INFLUENCE OF HUMAN ACTIVITIES ON THE DEGRADATION OF MONTANE FORESTS IN MAGAMBA NATURE RESERVE, LUSHOTO DISTRICT, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN LAND USE PLANNING AND MANAGEMENT OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

A study was conducted in Magamba Nature Reserve (MNR), Tanzania to determine the influence of human activities on the degradation of Montane forest in order to generate information for guiding forest conservation and management approaches. Field survey coupled with remote sensing and Geographic Information System (GIS) were used to collect data on land use and human activity patterns. Participatory Rural Appraisal (PRA) tools including focused group discussion, questionnaire survey and participant observation were used for human activities data collection. Ninety respondents were randomly selected for the questionnaire interview in order to determine the human activities in MNR. The forest degradation was determined by means of systematic sample plot inventories, where stems density, basal area and stand volume of stand trees including biomass for 2009 and 2013 were measured. Data collected were analysed using GIS and descriptive statistical procedures. Multiple regression analysis was used to establish the relationship between forest degradation and human activities. Results indicate that the major human activities in the study area on average are collection of firewood (23 %) and medicinal plants (19 %), illegal lumbering (10 %), cutting trees for building poles (3 %) and animal grazing (10 %). The results indicate a significant correlation between biomass change due to firewood collection and distance from village centre (R^2 = 0.706) and distance from major roads (R^2 = 0.650). These results suggest that forest degradation is higher near major roads and village centres. Distance from major roads and village centres can thus be taken as predictors of forest degradation. The findings of this study will enable the understating of the drivers of deforestation and forest degradation and will also be fundamental for the development of policies and measures that aim to alter current trends in forest activities toward a more climate and biodiversity friendly outcome.

DECLARATION

I, Mohamed Fadhili Mwabumba, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

To my Parents, my late father Mr. Fadhili Issa Mwabumba and my mother Mrs. Saida Mwabumba who built a strong foundation for my education, also to my wife Sekela Twisa, my daughter, Nadia and Son Alpha.

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LIST OF ABBREVIATIONS AND SYMBOLS

CEPF	Critical Ecosystem Partnership Fund
DBH	Diameter of Breast Height
FAO	Food and Agriculture Organisation
FBD	Forest and Beekeeping Division
FR	Forest Reserve
G	Basal Area
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
GR	Game Reserve
H	Height
Ha	Hectare
M	Metre
m^2ha^{-1}	Meter square per Hectare
m^3ha^{-1}	Meter cubed per hectare
MNR	Magamba Nature Reserve
MNRT	Ministry of Natural Resource of Tanzania
Nha^{-1}	Number of Stems per hectare
NBS	National Bureau of Statistics
NCAS-T	National REDD Strategy and National Carbon Assessment System.
NMRV	National Measurement Reporting and Verification System.
REDD	Reduce Emission from Deforestation and Forest Degradation
R-PP	National Readiness Preparation Program
SEKOMU	Sebastian Koloa Memorial University

SPSS	Statistical Package for Social Sciences
T	Tonnes
tha^{-1}	Tonnes per hectare
TM	Thematic Mapper
UNESCO	United Nations Educational, Scientific and Cultural Organisation
URT	United Republic of Tanzania
USGS	United States Geological Survey
V	Volume

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Montane forest ecosystem in Tanzania covers about 2 million hectares of land (URT, 2009). Most of these forests are located in the mountainous areas including the eastern arc mountains at an elevation ranging from 1400 to 1800 m above sea level (Mbwambo *et al*., 2012). Montane forests in Tanzania are potential water catchments for major rivers including Kilombero (Rufiji basin); Wami, Ruvu and Kihansi (Wamiruvu basin); Pangani and Sigi (Pangani basin). They are also centres of high biodiversity of flora and fauna harbouring endemic and near endemic species (21 % of *sphaecidae* (*Hymenoptera*), 45 % of the world known *Gastropoda* (snails, slugs etc.) (Pocs, 1988; Bjørndalen, 1992). These forests are regulators of micro-climates and are potential for carbon sequestration, also are important for timber and non-timber products (URT, 2007).

