appropriate for problem solving, have proven more meaningful and practical. A more accurate framework for the identification of conditions under which specific population dynamics generate critical environmental consequences need to be developed and put into application (Lutz, Prskawetz and Sanderson, 2002). Such frameworks have to include demographic characteristics, magnitude and degree of criticality in order to determine the manner and form at which population impacts on environment (Martine, 1996; Sanderson *et al.,* 2002; Yanda and Madulu, 2003).

1.6 Conceptual Framework and Theories Guiding the Study

PDE is the framework adopted in this study. It borrowed basic conceptual features of PDE from the International Institute for Applied Systems analysis (IIASA) PDE Model. The combination perspective is used in the analysis. The model is graphically organized in three concentric circles, with population and development embedded on environment, indicating the existing interactive tripartite linkages between the three components. It implies that population aspires for development, realized through livelihood activities that necessitate natural resource use. Extensive and intensive resource uses, over use, misuse and/or abuse culminate in adverse impact on the environment.

The PDE model differs from other conceptualizations whereby the three components, i.e. population, development and environment are shown in interconnected boxes linked by causal arrows. The model was developed to address the analysis of the highly complex issues pertinent to interactive nature of PDE relationship necessary for decision making. The reality is that the three components are not separate entities, to be seen independently or even in opposition of each other. Under normal circumstances, human population is part of the biosphere, and is not independent of it; therefore the concentric circles model adopted provides a more adequate representation of the existing relationship between population, development and environment (IIASA, 2001).

Figure 1.1 PDE CONCEPTUAL FRAMEWORK



KEY:

Population: People of different Age, sex , Levels of education and Culture

Development: Economic/Livelihood Activities e.g. Agriculture, Industry, Logging, transportation etc

Environment: Air, water, land, Animals, Plants

Adapted from IIASA, 2001 from www.iiasa.ac.at/research

The conceptual framework positions population and people's quality of life, at the focal point of interest; thus the core aspect placed at the centre (P). Development (D) includes all essential activities for household's economic development. It is through pursuit and expansion of development activities that the environment (E) is adversely affected. Population is, therefore, considered 'a driving force' and responsible factor for the creation of human-made environment, perceived as 'development'; which, if not properly managed affects air, water, soil and forest cover. Catchment forests constitute habitats for both *flora* and *fauna biodiversity* and are the main sources of rivers.

The approach adopted by the thesis explores alternative ways to sustainable development. Knowledge, concepts and data from various disciplines like demography, geography; ecology, agriculture and forestry are linked in the analysis of existing PDE relationships. The conceptual framework simplifies, though at the same time, provides details of the complex linkage between population, development and environment. It makes it more understandable for practical for decision-making and application.

The inherent complex issues are presented in terms of specific variables in this context. The cause-and-effect relationships on specific demographic, social and environmental issues; and their inter-linkages and interactions are analyzed more elaborately and the conclusions drawn assume high validity and greater reliability. For more effectiveness, the thesis used both quantitative and qualitative data collected through household surveys and participatory appraisals. Published and/or official data on population, climate and *river discharge* are also analyzed.

In this context Population (P) is never perceived as the root cause of the deforestation but a variable that may aggravate the more basic root problems when not "in balance" with Development (D) and Environment (E) components. The thesis asserts that to achieve sustainable forest conservation, it requires case-to-case identification, of the causes and ultimate drivers of deforestation based on the social, economic, political and environmental conditions of a particular locality.

It is envisaged that a combination of different location-specific causes of deforestation amount to a broad environmental problem likely to affect a wider area. Logic dictates that such problems would effectively be solved in a *mosaic pattern,* i.e. at specific localities. In this case, the *mosaic* is the WMCA, i.e. a 'small' physical area with similar demographic, social, economic, *edaphic*, geographical, physical and political characteristics. The thesis rules out the possibility of 'blanket or ready made solutions' to deforestation problems covering a larger area for failing to address the real causes which vary over space and time.

Human beings are responsible for both resource use and land resource conservation, since they are the drivers of the development process (IIASA, 2001). However, people are not at all times causative of environmental problems; neither do they cause such problems irrationally. Examination of a specific phenomenon in a particular geographical space and in specified time frame becomes primary in determining the nature and character of existing PDE linkages.

1.7 Context of the Study

Population dynamics has to be understood as changes in population disaggregates of age and sex whose descriptions go beyond mere changes in numbers of people caused by births, deaths and migration (Sanderson *et al.*, 2002). It is based on cohort analysis of both household populations and population disaggregates of age structure and sex composition over a considerable time. Education was used as a dimension of disaggregation since it may affect one's involvement in specific development activities leading to deforestation.

Sustainable forest conservation refers to the actions and behaviours that maintain the forest cover. It includes sustainable utilization of forest resources and their due replacement where overexploitation or depletion was noted (UICN, 2004). It is a complex concept that needs to be put into reality. For the purpose of the thesis, identifying the *key actors* in deforestation and conservation, by their demographic characteristics is among the necessary conditions for sustainability because it allows for planning and implementation of effective conservation efforts. Participatory resource management is generally viewed as prerequisite of sustainability (Mintzer, 1992; URT, 1998a; Madulu, 2001a).

Analysis of relationship between population, development and environment in the WMCA took into consideration the Tanzanian socio-economic and political situation. The way people interact with the environment can not be separated from the existing socio-economic and political situation. Peoples' behaviour is likely to be shaped by the prevailing socio-economic and political context. Current sectoral policies, programmes, strategies and institutional frameworks were taken into account while developing the thesis. Policies and programmes operational in the area, in different periods under review, were necessarily articulated in examining various crosscutting issues inherent in the PDE relationship.

Tanzania national policies, namely Population Policy (1992) and Environmental Policy (1997) provided general guidelines to the management and control of population and development is thus likely to influence the character of PDE relationship. It is clear that population of the WMCA formed a subset of the larger population of Tanzania, thus bearing similar socio-economic, political and legal characteristics. Three major sectors, i.e. population, development and environment were analyzed in this regard.

1.7.1 Population Policy (1992)

The policy places people of Tanzania at the central location of development process hence incorporated in national development planning. Carrying out of decennial censuses is a step towards the same. Aims of the policy include enhancing health programmes to reduce mortality, reducing rural urban migration and relocating people from areas of resource scarcity to those of plenty.

Implementation of the policy was carried out under the National Population Programme (1992). The programme activities followed principles and objectives of the programme of action of the International Conference on Population and Development (ICPD, 1992). The four adopted strategies were advocacy, lobbying, Training and Systemic improvement. The specific strategies included advocacy, lobbying, training and systemic improvement.

1.7.2 Environmental Policy (1997)

The policy provided the framework for bringing about environmental considerations into mainstream decision making. Guidelines, plans and guidance for priority actions and monitoring mechanisms for reviewing the plans and programmes on a cross sectoral policy analysis to exploit the existing synergies formed part of the policy.

Ensuring sustainability, security and equitable use of resources to meet the basic needs of the present and future generations without degrading the environment or risking health or safety was the main policy aim. It had to prevent and control degradation of land, water, vegetation, and air which constitute our life support systems. It was to conserve and enhance our natural and man-made heritage, including the biological diversity of unique ecosystems of Tanzania. The policy was to improve productivity without destroying the aesthetic nature of surroundings. Promotion of individual and community participation in environmental action was meant to be achieved through raising awareness on the PDE linkages.

Promotion of international co-operation on the environmental agenda, and to expand our participation and contribution to relevant bilateral, sub-regional, regional, and global organization and programmes, including implementation of treaties constituted another policy objective.

Implementation of the policy was carried out under various sectors such as agriculture, forestry and industry. National Environmental Council (NEMC) is the advisory and supervisory body on environmental matters. Ratification and legal framework were the institutional structures used.

Stakeholders on environmental issues put emphasis on promotion, strengthening and sensitizing communities and individuals' participation to invigorate environmental conservation and management. Awareness campaigns, environmental education and skills development complemented environmental management and conservation issues. Emphasis was on raising the capacity of individuals and the community ability for sustainable management for benefits of their own and future generations.

1.7.3 Sectoral Policies Linked to the Environment

Sectoral policies that impacted on the population, development and environment articulated in the analysis of the thesis included Forest Policy (1998), Land Policy (1997), Water Policy (2002), Agriculture Policy (1997) and Energy Policy (1997). The policies were considered significant to influencing and shaping the population, development and environment relationship. The respective programmes, institutional/legal structures and implementation strategies were, as well, considered in the analysis. Village level bylaws, Village Management Systems and development plans and implementation strategies were also conceptualized and linked in the analysis of the PDE relationship.

The thesis conceded with the national population policy which asserts that for equitable development to be attained *optimum* resource utilization in both rural and urban sectors become a necessity (URT, 1992; UN, 2002). Development of conservation culture among youth and requisite support of the elderly and disabled is the prerequisite. Population, i.e. people of Tanzania, is central to policy implementation. The policy conceded the existence of a knowledge gap on how population is linked to the environment. The thesis is an endeavour towards bridging the gap in assurance of sustainability of both population and resource base.

1.8 Conclusion

The study on population dynamics and sustainable conservation of catchment forests is termed as both multidisciplinary and complex. It covers a broad range of disciplines and that tackles crucial aspects for the survival of humankind and biodiversity. The study faced challenges generally conceded by other academics and professionals due to the state of *flux* of the PDE variables. The importance and necessity of the thesis findings, for the future sustenance of life systems made it to be undertaken.

Despite the widely conceded conspicuous role of population size in causing deforestation, that is linked to expansion of human activities, as prompted by the increase in demand for food and forest resources, it does not remain to be the only population variable in explaining deforestation phenomenon. It is unlikely to obtain the sustainable solution to deforestation based wholly on the inclusion of this single demographic variable, i.e. population size. More detailed analysis that include of other demographic variables, i.e. age groups and sex categories form the basic tenet of the thesis.

Multisectoral characteristics of the causal factors to deforestation calls for a multidimensional approach that include demographic analysis aligned with the ecological, geographical, economic and socio-cultural knowledge and perspectives in the formulation of more sustainable environmental conservation strategies. Substantial growth in food demand is a consequence of growth in human population and the rising *per capita* food consumption (Bongaarts, 1996; UN, 2002). Meeting the increased future food, demand would involve substantial increase in the four factors that determine availability of food crops, i.e. the proportion of land cultivated, cropping frequency, crop yield and food brought in through trade.

The need to seek for a sustainable solution to future environmental, economic and social problems was broadly appreciated (UN, 2002). However, paucity was noted regarding knowledge about the impact of population to the environment. Nothing was discussed on the impact of the consequent changes on the environment to the local human population.

Although future population growth is yet to be the real cause of contemporary deforestation, it was necessary to examine it's potential since human beings are considered the persistent driving force or *key actors* in deforestation. The line of interface between human beings and the forest is theoretically drawn at the point of people's engagement in various economic activities that impact on the vegetation cover thereby adversely affecting the forested area and forest quality. However, demographic characteristics of the population segments that actually interact with the environment were yet to be established and articulated in the formulation of conservation methodologies and packages. The observed field reality is that not the whole population interacts with forest cover in the same manner (Orians and Skumanik, 1997; Sanderson, *et al.,* 2002).

The mode of interaction, i.e. the actual engagement in livelihood/development activity, was an aspect that needed be examined in detail. Efforts towards controlling population growth, *cateris peribus*, are likely to constitute an essential part of the comprehensive policy towards ameliorating deforestation. This may partly reduce consumption levels of vegetation resources and lower food requirements although it might not necessarily constitute an ultimate solution to all environmental problems at hand.

The control of population growth and development of alternative energy sources (to firewood and charcoal), intensification of agriculture, if carried out together, are aspects that engender an ample solution to reduce the demand for vegetation resources, therefore raising the possibility of reducing pressure on the land resources; and concomitantly enhancing sustainable conservation of forests.

The basic question to be addressed at this point was whether population growth and development activities that made use of forest products had a positive linear relationship. If yes, then the above three factors, i.e. PDE, would expand and impact on each other. Therefore, controlling population would directly and effectively assist in curbing further damage to the environment caused by expanded economic activities. Understanding and considering population size alone would therefore be satisfactory to explain population-resource interface, therefore directly contributing in solving the ailing deforestation situation.

Demographic disaggregates of population, i.e. age structure and sex composition, inclined to individual's levels of education, influenced one's involvement in deforestation-related activities. Thus, a more scientific solution can be developed based on findings from this study. The focus should be on the analysis of the demographic variables and their practical interplay with the social and economic factors leading to behaviours that physically translate into the deforestation process.

Implementation of MDGs, as agitated by African Union, would be realized through understanding the nature of the 'demographic trap' the continent finds itself in and how the trap is related to the shaping of characteristics of the environment through human struggles towards earning a livelihood from nature. Specificity in terms of identifying the actors in the process of deforestation, the reasons behind their engagement in the process and the mode of engagement is of prime significance in the development of sustainable conservation efforts.

In the case of Tanzania, sustainable conservation is an important aspect towards achieving its National Strategy for Growth and Reduction of Poverty, i.e. MKUKUTA (URT, 2006). The fact is that poverty causes environmental degradation; while at the same time environmental degradation tends to perpetuate poverty and other socio-economic problems such as lack of food, prevalence of diseases and low productivity (URT, 2005a). Poverty is considered destructive to both the environment and livelihoods, leading to worsening the poverty levels (Geist and Lambin, 2001; Scherr *et al.,* 2004; De Souza, 2006). Since the poor are people, detailed analysis on how they actually interact with the forest resources remains critical to the development of sustainable conservation efforts.

To ensure effective management of population, development and environment, the implementation of sectoral policies, programmes and strategies becomes necessary (UNCED, 1992, UN, 2002). Despite existence of policies and strategies, the problem of deforestation has persisted. The thesis perceives that the 'omission of the inclusion' of population dynamics in the planning and undertaking of conservation activities explains the failure on many interventions in this area. The complex linkages explained on the basis of nature and character of population characteristics; their engagement in processes that lead to environmental change in general are aspects to be articulated for the success and sustainability of future conservation efforts.

One perceives the need to explore the existing sectoral linkages, i.e. linkages between population, forest and water policies; and the strategies used in mitigating the negative effects of population on the environment and *vice versa* (URT, 1997a). Faulty development policies may play a role in fostering deforestation process (Myres, 1990; Geist and Lambin, 2001). Faulty policies are of dual types, i.e. the ones that are misdirected, thus leading to unintended deforestation; and those which are caused by inability to formulate preventable policies (Geist and Lambin 2001; URT, 2006).

The National Forest Policy (URT, 1998) underscores the need for gender specific direction of extension advice. However, no mention about the variations of the members in the population based on the age is found in the policy. The thesis asserts that both age and sex are critical variables in determining division of labour and specialization, thus are significant factors in the understanding of PDE relationship. The original focus was on 'who does what and why', while the thesis went further into probing as to 'when' and even 'how much'. The 'bottom up' approach was considered more effective as it acquires a more profound stage on the local community members' practical decision making in managing their own natural resources.

Reshaping of policies; programmes and strategies could be more guided after having underscored the nature of interface between population and environment. Identification of the *key actors* and understanding the people's engagement in the actual process of catchment forest destruction, by demographic characteristics, remains crucial in the development of focuses and user friendly forest conservation extension packages and the right timing of interventions. This is considered to be the gist of sustainable conservation efforts.

Status of the environment in the WMCA revealed negative trends despite the implementation of the population policy, which calls for more effective steps in addressing deforestation. Effectiveness in conservation may be achieved through devolution of the environmental management functions to the local population. Demographic characteristics of the *in situ* population, i.e. the drivers of deforestation process are vital to the understanding of the way population interacts with the environment (UN, 2008). Disentangling the population sub-groups by specific age and/or sex groups on the way they deal with deforestation-related activities and the respective impacts, which could be statistically quantified, is also a necessary step towards achieving sustainable conservation. This is a more practical and realistic approach.

Specificity in the understanding of the PDE variables enables for examining the real linkages; and acts against generality whose effectiveness in conservation endeavours has always been questionable and practically unrealistic. Unfolding PDE linkages, despite its complexity, is considered an essential and indispensable step towards achieving sustainable conservation efforts; therefore we found it to be the right move towards achieving sustainable development.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Various scholars devoted time and resources researching and documenting the relationship between population, development and environment (PDE). Thomas Malthus initiated the debate on the relationship between population growth, human welfare and natural resources (Brown, 2002; Ayoub, 2007; Satihal, 2007).

Researchers in the PDE area focused their efforts within their lines of professional specializations, therefore collapsing into the apparent academic and/or professional bias (Lutz, *et al.*, 2002a). Issues pertinent to forest conservation, in fact and by nature, require knowledge, experience and perceptions from various other fields of life. It includes demography, forestry, hydrology, ecology, community and rural development, agricultural systems, planning, sociology, gender issues and many others. The subject involves and transcends many academic and professional *arenas*, thus qualifying as being both multidisciplinary and complex (IIASA, 2001; Lutz, *et al.*, 2002a; Lutz *et al* 2002b; Sherbinin, 2006).

Most of the studies focused on the analysis of population size, while paying less attention to other population disaggregates such as age groups and sex categories which impacted on environmental activities (Orians and Skumanik, 1997; Liu *et al.*, 2000; Lutz *et al.*, 2002a). This thesis examines other attributes of the population such as age and sex that are significant in influencing both resource consumption and consumption rate. Hopefully, this will also assist in determining the right population *target group* for the development of sustainable conservation interventions which is critical for sustainable forest conservation. A holistic perception, coupled with an interdisciplinary operational framework would uncover the basic aspects of nature of the phenomenon under scrutiny (IIASA, 2001). The thesis ultimately intends to establish the existing relationship between population characteristics and environmental changes, forest cover change in particular based on knowledge, skills and experiences from various disciplines.

2.2 About Population

2.2.1 Population Growth

There have been no disputes noted among social scientists concerning the fact that population growth is fastest in developing countries, Africa in particular (UNFPA, 2001; UNFPA, 2007). Population of the world has grown at unprecedented rate with the fastest rates recorded in developing countries. Global population more than doubled to reach 6 billion by 1999 (UNFPA, 2001). By 2006 the population was estimated to reach 6.7 billion (UNFPA, 2007). It is projected that by 2050 the world population will reach 9.2 billion (Smith, 2008).

The present population data for Africa indicate extreme rapid population growth of over 3%. *Natural increase* indicates the possibility for further growth in the next decade. In 1950 the population of Africa was estimated to be 220 million. Currently the continent has about 650 million people. The continent is estimated to have about 1.5 billion people by 2025. In 1960 Africans represented 9% of the world population, which is estimated to reach 19% by 2025 (Tabutin, 1991). Despite the rapid growth of population in the continent, there are significant socio-economic and rural-urban differentials although the educated urbanites were observed having reduced their family size.

What poses a heated debate is on the causes, ways and the means instituted to control further growth. There are, as well, some notable variations regarding the way different researchers appreciate the impact of population growth to the environment and the threats it poses on the livelihood and survival of humankind. Population growth, being one of the main causes of deforestation calls for efforts to understand the existing link between the *duo*.

2.2.2 Causes of Rapid Population Growth

Various studies observe *high fertility rates* prevailing in developing countries (UNFPA, 2001). Other reasons advanced to explain the rapid population growth in developing countries include *low mortality*, *longer life expectancy* and *population momentum*. High fertility rate, combined with the "unmet need" of contraceptives use and limited family planning efforts are some of the explanations frequently used for the variation in fertility levels (Pritchett, 1994; UNFPA, 2007).

Population momentum refers to presence of a large proportion of people in young age groups which lead to higher concentration of people in the youngest ages. This results in continuous growth of the population after *replacement level fertility* (PRB, 2004). The phenomenon is a characteristic of populations of the developing countries like Tanzania. Improvement in social services, especially maternal health and general medicine lowered mortality thus contributing to rapid growth (Mbonile and Kivelia, 2007; UNFPA, 2007).

The small impact of family planning program, however, does not seem to contradict the minimal role of contraceptive use and its "unmet need". According to the above observation by Caldwell *et al.*, (1992), population is likely to increase despite the family planning efforts Hence the environment is likely to be affected more adversely by the growing human population if no concerted efforts to conserve nature are put in place. A study by the WWF confirmed that low rates of female literacy were associated with high population growth. Also, areas with high deforestation rates experienced high rates of migration and rapid expansion of maize farms (UNFPA, 2001; Satihal *et al.*, 2007). Soil erosion was observed in areas with high *population density*. Variations in traditions and religious beliefs have a tendency to influence fertility decisions, particularly regarding the use of effective family planning measures.

2.2.3 Significance of Considering Cultural Values in Family Planning

According to Caldwell and others (1992), in Africa, fertility levels are controlled by traditions and religions, which emphasize on the importance of ancestry and descent. They further noted that having more children is considered as morally correct while childlessness or having few children is perceived as evil.

Large number of children is preferred mainly due to the previous high mortality levels among infants and children. Fear of family extinction is considered to be the main reason behind high fertility levels in African. The current falling mortality levels due to the availability of better health facilities, contributes to unprecedented population growth. In most patrilineal societies, husbands made reproductive decisions, including the use of contraceptives. A similar situation is experienced in Tanzania, where despite the introduction of contraceptives their actual use and its impact has been significantly low (Madulu, 1996).

Although there has been controversy on the extent to which traditional values control premarital sex, there is no dispute about widespread extent of contemporary female (and male) premarital sexual relations (Caldwell, *et al.*, 1992). Premarital sexual activity has the risk of pregnancy and likelihood of forced marriages or single motherhood. Furthermore, pregnancy limits the possibility for girls to continue with further education and therefore unable to join modern economic systems, relegating them to traditional economies (Caldwell, *et al.*, 1992; Mulama, 2006). PRA results indicated a similar trend, particularly with regard to early marriages and resulting 'unwanted pregnancies'. Some forced marriages resulted from parents who compelled their children to marry early for greed of dowry price.

Underscoring the significance of the cultural setting of the local communities where, the research activity is undertaken, is essential in determining the rate and shape of *fertility transition* (Fricke, 1977; Chu and Yu, 2002). This aspect enables the acquisition of a better understanding of cultural meanings and incorporating them into explanations on individual level fertility and mobility decisions that shape demographic processes and impact on the environment. In the context of Tanzania, traditions, religions and customs contributed to unequal gender roles and values that manifest more in situations of widows, division of labour, genital mutilation, bride price and early marriages (TGNP, 2007).

Articulation of culture in the analysis waives the existing crisis that replaces the collapsed "classic demographic transition model". It is noted that socio-cultural conditions of a particular population of a specific setting tend to influence their demographic behaviours. D'Andrade (1984) argues on focusing on the negative sanctions, control, and enforcement mechanisms rather than the culturally internalized motivations for specific demographic behaviors, which are misleading and impractical. This way of perceiving fertility decisions, is a misconception. Fricke (1997) emphasizes on his own words:

> "As models of reality, cultural patterns constitute the perceived worlds of the human actors and define the significance of behaviours and institutions for analysts. The beginning with cultural models of reality allows demographers to discover what is significant from the point of view of the actors".

Community or village level studies are considered more practical since they cover small areas inhabited with people of the same culture. People of the same culture are likely to behave in the same manner. To be more objective, with less individual level variations, the use of demographic data in PDE analysis becomes indispensable (UNCED, 2002; Liu *et al.,* 2001). Culture influences community's behaviours with important meaning and relevance to both development and environmental phenomena. Though in some instances the same or similar behaviour may be linked to people of different demographic characteristics, we may still argue that the inclusion of cultural aspects in the PDE analysis is necessary.

Population change and environmental degradation, irrespective of the forces behind the causes of fertility patterns, constitute the focus of this thesis. Influence of population on natural resources and socio-economic environment necessitates for examining trends not only in population growth and distribution but also in terms of its age structure and sex composition (Lutz *et al.,* 2002a; Mung'ong'o and Mwamfupe, 2003; Madulu, 2004).

2.3 Population and Development

The debate on whether food production can in the long run keep pace with the demand for rapid rate of population growth takes us back to the Malthusian era (Brown, 2002; Ayoub, 2007; Satihal, 2007). Experience has shown that various improvements attained in the agricultural sector in the past century brought about an increase in agricultural output (Myers, 1990; Ahlburg, 1998). However, experts differ sharply on this aspect ending up into two main clusters, conveniently labeled as pessimistic and optimistic schools of thought (Ayoub, 2007).

2.3.1 Pessimistic and Optimistic Views

Pessimistic scholars hold the position that a lot of environmental stress and difficulties that are caused by the growing population tend to limit the availability of land for agricultural expansion, water supply and reduce crop yield and pest control (Ehrlich and Ehrlich, 1990; Ehrlich, Ehrlich and Daly, 1993, Madulu, 2004). To them, large scale expansion of agriculture and crop yield will reach a limit; and hence doubting whether the highest crop production levels can be sustained in a number of countries to meet the increased demand.

In contrast, optimists tend to emphasize that relatively low yields harvested in the developing countries resulting from inefficiencies experienced in all stages of food production, transportation, storage and consumption. Reduced intensification limits the size of the potential arable land and by putting more land into continuous cultivation mines soil fertility and triggers food scarcity (Simon, 1981; Heiling, 1994; Smill, 1994; UNFPA, 2001).

To the *optimist scholars*, sound government policies, wider application of green revolution technologies, reduction of inefficiencies and greater investment in human resources and research would enable higher harvests without any insurmountable future environmental concerns. However, the situation on the ground is what actually translates into the observed state of the environment we are living in, i.e. environmental degradation; deforestation in particular (FAO, 2003). Our being *optimistic* or *pessimistic* does not change this state of affairs. What is needed is an understanding of the PDE phenomena and mechanisms that lead to deforestation in order to effectively engage in sustainable development that enhances and contributes positively to sustainable conservation.

2.3.2 Population and Development Debate and Related Issues

2.3.2.1 Julian Simon' Ultimate Resource

Julian Simon analyzed the relationship between population and development; which contributed on the 20th century public policy formulation on population, by demonstrating that conceptualizing demographic expansion to be a menace of human welfare was wrong (Simon, 1981). To him the proposals for policies aimed at slowing down population growth were mistaken. The advanced and challenging argument was presented in the book titled *Ultimate Resource (*Ahlburg, 1998).

Preston (1982) reviewed Julian Simon's work and supported the initial argument. The four periods under review realized different scholarly dimensions about population growth. The first period was between 1945 and 1965, known as the Neo Malthusian period that realized the shifting concern from population size to population growth rate. During this period, scholars justified policies and programs that sought to slow down the rapid population growth rate. The second period was from 1965 to 1974 that observed the rise of opponents of population growth consisting of more outspoken demographers and others calling for solutions beyond family planning. Provision of disincentives to child bearing; sterilization, declaring bearing children illegal, legalisation of abortion and the like were the suggested mechanisms (Hodgson and Witkins, 1977, cited in Ahlburg, 1998).

Julian Simon joined the debate from 1974 to1985, when there was significant demotion of fertility control on the agenda, with an emphasis on policy interventions. From 1985 to date, Neo

Malthusians opposed "revisionist views" by Simon, economists and other scholars. Prior to writing *The Ultimate Resource*, Simon believed that rapid population growth was a major threat to world's economic development agenda. His book "The Economics of Population Growth" portrayed need to combat demographic problems; and attempted to bring about a 'balance' to the debate, by equally discussing the benefits of population growth.

He proposed a careful distinction between short term non-economic consequences of population growth that were largely negative and the long run effects, perceived as being positive. The revisionist methods used stood as the blueprint for the evaluation of consequences of population growth. The conclusion reached was that positive population growth produced considerably better economic performance, thus portraying population optimism (Ahlburg, 1998).

Sanderson (1980) observed a number of questionable critical features in Simon's Model. The social overhead capital, i.e. better roads and communication, economies of scale, improved government organization, and health benefits, are assumed to follow from population growth. Therefore, social overhead capital tends to increase output. However, it was noted that doubling of population would not just double production but increase output by an addition of only 20%. The model was proven to be not satisfactory in explaining the PDE relationship (Sanderson, 1980).

2.3.2.2 The World Bucharest Population Conference (1974)

The World Conference held in Bucharest (1974) was attended by many third world leaders who challenged the neo Malthusian position. They chartered out the World Population Plan for Action that declared, "of all things in the World, people are the most precious … mankind's future can be made indefinitely bright" (Ahlburg, 1998).

The Indian delegation proposed that development to be the best contraceptive, implying that support for family planning was based on human rights rather than economic considerations. Although delegates at the World Conference held in Mexico City (1984) expressed concern about the negative consequences of population growth, the document that emerged out of the conference was largely a refinement of the one at Bucharest (Demeny, 1985). It implied that with advancement in socio-economic and technological spheres population can be more manageable and the quality of life improved.

2.3.2.3 The World Bank on Population and Development

World Bank's World Development Report (1984) emphasized the need to study economic and demographic interactions which established that moderate population growth could stimulate demand, encourage technological innovations, and reduce investment risks. In sparsely populated countries, population growth shortened the time needed to reap the benefits of economies of scale in transport, communications, social services and production.

In general rapid population growth was considered a fetter to economic development. The report, however, did not consider the impact of population pressure on natural resources and food as significant problems to humankind. Rapid population growth was thus found to adversely affect the formation of human capital with likely negative impact on both development and environment.

2.3.2.4 The Natural Resources Council (NRC)

The Natural Resources Council (1986) produced a landmark report on the economics of population growth. The report concluded that on balance, slower population growth would be beneficial to economic development of the developing countries. However, the NRC found that population growth had little impact on non-renewable resources.

Simon (1981) differed with the view that the long run positive impacts of population growth outweighed the short run negative impacts on population and the environment. The study by Simon did not see population growth as a problem but unveiled signals given by the negative impacts of population growth will be clear and early in order to develop pro-active measures prior to the negative impact. In developing countries' relativity in the two phenomena is not certain if not non-existent at all, especially with regard to common property resource(s).

The review of *The Ultimate Resource* by Timmer (1982) argued that because of structural changes in the relationship between population, resources, and knowledge, the future may be quite different from the past. Timmer criticized the study by Simon based on the fact that most economic models assume linearities; discontinuities and non-reversibility were present in the environment. The reality is that PDE relations are location-specific and that such relations are influenced by socio-cultural, technological and geographic factors (IIASA, 2001). Warren Sanderson (1980) developed an indigenous collapsible econo-demographic environmental model called "Wonderland" that incorporated socio-cultural, technological and geographic features. However, the model could not bring about replicable results meaning that the PDE relationship was more interactive and complex. Sanderson observed that with non-linearities, relatively large changes in some variables can happen over short time periods (Sanderson, 1980).

2.3.2.5 The Kyoto Conference on Global Climate Change (1997)

The Kyoto Conference (1997) suggests that issues of environment such as acid rain, global warming and ozone depletion would pose a greater challenge to solve as they involve consideration of equity in the use of public goods and are trans-boundary. Other concerns on the environmental issues of the past decade include wilderness destruction and extinction of plant and animal species.

Environmentalists and ecologists are concerned with the well-being of both human and non-human species, while social scientists and policy makers focus on the consequences of the environment change for human welfare alone, thus compromising environmental sustainability. Plants and non human animal species are valued only to the extent that they are perceived as useful only for human life; now or in the future (Demeny, 1991; McNicoll, 1995 in Ahlburg, 1998). The United Nations International Conference held in Nairobi (2006) to review the Kyoto Protocol observed that it is not lack of solutions which holds us back, but the effective way to actually engage people in environmental conservation (WWF, 2006; UN, 2006).

It is appreciable that anthropogenic changes have improved fertility and pesticides in agricultural land protecting people from exposure to disease agents and improved life standards; and enhanced people's mobility over the planet. However, many of these changes have brought substantial environmental costs. The negative effects accrued from such developments have received little attention (UNFPA, 2007; UNFPA, 2001; Lutz *et al.*, 2002b).

Many observers noted that population growth was the major cause of environmental problems (Ehrlich and Ehrlich, 1990; Kates, 1996; Smail, 1997; UNFPA, 2001). In recent years, this belief has exerted more pressure on demographers to pay attention to the environmental consequences of demographic behaviours. The review of Kyoto Protocol demanded for participation of all nations, developed and developing in addressing issues of global warming that threaten survival of the earth (UN, 2007).

2.3.3 Population and Development in Specific Context - WMCA

Natural forest cover of the Songea district and WMCA is affected by human activities especially through agriculture (Huvisa, 1997; URT, 1987; URT, 1997). Population is regarded as a 'single unit' which interacts with the forest as a "whole". The Malthusian debate, in the context of this thesis, is considered basic but simplistic and a mere generalization. Homogeneity of the population, as assumed by Malthusians, is openly challenged hence demanding for a more explicit and scientific explanation for the nature of the relationship between population, development and environment.

Paucity of literature that link disaggregated population characteristics, particularly age structure and sex composition; and expansion of human activities such as farming, firewood use and the like was generally observed (UNCED, 2002; Lutz *et al.*, 2002a; Curran, 2002). Literature tended to link population size with environment, therefore prompted emergence of the two opposite and antagonistic 'camps'. The fact is that it is through pursuance of development or livelihood activities such as farming and collecting firewood pursued by people of certain age group and a certain sex category that the environment gets degraded (Chu and Yu, 2002; Katundu and Mwaseba, 2007; Mbonile and Kivelia, 2007).

The need to solve the existing environmental problems that are attributed to human population made us to examine the nature and character of PDE inter-linkages. It calls for a step by step analysis of the involved household members in selected specific deforestation-related processes in order to generate information essential for sustainable development, which takes into account environmental concerns. This thesis, however, does not rule out that changes in the environment do impact on both development and population.

2.3.4 Household Characteristics and Involvement in Development Activities

Household size is the most basic demographic characteristic that refers to the number of members a household contains. In his study called "Household Size and Composition in the Developing World", Bongaarts (2001) observed a steady decline in household size from 5 members to between 2 and 3 in 1990 in most of the developing countries. The decline in fertility, improvement in child survival, reduction of the number of adults *per* household impacted on reducing the number of children *per* household.

The average number of children, adult off springs and spouses were the key components of household size. These were related to a set of three proximate determinants of household size, *adjusted total fertility, mean age at marriage* and *divorces*. The observed decline reflected a shift from the traditional (more complex) household structures to simpler (nuclear households) that dominate modern societies. The average household size for Sub Saharan Africa (SSA) ranges between 3.6 and 6.7; and the standard deviation of household size for SSA is 0.7 (Bongaarts, 2001). The average Household size in Songea district is 4.7 (URT, 2004).

Household composition is the average number of adults (aged 18+) and children (aged <18) *per* household. In this case, heads of households who were under the age of 18 were considered as adults. In SSA the number of adults *per* household is 2.5, meaning that most households had two spouses. In SSA the average number of children *per* household is 2.8, which below the country's *total fertility rate* (TFR).

Household members' relationship to the head has been related to adults, meaning the head and the spouse who normally reside with them. In SSA many households have adults other than household head and his or her spouse. Understanding the role of extended family members and dependants in causing deforestation would surely depend on the nature or types of economic activities dependants are engaged in. These most common three adult categories, constituting about 85% of adults' household membership in the area are head, spouse and daughter/son. The most important category of adult household member other than the head is a spouse. On average, in SSA, about 66% of the heads has a spouse (Bongaarts, 2001). Others are sons, daughters, in-laws and parents.

The frequency with which adults reside in a household necessitates an increase in demand for more food and other resources, and therefore increasing impacts on deforestation The fact that children are among the significant actors in various types of land use made it necessary to understand the participation and contribution of the entire population for more reliability and validity of results (Punch, 2001; Sherbinin, 2006).

Household complexity refers to the situation which includes non-nuclear members of the family. A simple nuclear household consists of parents and their children. More complex households include other more distant relatives or individuals. There is no widely accepted and commonly used approach. Household complexity is measured in a variety of schemes used for classification of households by types (UN, 1980; De Vos, 1995). Generally, members of the nuclear family units tend to dominate. Whether the size of the household and its level of complexity were related to specific types of development activities leading to deforestation is another area of research. The above factors outlined tended to show the complexity imbedded in households and their composition.

Since only surviving children are included in household listing, *child mortality* seems underestimated as reduction of the potential actors and/or the effect of changes in environment. This is an important aspect to be taken into account in assessing the PDE relationship. This may be a cause or effect of the current and/or future demographic behaviours and processes. Equally, not all children reside in their mothers' households, thus some live with other family members than biological parents, the essence of extended family. Thus, the number of children *per* household was affected by not only childbearing and survival of children, but also by the propensity of adults to live together with their children.

In rural traditional societies, residential families are more often extended, either horizontally or vertically than in modern industrialized societies where independent nuclear family predominates (Punch, 2001). As society develops, extended households tend to be replaced by the nuclear or conjugal households. It remains vital to examine why traditional societies cling to extended family relations, while the achieved development process tended to split such relationships. The thesis strives to establish whether household size, composition and complexity have influence on development activities that impact on forest cover change.

2.3.5 Coping Strategies to Population Land shortage Environments

Societies have been surviving many types of difficulties through different coping strategies. Understanding such methods is significant for planning of external extension service and link such activities with local initiatives (Madulu, 1991; Mnyenyelwa, 2005). The coping strategies and conservation methods are to be based on local communities' long term skills, knowledge and experience which constitute indigenous knowledge.

There are variations in socio-economic and environmental conditions and types of indigenous knowledge. The many facets of indigenous knowledge like production practices, types of natural resources and their use, technologies employed varied over space and time. Despite the utility of indigenous knowledge, it should not be considered superior to modern systems all the times (Madulu, 1991; FAO, 2000).

It sounded complex to spell out the system for categorizing coping strategies to various changes, including deforestation. However, the main classification criteria included economic/material, technological, social/organizational and cultural.

There are two safety-net strategies adopted by poor farmers in response to deforestation. They include diversification and coping strategies which operate at the expense crop reduction and work in areas with larger population increase. Aforestation is a diversification action resulting into forest cover increase (Delacote, 2007). The coping strategies do not necessarily add forest cover; it may conversely reduce it, thus augmenting deforestation. Sometimes there is conflict existing between agricultural activities and forest conservation (Madulu 1991a; Geist and Lambin, 2001; Chu and Yu, 2002). It is not the objective of the thesis to advocate for conservation of all forest stocks, but rather to emphasize the significance of catchment forests and advocate for their sustainable use.

Researchers commonly agree that farmers with limited assets and opportunities rely on common property for income, subsistence and advocate for risk coping (Jodha, 1986; Dasgupta, 1993). The services provided by the environment, i.e. the subsidy from nature are basic for livelihood and survival of most of rural economies (Hecht *et al.,* 1988). The fact is that this is 'their wealth' which if combined with labour can ensure the rural *continuum* (Arnold, 2001).

Small scale rural farmer perceive the value of the environment broadly than what one would think as it forms a means of livelihood. Other than the current land uses on the cultivated land, the remaining cultivable land, currently covered by the forest has potential for future use. Such tracts of land are a form of security and alternative for local communities. There is a need to extend sustainability knowledge by adoption of sustainable methods applied by local communities. This, therefore, becomes a matter of primacy for future sustainability of both the forest and humankind.

2.4 Forest Status and Deforestation in Tanzania

Tanzania is endowed with vast forest cover of about 33 million hectares, of which 57% were, largely unprotected and outside government forest reserves (URT, 2001, cited in Blomey and Ramadhani, 2005). Forest areas are threatened mainly due to expanding human activities. The activities related to dwindling forest cover are expansion of human settlements, extensive use of firewood and farm expansion (Chu and Yu, 2002; Scherr *et al.,* 2004; Delacote, 2007). Thus population growth is considered the driving force for deforestation that results from expanding development or livelihood activities. Establishing how population contributed to forest cover change is the main subject of this thesis.

Deforestation in the case of Tanzania can be traced back to 1970s when village reforestation programmes were introduced (Katundu and Mwaseba, 2007). In Tanzania, depletion of firewood sources culminated into faster rate of decrease in firewood supplies than it was expected (Misana, 1999). This necessitated undertaking of tree planting for fuel wood and building poles to save the country from desertification (MLNRT, 1989)

2.5 Population, Development and Deforestation

Population distribution is perceived as the major contributor to intensification of resource use than mere population size. Population is viewed as an essential resource for development, which increases demand for landed resources and thus degrades the environment (Madulu, 2004; Sitihal, *et al.*, 2007). Population distribution indicates the way people are scattered over a specified geographical area, thus reflecting the environmental implications of the population in specific areas. Both population size and density conceal the population's internal disparities regarding people's concentration over space and the role they play that manifest into the observed forest cover change.

Studies indicated that linking population with deforestation, in terms of increased demand for the forest products and expanded agricultural activities alone is too general and simplistic (Harrison, 1997; FAO, 2000; Chu and Yu, 2002; Lutz *et al.*, 2002a). The logical need to establish more detailed PDE relationships remain critical. This is necessary for practical and effective natural resource planning and management.

Rapid urbanization that is experienced world over causes land cover change and results into habitat loss. Urbanization does not only increase pressure on the land resources due to increasing numbers, but also changes the types of land uses triggering vast land cover changes in the peri-urban areas (Geist and Lambin, 2001;UNFPA, 2007). A similar situation was observed in WMCA whereby farmlands were repossessed by the municipality for surveying and allocated to new owners as residential plots. This is typical of 'environmental transition' i.e. a change from rural to urban land use types.

Small scale intensive community studies that employ a combination of surveys, focus groups and general ethnographic interviews were considered more practical model relevant for the understanding of various demographic processes. This disentangles the complexity of the interactive factors (UNCED, 1994; WCFSD, 1991; Lutz *et al.*, 2002b). A similar challenge emerged in the case of WMCA called for the adoption of a *combined method.* It is of interest to underscore this fact because vast literature indicated that rapid population growth played an important role in causing deforestation in most parts of the developing countries without a deeper analysis of the specific relationship(s) between the demographic and environmental variables at hand.

The fact that deforestation takes place in specific locations calls for location-specific understanding of population-development phenomena in a 'small area'. Locating the demographic processes within a *cultural matrix* requires more detailed research efforts that combine various suitable methods relevant to the different academic and professional disciplines. Such methods enable the effective collection of requisite types and volumes of data and the analytical strategies that encompass different models that underline the socio-economic, physical and demographic actions in force within a particular locality and time frame.

2.6 Sustainable Development

There are many definitions of sustainable development but the best known is the one by the World Commission on Environment and Development (WCED). Sustainable development is the socio-economic discourse that 'meets the needs of the present without compromising the ability of future generations to meet their own needs'. This implies undertaking economic growth with environmental concerns (WCED, 1987:43). The gist of sustainable development is reinforcing the relationship between population demands and natural resource use.

According to the International Union for Conservation of Nature (IUCN) Programme 2005-2008, the guiding rules of sustainable development is the sharing spirit among people in caring for the earth. It means that humanity should not take more from nature than that which can be replenished (UICN, 2004). The programme implementation goes with adoption of lifestyles and development paths that optimizes resource use. This may be achieved with or without any technological changes as both low and high technologies have their own environmental limitations.

Sustainable development may be achieved through concerted efforts of not only conserving nature through protection but also through provision of alternatives to utilization of natural forest cover by shifting to tree planting that would cater for various purposes like wood poles, firewood and fodder and replacing more energy efficient technologies, in so doing reducing pressure on natural forest cover reported to be dwindling.

Sustainable development respects the limited capacity of the ecosystem to absorb the impact of human activities. Conservation of the environment for species and humans constitute the aspect of sustainable development. It is a concept that calls for the maintenance of a delicate balance between human need to improve lifestyles and preserving natural resources and ecosystems, to be used by future generations. Many scholars believe that participatory democracy, not dominated by vested interests is a prerequisite for realizing sustainable development (Mintzer, 1992; UNCED, 1992; Madulu, 2001) in which a proactive, concrete operational framework is required (Gladwin, 1995; Robert *et al.*, 2002).

There were many controversial issues associated with sustainability. The concept calls for the maintenance of *biodiversity* not only for productivity but also for its own existence. Ideally, vigorous efforts to protect the environment existed before sustainable development literature. However, they did not halt the problem of environmental degradation just like the situation in the post-sustainable development literature. Therefore sustainable development remains as a concept that has to be operationalized to make it concrete (Gladwin *et al.*, 1995; Mebratu, 1998; Davis, 2002; Youth Forum, 2006). To some scholars sustainable development was impractical for any environmental utility unless it is put into a functional context within a specific location.

Some analysts questioned the definition of sustainability and the time frame to protect the environment. Another area of critique is based on types of resource to be protected and the exact meaning of sustainability in the context of sustainable development (Davis, 2002).

The principles adopted in the Rio de Janeiro 'Earth Summit' of 1992 provided a framework to improve both environment and economic development globally (Davis, 2002). Most of the efforts on sustainable development focused on ways of managing diverse resources while some aspects were left aside the concept's spectrum (Pearce and Atkinson, 1998; Mebratu, 1998). The ever-changing nature of technology, its role and related adverse effects is an aspect that poses a question on the future of the environment. Variability in definitions and interpretations of sustainable development led into its skewed applicability that affects conservation results.

Davis (2002) argues that to those who believe that free market is the answer to all worlds' problems, sustainable development is a dangerous notion that can collapse their economies. This is typical of developed countries. For poor countries, a more equitable distribution of wealth is an appealing idea. The concept sustainable development has captured wide public and political imagination over vast parts of the world despite some controversy (Mebratu, 1998; Davis, 2002; UN, 2002).

2.6.1 Sustainable Forestry

Sustainable forestry is a subset of a broader concept 'sustainable development'. The concept sustainable forestry captures the significance of trees, wood, and the forest products for sustainable development. The remaining challenge is to meet the increasing needs, prompted by the rapid growth in human population, through minimizing unsustainable consumption of both renewable and non-renewable resources. Temperate Forest Foundation defined sustainable forestry as that which is socially beneficial, economically feasible and ecologically sound. Sustainable forestry is managed through an ecosystem approach and has to cover a broad area (Temperate Forest Foundation, 2003).

Sustainable forestry calls for responsible forest resource consumption. A transition to a more sustainable society demands a slowing down of forest resource use and rising conservation. The *optimum point* lies between regulated consumption and conservation which may best define 'sustainability'. Consumption is part of culture which draws together social relations and transforms them into production. Such relations have to be incorporated as a condition to conserve sustainably (Milbrath, 1989; UNFPA, 2001). Sustainable forestry is perceived as a dynamic concept that involves experience and new knowledge obtained through research. Sustainable forestry demands for sustainable consumption and better forest stewardship (F&PA, 1994; Kant and Lee, 2004).

Sustainable forests are managed to produce a variety of values and benefits. Values observed to go beyond sustainability of the forest ecosystem include aesthetics, wilderness, recreation, biodiversity and non-traditional forest products; the essence of social forestry. Local communities are significant players in this stage. According to Kant and Lee (2004) for forestry policy to be truly sustainable it should be socially acceptable, economically feasible and biologically possible. Conservation cannot be achieved without some degree of predictability as conserving the forest means waiting for future rewards to be reaped by descendants. Devoid of predictability in the future, it would be difficult to plan for sustainability. Trees take long to grow, thus owners need to be secure about land ownership for long term management plan execution. For sustainability, prediction has to go with population projection (Kant and Lee, 2004).

Sustainable development cannot be achieved without conflicting with sustainable forestry (Temperate Forest Foundation, 2003). Knowledge in science and technology is required for effective monitoring and modeling programs on forest cover. Other areas of study like demography and culture play an important role in sustainability though are sometimes neglected. Understanding the forest dynamics makes it possible for effective management of forest ecosystems.

Conversely, from the point of view of the population, understanding population dynamics, i.e. the actors in forest degradation, is considered the cornerstone to sustainable forest management. These are ideally the ones to be targeted for the extension service and engaged in conservation activities for better and easier future resource harnessing. It should be noted that sustainable forestry focuses on achieving future goals and maintenance of the integrity of the forest ecosystem for the production of goods and services within the present constraints and for future use. Intensive forest management constitutes part of the framework only if it is part of ecosystem management.

It is envisaged that education is a vital key to sustainability. Since informed choices can only be made if people understand issues and options of resources management education remains an important 'vehicle' for delivery of extension services. The challenge remains as to who should receive which body of knowledge, using which method, when and in what setting. The thesis sees the need to discern the *key actors* by specific activities as the target group for agriculture and forest conservation extension service. Those who actually make choices to chop trees for specific reasons are the ones expected to make 'intelligent choices' on where to plant trees, their use and maintenance in order to foster sustainability. The dialectical relationship between farm expansion and forest cover change echoes the same approach.

2.6.2 Sustainable Agriculture

Definition of sustainable agriculture refers to forms of on-farm practices that are economically viable and environmentally positive and take into account life quality (UN, 2002; IISD, 2002). Sustainable agriculture, like sustainable development, is not linked to any type of technology as it requires different practical mechanisms to meet its different, and sometimes contradicting, objectives. It takes into consideration requisite demands for natural resources for production and its ability to protect the soil and other related resources (IISD, 2002). It is an adaptive and flexible path that does not allow for depletion of soil nutrients or pollute the soil only to suffice the market demand and high profitability (Gladwin, 1995; Wilson and Tyrchniewitz, 1995).

The WCED saw the necessity to address the challenges of population growth and strategies towards meeting the growing food demand and to conserve natural resources. Agenda 21 outlined a plan of action for implementation of sustainable development. Since the study area is largely dominated by agricultural activities its sustainability is significant in sustainable forest conservation (WCED, 1987).

In the context of this thesis, therefore, a more flexible definition is adopted while embracing the key words of the WCED. Sustainable forest conservation refers to the utilisation of forest resources that does not diminish the prospects for future generations. It involves replacement of forest cover, caring for the planted and protection of the existing natural vegetation cover for *habitats*, thus conserving the entirety of *biodiversity*.

2.7 Similar and Related Studies on Population Development and Environment

2.7.1 Similar Studies Conducted In Tanzania

Many studies such as the one by Liu *et al.*, (2000), Orians and Skumanich (1997), Lutz *et al.*, (2002) and others concede that population is closely linked to the environment and that population growth normally brings about negative impact to the environment. Rapid population growth thus is related to the currently alarming rate of deforestation. However, the studies observed paucity of detailed and focused explanations on the relationship between demographic dynamics and conservation as a measure towards attaining sustainable resource conservation and management (Liu *et al.*, 2000;

Orians and Skumanich, 1997). This is a bias based on prejudice and entails critical information for environmental sustainability.

Such studies generally advocate for the anticipatory, preventive and proactive direction of resource management, which address the key aspects of the new systems level approach for relationships between demographic dynamics and environmental change. Such studies urge for the local community participation approach, well known for promoting a sense of "ownership" and "responsibility" among the respective local communities in managing their local natural resources (URT, 1997; URT, 1998b; Liu *et al.*, 2000; Madulu, 2001).

A study conducted in Kondoa district of Tanzania by Ndalahwa Madulu titled "Demographic Dynamics and Environmental Change: Case of Swagaswaga Game Reserve (SGR)", is an attempt to underscore the existing link between population and environment (Madulu, 2001). Populations of villages located in SGR were analyzed in terms of size, growth rates, migration, household size on the one hand, and the status of the environment on the other hand. Information about main human activities conducted in the area was also gathered.

The main study findings indicated that household size differed among villages of SGR. The mean household size was 5, while about 45% of the population was aged below 15. The proportion of the old people (aged 65 and above) was insignificantly low in all villages. Dependence ratios were generally below 100, meaning that there were a significant proportion of people in the dependent age. Some of households had dual homesteads with some of their household members staying outside SGR. A high dependency ratio was attributed to the past and current fertility and migration trends.

The migration was a recent phenomenon. Most of the migrations were *intra-district*. Inhabitants acquired land through clearing, inheriting, hiring and purchasing. The increased population pressure, caused by increased household size raised the demand for land.

The main reason for encroachment of the SGR was searching for new farmland, charcoal making, lumbering and beekeeping. No mention was made about the causes of deforestation. Expansion of farms and *shifting cultivation*, i.e. *slash and burn* practice alone do not at all the times justify the encroachment. It may be attributed to shortage of land or loss of soil fertility in the original settlement. It is our observation that long term practice of *shifting cultivation,* as a solution for soil fertility decline or scarcity of cultivable land was likely to culminate in encroachment and deforestation (Geist and Lambin, 2001).

Furthermore, the study was silent on how much land was encroached by the population, therefore failure to establish the quantitative impact of population dynamics on the environment. The study could not mention about the *key actors* in deforestation-related activities in terms of age, sex and levels of education. The more generalized findings did not define specific actors in activities that caused deforestation hence posing a gap about population-deforestation relationship. The target population groups for forest extension services were not identified. Information on the *key actors* is considered critical for the planning of sustainable conservation programme. The impact of environmental change on the population of SGR did not form part of the study. Effort towards determining the interactive relationship between population and the environment was partly attained but with less specificity, thus achieving less practical results.

Negative perception of local communities on the SGR was an important indicator that can be used in the selection of methods and levels of community participation in development and conservation activities based on the *key actors*' characteristics. Levels of participation refer to both stages and activities for engaging local people in planning, implementation, monitoring and evaluation. Such information is considered essential for enabling sustainable forest conservation. The gap was observed as the study did not cover an analysis of changes in population structure and its impact. The study did not provide a comparative analysis of the situation between households of different sizes and their respective environmental impact, neither did it explain about how people of different sex, age and levels of education participated in forest encroachment. The study, therefore, lacked detailed and specific findings on the population-environment interface.

The study perceived the possibility of continuous depletion of the SGR's resource base, if no requisite steps were taken to control population growth and enforce conservation practices. Local communities needed to enjoy natural resource benefits such as fuel wood, bees wax, building poles for them to get motivated to conserve. Obviously, SGR, being a reserve, did not give local communities access to resources which alienates them, thus waving the possibility for sustainable conservation (Madulu, 2001). The highlighted gaps in SGR study called for more detailed studies on the PDE relationship. This thesis is an effort to address these issues.

2.7.2 A Case Study of Wolong Game Reserve in China

A study by Liu *et al.*, (2000) titled "Changes in Human Population Structure and Implications for Biodiversity Conservation" was conducted in Wolong area of China, where both panda and tree species were threatened by extinction. The increase in firewood consumption from 4,000m^3 to 10,000m^3 for the two decades fragmented and destroyed *panda habitat* by 20,000 ha. Although human population size in the Wolong reserve increased by 15% in the past 15 years, there was no information to establish whether the population structure had changed. Therefore, two major issues covered by the study were whether human population structure (age, sex ratio, composition and level of education) in Wolong village changed during the last 15 years, but it did not establish the implications of the changes in human population structure on the giant *panda habitat*.

The available resources in the game reserve were established which included about 1000 panda and the reserve area that expanded from 20,000 Ha by 1962 to 200,000 Ha in 1975. The reserve had 47 animal species and 4,000 plant species and was part of the World International Man and Biosphere Reserve Network. Between 1982 and 1996, the population of the area increased by 14.7%. The birth rate was about 2.5, relatively higher than the 'one child' national policy. The majority were farmers engaged in agriculture, fuel-wood cutting, lumbering, home building, transport, traditional herbs and tourism.

The age structure of the population indicated that between 1982 and 1996, the people in the age group of between 20 and 34 years doubled. The number of those in age group 20-59, which constitute the main labour force, increased by 59.67%; while that of very old people, i.e. 60+ increased by 24.47% implying a greater possibility of more habitat loss. In the same period, the sex ratio was almost the same. In1982 the number of males (89) and females (90) were almost the same (Liu *et al.,* 2000).

With regard to education, from 1982 to 1996, illiteracy dropped from 30.85 percent to 24.60%. The percentage of people who attended elementary school only was dropped from 55.10% to 47.94%. The percentage of people who received middle school, high school and college education increased. The increase in the number of those with higher education reduced the pressure on land resources, as they got formal employment in cities and other places outside the reserve, thus their offsprings had no connections with the game reserve at all.

The comparison between population growth and growth of the labour force indicated that although the total population increased only by 14.65% from 1982 to 1996, the labour force (20-59 years) increased by 59.76% implying that the rate of change in the labour force was three times higher than the rate of change in the total population. This sharp increase in the labour force was found to be exceptionally significant with regard to human impacts on the *panda habitat.* The skilled and educated young men formed the labour force employed in the urban sector thus reducing pressure on the game reserve.

Marriages brought girls into the reserve thus adding more pressure to *panda habitats* through increased population and labour force participation. Men were found to be more influential in performing heavier jobs than women leading to more negative environmental impacts. This was in contrast to some other parts of the world in which women were mainly responsible for collecting fuel-wood and managing natural resources.

A survey conducted to assess residents' opinions and attitudes towards relocation found that most young people were willing to settle outside the reserve before they got married, especially those with higher education, with expectations for job opportunities in the cities. Older people did not prefer to move out but supported and encouraged their children and grandchildren to obtain college education and work outside the reserve. Thus higher levels of education could help young people to move out of the reserve and thus reduce future human impacts on the *panda habitat*. Despite the general improvement in levels of education over the last 15 years, the percentage of people who had higher education was found to be still incredibly low (Liu, *et al.*, 2000).

Young people moved out of the reserve more easily to find professional jobs. Moving one young person out of the reserve is equivalent to relocating a larger number of people over time, because the young people will not have their children and grand children living in the reserve. In conclusion, the study by Liu *et al.*, (2000) observed that while population structure changes are a common phenomenon and biodiversity loss becomes increasingly severe, research on the linkages between population structural changes and biodiversity conservation is largely lacking, thus urged for more location-specific PDE studies.

The study by Liu and others limited itself to identifying the impact of changes in population structure without actually establishing the specific *key actors* in causing deforestation. The thesis reiterates that lack of such information signals the gap of essential knowledge for the planning of sustainable conservation; or else, like its predecessors, still generalizes the population-resources interface based on the population size.

2.7.3 A Case Study of USA

The study by Orians and Skumanik (1997) titled 'The Population-Environment Connection' was conducted in the United States of America (USA). The analysis was conducted by disaggregating population into its component parts and then linked them to changes in the environment. Population size, distribution, age structure, racial ethnic identity, socio-economic status, and migration; and household composition were the sub-groups. Changes in population in terms of its size, distribution, and composition were more significant in the improved understanding of the way population shapes environmental problems faced today and those in the future. The location, timing and magnitude of environmental problems that emerged were said to affect by specific population components.

Concerns about effects of environmental conditions were thought to be addressed better through improved understanding of population size, distribution and composition. The study underscored the fact that the linkages differed in their complexity. The uneven population distribution and a variation in population segment based on age groups, sex composition and level of education were aspects that tend to complicate the demographic complexity. It was important to examine the consequences of population change to the environment based on detailed demographic characteristics like age structure and sex composition. This was based on the variables of population and how they were linked to changes in environment over time, which was considered to be among the possible remedy for areas of misconceptions and confusion surrounding issues of connection between demographic change and environmental change (Orians and Skumanik, 1997).

Age structure had an impact on the environment, and increased consumption patterns. Age structure is the representation of the distribution of the population by age and by sex. It was further noted that age structure has a powerful effect on influencing the migration and population distribution pattern. Age structure had also a great influence on consumption patterns. The different specific environmental implications caused by age structures included increased demand for social services and hence reduced money available for protection or conservation activities (Orians and Skumanik, 1997).

Orians and Skumanik (1997) saw the increase in demand for more land as sometimes being attributed to the new families that established themselves with time. Changes in population composition were likely to result in shifting patterns of exposure to environmental hazards among various minority groups, and thus contributed to heightened concerns about environmental justice. It is worth mentioning at this point that having been conducted at national scale, the findings lacked specificity regarding the actual relationship that existed between population dynamics and environment.

The relationship between level of education and involvement in deforestation-related activities was weak or non-existent, although education, particularly of women affected fertility and hence lowered the rate of population growth. It was also noted that income growth does positively correlate with demand for goods and services even in the absence of population growth. Socio-economic characteristics, particularly income, are linked with the environment as it can be translated into greater willingness to pay for environmental protection (Orians and Skumanik, 1997).

Household composition and family size normally makes a unit for analyzing market demand since family is the primary unit for consumption of commodities. Therefore the larger the number of households, the greater the likelihood the total population had increased. In the United States, while the number of households increased by 27% in 1970, population increased by 11.4%. Thus household growth continued to outpace population growth in 1980s, i.e. 14.4 and 9.8 respectively. This raised the demand for products and services required by a household such as energy for heating and cooking, major household appliances, building materials and the like, keep pace with growth in the numbers of household. One may clearly note that the study did not highlight anything on variations in family size and its respective impact to the demand for energy and other products.

Orians and Skumanik (1997) found that few studies linked population structural changes and their possible negative impacts on biodiversity, and thus urged for the urgent need to the exploit such an "un-chartered field". The area was considered significant in understanding the underlying mechanisms behind the human impacts on deforestation. The findings would enable the formulation of effective socio-economic policies for participatory nature conservation methods. The significance of such approaches arises as the conventional approach of establishing protected areas, reserves and parks has, in most cases, proved to be a failure (Madulu, 2001; UNCED, 2002).

However, since the study by Orians and Skumanik (1997) was conducted at national level, the findings could not directly be applied in a specific context. The role of population factors in environmental degradation in location-specific and quantitative terms due to spatial variation in population characteristics, physical and economic activities could not be established.

2.7.4 Other Related Studies

It is easy to direct blames to *slash and burn* and population growth as the causal factors for deforestation (Harrison, 1997; Geist and Lambin, 2001). It is easy to think that population growth was the sole cause of deforestation. This is an oversimplification of a complex relationship. An improvement in technology that went with growth in human population would not necessitate more forest destruction to feed more additional people (Chu and Yu, 2002; Lutz *et al.,* 2002b). In such circumstance, one would easily think of "technology lag" and poverty as the factors to blame for deforestation than mere population growth.

Decline in commodity prices, misguided government policy, which control prices and markets has also influenced deforestation (Harrison, 1997; Geist and Lambin, 2001). All these factors are also simplifications since in case the population was not growing; there was no need to clear vast forests for cultivation. This thesis calls for deeper analysis on the nature and character of PDE relationship, the cornerstone for the formulation of more practical solutions to ailing environmental problems.

The study by Tiffen *et al.,* (1994) suggests that under some circumstances, population growth fosters conservation, thus posing no threat to the environment. There are circumstances whereby, "more people" caused "less erosion". Population increase challenged people to adopt more intensive cultivation practices, therefore reducing extensive deforestation. Tiffen and others carried out case studies in six countries of Africa including Tanzania (Tiffen *et al.,* 1994). However, a review of Tiffen's study by Boyd and Slaymaker (2000), established that the Tiffen's thesis was far from being generalized as in most cases it could not be replicated (Boyd and Slaymaker, 2000). The Tiffen's "More People Less Erosion" hypothesis was applicable only in specific locations, especially in areas with highly intensive farming practices.

Boserup's (1981) Model, postulated that there would be an increase in land use intensification in line with population increase which would be characterized by the use of more farm inputs and reduced fallow periods. Despite lack of possibility for the generalization of these results, location-specific studies proved more practical for problem solving than the production of general theories that cannot be easily applied (Harrison, 1997; Lutz *et al.*, 2002a).

The current knowledge about the influence of population dynamics on the environment was synthesized when examining the relationship between demographic factors, i.e. population size, distribution and composition; and environmental change (Hunter, 2001). Some studies have considered the role of mediating factors in influencing the PDE relationship. The mediating factors include technological, institutional, policy and cultural forces (Pearce and Atkinson, 1998; Hunter, 2001). The two specific aspects of the environment that formed a focus of the study by Hunter (2001) were climatic change and land-use change; and their implications for policy and further research. One of the findings of the study was that population dynamics have important environmental implications; and that the sheer size of the population represents only one important variable of this complex relationship (Sanderson *et al.*, 2002; Lutz *et al.*, 2002a).

Other demographic dynamics, including changes in population flows and densities were found to pose challenging environmental problems. Population distribution, at the global scale, posed implications to the environment as less developed regions could not cope with the growing share of the population, thus, increasing pressure on the already dwindling resources (Hunter, 2001; Madulu, 2003; Chu and Yu, 2002). Migration influenced the relative shifting of population pressure exerted on local environments by easing it in 'the source areas' and straining it in 'destination' areas (Curran, 2002).

Population composition contributed to environmental problems as different population sub-groups behaved differently with regard to the use of natural resources. A population with a large cohort of young people (age 24 and below) and a large proportion of elderly group will have different behaviour leading into different implications for the environment. However, though the findings are not negated, to generalize such study findings would require a more detailed location-specific analysis that thesis was deemed to undertake.

Lack of energy to about 2 billion people world wide, despite large scale expansion of energy services, coupled with dominance of traditional energy sources has tended to exacerbate deforestation (UNDP, 2003). It was observed that in most cultures of developing countries, men and women had different socio-economic roles and responsibilities. Women were overburdened by all subsistence activities, including collecting firewood (Mbilinyi, 1997; UNFPA, 2001). Hence, it was necessary to apply demographic knowledge in the analysis of the role of various development or livelihood activities in effecting environmental degradation since they involved actors with different demographic characteristics.

2.8 Conclusion

Based on the proceeding discussion, it is evident that population, development and environment are interlinked and related components basic in sustenance of life. The exact way in which the three components, i.e. population, development and environment, are linked is not yet clearly established and known. The link between PDE is classified, by many studies as complex (Hunter, 2001; IIASA, 2001; Lutz, *et al.*, 2002). Naturally, population growth is associated with changes in age structure and sex composition. Therefore understanding how changes in the two demographic variables impact on deforestation is essential in comprehending the population-resource relationship. Knowledge on the PDE relationship generated can be used for the formulation of practical sustainable forest conservation policies.

Martine (1996) sees the significance of understanding PDE relationship being examined within the light of the on-going economic growth efforts operating throughout the world, i.e. within the context of the on-going economic globalization which displayed enormous expansion of economic activities, some of which were at the expense of forest cover (Menotti, 1998; UN, 2002).

Relative concepts and processes of environmental conservation and degradation need clarification and sustainability of the environment depended highly on the combination of economic resources, technology, environmental awareness and economic growth prospects. In Africa, where population growth and environmental degradation are experienced at unprecedented rates, the significance of such studies needs can not to be overemphasized.

The formulation of more standard household-based demographic analyses based on the socio-economic data that incorporates the reality of life styles of specific local communities within a specified time frame is deemed vital in the PDE analysis. It implies the disaggregation of the population into sub-categories of age, sex and education, in an attempt to establish the *key actors* in deforestation-related activities. It is only after the *key actors* and the kind of interface individual population members have with the environment is made known that the appropriate conservation packages can be developed and more precisely targeted. This is considered to be the essence of the effectiveness and sustainability of conservation efforts.

The inclusion of household demographic knowledge in the planning and implementation of conservation efforts is significant for identifying people's involvement and contribution to deforestation. This thesis reiterates the vitality of emphasizing the involvement of the *key actors* in deforestation for effective conservation efforts. It includes those members who are affected more by the impact of deforestation. Massive involvement of children in farming and firewood collection need not to be undermined in the PDE analysis (Punch, 2001; UNFPA, 2001; Sherbinin, 2006). The conspicuous role of women in production and reproduction duties and their impacts on environmental degradation should be underscored in order to formulate more effective intervention strategies (Mbilinyi, 1997; UNFPA, 2002).

The methods of forest conservation to be adopted and the timing of intervention can be more precisely selected and planned for effectiveness and sustainability of the conservation activities if demographic dynamics coupled with existing socio-economic conditions are taken into account (UNCED, 2002; Lutz *et al.,* 2002). More inclusive explanation than a mere correlational analysis of demographic, developmental and environmental variables was significant and necessary (Fricke, 1997; O'Neill, 2002). Other relationships like socio-cultural values and levels of technologies play a significant role in determining the nature and character of the interface between local community members and their surrounding natural resources. Culture has a lot of uses in demographic research (Fricke, 1997; UNFPA, 2001), hence the incorporation of cultural meanings to demographic processes allows for a better understanding of the gist of various phenomena observed in particular social settings.

Knowledge, experiences and skills of local communities are significant in analysing location-specific phenomena like deforestation (UN, 2002; Yanda and Madulu, 2003; Kant and Lee, 2004). PRAs and surveys have to be given prominence than dependence on population size alone, leaving aside other characteristics such as age structure, sex composition and level of education.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This thesis is a multidisciplinary study dealing with a wide range of data used in examining the existing links within PDE relationships in the WMCA. The range of data is broad in terms of the time frame, i.e. from 1978 to 2005, the types of data and their sources. This chapter explains the methodology adopted in the study.

The methodological framework of the study hinges on the PDE analysis based on serial data sets of population, development activities and environmental change. The data sets were vital for the analysis and consequent drawing up of conclusions about PDE relationships for years 1978, 1988, 2002 and 2005. The first three periodic years in question were based on readily available and reliable population census data.

3.2 The Study Site and Location

3.2.1 Geographical Location and Ethnic Groups of the Study Area

The West Matogoro Catchment Area (WMCA) is located in the Songea district of Ruvuma region, in southern Tanzania. The district borders Mozambique to the south, Mbinga district to the west, Namtumbo district to the east and Iringa region to the north. Population of Songea district constitutes people of various ethnic origins, i.e. the Wan*goni, Wayao, Wamanda* and *Wandendeule* (URT, 1997c). Other ethnic groups of the region are the *Wahehe, Wabena, Wachagga* and *Wanyakyusa* who migrated into the area from various part of the country. The location of WMCA, the subject of this study, is shown in Figure 3.1.

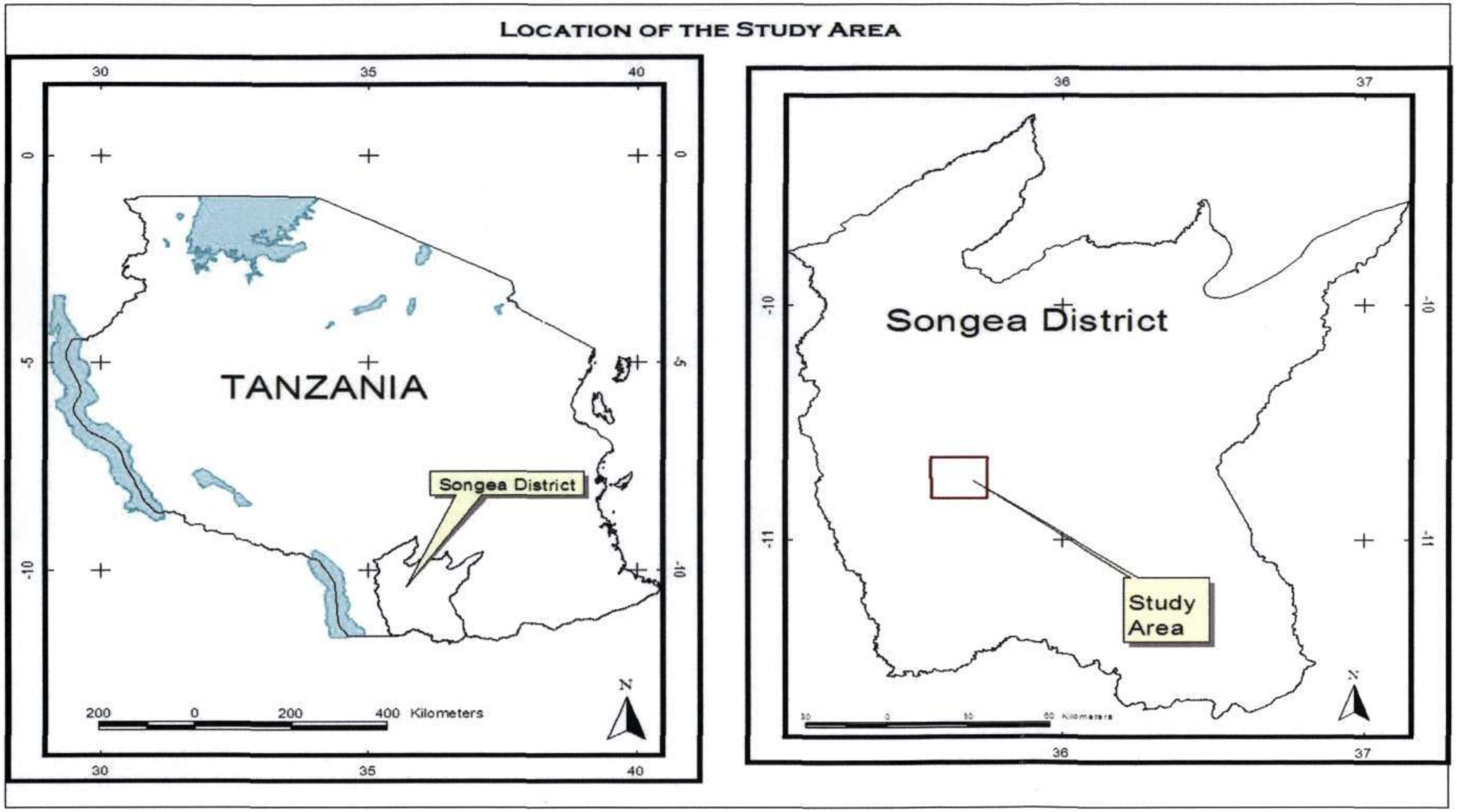
3.2.2 The Main Economic Activities of the WMCA

Subsistence farming is the main economic activity. Smallholder system dominates farming that includes crop cultivation and livestock keeping. Major food crops grown are maize, cassava, millet and beans, while tobacco and maize are the chief cash crops (URT, 1997c). Other cash crops include sweet potatoes, bananas, vegetables and tomatoes. The area experienced seasonal movements of people from Songea town in search for cultivable land, therefore raising population pressure in the *peri-urban* sectors (Gama, 1989).

3.2.3 Catchment Areas of Songea District- Coverage and Quality

Songea district has the total catchment forests area of 311,700 hectares, i.e. about 50% of the total catchment forests of Ruvuma region. However, about 130,106 hectares of other catchment forests in the district are not yet gazetted as forest reserves. These are classified as general forest or public woodland, thus highly prone to the risk of depletion caused by expanding human population and

Figure 3.1 Location of WMCA in Songea District-Tanzania



the associated development activities. All types of forests of the area are at high risk of depletion for lack of concerted efforts towards protecting or conserving them (URT, 1998a; URT, 1996 cited in Huvisa, 1997).

Legally protected forests were also endangered as people from the adjacent settlements reportedly invaded them for various reasons. The rapid rate of population growth experienced in some settlements, attributed to high birth rates and declining mortality rates, augmented the problem (NEMC, 1994). In the WMCA, population pressure over land resources was observed to be on the increase. The Regional Socio-economic Profile stipulates that the problems of conservation of catchment forest in Songea district emanated from lack of effective protection of the existing forests (URT, 1997c).

The Participatory Rural Appraisal (PRA) findings indicated that majority of the local community members were aware of the significance of WMCA. However, some community members poached building poles and firewood from the same forest reserve. Lack of *buffer zone management* and absence of fire lines separating settlements and forest reserves were the main reasons for encroachment and poaching. Human activities affected the pace of natural forest regeneration, therefore reducing the *catchment value* of the forest. A shortage of trained forestry manpower at the Matogoro Forest Reserve was one of the reasons for the ineffectiveness in conservation activities (URT, 2005b).

This thesis deals with the dynamics of the human population of WMCA located within the proximity of 10 km from the fringes of the West Matogoro Catchment Forest Reserve (WMCFR). The total area covered by the study is about 155.2 km^2. It is important to mention at this point that WMCA forms the main water-shed of Southern Tanzania and the source of many rivers such as *Ruvuma, Luhira* and *Ndongosi.* Other small streams like *Liwoyowoyo, Lipasi, Mkurumusi, and Masumeli* originate from the area (URT, 2005b; PRA, 2005). *Ruvuma River* which originates in the area flows into the Indian Ocean and forms the major drainage system in the region and the border with Mozambique (URT, 2005b).

