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EFFECTS OF HABITAT FRAGMENTATION ON BIODIVERSITY OF ULUGURU MOUNTAIN FORESTS IN MOROGORO REGION, TANZANIA

Cuvillier Verlag Göttingen
Internationaler wissenschaftlicher Fachverlag

https://cuvillier.de/de/shop/publications/6333

CHAPTER ONE

General Introduction

1.1 Background Information

Fragmentation is the major threat to tropical forest biodiversity (Tabarelli *et al.*, 1999) as it tends to lower species number, modify community composition (Laurance *et al.*, 1998), decrease population productivity (Robinson *et al.*, 1995) as well as changing the micro-environmental conditions (Didham and Lawton, 1999). Usually, fragmentation occurs when the continuity of original vegetation is disrupted and reduced into smaller isolated fragments or patches (Franklin *et al*., 2002; Fahrig, 2003). It is most often a consequence of anthropogenic activities, for instance deforestation/clearance for agriculture, road construction, logging and urbanization (Tabarelli *et al.*, 2004; Jha *et al.*, 2005), which significantly alter pattern, composition and extent of vegetation due physical and biological changes (Newmark, 2001; Yan *et al.*, 2007) as well as alteration in the flow of resources (such as organisms propagules and nutrients) in the forest environment (Walker *et al.*, 2006).

Besides reductions in total area, fragmentation also modifies natural habitat by increasing the proportion of forest associated with edges, decreasing interior habitat, and isolating habitat fragment from other areas of habitat (Franklin *et al.*, 2002). The formation of edges is considered to be an important feature of fragmentation (Murcia, 1995). It has been observed that as the proportion of the edge zone increases, changes in microclimate occur, given that forest edges tend to be warm, windy and receive more light than forest interior (Didham and Lawton, 1999; Newmark, 2005). The modification in spatial configuration and microclimate within edges tends to affect species composition, abundance, natural regeneration and spatial distribution of biodiversity within fragments (Benitez-Malvido, 1998; Laurance *et al.*, 2007; Oliveira *et al.*, 2004). For that reason, fragmentation of habitat has become major topic of research and debate among conservation biologists and plant ecologists worldwide (Jongejans and de Kroon, 2005). Thus, assessing impacts associated with habitat fragmentation is an important step in prioritizing forest fragments for biodiversity conservation (Hill and Curran, 2001).

1.2 Problem Justification

Rapid human population growth in recent decades has increased pressure to the forest resources, which resulted in an extensive fragmentation and loss of habitat in many tropical forests (Bailly *et al.*, 2004). More than 500 million people are living in or near the world's tropical rainforests (FAO, 2003), the majority of whom depend on the forests as their primary source of supply for food, firewood, medicines, building poles and other indispensable needs (FAO 2003; Becker *et al.*, 2005). Tropical rainforests which encompass 6 % of the world's land area and which have at least 50 % of the world's total biological species are being deforested and fragmented at an alarming rate exceeding all other types of habitats (Ehrlich, 1981; Pimm *et al.*, 1998). Achard *et al.*, 2002 reported the decrease of tropical rainforests globally by an average of 5.8 x 10^6 ha per year in the year 1997 from the estimate of 1116 x 10^6 ha in the year 1991 due to deforestation. Moreover, FAO (2010) reported the global annual loss in forest area of 8.327 x 10^6 ha per year between 1990 and 2000 and 5.211 x 10^6 ha per year between 2000 and 2010. Thus, protection and conservation of forests has become an issue of increasing priority in recent years due to threats they are facing (Hill and Curran, 2001).