The most common timber tree species in the Montane forest include *Ocotea usambarensis, Podocarpus spp, Entandrophragma excelsum Sprague* and *Juniperus procera* (Conte, 1999). Tree species for non-timber forest products include *Catha edulis Forsk, Warbugia spp,* and *Prunus africana* (Msuya, 1998). However, these forests are threatened by unsustainable human activities. The most common human activities triggering degradation in Montane forests include, clearing for new farmland, pitsawing, illegal timber harvesting, collection of building poles, cutting trees for medicine, collecting fuel wood, and mining activities (Zahabu and Malimbwi, 1997; Maliondo *et al*., 2000; Malimbwi and Mugasha, 2001). For example, a study conducted by Ndagalasi *et al*. (2007) in the Magamba Nature Reserve in Tanzania, found that forest degradation of tree species including *Ocotea usambarensis* and *Podocarpus usambarensis* was rampant due to illegal selective commercial logging, subsistence harvesting of trees for building poles and fuel wood collection. Malimbwi *et al*. (2005) and Burgess *et al.* (2009) reported high amount of carbon losses estimated at 34 million tonnes for the past 20 years in the forest Reserves attributed to significant forest degradation. Due to the fact that mountain forests in Tanzania are centre for endemic forest plant species, loss of forest of a particular range will certainly lead to loss of species as reported by Burgess *et al*. (2002). It is argued that conservation and management of forests will require practical strategies and framework that enhance collaboration between forest managers and the adjacent communities (Iddi, 2000; FBD, 2006). Such endeavours are likely to minimise illegal human activities from adjacent local communities in the catchment forests like Magamba Nature Reserve (Kilahama, 2008).

For successful implementation of forest management strategies and frameworks, adequate data at landscape scale that link spatially land use and degradation of forest types will be required. Lack of such data has been pointed out as one of the major limitations for developing sophisticated management and conservation strategies of forest Reserves (Rondon *et al.*, 2012). This requirement can partly be achieved through a better understanding and analysis of the drivers of forest degradation in particular land use (Burgess *et al.,* 2010). This study therefore aimed to generate relevant data on human activities in Montane forests in relation to degradation of the same with Mgamba Nature Reserve being used as a case study. It is envisaged that such information would be useful in efforts aimed at guiding forest conservation and management endeavours.

1.2 Problem Statement and Justification

Baseline data on land use and forest degradation for implementation of forest conservation interventions are not readily available. For many of the existing pilot forest management projects, land use data have been determined from simple logical argument based on assuming continuation of past trends (Sandra *et al.*, 2003). Most studies on forest degradation have not been linked to the anthropogenic activities at the scale of landscape. For instance, studies conducted down the slopes of Mount Kilimanjaro including Montane forest belt revealed that cultivation and timber harvesting are the main drivers of forest degradation (Yanda and Shirima, 2001; Mbonile *et al*., 2003). Kihupi *et al.* (2004) also addresses this issue in a study on the contribution of shifting cultivation towards forest degradation. In this study it was reported that cultivation per se cannot be taken as the major cause of forest degradation but rather the methods of cultivation including slash and burn among other factors. This calls for a need to quantify at a Landscape scale the influence of anthropogenic activities on forest degradation.

In this study participatory approaches were used which contribute to better management and sustainable conservation interventions of Magamba Nature Reserve by making communities and resource officers work together. The approach is of paramount importance in addressing mitigation and adaptation measures in the light of climate change. Results from this study will provide input into endeavours geared towards mitigation and adaptation to climate change and to many local and national policies and programmes.

This will include the national forest resources monitoring and assessment, reducing emission from deforestation and forest degradation (REDD) initiative, REDD baseline scenarios development, national REDD strategy and national carbon assessment system (NCAS-T), national readiness preparation program (R-PP), and national environmental and forest policies as well as international policies related to climate change.

1.3 Objectives

1.3.1 Overall Objective

The overall objective of this study was to establish spatial information that link human activities and degradation of Montane forest, for guiding forest conservation and management initiatives.