3.2.4 The Villages Covered by the Study and their Selection

Eight villages sampled for the study and their respective distances from Matogoro Forest Reserve were *Chemchem* (3), *Mahilo* (1) and *Ndilima Litembo* (0.5) of the *Matogoro* Ward, *Mpingi* (4) and *Kikunja* (4) of the *Matimira* Ward, *Lilnwena* (5) and *Muungano* (4) of the *Subira* Ward and *Lipaya* (3) of the *Mpitimbi* Ward. Proximity to the WMCFR was considered to have an impact on the environmental conditions, especially forest cover and water sources.

Of the eight villages, *Mahilo* and *Ndilima Litembo* were situated on upper sections and on the steep slopes of the Matogoro Mountains bordering the Forest Reserve. Their sites were likely to trigger soil erosion. Topographical map sheets (1:50,000) were used for selecting the specific villages. The Global Positioning System (GPS) coordinates were used for the precise location of the villages on map Figure 3.2.

3.2.5 Rationale for Selecting the WMCA and the Eight Villages

The WMCA was deemed an appropriate site for the study mainly due to its location in the district with the highest rate of population growth in Ruvuma region (URT, 2004). The analysis of dynamics of population, in terms of growth, changes in age structure and sex composition, as affected by both *natural increase* and *migration* were studied. The region, WMCA in particular had few studies on development and environment such as Gama (1989), Huvisa (1997) and Haule (1998). However none was on the interaction between population, development and the environment.

Within the region, Songea district was endowed with more *catchment forests* compared to the rest of the districts, and was thus an appropriate site for the study. Such ecologically sensitive areas were threatened by the fast rate of deforestation, and demanded sustainable conservation. By the time of the study, the entire region had no reliable electric power supply. Local people depended on firewood as the main source of domestic energy, thus existence of a higher actual and potential for deforestation (Field Survey, 2005).

WMCA was the appropriate location for the study because it possessed the ideal social, environmental and demographic conditions for a location-specific research of this nature. The area represented two settings i.e. urban to the north-western side neighbouring Songea municipality, i.e. villages of *Chemchem*, *Lihwena* and *Muungano* and the typical rural setting was represented by *Lipaya, Ndilima Litembo, Mahilo, Mpingi* and *Kikunja.*

The *peri-urban* and rural settings that characterize the area, when put together, reflected the real situation pertinent to the population-resource relationship existing in the entire area. The land and/or vegetation resources do support *rural livelihood*, while at the same time they also serve the *urban demand* for the same forest and agricultural products. The adverse impact to vegetation cover and water sources is not solely attributed to the rural population. The demand and the actual consumption of rural products, in the urban setting, is reflected by their actual utilization, spatial expansion of cleared forest areas and their distribution at the 'source area', i.e. the respective rural setting.

Bairoch's (1991) concept of "*parasitic cities*" hinges in this context whereby urban centers benefit more from the respective areas which provide services to the city. They leave behind the 'environmental burdens' like deforestation, soil erosion and others. These translate into a reduction in farm productivity and reduction of water supply. Establishing whether Songea Municipality is *parasitic* or *generative* is beyond the scope of this thesis.

Being the main watershed and the sole supplier of water for Songea Municipality and other downstream settlements, WMCA is a priority area for conservation (URT, 1996; URT, 2005b). Water shortages in the Municipality faced over years could partly be attributed to catchment deforestation, the increased water demand was caused by rapid urbanization and by population growth.

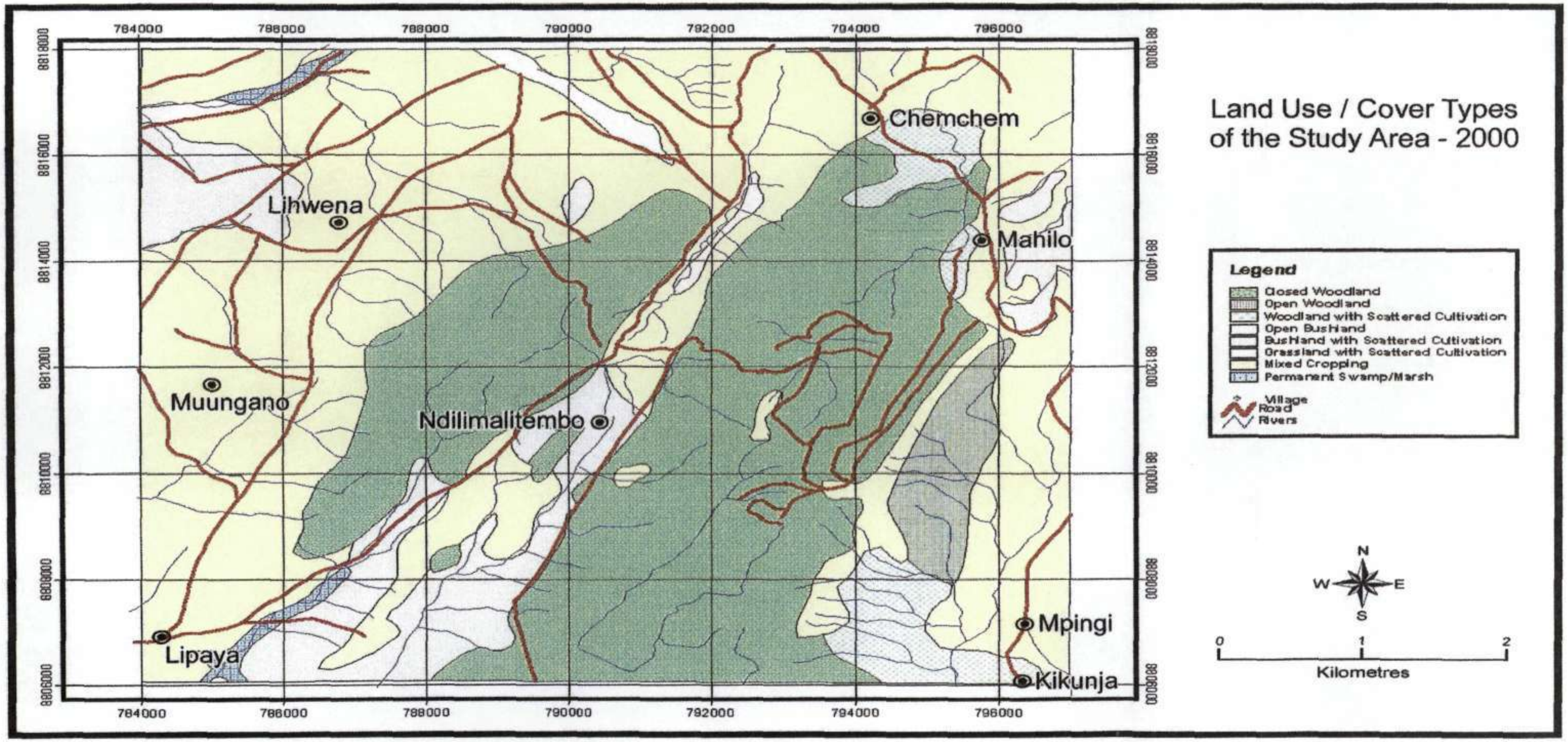
According to Regional Water Report (URT, 2005d), the *catchment value* of the WMCA is on the decrease with the river *flows* portraying a decreasing trend since the 1960s. Population growth and expanding human activities in the source area were identified as basis for the observed negative environmental trends. The report warned that unless serious efforts are taken to protect the catchment area and reduce human activities like poor farming methods, indiscriminate tree felling for fuel, building poles etc; there will be little, if any, water in the rivers and other water features due to declining *catchment value*.

3.2.6 Types, Quantity and Quality of Vegetation Cover in the WMCA

The area had both natural and artificial vegetation types. GIS data indicated a range of natural vegetation sub-types of the area, i.e. *Closed Woodland; Open Bush land, Bush land with Scattered Cultivation, Grassland with Scattered Cultivation, Mixed Cropping* and *Permanent Swamps*. The natural forest covered about 3634.04 hectares. *Miombo woodlands* dominated forests with indigenous tree species like *brachystegia spp, julbenardia spp, albizia spp, vitex spp, acacia spp, combretum spp, pterocarpus angolensis, uapaka kirkina, strchnos spinosa, pseudolanchnostylis maprouneisfolia, ficus spp, bridelia micrantha, breonadia salicina, afzelia quanzensis, ziziphus mucronata, swartzia madagascariensis* and *pericorpis angolensis*. The main grass species of the area were *hyperrhenia ruffa* (i.e. Kikuyu grass) and *lactus capensis* i.e. Elephant grass (URT, 2005b).

Artificial vegetation of the area included the Matogoro Forest Plantation covering an area of about 897.2 Hectares of exotic species mainly *pinus patula, pinus elliotii, curpessus lusitanica* and *eucalyptus*. It is a soft timber plantation, the largest in the entire region (URT, 2005b). The presence of key tobacco producing villages in the study area made it more challenging in uncovering the PDE relationships. Tobacco is known to significantly contribute to deforestation.

Figure 3.2 West Matogoro Catchment Area - Study Villages and Vegetation Cover



3.3 Research Assistants and PRA Participants

Following the multidisciplinary nature of the study, it was deemed important and necessary to engage technical expertise from other fields mainly for the collection, processing and the analysis of data on forest cover change, which employed GIS and remote sensing techniques. Climate data and *river discharge* data were interpreted with assistance of technical staff from respective institutions.

3.3.1 Research Assistants

There were four (4) research assistants (RAs) three of whom were university graduates specialized in Land Use Planning and Rural Development Planning. One of them had long-term experience in population related projects since he was an employee of the Central Census Office in Dar es Salaam. Another one was an Agricultural Extension Officer by profession, holding a diploma in crop production and a degree in physical resources. One was an undergraduate student of University of Dar es Salaam majoring in Rural Development. The RAs were recruited through an interview and were charged with the responsibility of interviewing respondents during household surveys during the data collection phase of this study.

The Research Assistants attended a two-day training that introduced them to the study objectives, questionnaires, questionnaire administration and ethical issues. The training was done on Thursday, 15th April 2005 and Friday, 16th April 2005. The training provided the RAs with detailed skills relating to the field work, standard procedures and the research protocol. The RAs were exposed to all research instruments used in the study i.e. the questionnaire and PRA checklists to familiarise them with the research work.

3.3.2 PRA Participants

The researcher made contacts with rural communities whose members were selected based on the principle of "maximum variation". The aim was to have representation of ideas from people of different socio-economic status, levels of education, religious affiliations and of both genders. Ninety six (96) members were selected for PRA discussions.

3.4 The Pilot Study

A pilot study was run at *Mbopo* rural settlement, located in the Kinondoni district, about 45 kilometres northeast of the City of Dar Es Salaam. The village was appropriate for the pre-test as it is located in a rural setting, closer to Pande Forest Reserve, and about 4 kilometres from the village center. The village had a similar setting to that of the WMCA. The pilot study was used to evaluate the appropriateness of research instruments and assess the training of Research Assistants (RAs).

The pre-test of the questionnaires and the Participatory Rural Appraisal (PRA) checklists took one day, i.e. Saturday 16th April 2005. The pre-testing helped in evaluating the logical arrangement and validity of the questions, time taken for the interview, effectiveness of interviewers in administering questionnaires and facilitating the interviews and PRA discussions. Questionnaires used in the pilot study were in the Kiswahili language and were literally understood by all the respondents.

The evaluation meeting was held on Sunday, 17th April 2005 and was aimed at receiving the feedback from the RAs about the pilot study. Necessary amendments were made to the questionnaires and checklists that included deleting of some of the questions found to be irrelevant. Some questions were modified and the formats of the questionnaires and interview guides were redesigned for logical flow during the actual field work. A few additional probe questions were included

3.5 Research Design

The actual data collection work commenced on 28th April and was completed on 24th August 2005. This activity took place in the season when the rain had just ended. This enabled the research team to easily access the sample villages, in off road locations on the Matogoro highlands which were not easily passable during the rainy seasons. During this period of the year, farmers had less work and were eagerly waiting for the harvest period, therefore providing a higher possibility for active participation in PRA discussions and household surveys.

3.5.1 Primary Data

Quantitative and qualitative data were collected from the field. The quantitative analysis dealt with statistical data, while qualitative data were used for generating knowledge from the assessment of opinions given by the respondents for obtaining detailed explanations on various significant phenomena that support the quantitative data analysis. Specific types of data collected covered the following aspects.

3.5.1.1 Quantitative Data

The study employed the stratified random sample design based on the total number of households located in each one of the selected eight villages. The total number of households in each village provided the main sampling frame for the study. Each village was used as a primary sampling unit. Forty percent (40%) of the households of each village were interviewed. One respondent, male or female, on behalf of the head of the household, responded to the questionnaires and provided requisite information of the entire household.

(a) Selection of Households for the Study

A *simple random sampling technique* was used to obtain the sample. The sub-villages were included in the population sample purposefully to ensure representation of different segments of the village settlement(s).

Forty percent (40%) of the households of each village were interviewed. Lists (of names) of all the households that were present in each village, according to their sub-villages, were obtained from respective Village Chairpersons and/or Village Executive Officers. A single number was assigned to each of the households in each of the sub-villages using the village population registers. A Table of random numbers was used to select the households that were interviewed in each sub village. A sample of between 57 and 113 households was obtained from all the respective eight villages covered by the study. In general, a total of 699 households from the eight villages were interviewed as shown in Table 3.1.

Table 3.1 Sample Population in the Eight Villages Covered by the Study

	No. of Households	Sample Size	Percentage Sample
Chemchem	282	95	40
Mahilo	141	65	40
Mpingi	262	103	40
Ndilima Litembo	185	69	40
Kikunja	245	85	40
Lihwena	161	114	40
Muungano	252	58	40
Lipaya	200	110	40
Total	**1728**	**699**	**40**

Source: Field Survey, 2005

(b) The Quantitative Data Collected includes the following:

(i) Demographic Data

The information on age, sex, and household size, number of children, levels of education, duration of their stay in the village, age and number of migrants (in and out migrants), the demographic characteristics of the migrants and causes of migration was collected. In cases where there were dependants living within the household, information about their age, sex, reason for his/her presence in the household, occupation, duration of stay and the area of his/her permanent residence were collected. Information about the common diseases that affected the majority of the respective rural population and the most vulnerable groups was also collected. The number of deaths in each household was also recorded.

(ii) Economic/Livelihood Activities and Household Income

The focus was on the main economic activity of the households, products/crops produced, the *key actors* in production process (by age, sex, level of education), reasons for the involvement of particular *key actors* and the extent to which they contributed to the activity. Other data included the reasons for the expansion of economic activities that caused deforestation, when was the expansion noted for the first time, how frequent was the expansion and the impact and extent of expansion on catchment forest destruction.

(iii) Means of Land Acquisition and Types of Land Ownership

Information was collected on the means of accessing and acquiring land, i.e. through buying, renting, clearing or inheritance etc. Data and information on household's farm size and its changes over time, type of land ownership, distance to the farms, types of land use practices, changes in village settlement size and village layout, reasons for new homestead establishment, expansion, *key actors* (by age, sex and levels of education) and changes in settlement patterns were collected. Various types of land use systems that existed in the area and their contribution to forest cover change were observed and recorded.

(iv) Farm Technologies and Sources of Domestic Energy

Information on the main tools used in the production process, tools used in households, means of transport for people and crops; and general use of fire was investigated. The farming systems, including the type of soil fertilizing methods and reasons behind it were studied and documented. Main sources of domestic energy used for cooking, drying and processing crops, distances to the source of domestic energy, the quantity of domestic energy used in a household in a week and the *key actors* (by age, sex and level of education) in collecting the energy sources were collected.

(v) Sources of Water for Domestic Uses

The focus was on source of water for a household, such as a tap, a well, a river etc; reliability in availability of water; variations in quantities of water at the source over years (since 1970s); average distance to the source; ownership of the source(s) of water; *key actors* in collecting water for the household use (by age, sex and level of education); the existing water resources management approaches and the methods applied in their conservation were collected.

(vi) Available Alternatives to the Utilization of Forest Products

Information about the planting of woodlots, the practice of agro-forestry, aforestation and the *key actors* in planting trees within and among the household members by age groups and sex categories were recorded based on both the extent of application and outcome.

3.5.1.2 Qualitative Data

Qualitative data were collected to complement the quantitative data, which dominated the research design. Two methods used for data collection were used as explained hereunder:

(a) Participatory Rural Appraisal (PRA)

This method entailed the conducting of participatory discussions involving a group of villagers that included village leaders, teachers, health workers, and normal villagers; and of course, the moderator and the note taker. Basic information on life systems and activities that were considered to contribute to deforestation, the extent of deforestation problem, and the consequences of deforestation according to perceptions of the PRA participants was obtained.

(i) Entry Point and Rapport Building

It was after the first two weeks' of conducting the survey that PRA discussions were conducted. This made the entry point for the PRA to be simple and discussions were more resourceful due to permissible environment with no suspicion. It was through informal meetings at the casual venues such as at local brew pubs, at funerals and public meetings that the research team acclimatized itself to the village life and got closer to the community members.

Ordinary social interactions and transport assistance the research team offered to the needy community members made the research team to be a "part of the village community", crucial for successful PRA results. The PRA were therefore run with little, if any suspicion regarding the objectives of the research, from the side of the local communities.

(ii) Selection of Participants for the PRA

The top village leaders like the Chairperson and Village Executive Officer were involved in selection of the PRA members following the criteria of gender mix, age groups, sub-villages composition, position or profession one held; nature of economic activities, social practices and culture. The PRA groups consisted of 8 to 12 members. This was the optimum size for the active interactions in soliciting the views of all individuals in the group while avoiding its domination by a limited number of speakers.

The numbers of 'professionals' and 'normal farmers' were tactfully balanced in the selection of PRA members and in the course of discussions. At times 'normal farmers' constituted the majority to avoid bias caused by those "who know" and those "who do not know". The atmosphere of inferiority and superiority complex among the participants was waived to foster reliability and validity of responses.

The PRAs constituted round-table discussion sessions, with the moderator moving around interacting equally with members. In general, a total of 100 community members of the WMCA participated in the PRA discussions. The distribution of PRA participants by villages is indicated in Table 3.2.

Table 3.2 Participants in the Participatory Rural Appraisal by Villages

Village	Expected	Actual
Lihwena	12	14
Muungano	12	8
Lipaya	12	12
Ndilima Litembo	12	9
Chemchem	12	11
Mahilo	12	11
Mpingi	12	23
Kikunja	12	12
Total	**96**	**100**

Source: Field Survey, 2005

(iii) Recruitment Sites for PRA Participants

The PRA members were recruited from their households and institutions such as schools, dispensaries and village based agricultural/forestry extension offices. Sub-villages were taken into account when selecting the PRA participants. Each sub-village was represented to accommodate views of all the segments of the village population

(iv) Approaches, Methods and Techniques Used for Facilitating PRA Discussions

A checklist of issues to be investigated was used as guidance for the discussion(s). Specific aspects meant to stimulate dialogue among the PRA members were stipulated. The Principal Investigator (PI) gave introductory remarks to village leaders on the discussions prior to the actual discussion sessions to underscore 'sensitivity' of the issues in specific settings and adopt the best way to handle them in the course of discussion(s). PRA participants had opportunities to introduce issues they thought important in their life like farming, use of firewood, setting bushfires, hunting and gathering, and general issues on population, development and environment. The specific PRA techniques of collection of information and data included *filling in the blank Table*, *pairwise ranking*, *cause and effect diagrams* and *trend analysis* (see PRA Checklist in Appendix 2).

(vi) Venues for PRA Discussions

All the PRA discussions except for *Mpingi* village were conducted within the respective school compounds. At *Mpingi* village, the PRA discussions were held under the tree located just outside the office of the Village Executive Officer. The area was normally used for village meetings. Therefore all members were used to it as an "assembly hall". The areas used for PRA discussions were carefully selected to ensure that they were free from any political and/or religious bias to enhance equal participation of all PRA members.

(b)Participant Observation

The research team members stayed in the field living with villagers for a period of six months. During the period we studied life systems and socio cultural issues of the communities. The team members participated in various activities in respective households and took notes of issues linked to population development and environment like use and sources of firewood, farming practices, sources of water, means of transport and division of labour and specialization. Other issues included social dynamics, planting trees, beliefs and norms of the communities. Information obtained was vital in the supporting the results of statistical inferences.

General observation included various aspects related to population, development and environment that were being observed throughout the period the research team stayed in the villages. This included observing village's population distribution, settlement patterns and village layout(s), identify farming and forest use practices, other economic activities and the social systems.

Spot observations were made through visits to specific sites like sources of some rivers to assess the real situation and observe if there was any evidence of deforestation. Data and information obtained through observation were recorded in the field note book and complemented the remote sensing and *river discharges* data. This enabled the analysis of the nature and pattern of deforestation on the ground that may be used for the interpretation of remote sensing data and variations in *river flows*.

The sites visited include the sources of *Makupe* and *Kapela Rivers* in the Lihwena and Kikunja villages, respectively. Both streams were in danger of drying out due to expansion of human activities in their catchments. A visit was also made to observe "modified wells" at Lipaya village. They are springs whose head waters were trapped by concrete barriers and directed to ooze through a hanging metallic pipe.

3.5.2 Secondary Data

Secondary data were collected from the respective government departments, institutions and agencies located in Dar es Salaam and Songea district of Ruvuma region.

3.5.2.1 Population Census Data

The National Bureau of Statistics, upon request, provided the population data for Tanzania, from which the villages' population data for 1978, 1988 and 2002 were extracted. The data were obtained from Official publications of the National Bureau of Statistics of the United Republic of Tanzania and the national censuses reports.

3.5.2.2 Changes in Forest Cover

Satellite images and digital maps were obtained and analyzed in order to obtain data on the deforestation rate. The *Land*sat images and digital maps were processed by the competent staff of the Tanzania Natural Resources Information Centre (TANRIC), a section of the Institute of Resource Assessment (IRA) of the University of Dar es Salaam. This was used to determine forest cover changes for years under review. A digital map of 1969; and *Land*sat images of 1990 and 2000 were used in the analysis.

The baseline vegetation data for 1969-1990 and 1990-2000 were used to determine the rate of deforestation for estimating the forest cover conditions for 1978, 1988, 2002 and 2005, the subject of this thesis.

Three data sets, from three different periods, were used to analyze land use and land cover changes. The first dataset was based on topographic maps at the scale of 1:50,000, which were based on aerial photography of 1969. The second and third datasets were based on *Land*sat TM of 1990 and 2000, respectively with a resolution of 30m, and were satisfactory for interpretation and analysis.

Different *land use/cover types* were delineated on the two topographic maps and were digitized to produce a land use/cover map of the study area for 1969. The extent of such digitization was used to clip the same area of the two datasets of *Land*sat images for 1990 and 2000. Visual interpretation was applied on the two sets of *Land*sat images, given the relatively small size of the study area. The resulting interpretation was also digitized using Arc INFO 3.5.1

The *coverages* or *layers* produced in Arc INFO were used to produce land use/cover maps of the three sets in Arc View 3.2. Analysis of data to produce the *change detection matrix* was done using Arc View and Microsoft Excel computer packages.

GIS generated reliable data on deforestation trends for the period between 1968 and 2000. The observed current settlement patterns and forest status over the study area were used for comparison purposes. Therefore both remote sensing and on-ground-observations were combined for greater reliability of the findings of this study.

3.5.2.3 River *Flows* and *River Discharge* Data

Data on Water Reports for *river discharges* meaning water *flows* in rivers for 1978, 1988, 2002 and 2004 were acquired from the Songea-based River Basin Management Project from the Ruvuma region Water Resources Engineer. Data availed were on changes in the volume of water and its speed (*discharge*) recorded at two *gauging stations* located on the main tributaries of the *Ruvuma River* that originate from the WMCA. It was noted that the recording of such data ended in year 2000 with the expiry of the DANIDA Water Project in the region.

River *flows* readings were recorded at the gauging station coded 1Q7, i.e. *Ruvuma River* at *Muhiga* and at gauging station 1Q10 *Likonde River* at *Ligowonga*. The data obtained and analyzed were only for the *minimum flows*. These were meant ascertain whether changes in the vegetation cover had impacted to water sources. The *minimum flows* were more realistic in this study since they indicated critical periods of lowest *flows*.

(b) Method of Interpretation

Discharge curves were drawn for the period for which data was available. This was used to determine the trends in the availability of water from the WMCA sources and the *catchment value* through time. The variations were correlated to changes in population size, age structure and sex composition to determine the existing relationship.

3.5.2.4 Atmospheric Temperature and Rainfall Data

The maximum and minimum temperature and rainfall data were obtained for the period from 1978 to 2004. The mean annual temperature, mean monthly temperature range, annual temperature range and mean monthly temperatures were calculated. The total annual rainfall and mean monthly rainfall from 1978 to 2004 was calculated. These were more significant climatic characteristics for analysis.
The data were collected at the *weather station* at the Songea Airport, located about 10 kilometres away from the WMCA. The data were used to link climate changes to changes in population characteristics. The intention was to establish the impact of population growth on deforestation and the consequent effects of changes in forest cover on the weather or *microclimate*.
Climographs were drawn using the annual means obtained through manipulation of temperature and rainfall data.

3.6 Monitoring of Field Activities

The monitoring of field activities was carried out on a daily basis throughout the field survey period. It aimed at ironing out administrative or technical problems.

Brief daily monitoring/evaluation sessions were held to resolve any issues of the day related to interviewing and to discuss the way forward. The daily evaluation meetings provided the PI and RAs time to be together to share the daylong experiences. All the completed questionnaires were collected by the Principal Investigator (PI) everyday and were kept at a safe place.

Weekly meetings were normally being held on Saturdays to assess the progress made and resolve issues that needed improvement. Each weekly meeting was an important starting point for the following week's tasks. In general terms, as days and weeks went on, the RAs gained more experience and so became more proficient in collecting data.

3.7 Data Processing

3.7.1 Quantitative Data

The quantitative data were keyed into the SPSS for processing and analysis. The data were used to develop the population, development/economic and environmental components for further analysis of the PDE situation of the study area.

'Comparison of averages' and 'comparison of quantities' were used in data analysis. The method was used both within a single component and between different components of the PDE. It was effective for comparison and trend analysis and sufficed for meeting the study objectives.

The selected processed quantitative information was entered in the Excel program for the drawing of graphs to establish the visual impact of the relationship between the various components of Population, Development and Environment dynamics in the WMCA.

3.7.2 Qualitative Data

Qualitative Data, obtained through the PRA were used to supplement findings from the quantitative data. The recorded interviews were carefully transcribed and translated from Kiswahili into English. All the emerging themes based on the points of agreement and disagreements were selected to guide the analysis.

The Participatory Rural Appraisal (PRA) was a constituent part of the data collection process, and formed an important and basic source of qualitative information for development of the thesis. A checklist was used for guiding the PRA discussions (Appendix 2).

3.8 Ethical Approval and the Study Permit

The Tanzania Commission of Science and Technology (COSTECH), through its Ethical Committee, granted the approval with reference number RCA 2004/113 (Appendix 3), for the study to be undertaken in the United Republic of Tanzania as scheduled.

The Ruvuma regional Commissioner and the Songea District Commissioner issued permit with reference number RUV/L10/II/III/116 for the same study to be conducted in the region and district respectively (Appendix 4). At village level permission was sought from the Village Chairpersons and Village Executive Officers by submitting letters from the region and district officials. The aims and objectives of the study were explained to the Village Chairpersons and/or Village Executive Officers. The schedule of research activities was presented to the same village authorities. The research team observed the calmed and the permissive environment for data collection to commence.

The village authorities disseminated information to the entire village communities about the research activities that were to take place and this reduced suspicion among the local communities, and facilitated their cooperation.

3.9 Conclusion

The methodology used to investigate the nature of the existing link between population, development and environment made it necessary to obtain a variety of data for formulating the three components necessary for the PDE conceptual framework (IIASA, 2001). The merging of data and information from different disciplines, of different academic backgrounds remained to be the biggest challenge presented by study.

Qualitative and quantitative methodology was adopted in the study. The adoption of the methodology ensured that all the research questions found satisfactory scientific answers and thus meeting the study objectives. This thesis is expected to extend the frontiers of knowledge pertinent to PDE relationship, significant in enhancing sustainable forest conservation in the WMCA and elsewhere, where socio-cultural, physical, economic and demographic characteristics are similar.

CHAPTER FOUR

HUMAN POPULATION CHARACTERISTICS AND THEIR CHANGES

4.1 Introduction

This chapter presents the analysis of the demographic situation and changes in human population in the study area in terms of size, sex composition and age structure from 1978 to 2005.

Data extracted from the national population censuses were analyzed to determine the demographic situations for years 1978, 1988 and 2002. The intercensal population growth rates and changes in age structure and sex composition were studied and documented for use in the PDE analysis. The analysis of changes in population characteristics for the period between 2002 and 2005 was based on data from the household survey.

The chapter attempts to establish the characteristics and changes in human population between the intercensal censuses periods and consequently drawing comparison on the magnitudes of such variations for analysis of PDE linkages. Quantitative changes or variations in population characteristics observed provided the necessary data and information needed for deeper analysis about association between changes in population characteristics, changes in environmental conditions, forest cover in particular.

The main assumption of this research work was an assertion that the understanding of the demographic characteristics of the population *in situ* is the cornerstone in analyzing and understanding the existing relationship between population, development and environment within a location-specific context. The assertion was based on the *tenet* that the interface between people and the environment was not homogeneous to all members of the local community in question (Orians and Skumanik, 1997). Therefore, people of different age groups, sex categories and levels of education, living in a specific locality or similar socio-economic and geographical conditions, were more likely to interact with the natural environment in different manners. Understanding the population characteristics therefore remained a primary component within PDE linkages.

Differences in modes and intensity of their interaction were logically attributed to the specific types of tasks they performed, tools and/or technologies employed, time and/or duration they spent on the activity, the extent to which they performed and the like. This being the case, it therefore, implies that people with different types of interface with forest cover have to be disaggregated based on age groups and sex composition. Such people would require different types of interventions, i.e. the content of the forest conservation extension packages, methods of delivery of the packages and possibly even the timing of the interventions to ensure effective uptake of improved technologies emanating the interventions.

Prior to the identification of the *key actors* in such anthropogenic processes that degraded the environment, carrying out analysis of their demographic characteristics was necessary. This marked the first and a significant step towards attaining a deeper underscoring of the PDE relationship.

4.2 Human Population and Its Changes for 1978, 1988, 2002 and 2005

The human population of WMCA has been changing through time for various reasons. This section analyses the characteristics of human populations for the three census periods and 2005 that form part of the study. The characteristics of human population analyzed include population size, sex composition and age structure.

4.2.1 Characteristics of the Population in 1978

(i) Population Size

According to data extracted from the 1978 National Population Census Report (URT, 1981)[2] presented in Table 4.1, the eight sample villages had a total population of 11,947 people, out of which 5,930 were males and 6,017 females.

PRA results revealed that in 1978 the population of WMCA was relatively small compared to that of 2005. This was signified by sparse distribution of homesteads and the availability of plenty of land for cultivation. The population of the time did not exert much pressure to the environment. The annual population growth rate for the region was 3.2 with a population density of 8.1 people per km^2, thus posing lesser threat for population growth on environmental degradation (URT, 2004).

Table 4.1 Distribution of Population of Sample Villages by Age-groups and Sex (1978)

Age Group	Male	Female	Total	Sex Ratios
0 – 4	1089	1045	2134	104.2
5 – 9	952	918	1870	103.7
10 -14	709	766	1475	92.6
15 – 24	974	1018	1992	95.7
25 – 34	715	825	1540	86.7
35 – 44	538	516	1054	104.3
45 – 54	316	364	680	86.8
55 – 64	398	331	729	120.2
65+	239	234	473	102.1
Total	**5930**	**6017**	**11947**	**98.6**

Source: Tanzania National Population Census Report, 1981

[2]The Tanzania National Bureau of Statistics published Population Data for 1978 in age intervals of 5 years for age groups up to 10-14, from age 15 the 10 years' interval was used. Data for 1988 and 2002 were presented in five years interval only. The analysis of data took this into account.

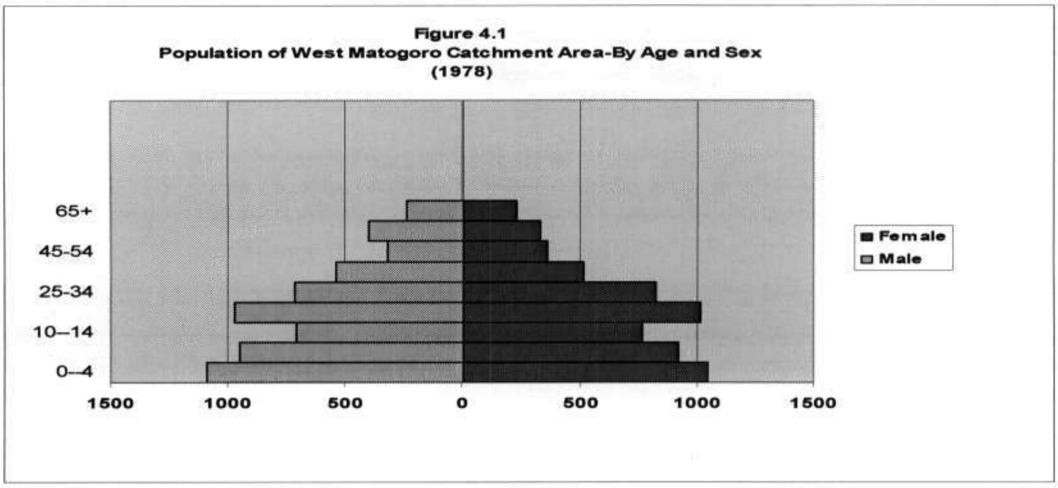
(ii) Population Composition

The sex composition of the human population of WMCA indicated in Table 4.1 demonstrates that in 1978 the sex ratio was 98.55 implying the presence of more females compared to males. The sex composition denoted higher fertility rates as females out-numbered their males counterparts. At district level, the sex ratios stood at 105.2 and 97.8 for rural and urban sectors respectively, portraying a similar picture (URT, 1981).

(iii) Population Structure of WMCA in 1978

The population age/sex pyramid Figure 4.1 demonstrated that the population of WMCA had a significantly large proportion of people in the younger age group, i.e. those aged between 0 and 24. However, the majority were concentrated in the age group of 15-24. Generally, people aged 34 and below constituted 75.4% of the entire population of WMCA, signifying the presence of a high potential for faster population growth in subsequent years. The notable presence of a small number of those aged 10 to 14 may be attributed to prevalence of high child mortality caused by tropical diseases in the past decade.

Old age people constituted a small proportion, i.e. about 4% of the population in the highest age group i.e. 65+. Population structure of WMCA was typical of many developing countries.



Source: Tanzania National Population Census Report, 1981

4.2.2 Characteristics of Human Population of WMCA in 1988

The 1988 Tanzania National Population Census Report was analyzed to assess demographic characteristics of WMCA as described in sub-sections (URT, 1990)

(i) Population Size

The 1988 National Population census is presented in Table 4.2 shows that WMCA had a total population of 12,979 people, out of which 6,371 were males and 6608 females. The annual population growth rate for 1988 was 3.4%, which was mainly attributed to natural increase compounded by high fertility rate and the decline in mortality rates (URT, 1997).

Table 4.2 Distribution of Population of the Sample Villages by Age Groups and Sex (1988)

Age Group	Male	Female	Total	Sex Ratios
0 – 4	1078	1085	2163	99.4
5 – 9	890	1027	1917	86.7
10 -14	936	939	1875	99.7
15 – 24	1214	1185	2399	102.4
25 – 34	780	797	1577	97.9
35 – 44	486	586	1072	82.9
45 – 54	397	388	785	102.3
55 – 64	245	309	554	79.3
65+	345	292	637	83.9
Total	**6371**	**6608**	**12979**	**96.4**

Source: Tanzania National Population Census Report, 1990

(ii) Population Composition

The population data portrays that in 1988, the sex ratio was 96.4 signifying that the population had a larger number of females than that of males. This had an influence on fertility rates of the communities, thus raising the likelihood of rapid population growth. At the district level, sex ratios stood at 94.75 for rural and 94.71 for urban populations portraying a similar status (URT, 1990).

(iii) Population Structure

Analysis of population structure based on Figure 4.2 demonstrated that the population of the WMCA had a larger proportion of young men and women i.e. those aged between 15 and 24, and below; who constituted about 18%, which was attributed to the past prevalence of high birth rates.

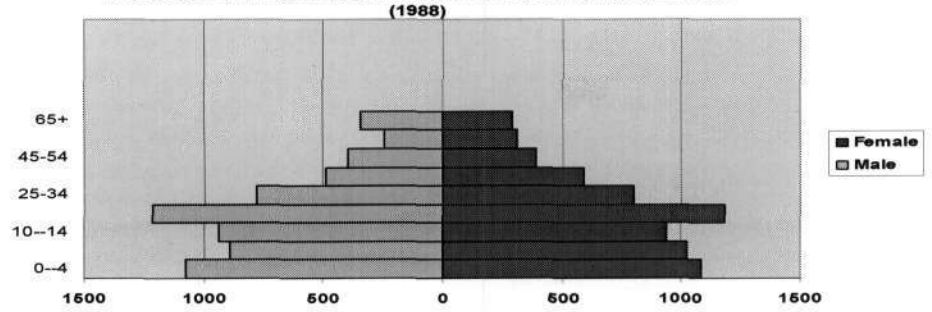
This status of the population demonstrated high birth rates despite a slight decrease observed for those aged between 0 and 14. People within the age group 34 and below comprised about 76.5% of the entire population, therefore underlining the presence of a younger population with high potential for future population growth due to the *population momentum*.

A smaller proportion of the aged, i.e. those aged 55 and above indicated persistent low *life expectancy*. The UNFPA statistics on the current *life expectancy* for Tanzanians is about 43.3, and may tend to be lower partly due to the impact of the HIV/AIDS pandemic (URT, 2007). Surveillance reports on Tanzania indicate a two fold increase of HIV prevalence from 7.2 to 13.3 percent among female blood donors during the last ten years, i.e. from 1990 to 2000 (URT, 2003). The relatively smaller proportion of those aged between 5 and 14 may be attributed to the effects of family planning programmes that significantly reduced fertility among women.

Estimates from UNAIDS shows that SSA has 22 millions adults and children living with HIV this includes 20 millions adult (15-49 years). This represents about 70% of the total HIV epidemic in the world. In Tanzania in 2007, it is estimated that a total of 1.4 millions adults and children are HIV infected. In a population of 38 millions there is adult sero-prevalence rate of 5% (UNAIDS, 2008).

Figure 4.2

Population of West Matogoro Catchment Area-By Age and Sex (1988)



Source: Tanzania National Population Census, 1990

4.2.3 Changes in Population Size and Structure between 1978 and 1988

(i) Changes in Population Size

Population data of the sample villages, presented in Table 4.3, indicated that the area experienced a significant increase of about 8.6% between 1978 and 1988. This could be attributed to *natural increase* and *in migration*. PRA results indicated that some areas of WMCA, especially those closer to Songea town, like *Chemchem*, *Muungano*, and *Lihwena* demonstrated faster growth of population mainly due to in-migration caused by urbanization. Most of them lived in the urban outskirts where they could still undertake subsistence economic activities.

Table 4.3 Comparative Population Data for Sample Villages by Sex and Sex Ratios (1978-1988)

Years	Males	Females	Total	Sex Ratios
1978	5930	6017	11947	98.55
1988	6371	6608	12979	96.41
% Change	7.4	9.8	8.6	-2.14

Source: Tanzania National Population Censuses Reports, 1981 and 1990

However, differences were observed in terms of the rate of increase in numbers of people in different villages. The variations may be attributed to the different socio-economic and local environmental factors. Villages like *Kikunja* and *Mpingi* which were formerly one village named *Milola* but were split into two due to population growth that qualified them as separate villages. The Legal Regulations for Governing Villages and Streets stipulates that for a settlement to qualify as a village it should have at least 250 households, enough economic and social bases to support the population and must have enough sources of income from its own resources (URT, 2000).

(ii) Changes in Population Composition

The populations of 1978 and 1988 were both characterized by larger numbers of females. The sex ratios for the two populations were 98.55 and 96.41 respectively. The comparison of sex ratios indicated a decrease of 2.14%, portraying the proportionate decrease in numbers of females *per* males in the 1988 compared to that of 1978. This implies that the number of males relative to females had proportionately increased within the decade in question probably contributed by rural urban migration, which mostly involves males.

(iii) Changes in Population Structure

The two populations, i.e. of 1978 and 1988 had the similarity that both were dominated by people in the young age group i.e. 15-24. The population of 1978 had a relatively smaller number of infants, i.e. those in age group 0-4; compared to those aged 15-24. The population of 1988 seemed to have almost the same number of people in the two age groups in question, but with a slightly higher number of infants, indicating more births. Those aged 34 and below accounted for 75.4% of the total population in 1978.

In 1988, people aged 34 and below constituted 76.5% of the total population. The dominance of a young population posed a great potential for future rapid population growth. A proportionate increase of numbers of people aged below 34 of about 1% was noted between 1978 and 1988. The unique feature about the population of 1988, as differentiated from that of 1978 was the presence of a relatively larger number of the elderly people, i.e. people aged 65+, particularly among males. This may be attributed to the return of the retired elderly people who decided to go back to their respective villages. Population pyramids (Figure 4.1 and Figure 4.2) provide a visual impression of the variations.

4.2.4 Characteristics of Human Population of WMCA in 2002

The population of WMCA was analyzed to identify those members who play some role in the selected activities leading to deforestation. The ultimate aim was to determine their impact on the environment. The analysis focused on population size, sex composition and age structure.

(i) Population Size

Data extracted from the 2002 National Population and Housing Census Report (URT, 2003b) and presented in Table 4.4 indicated that the population had grown to reach 19,446 people, whereby 9,506 were males and 9,940 females. During the intercensal period, the population growth rate for Songea district was 2.2% (URT, 2004). PRA results (2005) revealed that the growth of human population of WMCA was mostly attributed to *natural increase*. The rate of migration observed in the areas was small for which most of migrations were from rural to rural, an aspect that could not affect the population within WMCA.

Table 4.4 Distribution of Population of the Sample Villages by Age-groups and Sex (2002)

Age Group	Male	Female	Total	Sex Ratios
0 – 4	1452	1391	2843	104.4
5 – 9	1362	1346	2708	101.2
10 – 14	1271	1227	2498	103.6
15 – 19	1037	1023	2060	101.4
20 – 24	908	1187	2095	76.5
25 – 29	803	821	1624	97.8
30 – 34	609	659	1268	92.4
35 – 39	442	497	939	88.9
40 – 44	351	391	742	89.8
45 – 49	295	326	621	90.5
50 – 54	245	295	540	83.1
55 – 59	192	189	381	101.6
60 – 64	193	162	355	119.1
65+	346	426	772	81.2
Total	**9506**	**9940**	**19446**	**95.6**

Source: Tanzania National Population and Housing Census Report, 2003

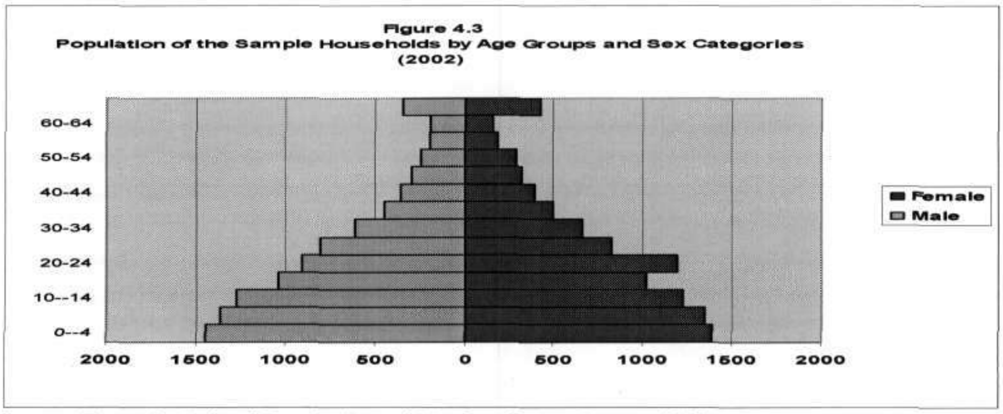
(ii) Population Composition

The 2002 population of WMCA had a slight difference in terms of numbers of males and females. The data indicates that the sex ratio was 95.6 meaning that the population had more females compared to males.

(iii) Population Structure

Figure 4.3 demonstrated the presence of a larger proportion of children in the age group 0-4, who accounted for about 15% of the total population (URT, 2003a). The population pyramid portrayed a decreasing number of people with increasing age connoting the situation of high birth rates resulting from high fertility.

The observed presence of more females than males in age group 20-24 may be attributed to out-migration mainly constituted by outward movements of young men. People aged below 34 formed 77.6% of the population, indicating presence of high fertility rate, thus signaling a possibility for future rapid population growth. At district level, sex ratios were 96 for the rural population and 98 for their urban counterparts. The most striking feature of the age structure for the 2002 population was the presence of a relatively larger proportion of old aged people, i.e. those aged 65+.



Source: Tanzania National Population and Housing Census Report, 2003

4.2.5 Changes in Population Size, Composition and Structure from 1988 to 2002

The need to appraise variations of demographic characteristics of human population within the intercensal periods was necessitated by the *tenet* that population growth rates and their engendered characteristics may have an influence on the individuals' tendency to involve themselves in activities that adversely impacted on the forest cover. Proving whether this was true or false was one of the objectives of this thesis. It was deemed important to underscore whether there had been any changes in the population size, structure and composition, prior to establishing the impact of such changes on deforestation.

Dynamics of the population of WMCA were related not only to births, deaths and migrations but also internal variations in the population's age structure and sex composition. While births contributed to growth of the population, deaths led into the permanent reduction of household members. Migration stood as the temporary phenomenon responsible for the 'shaping' of a population by either increasing it (in-migration) or decreasing it (out-migration) thus affecting numbers of people in different age groups and sex categories.

Understanding changes in population size and the inherent characteristics of age structure and sex composition such as the derivatives of births, deaths and migrations, was a significant effort towards obtaining specific scientific information regarding the state of the population of WMCA. This was of great practical use in linking population with socio-economic activities that impacted on the environment.

(i) Changes in Population Size

Population size of the sample villages has been growing tremendously for the period between 1988 and 2002 as indicated in Table 4.5. During the same period, the population increased by 49.8%, i.e. from 12,979 to 19,446 people. Long intercensal period, i.e. 14 years may partly account for the observed skyrocketing population growth. The Government of Tanzania had adopted the decennial census interval since its first National Population Census in 1968, while the second one was conducted in 1978 and the third in 1988. But in 1998 Tanzania not conduct census as expected due to other very pressing issues till August 2002 (URT, 2003a).[3]

Table 4.5 Comparative Population Data for the Sample Villages of WMCA (1988-2002)

Years	Males	Females	Total
1988	6371	6608	12979
2002	9506	9940	19446
% Change	49.2	50.4	49.8

Source: Tanzania National Population Censuses Reports, 1990 and 2003

[3]It should be noted that there was no elaboration or mention of specific 'pressing activities' in question.

(ii) Changes in Population Composition

Between 1988 and 2002 sex composition of the populations of the two censuses periods had not significantly changed. Data in Table 4.6 indicated that sex ratios had a slight decrease i.e. from 96.41 in 1988 to 95.63 in 2002, implying that the number of females had slightly increased in 2002 compared to 1988.

Table 4.6 Population Data for the Sample Villages by Size and Sex Ratios (1988 and 2002)

Years	Males	Females	Total	Sex Ratios
1988	6371	6608	12979	96.41
2002	9506	9940	19446	95.63
% Change	49.2	50.4	49.8	0.7

Source: Tanzania National Population Censuses Reports, 1990 and 2003

(iii) Changes in Population Structure

Between 1988 and 2002, the age structure of the population changed significantly. While both populations were characterized by the presence of a larger proportion of people in the younger age groups, i.e. from 0-4 up to 20-24; significant variation was observed in 1988 that had relatively fewer people at the base of the pyramid, i.e. age groups 5-9 and 10-15. The population pyramid in question displayed the proportionately larger presence of young people aged between 15 and 24.

The presence of more people within the old age group, i.e. 65+, in the 2002 population may partly signify the effects of improvement in the provision of health services and the general well being of the communities in question. The return of retired people to their respective rural areas may as well have contributed to it. Difference in sizes of age groups of people, used in the presentation of data for the two population censuses (1988 and 2002), and amplified the visually glaring variations in population structures observed for the two censuses. People aged 34 and below portrayed a very slight positive change, which rose slightly from 76.5% in 1988 to about 77.6%.

4.2.6 Characteristics of the Sample Population of WMCA in 2005

Survey conducted in the area resorted at identifying the main development activities, their *key actors* and the impact caused by the *duo* in causing and/or accelerating deforestation. The appraisal of the individual household members' involvement in various development and/or livelihood activities enabled for sourcing such basic data and information for analysis. Qualitative data and more detailed information were obtained through Participatory Rural Appraisal (PRA). The state of population change, expansion of livelihood/development activities and the consequent environmental impact, in terms of forest cover change was established and documented.

Analysis of demographic characteristics of the population of the selected villages of WMCA based on the data and information collected through field survey that covered 40% of the households. The findings of the study and its discussions are presented below. Descriptions about the population of WMCA based on the demographic characteristics and their changes are presented hereunder. This was considered a critical step towards developing the Population (P) component for the PDE analysis. The quantitative and qualitative information generated and presented in this chapter were basic for the other sections of the thesis whereby more profound linkages and analysis of population development and environment shall be examined. The chapter is indispensable in the effort towards establishing existing PDE relationships.

4.2.6.1 Population Size of the Sample Households (2005)

The survey data presented in Table 4.8 (see page 64) indicated that the 699 sampled households had the total of 3371 members, out of which 1690 were males and 1681females. PRA results revealed that population had grown through time due to *natural increase* and *migration*.

Survey data in Table 4.7 indicated that 88% of the households were headed by males and that only 12% were headed by females, portraying dominance of patriarchy.

Table 4.7 Distribution of Population of Household Heads by Sex in 2005

Sex	Number	Percentage
Male	615	88
Female	84	12
Total	**699**	**100**

Source: Field Survey, 2005

The *rural-urban* differentials of the sample households were considered in the analysis. About 59% of the interviewed households were in urban wards, while 41% were rural. Due to lack of a strong industrial base in the area, the development gap between rural and urban was virtually small. Thus, some of settlements in the urban wards like *Mahilo* and *Chemchem* of Matogoro Ward; and *Lihwena* and *Muungano* of *Subira* had typical rural characteristics. What differentiated them from rural wards was mainly the distance from Songea Municipality and bureaucratic classification as 'urban'.

4.2.6.2 Characteristics of the Population Living in the Sample Households

The section analyses the characteristics of the sample population in line with the data collected through both field survey and the PRA. Demographic characteristics, i.e. population size, age structure, sex composition; and the types and trends in migrations were also covered.

4.2.6.3 Population Size in the Surveyed Households

Field survey results indicated that households covered by the survey were found to have a total of about 4,759 people; out of which 2,342 were males and 2,417 females. Males constituted 49.2% of the population, while females accounted for 50.8%. About 23% of the members were absent as they lived elsewhere away from the sampled villages, therefore, they did not contribute to resource consumption levels. About 6% of the members were reported dead.

The total population included all the household members, i.e. household heads, spouses, siblings and other household members. For the analysis of the population dynamics, data for those present, absent and the dead were included.

Survey data in Table 4.8 indicated a total of 3371 people reported present in the surveyed households, out of which 1690 were males and 1681 females. The data on the 'present members' constituted the 'active population' and were therefore, directly applied in the analysis of the existing PDE relationship.

Table 4.8 Distribution of the Population of the Sample Household Members by Age and Sex

Age Groups	Sex			
	Male	Female	Sex Ratios	Total
0 – 4	233	220	105.9	453
5 – 9	241	269	89.6	510
10 - 14	226	219	103.2	445
15 - 19	174	147	118.4	321
20 - 24	115	141	81.6	256
25 - 29	131	153	85.6	284
30 - 34	106	107	99.1	213
35 - 39	127	91	139.6	218
40 - 44	53	67	79.1	120
45 - 49	75	64	117.2	139
50 - 54	42	59	71.19	101
55 - 59	45	40	112.5	85
60+	122	104	117.3	226
Total	**1690**	**1681**	**100.5**	**3371**

Source: Field Survey, 2005

4.2.6.4 Sex Composition of the Sample Households

The population data of study area in Table 4.8 demonstrated the presence of more females than males. The number of males and females tended to differ significantly in some specific age groups especially 5-9, 20-24 and 60+. While in the first two cases the number of females outpaced that of their male counterparts; in the third case the situation proved the opposite. High fertility of the past and out-migration were factors can be used to explain to such a situation.

The sex ratio was 100.53 signifying the existence of more males than their female counterparts. The age group-based sex ratios for those aged between 15-19 and 35 to 39 were among the highest in raking, i.e. 118.4 and 139.56 respectively. The elderly people, i.e. those aged 55+ indicated the significant predominance of males.

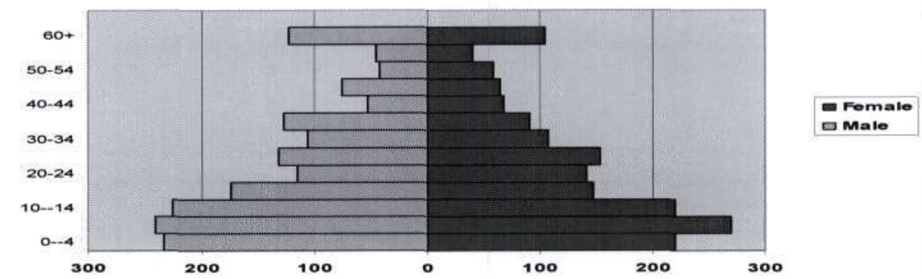
4.2.6.5 Population Structure of the of the Sample Households

Analysis of the field survey data, portrayed in the population pyramid Figure 4.4, demonstrated that the majority of people were at the base of the pyramid, i.e. those in age group 0-4. Another significantly big age group consisted of young men and women in aged 25-29. Other significantly big age group was 5-9.

There were fewer young men aged between 20 and 24 compared to their female counterparts probably attributed to the *rural-urban migration* that tended to affect more the out ward movements of young men.[4]

Population had relatively fewer members in the age groups 10-19. The presence of more people in the older age (60+) especially among males was noted and attributed to the return of the retired people[4] and/or deaths of the young aged people mainly as a result of diseases like HIV/AIDS.

Figure 4.4
Population of the Sample Households by Age Groups and Sex Categories (2005)



Source: Field Survey, 2005

4.2.6.6 Levels of Education of the Individual Members of the Sample Villages

Community members of WMCA had attained different levels of education. Survey data presented in Table 4.9 demonstrated that about 66%, attained primary education, i.e. standard seven, while 14% had ended up at primary standard four; most of whom were the elderly people who underwent studies during the colonial era[5]. A significant proportion of the population, i.e. 15% had not attended school at all, indicating low literacy levels. A few household members attained standard eight and ten, mostly old aged people who studied under the colonial educational system. Adult education that was introduced in Tanzania in the 1970s, a move towards reducing illiteracy, was attended by very few, i.e. 2%, thus denoting its decline.

Table 4.9 Distribution of the Total Sample Households Population by Levels of Education

Levels of Education	Number	Percentage
None	904	26.8
Primary std 7	1463	43.4
Primary Std IV*	176	5.2
Secondary	38	1.1
Adult Education	14	0.4
Primary Std 8*	9	0.3
Secondary Std 10*	8	0.2
Pupil	759	22.5
Total	**3371**	**100**

Source: Field Survey, 2005 *Levels used under colonial education systems

[4]Young men were generally mentioned to be the most frequent migrants

[5]The British colonial education system had standard four as elementary level of basic education in Tanganyika. After independence primary education ended at standard seven

Majority of other household members, i.e. about 61% ended up at primary seven education level. About 32% of other household members did not attended school, while a small proportion were yet to join school since they were below the compulsory school-going age, i.e. 7 years. The existence of few household members with secondary education or higher, i.e. about 1%, was the most striking feature. Paucity of higher education among members underlines the high rate of ignorance, thus raising the likelihood for engaging in primary economic activities such as farming that negatively impacted on natural vegetation cover.

PRA results revealed that shortage of secondary schools limited the number of primary school pupils selected to join secondary education; therefore culminating into proportionately low enrolment in higher education. Poor educational facilities in schools, shortage of teachers and lack of motivation for higher education among school pupils and in some cases among parents were among the factors that affected pupils' performance at primary school level. By the time of the survey, 23% of the population constituted pupils; who were mostly in primary schools. Since low literacy rates are related to high fertility (UNFPA, 2001; Satihal *et al.*, 2007) the thesis observes a great likelihood of the population of WMCA to grow faster hence rising the potential for deforestation.

4.2.6.7 Household Size, Leadership and Other Relationships

Survey data revealed that the average household size was 4.8 people, slightly higher than the district average of 4.7 (URT, 2004). The average number of off springs present in households was 2.4. If the dead and the absent were included in the analysis, the average number of off springs shot up to 4.4, accounting for about 64% of the would be total population.

For the purpose of the thesis, other household members constituted all other members except the head, spouse and their children. There was a small proportion of 'other household members' who lived in only about 4% of households, having different types of relationship to the household heads. Presence of other household members, particularly those aged below 18 raised the dependency ratio. High dependency ratio was an indicator and a factor for perpetuating poverty conditions. At district level, the dependency ratio was 86 (URT, 2004).

4.2.6.8 Households Composition and Their Dynamics

Despite having families with an average of about 2.8 off springs, the range of off springs was broad, i.e. from 0 to 26 children. Data in Table 4.10 shows that the off springs were the most common accounted for about 50.1% of household members. Household heads and spouses constituted 20.8% and 18.6% respectively.

Table 4.10 Households Members by Relationship to the Head (Present and Absent

Relationship	Status			Total
	Present	Percentage (Present)	Absent	
Spouses	627	18.6	1	628
Son/daughter	1689	50.1	1383	3072
Parent	29	0.9	0	29
Grand father/grand mother	4	0.1	0	4
Other	175	5.2	1	176
Labourer	8	0.2	0	8
Grand son/Grand daughter	104	3.1	0	104
Second wife	34	1.0	1	35
Third wife	2	0.05	1	3
Fourth wife	1	0.03	1	1
Household Head	699	20.8	0	699
Total	**3371**	**100**	**1102**	**4759**

Source: Field Survey, 2005

Survey data in Table 4.11 demonstrates the presence of less in-migration to the area whereby only 4% of the interviewed households had at least one member who joined the household in the past five years. It underlines the fact that population increase in the area is mainly attributed to natural increase.

Table 4.11 Presence of Other Members Who Joined Households in the Past Five Years

Response	Frequency	Percentage
Yes	28	4
No	671	96
Total	**699**	**100**

Source: Field Survey, 2005

Survey data in Table 4.12 demonstrates less out-migration whereby only 12.3% of the households had at least one of its off springs living away from core households. This was experienced in almost all interviewed households. Departure of off springs was mainly attributed to their reaching the maturity age, therefore socially marked as obliged to start own families and households[6]. The off springs left their original households, meaning localities where they were born. Age groups of the out-going off springs indicated that most of them left their households at the average age of 15.

Majority of household members, aged between 15 and 44, absented themselves to establish their own families elsewhere. PRA results showed that in some instances, young married members of the households, particularly sons, continued living within the respective core households and relied on them[7]. Few households remained without a single off spring.

[6]It was a social obligation of a Ngoni young man to get married and start his own family as soon as one reached maturity. Staying with a parent after completion of primary education was considered not being mature and attracted some discussions because it was something abnormal and shameful.

[7]PRA results revealed that according to the Ngoni customs the sons, unlike daughters, were regarded as permanent clan members while daughters changed their clan when they got married.

Table 4.12 Distribution of Households by Out-migration of Members from the Village

Response	Frequency	Percentage
Yes	86	12.3
No	613	87.7
Total	**699**	**100**

Source: Field Survey, 2005

On the sex composition of the population, survey data indicated that the majority, i.e. about 53%, of the other members were females while 47% were males. Less representation of males in the 'other members' population category was attributed to the propensity of males to out-migrate, caused by their need for alternative employment activities available elsewhere outside the rural setting.

The wide range of relationships existed between household heads and other members of the household. Thirty percent of the households had their heads living with their grand sons and grand daughters, while about 15% lived with in-laws and uncles. About 13% lived with their elder and or younger brothers or sisters. Statistics signify the presence of strong extended family relationships.

The thesis contends that other household members were theoretically supposed to live within their original or core families. However, for the purpose of the thesis such people were treated as permanent household members because they had equal chances in contributing in augmenting the volume of natural resources use and depletion.

4.2.6.9 Death of Household Members by Age Groups and Sex Composition

Survey data in Table 4.13 demonstrated that within the 699 sample households, a total of 286 cases of death of were reported by 2005, whereby 147 were males and 139 females. There was big possibility for understating the deaths due to cultural values associated with superstition.

Whether males were at a higher risk of dying than females and reasons behind it are aspects recommended for further research. However, it was implicit arguing that deaths led into reduced household size and adversely affecting the population size, age structure and sex composition.

Table 4.13 Household Members by Sex (Present, Absent or Dead)

	Status			
Sex	**Present**	**Absent**	**Dead**	**Total**
Male	1690	505	**147**	2342
Female	1681	597	**139**	2417
Total	**3371**	**1102**	**286**	**4759**

Source: Field Survey, 2005

Survey data in Table 4.14 demonstrated an association between people's age-groups and occurrence of deaths, whereby most of deaths occurred to people in the younger age groups. The most affected were those aged 0 to 4 indicating prevalence of high infant mortality rate (IMR). At national level, IMR stood at 102 in 1990 and rose to 122 in 2005 (UNICEF, 2007). Other age groups with high mortality rates were those aged between 5 and 9; and those in age group 10-14. In general 94% of the deaths covered those aged between 0 and 34. The younger section of the population was more susceptible to death than those in older ages, i.e. 35 and above, who accounted for only 6% of those who actually died.

Table 4.14 Household Members by Age Groups (Present, Absent or Dead)

	Status			
Age Groups	**Present**	**Absent**	**Dead**	**Total**
0 – 4	453	2	178	633
5 - 9	510	13	35	558
10 - 14	445	22	22	489
15 - 19	321	109	5	435
20 - 24	256	217	8	481
25 - 29	284	235	11	530
30 - 34	213	196	10	419
35 - 39	218	136	3	357
40 - 44	120	93	5	218
45 - 49	139	47	5	191
50 - 54	101	23	3	127
55 -59	85	6	1	92
60 - 94	226	3	0	229
Total	**3371**	**1102**	**286**	**4759**

Source: Field Survey, 2005

Survey data in Table 4.15 demonstrated that the general trends in incidences of deaths reported in sample households by 2005 portrayed increasing trends in the number of deaths with years. However, the maximum number of deaths was recorded in the intercensal period 1989-2002 which may be attributed to the longevity of the period, i.e. about 14 years a result of the postponement of the National Population Census planned for 1998. Eight deaths reported could not be periodized as to when they happened.

With the increase in population size, the proportion of those who die might be proportional; although optimism assumes that with improvement in health and medical science, deaths were slowly controlled, therefore rapidly decreasing the incidences of deaths. The crude death rates for the region have been declining from 22.4 in 1967; 20.7 in 1978 to13.5 in 1988 (URT, 1997c). PRA results revealed that the main cause of deaths were diseases especially malaria, dysentery, tuberculosis and diarrhea. Poor health/medical services and sanitation contributed to the soaring numbers of deaths.

Table 4.15 Distribution of Deaths of Household Members by Period of Death

Range of Years of death	Number of Deaths
1940-1968	32
1969-1978	41
1979-1988	70
1989-2002	108
2003-2005	27
Total	**278**

Source: Field Survey, 2005

4.2.6.10 Population Migration in WMCA

The population of WMCA was characterized by a low level of outward and inward movements of people although the exact volume of migration could not be specified and documented. According to migration theories by Ravenstein (1889) mobility of people was attributed to the "push" and "pull" factors[8].

'Push factors' are those forces that operate at the "source" or "area of origin" of the movement. They constituted the problems, limitations or adverse situations that make people to decide to move out of a specific locality. Such forces exerted pressure to the population making people to move from original areas of residences. "Pull factors" entailed "better conditions" that were thought to exist at the destination areas. 'Pull factors' attracted people to move into such areas. The theory formed the basis for migration data analysis.

(a) Main Types of Migration

PRA results indicated the existence of a proportionately small volume of out-migration, principally *rural-rural migration*, mostly motivated by the search for farmlands.

Pressure on natural resources in one village (source area) while at the same time acting adversely in the destination area. Some of the movements observed were both *temporary* and *repeated* like those of the *Wayao tribe*[9] who were reported to move between *Muungano* village located in WMCA and *Nambendo* village, about 50 kilometres away from the study area. The *Wayao tribe* members commuted repeat migrations in almost about every three years.

Rural urban migration was mostly undertaken by young men who moved into the Songea Municipality and to the neighbouring district towns of Tunduru and Mbinga to seek for employment or casual labour. Mining sites of Tunduru also attracted some young men from Songea and Mbinga (URT, 1997c). PRA results revealed that migrants considered urban life "better off" compared to rural life. In-migrations were studied in terms of the numbers of people who joined the households from original households for the past five years and have continued staying in some households. Most of households had in-migrants. Households located in urban wards had the highest number of in-migrants signifying prevalence of *rural-urban* migration. *Chemchem,* a semi-urban settlement, had 68% of households of in-migrants. Conversely, settlements in rural settlements like *Lipaya* had the smallest numbers of in-migrants. This indicated existence of more mobility in the *peri-urban* areas than in the typical rural settings.

[8] Ravenstein developed an explanation of the causes of migrations

[9]People of the *Wayao* tribe live in broad areas of southern Tanzania and northern Mozambique. They are historically known for their participation in local trade.

Survey data in Table 4.16 demonstrated different reasons for movements of people away from their core households. It included getting married (21%), to be cared for (23%) starting own life (18%) and following relatives (17%). Other reasons included seeking farmland. Generally, the reasons for migrating into another setting were a mixed bag of social, economic and cultural factors that differed from one person to another. PRA results indicated that the *Wayao* households were the most migratory social group in the area.

Table 4.16 Members Who Joined Households in Five Years' by Reasons of In-migrating

Reasons	Number	Percentage
Marriage	11	20.8
Farmland	4	7.5
Changing weather	1	1.9
Starting own life	10	18.9
Orphan	6	11.3
Be cared for	12	22.6
Follow relatives	9	17
Total	**53**	**100**

Source: Field Survey, 2005

PRA results revealed that people of WMCA lived in settlements based on clan clusters. Following their relatives, where they lived, was a common phenomenon. However, the survey data indicated the presence of fewer households, i.e. 12%, which reported that some of their members had out migrated. The majority, i.e. 88% had no out-migrants indicating less outward mobility of people. Less volume of out-migration inferred to the possible presence of high potential for future population growth, likely to exert more pressure to the land resources and possibly culminate into land degradation. About 34% of the households had moved out of their original areas to new locality in WMCA mostly to get married. Others left their areas for lack of enough land for farming. About 26% of other members moved out of their original localities to seek for employment. To such people, moving out of their villages was a solution to the problems they faced.

Most young men and young women left their basic households through marriages. In WMCA males married at the average age of 21, while most of females married at the average age of 16. The minimum marriage ages were 14 and 17 for females and males respectively. At district level, the average age at first marriage recorded was 24. On average, young men of WMCA married earlier than the district average age. To most of the young girls, completion of primary education was like 'the door opener' to marry.

Generally, the low levels of migration observed could not bring about serious cultural changes and changes in environmental phenomena. Its small volume and temporary nature made the phenomenon less devastative to the environment. At regional level, *net migration* grew from + 0.3 in 1967, + 0.5 in 1978 and +0.7 in 1988 (URT, 1997c). By 2002 the net migration was about 0.66 (URT, 2008).

4.2.7 Changes in Population Size, Structure and Composition between 2002 and 2005

It was deemed necessary to investigate whether there had been any changes in terms of population size, age structure and sex composition over years and ascertains the extent of the change to establish the basis for analyzing the existing causal relationship between population and the environment. The description of the causal relationship and the assessment of the impact of each characteristic on the environment could be attained only in case such magnitudes of changes were established in a quantitative and/or qualitative manner.

4.2.7.1 Changes in Population Size

The village vital registration records indicated that there were a total of 11,840 people, i.e. 5,529 were males and 6,311 females who lived in the sample villages of WMCA in 2005. Survey data in Table 4.17 demonstrate that between 2002 and 2005 population had drastically dropped by 76.1%. According to the National Population and Housing Census (2002) data, Songea district had the intercensal population growth rate of 2.2% (URT, 2004). The observed drastic drop in population size could be explained in terms of unreliability of vital registration systems, a common phenomenon in developing countries (Goldthorpe, 1952). However, for reliability and validity of research findings, selective use of PDE data for 2005 was made for this study.

The data were analyzed to obtain the basic research findings on people's involvement in activities that contribute to forest cover change. Inferences were then drawn and linked to the changes in age structure and sex composition based on the more reliable data, i.e. population censuses data for selected years, i.e. 1978, 1988, 2002 and 2005. The basic practical aspects of population-resources interface obtained from survey data were thus juxtaposed or improvised on the population-resources conditions for other years to establish existing PDE linkages.

Table 4.17 Population of Sample Villages by Sex in 2002 and 2005

Years/ Variations	Population By Sex		
	Males	Females	Total
2002	9506	9940	19446
2005	5529	6311	11840
% Change	41.8	-36.5	-39.1

Source: Extracted from theTanzania National Population Census Report, 2002 and Village Registers, 2005.

4.2.7.2 Changes in Population Structure between 2002 and 2005

Population of WMCA experienced a significant change in the age structure for the period between 2002 and 2005. Sizes of some age groups had significantly changed within the period in question. Both population pyramids, i.e. for 2002 and that of 2005 had broad bases demonstrating existence of people within the young age groups, with infants and children constituting the majority of inhabitants attributed to prevalence of high birth rates despite long term family planning efforts[10].

[10] In Tanzania, Family Planning Programmes were introduced in 1959 and operated by UMATI and 1992 under the National Family Planning Programme, but the impact is not very much visible

PRA results revealed that it was a common practice among young men to marry women from other neighbouring villages. The trend augmented the migration of women mostly at the average age of 16 when they normally got married to young men from other villages. This formed the basis for large scale *rural-rural* migration with little reduction on impact to the environment. People in the old age, i.e. those in age group 60+, particularly males, had their numbers increased significantly within the period in question. This was partly a result of the return of the retired people from duty stations to their respective villages. The analysis of household structure indicated the presence of a significant number of households with their 'old parents' living with them[11]. Parents, at their old age, preferred or were rather forced to live with their off springs only to be taken care of due absence of social security systems to take care for the old aged.

Generally, the population's age structure had a significant variation that could be observed and appreciated when studying the population pyramids of the two specified periods. Whether the changes in population structure impacted to catchment area deforestation was an aspect pursued in Chapter 7 of this thesis.

4.2.7.3 Changes in Sex Composition of the Population of WMCA

Survey data in Table 4.18 demonstrate that sex composition of the population had significantly changed. While the male-female ratio was 95.63% in 2002, sex ratio for the sample household data for 2005 was 87.6%. A decrease of 8.0% was recorded. The two sex ratios indicated that the number of males had proportionately decreased in 2005.

The decrease in sex ratios signified changes in population's sex composition. In case of existence of sex based differential involvement in activities leading to deforestation, then the understanding of sex composition was crucial towards establishing the implications of population change on deforestation.

Table 4.18 Distribution of the Population of the Study Area by Sex (2002 – 2005)

Years/ Variations	Population		
	Males	Females	Sex Ratios
2002	9506	9940	95.63
2005*	5529	6311	87.6

Source: Tanzania Population and Housing Census, 2003 and *Village Registers, 2005.

4.3 Community's Perceptions on Population Growth and Indicators of Growth

Local community views regarding population change and the respective indicators for the same provided basic information from the stakeholders' point of view. Knowledge, skills, experiences and ideas of community members were significant in examining the deforestation phenomenon for practicability of research results.

[11] Lack of effective social security programs made the aged to be dependants of their off springs.

4.3.1 Community Perceptions on Population Growth in WMCA

To be able to evaluate the existing relationship between population growth and deforestation effectively, some specific aspects of population were examined. This necessitated the observation and quantification of variables; and ascertaining whether the two variables (population and forest cover) changed over time. It also allowed to establish the extent or degree of change; and to establish whether such changes embodied some elements of relationships or linkages between the components. The specific aspects selected for determining the variables were termed as indicators.

Local communities mentioned a range of indicators of population change some of which were adopted in the analysis of the relationship between population, development and forest cover change. The discussion on indicators of population growth are covered in Section 4.3.2; while those of development are dealt with in Chapter 5 Section 5.8

4.3.2 Indicators of Population Growth in WMCA

In the course of PRA discussions, it was noted that the sample settlements realized aerial expansion between 1978 and 2004. The expansion of the village size was mentioned to have resulted from the increase in number of people mainly through births. A small proportion of the population increase was attributed to in-migration. In view of this result, population size stood as one of the indicators of population change.

The cultural obligation of parents to allocate part of family land to the male children, after having reached the age of about 18, or rather, as one completed primary education (standard seven) tended to result into *land fragmentation* that reduced sizes of farm plots. This led into concentration of more people (homesteads) in a small area, signifying high population pressure observed within various rural settlements. To reduce population pressure, invasion of the surrounding virgin forest lands and even more encroachment to the forest reserves, in some cases, was necessary. Issues of *land fragmentation* were thus qualified to be an indicator of population growth. PRA revealed that villages had more clustered homesteads by the time of the study compared to the past decade(s).

Slash and burn farming method, locally referred to as *matema,* was attributed to scarcity of farmland within the village centers coupled with lack of accessibility to other land and expensive soil fertilizing methods. The increase in the demand for food and other land resources necessitated opening up of new farmlands. This occurred at the expense of woodlands. The rate of opening of new farms was, hence, noted to be another indicator of population change.

Human settlements were noted to have expanded into areas previously covered by thick forests. By the time of this study, such areas with clustered homesteads had little evidence of forest cover. This indicated that population growth had increased demand for landed resources that led into expanded deforestation within the vicinity of the villages hence reducing the forest cover.

Due to reduction in size of farm plots as attributed to land fragmentation, some household members resolved to move to other areas located in the outskirts of the village and/or even to other villages, where they could obtain satisfactory land for new farm(s). The demand for food and other forest products that arose as a response to population growth were primarily reflected by the growth of household size, tended to cause such responses that could be classified as *rural-rural migration*.

It is worth mentioning, at this juncture, that changes in human population studied based on the analysis of demographic characteristics, i.e. population size, age structure and sex composition provided the detailed information necessary in the formulation analysis of the population component of the PDE analysis. Other variables such as social, cultural and economic, linked to changes in population, were to be articulated in the process of linking the PDE components. Elaboration of the existing linkages between the three PDE components in the context of WMCA is an aspect covered in details in Chapter 8 and Chapter 9 of the thesis.