In Tanzania, the populations has increased by more than quadruple between 1948 and 2002 from 7.9 million to 36 million people respectively, with 80 % of these people living in rural areas and depending up on subsistence farming. Forests cover is approximately 34 million ha with an annual loss of 322,000 ha/year noted between 1990 and 1995 (Newmark, 2002) and annual loss of 403,000 ha per year noted between 2000 and 2010 (FAO, 2010). This loss is mainly due to agricultural clearings, overgrazing, charcoal production, fuel wood harvest, fire and timber harvest (Newmark, 2002). The Eastern Arc forests have suffered extensive losses and fragmentation due anthropogenic disturbances and fire (Madoffe *et al.*, 2006). The rate of loss of original forest cover as a result of human disturbances in Uluguru forests is approximated to be 65 % (Newmark, 1998). The population growth rate in Uluguru is approximated to be 6.5 % per year where the loss of forests due to conversion to farmlands and encroachment were 1.7 % per annum between 1955 and 1977 and 0.6 % per annum between 1977 and 2000 (Burgess *et al.*, 2002). This loss of forests is directly linked with the increase of human population around the mountain areas (Nkombe, 2003), which results to over-exploitation of the forest resources due to increased demands for more land for agriculture, timber for building purposes and charcoal making for fuel (Hymas, 2000). Some forest patches have remained in farmlands around the Uluguru Mountains, and they are still under deforestation for small-holdings, except for sacred forests and some rocky outcrops areas (Burgess *et al.,* 2002). The increase of anthropogenic activities due to population growth and urbanization in Uluguru jeopardize not only common species, but strict endemic and near-endemic species are at high risk of extinction too.

Newmark (1998) and Burgess *et al.,* (2002, 2007) reported the existence of several fragments in various Eastern Arc Mountain blocks including Uluguru. No study has been conducted to assess and compare the species richness, diversity, structure and floristic similarity in various forest fragments of Uluguru Mountains. Therefore, it is an intention of this study to provide an understanding of existing knowledge discrepancy by assessing; (1) mature species richness, diversity, structure between forest fragments, (2) the differences in species richness, diversity and density between various understory layers, (3) the edge-interior variation in the species assemblages and (4) indigenous tree use, use values and human population effects on the species richness, diversity and tree density.

1.3 Literature Review

1.3.1 Definition of Fragmentation

Fragmentation is an ecological process that involves splitting up of large, continuous unaltered environment into smaller, isolated fragments (Fahrig, 2003), leaving isolated fragments with deleterious consequences for most of the native forest biota. The process has also been described as the disruption of structural and spatial continuity (Laurance *et al.,* 2002). Using this explanation, the concept seems to be more relevant to any ecosystem where continuity is important to ecosystem functions, regardless of scale (Walker *et al.,* 2006).

1.3.2 Causes of Fragmentation

Fragmentation can be due to human or natural processes. Anthropogenic activities are the main drivers of fragmentation as they alter environment on a much faster time scale as compared to natural ones (Tabarelli *et al.,* 2004). Example of anthropogenic activities include logging, clearing/deforestation of forests for agriculture, charcoal making, fire setting, road construction and urbanization while natural activities include natural fire and geological processes like volcanic eruption, earth quakes and landslides (Tabarelli *et al.*, 2004, Jha *et al.*, 2005).

1.3.3 Impacts of Fragmentation to Natural Habitats

1.3.3.1 Area Effects

When fragmentation occurs, the decrease in the size of the original forest habitat, also leads to changes in forest ecosystem and is hence known as area effects (Fahrig, 2003). The size of habitat is a key characteristic for forest species conservation, on basis of a positive relationship between habitat area and richness of species. The reduction in forest size significantly leads to decline in species composition, density and diversity in fragments (Laurance *et al.,* 1998; Hill and Curran, 2001), as a result, large forest fragments are necessary for conservation of species, especially strict endemic or near-endemic species (Cagnolo *et al.*, 2006).

According to island biogeography theory (MacArthur and Wilson, 1967), area effects could result in higher extinction rates in smaller habitats, resulting from their sustaining smaller populations which have a tendency being more vulnerable to environmental, demographic and genetic stochasticity (Hobbs and Yates, 2003). On contrary, large habitats usually encompass a wider range of environmental conditions allowing more habitat specialist species to develop (Saunders *et al.*, 1991). In addition, area effects and habitat heterogeneity have been noted to affect tree species abundance and diversity (Hill and Curran, 2001; Cagnolo *et al.,* 2006). In study conducted by Hill and Curran (2001) in Ghana forest fragments, it was observed that the correlation coefficients between the logarithm of tree species number and that of the area of isolated fragments were 0.92 ($p = 0.005$) and 0.87 ($p = 0.005$) for the regenerating trees and mature trees number respectively. The same trend of relationship was also observed by Lida and Nakashizuka (1995) on their study in Japan, which was concluded that large forest patches are significantly important for conservation of species, especially rare ones. This supports the theory that large fragments have greater density and diversity of tree species compared to small ones.