1.3.2 Specific Objectives

Specifically the study aimed to:

i. Examine the most common human activities associated with Magamba Nature Reserve.

ii. Determine the Nature of forest degradation in Magamba Nature Reserve in space and time.

iii. Correlate spatially the extent of forest degradation with respect to human activities in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Land Use and Human Activities

Land use is defined as "the total arrangements, human activities, and inputs that people undertake in a certain land cover type'' (Anderson *et al.*, 1976; FAO, 2006). The impact of human activities on natural landscapes has been increasing during the last few decades with loss of biodiversity as one of the negative results (Forester and Machlis, 1996; Shemdoe, 2004). Human activities have resulted in environmental changes that accelerate and interact with other environmental changes at local, regional and global scale. About 50 % of the land surface has been transformed by human action with significant consequences on biodiversity, nutrient cycling, soil structure and biology, and climate (Shemdoe, 2004).

For example, the study by Monga and Gwegime (2011) on the deforestation and degradation of Dar es Salaam green belt found that, human activities like animal hunting and charcoal burning are responsible for the increasing rate of deforestation and forest degradation of Pugu, South Ruvu and Kazimzumbwi forest Reserves. Human activities as will be used in this study indicate the land uses undertaken by the community surrounding Magamba Nature Reserve. Once all human activities on forests are well defined and their magnitude and interactions understood, a decision framework addressing the priority drivers of deforestation and degradation can be developed (FAO, 2010).

2.2 Forest Degradation

Forest degradation can be quite confusing as most of the literature and experts do not give a clear-cut distinction between forest degradation and deforestation (Arildsen and Kaimowitz, 2001; Geist and Lambin, 2002).

For example, Verolme *et al.* (1999) define forest degradation as the reduction of canopy cover and/or reduction in quality of the forest through logging, animal grazing and fuel wood collection. Bajracharya (2008) define forest degradation as changes within forest class, which negatively affect the stand or site, lowering the species composition, biological diversity and productivity. According to Milledge and Kaale (2003), forest degradation can be defined as impoverishment of standing woody material mainly caused by human activities such as over-grazing, over-exploitation (for wood fuel in particular), repeated fires, or due to attacks by insects, diseases, plant parasites or other natural causes such as cyclones. Singh (1998) defines degradation as “chronic disturbances’’; removal of only a fraction of forest biomass at a given time, while Murdiyarso and Skutsch (2006) defines forest degradation as a results of extracting more biomass from the forest than it can sustainably produce. In this study the definition adopted for forest degradation is in the context of climate change as defined by Zahabu (2008), which refers to the loss of carbon from within a forest due to thinning out of the biomass stock, without loss of forest area.

2.3 Human Activities and Forest Degradation

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There is significant reported forest degradation of montane forests occurring in many Nature Reserves in Tanzania (Malimbwi *et al.,* 2005; Mbwambo *et al.,* 2012). The agents of forest degradation include the increasing demand for more arable land and human settlements, overgrazing and uncontrolled logging (Kaoneka and Solberg, 1993). Illegal human activities like illegal timber harvesting, charcoal production, firewood extraction and animal grazing are reported major causes of forest degradation across Africa (Kissinger *et al.,* 2012). Halperin and Shear (2005), found that human activities like pitsawing, pole cutting, animal grazing and clearing forest for agriculture were major causes of degradation in West Usambara Forest Reserve. Although many studies have been done on human activities and forest degradation (Burges and Hipkins, 2002; CEPF, 2003; Milledge and Elibariki, 2005), the influence of human infrastructure associated with extraction of forest products has not been given due attention. In this study, using spatial analyses the influence of human activities and their infrastructure will be addressed.

2.4 Forestry in Tanzania

Literature shows that by 2010 Tanzania Mainland had a total of 33.428 million hectares (ha) of forests (URT, 2013). Woodlands occupy about 90 % of the total forest area.

The rest are mangrove forests, Montane forests, small patches of coastal forests and plantations of softwood and hardwood (URT, 2012). Of the total forest area, 16 million ha are reserved forests, 2 million ha are forests in national parks and 15.4 million ha are unprotected forests in Village land and in General land (URT, 2013).