4.4 Conclusion

Human population of WMCA, like of elsewhere in Tanzania, has been growing through time. The rate of growth varied in different intercensal periods. The Tanzania National Population Censuses data indicated that the annual population growth rate between 1967 and 1978 intercensal period was 2.9. Between 1978 and 1988 period the growth rate was 3.1, while the rate decreased to 2.9 between 1988 and 2002 (URT, 2003a).

When examining sex composition, a similar pattern was revealed for the study period in question. All the data sets extracted from the National Censuses of 1978, 1988 and 2002 indicated that females constituted the majority compared to males. Different patterns were noted for individual village population data obtained through the household survey conducted in 2005 whereby sex ratio was 100.5 indicating presence of more males. Sex ratios for 1978, 1988 and 2002 were 98.55, 96.33, and 96 respectively. The survey conducted in 2005 indicated that the ratio was 100.5, portraying existence of more males in the population thus recording changes in terms of sex composition over the period. At district level, the sex ratio was 96.0 (URT, 2005a).[12] At National level, the sex ratios were 96 in 1978, 96 in 1988 and 96 in the 2002, indicating that the proportionate numbers of females to that of males remained almost the same.

[12] The Tanzania National Population and Housing Census (2002) had for the first time analyzed data up to district level. There are no such data for previous National Population Censuses reports

The data revealed a change in the age structure when changes in age group sizes were analyzed for the same time interval for the three different censuses periods. Despite general similarity, specific variations observed indicated that in 1978 people in age groups 0-9 constituted 33.5% of the population, while in 1988, it accounted for about 31.73%, recording a decrease of 1.8%. People in age group 10-24 constituted 29% in 1978, while in 1988 they formed 32.75%, indicating an increase of 3.75% in numbers of people in the young ages. Those in the age group 25-44 accounted for 21.71and 20.9% for 1978 and 1988 censuses periods respectively, recording a slight decrease of about 1%.

The comparison of population data extracts for 1988 with that of 2002, in terms of age structure demonstrated that people in age group 0-9 constituted 31.73% in 1988 while they accounted for 28.54% in 2002, i.e. a decline of 3.19%. The section of the population aged between 10 and 24 constituted 32.75% in 1988 and 34.21% in 2002, indicating a slight increase of 1.46% in the younger population group. The younger population engenders the potential for future growth of population, expansion of development activities and, hence higher possibility for causing adverse impacts to the environment, forest cover in particular.

The comparison laid for the population data extracted from 2002 National Population and Housing Census and the data from the Field Survey established existence of drastic changes in population size, age structure and sex composition. The data indicated a population decrease of 39.1% for the period between 2002 and 2005, probably due to unreliability of vital registration systems generally characterized by understatement of vital events.

The intercensal growth rates reported during all the censuses periods confirmed the increase in population size over time. The differences in age structure were noted when specific age-groups were examined. Changes in sex ratios portrayed changes in sex composition of the population.

It may generally be inferred that the human population characteristics of WMCA changed in terms of size, age structure and sex composition in the periods under review. It was the main interest of the thesis to establish whether the observed were related to expansion of livelihood/development activities that contributed to deforestation. In case the relationships existed then the thesis had to examine the nature of the relationship and extent of environmental changes they caused. Such knowledge is considered significant in development of sustainable conservation initiatives and strategies. The way PDE variables are linked is demonstrated and presented in Chapter 7 and Chapter 8 of the thesis. A positive relationship was observed to exist between population change and expansion of development or livelihood activities.

CHAPTER FIVE

LIVING CONDITIONS, LAND TENURE AND DEFORESTATION-RELATED ACTIVITIES

5.1 Introduction

This chapter is an attempt towards describing the socio-economic environment characterizing WMCA. It is an effort geared towards generating data, information and quantitative explanations that constitutes the development component to be used in the PDE analysis. In this context Development component is the specific comprehensive analytical description of development and/or livelihood situation of the study area. It is an important component in the framework adopted by the thesis. The Development component (D) is an integral part of the PDE analysis and central in examining the existing relationship between population and environment.

Various development and/or livelihood endeavours carried out by the local communities of WMCA, especially those with links to deforestation were examined to generate reliable information and data regarding their state and the timeline variations. Development issues reviewed include modes of land acquisition and ownership; and main economic/livelihood activities. Others were the main types of *land use* and the applied production practices. Trends in changes of production systems, the status and changes in livelihood/economic activities were also analyzed.

Mediating factors, i.e. types of production/livelihood technologies such as sources of domestic energy, production tools, status of social services such as health education and transport were analyzed and recorded. Mediating factors enabled for the precise PDE analysis since they were significant in unfolding the nature of linkages between the population and development/livelihood activities which manifested into changing state of the environment component. Mediating factors influenced both the nature and the pace of expansion of human activities into areas previously covered by natural forests and peoples' propensity to participate in deforestation and/or aforestation-related activities[13].

Perceptions on the changing village size and *patterns* of village settlements and on main types of the building materials were identified and analyzed with an understanding that part of natural vegetation was cleared for the purpose of obtaining building materials such as wood poles, grass and timber an effort to build required shelters for extra population.

[13] People played both positive and negative roles in bringing about forest cover changes. Mediating factors influenced the speed at which such changes took place and the likelihood of participating.

The *crux* of the chapter lies on the conception that various human activities taking place in WMCA had economic, social and logical significance; thus indispensable from people's livelihoods. Arguably, such activities made local community members attain their livelihoods in terms of earning their basic requirements for survival and for 'development'. The fact remains that through excessive and/or uncontrolled pursuance of such livelihood and/or development activities natural vegetation cover got adversely affected. Generally, the trends in population growth are mentioned to massively influence the changes, i.e. in terms of affecting the quality and quantity of natural vegetation, hence threatening the survival of people who were already impoverished.

With this hindsight, the understanding of demographic characteristics of human population of WMCA; and the way local people interacted with the natural environment demanded a more detailed, age and sex-based analysis to uncover the nature and character of the population-resource interface. The analysis of such interface had to take into account the prevailing social, cultural, economic and political conditions.

The chapter attempts to identify and analyze the contribution of development/livelihood activities towards deforestation. According to the 2002 Tanzania Population and Housing Census Report, the percentage distribution of private households by building materials for walls countrywide shows that wooden poles and mud accounted for 34.4%, thus likely to have a significant impact on deforestation (URT, 2006).

Expansion of agriculture for food production alone was responsible for much of the world's deforestation as well as soil erosion through unsound practices (Ehrlich and Ehrlich, 1990; Ehrlich, Ehrlich and Daly, 1993; Bongaarts, 1996; Madulu, 2004). Understanding the contribution of various livelihood/development activities to deforestation becomes crucial in planning of forest conservation extension since it points out specific intervention areas by sectors and specific activity

5.2 Living Conditions and Social Services Available in WMCA

There was broad and multifaceted life systems scenery of the communities of WMCA. This state could facilitate generation of facts and explanations on the life systems and people's involvement in livelihood (development) activities within the respective localities. Issues covered included living conditions, economic activities and the types and qualities of social services. It is envisaged that such activities expanded with growth of human population, thus adversely affecting forest cover. Analysis of specific issues is presented in sections 5.2.1.and 5.2.2.

5.2.1 Living Conditions of People of WMCA

Like other parts of rural Tanzania, people of WMCA lived depending on farming and keeping of a few animals for their livelihood and development. The typical livelihood situation which portrays basic elements of level of development is stipulated in sections 5.2.1.1 and 5.6.1.2.

5.2.1.1 Average Households' Income

Survey data Table 5.1 indicated that the average annual household income for the communities of the area was about Tshs.344,363/-, i.e. about US$ 265. If divided by the average household size, i.e. 4.8, the *per capita* income for the area is about Tshs 71,742, i.e. about US $ 55. The current data indicate that *per capita* income for Ruvuma region was Tshs 499,716 in 2005, Tshs 513,018 and Tshs 599,794 for 2006 and 2007 respectively (URT, 2008). It implies that the communities of WMCA were relatively poor with a mere $^1/_6{}^{th}$ of the regional *per capita* of year 2005. Two households did not expose their annual income for unknown reasons.

Table 5.1 Distribution of Households by the Estimated Annual Income

Income (Tshs)	Number	Percentage	Cumulative Percentage
1.00 -100,000	194	27.7	27.7
100,001 -200,000	167	23.9	51.6
200,001- 300,000	115	16.4	68
300,001-400,000	76	10.9	78.9
400,001-500,000	48	6.9	85.8
500,001 -600,000	19	2.7	88.5
600,001-700,000	20	2.9	91.4
700,001+	58	8.3	99.7
Not exposed their income	2	0.3	100
Total	**699**	**100**	

Source: Field Survey, 2005

Watcher (1992) has observed that as productivity of the land declines, farmers and pastoralists find themselves in a downward spiral where incomes decline, subsistence becomes more difficult, and they become poorer. Poverty can lock farmers into a production pattern focused on satisfying their immediate needs, with very little opportunity to pursue alternative production activities. This was typical of the situation in WMCA. The tremendous fall in average *per capita* income from US $ 95 in 1994 to US $ 55 in 2005 underlines rising poverty conditions.

5.2.1.2 Types of Homesteads

Most of households, i.e. 78.4%, lived in homesteads built using baked bricks and the roofs were grass thatched. A few homesteads were roofed with corrugated iron sheets. Table 5.2 indicated that about 78% of the households made baked bricks at least once in their lifetime. Since no sale of bricks was reported, the bricks molded were mainly for respective household use.

Improvement of homesteads was reported as being a consequence of the *Mlale Resolution,*[14] which directed people to build better shelters and expand farms. Implementation of the *resolution* contributed into vast deforestation. At district level, 80% of homesteads were built using baked bricks (URT, 2004).

Table 5.2 Participation of Households in Molding Bricks Baked by Using Firewood

Response	Number	Percentage
Yes	548	78.4
No	151	21.6
Total	**699**	**100**

Source: Field Survey, 2005

5.2.2 Types and Quality of Social Services Available in the Area

The Participatory Rural Appraisal (PRA) conducted assessed the types of social services availed to the local communities. The types and status of the services were observed and noted as reported below.

5.2.2.1 Roads and Transportation

All roads of the area were of loose surface quality including those linking villages with the Songea Municipality. The roads were passable mainly during the dry seasons and were hardly passable during the rainy seasons. The mountainous terrain, characterized by steep and slippery surfaces, worsened the situation. By the time of this research, only a few buses operated along the road to *Muhukuru* serving the communities of *Lihwena, Muungano* and *Lipaya* villages. Other villages of *Mahilo, Chemchem, Mpingi* and *Kikunja* had no bus transport at all.

A common feature for the sample villages was the prevalent use bicycles as the major and reliable means of transportation for people and goods. The presence of poor roads limited the number of vehicles plying within the areas. Poor transport system contributed to poor economic performance as some villages were de-linked from the markets, sources of farm inputs and important social services.

Poor transport was also a limiting factor to the outward-movements of people, therefore augmenting population pressure in the villages. Conversely, poor transport enhanced forest conservation as the areas were isolated from neighbouring urban areas, thus reducing exploitation of forest products mainly firewood and charcoal.

[14]Mlale Resolution was a regional political and economic programme declared by the Ruvuma regional authorities as an effort towards improving the status of development in Ruvuma region through boosting agricultural production, improving homesteads and life conditions of people of the Region that lagged behind.

5.2.2.2 Health and Medical Services

PRA results revealed that only two villages of WMCA had health services offered at government owned dispensaries. By the time of the study, only *Ndilima Litembo* and *Kikunja* villages had dispensaries. *Chemchem* settlement had its dispensary still under construction.

A significant number of community members could not access medical/health services at the dispensaries for lack of a monetary contribution payable prior to receiving the service. People's low income hindered their access to medical services signifying persistent poverty conditions. Shortage of medicines, scarcity of qualified staff and absence of maternal health services characterized the poor medical services; a factor for prevalence of high morality rates.

5.2.2.3 Water Supply and Sources of Water for the Local Communities

Water is considered, and it is in fact, an important liquid for daily life and survival of human kind. Of the eight study villages, only four had running tap water supplies that included *Chemchem*, *Mpingi*, *Ndilima Litembo* and *Kikunja*. However, the four villages with tap water, not all households had tap water, thus some depended on traditional sources. Survey data in Table 5.3 demonstrates that about 41% of the households of WMCA had tap water, while about 43% got water from shallow wells. About 12% obtained water from drilled wells and 3% drew water from streams. The rest used water from boreholes while others harvested rain water. Tap water supplied to the communities was not treated; therefore was not totally sanitary, hence unsafe[15] for human consumption prior to boiling. Prevalence of water borne diseases such as diarrhea and dysentery that commonly affected most of the inhabitants, substantiates the fact. Malaria was rated to be among the chief killer disease especially for infants and children.

Table 5.3 Distribution of Households by the Main Source of Water

Sources	Number	Percentage
Water tap	288	41.2
Wells	303	43.3
Boreholes	3	0.4
River / streams	21	3
Rain water harvesting	1	0.1
Drilled well	83	11.9
Total	**699**	**100**

Source: Field Survey, 2005

5.2.2.4 Educational Institutions Enrollment and Pupils' Performance

Appraisal of educational facilities, according to the PRA results, revealed the presence of at least one primary school in each village. Only *Lipaya* village had two primary schools. Reports from the primary schools indicated low enrolment rates with significantly high drop out levels.

[15] Unsafe water could not be drunk untreated. It is necessary to be treated before consumption from water taps.

The actual numbers of those who completed primary education was significantly low. Pupils' performance in national examinations was poor, with very small number of primary school leavers passing final examinations to join secondary education. Various reasons were mentioned as causes for the low educational achievement. They included, among others, scarcity of desks, shortage of qualified teachers and the limited number of classrooms.

Lack of motivation for higher education among parents had trickled down to their children, making the breakthrough in education more difficult. This 'tradition' made some parents to dislike children who passed examinations. Those who joined secondary school continued to be dependants, while according to such parents, they were supposed to be independent. Worse is the fact that the same parents were supposed to pay fees. Hence, to such parents, their children's passing examinations meant incurring unnecessary extra cost for sometime till they complete studies.

The low numbers of school leavers, as shown in Table 5.4, as opposed to the noted dominance of people under the age of 15 in the population signified the presence of low enrollment in schools that was ultimately reflected into worse future environmental conditions. Most of children who had to join school did not do so; and of those few who joined only a small proportion completed and fewer (if any) continued to higher levels of education. Scarcity of secondary schools, coupled with poor performance in primary schools compounded into the limited numbers of people who attained secondary or higher education levels. During the study period, the entire WMCA had only one secondary school, Kalembo Secondary School, located in the Matogoro urban ward.

Limited numbers of those enrolled for further education, and high rates of drop outs led the majority of the population to remain in the villages compelled to deal with rural economies which adversely affect the environment. Lack of academic qualifications limited their mobility to urban areas.

Table 5.4 Performance in Primary Schools and Selection for Secondary Education 2001-2004

Year	Number of School Leavers	Number of Those Passed exams	Percentage Passed
2001	219	11	5
2002	263	29	11
2003	263	22	8.1
2004	255	17	6.6
TOTAL	**1000**	**79**	**7.9**

Source: Participatory Rural Appraisal Report - Head Teachers, 2005

Technologies adopted in production were of low level. This was due to persistence of relatively low levels of development based on production for livelihood, i.e. the essence of subsistence production. Majority of inhabitants lead a modest life style whose basic livelihood depended on what nature, i.e. soil, vegetation and weather provided. Surplus crops produced were sold to obtain some cash needed for the purchase of 'crucial' industrial and other products such as kerosene, boxes of matches, common salt, bathing soap, detergents and agro inputs.

5.3 Land Acquisition and Types of Land Ownership

WMCA had large tracts of land most of which were classified as forest reserves, protected and conserved for water catchment. As mentioned earlier, the total land area covered by the study is approximately 155.2 km^2, with seven of the eight villages almost surrounding the forest reserve; while *Ndilima Litembo* was located amidst the forest reserve.

There were a variety of ways used to acquire land. In most cases, the acquisition of land involved individual initiatives to clear the natural vegetation, most of which constituted *public woodland* areas which dwindled through time. Specific practical methods of land acquisition and types of land ownership are as stipulated in sections 5.3.1 and 5.3.2.

5.3.1 Means of Acquisition of the Land

Survey data in Table 5.5 indicated that a significant proportion of the households, i.e. about 38% obtained land through inheritance, while 20% were given land by their parents. About 12% were allocated land by village authorities during the *Operation Vijiji*[16] and 13% were allocated land by the same authorities after the *Operation Vijiji.* Another 13% acquired land for free from those with plenty of it. Very few households say about 6%, obtained land through buying and/or renting. The observed methods of land acquisition portrayed dominance of traditional or customary land ownership systems that was based on the *use value* rather than the *economic value* of land. Allocation of land by the village authorities both during Operation *Vijiji* and after the Operation *Vijiji* denoted the rising levels of government intervention on land distribution that influenced ownership systems within the rural settings.

Table 5.5 Distribution of Households by Means of Land Acquisition

Means of Acquisition	Number	Percentage
Allocated through Operation *Vijiji*	83	11.9
Inheritance	268	38.3
Buying	42	6
Given for free by people	75	10.7
Given by village government	88	12.6
Given by parent	138	19.7
Rented	4	0.6
Not Applicable	1	0.1
Total	**699**	**100**

Source: Field Survey, 2005

[16] Operation *Vijiji* was a nation wide relocation of people in villages towards creating Ujamaa Villages which would become centres of production whereby people could be easily provided with social services

In 1987, the Ruvuma regional administration, through the *Mlale Resolution* directed the district authorities to allocate land to the 'loiterers' and 'the lazy' who were repatriated from Songea and other towns where they had no formal employment (URT, 1987). This was part of implementation of the 'Human Resources Deployment Act', the national level policy (URT, 1983). Such a political move had negative implications to the forest cover as the implementation was realized through clearing of vast forest lands.

The trends in land acquisition and ownership, as guided by the current National Land Policy,[17] indicated the possibility of the social drifting, i.e. moving towards more control by the government authorities; thus lowering *tenure security* on land-related matters both in WMCA and the country at large.

5.3.2 Types of Land Ownership and Changes in Land Tenure from 1974 to 2004.

Like in many other rural areas of Tanzania, WMCA had land ownership systems mainly dominated by traditional or customary systems. The proportions of the population by types of land ownership, and changes in types of land ownership over time are presented in sections 5.3.2.1 and 5.3.2.2.

5.3.2.1 Land Ownership Systems Existed in WMCA

Survey data presented in Table 5.6 indicated that the majority of households, i.e. about 97% had no title deeds for their farm lands and homestead plots. Only about 3% of the households had title deeds mainly those living in the peri-urban areas particularly at *Chemchem*, a settlement in the Matogoro urban Ward of Songea municipality.

Generally speaking, land ownership in Tanzania was lopsided. The majority of title deeds were issued to those in urban areas, while most of the rural people, the majority, owned land on *traditional* or *customary basis*. Land titles are generally and legally recognized to be one of the common official mechanisms for recording and enforcing individual property rights.

Previous studies by Keck *et al.*, (1994) and Johnsen (1999) indicated that traditional (less formal) land rights systems adapt as the economic circumstances change due to population growth and technological progress. In Tanzania, the state is technically the owner of all lands including the surveyed or titled. Traditional land ownership systems, with some modifications, provided an adequate land *tenure security* even though the agricultural system was more intensive (Migot-Adhola *et al.*, 1991). Lack of *tenure security* had adverse effect since it hampered incentives towards investments, improvement of the productive capacity of the land and conservation initiatives.

[17] 1997 Tanzania Land Policy recognizes the economic value of the land unlike its predecessor that considered its use value. Such a change of perception impacted on land ownership and tenure security.

5.3.3 Changes in Land Tenure and land Use Systems from 1974 to 2005

Most of community members indicated to have not experienced any changes pertinent to land ownership through time. Survey data in Table 5.6 demonstrate that about 77% of household heads had effected no changes of types of land ownership since 1974. Those who experienced changes, i.e. about 14% realized such changes by mere transferring part of their land to their own matured male siblings.

There were incidents whereby some individual land areas were grabbed by the government for establishment of social services. About 1.3% of cases realized their land grabbed for building schools, 0.6 for establishing water supply systems and 1.6% for construction of roads. Few cases, i.e. 0.6% were reported whereby part of land was bought and 0.1% sold their part of their land. About 0.7% of cases rented their land to others who used it for crop cultivation, while 0.3% of cases had their land areas confiscated by those households with acute land shortage. A significant proportion of the household heads, i.e. 2.5%, had given part of land to relatives with land shortage, for free.

The 'free' provision of land to people with a shortage, and the fact that there were few instances where land was reported to have been sold and/or bought, demonstrated that land did not have *economic value*. It therefore underlined the point that the traditional economies dominated the life systems of local communities in question. As most of land continued to be common property, it faced a great risk of degradation (Madulu, 1991a). In general, WMCA realized no significant *internal based* changes in terms of land tenure systems indicating that the traditional economies were less affected by external forces.

Table 5.6 Distribution of Respondents by the Changes in Land Ownership since 1974

Changes in Land Tenure	Responses	
	Number of Cases	Percentage
None	546	77.1
Given portions of my land to my son	102	14.4
Part of it taken by the primary school	10	1.4
Rented to others to cultivate	5	0.7
Part was taken for road expansion	11	1.6
Part given to other relatives	18	2.5
Part farm taken by Operation Vijiji	5	0.7
Sold part of it	4	0.6
Part taken by the Water Author	4	0.6
Added more land through buying	1	0.1
Part invaded/confiscated by people	2	0.3
Total	**708**	**100**

Source: Field Survey, 2005

Dominance of customary or traditional tenure demonstrated long term prominence of subsistence farming in economies of the area. It, as well, implied that the majority of the households were still based on traditional economies, which for the most part depended on farm and forest products. For generations, such communities articulated their economic systems into daily life systems that were significantly unchanged despite farm expansion, mostly motivated by the need to feed the growing household population. In this way the definition and concept of development had to base on their valuable perceptions.

5.3.4 Coping Strategies Adopted to Land Tenure Changes since 1974

Diverse strategies were adopted by households to cope with the slight changes that occurred in land tenure systems. The strategies were only applicable in instances where such changes had actually taken place. Where no changes were realized, the implicit coping strategies were in place but meant for adopting changes in soil productivity, weather and others.

Survey data in Table 5.7 indicated that 28% of respondents did not adapt any coping strategy with changes in land tenure. The households in this category hardly experienced any land tenure changes. About 22% responded to the land tenure changes by expanding their farms. Farms were extended to areas previously covered by forests in order to replace the lost farm areas or to meet the growing demand of farm products. Farm areas occupied sections left aside for other purposes. This type of response or strategy directly exposed forests to deforestation.

About 34% of households responded to land tenure changes by expanding the homesteads, implying putting in place more building structures within their plots. Rising demand for accommodation, due to expanding household population necessitated this state. Expansion of homesteads was sometimes done on areas previously used for cultivation, i.e. in farm plots around the homesteads. This implies that homesteads expanded at the expense of croplands. PRA results revealed similar findings. The observed type of chain-response, based on farm expansion as a coping strategy, had the implicit negative effects which, at the end of the chain, contributed into accelerated deforestation.

About 11%, adapted to tenure changes by planting trees for various uses. Such trees were meant for timber, firewood and for producing fruits. Other forms of coping strategies adopted included the use of organic farming used by 3% of households.

It was observed that most aforestation efforts were aimed at the planting trees for timber, firewood and the like. Rarely were they linked to the direct conservation, i.e. improving the *catchment value* of the forests. This, technically, boils down to the critical issue of selection of appropriate plant *species* that would enhance *catchment value* of the forest rather than mere tree replacement. In fact, some planted tree species are documented to have adverse impact to water sources (URT, URT, 1997c). Tree planting provided an alternative to total dependency on natural forest, which minimizes loss of natural vegetation cover.

PRA results revealed that *diversification of farming*, which refers to a shift from dependency on crop cultivation alone to combining it with the keeping of animals, was a means used to adopt to land tenure changes. Some households started horticulture, meaning growing of vegetables that could fetch 'quick money' to cater for their daily requirements and survival. Keeping of animals supplied farmers with dung used in fertilizing the soil, while tree planting provided windbreakers, alternative supplies of firewood and shadow. Few households responded by selling their farms and by out-migrating. The outward movement of some farmers was motivated by the need to secure larger tracts of land, sufficient for household requirements. This was the basis for massive *rural-rural migrations*. Out-migration, strictly speaking, did not solve problems associated with population pressure; it rather transferred the problem from *source* areas to the *destination* areas.

Table 5.7 Distribution of Households by Coping Strategies to Land Tenure Changes

Coping Strategies	Responses	
	Number of Cases	Percentage
None	195	22.4
Giving it to my sons/children	43	4.9
Continue with expansion of farms	189	21.7
Use organic farming	24	2.8
Settlement (construct other houses)	297	34.1
Planting more trees	96	11
Keep more animals / poultry	10	1.1
To migrate	1	0.1
Selling it	4	0.5
We will be located (no plan)	3	0.3
To grow vegetables / tomatoes	8	0.9
Total	**870**	**100**

Source: Field Survey, 2005

5.4 Main Economic and Livelihood Activities in WMCA

There were a broad range of economic activities reported and observed performed by the local communities of WMCA. Such activities were related to socio-cultural and environmental conditions that characterized the specific localities. According to the survey data in Table 5.8, the main economic activities of the area included farming, livestock keeping, traditional crafts and petty business.

Farming was the main activity that occupied 96% of the households. Other activities included livestock keeping, casual labour and traditional crafts. Formal employment accounted for the smallest proportion of the population, mainly included primary school teachers and a few medical staff. Some local community members engaged in casual labour to obtain cash, crucial for purchase of industrial commodities such as kerosene, matches, salt and soap.

Generally, the technological levels applied in the production sector and in various other activities; natural resource endowment and the types of sources of energy used the WMCA influenced the type, extension and pace of the contribution of the activity in question. Since farming was the dominant economic activity, examining how it was practiced and its impact to the environment, was necessary.

5.4.1 Farming Practiced and the Major Crops Grown in the Area

The adopted farming practices and crops grown in WMCA were part of the function of the socio-economic and physical conditions. Their specific detailed descriptions are discussed in sections 5.4.1.1 and 5.4.1.2.

5.4.1.1 Types of Farming Practices

Despite being the main economic activity, accounting for 96% of the households, farming was dominated by *smallholder production* signified by predominant use of hand hoe and small farm plots. The crops were mainly meant for household use, though some excess output was sold. PRA results verified the same. Majority of the rural population of Tanzania constitute *smallholder* or *subsistence producers* who largely depended on natural resources exploitation for their survival (Madulu, 2001).

Table 5.8 Distribution of Households by Main Economic Activities

Economic Activity	Number	Percentage
Farming	671	96
Livestock	5	0.7
Traditional crafts	5	0.7
Petty business	3	0.4
Builder	3	0.4
Employment	5	0.7
Casual Labourer	2	0.3
Carpenter	4	0.6
Tailor	1	0.1
Total	**699**	**100**

Source: Field Survey, 2005

5.4.1.2 Major Crops Grown in the Study Area

Survey data presented in Table 5.9 indicate that maize was the chief crop, grown by about 94% of the population. The crop was used for preparation of staple food of the area called *ugali,* a kind of stiff porridge meal.

Cassava was the second major crop grown by about 46% of the households. Extensive growing of cassava was attributed to its biological conditions for growth which, according to the growers, did not require application of any fertilizers and that it is drought resistant. Households' involvement in growing crops such as potatoes, simsim and vegetables had bourgeoned over recent years. Most of crops were readily sold to obtain money for the purchase of industrial commodities like sugar, matches, kerosene and salt. Other crops grown include beans, tobacco, groundnuts and sunflower, banana and peas.

Table 5.9 Major Crops Grown in the West Matogoro Catchment Area

Crops	Responses		
	Number of Cases	Percent of hhs	Percentage of Cases
Maize	659	94.3	50
Beans	40	5.7	3
Finger millet	18	2.6	1.4
Potatoes	63	9.0	4.8
Peas	22	3.1	1.7
Cassava	322	46.1	24.4
Simsim	63	9.5	4.8
Rice	32	4.5	2.4
Groundnuts	9	1.2	0.7
Tobacco	65	9.3	4.9
Vegetables / tomatoes	15	2.1	1.1
Coffee	2	0.3	0.2
Sunflower	1	0.1	0.1
Banana	4	0.6	0.3
Not Applicable	3	0.4	0.2
Total	**1318**	-	**100**

Source: Field Survey, 2005

5.4.2 Average Household's Farm Size

Survey data in Table 5.10 demonstrated that the average farm size was about 2.5 Acres. About 54% of the population had their farms ranging from 1 to 3 Acres, while 13.7% had land areas of between 3 and 4 Acres. Ten percent had farms that covered between 4 and 5 Acres. A significant proportion of the households, i.e. about 17%, had their farms occupying more than 5 Acres, thus required more labour power and normally characterized by more household members to feed. It may be observed that smallholder farming characterized the economy of the area.

Small farm size coupled with less intensification lead into the practice of *shifting cultivation* and *bush fallowing*, farming practices detrimental to the existence of the forest cover. Repeated clearing of secondary forests quickly decreases soil fertility and increases labour input (Keck *et al.*, 1994).

Table 5.10 Distribution of Sample Households by Farm Size

Farm Size (Acres)	Number	Percentage
1 - 2	207	29.6
2.1 - 3	173	24.7
3.1 – 4	96	13.7
4.1 – 5	71	10.3
5.1+	119	17
Not Applicable	33	4.7
Total	**699**	**100**

Source: Field Survey, 2005.

Survey data in Table 5.11 indicated that about 44.8% of the 699 households had satisfactory farmlands for households' requirements. The remaining 54.9% experienced land scarcity, therefore marking a potential for farm expansion. Presence of high potential for deforestation caused by demand for more land for cultivation and other uses threatened the existence of both the public forests and forest reserves. The small farm size, coupled with continuous cultivation resulted into a fall in the crop output, hence necessitating clearing of the forest to establish more farms, relatively more productive at less production cost. With high rate of population growth, the danger of deforestation became more alarming.

Table 5.11 Respondents' Opinions on Satisfaction to Land Requirements

Response	Number	Percentage
Yes	313	44.8
No	384	54.9
Not applicable	2	0.3
Total	**699**	**100**

Source: Field Survey, 2005

5.4.3 Types of Farm Technologies Applied in the Area

Survey data in Table 5.12 demonstrated that majority of the respondents, i.e. 99.6 %, used a hand hoe as the main instrument of labour. In the entire WMCA, only a single household used ox-driven plough. Vast literature on Tanzania has revealed that farmers rely on simple tools mainly hand hoes (Mashalla, 1988; Mbilinyi, 1997).

The observed low levels of farm technology signify dominance of smallholder farming system characterized by subsistence nature of the economies. Subsistence economy linked with the poor social services, indicated prevalence of relative poverty conditions. As in many communities that practice *shifting cultivation*, farming becomes part of cultural life, meaning 'a way of living', other than a 'production system'; its negative effects on the environment were likely to be realized (Kerk *et al.*, 1994; Mwakalobo and Kashuliza, 1999).

Table 5.12 Distribution of Households by Types of Farm Implements Used

Tools Used	Responses	
	Number of Respondents	Percentage
Hand hoe	675	99.6
Ox-plough	1	0.1
Not Applicable	23	3.3
Total	**699**	**100**

Source: Field Survey, 2005

Adoption of low production technologies was a likely replication of poverty. The same could be a factor for low productivity resulting from predominant use of poor tools. The vicious cycle of low technology, low productivity and poverty is, in this case, realized. In villages like *Ndilima Litembo* and *Mahilo* small farm size was attributed to the proximity to the Matogoro Forest Reserve, hence having nowhere else to expand settlements and/or farms into.

5.4.4 Methods of Restoring Soil Fertility

Several methods of restoring soil fertility, aimed at enhancing crop output levels, were applied. Specific methods applied were related to the socio-economic and edaphic/physical conditions of the area and the status of a household in question. Applied soil fertilizing methods are described in sections 5.4.4.1 to 5.4.4.7.

5.4.4.1 Use of Industrial Fertilizers

Survey data in Table 5.13 demonstrate that most of the households, i.e. about 73% used industrial fertilizers in restoring soil fertility. The predominant use of industrial fertilizers was a legacy of the *Mlale Resolution* that aimed at boosting maize production in Ruvuma region (URT, 1997c).

The national and regional agricultural extension service had long term plans on 'modernizing farming' through dissemination of extension packages that advocated for both extensive and intensive use of agro chemicals to meet targeted levels of maize production[18]. The use of hybrid seeds and industrial fertilizers was highly promoted and generally adopted by farmers of the region.

Low External Inputs and Sustainable Agriculture (LEISA) contend that conventional agriculture and intensification has in the long term contributed to the decline on *biodiversity* in agricultural systems. Healthy agricultural systems were said to support ecosystem functions and contribute positively to the health of the surrounding environment (LEISA, 2004). Thus, *Mlale Resolution* was a success story with considerable damages to the environment of the region.

5.4.4.2 Practice of *Crop Rotation*

Survey data demonstrate that about 29% of the respondents practiced *crop rotation*. This is a farming practice whereby crops were interchanged within different plots. The method is based on the reality that different crops (plant species) required different soil nutrients and favoured different soil conditions. Therefore, rotating the crops boosted the out put. The nature of crops to be rotated was advised by the extension officer and/or experienced farmers.

5.4.4.3 Practice of *Bush Fallowing*

About 10% of the households practiced *bush fallowing* to allow time for farm plots to regain fertility naturally. The practice entailed the temporary abandoning of the exhausted farm plot for some time to recover. On average, the optimum period of about 20 years is required for soil to regain fertility (Pimentel and Pimentel, 2005). However, due to scarcity of land, only a short period could be 'sacrificed' for land areas left uncultivated, normally at the expense of shortage of food. *Bush fallowing* was practiced with shorter fallow intervals, thus soil fertility kept on being mined. With shortage of land, due to population growth, the practice declined but was replaced by more intensive farm production methods.

[18]Chemical fertilizers in Ruvuma region were reported to be used intensively in maize production. The common type of fertilizer used was mainly Sulphate of Ammonia which after its continuous use depleted soil nutrients. It is now recommended that farmers use UREA, NPK and CAN, which are less destructive to the environment.

5.4.4.4 Use of Animal Dung

Only about 11% of households used animal dung for fertilizing the soil mainly due to scarcity of animals in the area and in the region at large. Despite the extensive use of industrial fertilizers, most of the households tended to combine the above-mentioned coping strategies in an effort towards restoration of soil fertility.

5.4.4.5 Practicing of Shifting Cultivation

About 5% shifted from one farm, whose soil got exhausted, to another which was relatively more productive without considering to revert to the previous plot(s). This is an essence of *shifting cultivation*. The transformation was from various forms of shifting cultivation towards more sedentary farming systems, implied that more land was subjected to more frequent cultivation. This is what could be defined as agricultural intensification (Boserup, 1965). Population density, production tools and their types and levels of production systems defined the environmental situation of an area, i.e. vegetation and soil conditions in particular (Andrew, 1994).

5.4.4.6 Other Methods of Restoring Soil Fertility

There were other methods of restoring soil fertility used by relatively fewer households. They included the use of compost, sunhemp, mixed cropping and the growing of cassava, a crop that was grown without the use of fertilizers.

5.4.4.7 Not Used Any Soil Fertility Restoring Method

About 2% of the respondent households did not use any method of soil fertility. They grew crops in the same plots without fertilizing the soil. Such households might have practiced *crop rotation* or *mixed cropping* but did not know how the mechanisms worked out. However, it is obvious that such farmers had no initiatives to enrich soil fertility. In such farms, soil fertility was being mined as evidenced in a fall in soil productivity.

Soil degradation, which refers to severe soil erosion observed in parts of *Mpingi* village whereby devastating winds were reported causing destructions due to removal of natural vegetation cover. David Pimentel and Marcia Pimentel observe that intensive maize production entails the practice of crop rotation that goes with reduction of agrochemicals; reduce soil erosion and use of manure (Pimentel and Pimentel, 2005).

Table 5.13 Distribution of Households by Methods of Restoring Soil Fertility

Methods of Restoring Soil Fertility	Responses	
	Number of Cases	Percentage
None	13	1.4
Industrial fertilizer	491	52
Fallowing	93	9.8
Sunhemp	1	0.1
Compost	30	3.2
Dung	74	7.8
Crop rotation	188	19.9
Opening new farms	47	5
Mixing crops	3	0.3
Grow cassava (not need fertilizer)	5	0.5
Total	**945**	**100**

Source: Field Survey, 2005

5.4.5 Frequency and Reasons for Farm Expansion

The frequency of establishing extra farms was critical to determining the pace of deforestation and the spatial coverage of the effects of disappearance of vegetation cover. The frequency varied from one household to another, sometimes even among villages. Variation was based on nature of the soil, technology used and availability of the land. However, specific explanations on the frequency at which farms were actually expanded and the reasons for such expansion are issues covered in sections 5.4.5.1 and 5.4.5.2.

5.4.5.1 Frequency of Expansion of Farms

On the frequency of farm expansion, survey data in Table 5.14 demonstrated that about 49% of households did not participate in the activity. This was mainly attributed to the observed absence of public forests/woodlands for further expansion of farmlands in the respective villages. PRA results indicated that villages with acute shortage of farmlands included *Chemchem*, *Lihwena*, *Muungano* and *Ndilima Litembo*. While the first three villages had farm expansion limited by urbanization, the fourth village faced the problem of shortage of farm land, due to its location athwart the forest reserve, with high restrictions on expansion of human activities into the forest reserve.

On the timing and reasons for farm expansion, about 28% of the respondents expanded farms whenever soil fertility declined. The response was common for people of *Kikunja* and *Mpingi* villages, located far away form the urban centre, and hence had plenty of public woodlands that enabled farm expansion. About 10% of them expanded farms after every three years; while 6% expanded farms in four years' time and another 6% in two years.

The frequency of expanding farms was fast enough for its impact to be realized; especially in the areas with vast cleared areas. Sustainable *slash and burn agriculture* requires a rotation of about 20 years (Pimentel and Pimentel, 2005). However, population growth and the resulting shortage of arable land; proved to be a major constraint to its sustainable use. This observation was typical of WMCA where presence of forest reserves highly limited farm expansion resulting into over cultivation and mining of soil nutrients.

Table 5.14 Distribution of Households by Frequency on Expanding Farms

Frequency of Activity	Number	Percentage
Not at all	348	49.8
Every year	15	2.1
After two years	36	5.2
After three years	69	9.9
After four years	38	5.4
Soil fertility decreases	192	27.5
Only once	1	0.1
Total	**699**	**100**

Source: Field Survey, 2005

5.4.5.2 Reasons for Expanding Farms in WMCA

Various reasons were put forward in explaining what prompted farmers to clear the forest for farm expansion. Table 5.15 outlined the main reasons for expansion of deforestation-related activity. About 73% of the respondents dismissed the question for its inapplicability, since they did not expand farms at all. This included households that depended on other forms of livelihood than farming and those which depended on farming; but were in areas with acute land shortage; thus, they had no opportunity for farm expansion.

About 12% of the respondents opened up other farms whenever their farms had soil fertility exhausted from their farms. These are the ones who repeatedly expanded farms. Such households were in villages with vast public forest land, hence mostly practiced *shifting cultivation*. A *slash and burn cultivator*, operates not so much as a *shifting cultivator* but a *shifted cultivator*, meaning that a farmer finds himself landless in traditional areas, thus is forced to move to unoccupied available public lands to practice cultivation (Myres, 1990).

About 10% of the households were forced to clear the forest and expand farms to meet the increase in household's food demand prompted mainly by the growth in household size. About 4% of the respondents expanded farms to respond to households' raising income demands. They grew high value; fast-growing and marketable crops which were sold to obtain income. Two percent of the respondents opened up extra farms to establish their own (new) households. This mostly included young men at maturity age, which had to establish their own families; be it through marriage or cohabitation.

PRA results, through *pair wise ranking* indicated that for a young man to get married two prerequisites were to be met. One was having a farm and another was to own a homestead. Both requirements, impacted on forest cover, thus, contributing to deforestation. Introduction of other crops necessitated farm expansion. New crops demanded extra farm plots. Others households expanded farms to grow tobacco, a crop which could not be mixed with other crops. Some households expanded farms simply because land was plenty. They used the land available for actual crop production. This underlines less understanding or simply underrating the significance of the forest cover to their lives. Those in this line of thinking were likely to contribute more to deforestation because they attached less value to the significance of natural forest cover.

Table 5.15 Distribution of Respondents by Reasons for Expanding Farms

Reasons	Responses	
	Number	Percentage
Not applicable	1039	72.5
Drop in soil fertility	168	11.7
More demand for food	113	7.9
Introduction of other crops	5	0.3
Land is plenty	6	0.4
To increase family income	58	4.0
Growing tobacco	8	0.6
Growing other crops	13	0.9
Starting own family	23	1.6
Total	**1433**	**100**

Source: Field Survey, 2005.

5.4.6 Trends in Expansion of Farms between 1978 and 1988; 1988 and 2004.

Survey data on the trends in expansion of farms in WMCA demonstrated that some households experienced a faster rate of expansion of farms than others. PRA results indicated that most farms had expanded covering parts previously covered by forests. However, a significant proportion of the households, i.e. about 49% did not establish farms at all for lack of public forest areas for expansion.

A significant proportion of the households, meaning about 15% had given a portion of their land to their sons as part of inheritance. This was meant to enable others to engage in agricultural production for their newly established households. The practice led into *land fragmentation* caused by the mounting population pressure over land resources. *Land fragmentation* decreases farm size and settlement plots contributing into the critical household decision to or not to expand farms; the task normally accomplished at the expense of the natural forest cover. The actual amount of the forest land cleared for the purpose, in specific period(s) is described from section 5.4.6.1 to 5.4.6.3.

5.4.6.1 Trends in Farm Expansion between 1974 and 1978

Survey results in Table 5.16 indicated that about 381 acres of the forest were cleared between 1974 and 1978 for expansion of farms by only 115 households, i.e. 16% of households. It was noted that out of the 699 households, 586 did not clear the forest to expand farms within the specified period. They could not clear forest to expand farms for lack of public woodland areas in which they could expand farms. Those households that expanded farms, are in this thesis referred to as 'active households'. The average of about 3.4 acres was cleared by each active household *per* year.

During the period in question, the annual average of 95 acres of the forest was cleared for farm expansion, implying the average rate of about 0.8 acre for each 'active household'.

Table 5.16 Forest Areas Cleared for Expanding Farms (1974-1978 in Acres)

Acres	Frequencies	Cleared Area (Acres)	Percentage
1	16	16	4
2	38	76	20
3	15	45	12
4	23	92	24
5	7	35	9
6	5	30	8
7	2	14	4
8	3	24	6
9	1	9	2
10	2	20	5
20	1	20	5
Total	**113**	**381**	**100**

Source: Field Survey, 2005.

5.4.6.2 Trends in Farm Expansion between 1979 and 1988

Survey data in Table 5.17 demonstrated that between 1979 and 1988 about 467 acres of woodlands were cleared for the purpose of expanding the cultivated area. The number of 'active households' who expanded farms during the period in question was 147. The average of the forest land cleared by 'active households' was 467/147, i.e. 3.2 acres, while the sample household's annual contribution to deforestation, by farm expansion, was about 2.1 acres.

It could be inferred from data in Tables 5.17 and 5.18 that the size of the cleared forest area, by the sample households, increased from 381 acres for the period between 1974 and 1978 to 467 acres between 1979 and1988, translated into an increase of about 22.6%. The number of 'active households' rose from 113 in the period between 1974 and1978 to 147 between 1979 and 1988. This was an increase of about 30.1%. In general, while the number of 'active households' increased by about 30%, the total cleared forest area increased by about 23% within the same periods. Of the 699 households, only 147, i.e. 21% of households cleared the forest for farm expansion. The remaining 552 did not expand their farms for various reasons.

Table 5.17 Forest Areas Cleared for Expanding Farms between 1979 and 1988

Cleared Area (acres/hh)	Frequencies	Total Cleared Area (acres)	Percentage
1	25	25	5
2	47	94	20
3	24	72	15
4	26	104	22
5	8	40	9
6	6	36	8
7	2	14	3
8	4	32	7
10	5	50	11
Total	**147**	**467**	**100**

Source: Field Survey, 2005.

5.4.6.3 Trends in Farm Expansion between 1989 and 2004

Survey data presented in Table 5.18 indicated that about 1201 acres of the forest were cleared in the period between 1989 and 2004. The farm clearing season for 2005 was not yet due, i.e. from July 2005. The data indicated that during the period, there were a total of 326 active households. Therefore, the average household contribution in expanding farms recorded was 3.7 acres. For the period of about 15 years, i.e. from 1974 to 1988, the estimated total area cleared for farm expansion was about 1,201, acres leading to an annual average of 80.1 acres.

The number of 'active households' increased from 147 in the period between 1979 and 1988 to 326 between 1989 and 2004, recording an increase of about 122%. This implies that in the period of ten years the number of households that expanded farms had more than doubled. These changes, which are possibly related to changes in population size, age structure and sex composition of the population, is the subject of this thesis and is discussed in Chapter 8 of the thesis.

The size of cleared forest land increased from 467 acres in the period between 1979 and1988; to 1201 acres for the period between 1989 and 2004, recording a drastic increase of about 157%. Within the last fifteen years, the amount of woodland forest cleared had more than tripled. The drastic increase in the numbers of 'Active Households' and the consequent tripling of the cleared area would partly be explained to be the impact of the *Mlale Resolution* of 1987 that aimed at promoting agricultural and social development within Ruvuma region. It was noted that 373, i.e. about 58% of the interviewed households did not clear the forest for expanding farms for various reasons.

Table 5.18 Forest Areas Cleared for Expanding Farms between 1989 and 2004

Cleared Area (Acres/hh)	Frequencies	Total Cleared Area (Acres)	Percentage
1	41	41	12
2	96	192	26.7
3	49	147	13.5
4	47	188	13.5
5	32	160	8.9
6	28	168	8.6
7	5	35	1.5
8	11	88	3.4
9	3	27	0.9
10	8	80	2.5
11	1	11	0.3
14	1	14	0.3
15	2	30	0.6
20	1	20	0.3
Not Applicable	373	-	-
Total	**699**	**1201**	**100**

Source: Field Survey, 2005

5.4.6.4 Expansion of Farmlands and its Impact to the Forest Cover

The general trend in deforestation, as contributed by expansion of farms, indicated an increasing trend in terms of both the numbers of 'active households' in the process and the amount of cleared forests areas within the specified time periods. This concedes to the general assertion that population size impacts negatively on the forest cover conditions.

Population pressure as experienced in WMCA was caused by population growth, the major reason for expanding human activities to areas previously 'free' from such activities. In some specific cases, like at *Lihwena*, *Chemchem* and *Muungano* villages, lack of public woodlands for farm expansion, due to urbanization and proximity to forest reserve restricted farm expansion, despite rising demand for farm produce motivated by human population growth and other factors. Two major types of responses emerged as a means of ameliorating the situation, which in the context of this thesis, are termed as coping strategies.

One of the coping strategies was the adoption of alternative agricultural practices that facilitated the increase in farm output in the same farm plot. It implies intensification and the use of *crop rotation, mixed farming* and the like. This strategy was likely to realize less, if any, farm expansion, thus reduce deforestation rate. The second category resorted into expanding human activities into the public forests and forest reserve and other ecologically sensitive areas. Reports on encroachment and poaching within the West Matogoro Forest Reserve tended to justify this (URT, 2005c). Some households undertook both alternatives depending on the criticality of the problems and prevailing typical local conditions.

The trends and observations indicated that if there had been land areas available for farm expansion, deforestation would have continued for years at an unabated rate. The observed poaching and encroachment in forest reserves indicate the great potential for further deforestation in future. This raises alarm for public forests, classified as common property regarding higher risk of disappearing (Madulu, 1991a)

Survey data in Table 5.19 indicate that between 1974 and 2004, the total of about 2049 acres was cleared for the purpose of farm expansion, by only 326 households out of the 699 interviewed households. This was an average of 6.3 acres of forest for each 'active household' cleared in the past 30 years translating into an annual rate of farm expansion of about 68.3 acres.

The socio-political, geographical and demographic factors that prevailed through time bear some explanations on trends in changes in farm expansion. How changes in demographic characteristics were related to deforestation is discussed in Chapter 8.

Table 5.19 Forest Areas Converted into Farms between 1974 and 2004

Period (Years)	Forest Area Cleared (Acres)	Percentage
1974-1978	381	18.6
1979-1988	467	22.8
1989-2002	1201	58.6
TOTAL	**2049**	**100**

Source: Field Survey, 2005

5.4.7 Households' Participation in Tobacco Cultivation

When asked about their participation in tobacco farming, the responses were as presented in Table 5.20. It was only about 17% of the 699 households who indicated that they grew the crop. Field observations indicated that though the crop was grown by a small section of the population, it was grown in all the eight villages. However, most of the growers were from *Mpingi* and *Kikunja* villages constituting about 38.3% and 25% of the total number of tobacco producers in the study area respectively. Despite the few households that grew tobacco, evidence from literature shows that it is a crop known for augmenting deforestation particularly in *Miombo* woodlands of vast parts of southern Tanzania and Malawi (Geist, 1996). The crop requires bulk of firewood for curing. Some wood was needed for the construction of the curing chambers, while some of it was used as stands meant for hanging tobacco leaves during curing process (Katundu and Mwaseba, 2007).

Literature, on the use of biomass energy in tobacco processing in Tanzania revealed that one hectare of woodland was used to cure one hectare of tobacco. It means one stacked cubic meter of wood was required for every 7.5 kg of tobacco leaf. Additional wood was destroyed when clearing new (other) fields for the crop. For the purpose of the thesis, and following Wood and Baldwin (1985), therefore, the estimation of $1m^3$ of staked firewood was taken as the quantity needed for curing 7.5 kilograms of tobacco.

The Baseline Study on Biomass Energy Conservation (2005) observed the lack of reliable data on firewood used for tobacco curing in Tanzania. However, the study gave an estimated amount of biomass needed to cure one ton of tobacco that ranged from $20m^3$ to $50m^3$. The average figure commonly used to estimate the amount of firewood used to cure one tone of tobacco was $42m^3$ of solid firewood as suggested by FRMP (1996) cited in URT (2005b).

Table 5.20 Involvement of the Sample Households in Tobacco Growing by Villages

Villages	Yes	Percentage	No	Total
Chemchem	2	1.7	93	95
Mahilo	1	0.8	64	65
Mpingi	46	38.3	57	103
Ndilima Litembo	0	0	69	69
Kikunja	30	25	55	85
Lihwena	18	15	96	114
Muungano	7	5.8	51	58
Lipaya	16	13.4	94	110
Total	**120**	**100**	**579**	**699**

Source: Field Survey, 2005

The general trends regarding households' involvement in tobacco growing indicated a fall in the numbers of new and old tobacco-growers through time. The number of tobacco growers showed a decreasing trend. PRA results attributed the decline of the crop to the fall in its market price. Other causes were unreliability of the grading system which victimized growers at the advantages of the international marketing syndicate. The extent to which tobacco cultivation contributed to deforestation was expected to decline with the decrease in the numbers of cultivators, improved method of its processing and the adoption of modern kilns.

5.4.7.1 Size of Tobacco Farms in WMCA

Survey data in Table 5.21 illustrate the total land area that was put under tobacco cultivation in 2004 was about 175 acres. The average size of the tobacco farms was 1.5 acres. High demand of firewood posed by the crop, for curing, required more clearing of the forest despite the small size of tobacco farms. In case of the presence of larger tobacco farms, the optimism drives one to relate it with realization of unprecedented deforestation rate. The data indicate that majority of households, i.e. 579 which constitute 82% of interviewed households did not grow tobacco.

Table 5.21 Distribution of Respondent Households by Size of their Tobacco Farms

Number of Acres	Frequency	Area (Acres)	Percentage
1	70	70	40
2	46	92	52.6
3	3	9	5.1
4	1	4	2.3
Total	**120**	**175**	**100**

Source: Field Survey, 2005

5.4.7.2 The Year Households Started Tobacco Growing

Survey data in Table 5.22 demonstrated that 55% of households who grew tobacco started growing it between 1989 and 1998. Twenty percent started between 1979 and 1988, while 7.5% started between 1974 and 1978. About 11% started growing the crop between 1999 and 2002, while 4% started between 2003 and 2005.

The drastic fall in the numbers of new entrants in tobacco farming confirmed that the crop was declining in terms of its significance to farmers. It is worth noting that the decrease in numbers of new tobacco growers, coupled with the decrease in the numbers of actual producers had a significant effect on the characteristics of the vegetation cover. One would think of a positive state of the forest cover. Majority i.e. 85% of the 699 interviewed households did not grow tobacco.

Table 5.22 Distribution of Respondent Households by Years Started Tobacco Growing

Period (Years)	Number	Percentage
1974-1978	10	9.5
1979-1988	21	20
1989-1998	58	55.2
1999-2002	12	11.4
2003-2004	4	3.8
Total	**105**	**100**

Source: Field Survey, 2005

5.4.7.3 Varieties of Tobacco, its Production, Processing and Firewood for Curing

Field observations and PRA results noted the two main varieties of tobacco grown in WMCA. One variety was cured by using firewood smoke, while the other was dried on the sun. The former was the most common type and had been grown in the area for ages. PRA results revealed that many households did not grow it because of the difficulties involved in the processing, a critical and determinant for grading and, *cateris peribus* the determinant of its market price. Several incidences of deaths of processors due to suffocation while curing tobacco were reported.

Tobacco contributed into the extended use of firewood essentially for curing the crop; therefore augmenting deforestation. Geist (1996) emphasized the same fact. The sources of firewood used for curing tobacco as presented in Table 5.23 demonstrates that most tobacco growers, about 73% obtained firewood from neighbouring public forests. About 12% chop mango trees to obtain firewood for curing tobacco. A small proportion of the growers, i.e. 6% used branches pruned from planted trees. A paper by Katundu and Mwaseba (2007) indicated existence of some efforts by tobacco marketing companies to reforest tobacco growing areas. However, some problems like cattle grazing, fire outbreaks, pests and diseases, shortage of rains and poor knowledge of the soil limited the efforts. Tree survival was threatened thus hampering success and effectiveness of aforestation programmes.

A small section of the respondents, i.e. about 2%, obtained firewood from the Matogoro Forest Reserve indicating that they poached; a sign of acute scarcity of firewood. How much of firewood they collected from the forest reserve matters more than the mere percentage of the respondents who poached. By the fact that a few indicated poaching from reserve portrays a greater likelihood of having more poachers, who declined identifying themselves cognizant of the possible legal consequences. Majority of the interviewed households, i.e. about 83% did not respond to the question as they did not grow tobacco.

Field observations revealed that crop cultivation and its expansion that was attributed to population growth, had a big impact to the changing environment, forest cover in particular. Population growth was mentioned to be the main factor for farm expansion that increased demand for food to feed the additional population. The proportion of people of different age groups and sex categories were engaged in deforestation-related activities and their contributions to deforestation are covered in Chapter 8.

Table 5.23 Distribution of Households by the Sources of Firewood Used for Tobacco Curing

Sources	Number	Percentage
Neighbouring open forest	90	73
Planted trees	7	6
Mango trees	15	12
Buying	2	2
Grow sun cured tobacco variety	4	3
Forest reserve	2	2
Don't know	2	2
Total	**122**	**100**

Source: Field Survey, 2005

5.5 Main Sources of Domestic Energy and Their Levels of Consumption

Domestic energy was considered to be of indispensable importance for day to day production and livelihood activities within households. Energy sources were noted to be significant in facilitating cooking, crop processing, lighting and the like (URT, 2005b).

5.5.1 Main Sources of Energy Used

Survey results in Table 5.24 indicate that about 98% of the households used firewood as the main source of domestic energy. PRA results specified that firewood was mainly used for cooking in the kitchen and for brewing local beer commonly called *pombe*.

Extensive use of firewood was attributed to lack of alternative sources of energy especially electricity. Kerosene was commonly used mainly for lighting. Limited use of kerosene for cooking was attributed to its high price. Only about 2% of the households used charcoal for culinary purposes. The Baseline Study on Energy Conservation conducted in Tanzania observed similar results (URT, 2005b).

The wide use of firewood was practically attributed to its simplicity in obtaining and how to use it. Neither money nor special skills was needed for one to use firewood; unlike the cases for kerosene and charcoal. It was well summarized, during PRA results that "while every household member could pick firewood and use it, only a few households had a member who could make charcoal; and who actually made it for household use". However, most of the charcoal makers did it for sale other than for home use (Johnsen, 1999).

Fewer household members had enough money to afford buying kerosene for cooking. As a consumer good, charcoal competed with other commercially available fuels like kerosene, gas, electricity and marketed fuel wood. Charcoal has a higher calorific value than firewood, lighter in weight and is smokeless, therefore was at an advantage compared to firewood (URT, 2005b). It was also argued that charcoal causes more deforestation as the makers cut the whole tree as opposed to firewood at most obtained by cutting tree branches (Wood and Baldwin, 1985., Johnsen, 1999). Therefore having fewer households that used charcoal had greatly reduced the rate of deforestation caused by charcoal making.

Table 5.24 Distribution of Households by Main Sources of Domestic Energy

Sources	Number	Percentage
Firewood	686	98.1
Charcoal	11	1.6
Kerosene	2	0.3
Total	**699**	**100**

Source: Field Survey, 2005

5.5.2 Firewood Consumption Levels

The reported actual weekly household's firewood consumption levels differed between households. PRA results indicated that levels of firewood consumption were influenced by the household size, the types of staple foodstuffs, availability of the type of energy source in question, presence and/or absence of substitutes, i.e. alternative energy sources. The Baseline Study on Biomass Energy Conservation conducted in Tanzania held a similar view (Wood and Baldwin, 1985; URT, 2005b).

Cost of a particular energy source was a determinant factor on the type and quantity of energy a household used and this depended on the income levels of the household in question[19]. Levels of energy use depended on a *complex mix* of consumption factors which included settlement size and/or proximity to roads or large towns; household income, household size, fuel costs (in cash, time and energy equipment), end use technologies, climatic factors and culture (tradition) which shape diet, cooking habits, use of fires, etc (Leach, 1988).

Survey data in Table 5.25 demonstrated that about 50% of the households used two bundles of firewood in a week; 28% used one bundle, 14% used three bundles while about 8% used over four bundles in a week's time. The weekly average amount of firewood used in sample households was about two bundles. The reality was that firewood bundle sizes differed broadly from one household to another and even within the household in time and by specific collectors.

Table 5.25 Distribution of Households by Weekly Firewood Use

Quantity (Bundles)	Frequency	Percentage
Don't know	3	0.4
1 bundle	193	27.6
2 bundles	351	50.2
3 bundles	98	14.1
4+ bundles	53	7.6
Not Applicable	1	0.1
Total	**699**	**100**

Source: Field Survey, 2005

The complexity of quantitative analysis of firewood use is based on lack of standardized volumetric measures (Wood and Baldwin, 1985). More complications were noted on the consideration of the moisture content that brings in the distinction between 'stake cubic metre' and 'solid cubic metre'. The differences in sizes (length and diameters), shapes and packaging systems are aspects neglected by most studies.

[19]Most of the time a combination of factors acted together to determine household's firewood consumption.

Firewood samples were randomly collected from four of the eight villages, i.e. *Kikunja, Mpingi, Lipaya* and *Chemchem.* Each bundle locally called *mzigo*, from collectors who were randomly stopped, was observed, number of firewood sticks counted and measurements of individual firewood sticks, in terms of length and diameter were taken and recorded. The data obtained on average firewood size are shown in Table 5.26.

Table 5.26 Summary of Average Firewood Size for Four Villages and Estimated Volumes

Place Recorded	Av. No. of Pieces	Av. Length (cm)	Av. Diameter (cm)
Kikunja	10	120	3.0
Mpingi	11	137	3.6
Lipaya	14	146.8	3.5
Chemchem	15	101	3.3
Total	**69.5**	**504.8**	**13.4**
Average	17.2	126.2	3.35

Source: PRA, 2005

The formula $3.14 \times (1.68)^2 \times 126.2 \times 17.3 = 19349\text{cm}^3$ was used to convert the firewood sticks collected into volume. Technically, *calorific value* of wood was to be measured on an oven dry condition. Literature estimated the daily average firewood consumption quantity to range from 1.0 to 2.0 kg *per* person. Thus most of them clustered around 1.5 kg *per* person. The Baseline Study on Biomass Energy Conservation stipulated the national average wood fuel consumption *per capita* as ranging from 1.0 to 1.5 kg of solid wood. Households constituted the highest share of total energy consumption in Tanzania, i.e. about 91% (URT, 2005b).

The volume of bundles of firewood for WMCA was obtained after conducting the average size analysis[20] of firewood bundles. From the calculations, one bundle was about 0.02m^3 of wood which was equated to about 20 kilograms. Based on the above calculations, the total estimated volume of firewood used by the sample households in a week in the area was about 28.1m^3. Thus the average household's weekly consumption was about 0.04m^3. The estimated total annual firewood consumption of the 698 households amounted to $1{,}461.2\text{m}^3$.

The estimated size of one bundle was therefore established by the calculation. In most households, women were responsible for collecting firewood for domestic use. Survey data in Table 5.27 demonstrate that about 76% of the households had women as firewood collectors. In about 20% of households both males and females collected firewood. Only 4% of households had males alone as collectors of firewood. PRA results substantiated the findings. The reasons behind the sex based division of labour observed in this and other activities will be discussed in detail in Chapter 7 of the thesis.

[20] Analysis of firewood bundles involved the random obtaining of quantities of firewood collected for household use and trying to convert them into standard measurements.

Table 5.27 Distribution of Firewood Collectors by Sex

Sex	Frequency	Percentage
Males	28	4
Females	529	75.7
Both	138	19.7
Not Applicable	4	0.6
Total	**699**	**100**

Source: Field Survey, 2005

PRA results revealed further that collecting of firewood was a difficult task which involved walking long distances to the sources, selecting the 'right' tree specie, cutting, arranging and tying the bundle (heap) and transporting them back home. In the case of WMCA, the average distance to firewood sources was about 2½ kilometres. In the course of the participatory discussion, it was established that "the longer the distance to the firewood source, the more was the time taken, the worse was the assignment and the more was the torture to the side of the collector." Toughness of the task augmented as the distance to firewood source tended to increase with time.

5.5.3 Peoples' Views on the Presence of Large Scale Firewood Business

Survey data in Table 5.28 indicated that 60% of the respondents were aware of presence of firewood business in the area. This was common for those villages located along the *Muhukuru* road that were accessible throughout the year. The business was prompted by the urban demand for firewood and charcoal which contributed into negative impact to the forest cover. By the time of the study, the Songea municipal had electricity supply to only 24% of households, hence implying heavy dependency on firewood and charcoal (URT, 2004). Institutions like hospitals, schools and prisons demanded large scale firewood supplies. However, existent poor roads moderated the deforestation rate by lowering volume of firewood business along the road to *Kikunja*, thus in a way, contributing to conservation of the public forests due to their inaccessibility.

Table 5.28 Presence or Absence of Large-scale Firewood Business in WMCA

Responses	Frequency	Percentage
Yes	421	60.2
No	278	39.8
Total	**699**	**100**

Source: Field Survey, 2005

5.5.4 Other Sources of Domestic Energy

PRA results noted existence of other sources of domestic energy than the ones mentioned above. Crop residues like maize cobs, dry cassava stems, dry cow pee twigs and others were commonly used. Such materials were used in areas or seasons with acute firewood shortage. This included *Lihwena, Muungano* and *Chemchem* villages, located within the urban proximity.

Crop residues were mostly available and used during the post harvest periods. It was also noted that animal dung was rarely used a source of domestic energy mainly due to scarcity of domestic animals. Crop residues and cow dung were, however, considered poor substitutes to firewood as they emitted less heat, produce more smoke and require much attention in fire management (Leach, 1988).

5.5.5 Opinions on Firewood Availability and Trends between 1974 and 2005

Survey data in Table 5.29 demonstrated mixed feelings among the respondents regarding the trends in firewood availability. This could be attributed to the differential village-specific environmental conditions. While some villages had vast public woodland areas around them; others had hardly a few trees to be cut for firewood. A study in Tanzania by Nkonoki observes that firewood scarcities were rather site-specific, but they were expanding rapidly, covering more areas. Furthermore, differences in terms of tree cover and density; and the intensity/extensive use of forest resources differed in specific village localities (Nkonoki, 1981).

5.5.5.1 Respondents Views of Firewood Availability

On firewood availability; while 67% of the households reported a decreasing trend, 32% of the respondents were of the opinion that firewood availability had not changed. A marginal section saw the positive trend, i.e. firewood became more easily available with time. The existent situation by the time of the study, coupled with the increased use of planted tree branches for firewood, made some respondents not depend much on natural forests as prime firewood sources. Such forests had almost disappeared in some villages like *Lihwena*, *Muungano* and *Chemchem*. The presence of a significant number of households that fell mango trees or pruned branches[21] for firewood, as observed by PRA results indicated a similar situation. However, such households that depended on planted or mango trees were likely to report an increase in firewood availability.

Experiences form firewood consumption surveys, for domestic uses, indicated that in areas with abundant firewood supplies, consumption of firewood *per capita* have ranged from 1.5 to 2.5. The wood deficit areas have consumption levels of as low as 0.5m3 *per capita per annum* (FAO, 1984: IUCN, 2004). This manifested little conservation orientation among community members in question, thus indicating existence of 'a room' for more efficient use that was likely to lower its contribution to deforestation.

Let it be clarified, at this point, that easy availability of firewood did not necessarily imply that natural forest cover of the area was not affected. It may conversely imply a greater danger caused by a high potential for over use and/or abuse of such resources. For those villages with no tree cover, easy availability could be taken to mean firewood availability from the use of planted trees found just around the homestead compounds, while natural vegetation cover was observed being completely depleted.

[21] Mango tree branches-when pruned reduced the ability of a mango tree to bear fruits. It limits the supplies of fruits, a source of vitamin C which is important.

Since the majority of respondents (household heads) were males, whose participation in the activity was observed to be minimal, their observations on the matter would bear some elements of bias. To them as long as 'everything went on well', they could easily report having no problems in firewood availability, while leaving the burden to women and children, i.e. the actual main firewood collectors. However, rapid decline in fuel wood availability was a common phenomenon reported in all regions of Tanzania (Nkonoki, 1981; URT, 1998).

Table 5.29 Respondents' Opinions on the Trends in Availability of Firewood since 1974

Responses	Frequencies	Percentage
Not applicable	2	0.3
Increased	10	1.4
Decreased	465	66.5
No change	222	31.8
Total	**699**	**100**

Source: Field Survey, 2005

5.5.5.2 Trends in Firewood Availability from 1974 -2005

Survey data in Table 5.30 indicated that a significant proportion of the respondents, i.e. 35%, experienced scarcity of firewood that started in the period between 1999 and 2004. The fact that some respondents, relatively few, indicated that shortage of firewood was initially noted in 1974 implying that the use of firewood and its consequent shortage is a long term phenomenon.

The increase in numbers of households that experienced shortage of firewood from 1974 to 2004 denoted the cumulative effect of firewood shortage that may logically be linked to the trends in human population growth and progressive deforestation. Presence of few respondents who noted firewood scarcity as a recent phenomena draws from those young household heads with no long term past experience. A larger proportion of the interviewed household heads, i.e. 244 constituting about 35% could not recall as to when the scarcity of firewood began.

Table 5.30 Households' Observations on the Year Firewood Scarcity Initially Noted

Period (Years)	Frequencies	Percentage
1974-1978	30	6.6
1979-1988	74	16.3
1989-1998	133	29.2
1999-2002	158	34.7
2003-2004	60	13.2
Total	**455**	**100**

Source: Field Survey, 2005

5.6 Changes in Village Size, Homestead Plots and Types of Homesteads

The need to establish changes in village settlement size emanated from the fact that population increase gave birth to rising demand for shelter and food. Construction of extra homestead was necessitated by the need to carter for extra population. This could be reflected in terms of spatial expansion of settled area that generally took place at the expense of natural forest cover.

The establishment of changes in village settlement area was based on people's perceptions. The reality that none of the eight villages were surveyed necessitated for the use of qualitative information obtained through PRA. The fact that the initial land areas covered by villages were not determined posed difficulty in ascertaining the quantitative spatial rate of expansion of the same. The qualitative information on changes in settled area, however, boldly indicated appreciable trends in expansion of settlement areas in all the eight villages through time.

5.6.1 Changes in Village Size Based on Local Communities' Perceptions

Survey data in Table 5.31 indicate that between 1974 and 2005, the settlement area had expanded. About 86% of the respondents noted the tremendous expansion of their settlements. Six percent of them saw no change, while only 1% observed a reduction. Evidence from PRA results portrayed the spatial village expansion during the period. The fact that homesteads in specific locations, expanded to areas previously forested cannot be contested. By the time of the study, the scientific quantification of the rate of settlement expansion could not be possible as none of the eight villages was surveyed. Spatial coverage of the villages was, in fact, unknown.

Table 5.31 Respondents' Opinions on the Trends in Changes in Village Size since 1974

Opinions	Frequencies	Percentage
Decreased in size	7	1
Expanded village area	601	86
Not expanded (the same)	42	6
Slow expansion (somehow)	49	7
Total	**699**	**100**

Source: Field Survey, 2005

Survey data in Table 5.32 indicated the reasons for expansion of settlements. About 53% attributed it to population growth resulting from *natural increase*, while 35% linked it with *in-migration*. Unequitable land distribution was another reason given for village expansion. Ownership of large tracts of land by some households, led to the adoption of a *scattered settlement pattern* that culminated into rapid settlements' spatial expansion towards areas previously covered by forests. It was also noted that some people who migrated into WMCA were attracted by good weather and soil fertility.

Table 5.32 Distribution of Respondents by Reasons for Expansion of the Village Size

	Responses		
Causes	**Number of Cases**	**Percentage**	**Percentage of Cases**
Don't know	21	2.1	3
Good weather	11	1.1	1.6
Births	515	52.7	73.7
In-migration	344	35.2	49.2
Population relocated Vijiji	20	2	2.9
Out migration	17	1.7	2.4
Nearness to Songea town	30	3.1	4.3
Seek for fertile area	9	0.9	1.3
Few owning large land	5	0.5	0.7
Agricultural expand (selling)	5	0.5	0.7
Total	**977**	**100**	**139.8**

Source: Field Survey, 2005

5.6.2 Size Homestead Plots

Survey data in Table 5.33 indicated that most of households were located away from their farms though some homesteads were surrounded by small farms. About 75% of homesteads were located within plots of 1 to 2 acres. Those households with homestead areas of 2 to 3 acres constituted about 12%. There were fewer households that had plots of more than 3 acres. The average size of homestead farm areas was about 2.5 acres indicating small plots that portrayed the relatively *clustered* settlement characteristics. Small homestead land areas connoted the limited possibility for planting woodlots. Such small plots were un-surveyed and traditionally used for crop cultivation. About 162 households could not establish sizes of their farm plots.

In some specific local cases like those in the villages of *Lihwena* and *Chemchem,* their proximity to the Municipality of Songea was mentioned to be responsible for the rapid expansion of settlements. Faster growth of population was partly contributed by rapid urbanization.

Table 5.33 Size of Household Land around the Homestead

Area (Acres)	Frequencies	Percentage
1-2	403	75
2.1-3	66	12.3
3.1-4	19	3.5
4.1-5	21	3.9
5.1+	28	5.2
Total	**537**	**100**

Source: Field Survey, 2005

5.6.3 Types of Homesteads by Types of Building Materials

Survey data in Table 5.34 demonstrate that about 78% of the households had molded bricks at least once; and that their houses were built by baked bricks. A considerable proportion of the brick houses were thatched with grass. About 22% of homesteads were built by wood-poles and mud while grass was the main roofing material. Most of houses (about 51%) were roofed with corrugated iron sheets.

Table 5.34 Distribution of Households by Involvement in Molding /Baking Bricks

Response	Number	Percentage
Yes	548	78.4
No	151	21.6
Total	**699**	**100**

Source: Field Survey, 2005

The making and consequent use of baked bricks contributed into deforestation since it made use of firewood for baking bricks, culminating into a decrease in forest cover. The use of grass for thatching homestead roofs necessitated the use of wood-poles that augmented deforestation. The two aspects were noted to raise the degree of utilization of forest resources, thus increasing deforestation further. The extent various activities contributed to deforestation will be discussed in Chapter 8.

5.6.3.1 Estimated Number of Bricks Molded

A broad variation was noted in terms of the number of bricks made in the 699 sample households. Data in Table 5.35 indicated that about 548 households made baked bricks for their own homesteads. The remainder 151 had never made bricks and that they lived in homesteads made of mud and/or wood poles; thus they as well contributed to deforestation.

Of the 548 households that molded baked bricks, the minimum number of bricks *per* household was 300 while the maximum number was 50,000. The median value of bricks was 4000 bricks, while the mode was 3000. There were a small proportion of households which produced more than 20,000 bricks. Such households were big, therefore required more additional buildings to accommodate the extra household members. Survey data indicated that a total of 2,630,811 bricks were made by the households, recording an average of 3764 bricks *per* household, and 4800 bricks *per* 'active household'.

Baked bricks were locally made by using red and/or clay soils and burned by using firewood fetched around the construction sites mostly from within the respective villages. Household members performed the activity. PRA results revealed that bricks molding was the duty of mature males, who were traditionally responsible for building a shelter.

Table 5.35 Estimated Numbers of Baked Bricks Molded in Households

Number of Bricks	Frequencies	Percentage
300-5000	459	83.8
5001-10000	70	12.8
10001-15000	9	1.6
15001-20000	3	0.5
20001-25000	1	0.2
25001+	6	1.1
Total	**548**	**100**

Source: Field Survey, 2005

5.6.3.2 Frequency of Making Baked Bricks by Using Firewood Furnace

Different responses were obtained regarding the frequencies at which households made baked bricks. Survey data in Table 5.36 demonstrated that the majority of households, i.e. about 61% made bricks at least only once, while 14.4% made bricks twice; and 21.6% did not make bricks at all. As most of the bricks were made for use by the households, their frequency may reflect a number of buildings that were built by a specific household. Not having molded bricks meant living in a non-brick house. There was a necessity to estimate the amount of firewood used for brick burning in order to established and underscore the impact of the activity to deforestation.

Table 5.36 Distribution of Households by the Frequency of Molding/ Baking Bricks

Frequency	Number	Percentage
Once	423	60.5
Twice	101	14.4
Three times A year	15	2.1
Occasionally	9	1.3
Not Applicable	151	21.6
Total	**699**	**100**

Source: Field Survey, 2005

5.6.3.3 Amount of Firewood Used for Brick Baking

The bulk of firewood was noted to have been used for baking bricks. Since the majority of the households made baked bricks at least once, it implies that the activity had actually contributed into deforestation. The fact is that those who were yet to make bricks constituted potential baked brick producers and the future reducers of the forest cover. PRA results revealed that each household would like to have a brick house, which was an overt sign of development to the villagers of WMCA.

Survey data in Table 5.37 indicated that an estimated amount of 4196 m^3 of firewood was used for brick baking between 1987, when the *Mlale Resolution* was passed, and by mid 2005. The average amount of firewood used for the purpose was 7.6 m^3 *per* 'active household'. The average for the entire 699 interviewed households was 6.0 m^3 of wood.