1.3.3.2 Edge Effects

Edges are transition zones separating two or more adjacent habitat types in an ecosystem (Lidicker, 1999). This term is also used in conjunction with boundaries between two adjacent ecosystems (Saunders *et al.,* 1991). Effects associated with edges are normally created through the interactions between the two nearby ecosystems (Murcia, 1995). The formation of edges seems to be an important characteristic of forest habitat fragmentation, for the reason that as forest edge-interior ratio increase, modifications in forest environment, microclimate, vegetation structure, natural regeneration and species composition occur (Murcia, 1995; Jose *et al.*, 1996; Benítez-Malvido, 1998; Didham and Lawton, 1999) as well as forest litter structure and nutrient cycling dynamics (Didham, 1998).

Edge effects and area effects are linked together, and have been observed to be inversely related, *i.e.* as area of forest fragment increases, edge effects decrease (Hanski *et al.,* 1995) and the relative proportions of evergreen and shade tolerating species increase with respect to pioneers (Lida and Nakashizuka, 1995). The edge creation mainly alters microclimatic factors (such as light intensity and duration, air temperature, relative humidity and wind) and soil factors (such as pH, organic carbon, total nitrogen, available phosphorus, soil moisture and temperature), which tend to differ strongly over short distances towards forest interior (Williams-Linera, 1990; Jose *et al.,* 1996; Didham and Lawton, 1999; Newmark, 2001, 2005). According to Laurance *et al.*, (1997), for many physical phenomena, a reasonable assumption for the maximum penetration of edge effects is *ca.* 100 m. Therefore, an alteration in the physical environment situation at the edges, leads to changes in forest vegetation structure, distribution and species composition as compared to interior forest (Oliveira *et al.,* 2004).

In many tropical rainforests, the harsh external climate condition is normally buffered by dense canopy cover, but this breaks down near forest edges (Williams-Linera, 1990; Laurance *et al.*, 2007). Edge effects lead to higher mortality of desiccation-sensitive plant species and seedling damage caused by litter-fall and tree fall near edges (Laurance *et al.*, 1998), but also, it increase sapling mortality by competition with lianas, vines and ruderal species, and increase adult mortality by elevated rates of uprooting and breakage near forest edges (Laurance *et al.,* 1998) as fragmentation enhances accessibility to forest interior (Jha *et al.*, 2005). Strong turbulence can result when winds strike immediate forest edges; increasing rates of wind throw and forest structural damage (Ferreira and Laurance, 1997). Fragmented forests frequently exhibit a proliferation of vines, lianas, and secondary vegetation near edges (Tabarelli et al., 1999) and some forests appear highly prone to invasions of exotic plant species (Laurance *et al.*, 1997).

1.3.3.3 Isolation Effects

Habitat isolation refers to a measure of the amount of habitat to the landscape. When a patch is more isolated, the less the habitat there is in a landscape that surrounds it (Fahrig, 2003). The amount of habitat is the most obvious and visible effect of the process of fragmentation (Gascon *et al.*, 2001). A habitat can be detached from landscape in many various ways resulting in various spatial shapes and patterns (Franklin *et al.*, 2002). These patterns play a significant role in intensifying edge and/or area effects whereby habitat patches of irregular shape becomes more susceptible to edge effects that break through into the interior of the habitat (Hill and Curran, 2005). Normally, the loss of forested habitat results in formation of a new matrix habitat around the isolated forest patches. These matrix habitats facilitate the movement of species between forest patches while hindering others to do the same. Species adapted to disturbances tend to be present in the matrix and may invade forest patches and edge habitat (Murcia, 1995; Gascon *et al.*, 2001). The matrix habitat may also include human settlements, which increases disturbances in forest patch through changing land use, logging, hunting and fire (Newmark, 1998). Due to these grounds, dramatic changes in species composition, abundance and diversity have been recorded in forest patches (Matlack, 1994; Hill and Curran, 2005).

1.3.4 Ecological Consequences of Fragmentation

The tropical rainforests around the globe have undergone remarkable degradation since the beginning of settled agriculture, which was followed by rapid human population growth, the development of technology and increased economic activities (Houghton, 1994). The loss and fragmentation of forest habitats is a direct threat towards biodiversity (Tabarelli *et al.*, 2004). Besides to its intrinsic values, biodiversity is needed for the functioning of ecosystems

(Bierregaard *et al.*, 1992) and for the production of numerous goods potential for human consumption (Schaberg *et al.*, 1999). Always biodiversity is lost through the extinction of local populations of species (MacArthur and Wilson, 1967), and there is often a time lag between the process of habitat loss and the eventual extinction of populations (Tilman *et al.*, 1994). In addition to the loss of biodiversity, the fragmentation and loss of forest habitat jeopardize important ecosystem services (Laurance *et al.*, 1997) such as soil and water conservation (Fearnside, 2005), and a significant terrestrial store of carbon, which contributes to the mitigation of climate change (Glenday, 2006).