The Magamba Nature Reserve (MNR) located in the West Usambara Mountains has a diverse of vegetation types. These forests are of wetter type than those of Pare Mountains, further west of the area though all of them fall in the eastern arc mountains (Kilahama, 2008). Generally MNR has two main vegetation types with a variety of plant species. The two vegetation types are montane rain and dry forests. Montane rain forest is characterised by Camphor (*Ocotea usambarensis*) with some Podo (*Podocarpus usambarensis* and *Podocarpus pensiculy*) and dense undergrowth of *Lansthus cirumilee*. Montane dry forest is mainly characterized by cedar (*Juniperus procera*) with a thick shrub under story (Kiboga and Machange, 2006). These forests are important assets in Tanzania, offering numerous goods and services in the national economy and to local livelihoods. They contribute in protection of watersheds for power generation, source of water for irrigation and soil nutrient conservation for agricultural production (URT, 2001). Despite all the valuable goods and services provided by natural forests, degradation of forests continues to increase at an alarming rate due to various forms of human needs (Giliba *et al.*, 2011).

2.5 Drivers of Forest Degradation in Tanzania

Tanzania has multiple drivers of forest degradation which interact in a complex structure, mainly accelerated directly by human activities like, clearance for new farmland, pit sawing, harvesting for timber and building poles, cutting trees for medicines and fuel wood collection (Maliondo *et al.*, 2000). A number of studies on the degree of forest degradation caused by human activities on Forest Reserves (FR) have been undertaken.

For example, Rodgers *et al.* (1983) in a study on the conservation values and status of Kimboza Forest Reserve in Morogoro Tanzania reported the presence of forest degradation inside the Reserve, which was caused by logging activity. In a study on degraded vegetation communities in Kiono forest Reserve, forest degradation was largely attributed to land clearing for agriculture (Mwasumbi *et al.,* 1994). The study by Salas (2014) on the implementations of REDD+ in Tanzania, also identified human activities like illegal timber harvesting, charcoal burning, fuel wood extraction, animal grazing and mining activities as major drivers of forest degradation. That study concluded that, proximity and location of the forest relative to community villages and access roads/footpaths to the forest could be the factor accelerated some of the drivers of forest degradation, but did not explain sufficiently the overall relationship between spatial and temporal patterns of human disturbances on forest degradation.

2.6 Determination of Forest Degradation

Determination of forest degradation has been done by measuring changes on standing carbon using a ground forest inventory based on permanent sample plots (PSPs) (Zahabu, 2011) or temporary sample points that are selected randomly or systematically (Zerihum *et al.*, 2012). Forest inventory is the process dealing with measuring and assessing forest resources in terms of its quantity and quality, and monitoring their changes over time (Zahabu, 2008). There are commonly accepted principles of forest inventory following standard procedures which include sampling determination, sample plot layout, tree measurement techniques and data analysis (Philip, 1983, Malimbwi, 1997, MacDicken, 1997). The prevailing reason for conducting a forest inventory is to make better decisions about forest management. The primary need has been the quantification of volumetric product yield and structural composition of the forest. The volume of the timber resource is typically categorized by species, product and size (Scott *et al.,* 2002).

In addition, quantities like the number of trees and basal area per unit area are often desired (Scott *et al.,* 2002). Measurements of diameter at breast height (DBH) alone or in combination with tree height can be converted to estimate forest carbon stocks using allometric relationships. Allometric equations statistically relate these measured forest attributes to destructive harvest measurements, and exist for most forests (Brown 1997; Keller *et al.,* 2001; Chave *et al.,* 2005).

Although the ground measurements for forest resource inventory and assessment are more accurate than satellite measurements, the integrated analysis of environmental data with remote sensing imagery in a Geographical Information System (GIS) framework, allows inferences on how environmental factors influence forest ecosystem functioning. Mapping forest degradation with remote sensing data is more challenging than mapping deforestation because the degraded forest is a complex mix of different land cover types (vegetation, dead trees, soil, shade) and the spectral signatures of the degradation changes quickly (i.e. < 2 years) (Souza *et al.,* 2009).