Table 5.37 Distribution of Respondents by Amount of Firewood Used for Brick Baking

Firewood (m^3)	Frequency	Firewood (m^3)	Percentage
1	10	10	0.24
2	13	26	0.62
3	44	132	3.14
4	48	192	4.6
5	63	315	7.5
6	96	576	13.73
7	46	322	7.7
8	68	544	13
9	7	63	1.5
10	79	790	18.83
12	19	228	5.4
13	6	78	1.85
14	9	126	3.0
15	17	255	6.0
16	7	112	2.7
18	3	54	1.3
20	7	140	3.3
22	2	44	1
24	1	24	0.6
25	1	25	0.6
30	2	60	1.43
40	2	80	1.9
Total	**699**	**4196**	**100**

Source: Field Survey, 2005

The Baseline Study on Biomass Use in Tanzania indicated that the energy used to bake a brick in traditional brick kilns was between 1 and 4 MJ *per* kilogram of brick in Songea district. It was established that on average, 1m^3 of firewood was used to fire 1000 clay bricks and that 1000 clay bricks were required to construct a three bedroom house of which 10m^3 of firewood was used (URT, 2005b). The assumption was that all bricks were of the same size.

Field observations indicated that the efficiency in brick burning could be improved to reduce the energy expended for the activity. Supervision of the kiln during the firing period and the use of wood with less moisture alone would significantly reduce the quantity of firewood used (URT, 2005b).

5.6.3.3 Sources of Firewood Used for Baking Bricks

Since the activity of making and burning of bricks was carried out by some household members, in the respective homestead plots, collection of firewood for burning bricks was done within the village vicinity. Distance to firewood sources varied from one village to another depending on the environment of a specific locality, pertinent to presence of forest cover and its control. The volume of wood needed for the purpose was big enough to favour proximate firewood availability.

Survey data in Table 5.38 indicated that about 21% of the respondents did not make bricks at all therefore did not use firewood for the purpose. Most of households, i.e. about 39% of the respondents got firewood supplies needed for burning bricks from the *public woodlands* located within or adjacent respective localities. About 22% of the households used mango tree branches for brick baking. A small proportion of the respondents, i.e. about 1.5% bought mango trees from others for the purpose. Field observation revealed the extensive use of old mango trees for brick baking. Mangoes, being an important source of vitamin C, were reduced in supplies raising concern about the future availability of fruits. Eleven percent of the respondents obtained firewood from planted trees. Field observations noted existence of some exotic plant species most of which were planted in 1990s under regional Agro-Forestry Project.

Very few respondents, i.e. 1.6% conserved natural trees (natural forests), as their own initiatives towards protecting forests as sources of firewood and other products. They obtained firewood for burning bricks from self conserved forests. Others, i.e. 2% bought firewood that was brought from places they did not know; while 2% indicated to have obtained their firewood through poaching from the Matogoro Forest Reserve. The entire scenario pertinent to firewood supply signifies acute shortage of firewood. Poaching became an alternative solution to the rising firewood demand. The potential for poaching was likely to increase with the expanded resource scarcity over time and population growth.

Table 5.38 Distribution of Sources of Firewood used for Baking Bricks

Source	Number	Percentage	Percentage of Cases
Own Mango Trees	163	21.8	23.3
Planted trees	86	11.5	12.3
Open woodlands	291	39.0	41.6
Buying	14	1.9	2.0
Conserved Natural Forest (own)	12	1.6	1.7
Buying Mango trees	11	1.5	1.6
Forest Reserve	16	2.1	2.3
Not Applicable	154	20.6	22.0
Total Responses	**747**	**100**	**100**

Source: Field Survey, 2005

5.6.3.4 Trends in Use of Wood-poles in Construction and the Reasons Behind

PRA results observed that most of people of the area did not use wood-poles for homestead construction any more. The use of wood-poles in construction was termed as *out-of-date* and signaled 'backwardness'. Wood poles availability, meaning obtaining tall and straight poles was limited by forest depletion. The most preferred plant species for the purpose were in acute scarcity. Tree species locally called *Mivanga (afromansia angolensia)*, *Miombo* (*brachystegia spp*) and *Mimbula* (*parinari excelsa*) were no longer easily available. Long distances to the sources of such tree species, located in remotest sections of the forest, manifested the shortage and hindered their use.

When asked on the period of scarcity of wood-poles was initially noted, the responses were as presented in Table 5.39. About 39% of the respondents mentioned the period between 1988 and 1998, while about 28% reported the period of between 1999 and 2002. About 24% mentioned the period from 1979 to 1988. The general trend indicated a decline through time forcing some community members to stop using them. Majority of respondents, i.e. 402 constituting about 58% did not respond to the question likely for not knowing when the scarcity started.

Table 5.39 Households' Responses on Year Wood pole Scarcity was Initially Noted

Period (Years)	Frequency	Percentage
1974-1978	11	3.7
1979-1988	70	23.6
1989-1998	116	39.1
1999-2002	82	27.6
2003-2004	18	6.1
Total	**297**	**100**

Source: Field Survey, 2005

5.7 Main Types of Land Use and their Changes between 1978 and 2004

Appreciable spatial expansion of village settlements that took place in WMCA was likely to continue as population kept growing through *natural increase* and *in-migration*. Population growth raised the demand for more land for homesteads, farming and other services from natural resources. The range of social and economic activities carried out in the area expanded profoundly. It sometimes happened with the introduction of new types of land uses that were important to livelihood and development.

Expansion of human activities, in terms of spatial coverage, was a response to the types of land uses in practice. Conversely, types of land use do influence the appearance of the specific area in terms of natural vegetation cover. It is a *replica* of the actual natural resource use in the locality. Descriptions on types of land uses and their changes through time, based on the perceptions of the communities of WMCA, are presented in sections 5.7.1 and 5.7.2.

5.7.1 Main Types of Land Use

Survey Data in Table 5.40 indicate agriculture to be the main economic activity and the main type of land use. Farming was practiced mainly under *smallholder system* that dominated rural economies of WMCA and in Ruvuma region in general. A study by Haule (1998) indicates that farmers of *peri urban* Songea used small quantities of modern agricultural inputs mainly for lack of financial resources. Farmers could not afford buying enough agro chemicals since they were too expensive.

Smaller sections of the population dealt with animal keeping who grazed animals in public woodlands. Other small proportion of population dealt with other activities than farming that included carpentry, building, casual labour etc.

Table 5.40 Distribution of Households by Main Economic Activities

Activity	Frequency	Percentage
Farming	671	96.0
Livestock	5	0.7
Traditional crafts	5	0.7
Petty business	3	0.4
Builder	3	0.4
Employment	5	0.7
Casual labourer	2	0.3
Carpenter	4	0.6
Tailor	1	0.1
Total	**699**	**100**

Source Field Survey, 2005

Other economic activities of the area were as shown in Table 5.41. About 49% had no other activity than farming, while the rest of the population had alternative activities. About 22% of the households dealt with petty business mainly operators of small provisional shops commonly known as *duka.* From *dukas* community members obtained essential commodities mainly kerosene, salt, matches, soaps, stationeries and others. Field observation revealed that even those households whose main activity was other than farming reported to have actively participated in farming because they had to produce food for their households.

Table 5.41 Distribution of Households by Other Economic Activities

Activity	Frequency	Percentage
None	340	48.6
Cultivation	20	2.9
Petty business	156	22.3
Keeping animal / poultry	59	8.4
Casual labour	19	2.7
Lumbering	18	2.6
Milling cereals	3	0.4
Crafts	17	2.4
Builder	18	2.6
Making hair	1	0.1
Carpentry	14	2.0
Growing vegetables / tomatoes	29	4.1
Tailoring	4	0.6
Radio repairing	1	0.1
Total	**699**	**100**

Source: Field Survey, 2005

Settlements constituted the second major type of land uses. The rural settlements were designated as villages and administered under the local government system. Village administration and management powers were vested on the Village Executive Committee that reported to the Executive Officer, an employee of the government (URT, 2000). Lack of qualified personnel limited the functions of village authorities.

The Village Executive Committee oversaw daily running of the village, pertinent to productivity, peace, social services and environmental conservation. It was our observation that the continuous expansion of rural settlements, through time, to the areas previously covered by the public woodlands, needed a more effective land use planning. Due to rapid population growth, the rising demand for natural resources necessitated for the expansion of human activities.

Tree planting was another type of land use of the area though not extensive. Only a few areas had planted trees. The fact that the communities indicated shortage of vegetation resources that were important sources of firewood, building poles, wind breakers and the like, it was logical and significant to urge for enhancement of aforestation activities. This would provide alternative sources of wood materials as opposed to the traditional dependence on the already dwindling natural forest. Other livelihood activities were animal keeping, masonry, vegetable cultivation, traditional crafts making. Charcoal making was illegal, thus only few indicated engaging in the activity.

5.8 Indicators of Development

Development has been defined differently depending on ones perception. In the context of this thesis, it refers to any effort that transforms the household or community wholly or partially into a better status than it used to be. The definition was based on local communities' perception. The definition was leveled and practical at community level not at the level of an individual.

Several *indicators* were developed during PRAs when trying to define development. The ones agreed were adopted as indicators of development in this context. Based on the study findings, it was evident that development of WMCA could be traced based on the PRA defined indicators presented below.

5.8.1 Expansion of Farms

Owning a farm was noted to be among the highly ranked indicator of development. It meant having a tract of land with the possibility of tilling it and using products for other purposes. The possibility for expanding a farm whenever the need arose and the actual expansion of farms defined development in practical and spatial terms. The expansion of farming, which is the main economic and livelihood activity for people in WMCA, implied more income or insurance for the subsistence of households.

5.8.2 Firewood Availability/Scarcity

As firewood use dominated the area, it conventionally implied that the area was less developed. However, while carrying out a vertical assessment of the same community, issues of firewood availability, quantity and quality of firewood obtained became of significance. Firewood scarcity indicated development as the natural resources that were previously satisfactory became scarce, as its use expanded thus demanding for alternative energy sources. In this case, the more the firewood use the more the likelihood for people to indulge into vast development activities that affected the forest cover.

5.8.3 Expansion of Human Settlements

Expansion of village settlements, through time, denoted development as it implied growth in human population that necessitated expansion of economic activities which accounted for the observed forest cover change. Expansion of the village settlement, in spatial terms, was as well termed as development. This was associated with population growth that demanded for the necessary expansion of settlement to accommodate extra population in terms of both farmland and homesteads. Population growth and expansion of human activities pushes the frontiers of the forest away.

5.8.4 Owning a Modern House

Owning a homestead was another indicator of development. PRA results indicated that having a permanent house, which *Mlale Resolution* called "modern house' defined in terms of being built using baked bricks and roofed with grass or corrugated iron sheets, was an indicator of development. Having noted that brick houses dominated the area, it sounded logical to regard it as an indicator of development.

5.8.5 Income

Income was another indicator of development though the cut off point on how it benefited the community as a whole could not be agreed. The point of emphasis was that the condition of having constant household income or ability of purchasing the necessary industrial commodities such as sugar, soap, kerosene and the like were adopted. The rise in income, in terms of the amount of money one earned from his/her activities, was considered significant though the amount was mainly estimated incomes, although its availability was never regular.

5.8.6 Level of Education

Education was another indicator of development. The household with a member who achieved secondary education or higher and was formally employed in town realized trickle down effect of income remittances thus led to its enjoying relatively better life.

Having a *duka* was considered to be an indicator of development as it meant constant income earnings. Ownership of other items such as furniture, radio and bicycle were other indicators of development since they facilitated other activities through bringing comfort, informing and enhanced easy mobility of goods and people.

From the above, we were forced to adopt the definition of development, as guided by the local communities' initiatives to meet their livelihood requirements, basically through the utilization of surrounding natural resources. For the above reasons, words 'livelihood' and 'development' were synonymously used in this thesis. We tend to note, having a clear definition of indicators of development, for a rural setting, cannot avoid linkage to the environment. The land and forest cover remains basic for rural sustenance and advancement of the communities in question.

5.9 Conclusion

The general life systems of people and the respective supporting land use practices were observed to rely on the quantity and type natural resources available in the locality. The main primary resource used by local communities was land implying soil, spatial area, vegetation and water, which also included other natural resources included wild animals, fisheries, wild fruits, honey, and the like (Kerk *et al.,* 1994).

Communities of WMCA lived a modest life signified by small income levels. The average annual *per capita* income of Tshs 71,742 (US$ 55) indicated a conventionally low level of development. National statistics by National Bureau of Statistics (NBS) indicated that the incomes of the region increased from Tshs 57,600 in 1994 to Tshs 499,716 2005 in 2005. By 2007 the *per capita* of the region rose to Tshs 599,794 (URT, 2008), although the reality of the situation differed by locality and households. Nevertheless, the fact that they depended on subsistence economies justifies arguing that they were assured of livelihood through the use of natural resources at hand.

The area realized expansion of human activities through time. This was an indicator of development that came as a result of individual household's struggles with life. Between 1974 and 2004 about

2,049 acres of the forest were cleared for establishing extra farms. The very process of farm expansion signifies reduction of forest cover. It is important observing that farm expansion has been historical and that it will continue to expand as human population kept growing. By 2004, tobacco farms covered about 175 acres thus augmented deforestation in the area.

The settlement areas in each village was mentioned and observed to have expanded. The exact spatial dimensions of expansion could not be readily determined for lack of survey data. However, construction of extra homesteads meant to accommodate extra population necessitated the spatial expansion. Human settlement areas were mentioned to have expanded to areas previously covered by the forest.

The use of firewood as the main source of domestic energy was noted. The weekly household's average firewood consumption was $0.04m^3$. The total weekly firewood consumption was $28.1m^3$. The estimated total annual firewood use was $1,461.2m^3$, indicating that firewood use contributed significantly to deforestation. Dominance of households built using baked bricks was a remarkable development feature, despite its being linked to the observed vast deforestation. Poor social services that characterized the area translated into limited development endeavours. Poor roads, health services and educational institutions resulted into limited possibility for further growth and development. The communities of the area pursued more of livelihood than development.

Means of land acquisition tended to influence ownership. Most of the land was obtained by clearing the jungle thus owned through customary basis. Such land could easily be reclaimed by the government for the purpose of any community development project(s). The presence of few households that owned land formally indicated tenure insecurity, thus limiting possibilities for effective conservation and long term investment. The fact that changes in land tenure were minimal underlined the characteristics of *smallholders*, some of which were detrimental to forest cover.

The situation in WMCA indicated that the scale and extent of the impact of human activities on natural vegetation cover had risen precipitously in recent years; an aspect that possibly threatened the availability of water and changes in the *micro climate*[22]. The conceptualization that population growth leads into expansion of development activities has, for this case, proven correct. Agriculture, the main economic activity, was directly implicated as the more responsible factor for the decrease in forest cover. Other activities that contributed to forest cover changes included firewood use and expansion of human settlements. What needs to be known is whether the changes in development activities were related with changes in human population's age structure and sex composition, an aspect discussed in Chapter 8.

[22] Data on the climate of the area indicated a rise in mean annual temperature (minimum temperature) by 1.6°C. Total annual rainfall decreased by 264 mm and the rain season was reduced from six to four months

CHAPTER SIX

ENVIRONMENT OF WEST MATOGORO CATCHMENT AREA AND ITS CHANGES

6.1 Introduction

The chapter appraises, describes, and documents the environmental situation of WMCA particularly with regard the status of vegetation cover. It had to provide an in-depth description of the characteristics and changes in forest cover; and a review of the consequent hydrological and climatic conditions examined in terms of *river discharges*, temperatures and rainfall for the period between 1978 and 2005. The chapter constitutes the environment component used in the analysis of PD and E relationship. The chapter is aimed at producing requisite inputs for examining the existing relationship between population, development and environment, an aspect discussed in Chapter 8. The analysis covers the entire WMCA, with descriptions on the specific man-nature relationship based on the data and information from the eight villages covered by household survey.

Remote sensing techniques were used in monitoring changes in vegetation cover. Geographic Information System (GIS) was used as a tool for processing and analyzing data on the forest cover change. The availed *Land*sat images of 1969, 1990 and 2000 were used as baseline data for estimating the deforestation rates for the years under review, i.e. 1978, 1988, 2002 and 2005.

The information on trends in environmental changes will be linked with trends in changes in characteristics of human population, i.e. population size, age structure and sex composition to establish the existing PDE relationship. Involvement of household members in tasks that contributed to deforestation by age groups, sex categories and levels of education were considered significant variables in determining PDE linkages. These were variables that actually define the nature and character of the interface between population and environment.

Data on the *river discharges* of the two main rivers that originate from WMCA were analyzed to establish trends in *discharges* and the impact of catchment deforestation. Reliable data for the *minimum flows* of the two tributaries of the *Ruvuma River* for the period 1974 to 2000 recorded at two gauging stations, i.e. *Ruvuma River* at *Muhiga* (No. 1Q7) and at *Ligowonga* (No. 1Q10) on the *Likonde River* as presented in Table 6.7 and 6.8 were used in the analysis. Data on *river discharges* were obtained from the Songea River Basin Office[23]. The analysis on discharges covered the period between 1978 and 2000 for which data were available. Long term data series were used for trend analysis in volumetric changes of the two rivers.

[23] River Basin Office is the Regional Office that monitors river *discharges* and regimes within Ruvuma region. It is responsible for the management of the basins of the main rivers in the entire region

Climatic data on temperature and rainfall were obtained from the Tanzania Meteorological Agency Songea branch [24]. The data recorded at the Songea Airport weather station for the period of 26 years, i.e. from 1978 to 2004, were used in the analysis. The main hypothesis was that population size; age structure and sex composition, due to expanded human activities, negatively impacted on forest cover due to expanded human activities that caused or accelerated deforestation and adversely affected *weather* and *river discharges*. Deforestation reduced the *catchment value* of the forest which in turn adversely impacted on the *in situ* human population.

It could be logical and factual arguing that the impact of today's population, on the environment, is likely to be realized after a considerable period to come. The reality is that the population of 1978 had interface with the forest through various human activities. Its impact on vegetation cover might have initially be observed within a short period; while effects of the impact to the *catchment value* and/or climate would be realized, may be, after a considerably longer duration.

The extent to which human population impacted on the forest cover change, through various human activities, is an aspect thoroughly discussed in Chapter 8. However, the drawing of PDE linkages could not be possible devoid of the assessment covered in this chapter. The understanding of the environmental conditions and their variations or changes over time was deemed an indispensable step in analyzing PDE linkages. This generated baseline data and information was crucial for the time-line analysis of the linkages in terms of spot analysis and/or based on trend analysis. Local perceptions regarding 'causes and effects' of deforestation were significant in the analysis as it was the community members who caused deforestation; and were equally the very ones who required to play role in sustainable forest conservation. It was the gist of the chapter to quantify, rationalize and examine the trends in environmental changes as related to population changes and expansion of human activities.

6.2 Vegetation Cover Characteristics and Their Changes between 1978 and 2002

6.2.1 Changes in Vegetation Cover through Time

Vegetation cover of WMCA has been changing through time. Expansion of village size and the associated growth in demand of forest products and food, caused by population growth contributed to deforestation. Observations in chapter 5 indicated spatial expansion of farms and human settlements through time. Specific rates of decrease in forest cover resulting from such activities are issues discussed section 6.2.2 below.

[24] Tanzania Meteorological Agency Songea Branch is the Government Agency dealing with weather data collection, keeping, processing and dissemination. It is the organ that forecasts daily weather in Tanzania.

6.2.2 Peoples' Awareness on the Significance of Forests

Survey data in Table 6.1 portrayed high levels of awareness among local communities regarding existence and significance of natural forests. A large proportion of the respondents, i.e. about 43% mentioned Matogoro Forest being part of the catchment forests of the area. Other forests mentioned included *Masumeli, Mkurumusi, Matunduweli, Lihomenilo, Lipasi, Ndanji, Muwawa, Matarawe, Tulieni, Mwanzimmoja, Mamboya, Nanyimbo, Ngohi, Njuga* and Kilombero. The above-mentioned forests constituted a single tree cover *continuum* that formed the West Matogoro Catchment Area. PRA results indicated similar results.

The argument advanced at this juncture is that knowing the surrounding forests implies having a vested interest in them, an aspect that engendered the possibilities for using them (sustainable use), misusing them (over using or destroying them) and/or conserving them. The thesis perceived knowing state of the environment as the primary condition for planning of any sustainable conservation efforts.

The Matogoro Forest Reserve was known to most respondents by the fact it was a forest reserve. Matogoro Forest Reserve was significant in enhancing the *catchment value* of the area. Other forests, i.e. *public woodland forests* listed above were known to fewer people who directly used them in various ways.

Local communities regarded the *public woodlands* as areas designated for indiscriminate activities, thus they experienced fast reduction in tree cover. Such forests were highly affected by human activities whose extent and impact had to be determined. Although public awareness on the impact of global deforestation has been on the increase in recent years, the phenomena has not slowed down appreciably (WRI, 1998). Loss of vegetation cover was partially offset by plantations and gradual re-growth and expansion of forested areas in the developing countries. Generally the rate of deforestation has been noted to be higher than replacement levels (FAO, 2000b). It is envisaged that knowing or understanding the neighbouring catchment forests was the starting point for sustainable conservation efforts. The fact is that one cannot conserve the resource he/she is not aware of.

6.2.3 The Contemporary State of the Forest Cover in WMCA

FAO defines deforestation as "an ecosystem with a minimum of 10% crown cover of tree or bamboo, covering an area of not less than 0.5 hectare; with the minimum tree height of 0.5 metre; associated with natural soil conditions and not subject to agricultural practices. PRA results revealed specific indicators used to determine the changes in vegetation characteristics (FAO, 2000b).

The characteristics described in Section 6.2.3 were used to formulate the working definition used in the study context. Thus the definition of the forest generally adopted in the thesis is "the progressive removal of trees from the *woodland* without allowing requisite regeneration and/or planting". Hence, any activity that reduced forest cover was considered contributing to deforestation. The definition was focused enough to enable the analysis of PDE relationship. PRA results developed a general explanation regarding the rate of deforestation experienced in WMCA. PRA participants conceded on the sharp decreased in numbers of trees compared to the situation that prevailed in the last two decades. PRA participants were of the opinion that the distances to firewood sources had also increased over time. By the time the PRA was conducted (2005), the average distance to the sources of firewood was 2½ kilometers.

Those tree species, traditionally used for firewood, were no longer easily available. Even the plant species formerly not used for firewood like *Misuku* (*uapaca kirkina*) were found being used for the purpose. This indicated acute shortage of the preferred species. Some species like *Miombo* (*brachystegia spp)* were no longer easily available within closer range signaled progressive deforestation. Different tree species have different uses to local communities. Chimwala noted that *Masuku*, i.e. fruits of *Uapaca Kirkina,* the most preferred wild fruit, used as a raw fruit for making jam, its roots, barks and leaves were used for curing dysentery and indigestion (Geist, 1996).[25] In the case of WMCA, such trees were observed to be disappearing and had become endangered.

At *Chemchem* village, mango trees were commonly used for firewood mostly for burning bricks. The observed remains of mango tree stems, whose branches were pruned for the purpose, portrayed acute shortage of the energy resource and indicating extensive deforestation. There was a possibility for future shortage of fruits like mangoes to the population especially for children who need a variety of vitamins.

At *Lihwena* and *Muungano* crop remains were commonly used as a source of domestic energy for lack of firewood. Maize cobs, cassava stems and bamboo stems were more commonly used. They substituted the use of tree branches for firewood portraying acute firewood shortage. The area had notable absence of forests, a phenomenon hereby demonstrating deforestation.

Some of plant species like *Mivanga* i.e. *afromansia angolensia*, commonly used as building poles for their remarkable durability, had almost disappeared. In many instances such species were fetched from remote areas. PRA results revealed disappearance of some wild fruit trees such as *Ndavatava* (*flacourtia indica*), *Mimbula (parinari excelsa)* and *misuku* (*uapaca kirkina*). Wild fruits, formerly found within the village vicinity, could only be collected from far distance away from the vicinity of villages. PRA results also revealed that in some places some wild fruits had totally disappeared.

[25] *Uapaca Kirkina* was common wild fruit plant specie in Ruvuma region. Its wood was not preferred for firewood because of low energy potential. However, with shortage of firewood it became a substitute to the scarce preferred species, therefore slowly disappeared in most of the villages.

Strong winds were reported to destroy both homesteads and crops in vast parts of WMCA due to absence of trees that acted as the natural windbreaker, a phenomenon which depicts the impact of deforestation. Accelerated soil erosion reported at *Mahilo*, *Mpingi* and *Kikunja* villages, confirmed the same. Soil erosion led into the loss of *topsoil* leading into the consequent dwindling crop out put. The phenomenon prompted the high rate of farm expansion evident in the study area as a coping strategy to depletion of soil fertility. The practice of *bush fallowing* that translated into *shifting cultivation* was widely practiced in villages with *open forests* and greatly reduced the forest cover.

The frequently reported cases of encroachment and poaching within the West Matogoro Forest Reserve, notwithstanding the tight security system in place, manifested the increased human population pressure on the forests. Lack of alternative sources of forest-based resources, for local community members to use, necessitated poaching (URT, 2005b). Both PRA results and field observations revealed sources of some rivers being highly devastated by human activities as they were left devoid of vegetation. River valleys were mostly occupied by small scale farming, thus threatened to dry out; signaled and evidenced by decreasing water volume. *Land*sat image Figure 6.1 demonstrates the state of the forest cover in WMCA in 2000.

Deforestation, reported in WMCA, was an on-going environmental process attributed to expanded livelihood/development activities mainly of the *in situ* population, influenced by its engendered demographic characteristics.

6.2.4 Changes in Forest Cover Characteristics from 1978 to 2002

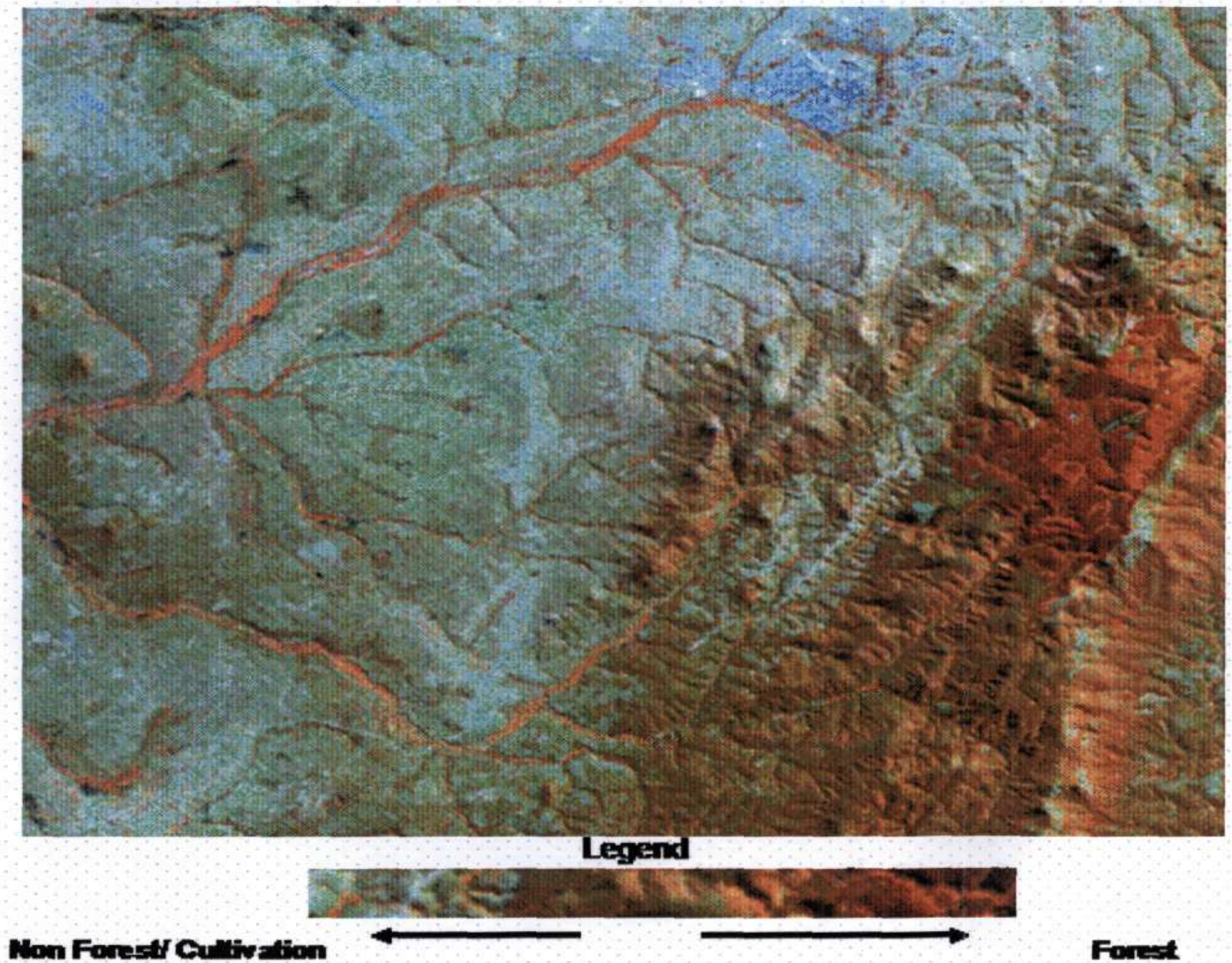
The changing characteristics of the forest cover for the period between 1978 and 1987, 1988 and 2002 and between 2002 and 2005 were analyzed. Analysis on the forest cover status and periodic changes in vegetation cover technically referred to as the Forest Cover Change Matrix is presented in Table 6.1.

Table 6.1 Forest Cover Change Matrix for WMCA from 1978 to 2005

VEGETATION TYPES	1978–1988		1988-2002		2002-2005	
	Ha	%	Ha	%	Ha	%
Closed Woodland	6,960.6	44.8	5,699.9	24.2	3,040.4	10.6
Open Woodland						0.0
Woodland with Scattered Cultivation			22.0	0.1	636.5	2.2
Open Bushland	408.0	2.6				
Bushland with Scattered Cultivation	3,641.0	23.4	6,091.3	25.9	5,484.5	19.1
Grassland with Scattered Cultivation	128.9	0.8	399.1	1.7	624.5	2.2
Mixed Cropping	4,252.7	27.4	11,392.7	48.5	19,169.3	66.8
Swamp/Marsh (permanent)	140.8	0.9	-92.1	-0.4	-249.8	-0.9

Source: TANRIC, 2005

Figure 6.1 Satellite Image of WMCA Showing Contrasting Vegetation Cover in 2000



Source: TANRIC, 2000

6.2.4.1 Extent of Deforestation for the Period between 1978 and 1988

In the period between 1978 and1988, about 608 Hectares of *closed woodland*, i.e. of 8.73 % of the forest that existed in 1978 was cleared. GIS results indicate that by 1988 the forest cover constituted 44.8% of the total study. In the period *swamp areas* were lost at the annual rate of 0.9%. The changes were mainly attributed to expansion or introduction of various types of *scattered cultivation* that increased by 23.4%. The observed increase of 27.4% in *mixed cropping* area indicated that some areas were completely cleared to pave way for agriculture. Changes in vegetation cover can visually be observed from the maps of the Area Maps Figure 1, Figure 2 and Figure 3.

The forest was mainly cleared for farming, thus demonstrated by expanded *mixed farming* areas. Some areas especially those constituting *scattered cultivation* experienced vegetation regeneration, hence showing signs of slight improvement in terms of the forest quality.

6.2.4.2 Extent of Deforestation Experienced between 1988 and 2002

The period in question experienced a significantly higher decrease of the *closed woodland* of 13.4%. The *closed woodland* area of about 851.2 Hectares was cleared for various types of land use. The remaining forest cover constituted 24.2% of the total study area. By the time *swampy areas* got lost at the rate of 0.4%, indicating a drop as compared to the previous period, indicating expansion of farming to the *swampy areas.*

The observed increase in *woodland with scattered cultivation* as a consequence of both the clearing of patches in *closed woodland* and conversion other vegetation types like *bushland* that was left for a long period. *Mixed cropping* areas constituted 48.5%, while *scattered cultivation* formed 1.7%, which resulted in expansion of grassland areas. In this period, the rate of forest clearing increased by 4.7%, compared to the decrease recorded between 1978 and 1988, meaning 8.73%, which constituted 608 Hectares of *closed forest.*

6.2.4.3 Extent of Deforestation for the Period between 2002 and 2005

In the period between 2002 and 2005 vegetation cover changed significantly. *Closed woodland* decreased by 2461 Hectares, marking a huge vegetation cover loss of 44.7% of the total *closed woodland* forest cover recorded in 2002. The rate was far higher compared to the rate recorded between 1988 and 2002, i.e. 13.5% with a recorded loss of about 851.2 Hectares of *closed forest cover*. By 2005 the *closed woodland forest* that remained was only 10.6% of the total forest area that existed in 1978.

6.2.4.4 Extent of Deforestation for the Period between 1978 and 2005

During the entire period of 27 years under review, i.e. between 1978 and 2005, a total of about 3,920 hectares of *closed woodland* was lost at the estimated annual rate of 0.8%. The cleared forest cover constituted about 56% of the woodland forest in existence in 1978, i.e. about 6960.6 Hectares. Areas with *mixed cropping* expanded from 4,252.7 Hectares in 1978 to about 19,169.3 Hectares in 2005, confirmed a significant role played by farming activities in augmenting deforestation.

The pronounced role of farming in causing deforestation was, as well, evidenced by the expansion of *scattered cultivation* in grasslands, *bushland* and *woodlands*. It implies that farming was responsible for converting *closed woodlands* into less dense vegetation types, while firewood cutting tended to remove even a few trees left behind during farm expansion. PRA results indicated that a few scattered trees that were left in farms were with time systematically cleared for firewood, leaving behind areas bare of vegetation cover. Such areas were highly prone to *soil erosion*.

In 1988, *closed woodland* areas accounted for 44.8% of the entire forest cover. Due to bourgeoning of human activities, it plummeted to 24.2% and 10.6% by 2002 and 2005 respectively. This state of forest cover change was unprecedented and considered to have adversely impacted to other environmental processes of significance to human life such as weather and *river discharges*.

Table 6.2 Forest Cover Changes for WMCA Closed Woodland (1978 to 2005)

Changes	1978	1988	2002	2005
Closed Woodland Forest	6960.6	6352.6	5501.4	3040.4
Cleared area (Ha)	-	608	851.2	2461
Cleared area (%)	-	8.73	13.4	44.73
% of Total Forest Cover	-	44.8	24.2	10.6

Source: Extracted from Land Cover Matrix for WMCA, TANRIC, 2005

The GIS data in Table 6.2 was derived from the land cover change matrix Table 6.1 based on annual deforestation rates. The data demonstrated the progressive vegetation cover changes from higher vegetation types i.e. *closed woodland* to lower vegetation types, i.e. *scattered cultivation* in woodland, *bushland* and *grassland* whereby in some cases trees were completely depleted. The period under review experienced sudden decrease in *swampy areas*, mainly due to the decrease in rainfall and the increased livestock keeping observed covering such ecologically sensitive areas. Drought conditions experienced in the area threatened the survival of *smallholder farmers*. The observed changes in forest cover status were a manifestation of environmental degradation, with high potential for negative impacts to both *flora* and *fauna* that included *terrestrial* and *aquatic* species.

It was important, therefore, to underscore that both the observed and recorded changes in forest cover, due to various changes in land use types and practices at hand, were to be examined along with changes in population size, sex composition and age structure in order to determine the existing relationship between population, development and environment (PDE).

6.2.5 Factors that Contributed to Changes in Forest Cover

Survey data indicated the presence of a number of factors that caused and/or accelerated deforestation. About 20% of the respondents indicated that the indiscriminate felling of trees for firewood was responsible for deforestation in the area, while another 20% mentioned clearing the forest for expansion of farms to be the key contributor to deforestation.

Other causes mentioned included poverty, joblessness and inequitable distribution of land that renders some peasants landless and hence raising the potential for invading the forest reserves. However, survey results were not very different from those by FAO (2000a) whose analysis concluded that the leading causes of deforestation were the extension of *subsistence farming* and governments' converting of forests into other large scale ranching areas, a view equally shared by the World Resource Institute (WRI, 1999).

The World Bank established that conversion of forests into new agricultural lands for the first time had several major initial impacts some of which are irreversible (World Bank, 1998). The impacts include loss of natural tree cover, soil erosion, declining soil fertility, destruction of *habitats* and extinction of species; and reduction of services provided by the ecosystems. Some of such impacts had already surfaced in WMCA.

From the above statistics one may infer on the conspicuous role of human activities in augmenting deforestation by specific activities. However, the statistics do not tell us much about the social economic dynamics that made households to contribute to deforestation by the activities in question and their extent. Survey data in Table 6.3 indicated that about 15% of the respondents were responsible for felling of trees for firewood and brick baking, thus contributing to deforestation. Seventeen percent attributed it to charcoal making and 12% reported the use of wood poles as the cause for deforestation. Other activities mentioned to contribute to decrease forest cover were tobacco curing, firewood business, personal habit or uninformed decisions.

The use of fire for clearing farms was among the common practices of people of WMCA. This accounted for most of the bushfires that ravaged vast forests. PRA results indicated repeated bushfires caused by those who cleared farms, hunters, charcoal makers, timber makers and honey collectors. In the process, the fires ran out of control and destroyed forests. In few instances fires were started by cigarette/ tobacco smokers and sometimes by the mentally ill.

Some fires were noted to be purposely started only to 'compete' and realize the magnitude one's fire ravaged the forests. The practice, traditionally known as '*Mkono wa moto*' was found to be still in place. Some community members set fires to allow re-growth of fresh grass to be used for thatching homesteads. Forests were sometimes set alight to "clean them", i.e. chasing dangerous wild animals and reptiles. In WMCA bushfires were a common place despite strict laws and regulations by the neighbouring forest reserve.

Table 6.3 Main Livelihood Activities Leading to Deforestation in WMCA

Main Livelihood Activities	Responses	
	Number of Cases	Percentage
Burning bricks	220	15
Making charcoal	252	17.2
Firewood	295	20.1
Wood poles	174	11.9
Clearing new farm	288	19.7
Tobacco curing	61	4.2
Timber / lumbering	105	7.2
Firewood / charcoal business	51	3.5
Greed for money (selling even mango tree	10	0.7
One's habit/decision to burn/cut tree for nothing	1	0.1
Population growth	7	0.5
Not Applicable	1	0.1
Total	**1465**	**100**

Source: Field Survey, 2005

It has been observed that the sharp rise in incidences of fire-related deforestation in various parts of the world mostly started in farms. Although most of the burning took place in the secondary forests, the impact has been highly associated with destruction of *habitats* of a variety of species of animals (WRI, 1999). Hence, as such, agriculture has been prone to starting bushfires.

There were mixed feelings on the period in which deforestation started to be observed in WMCA. Survey data in Table 6.4 shows the responses in which about 34% of respondents were of the opinion that deforestation was noted in the period between 1989 and 1998; while 26% mentioned that the phenomenon as noted between the 1999 and 2002. A proportionately smaller number of the respondents (21.6%) observed that deforestation was noted between 1978 and 1988. The noted declining trends on data regarding respondents' opinions, with the past years having the lowest percentages, portrays both the cumulative effect of population growth and its compounded impact on deforestation process for the period under review.

Table 6.4 Distribution of Respondents by the Year Deforestation was initially Noted

Period (Years)	Frequencies	Percentage
1974-1978	60	8.6
1979-1988	151	21.6
1989-1998	235	33.6
1999-2002	182	26
2003-2004	46	6.6
Do Not Know	25	3.6
Total	**699**	**100**

Source: Field Survey, 2005

Since activities mentioned above were all anthropogenic in origin, they could directly be linked to the variations in population characteristics, i.e. population size, age structure and sex composition. The thesis was a pursuit towards establishing nature and character of the link between population, development and environment. Quantitative and qualitative data on the contribution of people of different demographic characteristics in each of the above mentioned livelihood/development activity and the analysis regarding the *key actors* (in each activity) provides the basis for analyzing the existing PDE relationship.

In general terms, one may learn that deforestation observed in WMCA was an on-going physical environmental process, mainly caused by engendered *in situ* population constituting different demographic characteristics. A greater threat exists on further degradation of the *ecological*, *economic*, *edaphic* and *hydrological* systems that impact and affect other life systems including human life.

6.2.5 Impact of Changes in Forest Cover to Water Resources

Survey data on availability and seasonality of water was necessary to establish the impact of deforestation to the *catchment value* of WMCA. According the World Resources Institute (1998) the world's thirst for water is likely to become one of the most pressing resource issues of the 21st century. Global water consumption rose six-fold between 1900 and 1995, i.e. more than double the rate of population growth and it continues to grow rapidly as agricultural, industrial and domestic demand increases. Environmental degradation, deforestation in particular, was the major contributor to the decreasing trends in water supplies that is related to the dropping of the *catchment value*.

When asked about the seasonality in availability of water, from various sources, various responses were given as demonstrated in Table 6.5. The majority of the respondents, i.e. 55% indicated that water was available throughout the year. A significant proportion of them, i.e. 42% observed *intermittent* availability of water. A small proportion, i.e. 2% reported the shortage while 1% noted acute shortages of water. A wide variation in respondents' opinions was noted. The deviation resulted from specific local conditions of a particular household with respect to the water source. Survey results conceded to those of the PRA which revealed that the average distance to water points, from households was about 1.2 kilometres. However, those villages with tap water had its water untreated thus unsanitary. Boiling drinking water was necessary for health reasons. It was observed that having many small streams, rivers and wetlands reduced the average distance to water sources.

In some cases deforestation was more evident at sources of some rivers like *Kapela* and *Ndanji* Rivers at Kikunja village; and *Makupe* River at Lihwena. The three rivers were mentioned and visually observed to be highly endangered. Though not *gauged*, PRA results observed a remarkable decline in their *flows* through years. In some instances, the respective village authorities reported matters to the district authorities to enforce conservation efforts for the same water features, but no steps were taken. Other rivers which were negatively affected by human activities included the *Ruvuma*, *Lipasi* and *Luhira*; all of which supplied water to the neighbouring Songea Municipality.

With rapid expansion of the municipality, it was implicit that more supplies of water were required as prompted by the rising demand.

WRI observed serious water shortages that tended to shortchange human water needs and damage the *aquatic* and *terrestrial ecosystems* that depended on it (WRA, 1998). The World Conservation Union asserts that the limited nature of freshwater ecosystems was pertinent to the loss of proportionately greater part of their habitats, therefore threatening their *biodiversity* (UICN, 2004). Such dangers were likely to affect the study area. Other threats facing freshwater ecosystems were outlined were industrial and agricultural *discharges*, over-fishing, water diversion for agriculture and urban water supplies, siltation, pollution and competition from non-native fishes.[26] All these issues need to be considered when dealing with environmental sustainability.

Table 6.5 Distribution of Households by Opinions on Annual Availability of Water

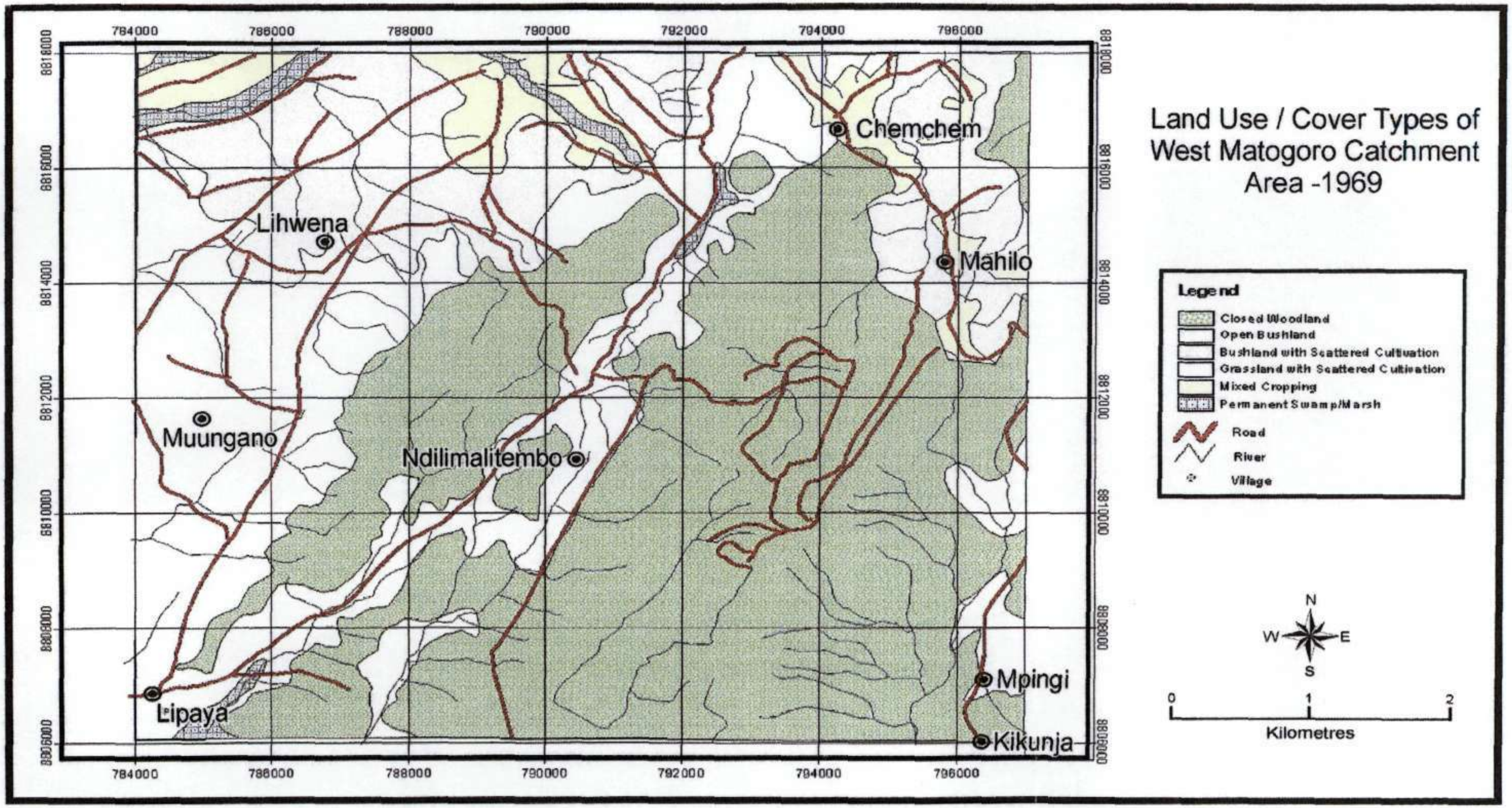
Respondents' Opinions	Numbers	Percentage
Very little	7	1
Little	12	1.7
Intermittent	296	42.3
Available throughout	384	55
Total	**699**	**100**

Source: Field Survey, 2005

Generally speaking, the hydrological situation of WMCA indicated a decrease in the water levels as evidenced by most of the respondents' observations. The extent of the decrease or the actual status of the *catchment value* was determined through analysis of hydrological data as discussed in section 6.3.2.2.

[26]Plenty of the waters of the Ruvuma and Lipasi rivers have been diverted for domestic use in the Municipality of Songea and small scale informal irrigation system. However, the sources of the Rivers were reported being threatened by human activities.

Figure 6.2



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Lipaya
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Land Use / Cover Types of West Matogoro Catchment Area -1969
Legend
Closed Woodland
Open Bushland
Bushland with Scattered Cultivation
Grassland with Scattered Cultivation
Mixed Cropping
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Figure 6.3

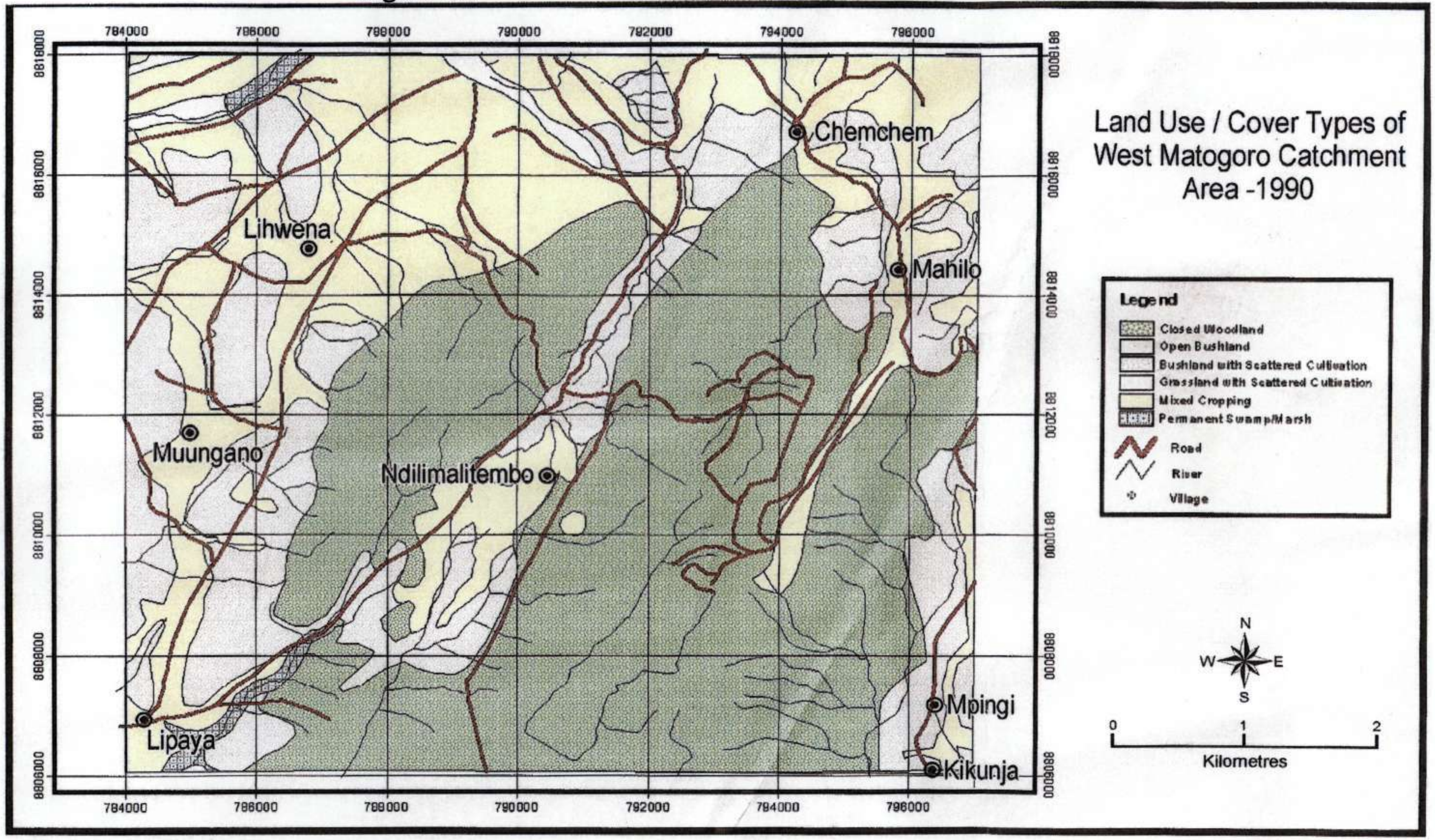

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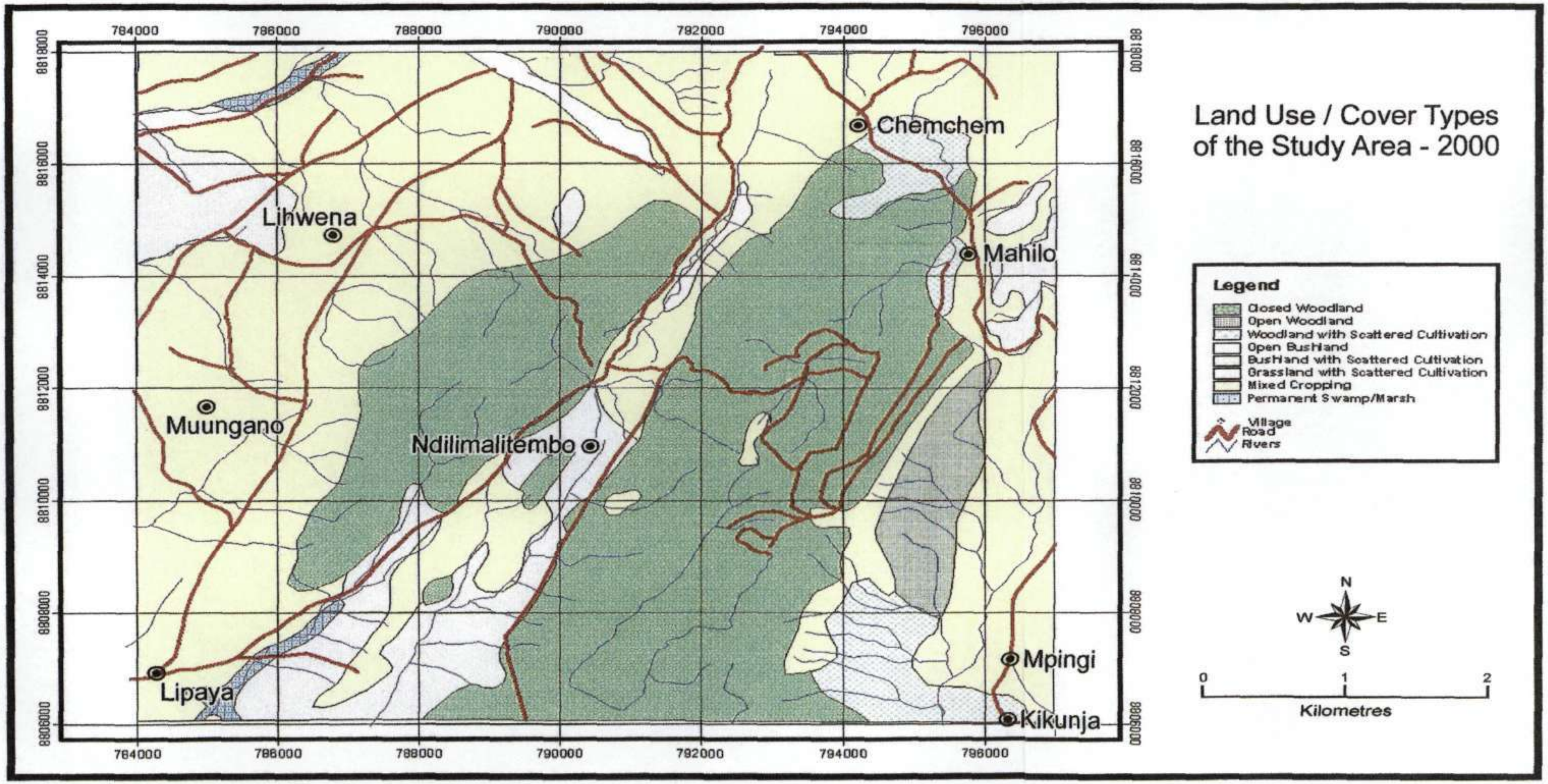
Figure 6.4


Land Use / Cover Types
of the Study Area - 2000
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Closed Woodland
Open Woodland
Woodland with Scattered Cultivation
Open Bushland
Bushland with Scattered Cultivation
Grassland with Scattered Cultivation
Mixed Cropping
Permanent Swamp/Marsh
Village
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Rivers
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6.3 Hydrological Characteristics of WMCA from 1978 to 2005

The situation of WMCA, pertinent to its hydrology, showed variations in water volumes with the general trends indicating a decline. Information and data from the survey and the PRA were tailored for the deep analysis of the environmental situation.

6.3.1 Peoples' Views on the Hydrological Conditions in WMCA

6.3.1.1 Peoples Views on Water Quantity Variations - Field Survey Results

Survey data in Table 6.6 revealed that the majority of the respondents, i.e. 52%, did not experience any water scarcity. About 46% of respondents experienced water scarcity in their villages observed mainly during dry seasons. A smaller proportion, i.e. 1% observed water scarcity in rain seasons. PRA results attributed the observed water scarcity phenomenon to drought condition that was associated with decreasing *rainfall amount* and its *erratic distribution.*

During the wet seasons, water scarcity was caused by blockade of pipelines and at water intakes. In general, one would conclude that water scarcity that affected human population needed to be addressed earlier because its magnitude was likely to grow with time. River Basin Management Office reported the falling *catchment value* of WMCA through time as attributed to expanding human activities.

Table 6.6 Distribution of Respondents by Views on Seasons of Water Scarcity

Respondents' Opinions	Frequencies	Percentage
None	363	52
Dry season	321	46
Wet Season	8	1
Throughout the year	7	1
Total	**699**	**100**

Source: Field Survey, 2005

6.3.1.2 People's Views on Water Seasonality-PRA results/Field Observation

PRA results and field observation revealed the presence of multiplicity of springs and streams in the area. The main streams include the *Ruvuma*, and *Luhira* flowing between Chemchem and Mahilo villages; *Makupe* and *Ruvuma tributary* flowing at Lihwena, *Miwili stream* and *Bwanambuzi* at Muungano. Other streams were *Ndilima River, Mkurumusi River, Lipasi River, Matalawe River* and *Mwanzimmoja River, Nakatuli Ndanji, Milola, Mangomela, Kapela* and *Mpila Rivers.*

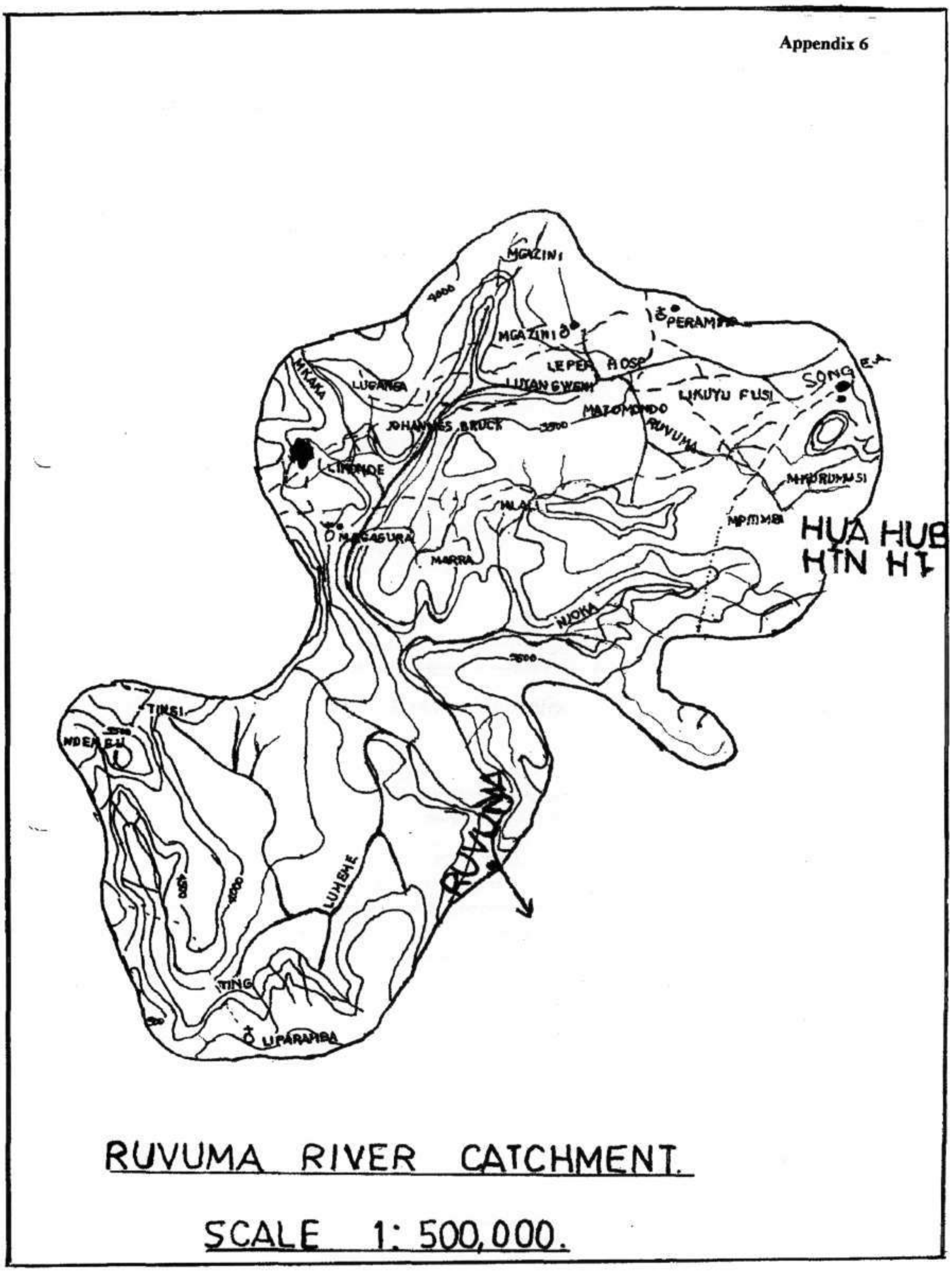
PRA results demonstrated a fall in water levels in rivers and wells especially during the dry seasons, particularly in the months of October and November, mainly associated with the decrease in the *rainfall amount* that caused a fall in water levels in both wells and streams. The decrease in *rainfall amount*, over time, was mainly attributed to deforestation caused by rapid population growth. The trends in *rainfall availability* and *temperature variations* are discussed in section 6.2.4.4.

6.3.2 Hydrological Conditions of WMCA between 1978 and 2005

The technical report on the *discharges* for the *Ruvuma River* covered the two major tributaries of the river, originating from the West Matogoro Mountains. *Discharges* data for the *Likonde River* and *Ruvuma River* constituted the main part of the scientific analysis of the hydrological situation of the WMCA.

The total catchment area of the *Ruvuma River* is 4125 km^2, while our subject for the purpose of the thesis, pertinent to analysis of the hydrological condition linked with the population and development activities was limited to 155.2 km^2. WMCA is the source of the head waters of the two tributaries whose *discharges* data were analyzed. Since the main tributaries of *Ruvuma River* originate from WMCA, it was assumed that any substantial vegetation changes in the area would impact on the *flows* of the same river. The observed changes in *discharges* were analyzed and the findings were used as study parameters in establishing the PDE relationship. Findings on the hydrological conditions are presented in sections 6.3.2.1 and 6.3.2.2. Sketch map of the entire catchment area of the *Ruvuma River* is presented in Figure 6.5.

Figure 6.5 Sketch Map of the Ruvuma River Basin



6.3.2.1 General Report on the Hydrology of WMCA

There were two gauging stations for the rivers that originate from the area namely *Ruvuma River* at *Muhiga* (No 1Q7) and *Likonde River* at *Ligowonga* (No 1Q10). The time series data of 27 years were analyzed for the study purpose. The *runoff magnitudes* and their characteristics based on analysis of the existing data were sufficient for the purpose. Data on the *minimum flows* of *water discharges* collected at the two gauging stations are presented on Tables 6.7 and 6.8, below. Generally, available *discharges* data were scanty, too short or incomplete[27]. Only *minimum flows* data were available for the period between 1974 and 2000. These data were considered satisfactory to meet the study objectives.

Table 6.7 Discharges Data for the *Ruvuma River* at *Muhiga* (*Minimum* Flows 1974-2000)

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Q in m^3/s	31.77	83.07	88.00	16.80	30.50	98.43	29.25	30.50	78.32	19.50
YEAR	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Q in m^3/s	9.58	15.14	28.4	24.7	37.3	14.7	21.14	87.47	1941	14.14
YEAR	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**			
Q in m^3/s	11.17	18.16	31.12	22.17	14.76	11.61	11.13			

Source: River Basins Management Office, 2000

Table 6.8 Discharges Data for the *Likonde River* at *Ligowonga* (*Minimum Flows* 1974-2000)

YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Q in m^3/s	1.47	1.14	0.46	091	1.40	2.88	2.11	1.14	1.27	1.08
YEAR	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Q in m^3/s	1.27	0.81	1.01	1.21	0.87	0.84	0.81	0.73	0.70	0.67
YEAR	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**			
Q in m^3/s	0.77	0.49	0.59	0.85	0.74	0.71	0.66			

Source: River Basins Management Office, 2000

6.3.2.2 The Hydrological Situation and Characteristics of WMCA

The report by the Songea based River Basins Management Office, stipulated the *watershed* situation and its management in WMCA. The situation regarding forest quality and tree density within WMCA area is pathetic. According to the report, unless very serious efforts were taken to protect the catchment area and stop denudation of hills and mountains, due to human activities like poor farming methods, cutting of trees for fuel and housing etc, the little water that was left will be flowing in rivers and other water features especially during the dry seasons.

From the hydrological data presented in Table 6.7 and Table 6.8; and the discussion in sections 6.3.3.1 and 6.3.3.2 one observes that in the last ten years, i.e. from 1990s to 2000, a significant of the *minimum flows* recorded compared to the period between 1978 and 1980s.

[27]DANIDA supported project that involved the gauging of the main rivers in Tanzania. The gauging stopped when the support ended, thus intermissions in data availability

The main causes of the negative trends, according to the local community members, included deforestation that was complemented by overgrazing, bushfires and the use agro-chemicals.

In Ruvuma region, extension of agricultural activities involved mainly felling of big trees and clearing other forms of natural vegetation, leaving behind areas bare of vegetation cover. This therefore, accelerated soil erosion. This situation threatened domestic water supply schemes since local communities depended mainly on surface water that already showed signs of drying out.

In some few areas, the introduction of *exotic plant species* threatened the volume of water at the river sources due to either their high water consumption rate or by obstructing infiltration rates. Species like *eucalyptus* tended to lower the *catchment value* of the forest. Typical example of such a case is that of the Matogoro Mountains Forest Reserve. The forest reserve which constituted *pines* introduced some years ago are reported to have killed almost all the natural species and highly reduced *water flows* by over 30% (URT, 2005b).[28] It was not clearly known whether the quality of water was affected.

Human activities were termed the major factor for destruction of water sources. Tobacco farming was noted for its frequent need for new land (uncultivated land area, a fertile one) in every farming season. It simply meant clearing the forest cover every year, with the fallen trees being burned to add nutrients to the soil (through ashes) for the crop to grow. In addition, more trees were cut to provide fuel for tobacco curing. The hydrological data of the rivers that originated from the area indicated a decrease in *catchment value* through time. Human activities were repeatedly mentioned responsible for such hydrological changes.

As human activities were implicated for the changes in water availability, it was not certain as to how household members of different age group, sex composition and levels of education contributed to causing deforestation and the consequent changes in water resources. The thesis urges further examination of this significant aspect aimed at establishing the specific people's engagement in causing environmental degradation by their demographic characteristics.

6.3.3 Changes of Hydrological Conditions of WMCA from 1978 to 2000

The section analyzes hydrological data recorded at the gauging stations located along the long profiles of the two rivers. The analysis was considered more realistic and scientific on the basis of the reliable data series on *river discharges*.

[28] Matogoro Report Observes that the planting of species like *pinus patula* reduced *catchment value* of the forest, and thus directed the removal of the specie for water conservation.

The *discharges* of the *Likonde River*, gauged at *Ligowonga*, station number 1Q10 and at Muhiga on the *Ruvuma River* number 1Q7 were analyzed and findings were used to depict consequences of deforestation on the *catchment value* of the source area

Using the time series data, it was observed that the *discharges* of the both rivers were *erratic* and indicated decreasing trends in water volume over time. The reasons behind the phenomenon demanded for an explanation. The specific variations in *discharges* over time period and the analysis of behavior of *discharges* of each river is presented in sections 6.3.3.1 and 6.3.3.2.

6.3.3.1 *Discharges* of *Likonde River* at *Ligowonga* (1Q10).

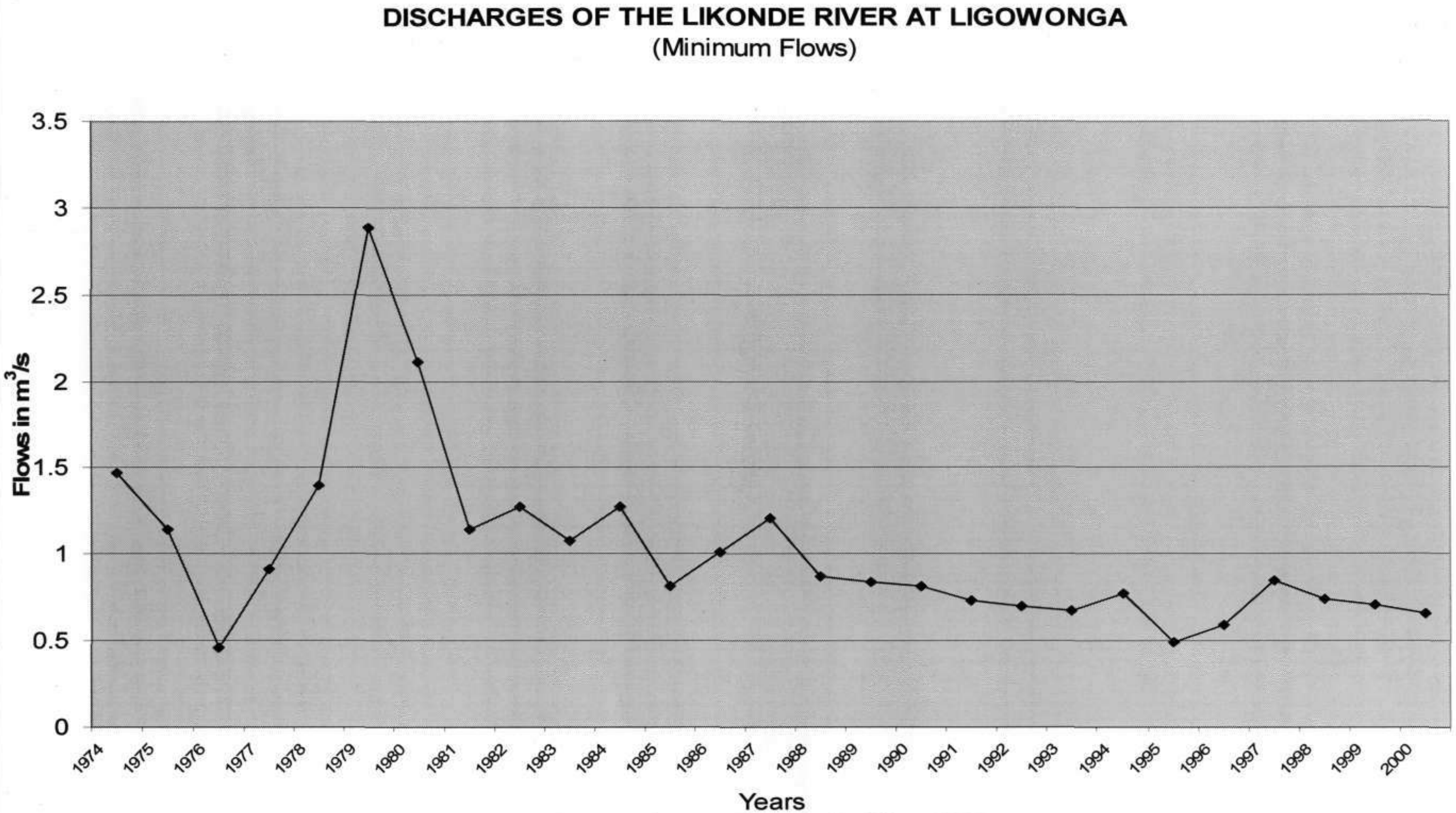
Discharges of the *Likonde River* indicated a decrease in volume of waters from 1974 to 1976. The *flows* tended to increase steadily from 1977 to reach its maximum in 1979. A sharp decline was noted between 1980 and 1981. A small rise was observed in 1982 followed by a decline in the following year. Between 1983 and 1988 there was alternating up and down variations in the *discharge*, a period in which the lowest *discharge* was recorded, i.e. in 1985. From 1988 to 1993, the *pattern of discharge* indicated a consistent and steady decline.

A small rise in waters was recorded between the 1993 and 1994, followed by a decline in water quantities in 1995. An *erratic discharge* was noted again between 1996 and 2000. The general *pattern of the discharge* of the *Likonde River*, as demonstrated by the graph in Figure 6.6 portrays a general decline in the *discharges* for the period between 1978 and 2000.

The quantitative changes in the *discharges* of the *Likonde River* indicated that the tributary had its highest levels of the *minimum flow* in 1974 whereby the *discharge* data recorded was 1.47 *cusecs*. The lowest *minimum flows* recorded were in 1995, i.e. 0.49 *cusecs*. However, for the last three years, meaning from 1998 towards 2000, the *discharges* data indicated a steady drop, i.e. from 0.74, 071 to 0.66, respectively.

For the period of 26 years from 1978 to 2000, the *discharges* or *river flows* dropped significantly from 1.47 *cusecs* in 1978 to 0.66 in 2000, marking a drop of about 55%. It implies that the rivers decreased by more than half its volume in 1978. The observed hydrological situation posed an obvious threat to both *aquatic biodiversity* and the river itself. Human activities taking place upstream and along the *long profile* are deemed responsible for decline in *discharges*. Changes in micro climates along the *river profile* affected *rainfall amount* and impacted on *river regimes* and *discharges*.

Figure 6.6



Source: Songea River Basin Office, 2005

6.3.3.2 *Discharges* of the *Ruvuma River* at *Muhiga* (No. 1Q7)

Ruvuma River, whose *discharges* data were collected at Muhiga and presented in the graph Figure 6.7, is a tributary of the main *Ruvuma River*. The period between 1974 and 1975 indicated a sharp rise in *discharges*, almost the doubling of the waters flowing in the tributary. A further slight rise was witnessed in 1976, followed by a marked decline in the following year. An increase in *flows* was noted again in 1978, followed by a drastic rise in 1979 that climaxed the entire period under review. Year 1980 realized a sharp decline towards 1985, recording the *lowest discharge* ever. Between 1986 and 1989, general rise in water quantities was observed, only to decline in 1990. A sharp increase was between 1991 and 1992 followed by a sharp and steady decline towards 1995. A rise was observed again between 1995and 1997 followed by a consistent and steady decline in *discharge* between 1997 and 2000.

The specific drainage characteristics of the *discharges* of the *Ruvuma river* indicates that the highest *lower flows* quantity it ever attained was 88 *cusecs* recorded in 1975 with the lowest *minimum discharges* of 9.54 *cusecs* recoded in 1984. For the last three years towards 2000 the *discharges* were 14.74, 11.61 and 11.3 *cusecs*, respectively.