Fragmentation of forest habitats is also described to cause ecological consequences, which can be categorized into abiotic effects, direct biological and indirect biological effects (Saunders *et al.*, 1991). All these effects are considered to affect the demographic processes of plants, which, in turn, affect the growth rate and survival of plant populations (Holsinger, 2000). Abiotic effects, involve changes in the microclimate conditions both within and on the edge of forest fragments (Murcia, 1995). Direct biological effects, involve changes in abundance and distribution of species, which are caused directly by the physical conditions near edges (for instance through desiccation, wind throw and plant growth) and determined by the physiological tolerances of species to the conditions on and near the edge (Didham and Lawton, 1999; Laurance *et al.*, 2007). Indirect biological effects, involve changes in species interactions, such as predation, parasitism, competition and pollination and seed-dispersal (Saunders *et al.*, 1991).

Due to changes in micro-environment conditions, forest fragment edges have been observed to have higher air and soil temperatures, which fluctuates more than within the forest interior, and they are more exposed to winds, which reduce humidity and soil moisture, and increase evaporation and desiccation (Didham and Lawton, 1999). The intensity of the edge effects depends much on the fragment size, shape and location in the landscape (Hill and Curran, 2005). Changes in the microclimate can have direct biological effects on plant regeneration and population growth by increasing mortality (Ferreira and Laurance, 1997; Laurance *et al.*, 1998; Mesquita *et al.*, 1999; Tomimatsu and Ohara, 2003) or decreasing seed germination (Bruna, 2002). In tropical forests, where seasonal droughts increase plant mortality, the effects of fragmentation on plant survival are likely to be more severe (Engelbrecht *et al.*, 2007). Thus, as forest becomes increasingly fragmented, populations of forest species are reduced, dispersal and migrations patterns are interrupted, ecosystem inputs and outputs are altered, and previously isolated core habitats become exposed to conditions, all of which result in a progressive erosion of biological diversity (Tilman *et al.*, 1994).

1.3.5 Status of Biodiversity in the Tropical Forests

The tropical forests are the most important areas for conservation in the world given that they contain more than 50 % of the world's species (Whitmore, 1998). Habitat loss and increased fragmentation are major threats towards tropical forests biodiversity (Laurance *et al.*, 1998, 2006, 2007; Benítez-Malvido and Marnítez-Ramos, 2003). Brooks *et al.*, (1999) revealed that forest fragments at the size of 1000 ha will lose 50 % of the forest depending species within the first 50 years following a fragmentation. Many species has already gone extinct in the 20th century due to loss and fragmentation of forest habitat, where 11 % of the world's birds, 18 % of the mammals, 5 % of the fishes and at least 8 % of the plants are threatened with extinction too (Vitousek *et al.*, 1997). Due to increased human population and their demands towards forest resources, about 10.4 million hectares of tropical forests were permanently destroyed worldwide in each year in the period from 2000 to 2005 (http://rainforests.mongabay.com/0801.htm). Moreover, the extreme poverty in many of the tropical developing countries causes loss of biodiversity, since the poverty forces local people to use short-sighted solutions without any concern of the future (Fjeldså, 2007). The utmost challenge for conservation of tropical rainforests for the future is to meet the needs of the present rapidly growing human population, but without compromising the ability of future generations to meet their own needs (UNEP, 2002).

Due to the threat of extinction, the Convention on Biological Diversity (CBD) in 1992 highlighted the global importance of biodiversity, and the need to protect our natural heritage for future generations (CBD, 1992). In supporting this, 190 countries worldwide including the government of the United Republic of Tanzania committed themselves to the Convention on Biological Diversity's 2010-goal, which aimed at significantly reducing the rate of biodiversity loss at global, regional and local levels, at the Johannesburg World Summit on Sustainable Development in 2002 (UNEP, 2002). For this goal to be more successful, focus needs to be put on conservation and development in the tropics, as biodiversity is not evenly distributed. Some areas are far richer on biodiversity than others (Mittermeier *et al.*, 1998, Myers *et al.*, 2000) and these areas are often those with few available resources for conservation (Balmford *et al.*, 2005).