There is not one method to monitor forest degradation that fits all circumstances and the methodological choice depends on a number of factors including the type of degradation, available data, capacities and resources and the potentials and limitations of various measurement and monitoring approaches. Current degradation rates can be measured through field based data (i.e. Multi-date national forest inventories and permanent sample plot data, commercial forestry datasets, proxy data from domestic markets, and/or remote sensing system) (Herold *et al*., 2011). To measure and monitor forest degradation, the IPCC (2003) defines five carbon pools to be measured and monitored: aboveground biomass, below-ground biomass, litter, dead wood and soil organic carbon. For the purpose of this study changes in aboveground biomass will be used in assessing forest degradation in Magamba Nature Reserve, by using spatial distribution and evolution of human infrastructure (example road and village centres) as proxies for degradation (Mollicone *et al.,* 2007; Protov *et al.,* 2008).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

Magamba Nature Reserve (MNR) is located in Lushoto district between coordinates 04°38S (9487760.14) and 38°10'E (408626.16) and 04°38’S (9487846.58), 38°19’E (425667.064), covering an area of about 340 km² in Lushoto district (Fig. 1). The Reserve is surrounded by 17 villages namely; Magamba village on the east, Kwesimu, Kwembago and Irente on the South – East, Lukozi, Viti, Ndabwa and Hambalawei on the Northern side, Kinko-Mpanda, Kireti and Migambo on the North – East, Mavumo, Gologolo and Manolo on the North – West, Nywelo and Mkunki on the West while Mazinde and Mkumbara villages border the Reserve on the Southern part. (Kilahama, 2008).

3.1.2 Climate

The climatic condition of the area is characterized by cool weather throughout the year. The area experiences two distinct rainy seasons, long rains (*Masika*), from mid-March to May and short rains (*Vuli*) between October and December (Shemdoe, 2004; Davis *et al.*, 2006; Kamugisha *et al.*, 2007). The mean annual rainfall is 600 - 2000 mm per annum. The mean annual temperature varies with altitude ranging from 25 to 27°C at 800 m a.s.l. and from 17 to 18°C on the plateau at 1500 - 1800 m a.s.l. (Neerinkx *et al.,* 2010).

3.1.3 Topography

The topography is highly variable ranging from undulating plains with gentle slopes to very steep sloping mountainous areas (Neerinkx *et al.,* 2010). Lushoto District comprises four agro-ecological zones, a dry warm zone, a dry cold zone, a humid warm zone and a humid cold zone (Debien, *et al*., 2010).

3.1.4 Vegetation cover

The main vegetation types in the West Usambara Mountains are natural and plantation forests. The vegetation of natural forest is comprised of Comphor (*Ocotea usambarensis*) with Podo (*podocarpus usambarensis* and *Pordicurpus pensiculi*) and an undergrowth of *Lansthus cirumilee* and other shrubs. Associated species are *Parinari excels Pygeum africanum, Ficalhoa laurifolie, Polycas spp. Macaranga kilindscharica, Crysophylum spp. Olea hochstetteri and Cassipourea spp.* The major species of plantation forest are *Cedar* (*Juniperus proceria*) *Cypress* (*Cupresuus lusstanica*)*, Pinus petula* and *Pinus radiate* (Jambia, 1998).

3.1.5 Land use

The dominant land uses include subsistence and cash crop agriculture (covering 58 % of the area), orchards and commercial plantations (11 %), indigenous protected forest Reserves (16 %) and pastures (15 %) (Shemdoe, 2002). The main cash crops are vegetables, fruits and irish potatoes, while maize (*Zea mays*), cassava (*Manihot esculenta*), beans (*Phaseolus lunatus*) and potato (*Solanum tuberosum*) are the main food crops (Kamugisha *et al.*, 2007).

3.1.6 Hydrology

Magamba Nature Reserve has almost 28 permanent and seasonal streams that start within the forest. These streams include Wanilo, Kweshiwi, Kwekulo, Mtonneswe, Kwemikeyu, Makulunge B, Kwekiluwa, Kwebuva A and B, Kwehondo, Bughai A and B, Mshelemele, Korongo (Nk'olongo), Kwemilungi, SEKOMU stream, Kibohelo, Kinko, Mpanda, Kabei, Ndabwa-Lukozi, Hambalawei, Kwekangaga, Mlomboza, Kwembago, Sungwi and Irente. Most of these streams are permanent because of the continuous forest canopy cover and other vegetation like ferns and Albizia spp. which form the catchment area. Magamba Nature Reserve is part of Mkusu watershed which drains into Mkomazi River one of the major tributary of Pangani river along the Mkomazi plains. Magamba Nature Reserve also comprises five dams and three waterfalls which provide good sites for ecotourism. These include Kwehondo, Mlomboza, Hambalawei, Nywelo and Grewal dams and Ngua Mazinde and Sungwi (Tembo Chipboard) waterfalls (Kiboga and Machange, 2005).