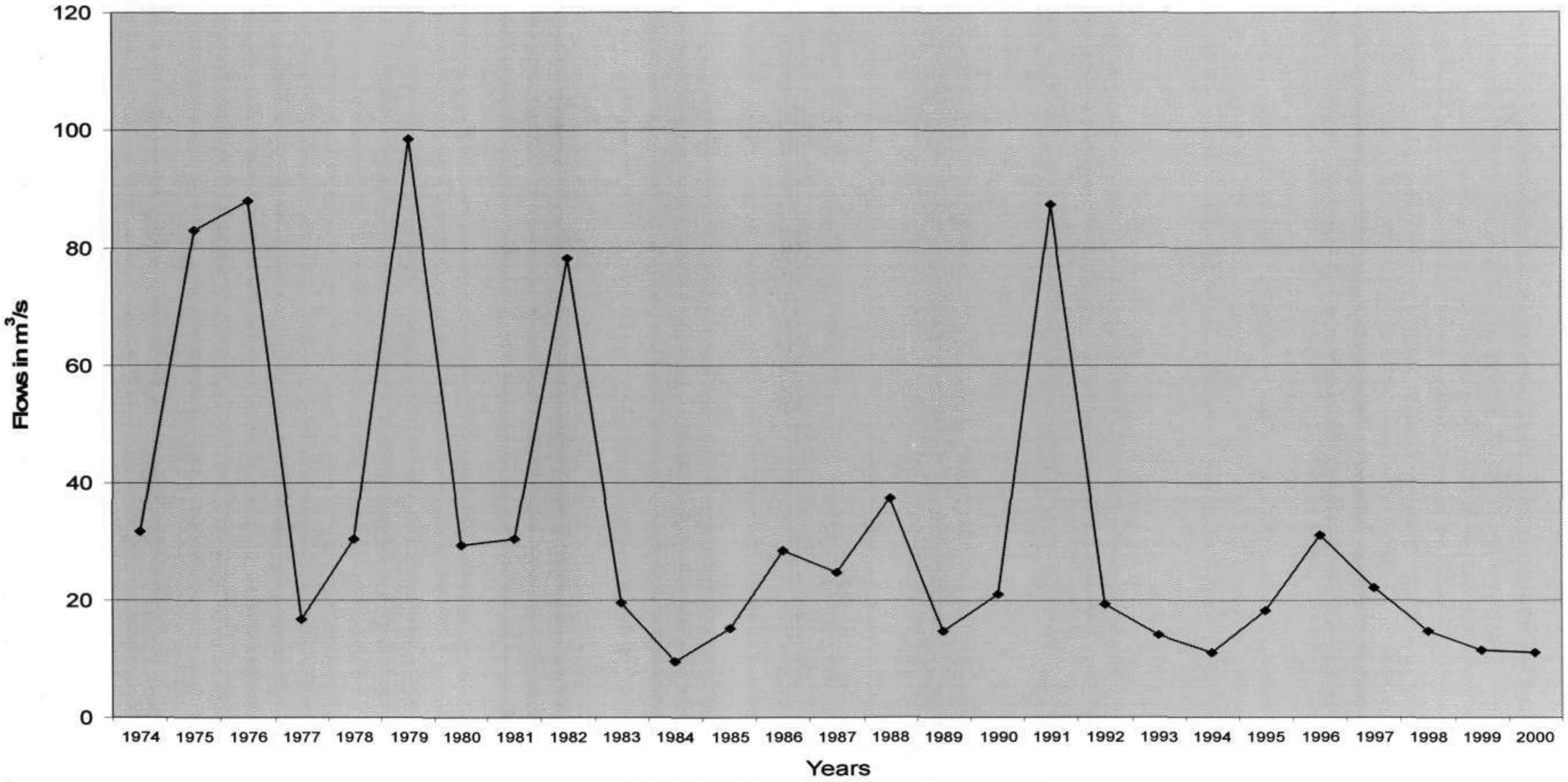
It could therefore be noted that in the past 26 years, i.e. from 1974 to 2000, *discharges* of the *Ruvuma River* fluctuated between 88 *cusecs* and 11.3 *cusecs*. As the trends indicated the general decrease, a drop of about 87% was observed. Since *discharges statistics* were based on the *minimum flows*, it shows that the situation was more critical as the stream was in a great danger of drying out. Human activities, both upstream and along the *river profile* partly contributed to the situation that endanger *biodiversity* downstream. The changes in water levels may pose a threat to *aquatic* and *terrestrial biodiversity*.

In general terms, the *pattern of discharges* of the *Ruvuma River* was more *erratic* than that of the *Likonde River*, though the former had more water quantities. Having less decrease in *discharges* in the *Likonde River* indicated the possibility of less human activities at the source and along the long profile, therefore culminating into less impact on the *head waters* compared to the *Ruvuma* counterpart.

Despite the fact that the *Ruvuma River* was far bigger compared to the *Likonde*, the extent to which the *Ruvuma* was affected placed it into a greater danger of drying out faster than the relatively smaller *Likonde River*. Since the *Ruvuma River* lost more than half of its head waters in 26 years, one may doubt about its future existence devoid of concerted conservation efforts. PRA results revealed other small rivers, like *Kapela River* and *Ndanji River* that were endangered mainly by human activities. Little or no possibility existed to quantify the impact of human activities as the same rivers were not gauged.

Figure 6.7

DISCHARGES OF THE RUVUMA RIVER AT MUHIGA
(Minimum Flows)



Source: Songea River Basin Office, 2005

Discharges, i.e. quantities of water passing at the gauging station *per* second; and the *regimes,* i.e. seasonal variations in water levels of both tributaries indicated environmental degradation. Both rivers had their *catchment values* significantly declining in the period under review. One would even question about water quality of their waters, an aspect out of scope of the thesis, hence recommended for further research.

6.3.4 Factors that Contributed to Changes in the Hydrological Conditions

PRA results observed evidences of encroachment of forests at river sources especially for rivers *Kapela* and *Ndanji* in *Kikunja* village. The two rivers were highly affected by human activities, mainly farming. Water volumes of the two rivers, though not gauged, were observed decreasing tremendously over time. Sources and the long profiles of other rivers, compared to the *Ruvuma, Luhira* and *Lipasi,* which supplied water to the Songea municipality were given less basin management and no, if any conservation efforts.

Human activities such as extensive farming, lumbering, bush burning and hunting invaded and destroyed the *ecologically sensitive areas*. *Mkurumusi* River valley, the border of *Lipaya* and *Mpitimbi* villages was occupied by *Mianzi (*bamboo plants*)*. *Mianzi* produced *ulanzi*, a traditional bamboo wine[29] that raised incomes of local communities. Its production all the year around due to irrigation ensured steady income to the local communities. Whether growing of *mianzi* within the river valley affected *river flows* was another area of enquiry outside the scope of this study. Population growth was mentioned to have contributed to the expansion of human activities to areas previously considered as 'wild and free'. Such areas required sustainable conservation.

PRA results revealed impact of soil erosion noted in some of the villages associated with both deforestation and drought. Destruction of houses by strong winds recently reported to affect homesteads at *Mpingi* and *Kikunja* villages was a result of deforestation. According to LEISA, the creation of *buffer zones* for the forest has slowly helped to reduce siltation and increased sustainability in soil productivity in the already cultivated lands in Sri Lanka (LEISA, 2004). Absence of *buffer zone management* in WMCA was responsible for this effect (URT, 2005).

Survey data in Table 6.9 indicated a list of a number of causes of water scarcity. Fifty percent of the respondents did not experience any water scarcity because they used tap water whose supply was constant. A relatively longer section, i.e. 31% attributed water scarcity to drought. About 6% did not know the reason behind water scarcity they experienced. About 5% attributed it to destruction of catchment forests. This state of affairs portrayed limited knowledge on natural resource base and called for intervention on sustainable conservation.

[29]Ulanzi is an alcoholic drink collected from young shoots of bamboo plants. It is a common drink in Southern Tanzania. It is normally obtained during the rain seasons when the bamboo shoots mostly grow.

The United Nations Assessment on Freshwater Resources put it clear that the global water situation will get considerably worse over the next 30 years without major improvements in the way water was allocated and used (WRI, 1998). The thesis emphasizes further on the need to develop more sustainable water resources utilization and conservation strategies for a better future and survival of humankind. It is the contention of the thesis arguing that sustainable water conservation cannot be achieved without detailed knowledge on the impact of human activities on *catchment value* and *ecosystems*.

Table 6.9 Distribution of Respondents by Causes for Water Scarcity in the Area

Causes	Responses	
	Number	Percentage
Not applicable	350	50
I do not know	44	6.3
Drought	218	31.1
Reduction in water volume in rivers	37	5.3
Destruction of water sources	34	4.9
Rubbish fill in the water wells or at in	9	1.3
God knows	7	1
Total	**699**	**100**

Source: Field Survey, 2005

6.4 Status and Changes in Climatic Characteristics of WMCA from 1978 to 2005

Climate of WMCA was analyzed based on *rainfall amount* and its *distribution* as well as *temperature* changes. The area was proven to have been affected by deforestation, mainly attributed to anthropogenic causes. However, it was difficult to clearly discern human caused versus natural caused deforestation[30]. The thesis assumed dominance of human factor to the observed deforestation. The contribution of deforestation, by specific human activities is examined and documented in Chapter 8 of the thesis.

It was of significance, according to the adopted methodology, to establish the possible outcomes of such tremendous disappearance of tree cover, particularly in terms of the changes in climatic conditions. What was of primacy, in this section, was to appraise the climatic conditions and their variations through time.

The analysis was carried out with awareness that while deforestation was a site-specific phenomenon, its effects, for the most part, tended to cover broader spatial areas. This was one of the complexities experienced in determining the impact of deforestation on the two elements of climate, i.e. *variability of temperature* and *rainfall*. In many areas a combination of factors acted together in bringing about the impact on the weather or climate (Aspen Global Change Institute (AGCI), 1995).

[30] There is complexity of discerning human and natural impact on deforestation. The same is for climate, i.e. when separating human induced changes from natural changes

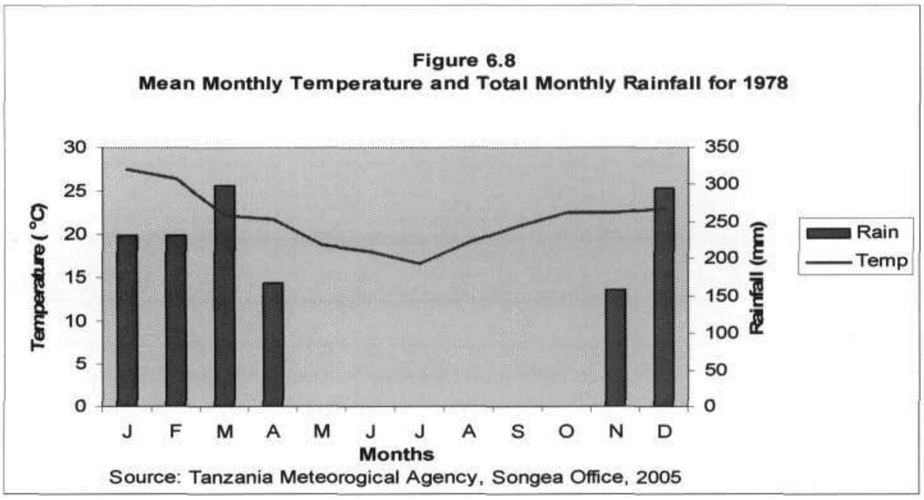
The case was the opposite within Southern Tanzania, and WMCA in particular. The spatially small area, with general paucity of industrial establishments, had a greater possibility for one to link drought and high temperatures with destruction of natural forests than other factors. The belief on the difficulty in sorting out the human impact from natural variability had no significant application for this case, as no options to be sorted actually existed.

To underscore weather conditions and their changes over time, *temperature* and *rainfall* data of 26 years meaning from 1978 to 2004 were analyzed. The analysis revealed the existence of significant climatic changes. Changes observed were meant to be articulated in the more complex analysis of the PDE relationship. The observed climatic/weather conditions are as summarized in sections 6.4.1.1 and 6.4.1.2.

6.4.1 Temperature Conditions of WMCA and their Variations through Time

6.4.1.1 Temperature Conditions in WMCA

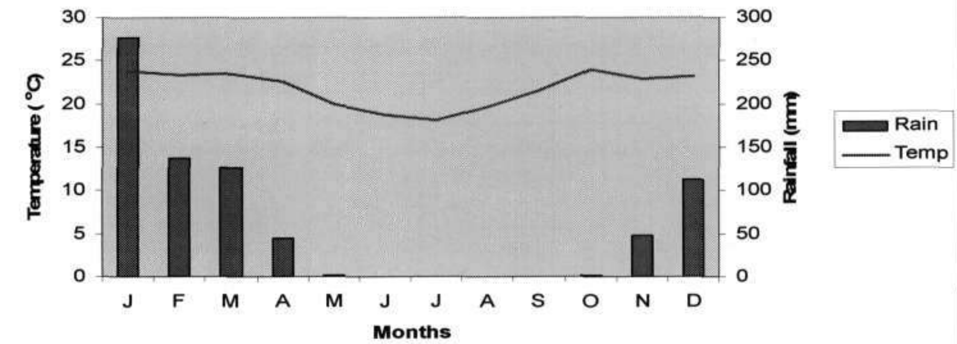
Located in the tropics, WMCA was characterized by relatively high temperatures. Graph Figure 6.8 indicates that summers were generally hot while winters were warm. The *daily temperature ranges* were mostly moderate. In 1978 the highest *mean monthly temperature* recorded was 27.5°C while the lowest was 16.5°C. Therefore the *mean annual temperature range* was 11°C. In the same year the *mean annual temperature* recorded was 21.6°C.



In ten years' period, i.e. between 1978 and 1988, the temperature conditions revealed different trends. The *maximum monthly temperature* recorded was 23.7°C, while the *minimum* was 18.1°C. The *mean annual temperature range* was 5.6°C, while the *mean annual temperature* for that year was 21.8°C.

Compared with the climatic conditions for 1978, the *maximum annual temperature* (in 1988) had decreased by about 3.8°C; while the *minimum temperature* had increased by 1.6°C. It implies that despite the fall in *maximum temperatures*, the overall atmospheric condition remained warmer as the lowest temperatures had risen by 1.6°C, the *mean annual temperature range* indicated a declined of 5.4°C. Figure 6.9 shows the climatic conditions in WMCA for 1988.

Figure 6.9
Mean Monthly Tempertures and Total Monthly Rainfall (1988)

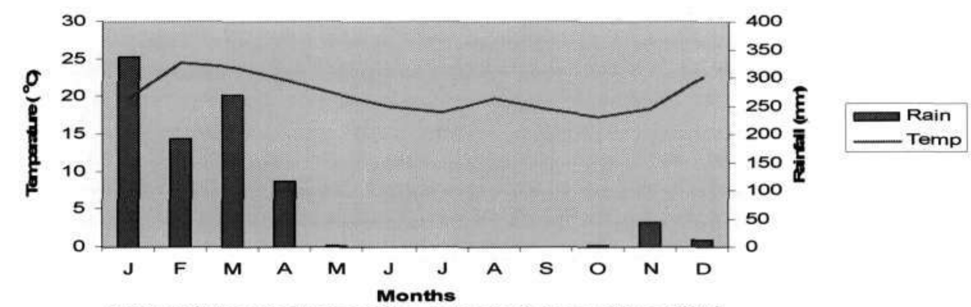


Source: Tanzania Meteorological Agency, Songea Office, 2005

Climatic data for 1998 in Figure 6.10 indicate that the *maximum mean monthly temperature* was 24.4°C, while the *minimum mean monthly temperature* recorded was 17.2°C; hence the *mean annual temperature range* was 7.2°C. In 1998, the *mean annual temperature* was 20.3°C. Compared to temperature conditions in 1988, a marked change was noted. The *maximum mean temperature* had risen by 0.7°C, i.e. from 23.7°C to 24.4°C; at the same time the *minimum mean temperatures* had as well risen by 0.9°C, i.e. from 17.2°C to 18.1°C; indicating that warmth had significantly risen by 1.6°C. Both the *minimum* and the *maximum temperatures* had risen. The annual temperature range rose by 1.6°C, i.e. from 5.6°C in 1988 to 7.2°C in 1998. Since the *maximum temperature* had risen by 0.7°C and the *minimum* by 0.9°C, it therefore means that the net increase in *temperature range* of 0.2°C was noted.

Figure 6.10

Mean MonthlyTemperatures and Total Monthly Rainfall (1998)



Source: Tanzania Meteorogical Agency, Songea Office, 2005

By 2002 the *maximum mean monthly temperature* recorded was 23.7°C and its minimum was 17.8°C; making the *temperature range* of 5.9°C. Five months prior to the undertaking of the study, i.e. in 2005, the *highest mean annual temperature* recorded was 24.6°C, while the *minimum* *temperature* recorded was 17.2°C. The *mean annual temperature range* was as big as 7.4°C. The *mean annual temperature* for 2004 was 21.6°C.

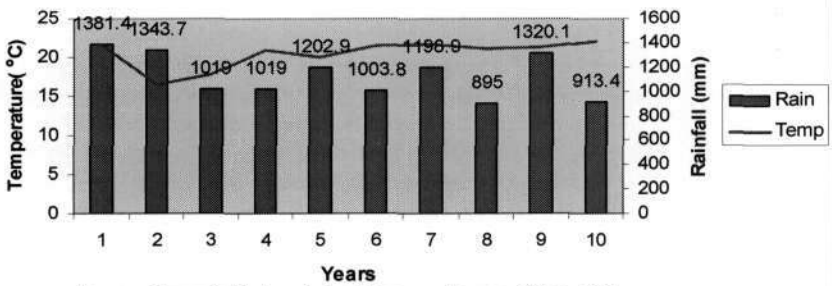
6.4.1.2 Trends in Temperature Changes from 1978 to 2004

Analysis on the changes in temperature conditions for the entire period under review, i.e. between 1978 and 2004 revealed marked changes in temperature conditions. Variation in the *maximum temperatures* of about -2.9°C was noted/meaning that the *maximum mean temperature* in 1978 was higher than that for 2004 by 2.9°C; while the *lowest temperatures* of 2004 were 0.7°C higher than that of 1978. The *temperature range* had significantly risen from 1.6°C in 1978 to 7.4°C in 2004, indicating a generally steady temperature rising pattern. This state demonstrated the creation of desert-like conditions, characterized by big temperature ranges. The 462% rise in *temperature range* within 26 years was an obvious indicator of worsening environmental conditions that can technically be linked to deforestation and/or drought. Throughout the period of 26 years, the *maximum temperature* ever recorded was 34°C, recorded on 7th November 2003, while the *lowest temperature* was 19.5°C, i.e. recorded on the 4th May 1981.

Figure 6.11 portrays a steady temperature rise between 1978 and 1988 while the graph in Figure 6.12 indicates the marked variations in temperature conditions coupled with unpredictable changes between 1988 and 1998. High fluctuations in temperatures could be linked with effects of environmental degradation, particularly with regard to forest cover change. However, the temperature trends from 2001 indicated a general and tremendous rise. It should be noted that lack of *maximum temperature* data for some months contributed to the lowering of the mean diurnal temperatures therefore consequently lowering the *mean monthly temperatures* and *mean annual temperatures*[31].

Figure 6.11

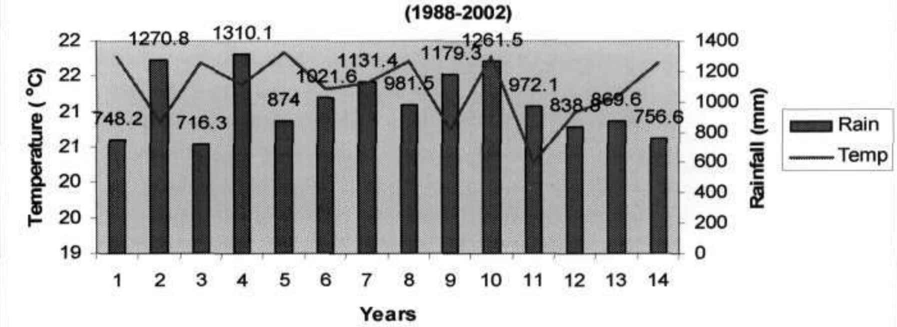
Mean Annual Temperatures and Total Annual Rainfall in WMCA (1978-1988)



Source: Tanzania Meteorological Agency, Songea Office, 2005

[31] From mid September 1998 to mid October 1999 only minimum temperatures were recorded.

Figure 6.12
Mean Annual Temperatures and Total Annual Rainfall in WMCA
(1988-2002)



Source: Tanzania Meteorological Agency, Songea Office, 2005

6.4.2 Rainfall Conditions and Patterns Over time

It was significant to analyze rainfall data for the years under review so as to establish the variations in terms of the *rainfall amount* and *distribution* through time.

6.4.2.1 *Rainfall Amount* and its *Distribution* in WMCA

Secondary quantitative data in Table 6.10 revealed that *rainfall amount* tended to decrease with time while its *distribution* became more *erratic* and *unreliable* for the small scale farmers who depended on it for agricultural production. PRA results revealed similar results.

Rainfall data for 1978 indicated that the *total annual rainfall* was 1381 mm which fell in six months mainly from November to April. The rest of the months were totally dry.

In 1988, changes in rainfall conditions were noted in terms of the amount, while its *distribution* was same, namely six months. The *total annual rainfall* recorded was 748.2 mm recorded from November to April. Negligible amounts of were recorded in October and May. The rest of the months were dry. When compared to the conditions in 1978, a remarkable decrease of rainfall of 632.8mm was noted, i.e. from 1381 mm in 1978 to 748.2 mm; equivalent to 54.2%. The observed significant decrease in *rainfall amount* had negative consequences to the farming communities and *biodiversity*.

In 2002 the *total annual rainfall* recorded was 799 mm, recorded mainly in four months from January to April. The *highest amount of rainfall* was recorded in January. However, negligible amount of precipitation was observed during May 2002. Unlike other years under review, in 2002 no *rainfall* was recorded in November and December causing an impact of low on-farm productivity that culminated into famine among farmers due to delayed rains. In that year the *rainfall amount* showed a decline, which was also more erratic and *unreliable distribution*.

The *total annual rainfall* of about 1117.3 mm, classified as heavy, was recorded in 2004 that was *distributed* over six months mainly from November to April. The *highest amount of rainfall* fell in

December. Negligible amount of *precipitation* was recorded in June and October.

Table 6.10 Mean Annual temperature and Total Annual Rainfall for WMCA 1978-2004

Years	1978	1988	1998	2002	2004
Mean Annual Temp (°C)	21.6	21.8	24.4	24.6	21.6
Total Annual rainfall (mm)	1381	748	632	799	1117.3

Source: Tanzania Meteorological Agency- Songea Branch, 2005

6.4.2.2 Trends in Changes in Rainfall Patterns from 1978 to 2004

The general situation, regarding changes in *rainfall amount* and *distribution*, between 1978 and 2004, based on data from the Tanzanian Meteorological Agency, demonstrated the decrease in the *rainfall amount* of about 264 mm, i.e. from 1381.4 mm to 1117.3 mm. The *distribution* was more *unreliable* marked by variations in rainfall seasonality over years. This posed a great threat to small scale agricultural systems on which the majority of the population depended.

Climate of WMCA, implying both *temperature* and *rainfall* conditions varied significantly in 26 years under review. The general trends indicated a slow but steady rise in temperatures. This was signified by the rise in *minimum temperatures*, therefore culminating into a decrease in the *temperature range*. Generally the area became progressively hotter for longer periods of the year than it used to be in the 1970s. The *rainfall amount* tended to vary, but with a decreasing trend. Its *distribution* was with increasing *unreliability*. The rain seasons consistently shortened from 1980s towards 2000 and beyond.

Reduction of tree cover tended to reduce *evapo-transpiration* therefore limited cloud formation, thus perpetuating drought conditions. In turn, drought tended to further constraint growth of vegetation and stimulated a rise in temperature. The projected temperature increases and decreased *rainfall amount* during the already dry months would bring about more severe droughts and substantial changes in seasonality. The observed temperature rise and rainfall reduction resulted into desert-like conditions that were detrimental to human communities. Other studies conducted elsewhere revealed a similar situation (WWF, 1997; AGCI, 1996).

In addition to removing the forest cover, deforestation causes negative impact to freshwater systems, loss of soils and decreased crop yields, increased insect infestation and the spread of infectious diseases (WWF, 1997). Aspen Global Change Institute (AGCI) emphasizes the need to avoid oversimplifying the causation between deforestation and climate change particularly due to the interactive relationship among the natural variables and the role of humans in the process (AGCI, 1996). Therefore, the existence of wide *annual variations* in *temperature* and *rainfall conditions*, were to be considered and had to be fully acknowledged in the PDE analysis.

Generally, variations and changes in climatic elements, i.e. *temperature* and *rainfall*, had mostly been linked with deforestation. Population increase had been repeatedly mentioned as being the responsible actor for the phenomenon. According to WWF, the rates of deforestation vary from one part of the world to another due to variations in the factors that drive the process (WWF, 1997).

Establishing the extent to which changes in population growth (and its inherent demographic characteristics), as the alleged major causal factor to deforestation contributed to deforestation, which in turn impacted on climate change of WMCA, was an aspect that called for a more detailed analysis of the PDE relationship, which the thesis undertakes to unveil.

6.4.3 Factors that Contributed to Climatic Changes

Similarity was noted between PRA responses and survey data on causes of changes in climatic conditions. PRA results indicated a general decrease in the *rainfall amount* over time from 1974. The phenomenon was mainly attributed to excessive deforestation compounded by the rapid population growth. Survey data in Table 6.11 revealed similar findings, whereby 44% of respondents noted that *rainfall amount* decreased, and 33% found it *intermittent*, while 21% did not notice any change. The climatic data of the area provided a similar scientific stance pertinent to the *rainfall regime* of the specified period.

Table 6.11 Households' Opinions on Variations in Rainfall Amount since 1974

Respondents' Opinions	Frequencies	Percentage
Decreasing	312	44.6
Constant	146	20.9
Increasing	13	1.8
Intermittent	228	32.6
Total	**699**	**100**

Source: Field Survey, 2005

Survey data Table 6.12 indicated that about 43% of the respondents mentioned deforestation being the main reason for decreasing *rainfall amount* and its *erratic distribution*. About 16% of them did not know the reason for the decline, while another 16% attributed it to weather changes. About 3% mentioned *drought* as the reason for less rainfall, while about 13% did not respond to the question. Seven percent attributed deforestation to 'God's plans'.

The above range of responses indicated limited understanding of environmental phenomena among respondents. It portrays the need for sensitization of communities on nature-related issues so as to facilitate success in future conservation initiatives. The critical aspect was on who should be educated, regarding what issues of environment and by which methods. These were issues aimed at enhancing effectiveness of programmes and sustainability of conservation results. The thesis addresses details of such issues in Chapter 7 and Chapter 8. These issues are considered constituting the area whereby sustainability could be forged, a gap of knowledge which the thesis strived to fill.

Table 6.12 Respondents' Opinions on the Reasons for Decline in *Rainfall Amount*

Reasons	Responses	
	Number	Percentage
Not applicable	17	2.3
God's plans & God's secret	48	6.6
Deforestation	314	43.2
Changes in weather	114	15.7
I do not know	116	16
Drought (desertification)	20	2.8
No Response	98	13.5
Total	**727**	**100**

Source: Field Survey, 2005

6.5 Indicators of Deforestation in WMCA

Deforestation is a phenomenon that refers to the decline in the state of forest cover (Jepma, 1995). The decline has generally been attributed to expanding human activities such as farming, firewood collecting, settlements and the use of bushfires (Savadogo *et al*., 2008). The above analysis has indicated appreciable expansion of farms. It was not readily known whether firewood consumption increased mainly for lack of reliable past consumption data. As trees take long to grow to maturity; and the fact that firewood was used by 98%, one would tend to anticipate an expansion.

PRA results identified several indicators of deforestation which included prevalent shortage of firewood and wood poles. This was shown by the long distances covered to source them. It was also demonstrated by the extensive use of other sources like crop residues and mango tree branches for firewood. Disappearance or reduction of some plant species such as the common wild fruits such as ndavatava (*flacourtiai indica*), mbula (*parinari excelsa*) and masuku (*uapaca kirkina*) indicated deforestation. Such trees were previously left for availing the community members with fruits, but with the scarcity of firewood, they were all cut to save this purpose.

Selective tree cutting and changes in *habitats* culminate into species extinction (Witmore and Saya, 1992, Turner *et al*., 1994). Selective tree felling is known to be caused by lumbering, firewood and wood poles cutting (Savadogo *et al*., 2008). Soil erosion and devastation caused by the winds to farms and settlements was also mentioned an indicator of deforestation (Ferraz *et al*., 2009). Such phenomena were reported in WMCA. Expansion of human activities removed the entire forest cover from farms and settlements caused by poor land management thus augmenting soil erosion (Turner *et al*., 1994).

Reduction in water levels in wells and rivers was mentioned to be another indicator of deforestation. Other studies obtained similar results (Cisternas *et al*., 2001; Biggs *et. al*., 2002; Thomas *et al*., 2004, PRA had similar findings. This was the cause of shortage of water for rural communities that were likely to increase distance to the water sources. Water shortage emanated from drought conditions characterized by reduction in *rainfall amount* and *temperature* rise.

The above information justifies arguing that deforestation was a reality and the product of development activities that, in turn, affected humankind (Wayland *et al.*, 2002). Field observation revealed areas that were bare of vegetation in vast parts of WMCA. A few exceptions were noted in Kikunja and Mpingi, where due to their remote location and their close location to thick forest reserves. However, with population growth the village frontiers were pushing the forest frontiers away. The impact of deforestation has already started being felt by the local communities. Land use history is considered important in assessing the current landscape conditions (Thompson *et al.*, 2002; Wayland *et al.*, 2002). The monitoring of deforestation is normally accomplished through calculation of the rate of deforestation expressed in terms of cleared area *per* unit time (km^2 *per* year). This indicator culminates into total deforestation that is extensively used in monitoring deforestation (Brasil, 2005).

6.6 Conclusion

It may be generally agreed from the analysis of findings of the PRAs, survey data and secondary data that the environment of WMCA changed through time. The changes were mainly attributed to expansion of human activities that culminated into adverse effects to the local environment. Various indicators of environmental change were observed and documented in the thesis. The use of historical deforestation data (based on indicators) in conjunction with present data (landscape structure) improves the analysis in examining the impact of deforestation (Ferraz *et al.*, 2009).

The forest cover decreased by 8.7% for the period between 1978 and 1988. A total of 608 hectares were cleared. Between 1988 and 2002 the forest cover decreased by 13.4%, implying that 851 hectares of the forest were cleared. For the period between 2002 and 2004 forest cover decreased by 2461 hectares, i.e. 44.7%.

The hydrological conditions indicated environmental degradation as the *flows* of rives that originated from the area were highly adversely affected. The *Ruvuma River* had its *minimum discharges* declining for the most period under review. Between 1974 and 2000, the *minimum discharges* declined by 87%, i.e. from 88 *cusecs* to 11.3 *cusecs*.

Micro climate of the area indicated a significant change. The *total annual rainfall* decreased by 264 mm while its *distribution* decreased from 6 months in 1960 and 1970s to 4 months by 1980s and ahead. The general tendency was decreasing in *rainfall amount* and shortening wet seasons with years. *Mean temperatures* tended to increase mainly as a reflection of the rise in *minimum temperatures* by 1.6°C while the *maximum temperatures* decreased by 2.9°C, thus a general rise in winter temperatures indicated by the decrease in *annual temperature range*.

Changes monitored in the study included forest cover changes, changes in the *catchment value* of the area, signified by the declining *river discharges*. The periodic rates of deforestation were established using GIS technique and results were analyzed. The status of weather, particularly regarding the variability of *rainfall amount* and its *erratic distribution* was established through the analysis of secondary data and the findings were documented.

It should, however, be noted that it is not the perception of the thesis to view the environment as a static entity, neither to blame human activities for the use of natural resources. The point is to urge for sustainable resource utilization through establishing the most *immediate agents* in the process, by their demographic characteristics. It was as well geared to establishing the extent of environmental changes, a step towards ascertaining the contribution of population factors to deforestation. This is considered important to achieve sustainable conservation since it enables the engagement of the right population category, i.e. the *key actors* in the process.

Many explanations are advanced to describe the causes of the observed state of the environment in WMCA. Expanded human population to the *ecologically sensitive areas*, *catchment forests* in particular was the main factor responsible for *ecological*, *hydrological* and *climatic* alterations that were linked to deforestation.

The main *tenet* of the thesis builds on the line of thinking that places the existing link between demographic factors, development activities and environmental effects at the centre of the discussion, for the formulation of sustainable conservation efforts in WMCA and elsewhere. The knowledge obtained, concerning the nature and character of PDE linkages remain crucial for the understanding of the real causes of deforestation, identification of the *key actors* in the deforestation process, their roles in the process and their contribution in accelerating deforestation. This provides essential inputs needed for the formulation of effective *conservation packages* and planning of *intervention strategy* and scheduling the *intervention timing*.

CHAPTER SEVEN

PEOPLE'S INVOLVEMENT IN DEFORESTATION-RELATED ACTIVITIES

7.1 Introduction

This chapter is an effort towards production of knowledge and explanations regarding involvement of people of different demographic characteristics such as age groups, sex categories and levels of education in deforestation-related activities. Specific activities under review included forest clearing for farm expansion and for firewood. Since the characteristics of the forest cover is a product of both deforestation and conservation, in this case means aforestation, it was necessary to include the latter in the analysis.

The chapter identified *key actors* in each one of the deforestation-related activity, as a profound step towards explaining the engagement of household members of different sex categories, age groups in such environmentally significant activities. Following Orians and Skumanik (1997), it was asserted that human population does not come into interface with the forest as a single unit but in its disaggregated manner.

The chapter advanced further into establishing the rationale behind people's differential involvement in such activities that characterized vegetation cover, with more focus on catchment forests. The actors in such activities were the ones who determined the interface between population, development and environment. The knowledge generated would facilitate the subsequent quantification of the extent to which various actors, by their age group and or sex categories, contributed to deforestation and conservation. It is hereby postulated that identification of the *key actors* in farm expansion and firewood collecting, by their demographic characteristics, was central in the PDE analysis.

The future planning and formulation of forest conservation strategies, packages and interventions were considered to be more focused and effective in case the *target populations* of the *key actors* was known not only in terms of who or how many they are; but more important are their demographic characteristics, the impact they caused and rationale behind their engagement. Such knowledge would ensure higher level precision in planning and directing of extension packages to the right *target population*, an aspect considered vital for the effectiveness and sustainability of conservation efforts.

The understanding and establishment of the specific man-resource interface is the main focus of the chapter. It is envisaged that without the identification of the *key actors* to the deforestation process, by their demographic characteristics, there would be less specificity in the tackling of various crucial stages of development of conservation efforts. This is likely to amount into misdirection and ineffectiveness of the conservation activities.

Population is a dynamic entity which required to be articulated in the analysis. Knowledge on population projection could hence be directly harnessed for use in an effort to examine and understand future trends in population and environmental changes if the *key actors* in environmentally significant processes were known. The *key actors* formed the *nexus*, i.e. the 'linking population'. They link between the total population and the actual 'resource harvesting' whose interplay impacted on the environment that manifested through the ailing state of the environment.

Changes in population of the actors in terms of size, age structure and sex composition for 1978, 1988, 2002 and 2005 were analyzed to determine trends and changes in population characteristics to compare such changes with changes in the development and environment covered in Chapter 8 of the thesis[32]. The chapter analyzed the data from Household Field Survey[33] and the Participatory Rural Appraisal (PRA).[34] Survey data covered specific household roles of all the 3371 individuals present in the 699 interviewed households. The individual household members' actual involvement in the deforestation-related activities was identified and recorded.

Vital registration statistics obtained from the village registers could not be used in the final analysis, due to inconsistency and unreliability. Environmental behaviours of household members, by age groups and sex categories noted in the analysis of survey data were extrapolated for 1978, 1988 and 2002 to determine changes in population characteristics and the environment. Since cultural values and customs take a long time to change, the division of labour that was based on age and sex take long to change. It was envisaged that the kind of *division of labour* observed remained the same for the entire period under review.

It is worth mentioning, at this stage, that the Chapter was developed cognizant of the fact that population growth accelerated the demand for food and other forest products that necessitated the expansion of farms and enhanced extensive and intensive use of firewood. This analysis based on the classical development paradigm that assumes the *key actors*, be it males and/or females, were 'mere agents' of the rest of the household population that benefited from the role of such *key actors* in activities that contributed to the observed status of the forest cover.

[32]The Data For 2005 are the Households survey data.

[33]Household Field Survey was conducted in eight of the eleven villages of WMCA to collect data and information to be used in the analysis of PDE relationship in this study.

[34]Participatory Rural Appraisal was conducted in the study area to collect the qualitative information and data whose analysis provided explanations attached to the quantitative data analysis.

The complexity regarding deviations in environmentally-related behaviors within specified age groups, between the age groups and sometimes even within a single age group with time, were issues taken into consideration. The method adopted for the analysis of the population was based on the understanding of the *modus operandi* of the members of the population on the environment. It was assumed that household members, by age groups or sex categories classified as *key actors,* behaved in a similar way when they interacted with the environment in terms of both the intensity and the duration of such activity that shaped the forest cover characteristics.

In this manner, there could be no big variations like the case would be when considering the entire population which was more generalized and likely to be 'demographically misguided'. This was the essence of the need for a more focused degree of precision in the planning and implementation of the conservation efforts based on *key actors* identification which we propose.

7.2 People's Involvement in Activities that Contribute to Deforestation by Demographic Characteristics

PRA results indicated the existence of a relationship between demographic characteristics of the individual and his/her role in activities related to both deforestation and forest conservation. It means one's age group and/or sex category influenced his/her likelihood to get involved in those activities that caused or accelerated deforestation. A similar finding was observed regarding involvement of community members in conservation activities, studied basing on involvement in tree planting.

Age-based and gender-based division of labour was a significant factor in explaining the noted age-based or gender-based biases. The reality was that specific socio-economic tasks were traditionally assigned to individuals based on one's age and/or sex necessitated for the observed bias. It was this bias that made deforestation to be analyzed on demographic basis; and so was forest conservation.

However, investigating on the reasons behind traditional age and/or sex-based division of labour was beyond the scope of the study. Explaining its perpetuity in societies for generations, without significant changes, was considered another different subject of enquiry which was not part of the thesis.

7.2.1 Peoples' Involvement in Deforestation-Related Activities by Age-groups

Survey data indicated that age was among the major factors that influenced or determined one's involvement in activities related to causing deforestation. PRA results stipulated that people of low age-groups, such since those aged 0-7 could not play any significant role in deforestation-related activities as they had not physically grown up enough to take part in such labour intensive tasks. The same explanation was given for those in older age-groups, mainly aged 55 and above. Unlike their other extreme end age group members, i.e. those aged between 0 and 7 had one reason for not participating in the activity. The elderly people did not actively participate in such activities for two major reasons. One being that they had already participated in the activity during their young age; therefore they had already acquired enough cleared farm land. The second reason was that the elderly people had lost energy to continue with such labour intensive activities as attributed to old age.

PRA results indicated that it was an unavoidable social obligation for the young males and females to take care of both children and the aged. This basically included provision of food and shelter, aspects which resulted into reduced the aged and children's direct engagement on activities that affected forest cover. The fact is that clearing the forest could not just be stopped so as to conserve forest cover. However, the greatest challenge to the communities was finding out the way to achieve sustainable land practices that would cope with the increasing resource demand brought about by the growing human population. This was the essence of carrying out the PDE analysis.

From the above discussion, it was imperative that there is a particular age at which an individual household member begins undertaking such activities; we call it 'entry age'. Logically, it equally implies existence of 'exit age' for the same. Demographic characteristics were regarded central for the analysis that leads to understand the existing linkages between changes in population, development activities and environment change. Presentation of data and the discussion on the actual involvement of household members of different age groups in selected activities contributing into deforestation are issues covered in sections 7.2.1.1, 7.2.1.2 and 7.2.1.3.

7.2.1.1 People's Involvement in Clearing the Forest for Farm Expansion by Age-groups

Survey data in Table 7.1 indicated that out of 3,371 people who lived in the 699 interviewed households, only about 19% of them were involved in clearing of the forest for the purpose of expanding farms, while about 38% did not take part in the activity. The observed unique feature was that about 40% of the household members indicated that the activity was not applicable[35]. We may profoundly argue that farm expansion was an activity that involved a relatively small proportion of the population. Scarcity of *public forest land* for expansion of farms and the adoption of more intensive farming methods were main reasons for a significant proportion of the population not to be engaged in farm expansion. Both PRA results and field observations noted acute scarcity of both *closed woodland* forests and *open public* forests on which inhabitants could expand farms into.

[35]Most of the households depended on farming but they could not expand farms as there were no unoccupied public forest land areas on which people could expand their farms.

Table 7.1 Involvement of Household Members in Clearing Forest for New Farms

Responses	Number	Percentage
Yes	623	18.5
No	1294	38.4
Not Applicable	1454	43.1
Total	**3371**	**100**

Source: Field Survey, 2005

Communities of *Lihwena, Muungano* and *Chemchem,* had no possibility for farm expansion at all, mainly due to nearness to the municipality of Songea, whereby farming was legally restricted and that urban settlements expanded to the *peri-urban* with the tendency to occupy previous farm areas. Having been surrounded by forest reserves, inhabitants of *Ndilima Litembo* lacked the area for expanding farms. Under the observed land scarcity situations, any increase in farm output depended on either intensification of farming practices or encroachment of the forest reserves.

In WMCA it was common scenery to observe economic activities expanding at the expense of forest reserve areas and overt progressive clearing of a few remaining *mosaics* of *closed woodlands* and unoccupied *public forest lands*. Lack of *buffer zone management* was mentioned to be among the reasons for this situation (URT, 2005b).

Expansion of farms was reported to be driven by the rising food requirements for the growing size of households. However, farm expansion was carried out by only a few household members. Thus it was significant to identify the actors in the activity focusing on conservation activities for sustainable results. The population pyramid Figure 7.1 indicates that clearing the forest for the purpose of expanding new farms was an activity carried out by young adult males.

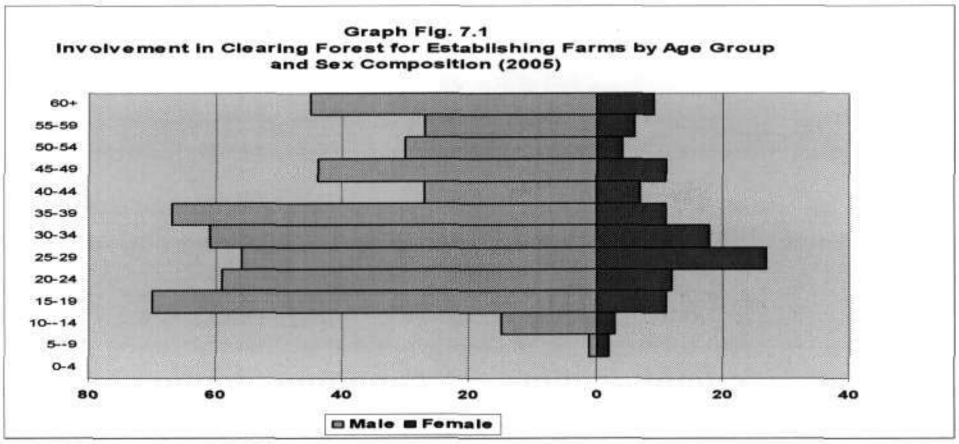
(i) Actors in Clearing Forests for Establishing New Farms by Age Groups

Survey data indicated that individual's interaction with the forest for farm expansion was noted to begin at the age of about 8. People in such younger age groups were 'inducted' into the activity as part of 'training' the younger generation to join the mainstream smallholder production systems. PRA results indicated that at the age of between 15 and 18 the involvement of male members of the households in the activity was almost compulsory since one had to have his own farm, a sign of maturity and socially responsible adulthood.

On this basis, it was not surprising for those in the age groups 15 to 39 to constitute the majority of the participants in the activity. The massive involvement of younger population in the activity derived from the fact that they constituted the young and energetic sector of the population, vested with socially significant responsibility that ranged from getting married, caring for their own children and other household members. The number of participants in the activity dropped drastically at the age of 49+ indicating the 'exit age'.

Existence of a proportionately larger group of people aged 60+ was likely caused by a misconception of the question. PRA results showed that such people apparently played a significant role in farm expansion sometime in the past, therefore would not like to remain unmarked for their contribution in farming. To the local inhabitants of Songea district, expanding a farm was a sign of profound success and an important investment for the household. Therefore it was derogatory for a person to indicate not having cleared the forest for the purpose. Thus, the possibility for over reporting on the issue could not be ruled out.

We emphasize that only a small proportion of the population was involved the important activity. Survey results indicated that out of 3371 household members, only 623 were actually involved in the activity, accounting for about 18.5%. However, the existence of a small proportion of actors in the activity did not; neither does it mean that the activity impacted less on the disappearance of forest cover. The extent to which the activity affected forest cover is discussed in Chapter 8.



Source: Field Survey, 2005

(ii) The Need to Identify the Key Actors

Analysis of the actors in various activities that contributed to deforestation observed that such *actors* existed in a wide range of age groups; with low initial age for household members joining the economic and/or livelihood activity. For consistency, reliability, more comparative and precise results, the use of the *key actors* in respective activities in the analysis was considered appropriate and was therefore adopted in the analysis.

The *key actors* constituted those household members considered to have played a more intensive role in specific deforestation-related activity. *Key actors* were selected based on their age groups and sex categories from a section of the household population with direct interface with the forest. The selection was based on responses from the household survey. PRA results helped in focusing the grouping of the *key actors* and the rationale for their involvement.

(iii) Method of Identification of the Key Actors

Identification of *key actors* in various activities that shaped the status of natural vegetation cover was done by plotting the data for participants and non participants of the activities by age groups in line graphs on the same *XY* plane (see Figure 7.2). The fact was that there were different ages at which individual household members started to get involved in the selected livelihood activity that reduced forest cover.

The trends indicated that the numbers of participants in the activity increased with increasing age from age groups 5-8 to 15-24. The opposite trends were noted for the population of those who did not take part in the activity whereby their numbers decreased with increasing age up to a certain stage where their numbers tended to increase.

The point at which the curve of non-participants intersected with that of the *participants* was considered to be the *minimum optimum age* for one to start getting involved in a particular activity. This was the 'entry age'. The next intersection of the two curves was considered the *maximum optimum age* of one's involvement in the activity which, in this case marked the 'exit age'. The area (shaded) between the two graphs constituted the *key actors* in the activity. It consisted of the population of interest on which the analysis was based on.

The theory behind this classification of the *key actors* is that the age at which involvement in activities differed from one household to another. In some households the involvement began at earlier ages while in other households it was *vice versa.* Therefore the need to determine the *optimum age* remained crucial. Another assumption was that those household members in lower age groups, like their counterparts in advanced age groups, were thought to, *cateris peribus,* contribute relatively less to the deforestation and conservation processes despite their involvement. This was attributed to their physical inability for more active involvement. The point of intersections compromised those who began the involvement earlier and those who joined it later, but at a particular age their numbers were the same as those who actually participated.

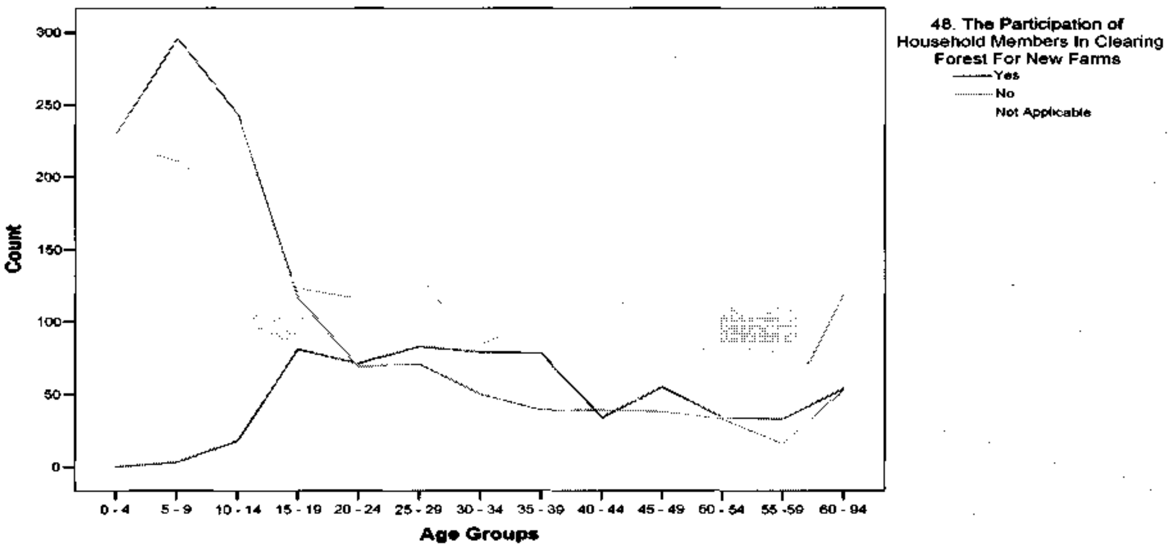
The general trends indicated that the 'entry age' for involvement in clearing the forest for farm expansion was as low as 8. It was well known that children played a significant role in agricultural production. Therefore it was boldly noted that children were commonly used in on farm tasks as part of 'induction' to agricultural production system, i.e. the basis of rural economies and livelihood (Mbilinyi, 1997; Kashuliza and Mwakalobo, 1999; TGNP, 2007).

Evidence from elsewhere indicated a close association between peasant agriculture and *high fertility* (Henin, 1969; Simmons, 1985). The cultural value of *high fertility* among the peasantry was mostly considered a function of high demand for labour that was a function of low levels of technology and stagnant returns; aspects which characterized rural economies (Kamuzora, 1980). The study conducted in central Tanzania by Madulu observed that *high fertility* and larger families in *smallholder* areas was linked to power, wealth and high crop output (Madulu, 1991b). Children were considered an asset that meant more hoes (labour) and more grain (Malcolm, 1953 cited in Madulu, 2001). Whether the broadly observed early involvement in production activities, at household level, could be classified as part of "child labour" is an aspect beyond the scope of the thesis.

(iv) Identification of Key Actors in Converting Forests into Farms

The method described above was used in the selection of the *key actors* in converting forests into farms. The graph in Figure 7.2 below illustrate that the *optimum* 'entry age' for the activity was 10 while the 'exit age' was 44.

Figure 7.2 Selection of *Key Actors* in Clearing the Forest for Farm Expansion



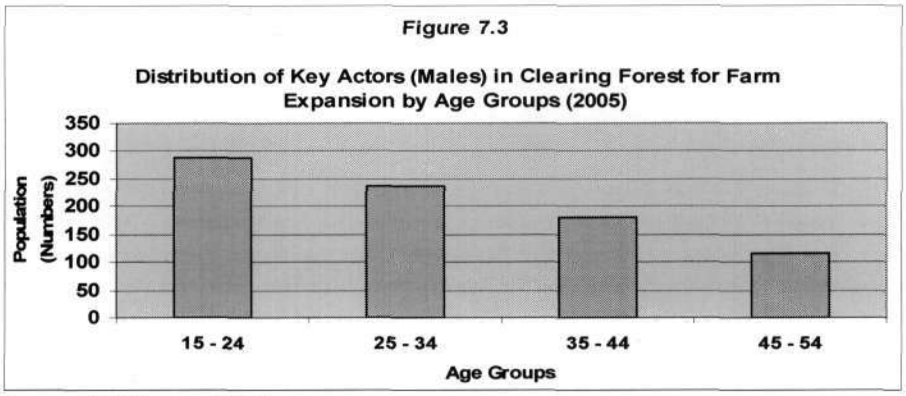
Source: Field Survey, 2005

(v) The Key Actors in Conversion of Forests into Farms by their Age Groups

Survey results demonstrated in Figure 7.3 indicated that the fastest rate of growth of numbers of participants occurred between age groups 10-19 and 19-24. This section of the population was noted to consist of people who were energetic enough to carry out tasks. The *optimum* point for them to start involving themselves in the same activity was at the age of 9, i.e. where curves intersected.

In this case the *key actors* in the activity therefore constituted those members aged from 20 to 44, which were the most active population segment in the activity. During the study year, i.e. 2005 there were 345 household members who constituted 10.2% of the total households' population and 55.4% of the total of 623 people involved in the activity.

When analyzing changes in age group sizes of the *key actors*, basing on Figure 7.3, it was noted further that the number of actors increased with increasing age, with the highest number of participants aged 20. The numbers of actors slowly but progressively decreased from age group 25-34 and 35 to 44. The less involvement of those aged between 45 and 55 may be explained to be the result of stabilization of household economies and/or activities, implying that the task of clearing the forest for extra farms was completed. It may also imply that the following generation (their sons) had taken charge as they should be in their 20s. There was a sudden drop of involvement at the age of 44 and above. Most of the people in the elderly age groups, i.e. those aged 55 and above ere less involved in the activity mainly on account of their physical weakness and self actualization.



Source: Field Survey, 2005

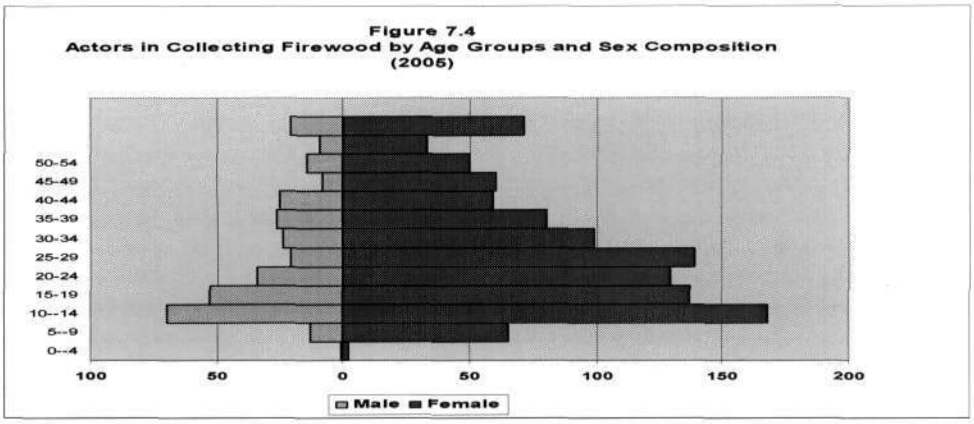
7.2.1.2 Involvement of People of Different Age Groups in Collecting Firewood

Survey data in Table 7.4 indicate presence of very few people in the age group 0-4 who participated in the task. PRA results attributed the trend to the lack of enough energy to carry a sizable heap and walk for a distance due to their young age. The age of 4 was considered too low for effective involvement.

(a)Actors in Collecting Firewood

Population pyramid Figure 7.4 demonstrate that there were 1,350 people who participated in the activity constituting about 40% of the total population of the households' members. The participants in the activity were within the age group range of 5-9 to 60+.

The age structure of the *key actors* in firewood collection, demonstrated by population pyramid Figure 7.4, indicates presence of relatively less participation of members aged above 40. This was mainly attributed to their old age associated being less energetic and that their off springs had already taken charge over the activity. A drop in numbers of those aged 40 and above implied a drop in their proportionate contribution to deforestation through the activity.



Source: Field Survey, 2005

Evidence from studies conducted elsewhere indicated that the task of collecting or cutting firewood began at a relatively tender age of 4 and was socially considered part of the training of the younger generation (Mbilinyi, 1997; Punch, 2001; Sherbinin, 2006). However the majority joined the task at the age group 5-9 and that PRA results pegged the initial age for the activity at age 8, implying prevalence of a form of 'child labour' in the rural setting.

The number of participants in the activity increased with increasing age up to the age group 25-29 where the initial decline was observed, with the general trend indicating a decreasing number of participants with increasing age. This trend could partly be attributed to the generally observed less involvement of males at maturity and advanced ages.

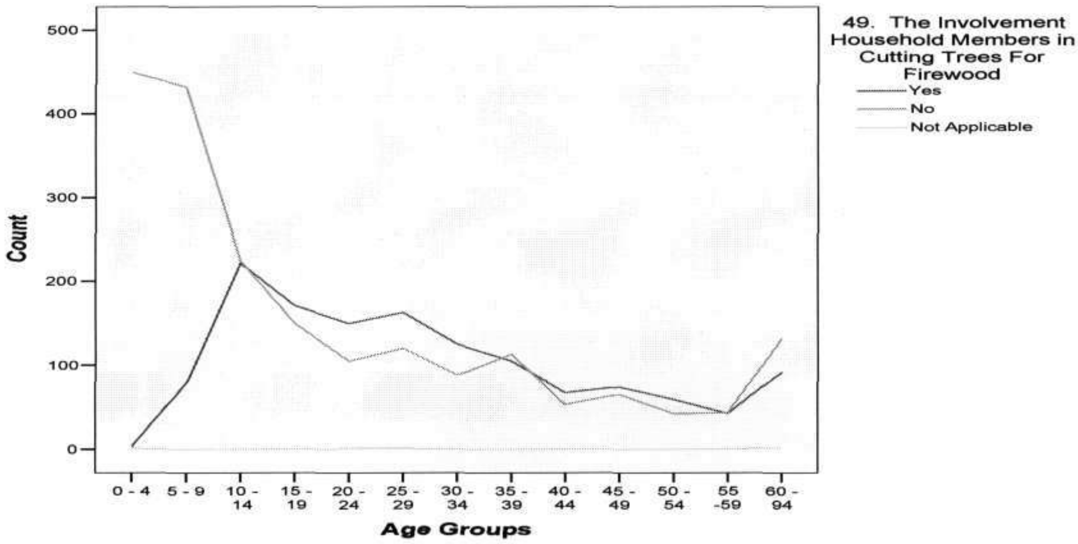
The observed unique feature was the sharp rise in the involvement of people in old age, i.e. aged 55 and above. This could partly be explained in terms of lack of effective 'social security mechanisms' to care for the elderly therefore, most of them were left to struggle on their own to earn a living. Most of such people were old males and females who had to take care of their grand children, orphans and widows for survival. A positive relationship between one's age and involvement in the activity of collecting firewood was noted. The most active age group in the activity was those between 10-14 and 35-39. The age-group range constituted of 935 household members, i.e. 27.7% of the total households' population; and 69.2% of the 1350 members who generally participated in the activity.

(b) Identification of the Key Actors by Age Groups

Figure 7.5 indicates that the 'entry age' for the activity was 10 while the 'exit age' was 49. The stability age was between 15 and 44. From that point the trends were on the reverse, i.e. a decreasing number of *key actors* with increasing age was experienced progressively towards an 'exit age' of 49. From the 'exit age', the number of *key actors* tended to decline further towards 60 and above.

People in the age group 10-14 constituted the majority of participants in the activity, though due to their relatively younger age, they likely contributed less to the deforestation. They were merely considered rendered 'assistance' to the more profound players in the activity. They constituted the *minimum age* group of the *key actors* as their presence in large numbers was likely to have brought about a considerable impact to forest cover despite their comparatively little individual impact. Although these were 'apprentices' in the process, they significantly contributed to deforestation. The impact they caused could provide for a better understanding of both their current contribution and the future potential in changing the forest cover. The Graph Figure 7.5 shows the *key actors' range* and basis of the 'entry' and 'exit' ages in the activity of collecting firewood.

Figure 7.5 Selection of *Key Actors* in Collecting Firewood



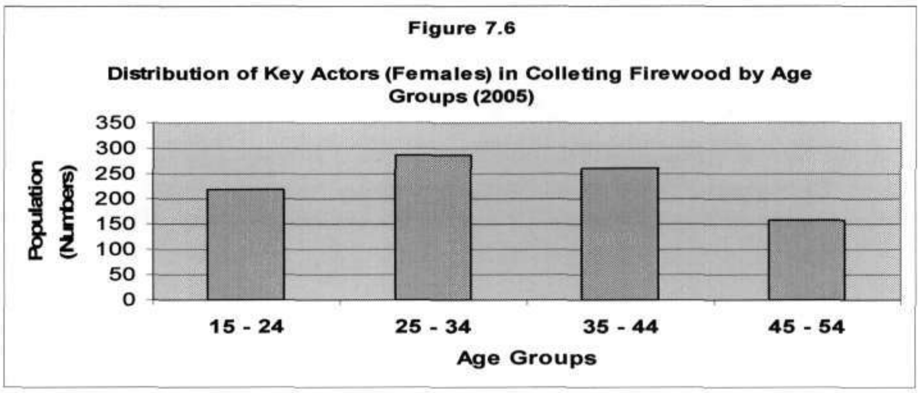
Source: Field Survey, 2005

(c) Key Actors in Collecting Firewood by Age Groups

While 40% of the household members played an active role in collecting firewood, 60% did not take part in the activity at all. The thesis perceived it imperative to establish the demographic characteristics of *key actors* in this activity to determine the main participants in the activity. Information obtained was basic to the improvement of sources of firewood and enhance sustainable resource utilization for the few firewood supplies available. Determining the *target population* for the activity that adversely affects the environment was therefore, indispensable.

The distribution of the *key actors* by age groups is illustrated in Figure 7.6. It illustrates that the key actor's age ranged from 10 to 44. The general trends in variations in age groups demonstrated an increase in the numbers of *key actors* with increasing age from low age groups towards age group 15-24.

From the above discussion, we may strongly argue on the existence of positive relationship between one's age and his/her involvement in the activity of felling trees for domestic firewood. We emphasize, at this point, that since not all household members experienced homogeneous type of interface with natural resources, carrying out demographic analysis of the population-resources relationship for sustainable resources use was both significant and necessary.



Source: Field Survey, 2005

7.2.2 Involvement of People in Activities that Contribute to Deforestation by Sex

PRA results revealed the differential involvement in various economic activities between males and females. This kind of relationship was, as stated earlier, mainly attributed to social division of labour and specialization, whereby some duties were designated for males and others were meant for females.

However, it was observed that in the event of the absence of a member of the sex 'designated' responsible for a particular activity, a member of another sex could just take over[39]. Community members regarded it a taboo for a particular member of a certain sex to play a socio-economic role meant for a member of a different sex category when the 'right candidate' was present and was in perfect physical and mental conditions.

Population pyramids, i.e. Figure 7.1 and Figure 7.4 demonstrating the involvement of household population in clearing of the forest for farm expansion and for firewood indicated existence of a broad sex bias in household members' involvement in the two activities. However, in firewood cutting, females were responsible mainly for collecting the already cut trees. Males were noted to be the ones responsible for the cutting or felling of trees.

PRA results pointed out the main reasons for explaining the state of affairs based on differences in terms of muscular capacities for labour between males and females as underlining in the observed division of labour. PRAs revealed that duties such as clearing the forest for farm expansion, molding and burning of bricks, construction of homesteads, etc were classified as "too heavy for females", therefore, a prerogative of their male counterparts. Whether such biological assumptions were scientifically proven is an aspect beyond the scope of this thesis.

7.2.2.1 People's Involvement in Forest Clearing for Establishing or Expanding Farms by Sex Categories

The population pyramid, Figure 7.1 indicated males' dominance in involvement in the felling of trees for farm expansion; therefore in that way, they contributed to more deforestation through this activity. Less involvement of females in the activity was attributed to the socially based division of labour, with males being traditionally charged with the responsibility of ensuring the continuous availability food for the household. PRA results underlined similar results.

Patriarchy formed the basis of dominance of male sex in the activity as males were the 'owners' of the homesteads, farms and farmlands. These were therefore logically responsible for farm preparation and maintenance. These findings have also been collaborated by Mbilinyi (1997) in her study in conducted in Morogoro, Tanzania.

Generally, based on data in Table 7.2, we may strongly argue that there existed a positive relationship between one's sex and involvement in the task of clearing of the forest for establishing farms. About 80.6% of the males participated in the activity compared to 19.4% of the female counterparts. Therefore, it is imperative that males dominated the activity. Similar results were echoed by the PRA results.

Table 7.2 Involvement of Household Members in Clearing Forest for Farm Expansion by Sex

Sex	Numbers	Percentage
Male	502	80.6
Female	121	19.4
Total	**623**	**100**

Source: Field Survey, 2005

However, the sex based proportions of those members to whom expansion of farms was not applicable were 48.4% for males and 51.6% for females. Presence of a large number of people to whom the activity was marked as "not applicable" emanated from scarcity of land area for farm expansion.

7.2.2.2 People's Involvement of in Collecting Firewood by Sex

Survey data in Table 7.3 indicated that females were much more involved in the task of collecting firewood than their male counterparts. Females' involvement in the activity was 80.9% while male involvement accounted for a mere 19.1%. The population pyramid (Figure 7.3) above indicates a notable bias in terms of the differential involvement of males and females in the activity by age groups. However, there were very few households (about 4%) in which only males collected firewood. About 20% of households had both males and females collecting firewood. Hence the majority of households, i.e. about 74% had females as firewood collectors. A similar observation was noted for the entire developing world (Dutta, 2003).

PRA results revealed the same pattern of division of labour whereby the conspicuous role of females in firewood collecting was observed and noted. This was attributed to the fact that females were the ones socially responsible for the cooking task. They were the implicit members who knew the right types of wood needed, based on vast experiences acquired through generations. Females knew about the right type of trees for firewood based on the quantity of energy produced and other characteristics such as amount of smoke it produced, the duration of burning and many others experienced in the kitchen where they were predominantly responsible.

Table 7.3 Involvement of Households' Members in Collecting Firewood by Sex

Sex	Numbers	Percentage
Male	258	19.1
Female	1092	80.9
Total	**1350**	**100**

Source: Field Survey, 2005

In rural areas, firewood is normally not a commodity and that it takes between 2.6 to 10 hours to collect it; a task normally done by women and small children (FAO, 1984). The same fact was echoed by Johnsen, who argued that in most of the tribes of Tanzania, firewood gathering belonged to women's duties (Johnsen, 1999). The observation implied that the social division of labour has been a long term customary practice.

General trends, as demonstrated in Table 7.4, indicated that only a small proportion of the population, i.e. about 40% that was actually engaged in the activity. The fact that majority of the respondents, i.e. 69% obtained firewood from the neighbouring forests, makes it difficult to separate the impact of firewood collection from farm expansion since the two activities affected the same area in the same period.

Farm expansion was a more general activity which cleared almost all vegetation in the farm area, at the same time and by the very process trees ere cut during farm expansion. These trees which were cut down were later used for firewood. Huge logs were normally burnt in the farms or used for other activities like brewing and/or brick burning. Thus separating the impact of deforestation by activity, in the real situation could practically not be possible.

Table 7.4 People's Involvement/Non Involvement in Collecting Firewood by Sex

	Involvement in Collecting Firewood			
Sex	Yes	No	Not Applicable	Total
Male	258	1429	3	1690
Female	1092	587	2	1681
Total	**1350**	**2016**	**5**	**3371**

Source: Field Survey, 2005

7.2.3 People's Involvement in Deforestation-Related Activities by Levels of Education

The thesis postulates that levels of education influenced one's possibility of involvement in deforestation-related activities. A study conducted elsewhere in Tanzania indicated that the children in towns are much more likely to get education than their rural counterparts due to concentration of capital and educational services in urban centres. The continuous flow of educated people from rural to urban areas increased the difference in numbers of educated people between the two areas (Claeson and Egero, 1972). This indicated presence of more people with low levels of education in rural areas. People with low levels of education were relatively less mobile compared to their counterparts with higher levels of education. Such people were more likely to stay back in the respective rural settings and deal with primary economic activities that are detrimental to existence of forest cover.

Survey results indicated that in the period of three years, i.e. from 2001 and 2005, only 85 out of 699 surveyed households had member(s) who moved out. They constituted only 12% of the surveyed households of whom only 10% indicated that they moved to the urban area to seek for employment. The rest constituted *rural-rural* migration, hence signifying no change in land use types. Early marriages, at age 16 for females and 19 for males, partly resulted from lack of chances for advancing in education, thus lead into greater likelihood of expanding human population and become directly engaged in rural economic activities that adversely impacted on natural vegetation. For males, who married regarded it as a step towards maturity and self reliance.[36] PRA results indicated similar findings.

Relationship between people with different levels of education and actual involvement in activities that caused or accelerated deforestation is the subject discussed in items 7.2.3.1 and 7.2.3.2.

7.2.3.1 Involvement in Clearing Forests for Farm Expansion by Levels of Education

Survey data in Table 7.5 indicate that the majority participants in the activity were primary school leavers. Such results cannot be easily contested as they carry a statistical logic based on the fact that most of the inhabitants, i.e. about 61% had attained primary education, with their life systems totally dependent on small scale farming activities.

Since the majority of household members ended up with primary education, they hardly had any alternative socio-economic activity than converting the forest into own homesteads and farms for their livelihood. The socio-economic conditions in the rural settings 'compelled' them to enter into early marriages. Even the question of 'early marriages' was to the rural people's perception questionable. To them that was the right moment towards engagement in social, traditional and economic responsibility.

[36] Self reliance was the target behind *Ujamaa* policy which meant the ability to have the basics of life.

Existence of a proportionately smaller number of pupils selected for secondary education or other types of training tended to aggravate the situation. Such people, with low levels of education, participated wholly in rural economies while those with secondary or higher levels of education normally got formal employment, thus having less possibility of impacting on the forest cover.

For the period of four years, i.e. from 2001 to 2004 one thousand pupils completed primary education in the eight sample villages. However, only 79, i.e. about 8% passed exams leaving the rest 92% entrenched in rural economies that have proved to be as detrimental to forest cover. It may generally be argued that levels of education have an impact on influencing one's involvement in activities classified as causing or augment deforestation. Other things being equal, one's possibility to engage in activities that directly augment deforestation tends to be less as one climbs higher the 'ladders of education.'

Education has a general tendency of 'shifting people' from rural systems to 'modernized', i.e. urban activities characterized with more formal employments that reduced population pressure as it de-links the population from deforestation causing activities. Education of local community members facilitated *rural-urban migration* from the forest reserve and ensured sustainable conservation of Wolong forest and the threatened giant panda (Liu, *et al.*, 2000). The same could also be applicable in WMCA.

Table 7.5 Involvement in Clearing Forest for Establishing Farms by Levels of Education

Levels of Education	Involvement in Clearing Forest for New Farms			Total Number
	Yes	No	Not Applicable	
None	55	420	429	904
Primary std 7	445	411	607	1463
Primary Std IV	64	36	76	176
Secondary	14	6	18	38
Adult Education	8	0	6	14
Primary Std 8	4	1	4	9
Secondary Std 10	1	1	6	8
Pupils (Still in Schools)	32	419	308	759
Total	**623**	**1294**	**1454**	**3371**

Source: Field Survey, 2005

7.2.3.2 Levels of Education and Involvement in Collecting Firewood

Survey data in Table 7.6, on the involvement of people of different levels of education in collecting firewood, displayed a mixed relationship. Those who attained primary education and involvement in the activity were 509 making up 81%, accounting for the majority of the inhabitants. They were the ones who constituted the most active group in the activity of collecting firewood.

PRA results indicated a bias against males in the activity of collecting firewood irrespective of their (males) levels of education. Furthermore the population had a few members of the households who attained higher than primary level of education. Female household members, with higher levels of education, collected firewood, like their female counterparts with primary or lower levels of education. Generally, we may argue that levels of education alone cannot be considered to be a sufficient and necessary condition to influence one's involvement in activities of collecting firewood. Other factors ought to be taken into account when analyzing such complex relationships. Cultural values appeared to be more influential. The fact was that in a rural setting, significance of levels of education in determining his/her social/economic was not very evident as the community was predominantly composed of members with low levels of education.

Table 7.6 Involvement in Collecting Firewood by Levels of Education

Levels of Education	Involvement in Collecting Firewood			Total Number
	Yes	No	Not Applicable	
None	125	777	2	904
Primary std 7	799	662	2	1463
Primary Std IV	85	90	1	176
Secondary	24	14	0	38
Adult Education	5	9	0	14
Primary Std 8	1	8	0	9
Secondary Std 10	4	4	0	8
Pupil	307	452	0	759
Total	**1350**	**2016**	**5**	**3371**

Source: Field Survey, 2005

7.3 People's Involvement in Conservation by Age, Sex and Levels of Education

To underscore involvement of people of different demographic characteristics in deforestation-related activities alone was unsatisfactory for generating detailed explanation concerning their specific roles and respective contribution to forest cover status. Neither was it a satisfactory step towards determining the past and the current environmental status of WMCA which was concurrently shaped by both deforestation and conservation.

Both negative processes, i.e. deforestation and positive processes, i.e. conservation in this case taken to mean tree planting collaborate and determine the state of the forest cover in terms of both its spatial coverage of natural vegetation and tree density. The argument is that considering deforestation alone undermines all the past and present conservation efforts that include aforestation and maintenance of designated forest reserves.

The relationship between population, development and environment was not at all times negative. Neither was it always positive. Therefore, there existed many positive aspects to be considered for a more realistic assessment and analysis of such relationships especially when dealing with a location-specific study of this nature. The basic issue at stake was that human population continues to make use of the land resources for its livelihood and development. The contemporary challenge is based on how to make effective use of the natural resource endowment sustainably.

Survey data in Table 7.7 indicate that only about 29% of the 3371 members of households participated in forest conservation activities by tree planting, mainly dealt with aforestation. Others were involved in conservation by 'abiding to the conservation regulations' i.e. by avoiding invading forest reserves, therefore fostering forest conservation initiatives.

For the purpose of this thesis, the planting of trees was investigated in detail and was quantitative enough to be included in the PDE analysis. This included determining the role and contribution of people of different age-groups, sex categories and levels of education in planting trees. Survey data indicated that 71.4% of households participated in conservation through planting trees. However, the proportion that actually planted trees accounted for only 29.8% of the entire surveyed households' population.

The proportion of those who planted trees by sex categories of actors, and age groups pointed towards a broad male bias. This necessitated examining more detailed explanation on the reasons for this phenomenon. The basis of the bias and use of the same findings and knowledge in the analysis of on-going conservation efforts was considered of great utility for future conservation activities.

The main concern of the section was to identify the *key actors* in conservation, by age-groups, sex categories and levels of education. It would enable for the understanding of the differential engagement of the population in deforestation-related activities and their respective contribution to conservation. This was an aspect that could, according to the thesis, be termed as the cornerstone in the development of sustainable conservation efforts.

Specific roles and involvement of people of different age-groups, sex categories and levels of education in tree planting are aspects reported in sections 7.3.1, 7.3.2 and 7.3.3 below.

Table 7.7 Distribution of Households by their Involvement in Tree Planting

Response	Frequency	Percent
Yes	499	71.4
No	197	28.2
Not responded	3	0.4
Total	**699**	**100**

Source: Field Survey, 2005

7.3.1 Involvement of Household Members in Tree Planting by Age-groups

Tree planting was an important and significant activity in the practical conservation initiatives. At community level, it was important to establish whether a household had planted trees nor not. More important was the specific involvement of household members in the activity by age groups, sex categories and levels of education. This was an important step towards understanding the positive PDE relationships, significant for the sustainable planning of future resource use. We argue strongly that humankind does, as well play a positive role to the environment.

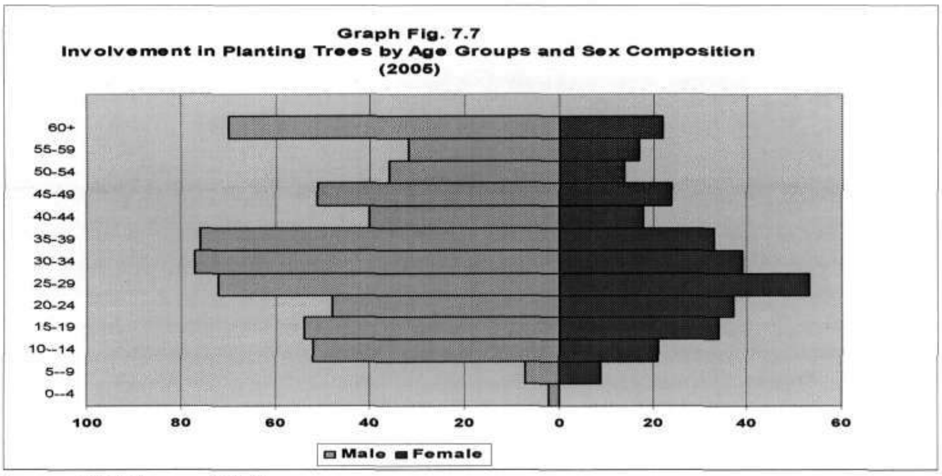
7.3.1.1 People's Involvement in Tree Planting (Conservation)

Population pyramid Figure 7.7 demonstrates the involvement of people of different age-groups in tree planting. It indicates that the 'entry age' was 4, while the 'exit age' was 60+. PRA results indicated that the initial age for involvement in the activity was 8. The total number of people who actually planted trees was 938, which constituted 27.8% of the households' members. It means that the majority of the household members did not play a significant role in tree planting.