1.4 Objectives of the Study

The study specifically looks at the following objectives within forest remnants in the Uluguru Mountains;

1. To determine and compare floristic composition, species diversity and structure of mature trees (≥ 10 cm DBH) among selected forests.
2. To determine understory composition, diversity and natural regeneration status of selected species among forest fragments.
3. To examine variation in species richness, diversity and density along the edge-interior gradient.
4. To examine indigenous use, tree use values and human population impacts on forest size, species richness and density in Uluguru forest fragments.

1.5 Significance of the Study

Understanding how plant populations respond to spatial and temporal environmental changes is an important aim of plant ecological research (Jongejans and de Kroon, 2005), as species strongly vary in space and time in response to micro-environmental variations in their habitats. Thus, the findings presented in this study provide valuable knowledge concerning the consequences of habitat fragmentation impacts on plant communities as well as the current understanding on species composition, diversity, natural regeneration and their distribution pattern within the fragments. Additionally, the study offers possible recommendations for future studies to be undertaken and it gives suggestions for management and conservation of the forest fragments and their biodiversity.

1.6 Description of the Study Area

1.6.1 Physical Profile

Uluguru Mountains forests (Figure 1.1) are located at about 200 km West of Dar Es Salaam City, and lies South of Morogoro town in Morogoro region. The Mountains form one of the component blocks of the Eastern Arc Mountains forests, stretching down the coast of East Africa from Taita hills in southern Kenya to Udzungwa Mountain in south-central Tanzania (Lovett, 1998; Munishi *et al.*, 2007). The Eastern Arc Mountains are known to be a biodiversity hotspot, a globally important ecoregion and an endemic bird area by conservation organizations such as Conservation International (Mittermeier *et al.*, 1998), the Worldlife Fund for Nature (Burgess *et al.*, 2004) and BirdLife International (Stattersfield *et al.*, 1998). The Uluguru Mountain cover an area of 1,500 km^2 and altitude ranges from *c.*150 m on the southern-eastern margin to a peak of 2630 m at its highest point above sea level (Burgess *et al.*, 2002). The Mountain bedrock is made up of Precambrian metamorphic rocks dominated by hornblende-pyroxenes granulites with injections of granite and gneiss (Munishi *et al.*, 2007).

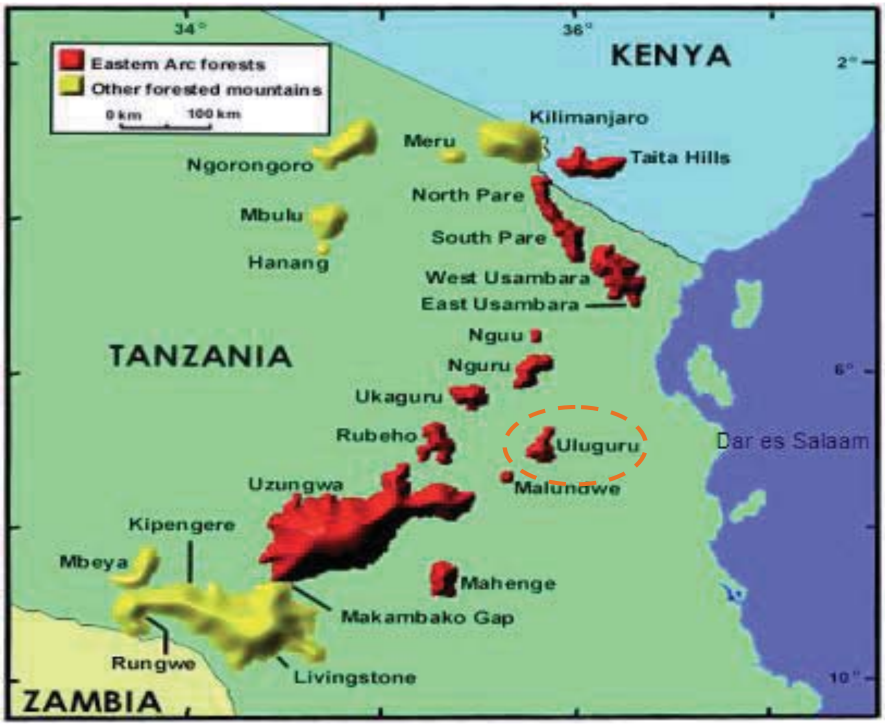

Figure 1.1: The map showing Eastern Arc forests (including Uluguru) and other Mountains forests. *(Source: Eastern Arc Conservation Endowment Fund)*