3.1.7 Population

According to the 2012 census, Lushoto District is leading in terms of population density compared to the other districts in Tanga region and has a, total of 492 441 inhabitants (NBS, 2013).

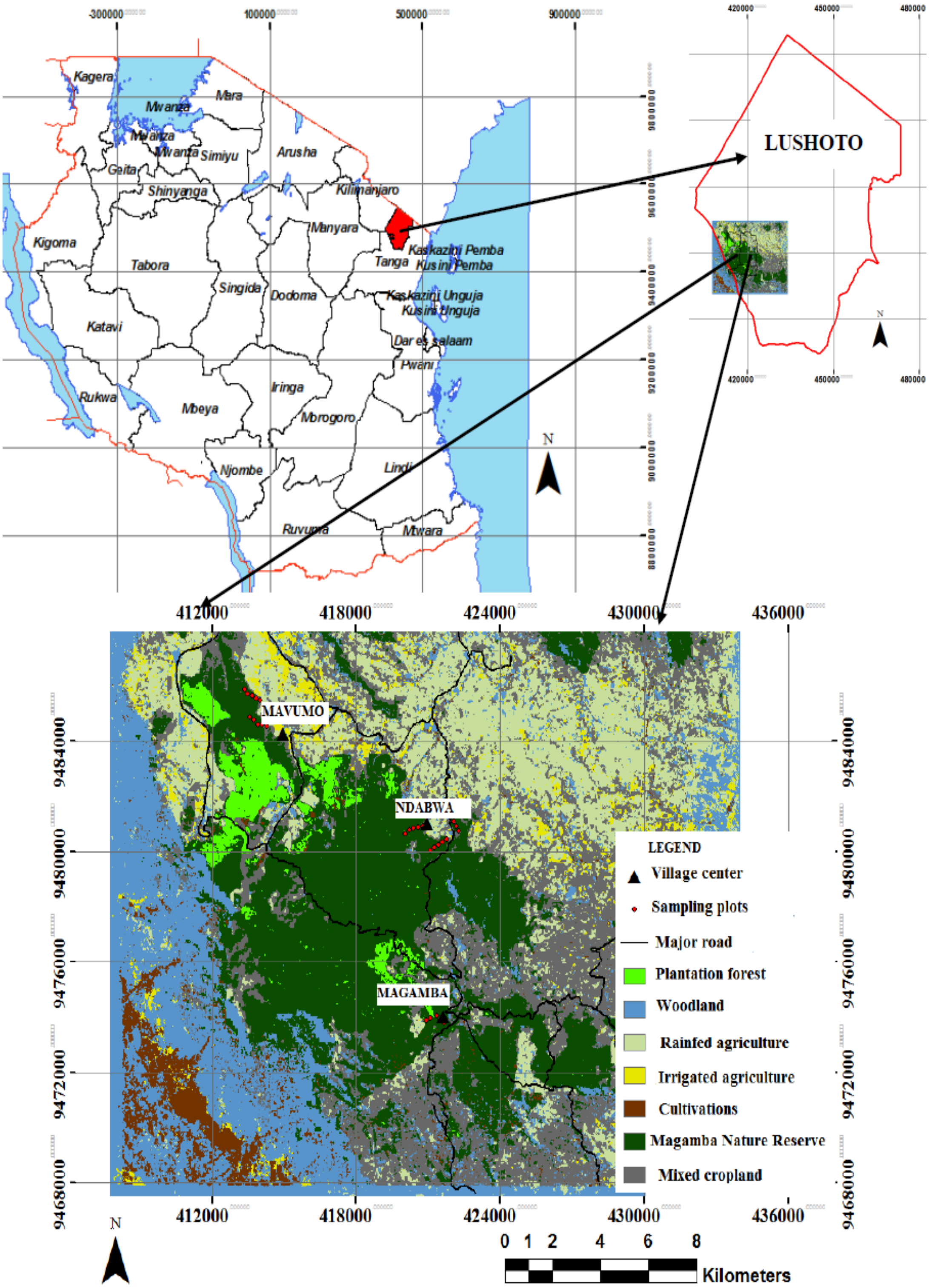

Figure 1: Land cover map in the background showing the studied villages and Magamba Nature Reserve