The most striking feature was the observed a wide range of age-groups of participants in the aforestation activities, though the proportion of the participants was small. It indicated that tree planting was given less importance, thus limited members' involvement by planting relatively few trees.

A larger proportion of those to whom the activity was 'not applicable' constituted those who lived in areas with acute shortage of land and/or too young, i.e. in age group 0-4 and the elderly, i.e. aged above 55 and above. To some, especially those in the middle age groups, their not involved in tree planting could be attributed to their own decision that may be influenced by lack of motivation and/or mere negligence.

One may strongly argue that one's age had a strong relationship with the activity of tree planting, though within the same age group, a large proportion of the members did not take part in the activity for various reasons. Lack of priority on the activity was a limitation to one's involvement. PRA results revealed that tree planting was done at one's discretion. It was not a compulsory activity. Generally, people's level of involvement in the activity appeared to be increasing with increasing age.



Source: Field Survey, 2005

7.3.1.2 Involvement of the *Key Actors* in Tree Planting by Age-Groups

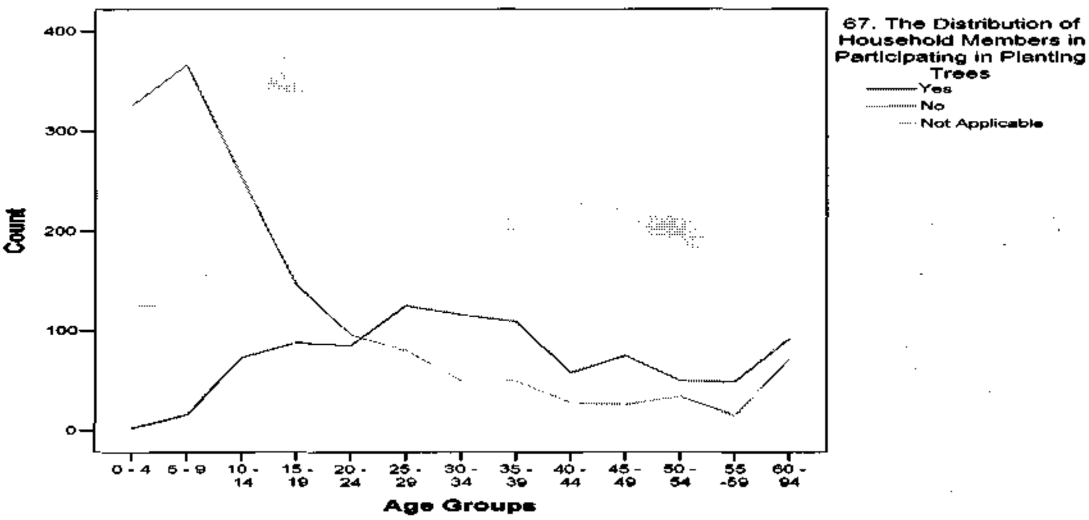
Conservation, in the context of WMCA, was taken to mean an effort towards replacing lost vegetation cover through tree planting[37]. This task, according to the local communities' perception aimed at replacing the tree cover to be used for firewood and timber building poles. This necessitated planting exotic tree species.

Aforestation, as a process, had a double impact towards the protection of the natural forest cover. First it replaced the lost tree cover, though most of it constitutes some exotic species whose impact on the areas *biodiversity* may be questionable. Secondly, was the fact that it provides an alternative to the natural forests through provision of services such as firewood, timber, poles, etc; which would otherwise be obtained from the natural vegetation cover, therefore threatening its existence.

(a) Selection of the *Key Actors*

The age groups classified as *key actors* in the activity, as illustrated in Figure 7.8 were between 20 and 59. The graph illustrated that the "entry age' to the activity was 20 while the 'exit age' was 59.

Figure 7.8 Selection of *Key Actors* in Tree Planting as a Method of Forest Conservation



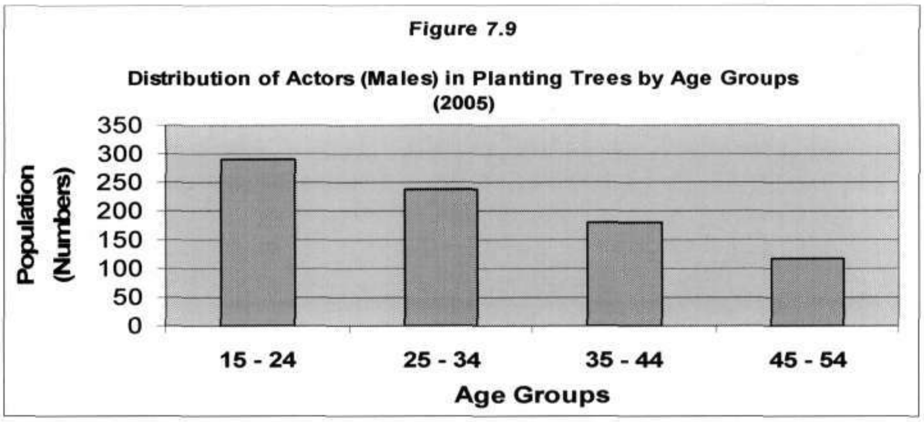
Source: Field Survey, 2005

(b) Identification of *Key Actors* by their Age Groups

Figure 7.9 illustrated that the initial *optimum* age for peoples' involvement in the activity of tree planting was 20. The age was within the marriage age whereby most individuals started their own households, thus shouldered added social and economic responsibilities. Involvement in the activity expanded with stability, up to about the age of 59. People aged over 59 realized increasing numbers of participants, though the impact they caused was thought to be on a decrease due to their old age.

From the above, one may categorically classify the *key actors* in planting trees as those males aged between 20 and 59, who consisted of 432 people, accounting for 12.8% of the total population; and 64.8% of those involved in the activity. Most of the *key actors* were in the age group 15-24. Figure 7.9 indicates the general decline in numbers of *key actors* with increasing age from age group 15-24.

[37]Conservation is a broad scientific term, however for the purpose of the thesis it is used to mean the progressive removal of trees with little, if any replacement or allowing for natural plant regrowth.



Source: Field Survey, 2005

7.3.2 Involvement of Household Members in Tree Planting by Sex Categories

Sex of an individual had association with tree planting. Planting trees was mostly done by males. Survey data in Table 7.8 indicate that males dominated the activity by 66% while female involvement accounted for the remaining 34%. The relationship was relatively weak and marked by the difference in percentage of participants, notwithstanding the actual numbers of trees they planted. In general, the total population segment involved in the activity constituted only about 28%, indicating that only a small proportion of the population actually planted trees. A larger proportion of the population did not plant trees at all.

The decline in the forest cover was partly aggravated by the observed less replacement through tree planting, an activity undertaken at one's liberty, making most of people not to participate in the activity. Massive involvement in deforestation-causing activities as differentiated from less involvement in planting trees that harbours the potential for further negative state of the forest cover.

Other categories like those who do conserve the forest but do not destroy forests; and their extreme counterparts who do both plant and destroy need to be analytically sorted, though the former does not pose any big threat to the environment. There could be a threat in case replacement levels lagged behind destruction rate. Those who just 'destroy' poses challenges as they conspicuously act in a negative way to the environment.

One may realize a form of laxity regarding the management of both processes, i.e. 'removing' and 'replacing' of the tree cover, hence the observed dwindling forest cover. The problem arises from the differential rates of removal and that of 'replacement'; and the duration taken to 'remove' and to 'replace'. The obvious imbalance between these aspects was reflected in terms of extensive deforestation and its associated adverse impacts currently observed.

Table 7.8 Household Members' Involvement in Tree Planting by Sex Categories

Sex	Involvement in Planting Trees			Total
	Yes	No	Not Applicable	
Male	617	625	448	1690
Female	321	918	442	1681
Total	**938**	**1543**	**890**	**3371**

Source: Field Survey, 2005

Analysis of those who planted trees by age groups and sex categories shed more light about the group of people to whom conservation packages were to be effectively directed. The impact of the *actors,* i.e. those members who actually planted trees, and the extent in terms of their estimated spatial tree coverage, is an aspect discussed in Chapter 8.

Based on data in Table 7.9 one would generally note that male household members played a greater role than females in activities related to planting trees. PRA results attributed the same to the positions of males as both heads of households and the owners of the land and other landed properties of the respective households. Other limitations noted during PRAs were the lack of seedlings, lack of money for buying seedlings when available and lack of 'know how' in tree planting.

Table 7.9 Actors in Tree Planting by Sex Categories

Sex	Number of Actors	Percentage
Male	617	65.8
Female	321	34.2
Total	**938**	**100**

Source: Field Survey, 2005

Literature indicates that customary law was the main factor leading to a bias in tree planting since females could not plant trees on the land they did not own (Howard, 1985 and Mbilinyi, 1997). In most cases, customary laws denied females from owning land. The gender stereo type was no more tenable as the Tanzania Land Policy had changed such *patriarchal*-based laws. Similar findings were observed in other communities in Tanzania whereby women were victims to access of land in terms of both ownership and control despite the country's socialist oriented policies (Howard, 1985; Mbilinyi, 1997).

Tree planting, being a semi permanent investment, demanded for the 'authority' of the household head who knew the entire plans for the household in terms of the types of land use and was as well the custodian of such and other development plans. All permanent and semi permanent activities, pertinent to the household, were a prerogative of the household head, most of whom, and in this case were males (Mbilinyi, 1997).

Village aforestation is recommended to be a national issue to register a significant success. Since the main beneficiary of aforestation were women and children, implying that they are the ones who shouldered that arduous task of collecting firewood whose involvement was likely to be remarkable, their involvement in conservation is necessary (Aina and Odebiyi, 1998). However, there has been no evidence that women were more interested in tree planting than men. In fact the thesis proves, once more, that the activity of planting trees to be male dominated. In Tanzania, women organizations dealt with many development issues but did not touch anything about tree planting, even for firewood supplies (Mnzava, 1985). However, men tended to be slightly more interested in starting communal woodlots than women (Skutsch, 1985).

The study conducted in Karatu district in Tanzania indicated that women and children were responsible for watering the planted trees. To them, tree planting, meant augmenting the burden because water was fetched from a distance. However, men had the last decision regarding pruning branches or felling of some trees, therefore created a disincentive to women and children (Helmfrid and Persson, 1987).

7.3.3 People's Involvement in Tree Planting by Levels of Education

Level of education of an individual was thought to influence one's perception on the significance and use of natural resources, especially natural vegetation. The possibility for one to conserve nature depended on, among other things, the ability to 'create' an alternative to the type of commonly used resources, to avoid the likelihood of *mining* and consequently depleting it. Appreciation of the importance of natural environment and its status was partly a result of education which broadens individual understanding and influences the line of action.

7.3.4 Actors in Tree Planting by Levels of Education

Survey data in Table 7.10 indicate that of the 3371 household members, only 938, i.e. about 28% participated in tree planting. Of the 938 household members who played part in planting trees, 67% had attained primary education, about 10% did not attend school at all, another 10% constituted primary school pupils. While 9% were those who attained primary standard 4, about 2% attained secondary school or higher and 1% who had attained adult education. A significant segment of primary school pupils, i.e. 10%, were actually involved in tree planting.

PRA results indicated that pupils took part in tree planting both within respective households and even in schools. At this point we may strongly argue that the direct impact of education in influencing one's involvement in the actual activity of tree planting was not readily visible.[38] This was justified by non-differential involvement of people of different levels of education. Presence of fewer members with secondary education or higher made the possibility of the reliable comparative assessment of people's involvement in the activity by levels of education to be largely obscured and invisible.

[38] The rural has fewer chances for further education; the educated few are likely to move to towns therefore leaving behind people with low levels or not educated at all.

In a study of four villages in Morogoro region, Kajembe found a significant positive correlation between the number of trees planted in the farm on the one hand, and land size, household labour and education level on the other hand (Kajembe, 1991; cited in Johnsen, 1999). Such a conclusion was far from reality in respect to WMCA due to the predominance of members with primary education or lower because as argued by Claeson and Egero (1972) education is synonymous with town life.

In the situation where *smallholder farming* dominated, it could not be possible to realize a broad differentiation in terms of land use among rural households, be it in conservation or degradation-related activities. The general trend in people's involvement in tree planting, like in other activities, show that level of education was not a factor that directly differentiated people's involvement.

Table 7.10 Involvement in Tree Planting by Levels of Education

Levels of Education	Involvement in Planting Trees			Total
	Yes	No	Not Applicable	
None	90	565	249	904
Primary std 7	627	449	387	1463
Primary Std IV	82	49	45	176
Secondary	17	15	6	38
Adult Education	11	0	3	14
Primary Std 8	8	0	1	9
Secondary Std 10	5	2	1	8
Pupil	98	463	198	759
Total	**938**	**1543**	**890**	**3371**

Source: Field Survey, 2005

7.4 Changes in Population of the *Key Actors* in Deforestation and Conservation (1978 to 2005)

This section demonstrates changes in numbers of the *key actors* in specific deforestation-related activities. This was done by analyzing the proportionate changes in sizes of *key actors' segments* over time, based on data extracted from the Tanzania National Population Census for 1978, 1988 and 2002.

Findings on the analysis of the survey data, regarding the *key actor groups* in terms of age groups and sex categories were adopted for simultaneous comparison using the survey data as the baseline.

The *key actors* in specific activities tailored with qualitative information obtained from PRA results enabled the identification and the sizing of the *key actor groups* that were adopted for the comparative analysis and determining trends in changes in population characteristics and the changes in the status of forest cover over years.

Understanding the quantitative variations in the population characteristics was of great significance for the comparison of the changes in population and environmental phenomena. In this case, focus was on forest cover change and the selected possible subsequent effects in the hydrological and climatic changes.

7.4.1 Changes in Age Structure and Sex Composition of the *Key Actors* in Deforestation-Related Activities.

The study found it significant to establish changes in *key actors*' population characteristics such as age structure and sex composition. The information generated was critical in the analysis of the magnitude of such changes and their impact on changes in the forest cover between 1978 and 2005. The impact of changes in *key actors* on vegetation cover forms part of the discussion in Chapter 8.

7.4.1.1 Changes in Age Structure of *Key Actors* in Deforestation by Specific Activity

(a) *Key Actors* in Clearing the Forest for Farm Expansion

Survey data demonstrate an increase in the size of the population segment of the *key actors* in farm expansion that included males, aged between 20 and 44.

In 1978 there were a total of 2,227 household members in the *key actors' category* which constituted 18.6% of the total population. Between 1978 and 1988 the segment of the *key actors* grew slightly to constitute 19.1%, marking a marginal increment of 0.5%. The proportion of the *key actors* rose by 2.2% in the period between 1988 and 2002, meaning from 2480 to 4150 people. Using the survey data based on vital registration total population data, the proportion of the *key actors* in 2005 was about 2.1% indicating a decrease of 0.3% from that of 2002.

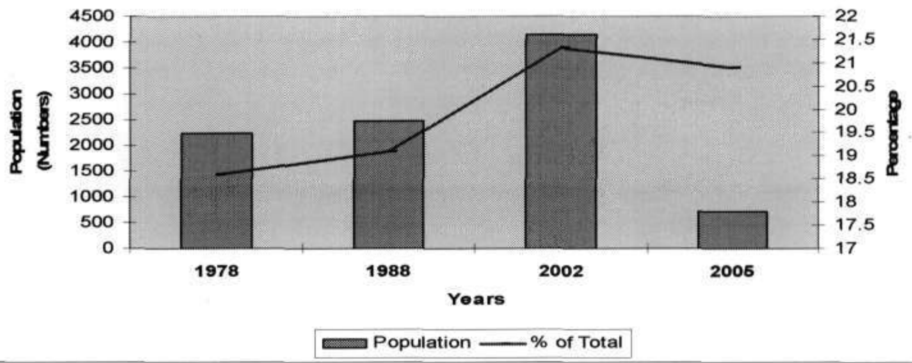
The general trend indicated an increase in the proportion of the *key actors* to the respective total population in the activity by 2.7 between 1978 and 2002. When including the data for 2005, where a decline of 0.3% was observed, the net effect was a total increase of 2.5% in the size of the *key actors' group* between 1978 and 2005. The data on the total population for 2005 were obtained from the vital registration which in most cases as subject to criticism due to unreliability[39].

It was the contention of the thesis to argue that the increase could largely be attributed to the proportionate increase in the population size. Figure 7.10 illustrates the same finding as there was correspondence between the changes in *key actors* segments of and trends in total populations for the years under review.

[39] There was a possibility for understatement of the number of children with higher levels of education and employed, thus indicating a decline. PRA revealed that superstition biased the respondents.

Figure 7.10

Total Population of Key Actors in Converting Forests into Farms and Percentage Total Populations (1978 - 2005)



Source: Tanzania National Population Censuses 1981, 1990 and 2003 and Field Survey, 2005

(b) *Key Actors* in Clearing the Forest for Collecting Firewood

Survey data indicate changes in *key actors* in the activity of felling trees to obtain firewood to the respective total populations. The changes were noted in terms of both the numbers and proportions of the respective total human populations.

In 1978 the population of *key actors* in the activity, i.e. females aged between 10 and 39, was 3125, which constituted 26.1% of the total population. Their proportion grew by 0.9% between 1978 and 1988, i.e. from 26.5% to 27% respectively. Between 1988 and 2002 the *key actors' population* grew by 3.8%, meaning from 27% to 29.8% respectively; implying an increase of about 4.7% in the proportion of the *key actors*.

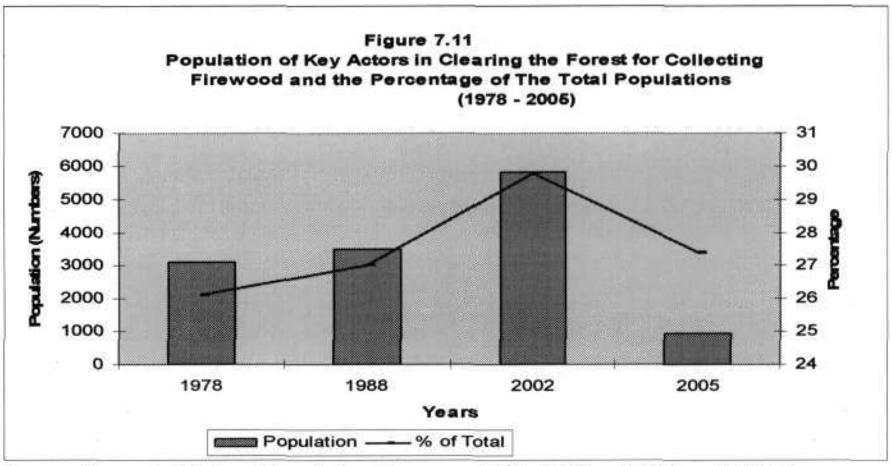
However, a drop in the proportion of *key actors* of 2.4% was noted between 2002 and 2005, i.e. from 29.8% to 27.4% respectively. A drastic drop in the proportion of the *key actors* observed in 2005 was attributed to unreliability of vital registration data characterized by a higher of understatement of vital events.

The decline could, as well, result from rapid urbanization of the Songea Municipality especially in *peri-urban* settlements such as *Chemchem, Lihwena* and *Muungano* all of which reported to experience acute firewood shortages. Such settlements increasingly depended on firewood bought from the mobile firewood vendors. However, PRA results indicate that the urbanization process, in the context of WMCA, did not bring about a significant shift in terms of types of energy sources. It merely augmented firewood scarcity as the forest was extensively cleared and the tendency was towards commoditization of firewood. National statistics indicated that only 24% of households of Songea urban were connected to electricity (URT, 2004). Even those with the electric power connection did not use it for cooking due to prohibitive electricity tariffs, thus use of fuel wood dominated.

The national rate of urbanization for Tanzania was 53% between 1978 and 1988, thus qualified to be among the fastest urbanized countries in SSA (Mbilinyi, 1997; US Bureau of the Census, 1995). By mid 2005, the town of Songea was granted municipality status, meaning that it occupied larger spatial areas formerly designated as 'rural'. Such areas included *Muungano* and *Lipaya* villages.

With such changes in land use, i.e. from rural to urban activities, consumption and use of firewood remained high, despite the noted declining numbers of the 'collectors'. In this case, it was imperative to mention that urbanization did not reduce deforestation, though it could have significantly reduced the numbers of *key actors* from the specific settlements. In *peri-urban* areas, the number of *key actors* in firewood collecting decreased, while at the same time, the process apparently intensified in suburbs as more farm and forest areas were converted into human settlements. The firewood collectors in the suburban areas were forced to 'produce firewood' at two levels, i.e. for their own household use and for sale in the urban centre.

Survey data indicate that the net effect of changes in the population structure of the *key actors* in felling trees for firewood marked an increase of 2% of the proportion. Figure 7.11 demonstrate the same. Whether the decline in the proportions of the *key actors* in the activity amounted to the decline in the volume of the activity is an aspect discussed in Chapter 8.



Source: Tanzania National Population Censuses, 1981, 1990 and 2003 and Field Survey

7.4.1.2 Changes in Population Composition of the *Key Actors* in Deforestation-Related Activities

(a) *Key Actors* in Clearing the Forest for Expansion of Farms

The sex ratio of the *key actors* was an index used to determine sex composition of the *key actors* in the activity. The increase in sex ratio meant an increase in numbers of males compared to that of their female counterparts and *vice versa*.

From the above sections, we noted that the *key actors* in converting forests into farms were mostly males aged between 20 and 44 were as presented in Table 7.11. The analysis of the population data illustrated that the proportion of the *key actors* to the total number of people of the same sex category rose from 37.5% in 1978 to 38.9% in 1988; registering an increase of 1.4%. It implied that within the period, the male actors in the same category (age groups and sex) had relatively increased in numbers by 1.4%.

Between1988 and 2002 there was an increase of 4.7% in the proportion of the *key actors* relative to the total number of males in the same group category. The proportions rose from 38.9% in 1988 to 43.6 in 2005. For the entire period under review, i.e. between 1978 and 2005, the number of *key actors* rose by 6.1%.

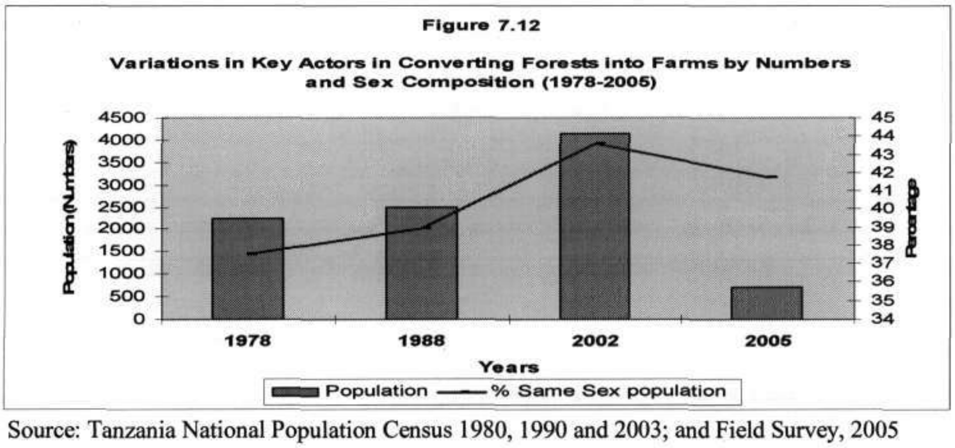
The decline in the proportionate number of males engaged in felling trees for farm expansion of 1.8% was noted between 2002 and 2005, implying a relative decline in the numbers of males within the group of the *key actors* compared to the total number of males, showing a positive relationship between the two variables.

Table 7.11 Population Characteristics and Involvement in Farm Expansion 1978-2005

Years	Population	Key Actors	Sex Ratio	Same Sex Proportion
1978	11,947	2,227	98.6	37.5
1988	12,979	2,480	96.4	38.9
2002	19,446	4,150	95.63	43.6
2005	3371	706	100.5	41.8

Source: Tanzania National Population Census Report, 2003; Field Survey, 2005.

When comparing the changes in the composition of the group of *key actors* and that of the total population, based in sex ratios, marked differences of significant levels were noted. Figure 7.12 demonstrates the comparison of the changes in proportionate numbers of *key actors* within the age group; while Figure 7.13 demonstrates the variations in sex composition within the *key actors* as it relates to the total population's sex ratio. The sex ratio that stood at 98.5% in 1978 had declined by 2.1% to reach 96.4% in 1988 indicating decline in proportion of males in the population.



Source: Tanzania National Population Census 1980, 1990 and 2003; and Field Survey, 2005

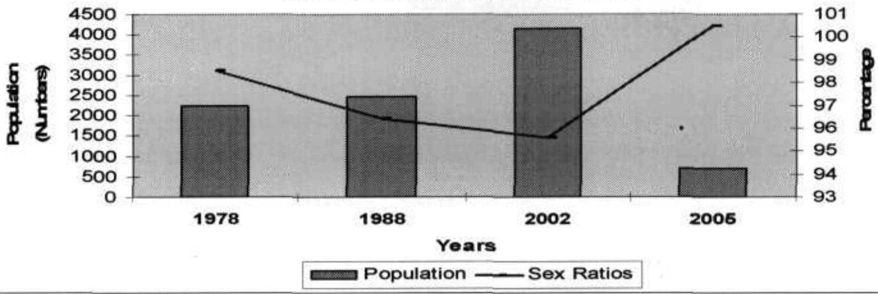
The sex ratio declined again, by 0.8% only between 1988 and 2002, indicating further the decline in numbers of males relative to that of females, implying the decline in numbers of the *key actors* in farm expansion, therefore reducing chances for expansion of farms since the decrease of the numbers of actors reduced the potential for the activity.

A sharp rise in sex ratio of 4.9% was observed between 2002 and 2005 implying a proportionate increase in numbers of males relative to that of their female counterparts. This state portrayed an increase in the possibility for more involvement in the activity caused by the relative increase in the *key actors* in farm expansion. It also signaled a greater possibility for more deforestation. By this period there was a small possibility for females to join the activity as their numbers had proportionately and steadily been declining between 1978 and 2002. Females' involvement could have picked up in the period between 2002 and 2005 when numbers of male actors dropped.

Generally, the statistical scenario above indicate that while the number of the *key actors* by their sex and age groups had proportionately increased; the proportionate numbers of female counterparts had been consistently decreasing. The impact of the observed variations in population characteristics to forest cover changes, if any, is discussed in Chapter 8.

Figure 7.13

Variations in Key Actors in Coverting Forests into Farms by Numbers and Sex Composition (1978-2005)

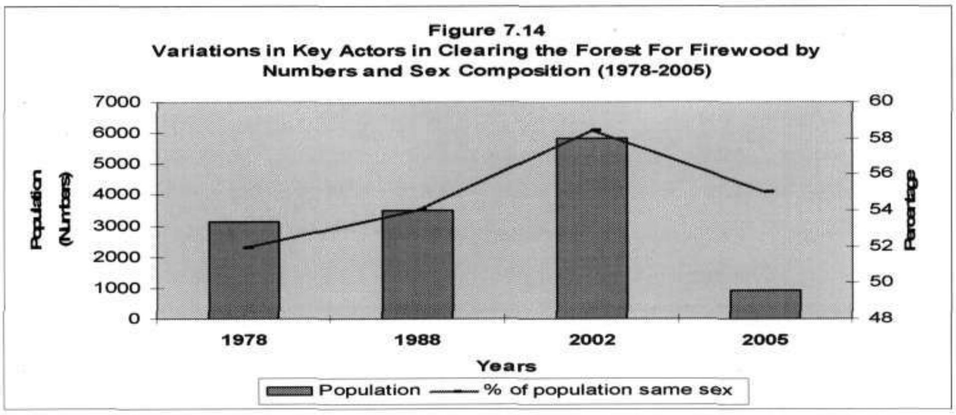


Source: Tanzania National Population Census, 1981, 1990 and 2003; and Field Survey, 2005

(b) *Key Actors* in Clearing the Forest by Collecting Firewood

The sex composition of the *key actors* in collecting firewood, i.e. females aged between 10 and 39 underwent significant changes between 1978 and 2002. In 1978 there were 3,125 *key actors* who constituted 51.9% of the total number of females in that year, implying that a larger proportion of females were actually engaged in the activity. The proportion rose to 54%, i.e. an increase of 2.1% in 1988. In 2002 the proportion of the *key actors* reached 58.4% recording an increase of 4.4%. The graph in Figure 7.14 illustrates the changes in actors' population characteristics over time.

However, a fall of about 3.4% in the proportionate numbers of *key actors* was noted between 2002 and 2005. It means that within the period of three years, the numbers of females who were involved in firewood collection decreased despite the increase in number of women in the respective age category.



Source: Tanzania National Population Census, 1981, 1990 and 2003; and Field Survey, 2005

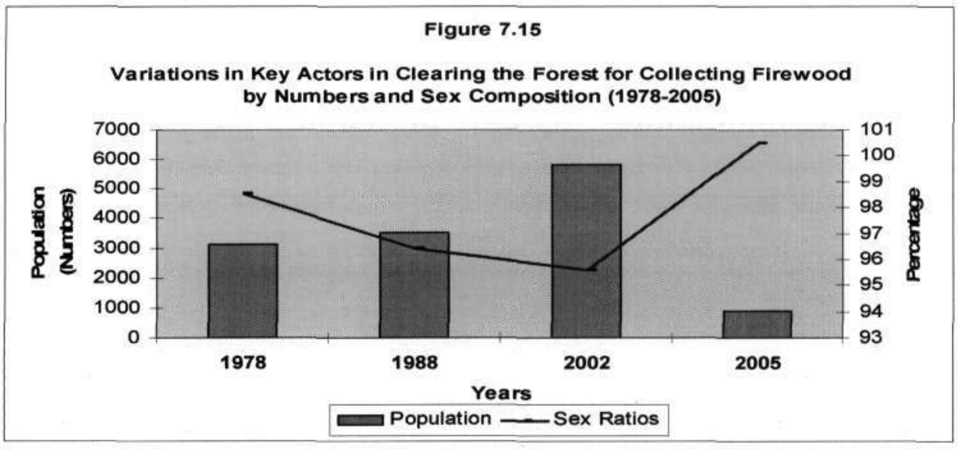
When linked with changes in sex composition of the total population, as demonstrated in Table 7.12, results indicate that the sex ratios declined from 98.5 in 1978 to 96.4% in 1988, showing that the numbers of males was declining relative to that of females. Since females were the *key actors* in the activity of collecting firewood from trees fallen by males, their proportionate increase does not imply presence of a greater potential for the activity to expand and aggravate deforestation through felling of trees for firewood. Changes in population characteristics of the actors' population in collecting firewood relative to changes in sex ratios are illustrated in Figure 7.15.

Table 7.12 Population Characteristics and Involvement in Firewood Collecting 1978-2005

Years	Population	Key Actors	Sex Ratio	Same Sex Proportion
1978	11,947	3,125	98.6	51.9
1988	12,979	3,895	96.4	54
2002	19,446	5,805	95.63	58.4
2005*	3,371	925	100.5	55.7

Source: Field Survey, 2005 *Based on sample household's population

The rise in the sex ratio from 2002 to 2005 portrays the presence of more males than females in the population. It implies that the proportion of females, the *key actors* in the activity of collecting firewood declined; hence not likely to reduce the pace of clearing of forest cover by firewood cutting, which was done by males. An account of impact of changes in population composition on forest cover change was given and discussed in Chapter 8.



Source: Tanzania National Population Census, 1981, 1990 and 2003; and Field Survey, 2005

7.4.2 Trends in Changes in Population Characteristics of *Key Actors* and Their Contribution to Forest Conservation Activities

As noted earlier, the main activity in forest conservation in WMCA was tree planting. It was an effort to avail an alternative source of firewood and other forest-based resources to the population and conserve the already progressively dwindling natural forests. In such a way, the planted trees reduced pressure on the natural forests, therefore implicitly contributed to conservation of natural forests.

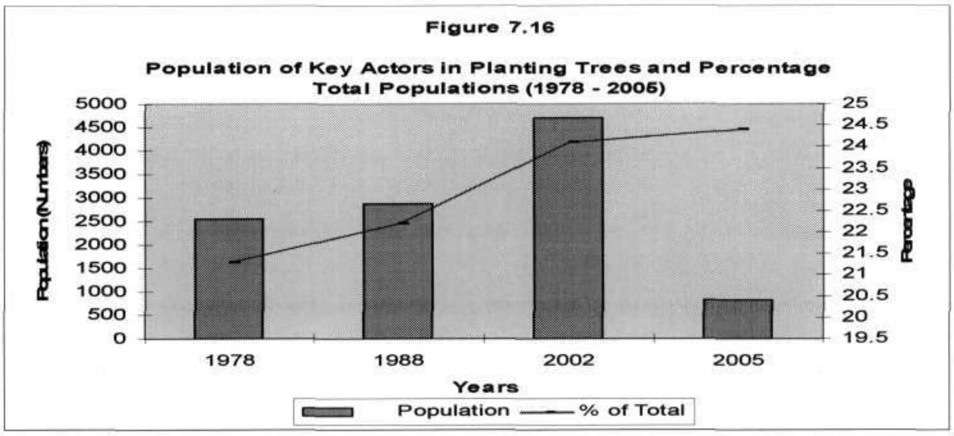
Characteristics of the trends in changes in the population structure and composition of the *key actors* based on size, relative to the members of the same age and sex segment of the population; and the comparison of its variations relative to sex ratios of the entire population were established. The detailed analysis was conducted to underscore the variability of the *key actors' proportions* by specific conservation activity for 1978, 1988, 2002 and 2005. This information was critical in establishing the relationship between the changes in population characteristics and changes in forest cover within the same timer frame.

7.4.2.1 Changes in Population Structure of the *Key Actors* in Planting Trees

Data on numbers of individuals in specific age groups and sex categories, classified as the *key actors* in the activity of tree planting, varied with time between 1978 and 2005. The *key actors* in question were males aged between 20 and 59. In 1978 they were 2877 *key actors* who constituted 21.3% of the population of males in that age group and sex category. By 1988 the *key actors' population* rose by 0.9% while a relatively faster increase in the *key actor segment* of 1.9% was realized between 1988 and 2002 and a small rise of 0.3% was also recorded between 2002 and 2005.

General trends shown in Figure 7.16 indicate a relative increase in numbers of males who entered the active age group in the activity between 1978 and 2002. However, the rate tended to decrease towards stabilization between 2002 and 2005. This state showed the proportionate increase in male's involvement in tree planting between 1978 and 2002. However, fewer people joined the activity by 2005.

Trends in proportionate declines in numbers of *key actors* could be linked to the observed trends in changes in numbers of planted trees, depicting the real situation in respect to the use and replacement of natural forest cover; and state of the environment, deforestation in particular.

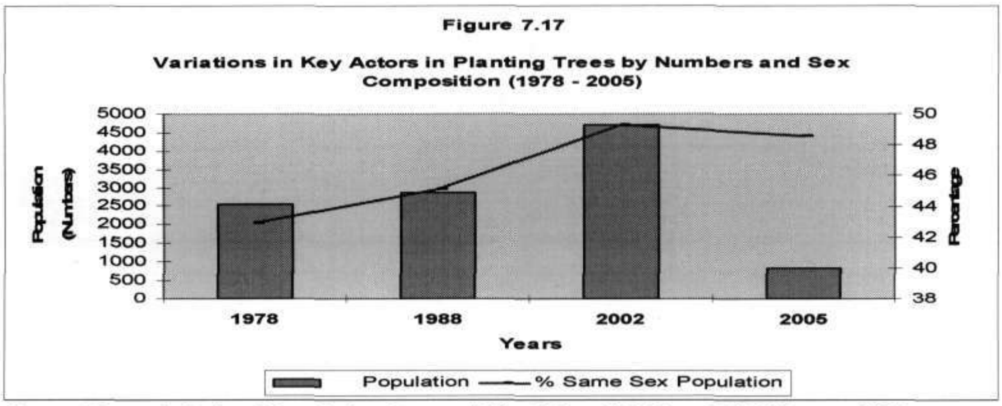


Source: Tanzania National Population Census, 1981, 1990 and 2003; and Field Survey, 2005

7.4.2.2 Changes in Population Composition of the *Key Actors* in Tree Planting

Data on population of the *key actors*, i.e. males aged 20 and 59 indicate changes in terms of their composition. Figure 7.17 demonstrates that in 1978 the proportion of the *key actors* to that of other males in the same age group was 42.9%. The proportion which rose by 2.2% in 1988, indicates 'entrance' of more people in that age segment, therefore raised the potential actors in tree planting. A faster rate of an increase of 4.2%, i.e. from 45.1% to 49.3% was experienced between 1988 and 2002, implying further enhancement of the potential for tree planting.

A slight decline in the proportion of *key actors* of 0.7% was noted between 2002 and 2005 indicating a slow decline in the proportion of those in the age and sex segment which dealt with tree planting, therefore reduced the pace of the involvement in the activity.



Source: Tanzania National Population Census, 1981, 1990 and 2003; and Field Survey, 2005

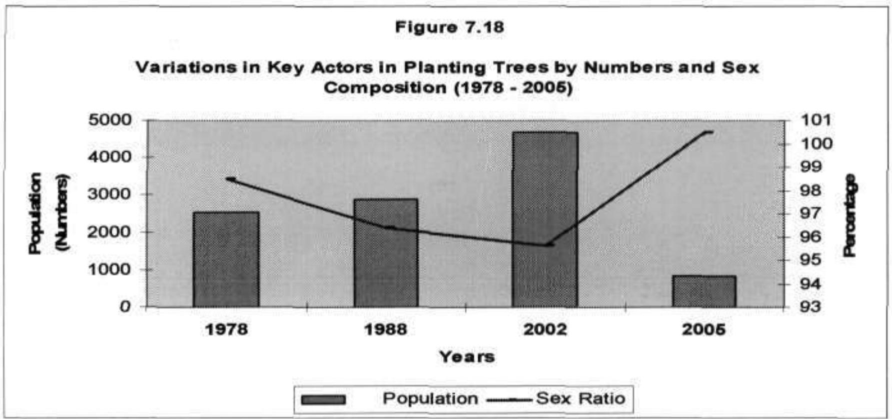
Linking the changing proportions of the population segments of the *key actors* with the respective sex ratios demonstrated in Table 7.13 was done as a step towards generating detailed information on the link between changes in sex composition of the *key actors* and people's involvement in tree planting. The graph in Figure 7.18 indicates that in the period between 1978 and 1988 sex ratios declined by 2.1%, i.e. from 98.5% to 96.4 % respectively. Further decline of 0.8%, i.e. from 96.4% to 95.6% was noted between 1988 and 2002. The decrease in sex ratio means that there was a decline in the number of males relative to that of females who participated in the activity.

Table 7.13 Population Characteristics and Involvement in Tree Planting 1978-2005

Years	Population	Key Actors	Sex ratio	Same sex Proportion
1978	11,947	2,543	98.6	42.9
1988	12,979	2,877	96.4	45.1
2002	19,446	4,690	95.6	49.3
2005**	3371	823	100.5	46

Source: Field Survey, 2005 **Based on sample household's population

The decline in the numbers of males, the *key actors*, *cateris peribus,* meant a reduction in the possibility for the activity to expand. The decline in involvement in tree planting observed in WMCA could partly be attributed to the noted decline in the proportionate numbers of those involved and those in the active population segment but were actually not involved in the activity. Sex ratios demonstrated a rise of 4.9% from 2002 to 2005, indicating a drastic rise in the number of males relative to that of their female counterparts. In the period, the potential for tree planting had increased as the *key actors* representation had proportionately increased in numbers. The impact of changes in population characteristics of the *key actors* on forest cover is covered in Chapter 8.



Source: Tanzania National Population Census, 1981, 1990 and 2003; and Field Survey, 2005

7.5 Conclusion

It has been evident from the findings in the Chapter that household members of different demographic characteristics such as age groups, sex categories and levels of education were involved in different development or livelihood activities; thus a different nature of interface with the environment, forest cover change in particular as encountered.

The sex of an individual was found to influence one's involvement in specific socio-economic activities although deforestation-related activities were mainly performed by males. The activities were socially biased specifying males and females to different activities. While males dominated in converting forests into farms, females played a significant role in collecting firewood from the trees cut by males. Variations were noted among villages in the magnitude of converting forests into farms. Lack of *open public forest* areas limited farm expansion in some localities. Under such circumstances, people were left with two main options, either to intensify farming or migrate to areas with plenty of land.

Firewood scarcity reported in some areas of WMCA, was evidenced by the increased distance to sources, making the task of collecting it more difficult. Extinction of 'preferred' tree species for firewood made people opt to use other species already reported declining. PRA results revealed that males dominated firewood business, firewood for baking bricks, for tobacco curing and wood-poles for homesteads constructions.

The thesis established existence of relationship between one's age and involvement in deforestation-related activities. The *active age segments* and the *key actors* for specific development and or livelihood activities were as well identified. The activity of clearing forest for farm expansion was conducted by *male key actors*, i.e. those aged between 20 and 54, which constituted about 13% of the households' population.

In WMCA, firewood collecting started mainly at the age of 8; and that the actors in the activity were *female key actors* i.e. were females aged between 10 and 49 accounting for 31% of the total households' population of 3371. Cutting trees for fuel wood was done by males and considered among the major contributor to deforestation and environmental degradation, an aspect which brought about a social impact on acute shortage of households' domestic energy (Johnsen, 1999; Scherr *et al.,* 2004; Chu and Yu, 2002; Delacote, 2007). The main observation is that the ones who cut the trees were different from the ones who collected firewood. It means that firewood demand and use is the reason behind tree cover loss. Males and females are actors only driven by the energy source demand and may be lack of alternatives.

It was logical and significant to examine the involvement of people in conservation related activities in order to assess the type of actors and *key actors* (based on age groups and sex categories) and proportions of 'destroyers' and the 'conservers'. The reality is that both were actors and beneficiaries of the two antagonistic processes, i.e. 'deforestation' and 'conservation' which characterized forest cover.

Regarding conservation, sex composition had an influence on one's involvement in activities related to conservation, the planting of trees in particular. In this activity, males were more prominent compared to their female counterparts. Age groups had, as well, positive relationship with one's involvement in conservation activities with the *key actor population* in the activity being males aged between 20 and 54 who accounted for about 18% of the households' population.

However, it was difficult to ascertain the differential involvement of household members in tree planting by levels of education since the population was highly dominated by those with primary education level and below. Despite their smaller numbers, individuals with secondary or higher education actively participated in the same on-farm activities like their counterparts with lower levels of education. PRA results indicated that most of the individuals with higher education moved to urban centres.

The chapter noted the variability in terms of age structure and sex composition of the population of the *key actors* in specific activities that contributed to deforestation and conservation between 1978 and 2005. However, the thesis reveals that the understanding of who actually cuts trees and who plants the trees was critical in order to establish sustainable solutions to deforestation. Whether changes in sex composition, which refers to the proportionate numbers of males to that of females, and the variation in the *size of key actors* relative to people of the same sex brought about any impact on deforestation and/or conservation is an aspect discussed in Chapter 8.

From the above findings, it can be inferred that demographic characteristics had significance on one's involvement in specific livelihood or development activities that impact on the environment. The actual individual household member's *involvement in* deforestation-related activities, based on age and sex characteristics, the proportionate contribution of household members in deforestation would be compared and linked using qualitative data to establish the existing relationship between population, development and environment. It is worth emphasizing that it is after the role of the *key actors* in deforestation process was estimated and made known, more light would be shed on to the analysis of the PDE relationship and make it more understandable for practical utility in sustainable forest conservation.

CHAPTER EIGHT

POPULATION, LIVELIHOOD ACTIVITIES AND ENVIRONMENTAL CHANGE

8.1 Introduction

This chapter demonstrates the practical aspects on the linkages between population development and environment. It is a step towards establishing association and linkages between population characteristics discussed in Chapter 4, deforestation-related development activities discussed in Chapter 5 and environmental change observed and discussed in Chapter 6. The findings in the above mentioned three chapters constituted PDE components considered basic for the final analysis of the existing relationship between population, development and environment.

Chapter 7 examined the connection between population and development, which in the context of this thesis constituted the essence of PDE relationship. Its significance emanated from the fact that it constitutes the area of interface between population and the environment, and therefore is a necessary and significant step in the PDE analysis. This is a step where the *key actors* in deforestation-related activities were identified and determined. At this stage, quantitative data were linked with qualitative data to determine the existing PDE relationship.

The analysis used in the thesis, based on the PDE model, emanated through underscoring of the differential involvement and the consequent quantification of contribution of people of different demographic characteristics in the deforestation process. Information on differential involvement whether it implied differential contribution to deforestation or not, was considered to be the *nexus* for understanding the nature and character of the PDE relationship.

Understanding the characteristics and role of individual household members in shaping characteristics of natural vegetation cover formed an important component in the understanding the existing PDE relationship. It is imperative that the changes in forest cover actually occurred at the point of interface between an individual, i.e. *key actor* and a particular tree. But how much one continued felling more trees, and for what purpose, remained to be of more significance than just knowing "who did what" with no insight "why and to what extent".

The PDE analysis was based on the study of specific demographic characteristics by specific development activity and its associated impact on the environment. The mode of analysis and presentation was that of *time-line comparative* and *descriptive* interpretation of the specific PDE elements of the selected PDE components. In this chapter, the variability of the relationships in specific time periods was observed by carrying out spot analysis of data for specific years under review, i.e. 1978, 1988, 2002 and 2005. It also involved analyzing the relationships between variations in PDE components and the impact it caused to local communities in terms of other environmental changes like water availability, *river discharges* and *micro climatic changes*.

The Chapter established a more scientific and detailed explanation pertinent to PDE issues in WMCA and elsewhere, where similar socio-economic, political and environmental factors existed. The detailed discussion on the PDE relationship forms the main content of this Chapter. It entails the merging of the theoretical and practical aspects of the PDE relationship in WMCA, in Tanzania and the world socio-economic context.

8.2 Population and Forest Cover Change by Selected Livelihood Activities in 2005

The findings revealing that people of different age groups, sex composition and levels of education played different roles in deforestation-related activities lead us to argue that they impacted differently on the environment. It implicitly meant that the magnitude of impact caused by different population sub-categories could be deduced and was likely to vary with space and time. It was essential to establish the quantitative contribution of active household members in forest cover change based on their age and sex characteristics.

Changes in vegetation cover determined by GIS, quantified the magnitude of forest cover change as indicated in the forest cover change matrix Table 6.1 on page 124 calculated from the Forest cover matrix Table 6.1 based on data for years 1969, 1990 and 2000 demonstrated in maps Figure 6.2, Figure 6.3 and Figure 6.4. To standardize the impact of various deforestation-related activities such as felling trees for firewood, charcoal making, farm-expansion was necessary. The use of GIS data was critical since it provided more scientific and reliable combination of all variables that lead into forest cover change that do not act in isolation (FAO, 2003)

The endeavour of this thesis was to fill the knowledge gap in focusing the conservation process through targeting the right audience for the right extension message at the right time and locality. We further argue for the engagement of the 'right section' of local communities in conservation activities by taking into account their 'entry age', 'stabilization stage' and 'exit age' for their effective contribution in sustainable resource use and enhancement of forest conservation. The thesis envisages that the framework adopted provides more insight in endeavours to highlight and establish the relationship between population, development and environment at locality level.

Since different *key actors* based on age groups and sex compositions were identified in different development or livelihood activities, it was implicit that the analysis of their contribution should be based on the same theory. Descriptions and analysis of the estimated contribution to deforestation; and the analysis of the existing relationship between PDE are discussed in sections 8.2.1 and 8.2.2.

8.2.1 Population, Firewood Use and Forest Cover Change

Based on PRA discussions, males were noted to be the *key actors* in the clearing the forest for firewood, while females were *key actors* in firewood collection. The age specific identification of the *key actors* in collecting firewood noted that those females in age group 10-39 were the *key actors.* The proportions of the *key actors* based on age groups and sex categories of the total population were obtained from the total populations of the respondents' households. The data deduced from Table 8.1 indicates that the population of the *key actors* in firewood collection was 752, accounting for about 22% of the total households' population of 3371 members. Females represented about 80% of all the 935 participants in the activity.

The male participants accounted for only 9.4% of the total households' population; and 22.6% of the total number of participants. In general, household members aged between 4 and 60+ constituted 1411 participants of the activity, meaning 41.8% of the total households' population. Female participants in the activity accounted for 32.3% while male participants occupied only 9.4% of the total households' population.

While sex categories and age groups were noted to have a relationship to one's involvement in collecting firewood, it could not be directly established as to whether changes in the composition of the individual household population brought about a differential or the same demand for firewood or *vice versa*. This did not form part of the study objectives, thus recommended for other research. PRA results indicated that deep rooted traditional values which were entrenched in culture of people of WMCA dictated division of labour and specialization. It was the division of labour and specialization that formed and maintained differential engagement in development/livelihood activities.

Table 8.1 Participation in Firewood Collection by Age Groups and Sex Categories

Age Group	Male	Female	Total
0 - 4	1	2	3
5 - 9	13	65	78
10 -14	**70**	**168**	**238**
15 -19	**53**	**137**	**190**
20 -24	**34**	**129**	**163**
25 -29	**21**	**139**	**160**
30 -34	**24**	**99**	**123**
35 -39	**26**	**80**	**106**
40 -44	25	59	84
45 -49	8	60	68
50 -54	14	50	64
55 -59	9	33	42
60+	21	71	92
Total	**319**	**1092**	**1411**

Source: Field Survey, 2005

8.2.1.1 Population, Firewood Amount, Amount and Forest Cover Change

Survey data indicate that the total amount of firewood collected by interviewed households in a year was about 1461.2 cubic metres. The average *per capita* firewood for a Tanzanian was about 1.5 kilograms *per* day, which has been documented to be responsible for the clearing a vast forest areas (Wood and Baldwin, 1985).

Most of firewood was collected out of fallen dry tree branches other than cutting or the actual felling of trees used branches (Leach, 1988; Madulu, 2001). A similar view was held by other studies that observed the chopping of tree branches for the firewood to be used in tobacco curing and charcoal making (Hosier, 1988; Johnsen, 1999 and Dutta, 2003).

Complexity was observed in segregating the manner in which firewood was obtained and the difficulty in discerning the collecting process and its impact as opposed to that of farm expansion and other forms of land use. However, the thesis adopted analyzing the tree cover change in totality, i.e. irrespective of the specific activities which seemed to overlay.

The fact that felling trees for firewood involved selecting specific tree species while felling trees for farm expansion was not selective. Nevertheless, felling of trees for firewood made the two activities practically inseparable, thus registered another level of complexity. The difficulty to single out the extent to which specific activities contributed to the deforestation phenomenon was realized and sorted. Since trees cleared for farm expansion were also used for firewood, it was not easy to separate the two when it comes to establishing which activity among the two contributed to what extent in forest cover loss.

Because the volume of firewood used was made known, it suffices to note the role of firewood as a source of domestic energy in augmented deforestation. In practical terms, the possibility for obtaining data pertinent to the past years' firewood uses were nonexistent; therefore posing a problem regarding scientific analysis.[40]

Areas where firewood was collected were not always devoid of total vegetation cover, complicated for the spatial dimensions of the impact of the activity for it to be singled out from other activities especially agricultural expansion. Field observation and PRA results noted that within farms, not all trees were removed. In reality some of the trees were left behind for shade, wind breakers and future firewood supplies.

[40] Data on firewood quantities were not available within the region and countrywide. It shows less concern on the main source of domestic energy.

It should be noted that the issue of rural energy is a complex topic entailing other forms of land uses (Wood and Baldwin, 1985). The fact that less attention was put on fuel wood leaves the majority of rural people to lack energy planning, thus greater likelihood for deforestation (Dutta, 2003).

In WMCA, most of the respondents indicated that they obtained firewood from farms meaning that the two aspects were linked though could be viewed as separate factors. The fact that an additional household member does not imply additional firewood makes the matter even more complicated. Therefore, we cannot generalize on firewood sources for simplification purposes, rather than dealing with both issues as part of rural subsystems with its linkages based on the livelihood/development and existing social systems.

8.2.1.2 Trends in Population Characteristics, Forest Cleared for Obtaining Firewood and Forest Cover Change

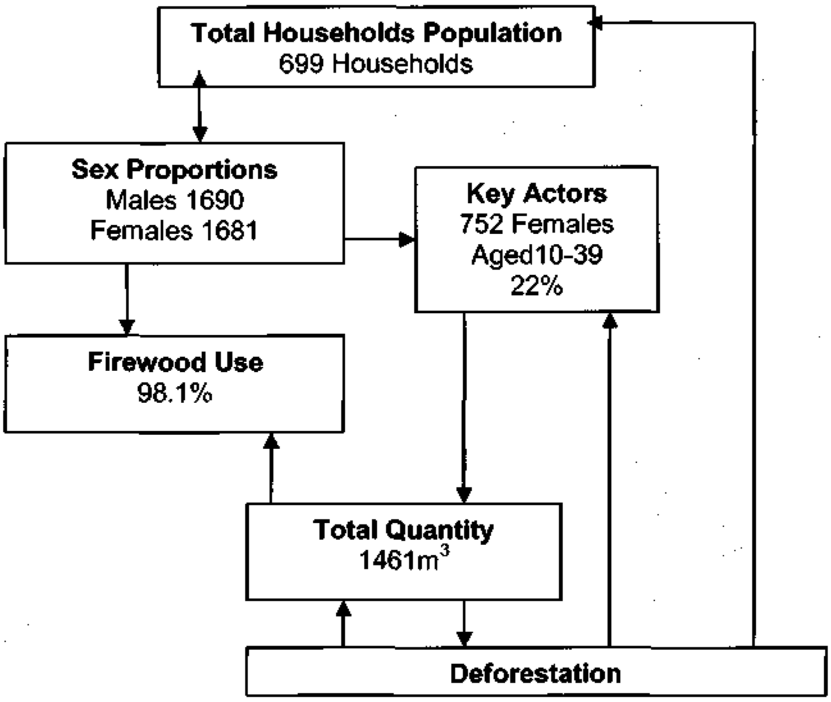
To address the research questions more precisely, conducting a detailed analysis on farm expansion a more rigorous and measurable process, was undertaken to shed light on issues pertinent to PDE relationships. The process of deforestation was conceptualized on a schematic diagram (Figure 8.1) with values attached to each section in order to depict the reality on the ground.

GIS data on forest cover change was not included in the schema since it was the cumulative impact of previous population and development issues. Such data were tailored in the comparative analysis on the extent of changes in forest cover as a result of various human activities, i.e. farm expansion and firewood cutting at a later stage of the thesis.

The Schema in Figure 8.1 above indicates that despite firewood being the main source of domestic energy for the majority of the people of WMCA, the proportionate number of those who actually collected it was small. Actors in the activity could be identified and/or grouped by their demographic characteristics, i.e. those females aged between 10 and 39 who constituted about 22% of the total population. The *key actors* were responsible to collect this energy source that accounted for 98.1% of the households who consumed about 1461m^3 in a year. The findings indicate the possibility for the applicability of the demographic knowledge such as population projection to monitor growth in *key actors' population segments* for sustainable resources utilization and conservation.

The observation that females are the *key actors* in firewood collecting make females qualify to be the 'right' and likely the most effective groups in forest conservation attained through tree planting that are meant for firewood. Being the most affected category, in terms of walking for long distances and carrying large volumes of firewood, they demonstrate greater likelihood for them to actively participate in tree planting and sustainable conservation.

Figure 8.1 Schema for PDE Relationship for Felling Trees for Firewood for Domestic Use



Source: Data from Households Field Survey, 2005

Survey data indicated that WMCA faced firewood shortage, though respondents differed widely as to when the shortage began. About 35% observed that the shortage of firewood emerged between 1999 and 2002; and about 29% mentioned it to have begun between 1989 and 1998. It implied that firewood shortage increased with time. The use of alternative energy sources, like crop residues, was observed and noted as a sign of the progressive shortage of firewood. Understanding the real situation was significant for sustainable development.

In order to establish the PDE relationship, agriculture was studied in more details as the main type of land use and the major contributor to land cover change. However, this did not mean that firewood cutting did not contribute to deforestation, but the mechanisms for the *duo* processes were different and needed to be totally isolated from agricultural and other aspects of land cover change.

8.2.2 Population, Human Settlement Expansion and Forest Cover Status

PRA results established that the active population group in felling trees for firewood used for burning bricks consisted of the same members who expanded farms, i.e. males aged between 20 and 44. These were the *key actors* in the activity who constituted about 8% of the total households' population.

8.2.2.1 Population, Firewood Used for Burning Bricks and Forest Cover Change

Survey data indicate that 78% of the interviewed households made a total of 2,529,110 bricks, i.e. an average of about 3618 bricks *per* household. Findings by the Songea District Council indicated that

$1m^3$ of round wood was needed to bake around 1000 bricks. Thus the bricks made by the sample households required about 25,291 m^3 of firewood (URT, 2005b), implying that a large quantity of firewood was used for the purpose thus contributed significantly to deforestation. The study established that ten thousand bricks, which could be used to construct a three bed-room house, required a total of about 10 cubic metres of round wood. The amount of round wood used for burning 5000 bricks, the average for the study area, i.e. twice the normal brick size was equivalent to $10m^3$ (URT, 2005b).

Since about 78% of the households had constructed and lived in brick houses; and that the average household size was 4.8 people, it implies that they had relatively larger houses, therefore used of more bricks and used enormous amounts of firewood that contributed significantly to deforestation. It was difficult to specify the spatial coverage of deforestation by specific activity since human activities were both overlapping and formed a *continuum*.

8.2.2.2 Changes in Population Characteristics, Settlements and Forest Cover

The use of firewood for burning bricks bears a similar complexity in separating it; as explained separately in item 8.2.1. However, it was found important presenting the data regarding firewood use for burning bricks. Burning of more bricks was necessitated by population growth that raised demand for extra shelter, thus negatively impacted on forest cover.

8.3 Development and Environment

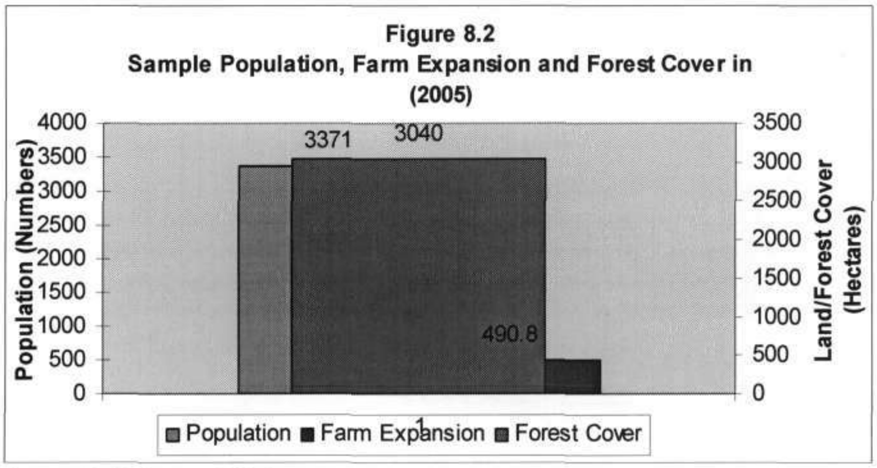
Conversion of forests into farmlands was realized and observed over vast sections of WMCA. The net effect was the observed shrinking of the forest cover which was being replaced by the expanding agricultural activities. Agriculture, being the major livelihood and development activity was a constituent part of life systems. People's involvement in farm expansion went with socio-economic changes characterized by in-born demographic connotations that influenced engagement in environmentally significant behaviours, with adverse impact on forest cover. How much contribution the inherent demographic characteristics posed to forest cover change and how the relationship between changes in population characteristics was; and changes in forest cover are issues discussed in section 8.3.1.1 and 8.3.1.2.

8.3.1 Population, Development Environment Situation in 2005

The analysis of PDE situation in WMCA for specific years under review formed the main content of this section. The spot analysis was based on empirical qualitative data and information, both primary and secondary. The real PDE situation was briefly and specifically presented, discussed and documented.

8.3.1.1 Population, Farm Expansion and Forest Cover Change

Survey data indicate that the households had a total of 3,371 members of whom 1,690 were males and 1,681 females. The sex ratio of the respondents was 100.5. The *key actors* in the activity were 270 males in the aged between 20 and 44; who constituted about 8% of the total households' population. In the period between 2002 and 2005, about 490.8 hectares of forest were cleared for establishment or expansion of farms out of which 4.1 hectares were cleared for growing tobacco. Figure 8.2 demonstrate PDE situation in 2005.

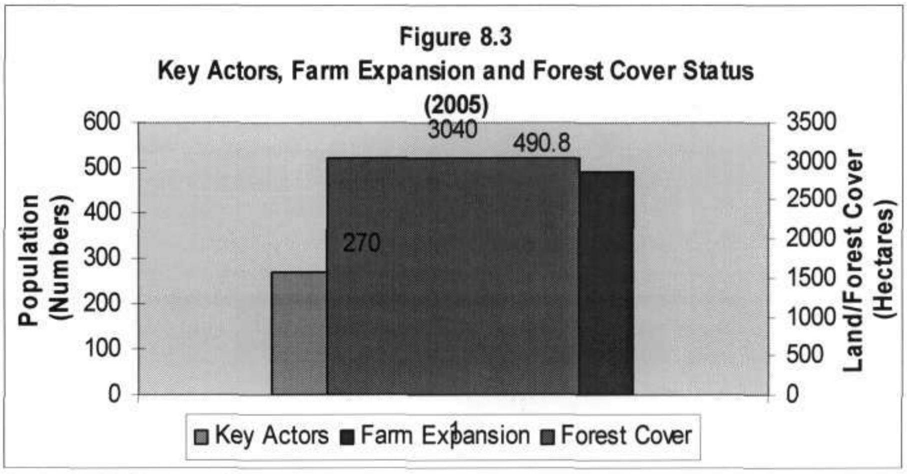


Source: Field Survey, 2005

Survey data indicated that not all household members played a role in farm expansion. Only a small proportion participated in the activity. Various reasons were mentioned to explain this aspect. However, it was observed that population increase brought about an increase in the number of actors which in turn led into more reduction of the forest cover. The year 2005 experienced expansion of population size, *key actors* and farms. During the same year, a reduction in forest cover was experienced. We cannot hesitate documenting a linear positive relationship between the three variables. Figure 8.3 demonstrates PDE situation based in *key actors population* in 2005.

Satellite imagery indicates that in 2005 the total land cover in WMCA was 3040.4 hectares. This implies that any further increase in population was likely to increase the population of the *actors* and subsequently reduce forest cover that remained as an island covering only 10.6% of WMCA.

As farm expansion was inversely related to forest cover, it implicitly shows that population growth necessitated expansion of the development activity (farm expansion) through not only raising the demand for food and other farm products but more important its expansion of the segment of the actors who actually carried out the expansion process. Logic dictates that food demand could be solved using other alternatives had there been no open forest land for farm expansion; and more important devoid of actors in the activity.

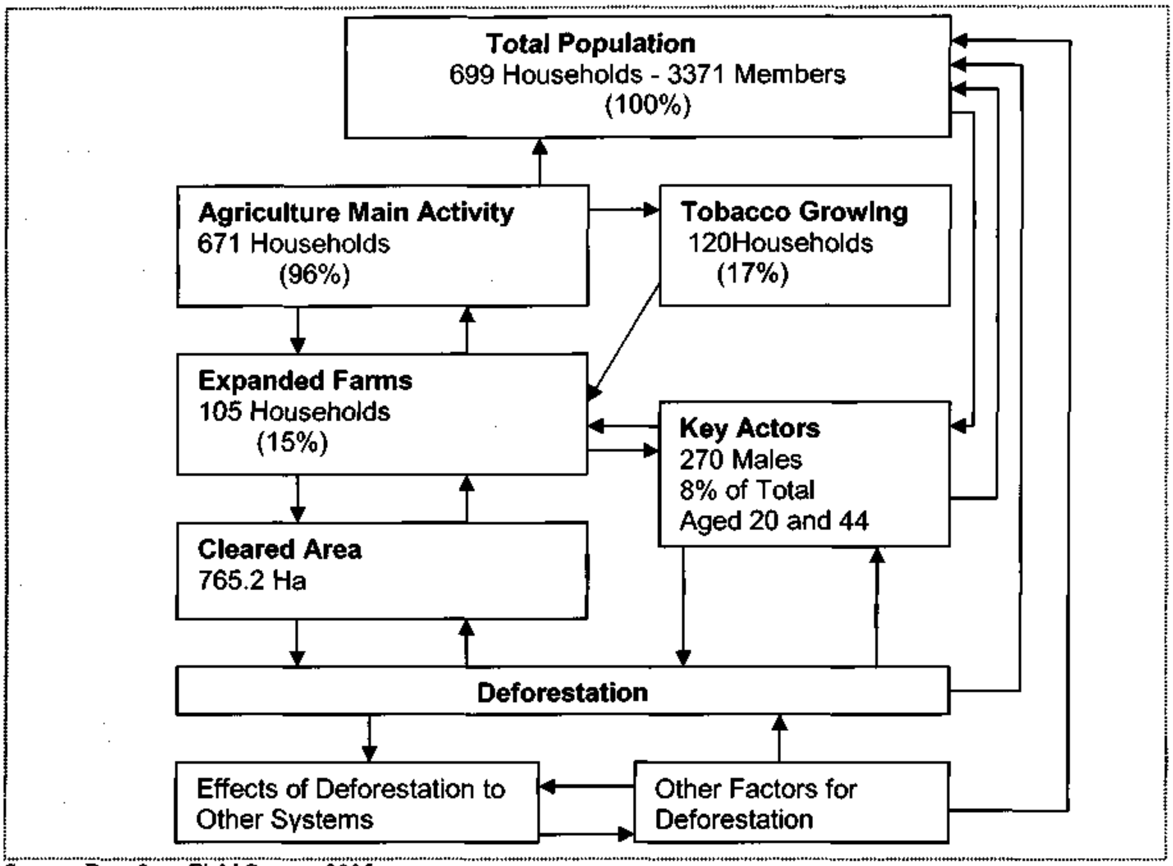


Source: Field Survey, 2005

Figure 8.4 is the *Schema* indicating the quantitative status of the linkages between population, farm expansion and forest cover status. The *schema* as well, portrays the reality that not all members of the household population were involved in clearing the forest for establishing or farm expansion. The *key actors* in the process constituted a small proportion of the population. Sex and age-based division of labour, deep rooted in cultural values of the local communities, was the main reason for that. One may infer that the *key actors* were not only the product of population growth, as aforementioned, but also a creation of cultural values and customs entrenched in the community in question.

The schema Fig. 8.4 demonstrates that not all households are engaged in felling trees for expanding farms. In For the case of WMCA only 15% of households cut trees for the purpose, whereby the actual population that was engaged in the activity was only 8%. This active population for felling trees when expanding farms was predominated by males aged between 20 and 44 years. The age and sex specificity that characterized the active group is considered significant for planning and targeting the forest conservation activities in the area. This avoids problems associated with 'blanket extension service' that include high cost, misdirection and less effectiveness.

Figure 8.4 Schema on the Status of Population, Farm Expansion and Forest Cover Status



Source: Data from Field Survey, 2005

8.3.1.2 Population, Development and Environment Situation for Years under Review

Based on GIS data in Table 8.2 below, it was evident that between 1978 and 2005, a total of 1135.4 hectares of forest land was cleared for crop cultivation (including tobacco) in the 699 interviewed households, leading to an average household clearing rate of 1.62 hectares. In the same period, a total of 674.8 hectares were cleared for cultivation of other crops than tobacco.

Table 8.2 Trends in Conversion of Forests into Farms from 1978 to 2005

Period	Farm Size (Hectares)	Percentage	% Change	Cumulative Area (Hectares)
1974-1978	160.2	14.1	-	160.2
1979-1988	210	18.5	31.1	370.2
1989 -2002	274.4	24.2	30.6	644.6
2003 - 2005	490.8	43.2	78.8	1135.4
TOTAL	**1135.4**	**100**	-	

Source: TANRIC, 2005

Data in Table 8.3 indicate that tobacco had a number of isolated activities that contributed to deforestation. About 57.9 hectares were cleared for tobacco cultivation, while an extra 57.9 hectares of the forest were cleared for firewood used in curing of the same crop. Studies conducted by Mnzava (1981) revealed that in the savannah areas, growing tobacco on 1 hectare cleared another one hectare of the forest for firewood used for curing tobacco leaves. Hence the forest area that was cleared for tobacco farming and curing was about 115.8 hectares. It was not of interest to the thesis to single out the impact of tobacco growing; however its significance in accelerating deforestation was enormous (Geist, 1996; Mnzava, 1981; Wood and Baldwin, 1985).

Table 8.3 Expansion Tobacco Farms and Decrease in Forest Cover from 1978 to 2004

Period	Area Cultivated Ha.	Firewood (curing) Ha.	Total Area Ha.	% Increase	Cumulative Cleared Ha.	Cumulative %
1978– 1988	12.8	12.8	25.6	22.1	25.6	22.1
1989 -2002	42.7	42.7	85.4	73.8	111	95.9
2003 -2004	2.4	2.4	4.8	4.1	115.8	100
TOTAL	**57.9**	**57.9**	**115.8**	**100**		

Source: Field Survey, 2005

The isolation was conducted for the sample households only to signify that tobacco cultivation has a great impact to forest cover changes (Geist, 1996). The findings, based on the mathematical link between the PDE components, as demonstrated in the graph Figure 8.2, indicate that in a population of 3371 people, only 270, i.e. 8% dealt with farm expansion; and that where farms were expanded, the activity was mainly conducted by men aged between 20 and 44.

Generally, only 8% of the population was engaged in the clearing of at least about 765.2 hectares of the forest for crop cultivation between 1989 and 2005. This was the contribution of farming to deforestation. From this finding, we may observe that the total population cannot be exonerated from the contribution to deforestation for it engenders both potential demands for agricultural products, shelter and the basic means of subsistence.

To meet the demand the *key actor population segment* that grew as a derivative of population growth worked in the manner determined by the socio-cultural, political, geographical and technological factors to cope with the ailing situation. It should be emphasized that the growth of population with the concomitant expansion of *key actors segment* 'enabled the expansion of deforestation, through expansion of development or livelihood activities.

More details on whether changes in age structure and sex composition impacted to deforestation are a discussion in section 8.2 of the chapter. GIS data indicated that within the period under review, i.e. from 1978 to 2005, about 3920.2 hectares of *closed woodlands* were cleared for various uses. This constituted about 56% of the total woodland that existed in 1978. The observed expansion of areas with *scattered cultivation* and *mixed cropping* tended to justify the same.

8.3.1.3 The Relationship between Population, Development and Environment in WMCA

The observed specific PDE situations above, supported by empirical data obtained from the field survey and conceded by PRA results, revealed the presence of different *key actors* responsible for carrying out different deforestation-related activities. It was also revealed that the *key actors* in question constituted a smaller proportion of the entire population, biased based on sex categories and age groups.

Effects of changes in the proportion of the *key actors* to the activity were established through *time line data analysis* to allow for tracking the changes in population, development and environment. It was generally noted that growth in human population brought about an increase in the number of the *key actors* in the activity that culminated into the observed disappearance of the forest cover.

The juxtaposition of the PDE situation was based on the data and the percentages changes in *key actors'* populations in 2005 from the survey results to the village population data extracted from national population censuses for 1978, 1988 and 2002. The identified *key actor population segments* were linked to changes in development activities and environment observed in other years under review. The yearly findings, i.e. 'spot analysis' of changes and trends in population characteristics, expansion of development activities and forest cover change are presented in section 8.3.2.

One area of complexity observed in the analysis was on the 'entry' and 'exit' ages of the household members to a particular activity. It implied that at the *minimum age* of, say 8, one started getting involved in the activity, while at the *maximum age* of 44 one stopped being involved in it. The fact was that not all the actors who 'entered' in the same period attained 'stability' stage as some had exited through death, migration and changes in activities. More complexity emerged since most of the members were likely to reach 'stability' and 'exit' stages while out of original households. They may reach 'stability' and 'exit' while in their own households that were established through marriage, cohabitation or mere departure from parent's household for other reasons. Thus the thesis observed the spiral pattern of growth of population size, changes in age structure and sex composition and expansion of human activities that resulted into forest cover change.

Percentage changes in volume of activities contributing to forest cover change were combined and represented using GIS. Forest cover change was mainly attributed to farm expansion. Generating the knowledge on the differential role and contribution in forest cover changes was among the objectives of the thesis. The demographic analysis, based on population projections may take over from the thesis and articulate other dynamics of both, i.e. environment and the human population. The adopted analytical framework was based purely on the proportion of active household members and the same activities observed by the field data results.

8.3.2 Population, Development Environment Relationships by Censuses Years

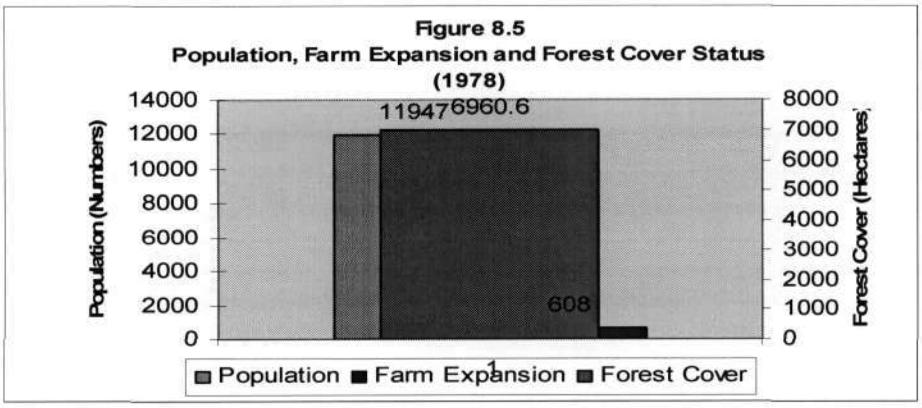
The data extracts from population censuses of 1978, 1988 and 2002 were used in the analysis. The age groups and sex category identified by the field survey as the *key actors* in specific economic/livelihood activity were applied as the *key actors* for other years under review. Transposition was effected, thus segmentation on their size, composition and percentage changes was applicable.

The activity of establishing and/or expanding farms, i.e. the main development activity and contributor to deforestation was considered for specific analysis. Since other activities such as firewood use and settlement expansion overlapped over space and time, thus it was practically not easy to discern them. GIS data on forest cover change were used in the analysis. The PDE situations and the existing relationship between specific population, development and environment scenarios for specific years under review were analyzed and reported in sections 8.3.2.1, 8.3.2.2 and 8.3.2.3.