1.6.2 Climate Profile

The Uluguru Mountains forests are one of the wettest areas in Tanzania as they receive high rainfall and form vital water catchment in the country supplying Ruvu River the principal water supply to Dar Es Salaam where more than 6 million people live and most of the industries of Tanzania are based (Burgess *et al.*, 2002; Yanda and Munishi, 2007). The climate is oceanic due to proximity to Indian Ocean with bimodal rainfall regime, the long rains last from March to May peaking in April and the short rains last from October to December. The mean annual rainfall in Morogoro region is about 740 mm with the mean monthly minimum and maximum of 440 and 1094 mm of rainfall. The mean annual temperature is 25.1° C with the mean monthly maximum temperature of 30.6° C and the mean monthly minimum temperature of 19.7° C.

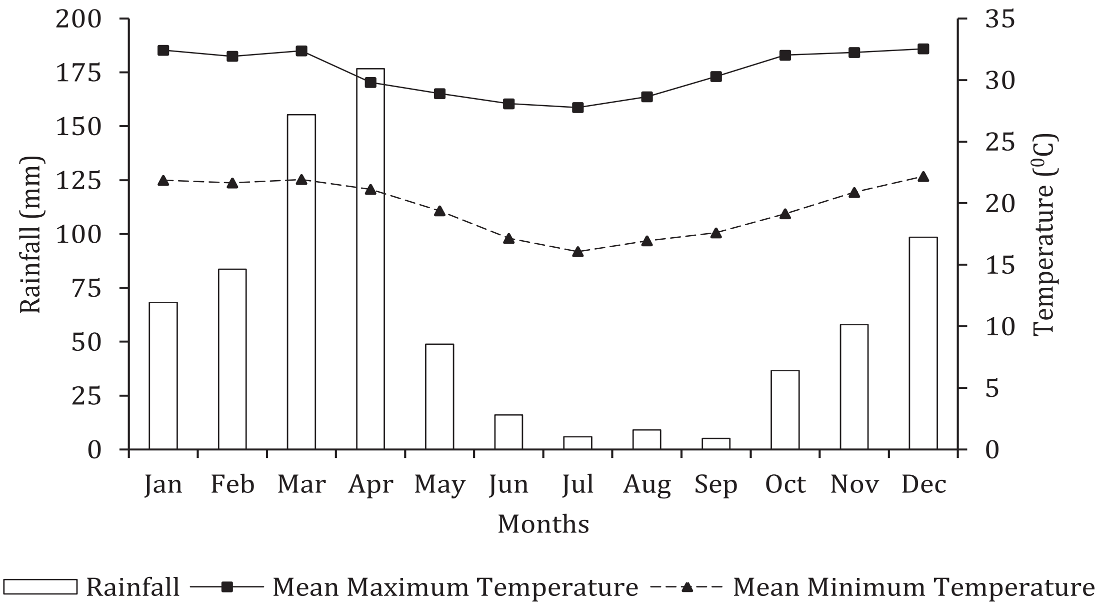

Figure 1.2: Monthly mean rainfall, mean maximum and mean minimum temperatures of Morogoro (2000 -2010).

Source: Morogoro Meteorological Station.

1.6.3 Population size and growth

According to the national population and housing census of 2002, Morogoro region had a population of 1,753,362 male accounting for 49.8 % and female 50.2 % with an average of 4.6 people per household. The regional population growth rate is 2.6 % per annum and had population density of 28 people per km in 2006. In 2002, Morogoro rural district had a population of 15 % of the total population of Morogoro region. The inter-censual population growth rate of the district was 2.2 % and 1.1 % between 1978-1988 and 1988-2002 respectively, the population density of 24 people per km and average household size of 4.7 in 2006. The decline in population between 1978 and 1988 was due to division of this district into two other districts (MRCO, 2006). The wards in which the studied forests are located had population of 2.8 %, 5.2 %, 6.1 % and 7.4 % of the total Morogoro rural district population by the year 2002 for Tawa, Kisemu, Kisaki and Mkuyuni ward respectively.