8.3.2.1 The Population Development and Environment Status in 1978

The Tanzania National Population Census 1978 report indicated that the population of WMCA was about 11,947 people, i.e. 5930 males and 6017 females (URT, 1981). The sex ratio was 98.5. In 1978, there were about 2,227 *key actors* in clearing the forest for expansion of farms who constituted about 18.6% of the total population. Survey findings indicate that the amount of forest converted into farms, by interviewed households, was 160.2 hectares, i.e. about 40% of the total area. Farm expansion was observed the main activity responsible for accelerating deforestation. Figure 8.5 demonstrates the PDE situation in 1978 based on the entire population.

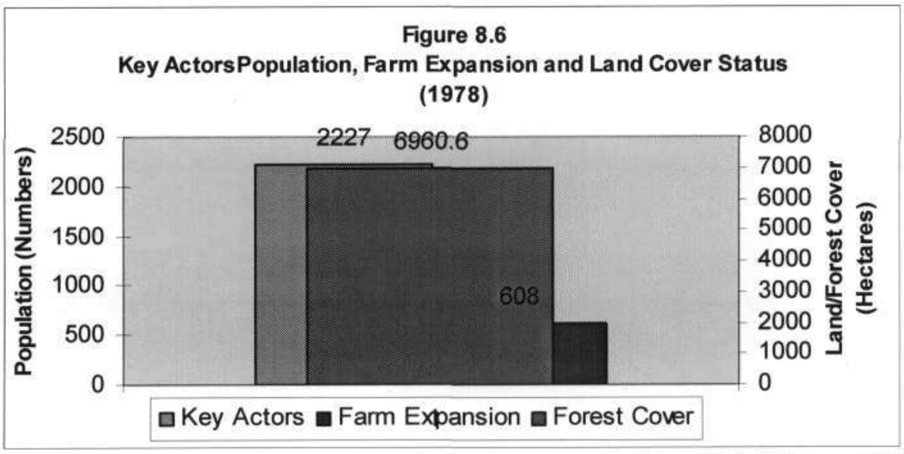
In 1974 the government of Tanzania declared *Operesheni Vijiji.* The operation involved massive relocation of the people from their original areas to *Ujamaa* villages. The relocated households were allocated forest areas to clear them for agricultural and settlement use. During the campaign, extensive forest areas were converted into agricultural land over vast parts of the country.



Source: Tanzania Population Census Report 1981 and Field Survey, 2005

Analysis of the forest cover change, as deduced from *Landsat* imagery, demonstrate that the total forest area that remained was about 6960.6 hectares, i.e. about 92% of the forest cover existed in the area by 1969, i.e. 7568.6 hectares. For the period between 1969 and 1978 only about 8% of the *closed woodland* forest was cleared.

It was noted that the population did not wholly engage itself in the activity; rather only a small proportion of it was involved for the benefit of the entire respective household population. While the total household and village population tended to influence the demand for forest resources, due to rising food requirements and other needs, the *key actors* were the ones who actually came into the interface with the forest cover. Figure 8.6 is demonstrates PDE situation based on the *key actor population* in 1978.



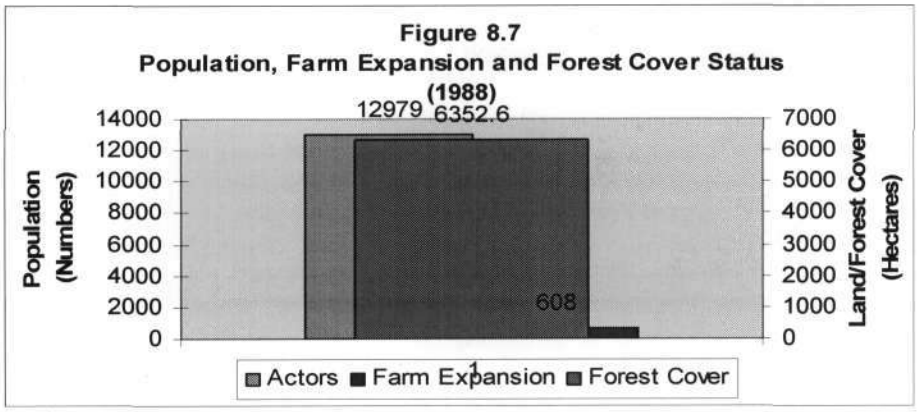
Source: Data from Tanzania National Population Census Report 1981 and Field Survey, 2005

Methods and difficulties in harvesting which determined the pace and process; or availing such natural resources is an aspect that faced the actors. The difficulty referred hereto included distance, labour intensity and loss of time; may be turned into 'incentives' towards improved future conservation strategies.

8.3.2.2 Population, Development and Environment Status in 1988

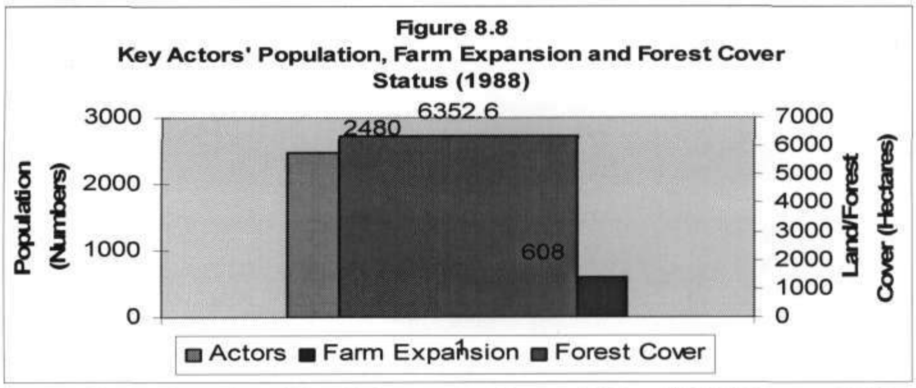
The National 1988 Census Report indicated that WMCA had a total of 12,979 people, out of whom 6,371 were males and 6608 females (URT, 1990). The sex ratio was 96.4. In 1988, there were 2,480 *key actors* in activities leading into forest cover change who constituted 19.1% of the total population. Figure 8.7 demonstrates the PDE situation in 1988 based on the entire population.

Field survey results indicated that about 40% of the households from the sampled households indicated to have cleared a total of about 210 hectares of the woodland forest for establishing or expanding farms; therefore contributing into reduction in the forest cover. Out of the cleared forest area, expansion of tobacco cultivation occupied 25.6 hectares of the forest that was cleared for tobacco farming.



Source: Data from National Population Census Report 1990 and Field Survey, 2005

The analysis of *Land*sat imagery indicates that the forest cover of *closed woodland* was reduced by 608 hectares, i.e. 8.7% of the total *closed woodland* forest area recorded in 1978, i.e. from 6,960.6 hectares. Figure 8.8 shows the PDE situation in 1988 based on the *key actors' population*.



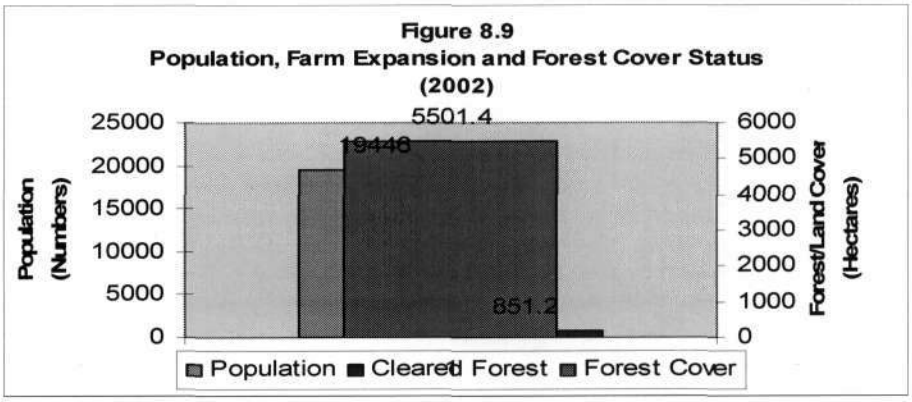
Source: Tanzania National Population census Report 1990 and Field Survey, 2005

It was noted that population increase brought about an increase in the size of population group of the *key actors* which culminated into higher pace of forest clearing, therefore reducing the natural vegetation cover. The growth in human population size was inversely related to the state of the forest cover. Whether the changes within the PDE components were proportional and/or consistent is an aspect discussed in section 8.3.3.

8.3.2.3 The Population Development Environment Status in 2002

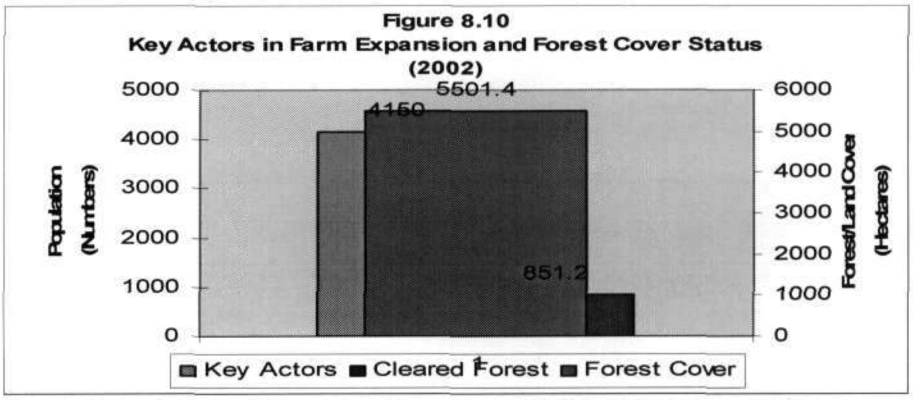
In 2002 there were a total of 19,446 people out of whom 9,506 were males and 9,940 females (URT, 2003a). The sex ratio was 95.6. The total number of *key actors*, i.e. males aged between 20 and 44 were 4,150, constituting 21.3% of the total population. Figure 8.9 demonstrates the PDE situation in 2002 based on total population.

Field survey data indicate that between 1988 and 2002, the interviewed households, i.e. 40% of the total households of WMCA, cleared about 1,201 hectares of woodland forest for establishing or expanding farms. In the same period, out of the cleared forest about 85.4 hectares were cleared for tobacco cultivation.



Source: Data from National Population Census Report, 2003 and Field Survey, 2005

Landsat imagery analysis indicate a land cover loss of *closed woodland* of 851 hectares, i.e. 13.4% of the total *closed woodland* forest area in 1988, i.e. a decline from 6,352.6 hectares, recorded in 1988. Figure 8.9 demonstrates the PDE situation in 2002 based on the *key actors' population*. Figure 8.10 demonstrates the PDE situation in 2002 based on *key actors*' population.



Source: Tanzania National Population Census Report 2003 and Field Survey 2005

A smaller proportion of the population constituted the *active* population in the farm expansion; while the forest cover of the area dwindled with time. The increase in the total population brought about an increase in the number of the *key actors* who expanded the farms leading into rapid reduction in forest cover.

8.3.3 Changes in Population, Development Activities and Forest Cover (1978 - 2005)

There have been notable changes in population characteristics, development /livelihood activities and the forest cover. As observed earlier in this Chapter, farm expansion was the focal point when establishing the relationships between the P, D and E components in a rural setting where agriculture and firewood use were ubiquitous. This hinged on the significance of agriculture as the main economic activity.

8.3.3.1 Changes in Population, Farm Expansion and Forest Cover from 1978 to 1988

The National Population Census data indicates that population size changed by 8.6% between 1978 and 1988, i.e. from 11,947 to 12,979 people. The population of the *key actors*, i.e. males aged between 20 and 44 had their population increased by 11.4%, i.e. from 2,227 people in 1978 to 2,480 in 1988. Within the same period, the total *closed woodland* cleared for farming increased by 6.8% i.e. from 381 hectares in 1978 to 407 hectares in 1988. The percentage changes in forest cover for the period between 1978 and 1988 was about 8.3%, i.e. a decline of tree cover from 6,960.6 hectares to 6352.6 hectares.

Growth of human population brought about a rise in farm size though in different proportions. A decrease in forest cover observed in the period was neither proportional to the population growth nor to the rate of farm expansion. It implies that the three variables were related but not in a direct and linear relationship, meaning that there were other factors that came into play in the process. Such factors are crucial in influencing their relationship. A more detailed study is hereby recommended.

8.3.3.2 Changes in Population Variables, Farm Expansion and Forest Cover from 1988 to 2002

The National Population Census data indicated that population size changed by 49.8% between 1988 and 2002, i.e. from 12,979 to 19446 people. The *population of the key actors*, i.e. males aged between 20 and 44 increased by 67.3% i.e. from 2480 in 1988 to 4150 in 2002. Within the same period, the forest area cleared for farming almost tripled, signifying a marked increase from 407 hectares in 1988 to 1,201 hectares in 2002. In the same period, farmland area increased by 195%. The percentage changes in forest cover within the period was about 13.4%, i.e. a decline of tree cover from 6352.6 hectares in 1988 to 5501.4 hectares in 2002.

A significant rise of population brought about a drastic rise in farm expansion leading to a significant decline in forest cover. In this case the variables showed a relationship, but did not display any proportionate association. It meant that other factors were at play in concretizing the existing relationship among them and shaped the linkages.

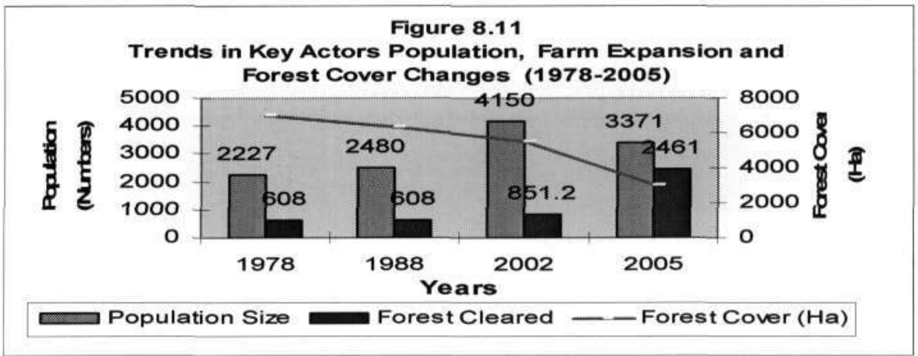
8.3.3.3 Changes in Population Characteristics, Farm Expansion and Forest Cover between 2002 and 2005)

The National Population Census data indicate that population size decreased by 39.1% between 2002 and 2005. Population of the *key actors*, i.e. males aged between 20 and 44 decreased by 18.8% i.e. from 4,150 in 2002 to 3,371 in 2005.

Within the same period, the *closed woodland* forest cleared for farming increased by 44.7% i.e. from 851.2 hectares in 2002 to 2461 hectares in 2005. *Land*sat imagery indicate that the percentage of forest cover within the period decreased from 24.2% to 10.6% indicating a decline of tree cover from 5501.4 hectares in 2002 to 3040.4 hectares in 2005.

Population growth brought about the increased size of the *segment of the key actors* and a drastic rise in farm expansion; thus the observed significant declines in forest cover. The increase in numbers of *key actors* was a direct result of growth in human population. Whether the increased number resulted into the increased demand for households' requirements for food and other forest products or it was the one caused by the extra population of the *key actors* to act on the forest cover, is another subject recommended for more detailed enquiry.

The complexity existed between the three variables was the inclusion of the other factors which tended to vary from an individual, among household members and even in the entire population. Such factors and their role in the PDE relationship in WMCA, which in this thesis are termed mediating factors, are discussed in section 8.6. Figure 8.11 demonstrates the trends in changes in human population; farm expansion and forest cover change.



Source: Tanzania National Population Censuses 1981, 1990 and 2003; and Field Survey, 2005

8.4 Trends in Changes in Population, Development Activities and Forest Cover (1978 - 2005)

The observed changes in population size, age structure and sex composition were analyzed in order to establish whether they impacted on the development/livelihood and the forest cover in the period under review.

The 'spot analyses', mentioned in section 8.3.2, indicated the presence of strong positive relationship among any two of the three PDE components. The measurement of variation of social behaviours over time and space was considered important in establishing the consistency and bondage between the PDE components. The specific relationship between changes in population characteristics and forest cover are covered in sections 8.4.1, 8.4.2 and 8.4.3.

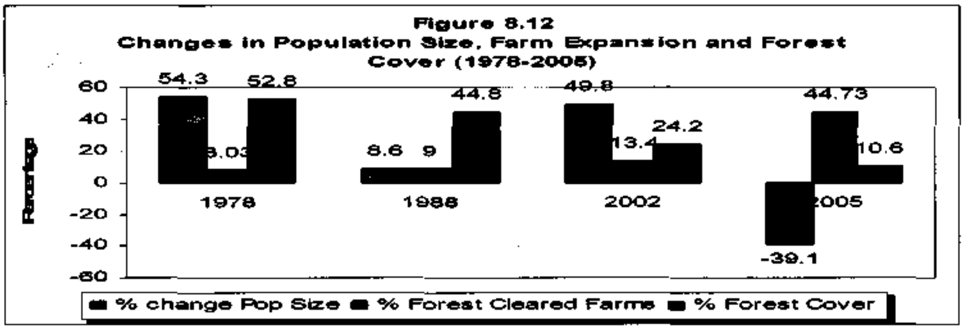
8.4.1 Changes in Population Size, Farm Expansion and Forest Cover (1978 to 1988)

Figure 8.11 indicates that between 1978 and 1988 population grew by 8.6 %, i.e. from 11,947 people to 12,979. The growth of 49.8% was experienced between 1988 and 2002. A drastic decrease of 39.1% in human population was recorded between 2002 and 2005, i.e. from 19,446 to 11,840 people. Population growth was observed in the entire period under review.

Concerning forest cover, between 1978 and 1988 about 608 hectares of the *closed forest* were cleared for establishing farms, while 851.2 hectares were cleared between 1988 and 2002 for various activities that include farm expansion, firewood and expansion of human settlements. Vast forest areas were cleared for the same purpose between 2002 and 2005, covering about 2461 hectares. This implies that throughout the period under review, farms were progressively expanded while the forest cover was on the decrease. Figure 8.12 demonstrates relative changes between population composition, farm expansion and forest cover.

The three variables indicated relative disparities among them though the magnitudes of variations were inconsistent. The growth in human population corresponded to the expansion of the cleared farm area, leading into a tremendous and progressive decrease in the forest cover. One cannot easily deny the fact that population size influenced the observed fast pace of both farm expansion and deforestation. The drastic growth in human population was reflected in terms of a decrease in forest cover mainly due to the expanded economic and livelihood activities in the area. As to whether the drastic expansion of the farm area was primarily caused by the population growth alone is a disputed fact since proportionate change would have resulted, if that was the case.

Detailed linkages of the three PDE components demanded for the analysis of the existent *mediating factors* operating within the specified locality and time. Further analysis on how changes in other demographic characteristics, i.e. sex composition and age structure were related to changes in farm expansion and forest cover was conducted and documented. The *mediating factors* such as type of technologies used, policies and cultural values influenced the decisions and choices of specific land use types and production practices; therefore determining the pace of exploitation of natural resources.



Source: Tanzania National Population Censuses 1981, 1990 and 2003; and Field Survey, 2005

8.4.2 Changes in Sex Composition, Farm Expansion and Forest Cover (1978- 2005)

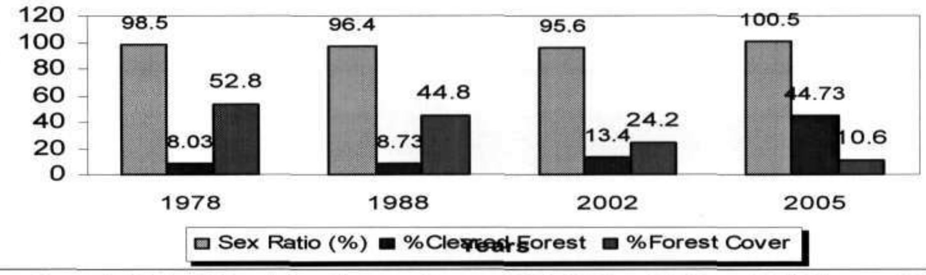
Figure 8.13 indicates that in 1978 the population of the area was 11,947 with a sex ratio of 98.5 showing the presence of more males than females. Between 1978 and 1988 the population grew by 8.6% to reach 12,979, while the sex ratio stood at 96.4. The population increased further to 19,446 in 2002 which marked a sudden rise of 49.8%. A sudden fall in population size of 39.1% was noted between 2002 and 2005.

In 1978 there were 2227 *key actors* in expansion of farms, with a sex ratio of 98.5. The population of the *key actors* grew to 2,480 while the sex ratio was 96.4 by 1988. The *key actors' population* had reached 4,150 in 2002 with a sex ratio of 95.6. The sex ratio of the population within the *key actors' age groups* was, 98.5 and 96.4 for 1978 and 1988 respectively recording a falling proportion of males in the population. For 2002 and 2005, the sex ratios were 95.6 and 100.5 respectively.

By 1978 there were about 6,960.6 hectares of the *woodland forest* were converted into farms. By 1988 about 608 hectares were cleared for farm expansion. An extra forest cover of 851.2 Ha was cleared in the period between 1988 and 2002. Vast *closed forest* areas were cleared for new farms between 2002 and 2005 while about 2461 hectares of the *woodland forests* were converted into new farms.

The data analysis implied that despite the decrease in the proportion of males (sex ratio), i.e. the *key actors* in farm expansion, between 1978 and 1988, farm area expanded from 8.03 to 8.73% causing decrease in forest cover. Another fall in the sex ratio that was noted between 1988 and 2002 resulted into an increase in cleared farm area from 8.73% to 13.4% and a decrease in forest cover. The increase in sex ratio observed between 2002 and 2005 brought about a drastic increase in the farm area, which contributed to the recorded decrease in forest cover. We cannot hesitate arguing that sex composition of the population is not directly linked to the rate of clearing the forest cover for farm expansion despite involvement of males in the activity. What should be born in mind is that population growth is a stronger factor in influencing farm expansion than changes in sex ratios.

Figure 8.13
Variations in Population Composition, Farm Expansion and Forest Cover 1978-2005



Source: Tanzania National Population Censuses Reports 1981, 1990 and 2003; and Field Survey, 2005

Appreciable changes were observed in terms of sex composition in the population of WMCA as indicated by variations in sex ratios over time since 1978. Between 1978 and 1988 sex ratios declined from 98.5 to 96.4 implying that the numbers of males were relatively declining. Since the *key actors* in clearing the forest for establishing farms were males, the relative decrease in their numbers was likely to decrease the impact to the forest cover. But the opposite was observed in this context. This shows that other factors are at play in influencing farm expansion decisions.

Further decrease in sex ratios, i.e. from 96.4 in 1988 to 95.6 in 2002 indicated further discrepancy between numbers of males and females in the local communities. The decreasing proportion of males, who were the *key actors* in the clearing of the forest cover, however did not translate in the reduction of the forest cover, instead it accelerated it. A different *scenario* was observed between 2002 and 2005 whereby the sex ratios rose from 95.6 to 100.5 indicating the massive presence of males in the population than females. The forest area cleared for farm expansion for this period increased drastically, i.e. from 13.4% to 44.73%.

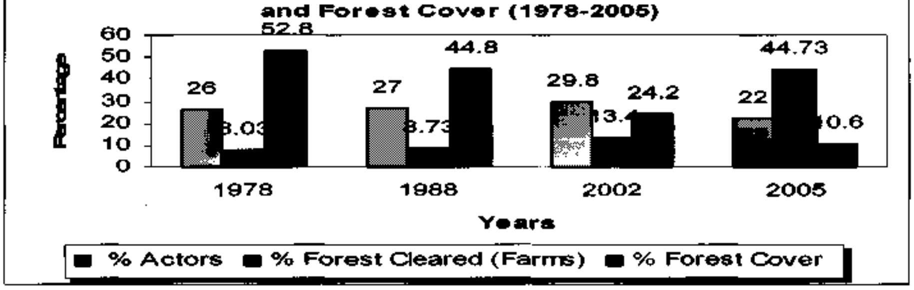
The inference one would make on the above findings is that changes in the sex composition had no direct impact on the expansion of the activity of farm expansion and in determining the amount of forest cover that an area constituted. There were instances where weak relationships were noted but they were unstable and inconsistent, therefore making no room for drawing any general conclusions. The drastic rise in sex ratio in 2005, coupled with the drastic augmented rate of farm expansion may be considered to be a coincidence.

Changes in sex composition, however, had a direct impact on increasing numbers of the *key actors* in deforestation, partly because of the dominance of farming as the main economic activity; hence variations in population characteristics could always be reflected in terms of their involvement in farming. The same was contributed by the prevalent sex-based division of labour, which if operationalized within the demographic dimension the results tended to assume such a bias.

8.4.3 Changes in Age Structure, Farm Expansion and Forest Cover (1978- 2005)

The graph in Figure 8.14 indicates that in 1978 the *key actors* constituted 26% of the population and that the proportion rose to 27% in 1988. In 2002 their proportions rose to 29.8%. In all the three periods, the clearing of the forest for farm expansion kept on increasing with a noted concomitant decline in the forest cover. In general, one would argue that sex composition has an impact in determining the size of *key actors group* within the population. The percentage number of the *key actors* had a direct positive relationship with the phenomenon 'farm expansion' and an inverse relationship to the vegetation cover change.

Figure 8.14
Variations Population Structure, Farm Expansion and Forest Cover (1978-2005)



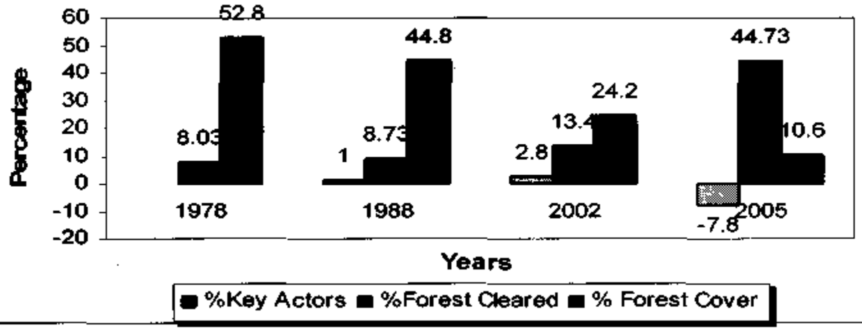
Source: Tanzania National Population Censuses 1981, 1990 and 2003; and Field Survey, 2005

In 1978 the population of *key actors* was 2,227 while in 1988 it grew to reach 2,480, recording a growth of about 11.4%. In 2002 the *key actors' population* had reached 4,150, i.e. recording a drastic increase of about 67.3%.

Between 1969 and 1978, about 608 hectares of *closed woodland* were cleared, i.e. about 8% of the total closed forest area in 1969. By 1978 *closed woodland* constituted about 6,960.6 hectares. General observation indicates an increasing rate of conversion of forest into farms with time. Between 1978 and 1988 about 608 hectares of *closed woodlands* were cleared for farm expansion and an extra forest cover of 851.2 hectares was cleared between 1988 and 2002 for the same purpose.

Between 2002 and 2005 about 2,461 hectares of the forests were cleared for establishing or expanding farms. In general terms, *Landsat* imagery indicate that the forest cover changed by 44.8% between 1978 and 1988. Between 1988 and 2002 forest cover decreased further to 24.2%, and a 10.6% decrease was noted between 2002 and 2005. Figure 8.15 shows the relative changes in *key actors' population,* farm expansion and forest cover between 1978 and 2005.

Figure 8.15
Changes in Key Actors Population, Farm Expansion and Forest Cover 1978-2005



Source: Data from Population censuses 1981, 1990 and 2003; and Field Survey, 2005

Changes in population structure, measured by the variations in the numbers of people in respective age groups, were arguably responsible for farm expansion in the study period. Despite changes in population structure, the variations in forest cover were not proportionate. Thus, we can strongly argue that changes in terms of both cleared forest areas for farms and the general forest cover change occurred due to expanded human activities mainly prompted by human population growth.

We observed the existence of relationships between the three components were such that as the population of the *key actors* increased, the size of farms expanded and so reduced the existing forest cover. The fact was that there was no consistency in terms of the effects of the changes in population structure to both farm expansion and forest cover change.

The main argument at this point is that changes in population structure had an impact on accelerating activities that led into forest cover change. However, the impact of such changes had not been consistent as they tended to differ from one location to another, or sometimes within the same locality with time. The increase in the size of age groups in the activities that reduced forest cover were more likely to, and they actually did, reduce the forest cover.

8.5 Population Characteristics and Peoples' Involvement Conservation Activities in WMCA

8.5.1 Peoples' Involvement in Tree Planting

Survey data revealed that the *key actors* in planting trees in WMCA were males in the age groups ranging from 20-24 to 55-59. They constituted about 13% of the total households' population. Female participants, in the same age group, i.e. 20-59 accounted for about 7% of the total households' population (See Figure 7.7 on Page 172).

However, the entire active population in the activity had 938 members who ranged from the age of 4 to 60+ and constituted about 28% of the total households' population, in which 18% were males and 10% females. The sex based composition of the actors indicated that males accounted for 65%; while females constituted 35% of the actors in the activity. However, there was no evidence that women were more interested in planting trees than men (Johnsen, 1999). A study, conducted in Karatu District of Tanzania noted that men tended to be slightly more interested than women in starting communal woodlots (Skutch, 1985).

PRA results indicated that most of the trees were planted between the mid 1990s under the Agro Forestry Project[41] while some were planted in 2005. A total of 67,814 trees, of different species, were planted by the interviewed households, i.e. an average of 97 trees *per* household. The exact spatial coverage of the planted trees could not be established since trees were planted arbitrarily, i.e. without following specific constant measurements. The planted trees were *mosaics* that could not easily be put together for obtaining their spatial coverage. The fact that different species were preferred and planted by different households also caused the differential spatial dimension of their coverage.

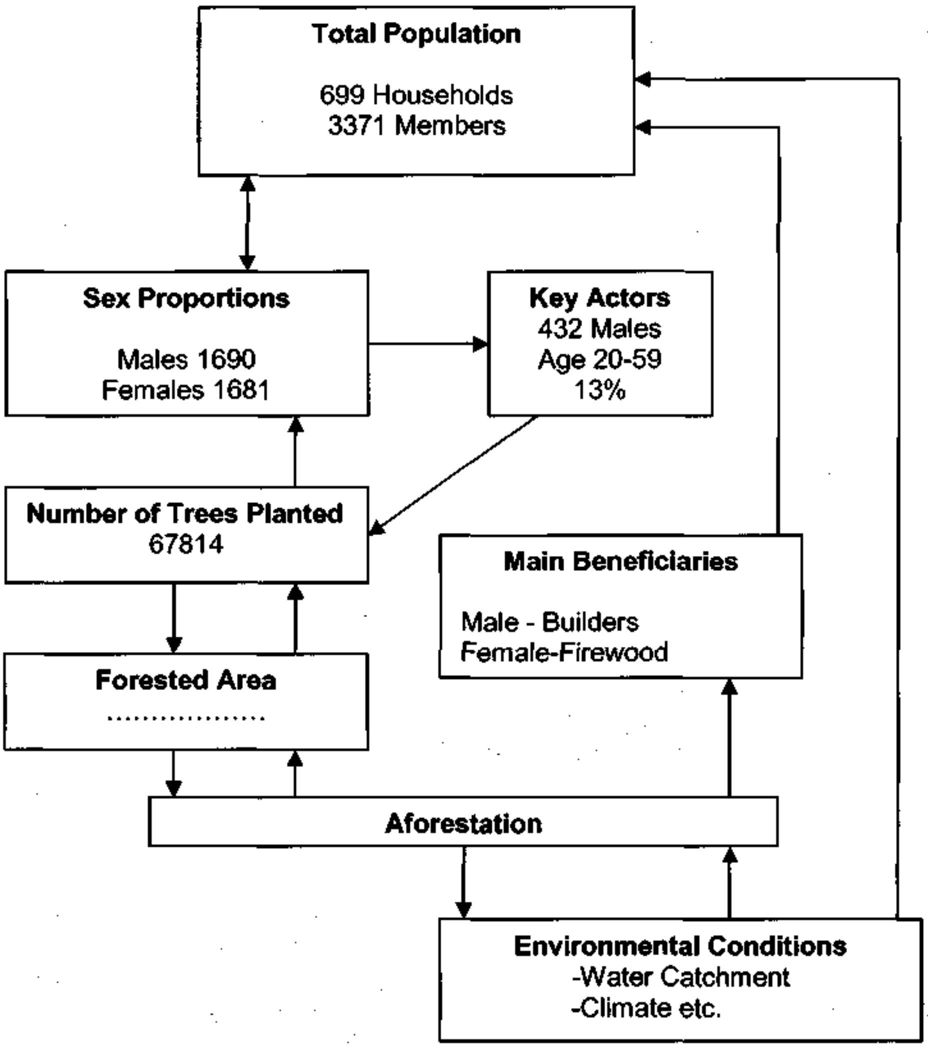
PRA results indicated that the majority of people who actually planted trees were those living in sections of settlements with acute shortage of firewood mainly at *Lipaya* and *Mahilo*. However, villages of *Lihwena* and *Muungano* had fewer planted trees despite the observed alarming firewood shortage. Inhabitants of *Kikunja* and *Mpingi* planted fewer trees because the areas still possessed vast woodland areas at their disposal. At *Ndilima Litembo* village people were found trapped between shortages of farm land and sources of firewood since the village is surrounded by the forest reserve. They, therefore could not plant trees on their land areas because this would limit the crop production area although they lacked firewood since there was no *public woodland*.

[41] Agro-forestry Project was an externally funded project that engaged farmers in tree planting within their farms. The seedlings were grown outside villages and distributed to villagers to plant them.

It should be noted that analysis of the proportionate contribution of the *active population* and that of the *key actors,* bare inference on the quantitative contribution of the actors in deforestation by specified activity. It could be noted further that efforts towards reforestation fell far behind the observed high rate of deforestation, implying that the planted trees could not replace the gap for various reasons.

The schema Figure 8.16 indicates that despite a large number of households that indicated to have planted trees, only a small proportion of the population, i.e. 13% was more active in the activity. The active population in the activity was males aged between 20 and 59. The optimism is that in case more people were engaged in tree planting the rate of aforestation would be observed. As the proportion of those who clear the forest for farm expansion are fewer (8%) than those who plant (13%) while the forest is constantly dwindling, it implies that the number of trees planted fall far behind the number of those that are felled. The same is implicated by the wider the range of the tree planters i.e. 20 to 59 as compared to those who actually cut trees i.e. aged between 20 and 44.

Figure 8.16 Schema for People's Involvement in Planting Trees in WMCA 2005



Source: Field Survey, 2005

8.5.2 Effects of Population Changes in Peoples Involvement in Tree Planting

It was vital to understand the relationship between changes in population size, sex composition and age structure; and one's involvement in tree planting. This was significant in examining the household members' demographic characteristics and to ascertain the members who actually planted trees, those who did no plant and why.

The thesis asserts that knowing household members who were responsible for accelerating deforestation, reasons for their involvement in various activities by their demographic characteristics, constituted only one side of the phenomena that characterized the state of physical environment, and forest cover in particular. Therefore, the understanding of demographic characteristics of actors in replacing the lost tree cover was equally significant for sustainable forest conservation strategies. This emanates from fact that forest cover status is a product of both negative and positive anthropogenic processes. The two aspects have to be taken into account for any holistic and sustainable conservation programme.

It should be mentioned, at this point, that *naturality* of the natural environment, forest cover in particular, hardly existed devoid of human influence be it by *commission,* i.e. positive forest cover 'additions' and negative processes, include 'reduction' of the forest cover; or by mere *omission* which entails purposeful leaving the forest cover to naturally maintain its existence, with minimum or no human impact at all. Conservation that tends to strike a balance between the two, i.e. *commission* and *omission,* in fact, according to the thesis, defines the term sustainability at best. It underlines the practical path to sustainable conservation.

The reality is that human population has traditionally been playing both destructive and constructive roles. The balancing of the two may be sustained through understanding the *key actors* for each and link them in conservation efforts through reduction of activity, acceleration of replacement, i.e. alternatives and the moderation of the mediating factors, known for influencing the pace and impact of deforestation.

The thesis could not establish the number of trees that were planted by specific years for lack of reliable data and absence of evidence on their growth to maturity due to low survival rate. PRA results reveal that a few trees planted could not reach maturity as they were destroyed by fires and domestic animals, mainly goats. In most of the villages only a few households planted trees and of the few planted trees only a few had actually grown successfully (Johnsen, 1999).

Tree planting that tended to coincide with crop cultivation was ineffective as it diverted labour from the mainstream activity. Some plant species hindered growth of crops due to the shade they cast on them. The fact that trees took long to mature, i.e. more than 10 years, was a disincentive to farmers who were more motivated by immediate benefits (Johnsen, 1999). Despite the existence of by laws that prohibited free movements of animals and the setting of bushfires, enforced by village leadership, such activities were common place hence frustrated conservation efforts.

The main argument put forward here is that the notion of tree planting needs not to be oversimplified. It is a complex activity that requires wide social, cultural, economic and environmental considerations. The complexity is based on underscoring the values of a society in question regarding trees and more important specific species to be planted. They were to be socio-culturally acceptable, economically viable and environmentally suitable.

It is the profound position of the thesis to assert that the striking of the balance between the three areas of interplay within a household or community would make tree planting an attractive and indispensable activity at household, community and national level. As trees are permanent or semi permanent and that they take long to grow, a secure land tenure system would guarantee more planting of a variety of species.

8.6 Mediating Factors Influencing Household Members' Involvement in Activities Contributing to Land Cover Change

Literature indicates that people do not cut trees without a reason. They cut trees for specific demand that could be met only by cutting trees (Hosier, 1988; Chu and Yu, 2002; Scherr *et. al.*, 2004; Delacote, 2007). In a strict sense, people may not starve so as to conserve trees in case they cut them to expand farm area to make a living. The same was true for firewood use, whereby a household could not stand hunger in favour of forest conservation objectives. Myers (1990) holds a similar view when he argued that the small scale cultivator to be an agent of deforestation. The rising consumption in developing countries necessitated expansion in farming at the same time caused deforestation. Therefore, forests were depleted more by an increase in human consumption than their numbers.

The need to discuss various *mediating factors* that influenced household members to involve themselves in the activities that caused or accelerated deforestation in WMCA was a step towards identifying the missing linkages within PDE components. These are factors which come between *actors* and environment. In case the *mediating factors* were taken care of, sustainability within resource use could be attained since they are known to influence one's involvement, type of the activity (interface) and the pace of engagement.

The number of household members was not the only and satisfactory criteria for farm expansion. Other factors responsible in explaining the same included availability of forest/land for farm expansion, availability of labour force, the types of crops grown and level of intensification of farming. Other major factors included production technology, national policies, regional policy and international policy. A brief discussion of some policies with impact on forest cover in WMCA is presented from section 8.6.1 to 8.6.5.

8.6.1 Availability of Farmland

The above discussed factors had great significance in the 'operationalization' of rural socio-economic systems as they touched issues related to livelihood and development. In WMCA availability of land for expansion of farms was mainly limited by the nearness of some settlements to the Songea municipality whereby urban land uses tended to dominate the rural settings. Some settlements experienced scarcity of land due to their proximity to the forest reserve where any use of the forest resources was limited by law. Shortage of such resources encouraged poaching and encroachment that negatively affected the forest cover.

8.6.2 Availability of Labour Force

Availability of labour force depended upon the age groups and sex categories of individuals who directly acted on resources. Clearing of the forest for farm expansion was done by young men, aged between 20 and 44. This, however, does not mean that the elderly did not take part in the task, but the extent of their involvement and the impact caused was relatively less compared to the able bodied young men in the age group of 20-44.

8.6.3 Types of Farm technology

PRA results indicated that the growing of some crops did not require the use of fertilizers. This provided the best option when fertilizer prices were prohibitive. Such crops included fingure-millet and cassava. The same crops favoured drought conditions. The fact is that the commonly grown crops like maize, beans, simsim and peas could not be grown without application of fertilizers. Millet and tobacco were said to require frequent shifting of plots as they could not flourish in the same plot for two consecutive years. In this way they had a greater potential of accelerating deforestation. However, tobacco had more potential to reducing forest cover as it required firewood for curing, an equivalent to the plot of the crop itself (Mnzava, 1981), which is 1 cubic metre of firewood for curing 7.5 kilograms of tobacco (Wood and Baldwin, 1985).

The degree of intensification implies increased use of external farm inputs, mainly industrial fertilizers and pesticides. This depended on the economic power of the household in question. Although the majority of the respondents indicated that they used industrial fertilizers in their farms, most of them complained about high prices of the agro inputs. Studies conducted elsewhere in Tanzania indicate that because of economic hardships most of the farmers applied less fertilizer than the recommended quantities or else they did not apply at all (Mbilinyi, 1997; Mashalla, 1988). This was mentioned to be detrimental to both crop output and soil fertility.

A proportionate size of households used other methods of recovering nutrients in the soil that included the practice of *bush fallowing, shifting cultivation* and *crop rotation.* Since fewer nutrients were replenished into the soil, the possibility for soil exhaustion was greater, therefore raising the likelihood for opening up extra farms, accomplished at the expense of the forest cover.

8.6.4 Regional and National Development Policies

National and regional policies were noted to augment the conversion of forest lands into farms and settlements. Literature indicates that the declaration of *Ujamaa* policy in 1967 that was followed by establishment of *Ujamaa* villages in 1974 brought people into settlement clusters that augmented pressure to the surrounding natural resources, forest cover in particular. Some negative effects of *Ujamaa* included the clearing of large tracts of land for farms, firewood and human settlements. Degradation of the forest was realized around many villages with a decrease in forest cover (Madulu, 2001a; Mashalla, 1988).

Since *villagization* was a national policy, its impact was felt in rural areas all over the country. With rapid population growth, most of the *Ujamaa* villages turned into towns and townships with more tremendous impacts to forest cover. PRA results observed spatial expansion of the sample households by a factor of 3 and above. Field observation revealed presence of larger rural settlements at *Lipaya* and *Kikunja.* Other villages like *Chemchem, Lihwena* and *Muungano* expanded and constituted part of the newly established Songea Municipality.

The *Agizo la Mlale,* the regional development policy declared in 1977, aimed towards making Ruvuma region the key producer of maize, tobacco, coffee and cashew nuts in Tanzania. The declaration directed people to expand farms by specified magnitudes for specified types of crops. Each household had to clear two more acres over and above the previous three. The employed had to have at least one acre of food crops. Households that depended on petty business had to have two acres food crops (URT, 1987).

The declaration emphasized expansion of tobacco cultivation, the major cash crop grown in Songea district without emphasizing corresponding planting trees for curing the crop. It directed villages to annually plant five acres, focusing a wrong target, i.e. the village authorities instead of the actors, i.e. farmers. The directive cited that each household should establish irrigated farm in the river valleys without professional guidance and precautions regarding elements of sustainable water resources management.

Furthermore the declaration of the *Mlale Resolution* directed all residents of the region to build "modern houses" for the respective households. According to the declaration a 'modern house' was defined as

> "the one that suffices one household, built by using baked bricks or cement thatched with corrugated iron sheets or tiles with wide windows and doors which is well floored and that can be used for more than twenty five years. It should, as well, have good furniture and that some fruit, shadow trees and flower plants found in its surroundings" (URT, 1987).

The interpretation of the *Mlale Resolution*, in terms of the impact to the environment, meant felling thousands of trees for farm expansion and for burning bricks. If translated in terms of average forest size in the area, a significant number of trees were cleared by a single household for the purpose. The net impact of implementing the declaration was adverse and cumulative as generations continued with the same practice over years. The *Mlale resolution* remains to be blue print to development of people of Ruvuma region to-date. One would argue that in most of villages in the region, houses were still being built using baked bricks, mostly at the expense of the forest cover. At the same time, expansion of agriculture tended to aggravate further the negative forest cover situation. The fact is that under such life systems (social, economic, political), deforestation was more likely to continue with unabated negative consequences to both the environment and population.

In 1983 the Tanzania government declared the Human Resources Deployment Act referred to as "Nguvu Kazi" (URT, 1983). The Act compelled all able bodied citizen to engage themselves in agricultural production. It involved the repatriation of the unemployed from urban areas to their respective regions. The repatriated were to be given forest areas to clear and establish farms (Mbilinyi, 1997; Madulu, 1991a).

Implementation of the Act did not cover only the unemployed, as it compelled even the employed rural and urban citizen to acquire rural land and cultivate crops. In that way vast forest land areas were cleared in both the urban outskirts and in rural areas. Farm expansion was of adverse impact to forest cover countrywide. The above situation indicates that both national and regional policies, which overlapped in terms of the timing of declaration and implementation, played a significant role in augmenting the rate of deforestation.

8.6.5 International Economic Policies

The world economic system and the role of the World Bank (International Bank for Reconstruction and Development) and the International Monetary Fund (IMF) as well, contributed into disappearance of the forest cover in vast areas of Tanzania, WMCA in particular. The Structural Adjustment Programmes (SAPs) of the 1980s restricted the subsidies in agro inputs and halted the operation of the agricultural extension service. These policies and other conditionalities resulted into negative consequences to the agricultural sector and accelerated disappearance of forest cover

(Menotti, 1999). The failure of farmers to afford the unsubsidized fertilizer prices lead to the continued practice of traditional methods of slash and burn, which is in essence shifting cultivation, therefore augmenting deforestation. Vast forest area of about 1459.2 hectares, i.e. about 21% of the *closed woodland,* was lost in that period alone due to this practice in order to realize the regional development policies.

Agricultural extension service was termed by IMF as 'expensive' and that it was to be abandoned by the Tanzania government. The disbanding of the extension service and waiver of subsidies on farm inputs resulted into collapse of the agricultural sector in terms of a fall in crop output and aggravating environmental degradation. The reality was that farmers could not adjust to any productive and/or sustainable production practices other than going back to traditional methods which were cheap, unproductive and detrimental to forest cover and the health of the soil.

In order to raise household income other investments in terms of labour were more preferable than buying agro inputs as market price of crops were too low to earn profit. This was the effect of *globalization* which left *smallholder farmers* at the edge of confusion and collapse (Mbilinyi, 1997; Mwakalobo and Kashuliza, 1999). *Globalization* accelerated deforestation by shifting the control of earth's natural resources from local communities to transnational corporations whose main motives are purely economic (Menotti, 1999). Such corporations had no ecological concern. Their policies and governments acted *contra* to the Rio declarations, just five years after the conference. Free trade treaties were aimed at expanding access to natural resources and consumer markets at the expense of the environment.

8.7 The Impact of Population and Forest Cover Changes to Other Environmental Phenomena

8.7.1 Population Change and Changes in *Rainfall Amount*

Available literature indicates that the decline in forest cover had a long run impact in reduction of *rainfall amount* (Wood and Baldwin, 1985; Myers, 1990). PRA results also indicate a significant decline in *rainfall amount* coupled with *erratic distribution.* The reduction in *rainfall amount* influenced the population especially where *small scale agriculture* formed the main development and/or livelihood activity. This is not only responsible for reduced farm output but also hunger and famine. In the case of growing cash crops, drought leads into a fall in income and thus perpetuates poverty conditions.

Other than the impact on reduction in *rainfall amount*, deforestation, especially in the Matogoro catchment forest, adversely affected the *catchment value* of the *watershed.* This was observed in terms of reduction of the volume of water flowing in rivers of the area, therefore demonstrating environmental degradation. Both PRA results and Survey data observed the declining water levels in wells and in rivers between the 1970s and 2005. The relationship between changes in population size and trends in population, forest cover change and *rainfall amount* discussed in items 8.7.1.1 and 8.7.1.2.

8.7.1.1 Population Size, Forest Cover and *Rainfall Amount*

The need to establish the relationship between population, deforestation and *rainfall amount* was a step towards highlighting the indirect impact of deforestation to the population that affected livelihoods of the local communities. Data on population size, forest cover change and the total annual rainfall were analyzed for the same purpose. The observed relationship is described from section (a) to (c).

(a) In 1978, the population of the study area was 11,947, while forest cover was recorded to be about 6960.6 hectares and the *total annual rainfall* was 1381 mm experienced in 6 months. The period experienced heavy rainfall, while the forest cover was extensive enough occupying about 52.8% of the total land area. The human population was relatively small with a proportionately smaller number of *key actors* in various development/livelihood activities that impacted on the forest cover. The activities did not expand much as societal demands for such resources and food requirements could be met with less clearing of natural vegetation cover. By that time population size, vegetation cover and climatic condition were in a 'balance' probably because more than 50% of the forest cover existed.

(b) By 1988 the human population grew to reach 12,979, a growth of about 8.6%. During the period, the amount of forest cover was 6352.6 hectares, registering a decrease of 608 hectares from that in 1978, which was a decrease of about 8.7%. In 1988, *closed woodland* accounted for about 44.8% of the total area. In 1988 the total annual rainfall was 748.2 mm. The amount decreased considerably by 632.8 mm from that of 1978. It means that drought condition started to prevail, an aspect with obvious negative consequences to small scale farmers whose production system depended on rainfall; who statistically constituted the majority of the population. Expansion of human activities prompted by population growth, contributed into the decline of forest cover; and in the long run adversely affected climatic conditions, for this case the *rainfall amount*.

(c) In 2002 the human population reached about 19,446, indicating a growth of 49.8%. During the same period, forest cover decreased by 13.4%, i.e. about 851.2 hectares were cleared. By the time forests covered about 5,501.4 hectares, accounting for about 24.2% of WMCA. The *total annual rainfall* recorded was 799 mm, recording an increase of 50.8mm, i.e. from 748.2 mm, the total amount in 1988.

It was observed that the *rainfall amount* had relatively increased. However, it fell only in 4 months, therefore posing a threat to agriculture which solely depended on rainfall. Farms were expanded, to encroach the areas previously covered by forests, as a response to the impact of changes in climatic conditions especially rainfall.

We generally observed that the rapid rate of population growth coincided with the expansion of farms that concomitantly caused reduction of forest cover which partly contributed to the reduction in *rainfall amount* and alterations on its *distribution*.

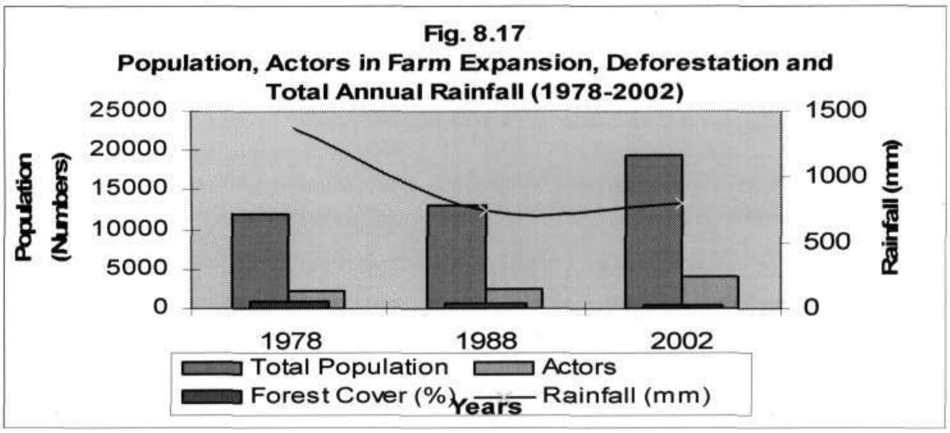
8.7.1.2 Trends in Changes in Population Size, Forest Cover and *Rainfall Amount*

WMCA experienced rapid population growth through time since 1978. The clustering of population within specific localities was a consequence of the implementation of 'Villagization Programme' of 1974. The programme created areas of high population pressure, i.e. villages, whose impact to the environment were observed to be negative.

Expansion of farms or establishment of other farms increased with an increase in human population size. Therefore population growth showed a positive linear relationship to the expansion of farms. This can be explained in terms of the expanded demand for natural resources that necessitated clearing of more forest land. It could also be explained in terms of the expanded volume of socio-economic activities, and settlement area that caused or was facilitated by availability of much labour indicated by the increasing number of the *key actors*.

Findings of the thesis, as demonstrated in Figure 8.17 indicate the existence of an inverse relationship between population growth and forest cover change. The observation is that while population expanded, the size of the forest cover was progressively reduced, while at the same time rainfall tended to decrease with time from 1978. One could assume a direct link between decline in forest cover and the anthropogenic factors; mainly expansion of farms. From the above findings, we cannot hesitate pointing out that the observed declining *rainfall amount* may be contributed by deforestation, among other factors.

The thesis reiterates that despite the observed positive relationships, the variations of PDE factors were not proportionate. Figure 8.13 indicates that between 1978 and 1988 population of the *key actors* grew by only 1% while farms were expanded by 0.7%, and forest cover was lost by 8%. This means that the increase in population size did not bring about a proportionate expansion of farms, therefore logically failed to result into a proportionate decrease in forest cover. Several issues or factors come into play when explaining this state of affairs that the thesis strived to uncover.



Source: Population Censuses Reports 1981, 1990 and 2003; Field Survey, 2005 and Tanzania Metrological Agency Songea, 2005

8.7.2 Population Change, Deforestation and Variations *Discharges* of *Ruvuma River.*

Flows of the *Ruvuma River* were studied as it had its watershed in WMCA. The aim was to establish whether human activities in the catchment area impacted on the *discharges* and downstream human population in order to enhance the understanding of the PDE relationship which is significant to sustainable conservation.

Spot analysis and simultaneous timeline analysis of the data was conducted for population, forest cover and *river discharges*. The results and analysis are presented in sections 8.7.2.1 and 8.7.2.2 respectively.

8.7.2.1 Population Size, Forest Cover Change and Variations in *River Discharges*

(a) In 1978 the population was 11,947; the forest cover was 6,960.6 hectares, accounting for 52.8% of the total land area. During the same period the *minimum flows* of the *Ruvuma River* were recorded at 50.2 *cusecs* indicating presence of requisite amount of water as the *minimum flows* were still high. There was greater likelihood for the presence of relatively high water levels during dry seasons, with much more water in the rain seasons. During the same period the impact of the human population on forest cover was less, therefore causing less impact on the *catchment value* of the river.

(b) By1988 the human population grew to reach 12,979 recording a growth of about 8.6%. During the same period, the amount of forest cover decreased by 608 hectares, i.e. a decrease of about 8.7%, while the *minimum flows* of the *Ruvuma River* were 45.5 *cusecs,* i.e. a reduction of about 4.7 *cusecs*. This was a significant drop in the volume of water that caused a significant fall in water levels during dry seasons.

(c) In 2002 the human population reached 19,446 people showing an increase of 49.8%. In the same period the forest cover had decreased by 851.2 hectares, resulting into the forest cover of only 24.2% in total. The *minimum flows* of the river ever recorded were 23.4 *cusecs*, marking another drastic drop in water volume of about 50% from that of 1988. The hydrological condition of the *Ruvuma* in

2000 indicated an alarming status. The decrease in *rainfall amount* and destruction of the catchment forest at the main watershed of the *Ruvuma* were attributed to the growing numbers of people.

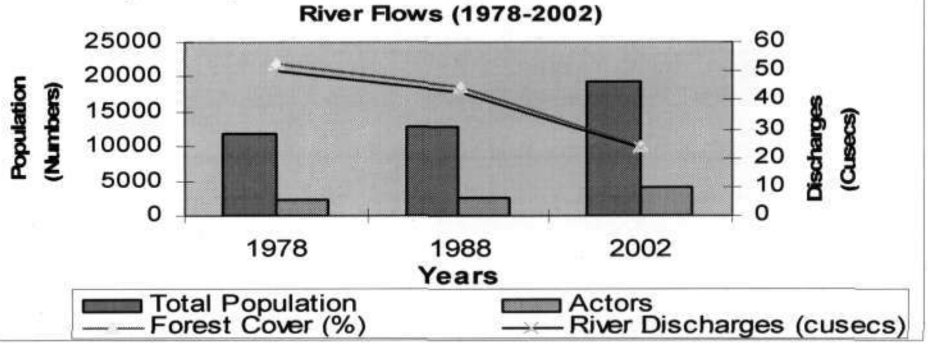
Based on the data and the above discussion, one may realize that for the entire period under review (whose data were available) the *discharges* of the *Ruvuma River* based on its *minimum flows* had dropped by 87% between 1974 and 2000. This state of affairs implies reduction in the volume of water and levels which have negative consequences to *aquatic* and *terrestrial* forms of life that depend on that river.

8.7.2.2 Trends in Population Size, Forest Cover and *Discharges* of the *Ruvuma River*

Figure 8.18 demonstrates that the increase in human population brought about an increase in the number of the *key actors* between 1978 and 2002. With the growth of human population, a decline was noted in terms of both forest cover and *discharges* of the *Ruvuma River* during the same period.

Thus the inverse relationship was noted between population growth and forest cover. The same relationship was noted between population growth and the decline in water *flows* or the river. The decline in *flows* could be explained in terms of the expansion of human activities in the source area of the river. It is our argument that human activities in the catchment area have been detrimental to both the forest cover and river *discharges*.

Figure 8.18
Population, Actors in Farm Expansion, Deforestation and River Flows (1978-2002)



Source: Population Censuses Reports 1981, 1990 and 2003; Field Survey 2005 and Songea River Basin Office, 2005

8.7.3 General Trends in Changes in Population Size, Forest Cover and other Environmental Conditions

The analysis of trends in changes in population size, forest cover and other environmental conditions, i.e. *rainfall amount* and *river discharges* was considered significant in understanding the existing relationships between the three variables. Population, being the 'driving force' for development activities, also became the driver for the processes that affected the environment. Changes in population characteristics, as reviewed in Chapter 7 played a major role in determining the nature and character of the forest cover. It was therefore important to underscore the relationship between the *trio* for sustainable management and control of the impact to the environment.

Forests are catchment areas for both rainfall and springs which form ideal sources of rivers. Human activities that took place in the catchment areas resulted into deforestation and consequent emerging scarcity of rainfall and reduction of water in springs and rivers. Sustainable mechanisms were to be sought through the inclusion of demographic analysis to determine the *key actors* in both deforestation and conservation activities. This was significant in redefining conservation efforts in order to enhance sustainability of its results.

Recent studies linked extensive deforestation with major *climatological* and *hydrological* changes, aspects that the thesis observed having a strong relationship (Wood and Baldwin, 1985). The consequences of forest cover change to human population of WMCA are covered in sections 8.8.

8.8 The Impact of Forest Cover Change to the Local Population

The process of deforestation had a reverse impact to the population of WMCA. The fact that deforestation was noted to cause shortage of firewood and wood poles augmented the difficulty in the task of obtaining them. The burden caused by deforestation was not the same to all household members. This derives from the fact that different household members played different roles in the process leading to deforestation based on their age and sex.

The implication was that some household members suffered more in respect to the direct effects of deforestation depending on their involvement in specific tasks that lead to deforestation. Others were affected more by the effects of the changes in tree cover on other natural phenomena like climatic change and the consequent impacts on water availability and other supply systems. The impact of deforestation to household members by their specific demographic characteristics is covered in sections 8.8.1, 8.8.2 and 8.8.3.

8.8.1 Forest Cover Change and Firewood Availability for Domestic Purposes

Survey results established that firewood collecting/cutting was the task performed mainly by females aged between 10 and 39. Taking into account the initial age, i.e. when one started joining the activity, it can be observed that the task made use of a form of 'child labour'. The local community's view on the engagement of children in such tasks like collecting firewood was described as 'induction' to the reality of life.

Young girls who took part in collecting firewood, like their elderly female counterparts, walked for long distances, which kept increasing with population size and time. This implies the expending of muscular energy that would, otherwise, be used for some other important productive work. Some of the children did not attend school since they participated in such socially important tasks that are important to the livelihoods.

8.8.2 Forest Cover Change to Firewood Availability for Baking Bricks

PRA results revealed that males, mainly those aged between 20 and 44 were found responsible for molding and baking bricks for building homesteads. With time, such firewood appropriate for the task was found dwindling in supplies. This led into the increased distances to obtain the same. In some instances, like the cases reported and observed at *Chemchem*, *Muungano* and *Lihwena* settlements, it was common for households to fell mango trees to obtain firewood for the burning bricks.

About 28% of the 548 active households in the activity of molding and baking bricks indicated that they cut mango trees for that purpose, translating into the reduction of fruits, an important source of Vitamin C which is crucial for health especially for children. The prevalence of diseases caused by deficiencies of vitamin C was likely be realized as there were a few, if any mango trees remaining in the area. The use of mango trees was, however, not a lasting solution to the shortage of firewood, rather the generation of other more profound problems.

8.8.3 The Impact of Forest Cover Change to Water Sources and the Water Collectors

It was noted that WMCA had experienced reduction in terms of *rainfall amount* and *erratic distribution* for the period between 1974 and 2004. Whether the changes in forest cover had brought about this state of affairs is an aspect that calls for a more specialized study. The observed decrease in *rainfall amount* and its *erratic distribution* culminated into the falling water levels in wells and rivers especially during the dry seasons. Thus the thesis assumed the logical causation regarding relationship of the *duo* because of this state of affairs.

The hydrology of the tributaries of the *Ruvuma River*, namely *Likonde River* and *Ruvuma River* indicated notable reductions in *discharges* for the period between 1974 and 2000. While the *discharges* of the *Likonde tributary* plummeted by 55% the *Ruvuma tributary* faced a decline of about 87%. *Aquatic* species, i.e. both *flora* and *fauna* were likely affected by such changes in *discharges* which affected *river regimes*. How much the changes in *river discharges* impacted on *biodiversity* of the area is another subject of research.

The observed reduction in *discharges* meant more work to women and children who had to cover long distances to fetch it. The observed decrease in temperature range, caused by a slow but a clearly steady rise in minimum temperatures by 1.6°C, an indication of climate change reflected in the increasing drought conditions and threat to *biodiversity*. This state was responsible for the dwindling crop output caused by emerging drought and the possible rise of new crop diseases. People of all age groups and sex categories were affected by famine, be it in neighbouring rural or urban areas.

Because water was directly drawn from wells or streams was associated with the prevalence of a wide range of waterborne diseases such as dysentery and diarrhea that affected local community members, mainly children was inevitable. The piped water supplied to some villages was reported to be untreated which had higher probabilities of disseminating diseases, in case the water was not boiled prior to drinking.

Since the majority of the household members had attained primary education, it deemed necessary to have in place a carefully planned intervention strategy, formulation of extension packages understandable to the lowly educated and/or the uneducated members of communities. The interventions should be formulated in a participatory manner and so that they are supported by the local communities.

Generally, it is argued that determining the *key actors* by their demographic characteristic is the most significant and effective way to deal with causes and impacts of deforestation. The fact remains that household members acted differently to natural environment and that they were affected differently by the impact of deforestation. This logically calls for specialized and more targeted conservation extension system that was noted to be missing. The introduction of such interventions is likely to bring about effectiveness and sustainability in future conservation endeavours.

8.9 Conclusion

The study established the differential involvement of household members in activities that lead to deforestation and forest conservation in WMCA by both sex and age groups. Levels of education could not indicate clearly its influence on individual's involvement in various activities that lead into deforestation. This was mainly due to dominance of people with low level of education, whose means of livelihood constituted farming, the main activity in the rural setting.

Variations were noted in terms of the proportions of *key actors* who played a major role in different activities that caused or contributed to deforestation. The *key actors* to deforestation process contributed differently through different activities that exacerbated deforestation. It is therefore inferred that there were different magnitudes of contribution to changes in vegetation cover which were linked to different activities carried out by different *key actors*. Although the impact of deforestation, affected the entire local communities, its 'burden' was felt more by some population sub-groups. The 'burden' was shifted to some specific age-based and sex-based population segments mainly by the socially assigned division of labour and specialization.

While males were beset with those activities that took a year or so to recur, like felling of trees for farm expansion or building of shelter, females and children were burdened with routine activities of collecting firewood and fetching water which devoted much of their productive and reproductive time and energy. Despite the cultural-based reasons given for the observed gender-based division of labour, with demographic characteristics embedded in it, there was a need for it to be uncovered to scientifically use the findings for the formulation of better planned and more effective conservation activities. The need to transform the old patriarchal vales which dehumanizes humankind, women and children in particular was important. It also entailed addressing the social complexity of such relations, which pose and threaten the environment. This is another area which requires to be investigated but lies beyond the scope of this study.

One may, at this juncture, note that the relationship between population, development and environment had some linkages to economic, technological, political and socio-cultural aspects of the community in question. Addressing issues of deforestation through promotion of conservation activities calls for a multidisciplinary or holistic approach in the conceptualization of planning (of the content, strategies and methods), implementation, intervention, monitoring and evaluation. Demographic characteristics of the *key actors* in a particular environmental activity have to be taken into account for more precise development of conservation strategies and the targeting of stakeholders who are expected to effectively be involved in conservation efforts.

CHAPTER NINE

DISCUSSION OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

9.1 Introduction

It has been a long tradition to associate population growth with environmental degradation, deforestation in particular (Harrison, 1992; Jiang *et al.*, 2005). The link between the two components has in most studies been described in general terms, based on the logical and apparent environmental consequences related to the growth in population size. The reality is that the *crux* of the linkages between population, development activities and environment is entrenched in the intrinsic causal relationship that exists between the *trio* components. Most of the literature termed the relationship to be both multidimensional and complex (IIASA, 2001; Lutz, *et al.*, 2002a; Lutz *et al.*, 2002b; Sherbinin, 2006).

A multidisciplinary, location-specific study that covers a considerable period of time, with the use of reliable time-line-data for the three components was vital in establishing PDE relationship of WMCA (UNCED, 1994; WCFSD, 1999). Data for the sub-components of the three PDE components was necessary for carrying out detailed analysis of the practical relationship. The analysis followed the line of causality and the identification of the *key actors*, based on analysis of the demographic characteristics of the household members who played a lead role in the selected activities classified to be deforestation-related.

The analysis of the PD and E components presented in Chapter 8 of the thesis provided the analytical tool and guidelines for a better and more focused explanations of the PDE relationship. While the analysis of quantitative data was used to determine the states and changes in volumes of variables of the PDE components, qualitative data provided detailed explanations on the rationale for such relationships and trends.

To achieve the study objectives, examination of the variability of human characteristics, their spatial impact over heterogeneous and the progressively changing physical, economic and socio-cultural environments; aspects that engendered the nature and character of the man-environment interface was necessary. Variations in such factors over space and time tended to limit generalizations of findings of such location-specific studies. This chapter is a summary of the major findings, discussion of the findings, policy recommendations and conclusions.

Despite the noted complexity on the subject matter, the thesis viewed the PDE relationship using a self adopted 'step by step' analytical framework to ascertain the causal and interactive relationship as novelty in the field. The study conceptualized population to be the 'driving factor' for various activities that meant expansion of socio-economic activities, which in turn exacerbated deforestation.

In the course of the analysis, the first step in the analysis was the understanding of how the population operated, during execution of economic activities in terms of who, what, how and how much. This was crucial in generating basic information on the linkages between the population and development components. The phase entailed the identification of the *key actors* in selected deforestation-related activities and quantification of the magnitude of activities; and the rationale behind their involvement.

The second step entailed the evaluation of the impact caused by the population (P) and development (D) and their changes over time. This reviewed the expansionist character of development activities necessitated by variations in population and the resulting negative effects on forest cover. This was, in fact, a step towards analyzing P and D from the outcome point of view which constituted another process, i.e. environmental degradation. *Mediating factors* that provided the 'potential' for processes to take place and more important, shaping the character of the process. This was the mechanisms and speed the population acted on development activities, which made their articulation in the analysis indispensable.

The third stage was that of looking at the interactive impact whereby changes in the P, the driving force, were studied along with, or as a result of changes in the other components, i.e. D and E. The fact that each of the PDE component was in the state of *flux* qualifies the PDE studies to be complex, both in nature and character.

9.2 Summary of Major Findings

The major findings were classified into general findings that directly address the main research question while specific findings based on the specific research questions.

9.2.1 General Findings

9.2.1.1 Involvement of Population in Deforestation-Related Activities

The thesis established that despite the alarming rate of deforestation observed in WMCA only a small proportion of the population was involved in activities related to deforestation.

The major activity that contributed to reduction of forest cover was conversion of forests into farms. Only a small proportion of the total households of the area, meaning about 15%, dealt with farm expansion. However, the proportion of the population that actually dealt with the activity was only 8% of the total household members.

It was, therefore, established that a positive relationship between population growth, farm expansion and forest cover decrease existed.

(a) Population and Farm Expansion

Despite the fact that the contribution of farm expansion to deforestation was enormous, i.e. about 1,135.4 hectares in 27 years, i.e. between 1978 and 2005, the proportion of the population that dealt with the activity was relatively small, i.e. only about 8%.

(b) Population and Firewood Collection

Firewood was noted being used in almost all the households, i.e. 98.1% of the households attributed to the overt absence of alternative energy sources and its ubiquitous nature that made it to be accessed free of charge at the expense of energy expended. The proportion of the population engaged in the actual firewood collection, for domestic energy, was only 22% of the total population. The area experienced less firewood business, implying that domestic firewood demand and brick baking accounted for more to the observed deforestation by the activity.

9.2.1.2 Population Characteristics and Involvement in Deforestation–Related Activities

It was noted that demographic characteristics, i.e. age structure and sex composition had significant influence on one's involvement in the specific deforestation-related activity.

(a) Age Structure, Sex Composition and Deforestation-Related Activities

While the activity of converting forests into farms was dominated by males, aged between 20 and 44, firewood cutting was mainly performed by females aged between 10 and 39. The involvement of *key actors* in deforestation-related activities was mainly influenced by customs and tradition, biological ability (muscular energy) that hinged on the deep-rooted traditional gender and sex-based division of labour and specialization.

(b) Children in Deforestation-Related Activities

Massive involvement of children in various livelihood activities was observed and noted. Cultural and or customs of inducting the young ones to livelihood activities were mentioned to be the reason behind this social phenomenon. The gender-based division of labour was part and parcel of the people's life systems; not just a mere product of economic system.

9.2.1.3 Population Migration and Deforestation-Related Activities

(a) In-migrants in Deforestation Related Activities

WMCA had most of the households indigenous of the area with only a few households, about 8 %, which were households that migrated into the area in the last three years. The in-migrants households, like the indigenous counterparts were predominantly involved in farming using the same methods and technologies applied by indigenous households. They, thus, brought no significant changes in production and in life systems.

(b) Out-migrants in Deforestation-Related Activities

Low volume of out-migration reported meant its less contribution to the reduction of the population pressure on land resources. The few out migrants constituted mainly young men who mainly went out to seek for employment. Their main destination was the neighbouring Songea Municipality. About 35% of offsprings moved out of their respective villages in WMCA, where most went to other villages, marking the predominance of *rural-rural migration.*

9.2.1.4 Involvement of Population in Conservation-Related Activities (Tree Planting)

(a) Households in Planting Trees

While the majority of the households, i.e. about 71% indicated that they had ever planted trees, the proportion of the *key actors* in the activity was only about 13% of the total households' total population. The limited involvement of some household members in tree planting could mainly be explained in terms of mainly based lack of motivation despite the acute firewood scarcity experienced in some villages.

(b) Age Structure, Sex Composition in Planting Trees

Age of an individual was found to relate to one's engagement in tree planting. The *key actors* in the activity were those aged between 20 and 59. However, it was not established whether one's age had any relationship with the number of trees planted, an aspect significant for conservation but constituted an area recommended for future research. The presence of many households that indicated to have planted trees was not reflected when it came to individual involvement in the activity.

9.2.2 Specific Findings on People's Involvement in Deforestation and Conservation

Specific findings demonstrating the P, D and E linkages in WMCA directly addressed the research questions the thesis had to probe. The findings observed are presented in sections 9.2.2.1 to 9.2.2.6 below.

9.2.2.1 There was relationship between population growth, expansion of development activities and deforestation.

Growth of human population brought about both, a relative increase in the numbers of the *key actors* and expansion of the cleared forest area signified by reduction in the forest cover. The decrease in forest area was mainly caused by farm expansion, motivated by the rise in demand for food and other forest products posed by population growth. It is argued that the observed applicable low level of agricultural technology could not facilitate intensification hence fuelling deforestation. Policies like SAPs and *globalization* made farmers more vulnerable, thus forcing them to revert to traditional farming practices that are detrimental to the forest cover. Trends in population growth and the concomitant increase in numbers of the *key actors* were factors directly linked to farm expansion and responsible for the decrease in forest cover.

9.2.2.2 Changes in population structure and composition caused changes in development or livelihood activities therefore augmented deforestation rate.

(a) Changes in Age Structure, Farm Expansion and Forest Deforestation

Changes in population structure tracked through the analysis of changes in the size of age groups of the *key actors*' population, occurred simultaneously with changes in farm expansion, therefore reducing the forest cover in spatial terms. The majority of actors who were in 'stability stage' were in the age group 20-44 years. These were more energetic and charged with the social responsibility of feeding and caring for their households. Those in 'exit stage' had already contributed to deforestation, hence were not intentionally a target to conservation initiatives.

(b) Changes in Sex Composition, Farm Expansion and Deforestation

Population composition indicated by sex ratios, portrayed positive relationship with farm expansion and culminated into the observed reduction in forest cover. The proportionate increase in numbers of males in the population impacted positively on the number of the *key actors*; thus aggravated the negative forest cover situation.

9.2.2.3 Changes in Age structure, Sex Composition and Impact of Livelihood Activities.

It was noted that changes in age structure and sex composition, did not bring about a proportionate change in development/livelihood activities and forest cover. Despite the observed quantitative relationship between population, development and environment; it was noted that the variation in one component did not bring about a proportionate variation in another. This implies that the relationships were more complex than a mere arithmetical relationship, therefore calling for a more detailed research devoted in explaining the causes of such quantitative behaviours in order to determine the linkages in a more inclusive manner.

9.2.2.4 Magnitudes of Changes in population size, structure and composition in the period under review.

It was observed that changes in population size, structure and composition were not uniform for all period under review. Different magnitudes of changes were noted from one year under review to another, indicating the presence of other factors that came into play that explain the PDE phenomena. The difference in variation of population size, age structure and sex composition, related to development sub-components and forest cover changes, could be explained best in terms of the types and changes of the mediating factors. *Mediating factors* influenced the mode of operation, i.e. type of activities, pace of their expansion and their variations over space and time, therefore affecting the environment the observed manner.

9.2.2.5 Education and Involvement in Deforestation and Conservation-Related Activities

Levels of education displayed little influence to one's involvement in selected activities linked to deforestation and/or conservation. However, the dominance of people with primary education or lower made it impossible to disaggregate the people's differential involvement in selected activities by levels of education. What is clear is that levels of education slightly impacted on *rural-urban migration*; in which those with low levels of education remained in villages since they had no other alternative than dealing with primary activities which were noted to be detrimental to the forest cover. Those few youths who attended secondary education or higher were employed somewhere else within urban centres, thus reducing pressure on the land resources.

9.2.2.6 Mediating Factors Observed at Play in WMCA

Mediating factors impacted on decisions that affected the rate of deforestation and/or conservation. Such factors included policies, i.e. regional, national and international policies namely *Mlale* Resolution, *Ujamaa*, *Nguvu Kazi* and SAPs and globalization. Other mediating factors were economic conditions (signified by income), social services and low level of development of civil society signaling lack of local initiatives to development, hence culminated into deforestation.

The concrete situations where population, development and environment interact operated under the 'dictatorship' of the factors that covered the entire population but were directly linked by the *key actors* in a specific selected deforestation-related activity. Thus, the population impacted on the environment of the specific areas of operations in different nature and character.