1.6.4 Socio-economic profile and land use

Agriculture is the main socio-economic activity for the majority of people living in the villages that surround the studied forests. Food and cash crops are grown at subsistence level under a low input system. Example of food crops includes maize, beans, rice, cassava, groundnuts, sorghum, sweet & Irish potatoes and vegetables while cash crops include bananas, oranges, cabbages, mangoes, coffee, groundnuts, sunflower and palm oil. The crops are normally taken to the market centres of Morogoro, Dodoma and Dar es Salaam via road whereas produce sent to distant markets like Mwanza and Kigoma region go via rail. Other land use practices include livestock keeping especially poultry, goats and cows to a lesser extent. Fishing and carpentry are done at a small scale (MNRT, 2004). People living near the forests are also engaged in collection of different forest materials such as firewood for domestic uses, leaves and barks of tree species for medicinal uses. Mining activities were also observed to exist in the vicinity/within the river banks of the Ruvu River at Kibangile village to near to Kimboza forest. It was noted that local small miners are to some extent involved in forest destruction at Kimboza through cutting of poles for building temporary and permanent huts/shelters (MNRT, 2004). Illegal timber harvesting was also observed in the forests. Moreover, other studies (Sheil, 1992; Kaale, 2004) have reported threats to coastal forest species due to uncontrolled and unsustainable extraction trees for timber, poles, charcoaling, expanding agricultural activities and wild fires.

1.6.5 Biodiversity Profile

Uluguru Mountain forests are one of the regions of biodiversity hotspots and centre of endemism for both, flora and fauna (Myers *et al.,* 2000). Moreover, Uluguru is known to harbour a significant proportion of endemic/near endemic species (Temu and Andrews, 2008) and common species population that occur in other parts of the world (Moreau, 1966; Lovett, 1988). Although the vegetation cover of these mountains is less than 2 % of Tanzania's land area, they harbour 30-40 % of countries flora and fauna and the level of endemism is much greater than the African average (Brenan, 1978). Thus, the Mountains are one of the 10 most important tropical forest sites for conservation on the African continent (Burgess *et al.,* 2002). About 108 endemic plant species are known to exist in the Mountain forests, the majority being shrubs followed by herbs, trees and climbers, many being confined to family Rubiaceae (38 species in 11 genera), Orchidaceae (13 species in 7 genera), and Balsaminaceae (11 species in 1 genus) (Temu and Andrew, 2008). At least 16 endemic vertebrate are known to exist, with hundreds of more taxa for both flora and fauna being shared only with other Eastern Arc forests (Burgess *et al.*, 2002).

1.6.6 Site selection

Seven forests were selected (Table 1.1 and Figure 1.3) based on the following criteria; (1) forest fragments of different sizes (2) minimum anthropogenic disturbances and (3) homogeneous topography *i.e.* lowland forests. Some common anthropogenic disturbances could be observed in almost all forests with common activities including removal of tree barks for medicinal purposes, trespassing, and trees cutting for timbers, firewood/charcoaling and poles for building purposes. All the forests were surrounded by villager's farmlands. Of the 7 forests, only Kimboza forest is owned by the central government under the Morogoro regional catchment forest office while others are under the local village government authorities. Kimboza forest extends from Mkuyuni to Kisemu ward, Kisego and Gunauye are in Mkuyuni ward, Milawilila and Ngambaula are in Tawa ward, while Kilengwe and Nemele are located in Kisaki and Mtombozi wards respectively.

Table 1.1: List of studied forests, location, area and altitude in Uluguru, Morogoro

Forest Name	Latitude/Longitude	Area (ha)	Altitude (m)
Kilengwe	07°29´S/37°32´E	995	182-228
Kimboza	07°00´S/37°48´E	405	300-400
Kisego	06°59´S/37°47´E	119	280-420
Milawilila	06°58´S/37°45´E	13	320-400
Nemele	07°11´S/37°46´E	8	280-500
Ngambaula	06°58´S/37°45´E	3	480-594
Gunauye	06°58´S/37°50´E	3	300-420

1.7 Scope of the Thesis

This dissertation is structured into six chapters. This chapter provides the theoretical background, objectives, significance of the study and describes in details the study areas. Chapter 2 to 5 form an empirical part of the thesis, and address the four objectives respectively. Chapter two addresses the floristic composition, species diversity and structure of trees with DBH ≥ 10 cm in the selected Uluguru forests. Chapter three describes the understory species composition, richness, diversity and natural regeneration of the forests. Chapter four addresses the variations of species richness and diversity of four compartments (overstory, large saplings, small saplings and seedlings) along the edge-interior gradient in all the selected forests. Chapter five describes the uses and use values of different tree species by the local community in Uluguru. Finally, chapter six provides a general discussion of all the findings in relation to the objectives and gives conclusion as well as recommendations for further studies.

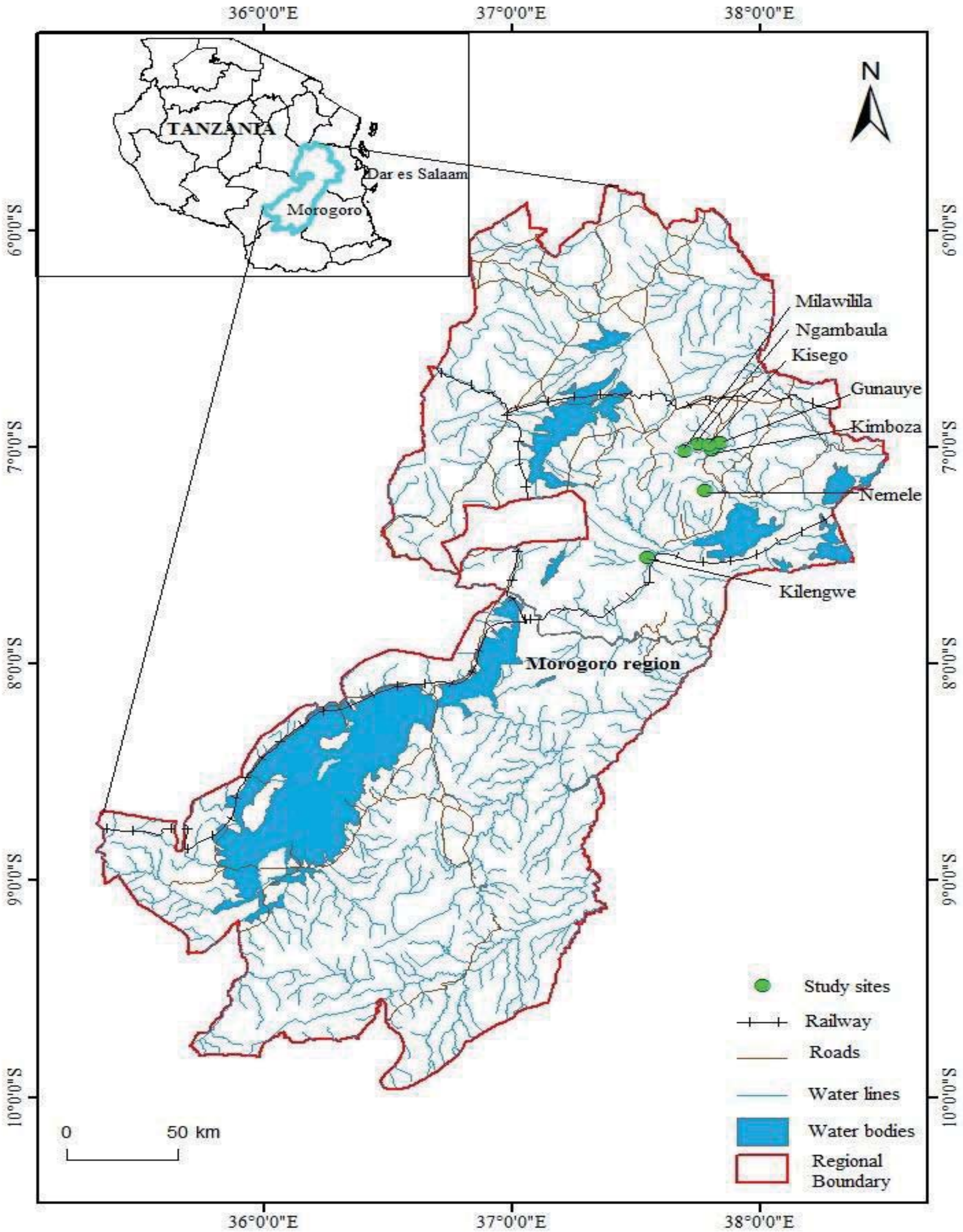

Figure 1.3: The map showing location of the study sites in Morogoro region.