9.3 Discussion of the Findings

9.3.1 Existing Relationship between Population, Development and Environment

The thesis established a strong causation relationship between population growth and development activities that impacted on the forest cover. Changes in human population size brought about changes in the environment that took place through expansion of development and/or livelihood activities, particularly conversion of forests into farms and felling trees to obtain firewood.

Growth in human population was responsible for the increased demand of food and other vegetation resources. Other studies observed similar findings (Jiang *et al.,* 2005; Teri and UNFPA, 2004). The thesis observed the dual impact of growth of human population, i.e. on one hand, expansion of farms and other forms of land use, while on the other hand, reduction in the forest cover. The two noted resultant processes were a product of one demographic process, i.e. population growth but with some internal variations engendered in sex composition and age structure. The thesis considered the variations as the internal dynamics of the population, similar studies did not include in the analysis.

The relationship between population, development and forest cover change was, however, observed as not being 'one to one'; meaning that the increase in population size did not bring about a proportionate increase in forest cover depletion. Differences in percentage change, in the three components within specific periods, tended to justify the point. This gave birth to the understanding that there were other factors that instigated people to clear the forest for more farms in the manner and magnitude they did than just a single factor of population growth. It specifically implies that not every time population increases necessitated a similar increase, if any, in forest cover depletion, even if that was the case, but not of the same proportion.

We established existence of differential involvement in development activities based on sex categories and age groups of those household members who actually participated in the selected development/livelihood activities. Customs and traditions, used to explain the phenomena, required a deep investigation to establish the manner they were instrumental in influencing people's decisions of environmental significance. The sex based differential involvement in development activities leading to deforestation hinged on cultural reasons, while age-based division of labour was a product of biological and/or physical capability and/or incapability of members of some age groups to carry out specified development and/or livelihood activities. Socio-cultural reasons were part of it. Household members in extremely low and old age groups generally did not constitute *key actors* for the same reasons.

Forest extension service normally covered only those aged between 18 and 50 in which the targeting was broad and not specific. It is a fact that WMCA's youth population, who were the majority of the *key actors* remained out of the scope of the extension service. Young men aged between 0 and 17 were left out by the extension service, while those in old age, i.e. 45 and above, and the 'exited' were still targeted.

While some studies argued for transformation of gender relations for equitable development, the thesis concurs with that view and that such transformation should not be too radical and interruptive to local communities (Mbilinyi, 1997). The transformation of gender relations was a long term process whose results would take a long time. We are of the opinion that the adoption of the targeting of *key actors* in conservation is likely to be more sustainable as it was embedded within the socio-cultural and economic systems of a particular community in question. The thesis, however, was not aimed at pre-empting the pursuit towards gender balance.

The analysis focused on the conventional active age group, i.e. those young men aged between 15 and 24 rather than carrying out analysis of the actual *key actors* for the activity in the specific area was broad and target less. This is what made us to adopt a more realistic situational analysis leading to the possibility of projecting the potential for future expansion of both livelihood activities and deforestation. This should be undertaken not only by considering population size, but also age structure and sex composition. Whenever possible, levels of education be included in the analysis though in this case its influence was insignificant. This kind of knowledge was considered vital for the formulation of sustainable conservation efforts.

Observations show that the relationship between population and development is basic in the understanding of the PDE linkages. The *key actors* were the *crux* of the relationship between population and development. These were individuals who would act rationally or irrationally when trying to meet respective household demands based on the concrete economic, social, political and environmental conditions. The *key actors* are an active factor in forging PDE linkages.

The *key actors* were 'men on the spot'. They were located between the total population and livelihood/development activities, thus at the same time and by the very same process affect the environment. How and how much they linked, where, why were the issues that determined the location and magnitude of the impact they caused to the environment were important aspects that required explaining. However, the fact is that environment, as well, played role in influencing the nature and character of the linkage. Logic dictates that one would make informed choices and decisions according to the surrounding environment.

More concrete descriptions on PDE relationship were developed after having identified the *key actors* and involved them in the analysis. Knowledge, skills and experiences accumulated would offer a pragmatic stand point in the analysis. Unfolding of their significance, was therefore, a vital contribution. The reality remains that the *key actors* could not be targeted as they were not only unknown, but also ways to identify them and their significance were diffuse.

Changes in population size, age structure and sex composition, implicated in determining characteristics and size of the *key actors*' segment, changed pace of development and/or livelihood activities for the periods under review, i.e. 1978-2005. Their variations, especially the increase in numbers most of the time was reflected in terms of the increase in clearing of extra forest cover mainly for farming.

Differences in proportions of changes in population characteristics, volume of development activities and degree of forest cover change over different years indicated that the decisions for a person to fell a tree was reached after a combination of factors acted together in a specific time. Factors that necessitated farm expansion included availability of forest land for expansion, soil fertility depletion, diet and/or eating habits, nature of the crop grown, household's economic condition and the political environment of the specified area and time. If examined closely, the factors were broader than just mere population or demographic issues. However, it was the *key actors*, who in the final analysis interpreted the combination of these factors and translated it into the actual activities which by their nature and character culminated into deforestation.

The finding that the 'entry' age of a large number of potential actors into the segment of those who dealt with farm expansion was low, i.e. 8 years, was likely to bourgeon and hence bring about an upsurge in farm areas while at the same times and by the very process, contributed to a decrease in forest cover. As the 'stability stage' had a longer span, i.e. aged 20 to 44, characterized by more mature and physically energetic individual, the impact they caused to development activities and forest cover change was enormous. The small span of exit age group, i.e. 45 years and above tended to indicate less contribution to both development and deforestation. These were those in retirement age who it can be agreed worked only for their survival.

The *key actors* were socially, economically and sometimes politically compelled to raise farm output that could be done, using affordable levels of technologies, i.e. hand hoes and axes. Conversion of extra forest lands into farms was a precondition for one to become self reliant in the feeding of their newly established families. This social fact had different impacts to human settlements with or without *public forest*, i.e. leading into expansion of farms, thus causing deforestation. In areas with no public forests it brought about land fragmentation. Reduction of household farm plots resulted from traditional practices of allocating part of household land to male children, especially at the age of 17 and above. This was detrimental to the household's production capacity, an aspect that demanded adoption of intensive farming methods which would not be practiced given existing socio-cultural environment.

The observed relationship that existed between changes in age structure and sex composition in one hand; and changes in forest cover on the other, was principally propelled by changes in the pace and volume of livelihood activities motivated by the demographic characteristics. More important was the population size, age and sex composition of the *key actors*; and the context in which they operated. Having noted that the *key actors* in the activity of farm expansion were males, aged between 20 and 44, variations in numbers of people in the age group impacted on the pace at which extra farms were cleared. PRA results indicated that young men were more notorious in engaging in activities that triggered the forest cover reduction for their urge to achieve 'economic development'. Thus having a larger proportion of young men meant having greater likelihood for more deforestation.

Trends in population growth can be closely associated with trends in changes in forest cover and to the consequent observed variations in *river discharges* and *rainfall amount*. It is imperative arguing that the destruction of forest cover influenced changes in *rainfall amount* and its *distribution*. Moreover, the destruction of catchment forests was detrimental to the *catchment value* of WMCA resulting into a decrease in *discharges* of rivers that originated from the affected catchment area (Jiang *et al.,* 2004; Liu *et al.,* 2000).

Periodic variations in population size were observed to correspond to changes in forest cover, and *river discharges* and to some extent *rainfall amount* for the specific period under review. The comparative analysis of the three components, i.e. Population, Development and Environment indicated that population growth resulted into a negative and declining status of the forest cover. More important was the fact that levels of changes in forest cover were 'cumulative' with more severe and progressive impacts observed with increasing time.

Agriculture, the main economic activity, contributed substantially to forest cover change. The existence of differences in rates of population growth and forest cover change does not imply that population growth was the only factor for such changes. Differential changes observed in different years, with different rates of population growth called for the need for other studies.

Relocation of Tanzanian rural population in 1970s had a remarkable contribution to the observed deforestation. Relocated households were allocated forest land areas to clear for farming and construction of homesteads. Population pressure caused by clustering of people in *Ujamaa* villages increased demand for other forest products like firewood and building poles, therefore contributing massively to reduction in the forest cover. This was an impact resulting from national level political decisions that did not take into consideration environmental consequences (Madulu, 1991a; Madulu, 2001b).

The same socialist-oriented relocation policies put in place subsidies to farm inputs, therefore enabling adoption of more intensive farming methods. Intensification made human population more sedentary, thus reducing negative impact to the forest cover. Subsidized fertilizers reduced likelihood to expand farms, therefore enhancing the forest cover status.

The Structural Adjustment Programmes (SAPs) era of the 1980s brought about, among other things, the *cost sharing component* and waver of farm inputs subsidies. The farm inputs were sold at market price that made farmers fail to afford. Various coping strategies ranging from the practice of extensive farming methods of *slash and burn* or *shifting cultivation* to reduce the recommended fertilizer quantities, thus compromising crop output *per* unit plot of land (Kashuliza and Mbiha, 1995). The period experienced less agricultural and forest extension service coverage giving room for rampant deforestation witnessing massive invasion in forests and forest reserves.

The fact that forests are of great significance to humankind cannot be contested. The thesis revealed both direct and indirect effects of the shrinking of forest cover over the period under review. The observed reduction of the firewood supplies was directly linked to depletion of the forests signified by the progressive dwindling tree cover and long distances to firewood sources. Firewood collection consumed precious time, of women and children, which could have spent to perform other productive activities. Studies done elsewhere indicated the same trends (Mbilinyi, 1997; Aina and Odebiyi, 1998).

The impact of forest cover was linked to the observed decrease in *rainfall amount* and the consequent reduction of the *water flows* in rivers. PRA results and field observations revealed declines in both forest cover and *rainfall amount*. The same was proven when climatic data were analyzed. Parallel declines in *rainfall amount* were observed between 1978, 1988, 2002 and 2004.

The *discharges* of the *Ruvuma River*, whose head-waters originate from WMCA, indicated a steady decline from 1970s. Explanations given included reduction of the *catchment value* that resulted from upstream human activities, especially farming. Whether changes in vegetation cover in the area brought about such impacts or an impact of broader environmental changes is an aspect recommended for other studies.

9.3.2 Linking Components of Population, Development and Environment

The population of WMCA was basically agrarian which maintained its livelihood through the local resource base, i.e. soil, water, firewood, wild animals and others. The dependable resource base, i.e. forested lands was affected by human activities mainly extensive crop cultivation, firewood use and expansion of human settlements. Population growth played a significant role in rising demand of the land resources needed to cater for the extra human population. Population pressure brought about negative impact to the basic services that nature provides i.e. reduction of *rainfall amount* and *river discharges*; and thus possibly culminated into *biodiversity loss* due to *habitat loss*.

The discussions in Chapter 8 revealed that population does not interact with the environment as a unit. It does so in its disaggregated manner, meaning that people of different age groups played different roles in activities that culminate into deforestation. Establishing the nature and character of relationship of the PD and E was the focus of Chapter 8. Despite the broad agreement on the complexity of studies aimed at describing the existing link between the three components, the thesis took the challenge and calls for more detailed studies. From sections 9.3.2.1 to 9.3.2.2, the thesis discusses the nature and character of the PDE linkages. The thesis emphasizes the understanding of the nature and character of linkages between PD and E, as an essential step for the development of future sustainable conservation packages.

9.3.2.1 Nature of PDE Linkages Manifested in WMCA

The thesis underscores that the interface between population, development and environment hinges on the population's demands for achieving its development and/or livelihood. It is natural and necessary for human population to use the surrounding and remote resources for its development and/or livelihood. The thesis located livelihood and economic activities as the second part of the equation, that sounded more profound as no livelihood or development took place devoid of resource use. Whether such resources would suffice the demand of the population in the long run, would depend on the rate at which they were consumed and/or how they got replaced. For renewable resources, like forest cover, the duration taken to regenerate, compared to the depletion rate, constitute the key determinant variable of resource sustainability. This is considered to be the essence of sustainable resource utilization.

The role of the population size, variation in the sex composition and age structure of the *key actors* in activities contributing to deforestation, in this context expansion of farms, and the ubiquitous use of firewood were critical variables in determining the pace of the uptake and replacement of the vegetation cover. The thesis underscores the fact that the *key actors,* by age groups and sex composition; and the applicable *mediating factors*, constituted an important component in describing the linkage between population, development and environment.

It is argued that not the whole population that matters when considering the direct interface with natural resources. The reality was that not the whole population would directly interact with the environment in the same way and at the same pace. However, one does not necessarily have to rule out the possibility that population increase does not lead into an increase in resource demand. Therefore it may, sometimes, result into a decrease in resource use, thus affecting the environment to a lesser extent. Neither does it mean that the *key actors* in the specified activities act only to meet their own demand; and not that of the household and/or of the community as a whole, while concurrently contributing into deforestation.

The thesis asserts that under the hypothetical situation, where a population with majority of those aged 10 and below like that with people aged 55 and above, with similar socio-economic and political circumstances to the one which prevailed in WMCA, would cause little or negligible impact to the environment regarding forest cover change. Lack of enough muscular capability for manning such difficult task among both the very young (children) and the aged was the main reason for less engagement hence caused the less impact. While the majority of the aged people did not play a major role in deforestation-related activities for 'self actualization', i.e. having accomplished the same at younger ages, the younger ones (children) were set to get involved in such activities at certain in future, i.e. 'entry age'.

Differences were noted from one activity to another in respect to demographic characteristics of the *key actors*. The *key actors* in converting forests into farmlands differed from those who dealt with felling trees for firewood in terms of both sex and age groups. Those who dealt with moulding of baked bricks were mainly men aged between 19 and 40. They were the ones at young age, ready to marry and establish own families. The variability of the *key actors* demanded understanding of their demographic characteristics in order to address the "right target group" when planning and implementation of conservation activities. A more *holistic* method that targets specific actors was found to be necessary for enhancement of sustainability of both development and conservation endeavours.

The fact is that farming was the major activity of the area and that it was instrumental in providing the households with food supplies and income. The *smallholder farming*, was more of 'part of life', i.e. not just a mere 'economic system'. *Smallholder farming* utilized free household labour which was normally not counted as part of the cost of production. The time taken for clearing the forest for a new farm, cultivation, harvesting and transporting the crops to the homesteads were rarely counted as production costs of the produced crops. Similar situation was noted for other livelihood activities like collecting firewood, construction of homestead and fetching water.

Understanding details of production systems and the division of labour, based on demographic characteristics throws light on the existing relationship between population and development systems and enhances specificity in the planning of future sustainable forest conservation efforts. PRA findings were vital for rationalization of the processes and the consequent impact. Environmental, population and development issues need to be dealt with from the local community's respective rather than basing on external research data, methodologies and interpretations. Field studies are therefore hereby, highly recommended.

9.3.2.2 Character of PDE Linkages as Manifested in WMCA

The relationship between population, development and deforestation was observed being driven by the human population through raising the demand for resources meant to meet livelihood and development needs. The demands and means towards meeting such demands was cultural based but with a demographic dimension emerging with a particular link to the age based and sex based division of labour.

The main observation, at this point is that development and/or livelihood initiatives tended to lag behind as traditional economies dominated the economic and social activities. This manifested in terms of low levels of farm technology observed *vide* less use of modern farm inputs and the dominant use of a hand hoe. Under such circumstances, the practice of *shifting cultivation* and its consequent extensive clearing of forest cover could not be totally avoided. Because of this, it is strongly argued that development initiatives lagged behind technological and market situations.

Changes in policies, i.e. both internal and external proved vulnerable to farmers and were detrimental to the existence of forest cover. This was basically an impact of the dominance of the 'top down' policies. The market-oriented economic conditions imposed to the small scale farmers limited the existence of *smallholder* as production conditions could not persistently sustain the system and the environment. Food shortages associated with low productivity as a result of drought, constitute a cycle that proved difficult for a normal farmer to break through, hence perpetuating poverty.

Physical isolation of the population of WMCA, in terms of transport and communication, made forest cover to experience less 'external impact'. This was with regard to limiting resource demand for firewood, charcoal and area for human settlement expansion. A few people migrated to remote villages of *Mpingi* and *Kikunja* for lack of reliable transport, which made them isolated. Limited interactions with external communities, especially the urban centre, caused relatively less resource utilization implying less deforestation. The observed vegetation cover decrease, in the two villages, was mainly associated with internal resource demand.

It is reiterated that the effects of population change could be studied in a more effective way in villages with little interaction with other areas, especially urban areas that may raise demand for resources outweighing the local consumption rate. However, in reality, there exists no such a community that is totally isolated from external influence. Resource inventories and their endowment statistics would help in the analysis regarding population, development and resource use.

The low levels of education that characterized population of WMCA signified by low school enrollment and fewer people who attained secondary education, made most of the population remain in the same rural setting. This aspect raised the potential for deforestation, which was exacerbated by the current *globalization* policies. The mobility of the population goes with skills and knowledge. Those members with little or no skills, i.e. those with little or without academic or professional qualifications tend to remain in their places of origin causing pressure to natural resources (Claeson and Egero, 1972). Low levels of education increased chances for *high fertility* as a consequence of the failure of family planning campaigns attributed to higher levels of ignorance.

Dependency on the government for obtaining the supply of various social services and even for conservation of the environment was a stumbling block for local communities in WMCA. Under such circumstances, local communities lacked of 'sense of ownership' of the natural resources. Thus little could be achieved in terms of sustainable conservation. When responding to the question on their views about population change, development activities and environment, a significant proportion of the respondents, i.e. 45% indicated that drought and deforestation was caused by weather.

Legacies of old socialist policies may blame for the peoples' overt dependency the central government whereby every aspect of life was centrally decided and that it was the task of the government not individuals to address it. The respondents called for the government to intervene on the deforestation which they caused. The observed absence of NGOs and CBOs for community development and conservation substantiates the same. This state demonstrated lack of local initiatives in promoting conservation and sustainable development activities.

PRA results indicated presence of high expectations among inhabitants of WMCA for government service delivery, but little was forthcoming. The area had poor transport, insufficient health services and inadequate water supply systems. While the forest cover was mainly changed by locality-based factors, the solutions were expected to be obtained from 'external' initiatives.' Such interventions were from the government-financed agricultural and forest extension services which disseminated 'ready-made extension packages' through the 'preset intervention methods' and pre determined timings. This was considered to be one among the reasons for the ineffectiveness and failure of past conservation initiatives. We thus urge for internal village-based solutions that would likely embrace some elements of sustainability.

Though population was closely associated with the growing demand for forest products and food that necessitated farm expansion, it was noted that the proportions of the population that dealt with such activities like farm expansion was small. This demanded for directing of extension services to the identified *key actors* for enhancement of effective local participation. This would decrease the budget for extension service and duration of its dissemination. The 'tailor-made extension packages' are hereby recommended as they address a specific locality and are likely to bring about more effective conservation results.

The *broad and target-less extension service*, that address the entire village population as a homogeneous unit, instead of the *key actors,* i.e. those aged between 18 and 55 is likely to miss the target and probably become a mere wastage. There was a considerable body of evidence that local participation, as it takes into account the stakeholders' interests, reduces cost, and guarantees sustainability obtained through empowerment of local communities (Green, 2000; Blomey and Ramadhani, 2005; Scherr *et al.,* 2004).

9.3.3 Complexity of the Link between PDE Elements

Literature on studies that were concerned with the linkages between population, development and environment conceded on the complexity they engender (IIASA, 2001; Lutz, *et al.,* 2002a; Lutz *et al.,* 2002b; Jiang *et al.,* 2005; Sherbinin, 2006). However, the complexity concurred in such studies stood as a challenge for more efforts and concentration by applying different methodologies and analytical frameworks.

The study on the PDE situation in WMCA was not devoid of noting such complicated relationships. We reiterate that correlation analysis alone (basing on numbers) was not enough to explain the existing relationships among variables, therefore the necessity for inclusion of qualitative analysis. It demanded for more detailed 'causes and effects analysis' of deforestation. While simple statistical comparisons gave an insight in the relationship, the PRA results enriched the findings with detailed clarifications about the mechanisms and reasons for such statistical relationships. The complex nature of the PDE situation observed and noted in the study area is discussed from section 9.3.3.1 to 9.3.3.5.

9.3.3.1 Multidisciplinary Nature of the PDE Studies.

The biggest challenge encountered while forging the linkages between population, development and environment was finding the association between quantitative elements of PD and E components and their variations in terms of size and trends that were based on a broad range of issues originating from different disciplines. Such disciplines included demography, development studies, agriculture, forestry, geography, ecology, and hydrology.

Complexity in understanding and consequently explaining the linkage between PD and E was observed after drawing together a variety of data from different disciplines and analyze them together in the *time-line comparison basis*. The reasonably valid and reliable piece of information for practical use in enhancing future conservation methods was then generated.

Since enough reliable data were available for the study, time variations of data were studied and the time series trends indicated existence of relationships between the PD and E elements. The notable fact was that the PDE elements varied with time. Whether given the same conditions, the observed proportionate variations of the same PDE elements would be replicated was an aspect beyond the scope of the thesis, hence it is recommended for further research.

The tailoring of technical knowledge and experiences of the local communities is considered a necessary input and unique to the thesis aimed to establishing the linkages between population, development and environment. It was evident that the volume of data, its diverse types of processing called for the adoption of diverse methods of analysis, a critical step for the linking of the PD and E components. The components were formulated and linked for the fabrication of new body of knowledge on the detailed PDE linkages.

9.3.3.2 Spatial Variability of the PDE Elements

Although WMCA is a relatively small area, covering about 155.2 km^2, it had diverse environmental conditions in specific villages. Different Agro-Ecological Zones (AEZs) were identified and recorded in different sections of WMCA. Having different AEZs implies the possibility for the variations in PDE relationships in case a more location-specific, i.e. village-based study was conducted. The question of the size of a 'small area' for a 'location-specific study' was found problematic, thus constituting another area of complexity. The four AEZs of WMCA and their characteristics are presented in Table 9.1.

TABLE 9.1 AGRO ECOLOGICAL ZONES OF WMCA

NAME of AEZ	ALTITUDE (m. asl)	NATURAL VEGETATION TYPE	VILLAGES	CROPS/ANIMALS
Lowlands	700-850	Scattered vegetation (Open woodland) Kikuyu and Elephant grass	Lihwena Muungano Kikunja	Rice, Maize, fingure millet, cassava, sweet potatoes, vegetables, cows, goats, tobacco, tomatoes and simsim
Intermediate /Slopes	850-1000	Thick forest with planted exotic species	Lipaya Mpingi	Vegetables, maize, tobacco, banana
Highland	1000-1400	Closed woodland Short grass	Ndilima Litembo Mahilo Chemchem	Maize, coffee, banana, Goats, cows, pigs
Summit	Above 1400	Forest plantation Thick forest	Staff quarters for WMCFR	Not allowed

Source: Field Survey/PRA 2005

The division of AEZs was in reality not as sharp as described in the text. However the difference in the types of vegetation and human activities tended to give a rough picture of a diffuse change across the four AEZs. Encroachments in the forest reserves affected the lower sections more, especially areas bordering the forest reserve mainly for shortage of resources and absence of *buffer zones*. The 'summit' was around *Ndilima Litembo* village, situated on the higher altitude of above 1400 m above sea level.

The variation of local conditions within WMCA, in terms of space was one of the greatest challenges that posed complexity in the establishment of the existing relationship between population, development and environment. The fact that villages from all the four AEZs were part of the study brings together representative information and data from all four different zones, therefore providing a reliable interpretation and reporting for the entire area.

9.3.3.4 Time as a Factor for Changes in PDE Factors

The findings of the thesis clearly indicated changes in all the three PDE components for the study years under review. Changes in population size were monitored and noted through time and recorded in terms of numbers of people and the percentage change. Observed changes in age structure were also recorded based on population census data. The observed variations in age groups of the *key actors* in activities related to cause deforestation were significant in the analysis of the PDE linkages. Changes in sex composition were analyzed based on the variations in sex ratios during the same period(s).

The Development Component constituted the main economic and/or livelihood activities carried out in the area from 1974 to 2005 that indicated expanding over time. Expansion of such activities like farming, firewood use and human settlements were physically and/or statistically observed. Expansion of farming activities was monitored through spatial expansion of farm lands expressed in hectares and percentage increase.

The impact of the expansion of human settlements was inferred through the analysis of the households' involvement in molding and use of baked bricks for homestead construction. It is important mentioning that by the time of the study, none of the villages was surveyed, thus making it impossible to determine the original settlement size. The *time-line spatial expansion* of the village both in square units and percentage could not be determined. The more reliable total estimated land cover reduction was obtained through satellite imagery which combined the impact of all the human economic activities and settlement expansion. This was the basis for their being, in the final analysis, treated together.

9.3.3.5 Inherent Changes in Population, Development and Environment (PDE)

Elements of change are engendered within each of the three PDE components. The variability in the three PDE factors complicated the situation and its analysis. With population change other factors that constitute development and environmental processes and/or livelihood activities were noted to have changed in quantitatively. The same applies to a change in development and/or environment which affected the population through imposing difficulty in obtaining the services due to the dwindling natural forests. It affects all procedures and reproductive systems, thus threatening human life. Qualitative information obtained through *participatory discussions* and *field observation* indicated that increased distance to firewood sources, augmented scarcity of water coupled with the rise in number of people was made worse by water borne diseases.

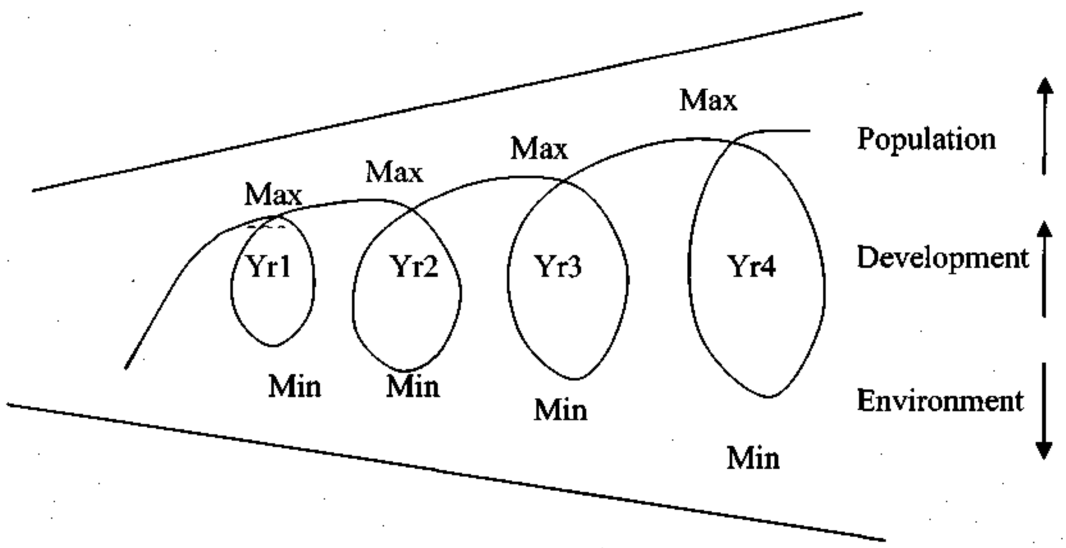
The fact that the PDE factors were studies in 'spot analysis', i.e. by specific years, i.e. 1978, 1988, 2002 and 2005) and by 'parallel dimension', i.e. in series; lead into logical and reliable conclusions pertinent to the PDE relationship. Estimated degree of deforestation was determined based on vegetation cover change for 1978, 1988, 2002 and 2005 obtained by GIS technique. Results were analyzed along with population data of the same period to determine the existing association and linkages. This was a critical step towards linking data series for the years under review.

One may not easily suggest the *optimum time* for the impact of population on environment to start being noted as it may vary for various socio-economic and geographical reasons. This is another avenue recommended for future researches. The inclusion of data and processes on the associated geographic phenomena namely *river discharges* and *climatic change* provided more empirical information on the impact of effects of deforestation, hereby termed anthropogenic, therefore unveiling founded grounds in underscoring the PDE linkages.

Two facts were underscored at this point. One was that the impact of today's population is not necessarily felt by the contemporary population. Second was the fact that the impact of human activities taking place at one point might not necessarily affect the *in situ* population, neither the population elsewhere alone. From this stand point, it is implied that the question of sustainability of the environment should not only be conceived basing on the population *in situ* but rather for the totality of the generations of population that affected the area, i.e. the past causal factors that acted on the environment at one point in time and the current population.

This also implied that the causality 'chain' of population, development and environment had the active population, i.e. characterized by the 'spiral' of population growth, changes in people's roles, i.e. 'entry' for the young, 'stability' for the middle aged and 'decline to exit' for the old ones. 'Exit' can be attained by establishing new household, migration or death. The 'spiral' changes were necessitated by engagement in socio-economic activities influenced by *mediating factors*. *Mediating factors* determined roles and household members' involvement in the activities by sex and age groups. As population increased, it increased the proportion of the *key actors* and culminated into deforestation. The cumulative impact of changes in population characteristics on forest cover change and to the consequent observed climatic and hydrological impacts were inevitable. Figure 9.1 portrays the PDE scenario observed in WMCA. The up-arrows show the increase, the down-arrow indicates the decrease, thus signifying deforestation.

Figure 9.1 The PDE Spiral for West Matogoro Catchment Area



Source: Field Survey, 2005

9.3.4 Significance of Understanding the PDE Relationship in a Specific Locality

The understanding of the PDE relationship, as observed through findings of the thesis, was an issue of great significance to WMCA and other rural areas with similar socio-economic, demographic and geographical situation. The findings are of practical application in the development of conservation packages since they are directed to the right group of actors and they prompt for greater effectiveness and sustainability in terms of extension packages' formulation and dissemination.

To the rural communities, factors like population increase resulted into clearing of more forest areas would not make much sense as it sounds too logical, truism and conclusive. However, the fact that the effects of such activities were detrimental to their livelihoods needed to be effectively communicated to the *right target group*. Extension packages should include some local evidences of the negative impact of deforestation to bring about more concern, thus making them engage in conservation activities. Knowledge of the 'active members', obtained through PRA, identified by their significant engagement in activities was to be tailored in conservation planning and to enhance the targeting of the same active population segment for future sustainable conservation initiatives.

Identification of different *key actors* in different selected deforestation-related activities would enable for the focusing of the extension packages and targeting of the right 'active population group'. This includes selection of the content of extension packages, methods and scheduling of the timing of delivery of such conservation packages. Avoiding the 'blanket packages' normally delivered at public village meetings was considered a necessary stage for adoption of more precise conservation extension packages with a much higher possibility of achieving positive results, which would hopefully enhance sustainability.

The fact that between 1974 and 2000 *river discharges* of the *Ruvuma River* decreased by 87%, i.e. from 88 in 1974 to 11.3 *cusecs* in 2000, provide more tangible reasons for the need for of more sustainable conservation initiatives to save the river from drying out. The already observed declining trends in *rainfall amount* and its *unreliable distribution* stood as basic reasons necessitating seeking of effective and lasting solutions to environmental problems based on research findings that advocate for engagement of local communities in conservation initiatives.

The finding that changes in population characteristics was associated with changes in development activities and environment could be of more significance as the *key actors* in the activities were known to have changed in numbers and were overtly reflected in the effects. The role of other factors like presence or absence of potential forest areas, for farm expansion, is of critical importance in the analysis of the PDE relationship. In areas with no such possibility of expansion of human activities into the forest land, intensification was the logical option especially to those households with enough income to purchase farm inputs. WMCA experienced the opposite, i.e. low incomes with less agricultural intensification that augmented poaching and encroachment of the forest reserve. Crop output tended to decrease with time.

The dwindling of farm plots due to growth in population was observed at household level, especially in areas with no forest areas for farm expansion. *Land fragmentation* took place as young male children aged 17 were given portions of plots of lands from their from parents' land. This impacted on reduction in production levels as a piece of land had a maximum level of crop output. As new more households emerged from the original household, the farms tended to decrease in size, which threatened production levels and households' livelihood and development.

From the above, one may strongly argue that the differential participation in various activities that lead into deforestation was based on sex and age groups. These findings would practically be used to project the rate of future deforestation by studying the human population growth, variation in sex composition and age structure of the population in question. The thesis generated data and information that could be effectively used for planning environmental conservation strategies, more focused implementation methods and the requisite evaluation methods/techniques.

9.4 Significant Lessons Learned through Field Experience

Many lessons were learnt from the field research that ranged from the significance of adherence to ethical issues to the practical aspects of data collection. The lessons included paucity of data clustered at village level. Despite the generally advocacy for location specific PDE studies focused on small areas, most of the population data, especially for developing countries like Tanzania, are limited to regional or districts levels. Village or street level data can only be extracted from national data sets.

Worse was the fact that village and street settings in place did not conform to the censuses enumeration zones in all censuses. Some of the villages were non-existent in previous censuses. Hence it was not possible to observe the comparative trends in population growth for specific villages other than for the entire WMCA in different times so as to meet the study objective of establishing the dynamics of human population, development and deforestation.

Selection of Research Assistants (RAs) hailing from the Study Area was critical as it waived the *communication barrier*, especially language and it eased socialization and acceptability of the RAs by the local communities.

The rural communities of WMCA indicated the significance of receiving feed back on research findings. The communities provided ample cooperation to a researcher as an effort towards solving the existing problems. They demanded that an action plan on environmental conservation be developed for practical problem solving. Sending feedback is considered significant for future research endeavours.

Participant observation was an important part of the learning process, an aspect that required extra time and extra financial resources. It included attending burial ceremonies, celebrations and even taking the sick to the hospital. This was significant in cementing relationship between the research team and local communities that enhanced data collection. It is implicit that the contingency or miscellaneous item in the research budget be in place.

9.5 Theoretical Reflections

Most literature classifies human activities or development or livelihood activities as critical in causing environmental degradation. The thesis vividly found the same in the context of forest cover change within WMCA for the years under review, i.e. 1978, 1988, 2002 and 2005. Therefore we concur with the findings of many studies which perceived population as the key player in bringing about environmental change.

The finding that internal dynamics of the population, i.e. changes in age structure and sex composition impact in changes in forest cover and hence affecting other environmental variables such as *rainfall amount* and *river discharges* confirm that population acts, on nature, in its disaggregated manner. Thus the need to consider the *key actors* in conservation efforts becomes a logical aspect. It is our contention that any efforts towards application of blanket conservation packages, issued uniformly to all community members, was not only a failure but also wastage of resources and time.

The fact that population growth resulted into an increase in the population segment of the *key actors* in specific activities that augmented deforestation, revealed to us by the *expanding spiral* of all the PDE variables. Expansion of the spiral was motivated by population growth, which increases the proportion of the *key actors*, thus expanding farms and use of forest products culminating into deforestation. The second cycle of the spiral was triggered by further population growth that increases a proportion of the *key actors* (by age and sex), thus demanding for more forest products and clearance of more land for cultivation.

Since population growth was mainly attributed to natural increase, and that involvement of household members in activities that reduced forest cover started at rather lower ages, i.e. 'entry age' of 8 years, and the *optimum* or 'stabilization age' for participation was 20-44 years; while 'exit age' was 45+, then it is imperative arguing that the lower climbing synclines of the spiral could stand for the entry age, with minimum contribution to forest cover change. Stabilization stage contributed much in deforestation; this was at the top of the crest, which was assisted in the process by both the young (at the bottom) and the aged located at the slopping down syncline. The overall character of the spiral was noted to be on the expansionist nature, indicating an increase in terms of population size, population segment of the *key actors*, economic activities, and hence the observed expanded deforestation.

9.6 Conclusion

The study on population, development and forest cover change observed the differential participation of people of different age groups and sex categories in activities leading to deforestation and conservation. Population characteristics, i.e. its size, age structure and sex composition were observed to pose differential impacts to the selected development activities. Contribution of people of different demographic characteristics, to forest cover changes could therefore be spatially quantified and demographically projected for the future development and implementation of sustainable conservation activities. It theoretically implies that changes in population structure and/or population composition tend to impact on the pace and intensity of deforestation within a specific area. Thesis findings confirmed the theory because it proved that variations in population composition, based on sex ratios, tallied with changes in forest cover despite the observed disproportionate characteristics of the changes.

The thesis went beyond by identifying the practical ways in which population engaged in deforestation process transcending to the linking of changes in population characteristics and variations in forest cover by specific livelihood or development activities. Identification of the *key actors* and the way they actually engaged in deforestation and/or conservation activities formed an additional body of knowledge vital for development of more pragmatic conservation efforts. The newly uncovered area of interface between population, through the *key actors* and vegetation cover, was necessary for underscoring the actual community engagement in both deforestation and conservation activities.

The contention, at this point, is that sustainable forest conservation may only be attained through the understanding the actual actors in deforestation process and those in conservation. These are, according to this thesis, considered to be the right people to be targeted for conservation efforts. Through demographic analysis, the thesis deduced more concrete suggestions that would guarantee future sustainable conservation efforts. The thesis is one step ahead of the contemporary knowledge in resolving the complexity of PDE studies confirmed in most literature.

The generalized manner of linking population with environment which considered only one population variable, i.e. size is hereby challenged because the thesis emphasizes the need to disaggregate the population into its sub-categories that actually engage in livelihood (development) activities leading to forest cover change and the consequent environmental effects like *catchment value* and *micro-climatic changes*.

A consistent lesson brought forward by the thesis is that population size is not a singular driving force as assumed by many studies, neither is it a trivial factor. Other population characteristics, i.e. age structure and sex composition were proved crucial in contributing to the expansion of development activities with concomitant adverse impact on the environment. This is a fact of profound significance in the planning and management of sustainable conservation efforts.

The thesis, having used unique research techniques that combined serial and parallel data analysis for population, development/livelihood activities and environmental variables provided the reliable *time-line* comparison of the three phenomena. Details on the relationship of the *trio* were availed through qualitative information obtained through PRA. The use of modern technologies in accessing environmental data and positioning of villages, i.e. GIS and GPS qualified the study being precise and objective. The step-by step analysis of PD and then DE formed a new input to PDE analysis studies. It implies that analyzing PDE linkages has to start with studying the Population, then Development and establish the existing link between the duo, prior to linking the relationship between Population and Development; with Environment.

Methodologically, the disaggregation of the characteristics of both population and environment for more objective analysis at theoretical levels; and re-combining them at another level was adopted to obtain the reality of the complex field situation. The interplay of the interwoven factors made the analysis of the PDE relationship a delicacy in terms of its interpretation.

In practical terms, the interface between population and development activities was vindicated through the *key actors* who actually harvested the products of nature. Identification of the *key actors* by their demographic characteristics of age structure and sex composition stands as an important step towards underscoring the nature and character of the existing PDE linkages. The *key actors* constituted the actual connection between population's demand and the process of resource utilization, which in this context reflected itself in terms of tree cover reduction.

The theory that population changes lead to expanded economic activities which impacted on the environment was withheld, while an input of knowledge on the impact of changes in population's sex composition and age structure stood out to be remarkable, novel and the greatest contribution of the thesis. The basic aspect, at this juncture, was the identification of *key actors* in specific selected activity. This was primary in appreciating the point of interface between population and development activities, i.e. a necessary step towards understanding the linkage of development and environment.

The existing principles of sustainability availed themselves with an extra input which was not taken into account, but brought about by the thesis, i.e. considering the internal dynamics of the population which constituted sex composition and age structure of the population in question. It is the contention of the thesis arguing that it is not enough to just appreciate the role of population in environmental degradation without consideration of the sex composition and age structure of the population which engender man-environment interface.

Local participation, broadly advocated for by vast literature and adopted by many governments, Tanzania inclusive, be it in the form of Joint Forest Management (JFM) or the Community Based Forest Management (CBFM) cannot guarantee sustainability without the analysis of *key actors* and their motivation in engaging in the activity. This provides ground for finding out alternatives that would reduce pressure on resources. Those who have to be linked to JFM or CBFM have to come out of the *key actors* in augmenting deforestation, and those who suffer more from the negative consequences of deforestation, i.e. women and children.

This was the essence of the body of knowledge, which was uncovered. It demands that the planning (extension message, dissemination method and timing of intervention) has to focus on the *right target group* based on age groups and sex category of the participants in the activity. For the purpose of WMCA males in age group 20-44 should be targeted by the extensions service for forest conservation. Females aged 10-44 are to be targeted where firewood happens to be the main cause of the dwindling forest cover. This will guarantee positive results in conservation efforts that will reduce cost and enhance sustainability.

A consideration on the 'spiral motion' of the changes of *key actors* in deforestation-related activities should be given when planning for sustainable conservation. The 'entry stage', i.e. people aged 17 years, 'stability stage', i.e. those aged 18-55 and 'exit age', i.e. those aged above 55 need to be addressed differently in respect to extension knowledge methodology and intervention strategies. Males and females respond differently regarding tree planting depending on the tree species to be planted, an aspect which dictate its use. If it is trees for firewood, women's participation will likely be higher, while males will be more active on timber and wood pole production species. Younger women are more likely to participate in tree planting for firewood production compared to their older age counterparts.

It is the contention of the thesis arguing that any sustainable conservation should directed to those in the 'entry age groups' by various ways possible. This will reduce their participation by possible reduction of their numbers or by adoption of sustainable resource use. The provision of fertilizers at affordable prices would limit extensive cultivation and hence conserve forests. Alternative sources of energy would reduce dependence on the traditional source, i.e. firewood which leads to deforestation. Those in the 'stability stage' have to receive knowledge and information on the development of alternative sources of energy which include tree planting for firewood.

The thesis reiterates that generalized efforts, based on population size, characterized by 'umbrella or blanket extension service' adopted for the entire country or region have proved to be a failure in past and present conservation efforts. The consideration of population size alone is viewed to be myopic since it does not embody details on the interactive nature of population, development and deforestation. Conversely the dispensing of the forest extension service packages in village general meetings is considered too general and simplistic.

The gap between those who 'destroy natural trees' and those who 'plant' tree species is of critical significance in the administration of the extension service in terms of content, methods, the venue and even the timing of intervention. The main challenge is to bridge the gap between the *key actors* in deforestation and those who directly acted in conservation. We are indeed able to strongly contend that the consequences of deforestation are not calculable from the physical dimension alone; they require much more attention, through a demographic dimension from which they are caused and experienced. The gap, i.e. difference between volume of actors in deforestation and those in conservation is likely to influence the intensity and pace of forest cover change. To prove this assertion requires further research. Now that it has become evident that it is out of the PDE linkages that issues of sustainability of conservation efforts are embedded, the thesis, however, recommends for pursuit of more detailed and similar research on the subject.

The thesis urges for increased objectivity in selectivity or identification of actors to specific deforestation and/or conservation-related activities. The thesis challenges generality in the planning and management of conservation activities, an aspect perceived to hamper environmental sustainability.

WMCA suffers from deforestation caused by expanding human activities prompted by human population growth. If the area is ever to recover drastic changes are needed that should involve underscoring the role of not only population size but also the age structure and sex composition. Drastic changes are also needed in all the sectors related to development (livelihood) activities and environment. More sustainable resource use is of great significance to positive conservation initiatives.

9.7 Policy Recommendations

Findings of the thesis had great significance in generating some policy commendations based on the observed linkages and *modus operandi* of the extension services, the adopted rural development strategies, the legal framework and the national policy clauses that limited the practical application of PDE analysis for sustainable development. The thesis outlines a set of recommendations that contribute important inputs for enhancement of sustainable conservation.

Since all the three aspects, i.e. population, development and environment are multifaceted phenomena, a grip of the role of the *mediating factors*, i.e. political, legal, cultural and technological issues displayed a higher degree of vitality in the analysis and in practice. The factors differed from one locality to another hence, arguably, impacted differently on the physical environment. The factors provided detailed and crucial description of the nature and character of the PDE relationship although it was out of the scope of the thesis to ascertain the contribution of such factors. This was another area recommended for further research.

9.7.1 Proposed Conceptual and Methodological Changes

The thesis perceives the need to institutionalize the conceptual and methodological changes to enable synchronized planning development issues along with population and environmental concerns. The consideration of the tripartite linkages was, according to the thesis, the cornerstone of success and sustainability of life systems. Such changes were recommended for areas discussed hereunder.

9.7.1.1 Adoption of more pro-active family planning strategies

The government has to take a more pro-active and targeted strategy that focuses on the potential segment of population, i.e. youths, is recommended. This should target pupils and students so that the values are inculcated in their minds rather than targeting pregnant women at MCH clinics.

Despite the observation that the increase in population directly impacted on the expansion of human activities that reduced forest cover, control in the rate of population growth is obviously not a panacea for reducing the negative impact. The adoption of more *participatory learning approaches* that take into account other factors contributing to deforestation is necessary. This entails family planning campaigns that take into account socio-economic and demographic conditions and environmental concerns of the community in question.

9.7.1.2 Necessity to articulate demographic knowledge in the formulation of effective conservation initiatives

The thesis recommends for formulation of location-specific and more targeted conservation strategies that take into account the active population segment by age groups and sex composition for more effective conservation efforts. This will bring the extension knowledge within the proximity of the members of the population who actually need to act on it. The *key actors* have to be identified as a first step towards targeting of the actors in deforestation and conservation activities. We profoundly contend that more focused extension programme to specific activity and specific actors is critical for effectiveness of resource use and sustainability.

The thesis, therefore recommends further that the agriculture and forest extension service to target males aged 20 and 44 when delivering their packages on promoting agricultural intensification and/or forest conservation in limiting expansion of farms.

While the intention was to reduce dependency on natural forests for firewood for domestic purposes, then females, aged 10-39 were the ones to engage, while in case of firewood for burning bricks males aged 17 to 44 would be the right target group.

The potential audience, i.e. those aged below the 'entry age' would be automatically, for socio-cultural reasons, inducted into the activity after the skills and techniques were adopted by the *key actor groups*. Thus conservation knowledge will, in the long run, be imparted to them from their predecessors. The current 'blanket' extension service should be abandoned.

It is recommended that the forestry and agricultural extension systems, represented by village based agricultural extension officers, forestry officers, health officers be strengthened and their staff become part of the technical team for village management and development. The thesis perceived *capacity building* to be of great importance for the generation of technocrats from a wide range of disciplines needed for result-oriented village management.

9.7.2 Proposed Policy Reviews on Sections that Inhibit Conservation

The thesis recommends for reviews of some laws, policies and specific national level issues to be addressed for facilitation of sustainable conservation of vegetation cover and other related environmental phenomena.

9.7.2.1 On Laws and Regulations on Lands

We propose for review of several national laws/ordinances/regulations and regulations that tended to limit effective land use planning. Such laws hampered conservation, hence culminated into the observed rampant and faster pace of environmental degradation. The laws suggested to be reviewed are presented under items (a) to (c).

(a) The Land Ordinance of 1999

The Land Ordinance (1999) places ownership of village land in the hands of village government not individuals. Such mode of land ownership was a disincentive to villagers who saw no reason to conserve natural resources like land and vegetation because their land and other natural resources do not belong to them individually. In fact, the village land and its resources is a government property delegated to village government, which is a sub-division of the central government. The small scale farmers, who are the majority of Tanzanians, are essentially landless with little or no incentive to conserve the environment.

(b) The Forest Ordinance Cap 389 of 1959

The Forest Ordinance reserves all trees be it in private lands or general lands as the property of the

Chief Conservator. The user rights and property rights of the land owner were restricted when it came to the cutting of a tree within one's farm land. The law was a disincentive to local community to conserve the forest. The question local community members asked themselves was why should a person conserve a resource which did not belong to and/or was not of usufruct significance to him? Worse was the clause on presence of planted trees whose user rights had to be sought from the Forest Officer who played no role in planting nor did own it. Law prohibits the harvesting of planted tree products without permission from the District Forest Officer discouraged both planting of trees and conservation of natural forest (Madulu, 2001).

(c) Law on Village Administration

Regulations and Legal Guidance for Administration of Villages and Streets (2000) recognizes the compulsory age for one to attend village meetings, i.e. those aged from 18 to 50. Since such meetings were venues for delivery of the forest and agricultural extension services, it implied that some *key actors* in various development activities like farming, cutting firewood and tree planting were technically sidelined. This included those members aged 10-17 who constituted a significant proportion of the *environmentally active population*. The sidelined population was likely to contribute significantly and negatively to the state of the forest cover. The thesis observed that the *key actors* in such activity were included on a legally set maturity age, i.e. 18 years and above. A significant proportion of them were below 18 and above 50.

The extension service should take the form of *focus group discussions* to allow a more interactive environment than a mere one way communication. It has to be directed on the *key actors group* and those groups affected by the impact of deforestation by specific activity. This will give much weight to the extension package since it shall be directed to the 'right', environmentally active, audience. General coverage of the service to the entire village population renders it being too general and allows for less adoptability.

9.7.2.2 Proposal to Survey All Villages and Village Lands and Issue Title Deeds

The fact that all villages of WMCA were not yet surveyed implies difficulty in carrying out technical land use planning since survey plan is a prerequisite of land use planning. In this case, title deeds could not be offered to farmers because there were no survey plans. The thesis recommends that all villages be surveyed as a step towards attaining more stable land tenure systems that would foster both ownership and conservation activities (URT, 2001). We urge the government to issue land ownership rights to individual rural people for their household lands to enhance future conservation activities.

9.7.2.4 The Need to Employ Competent and Qualified Village Authority Leaders

(a) On Qualifications and Competence of Village Administration Employees

We recommend for employment of more qualified staff capable for planning and supervision of the implementation of all development and conservation. The educational or professional qualification based on demanded capability for the post. No wonder this contributed to the current pathetic state of environment.

The current available academic and professional institutions, of middle and higher levels, may be charged to offer specialized courses in the disciplines related to rural development. This would make the graduates of such institutions employed for the posts. The academic institutions have to be linked to the society through outreach programmes, field attachments and research activities, rather than remain isolated from the local communities.

The thesis strongly recommends that decentralization of authority to the local or village government should consider the capacity for village level management. Devoid of this, delegation may be relegated to total neglect of the rural population. It is at the village level where deforestation occurs hence rural-oriented solutions are needed.

(b) On Villages Management Strategies

The thesis urges for the adoption of more *participatory approaches to rural development*. This will create effectiveness in implementation of various aspects of rural development ranging from production, social services, to environmental conservation. Since PDE were observed being interactive and interdependent components, resolving a problem in one component involves addressing issues in another. This requires involvement of the community in management of their environment, thus s holistic approach is hereby recommended.

The participation may take the form of joint management and Participatory Farmer Innovation (PFI)[41] and others, which would enhance productivity and development in a community requiring immediate competent and specialized manpower for dissemination of more scientific production systems and natural resources management. The Participatory Land Use Management Project (PLUMP) has emphasized the same (URT, 2001). The thesis observes that because village authorities have powers to deal with the management and control of the natural resources, it does not imply that the local communities are involved in the management of their resources.

[41] PFI Involving participatory research and involve farmer innovation for development of better practices that reduce resource use and enhance productivity (URT, 2001).

Enactment of bylaws, without involving the villagers, has never shown any success other than creating endless conflicts between government organs and local communities. The enacted laws were basically restrictive with clauses like 'do not', without providing any alternative to the problem in question. In most cases the fines to defaulters were too low thus attracted more destruction.[42]

The monies obtained as fines were not used to replenish vegetation cover of the affected area; thus it is recommended that such monies obtained from fines should be used for aforestation of the same area.

9.7.3 Proposed Policy Reviews

The study revealed the need for some policies reviews so that they effectively address contemporary socio-economic and environmental conditions. The inclusion of demographic analysis in the planning, implementation and monitoring of development and environmental activities was considered important for the success and sustainability of forest conservation endeavours.

9.7.3.1 On Population Issues

We recommend for revitalization of the vital registration system for development of reliable population data bases for future planning, research and development. The National Population Policy (2006) recognizes the role of sustainable development as human numbers constitute the driving force in undertaking development activities which impact on environment. The policy puts much focus on reducing numbers of people, through family planning, an instrument of the Population Programme.

9.7.3.2 On Energy Sources

It is recommended putting in place a system that ensures sustainable supplies of firewood other than the conspicuous dependency on natural vegetation, whose impact has been negative as it translates into deforestation. Emphasis should be put on enhancement of its recycling, mainly through tree planting.

The National Energy Policy (2000) appreciates the significance of firewood as the main source of domestic energy. However, it fails to outline the requisite alternatives to enhance or reduce its dependency on the users.

The thesis recommends for the establishment of sustainable firewood sources which would be more practical to the respective rural areas. This has to be done at household and/or at community (village) levels through planting of multipurpose tree species that would provide firewood, fodder and shade, while at the same time maintain the *catchment value*.

[42] The fines ranged from Tshs 5000, i.e. equivalent US D 4 to Tshs 10000, equivalent to USD 8, which could not convince one to stop committing crimes in question. The regulations were hardly enforced

Trees planted in the past and reduced *catchment value* should be cleared to allow for regeneration of natural vegetation. Efforts towards allowing for regrowth of natural trees is, in this context, perceived a crucial step towards protection of the *watersheds*.

Since a tree takes long to grow to maturity, the challenge that remains to foresters is to plant trees for firewood and to establish how to balance population change, demand and the plant growth cycles for continued energy supply. The thesis observes that conceding the significance of firewood as a source of domestic energy for the majority of Tanzanians alone is not of any practical significance because the use of firewood will continue to dominate for unforeseeable future (URT, 2000).

9.7.3.3 Regarding the Environment

The Tanzania Environmental Policy (1997) underscores the significance of Environmental Impact Assessment (EIA). However, the provisions and necessity for carrying out EIA is legally bound to other projects but not for small scale village settlement planning and rural development activities which are undertaken by majority of people hence adversely affecting vast land areas. The negative impact of smallholder systems to the forest cover has been documented by many studies conducted in Tanzania and elsewhere.

We recommend that the EIA be adopted for rural development projects as well. This would be a step towards sustainability and monitoring of the changes in environmental situation related to expansion of human population and requisite economic activities through time.

The thesis recommends for sectoral coordination among agriculture, forestry, water catchment, settlement planning, wildlife management and river basin management to allow effective control in conservation efforts. Such efforts contradict and limit farmers' possibility for expanding farms, thus resort into intensive farming agro forestry and conservation of natural vegetation, aspects more plausible and supportive of sustainable forest management. Expansion of farms conversely meant disappearance of the forest, hence need to coordinate and link forest conservation and agriculture.

It is important to formulate comprehensive village-based land use plans in the rural development sectors which limit further clearing of forests. Such plans should include physical demarcations for areas set aside for conservation and other types of land uses.

(c) Establishment of Monitoring Mechanisms for Forest Cover Change and *River Discharges*, *Climate Change*

The thesis recommends for having a modern forest cover monitoring mechanism as a step towards tracking vegetation cover changes over time. This includes the acquisition and use of remote sensing and digitized methods of determining land cover changes. There could be no effective conservation of resources whose location and stock was not known. Evaluation, as a management tool would enable for adoption of more effective and where applicable some emergency measures in areas with much more aggravated environmental conditions.

9.7.3.4 On Forestry

The thesis recommends for relocation of those settlements located within *ecologically sensitive areas* to reduce pressure to the forest reserve. The existence of a legal settlement like *Ndilima Litembo,* surrounded by the forest reserve is a problem especially to both residents and institutions entrusted with the management of respective reserve area.

Section 2.1 of the National Forestry Policy (1998) recognizes deforestation as one of the major environmental problems that threatens the existence of forests. More deforestation takes place in unreserved lands which are in fact state owned lands. Lack of local participation in conserving such land areas, which the communities did not own, was noted to be the main reasons for deforestation resulting from by activities such as farming, charcoal burning and firewood cutting.

One aspect is *population pressure* which slowly leads into fragmentation of farm plots to the extent of becoming un-economical. The second was the possibility of people to invade the Matogoro Forest Reserve to scarcity of firewood and farmland. Currently it is acknowledged, in official reports, that there are incidences of encroachment and poaching. The observed farming in the source areas and presence of numerous *misfit streams* are a glaring evidence of negative environmental impact of human activities.

(i) Demarcating the Areas Earmarked to be Conserved

Lack of demarcations observed in of all the eight village areas was partly a result of the villages not being surveyed and thus unplanned. Presence of the forests that were undesignated as forests, with no clear boundaries, made them exposed to fires and farming activities threatening their existence (URT, 2001a).

(ii) Introduction of Buffer Zones in Forest Management

The thesis recommends for creation of buffer zones to reduce pressure on the forest reserve. Creation of *buffer zones* is an essential step towards providing the community with *optimum* access to some vegetation resources around the protected area. The sharp contrast between village settlement area (and farms) and the forest reserves signify the absence of *buffer zone*, therefore making the forest cover easily misused, sometimes deliberately due to the need to meet household and development demands.

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Appendix 1

Main Questionnaires Document

UNIVERSITY OF KWAZULU-NATAL

QUESTIONNAIRES ON POPULATION, DEVELOPMENT AND ENVIRONMENT FOR THE COMMUNITIES LIVING WITHIN THE NEIGHBOURHOOD OF THE WEST MATOGORO CATCHMENT AREA IN SONGEA, TANZANIA

SERIAL NUMBER: **00001**

VILLAGE:………………………………………………………………………………………

NAME OF THE HOUSEHOLD HEAD:…………………………………………………………..

NAME OF THE RESPONDENT: …………………….AGE ………… SEX………………….
AGE OF THE SPOUSE ……………..

SECTION A: PERSONAL INFORMATION OF THE HOUSEHOLD

1. (a) How old are you? ……………………….. (b) How old is Your Spouse? ……………….
2. What is the highest level of education you have achieved? …………………………………..
3. What is your marital Status?
   1. Married
   2. Single
   3. Divorced
   4. Separated
   5. Widowed
4. In your life how many children did you ever had?...................... (Please give their details)

NAME (Not Necessary)	SEX		AGE	PRESENT	EDUCATION LEVEL	AWAY	DEAD (YR)
	MALE	FEMALE					

5. Are there any other people who for the most part live in your household?

Name	Sex		Age	Levels of Education	Relationship to Head	Economic Activity
	Male	Female				

6. Where were you born?
Village …………………..Ward………………………….District ……………………………

7. If you were no born in this village, when did you move to this location? ……………………...

8. Till today, for how many years has your family been living in this area? ……………………...

9. Why did your family move to this area? ………………………………………………………..

10. Are there some people living in your household who moved into this area for the past three years? **YES/NO (**If **NO**. Go to question 12)

11. If YES, give more details about the in-migrants

Name	Age	Sex		Level of Education	Reasons for in Migration
		Male	**Sex**		

12. Are there people who moved away from your household for the past three years? YES/NO
If **NO**, GO to Question 15.

13. If YES, mention the reasons for their moving out of the area. …………………………………
……………………………………………………………………………………………………..

14. Where did they move to?
Village…………………….Ward………………………District ……………………………….

SECTION C: LAND OWNERSHIP AND LAND USE

15. What is the size of the land around your household? (in acres) …………………………..

16. How did you obtain that land area? ……………………………………………………………

17. Do you have the land title deed for the land? **YES/NO.**

18. What changes have taken place regarding ownership of the land since year 1974 and beyond?
……………………………………………………………………………………………….

19. What are your future plans in changing the types of land-use? …………………………………
……………………………………………………………………………………………………..

20. Is your land area satisfactory for the household's requirements?
1=YES
2=NO

21. What are your views on the trends in changing size of the village settlement area since year 1974?
…………………………………………………………………………………………
………………………………………………………………………………………………...

22. What do you think are the reasons for expansion of village settlement area? ………………….
……………………………………………………………………………………………….

SECTION D: ECONOMIC ACTIVITIES, DIVISION OF LABOUR, TECHNOLOGIES EMPLOYED IN PRODUCTION AND COMMUNITY PARTICIPATION IN ACTIVITIES CONTRIBUTING TO DEFORESTATION AND CONSERVATION

23. What is the main economic/livelihood activity for your household? ....

24. If it is Farming, what is the size of your household's farm area? ....
    If NOT Farming, move to Question 31.

25. Mention the two major crops grown in your household. ....

26. What is the main instrument/ your household use for farming? ....

27. What methods of fertilizing the soil are used by your household in ensuring high productivity in the farm? ....

28. How may times does your household prepare new farms?
    1= NOT AT ALL
    2= Each year
    3= After every two years
    4= After every three years
    5= After every five years
    6=Whenever the soil fertility gets exhausted

29. How many acres of the forest has your household cleared in the following periods:
    1= 1974-1978 ....Acres
    2=1979 -1988 ....Acres
    3= 1989-2005 ....Acres
    4= NOT AT ALL

30. What are the reasons that make your household to clear new farm (s)? ....
....

31. What other livelihood/economic activities does your household engage in? ....
....

32. What is the estimated household income? ....

SECTION E: THE UTILIZATION OF FOREST PRODUCTS IN LIVELIHOOD/ECONOMIC ACTIVITIES

33. What are your household's uses for forest products? ....
....
....

34. Does your household make the bricks burned using firewood?
    1=YES
    2=NO
    If NO, Go to Question 39

35. **If YES**, how many times (for how long) does your household make such bricks? ....
....

36. How many bricks does your household make when it happens to do so? ....

37. Where does your household get supplies of firewood for burning the bricks? ....
....

38. How much firewood is used for burning one kiln of bricks (cubic metres)? ....

39. What is the main source of energy used in your kitchen? ....

40. How much of the energy source does your household use in a week? ....

41. Who are responsible for collecting firewood?
    1= Males
    2=Females
    3= Both
    4= None

42. Are there big firewood business men/women in this village?
    1= YES
    2=NO

43. Where does your household get firewood/charcoal from? ....

44. What is the trend in firewood availability?
    1= Increased
    2= Decreased
    3 = No change

    If **NO CHANGE**, Go to Question 49.

45. If **INCREASED** or **DECREASED**, explain from which year was the change noted? ....

46. What do you think are the reasons behind such changes in availability of the domestic energy source?
    ....
    ....

47. What do you think are the social and environmental problems resulting from the trends in energy source availability? ....
    ....

48. In your household, people of which sex and age groups are more engaged in the activity of cutting trees for preparing new farms? (Fill the Information in the Table)

AGE GROUPS	SEX CATEGORY	
	MALE	FEMALE
< 10		
10-19		
20-29		
30-39		
40-49		
50+		
TOTAL		

49. In your household, people of which Age Group and Sex Category deal more with the cutting of trees for Firewood for domestic use? (Fill the Information in the Table)

AGE GROUPS	SEX CATEGORY	
	MALE	FEMALE
< 10		
10-19		
20-29		
30-39		
40-49		
50+		
TOTAL		

50. Where does your household get wood poles for construction of homesteads? (TO BE ASKED (TO THOSE HOUSEHOLDS WITH HMESTEAD CONSTRUCTED USING WOODPOLES ONLY)
    ....
    ....
    .....

51. What is the trend in availability of wood poles in the area between year 1978 and 2005?
....
....

52. When such was a trend start being observed/noted? ....

53. In what span of time does your household have to build another homestead or do major rehabilitation of the same? ....

54. What do you think to be the negative effects of such trends in the use of forest resources?
....
....

55. Does your household grow tobacco?

    1=YES
    2=NO

If **NO**, Go to Question 59

56. In which year did you start growing tobacco? ....

57. What is the size of your tobacco farm? ....

58. Where do you get firewood for curing tobacco which you grow? ....

SECTION F: FOREST PRODUCTS, REASONS, TRENDS AND ITS IMPACT

59. Which forests (by Local names) are found in this area? ....
....

60. What are the main reasons for the decrease in forests in this area? ....
....

61. When (year) was shortage of trees started to be noted? ....

62. What do you think to be the advantages of forests to this village? ....
....

63. What do you think are reasons behind setting period fires in the forests in this village? ....
....
....

SECTION G: COMMUNITY PARTICIPATION IN FOREST CONSERVATION ACTIVITIES

64. What methods/strategies does your household use in conserving the forest? ....
....

65. Does your family have a plot of trees or planted some trees?

    1=YES
    2=NO

If **NO**, Go to Question 69.

66. If **YES**, how many trees has your household grown? ....

67. In your household, people of Which Age Groups and Sex Category do play more role in planting trees? (Fill the Information in the Table)

AGE GROUPS	SEX CATEGORY	
	MALE	FEMALE
< 10		
10-19		
20-29		
30-39		
40-49		
50+		
TOTAL		

68. What do you think to be the differences in forest conservation in the past and today? ....
....

69. What is the source of water for your household? ....

70. What can you say about water availability in a year?
    1=Very Little
    2=Little
    3=Change every season
    4=Changes Arbitrarily
    5=Other (mention)

71. In which season is water scarcity is most noted? ....

72. What do you think are the reasons for such water shortage in that season? ....
....

73. In which year was the water shortage initially noted? ....

74. What are your views on the changes in *rainfall amount* for the period ranging from year 1974 to 2005?
    1= Decreasing
    2= No change
    3= Increasing
    4= It varies
    5= Other (mention)

75. In your views, what might be the reasons for such changes/variations in *rainfall amount* stated in Question 74? ....
....

76. Kindly give your general views about population growth, state of the forest and forest conservation in the area. ....
....

Thanks

Appendix 2

The PRA Checklist

UNIVERSITY OF KWAZULU-NATAL

GUIDING QUESTIONS FOR THE PARTICIPATORY RURAL APPRAISAL CONDUCTED IN EIGHT VILLAGES LOCATED IN THE NEIGHBOURHOOD OF THE WEST MATOGORO CATCHMENT AREA OF SONGEA, TANZANIA.

SECTION A: BACKGROUND HISTORY OF THE VILLAGE AND SOCIO-CULTURAL SITUATION OF THE AREA

1. In which year was this village established? ……………………………………………………………

2. What is the size of this village? ……………………………………………………………………

3. What changes have been noted in terms of availability of land to the local community members between year 1974 and 2004? ……………………………………………………………………
……………………………………………………………………………………………………

4. What are the different ways though which one may acquire land in this area? ………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

5. How is the trend in population growth in the village between year 1974 and 2004? ………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

6. What do you think are the reasons for population growth in this village? ……………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

7. At what average age do most of young men of this village to get married? …………………………

8. What are the reasons for them to get married at this age? ……………………………………………
……………………………………………………………………………………………………

9. At what average age do most of the girls of this village get married? ………………………………
10. Why do you think are girls married at that age? ……………………………………………………
……………………………………………………………………………………………………

11. What are the things a young man must have so as to socially accepted as ready to get married? ……
……………………………………………………………………………………………………
……………………………………………………………………………………………………

SECTION B: ECONOMIC/LIVELIHOOD ACTIVITIES

12. What are the main economic activities which most of community members deal with? ……………
……………………………………………………………………………………………………

13. Why do most of people of this village depend on the activities mentioned I No.12 above? …………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

14. In your views do you think there is a relationship between one's age and involvement in the following livelihood activities?

1= Collecting/ cutting firewood	YES/NO
2= Burning Bricks	YES/NO
3= Constructing Wood pole house	YES/NO
4= Setting Fires on the Forest	YES/NO
5= Lumbering Business	YES/NO
6= Sending livestock to pastures	YES/NO

15. If **YES**, explain how is the relationship?

1. ………………………………………………………………………………………..
2. ………………………………………………………………………………………..
3. ………………………………………………………………………………………..
4. …………………………………………………………………………………………
5. …………………………………………………………………………………………
6. …………………………………………………………………………………………

16. Is there any relationship between sex of an individual and the following economic/livelihood activities listed below?

1= Collecting/ cutting firewood	YES/NO
2= Burning Bricks	YES/NO
3= Constructing Wood pole house	YES/NO
4= Setting Fires on the Forest	YES/NO
5= Lumbering Business	YES/NO
6= Sending livestock to pastures	YES/NO

17. If **YES**, explain how is the relationship?

1. ………………………………………………………………………………………..
2. ………………………………………………………………………………………..
3. ………………………………………………………………………………………..
4. ………………………………………………………………………………………..
5. …………………………………………………………………………………………
6 …………………………………………………………………………………………

SECTION D: POPULATION AND DEFORESTATION

18. Are there catchment forests within this village?
1=YES
2=NO
3=I DO NOT KNOW

19. If **YES**, explain their importance to people living in this area. ……………………………………..
……

20. How are your the trends in terms pf changes in forest density and area between year 1974 and 2004?
1= Decreased
2=Not Changed
3= Increased

21. What are the reasons for the trends mentioned in Question 20 above? ……………………………
……

22. Do you thin that there is a relationship between population growth and decrease in forest cover?
1= YES
2=NO
If **NO**, Go to Question 24.

23. If **YES**, explain how is the relationship? ……………………………………………………………..
24. What do you think are reasons for some people to set fires to the forests? …………………………
……

25. What can you say about the number of people who moved to this village between year 1974 and 2004?
………………………………………………………………………………………………………

26. What do you think are the reasons for such trends of in-migration into the village? ………………..
……

27. What can you say about the number of people who moved away from the village between year 1974 and 2004? ………………………………………………………………………………………

28. What might be the reasons for such trends in out-migration in the village? ……………………….
……

29. What opinions do you have on the comparison between the people who moved in and those who moved out of the village in terms of their numbers, Sex composition and age groups? …………………
……

30. What can you say about population growth in this village between year 1974 and 2004? …………
……

31. What do you sat about changes in the village settlement area for years between 1974 and 2004? …..
……

SECTION D: PARTICIPATION IN SUSTAINABLE FOREST CONSERVATION

32. Are there many woodlots (plated trees) in this village?
1=YES
2=NO

33. Why has the planting of trees in this village taken such a trend (described in question 32)? ………
……

34. What are the practical uses of woodlots (planted trees) in the village? ……………………………
……

35. How are local communities made to participate in conservation of catchment and other forests in the village? ……………………………………………………………………………………………

36. How are local communities engaged in activities linked to sustainable forest conservation? ……….
……

37. What are the major problems (limitations) in sustainable conservation of natural forests in this village?
………………………………………………………………………………………………………

38. What livelihood/economic activities carried out in this village contribute to deforestation? ………..
……

39. Are there bylaws by local government (village government) related to protection of catchment forests in this village?
1=YES
2=NO
3=I DO NOT KNOW

40. If **YES**, how are such bylaws enforced? ……………………………………………………………...
……

SECTION E: SOURCES OF DOMESTIC ENERGY

41. What do you think to be the main source of domestic energy to most inhabitants of this village? ….
……

42. Where do people of the village get supplies of such a source of energy? ....
....

43. What are views on relationship between one's age and the following economic/livelihood activities?

1=Collecting/Cutting firewood	YES/NO
2=Burning Bricks	YES/NO
3=Constructing Wooden Huts	YES/NO
4=Setting Fires on Forests	YES/NO
5=Lumbering	YES/NO
6. Sending Animals to Pastures	YES/NO

44. What is the average distance to where the sources domestic energy obtained? .... km.

45. People of which sex are responsible for collecting it for domestic use? ....

46. In case firewood is the main source of domestic energy, how do people get it (collecting, cutting stems, cutting branches, buying etc.) ....

47. Do you think there is a relationship between one's age and the amount of firewood he/she uses?
1=YES
2=NO

48. How is the relationship between one's age and activities that reduce forest cover in this village? .....
....

49. What may be the reasons behind the division of labour in activities that lead to forest cover reduction in the area? ....

SECTION F: WATER SOURCES AND AMOUNT OF RAINFALL

50. Where do most of inhabitants of this area get water from? ....

51. How can you say about the trend in water availability in the area? ....
....

52. What is the average distance to the sources of water? ....

53. How is the trend in rainfall availability between year 1974 and 2004? ....
....

SECTION D: HEALTH AND MEDICAL FACILITIES

54. Which health services are offered to people of this village? (Dispensary/ Health Centre/Hospital/Other) ....

55. Are there hospitalization facilities?
1=YES
2=NO

56. Are there mother and Child health (MCH) facilities?
1=YES
2=NO

57. What is the average distance from the health facility to referral medical facilities meant for people of this village? .... km.

58. What are the most common diseases in the area? ....
....

59.Who are the cadre of people that are most affected by diseases (women/men/male children/female children/all)? ....

60. Can I get supplied with data on the population of the village as categorized in the Table below?

Year	Male	Female	Children (Male)	Children (Female)	Total
1974					
1978					
1988					
2002					
2004					
Total					

61. Can I get supplied with data on Deaths for the past years as indicated in Table below?

Year	Male	Female	Children (Male)	Children (Female)	Total
1974					
1978					
1988					
2002					
2004					
Total					

SECTION H: EDUCATIONAL INSTITUTIONS LOCATED IN THE VILLAGE

62 Which educational institutions are located in the village (mention them)? ....
....

63. Can I get supplied with data on the number of pupils who passed examinations since year for the Years prescribed in the Table below:

Year	Male	Female	Total
1974			
1978			
1988			
2002			
2004			
Total			

64. Can you give any more information on population, development and environment for the area as you may just volunteer doing so? ....
....
....

Thanks

TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY (COSTECH)

Telegrams: COSTECH
Telephones: (255 - 22) 75155 - 6, 700745-6
Director General: (255 - 22) 700750 & 75315
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E-M: Rclearance@costech.or.tz;

Ali Hassan Mwinyi Road
P.O. Box 4302
Dar es Salaam
Tanzania

In reply please quote: **CST/RCA 2004/113/2004** **10th October 2004**

For Research Proposal No. RCA 2004/113

Michael John Haule
University of Kwazulu Natal
4041 Durban
RSA

Dear Sir,

RE: CLEARANCE CERTIFICATE FOR CONDUCTING RESEARCH IN TANZANIA

This is to certify that the research entitled: *Population Dynamics and Sustainable Forest Conservation: A Case Study of West Matogoro Catchment Area in Songea, Tanzania* whose Principal Investigator is Michael J Haule, has been granted ethics clearance to be conducted in Tanzania under Supervision of Prof. F.N Madulu, Institute of Resource Assessment at University of Dar es Salaam

Principal Investigator of the study must ensure that the following conditions are fulfilled

1. Progress report is made available to COSTECH
2. Copies of final publications are made available to COSTECH
3. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine

Duration of Study: One year

H. P Gideon
For Director General

Appendix 4

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

Mkoa wa Ruvuma
Simu Nambari 2602256/2602238
Fax Na.2602144

OFISI YA MKUU WA MKOA,
S.L.P. 74,
SONGEA.

Kumb. Na. RUV/L10/II/III/116

6 Septemba, 2004

Katibu Tawala wa Wilaya
S.L.P. 1
SONGEA.

YAH: KIBALI CHA KUFANYA UTAFITI

Kibali cha kufanya utafiti kuhusu Masuala ya **"Population Dynamics and sustanaible conservation of catchment Forest"** kimetolewa kwa Ndugu Michael J. Haule kutoka Chuo cha Biashara Dar es Salaam, pia ni Mwanafunzi wa Chuo Kikuu Kwa Zulu–Natal Afrika ya Kusini.

Tafadhali mpe ushirikiano unaostahili ili aweze kufanya utafiti wake. Atapendelea kufanya utafiti katika Vijiji zifuatavyo:-

(i) Lihwena,
(ii) Muungano,
(iii) Kikunja,
(iv) Mpingi,
(v) Ndilima Litembo,
(vi) Mahilo, Subira
(vii) Chemchemi.

Tunashukuru kwa ushirikiano wako.

M.S. Mgala
Kny: **KATIBU TAWALA WA MKOA**
RUVUMA

Nakala: Ndugu Michael J. Haule

Il VEOs
Mtajwa hapo juu anapewa kibali cha kuendelea na
utafiti kama katika maeneo yenu.
Salamu ya pili [illegible] mpeni msaada anaouhitaji.

KATIBU TAWALA WA WILAYA
SONGEA
25/[illegible]