3.2 Methodology

3.2.1 Collection of human activities data in different land uses

A base map of the study area was derived from different data layers including topographic maps of 1985 at a scale of 1:50 000, SPOT Image Level 1A of 2.5 m x 2.5 m resolution of 2007 and Landsat TM images of 2011 with a medium to high resolution (30 m). The base map was used in the field to locate major land uses, the villages, agricultural fields, plantations and roads surrounding the Magamba Nature Reserve. In this exercise field survey coupled with geographic location using Global Positioning System (GPS) were employed to locate and describe different land uses including farming practices, cropping patterns, grazing activities, settlement characteristics and forests according to FAO guidelines (FAO, 2006). Alongside land use description, detailed forest related human activities were studied at selected sample villages of Ndabwa, Magamba and Mavumo using semi structured questionnaires and key informants. In this exercise, random sampling technique was used for selection of respondents from the selected villages. A total of 90 respondents were interviewed to capture data on human activities in Magamba Nature Reserve such as firewood collection, illegal timber harvesting, animal grazing, collection of medicinal trees and collection of building poles. In addition to human activities secondary data on population and management plans of the MNR was obtained from literature.

3.2.2 Determination of forest degradation in Magamba nature reserve

The forest degradation was determined by means of systematic sample plot inventories using concentric circular sampling plots with radii 5, 10 and 15 m systematically located at 200 m intervals along transects with the interval between transects varying from 500 to 1000 m, established by Mbwambo *et al.* (2012). In this study, 30 sample plots laid out using GPS coordinates taken from the centre of each plot (earlier demarcated by Mbwambo *et al.,* 2012) near the selected study villages were used for the determination of forest degradation. Data collected included tree diameter at breast height (DBH) which was measured as follows: In the 5 m radius subplot all trees with DBH of 5 – 9.9 cm; in the 10 m radius subplot all trees with DBH of 10 – 19.9 cm and in the 15 m radius subplot all trees with DBH ≥ 20 cm. Three sample trees in each plot from DBH classes of 5 ≤ DBH < 10, 10 ≤ DBH < 20 and DBH ≥ 20 cm respectively were used for height (H) measurements. Tree parameters measured included, DBH ≥ 5 cm typically measured at 1.3 m above ground using callipers and tape measures. Heights of standing trees were measured using hypsometers. DBH of all trees and height of sample trees (mostly trees with smallest, medium and largest diameter) were measured directly in the plots. Data on each measurement were recorded along with the tree species name on the inventory form. All tree species were identified and recorded using local knowledge and experience as assisted by two old men from Magamba village, and later on identified in their scientific names by an experienced botanist at the Department of Forest Biology of Sokoine University of Agriculture, Tanzania.

3.2.3 Data analysis

3.2.3.1 GIS analysis

A land use map was created using remote-sensing and Geographic information System (GIS) techniques (Erdas Imagine 2011 and ArcGIS 10.0). The different locations of the origins and destinations of human activities were also identified in MNR with respect to proximity of the surrounding villages. These locations were mapped as point map and analysed together with other vector map layers of road network, forest plots and village boundaries using ARC GIS 10.0. These vector map layers were integrated with land use map in GIS to establish relationship between land use and human activities.

3.2.3.2 Human activities

Number of people per activity related to Magamba Nature Reserve and the studied villages of Ndabwa, Mavumo and Magamba were quantified using Statistical Package for Social Sciences (SPSS). Descriptive statistical analysis using frequency counts and percentages was used to explain human activities of communities adjacent to the MNR. Qualitative data were analysed using content and structural functional analytical techniques in which components of verbal discussions from different respondents were broken down into the smallest meaningful units of information, values and attitudes of respondents (Kajembe, 1994).

3.2.3.3 Determination of forest degradation in MNR

i. Stem density of standing trees (N)

Stem density (N) per hectare was computed as

$$N = \sum \left({n_i}/{a_i} \right) / n \quad \text{……………………………………………………………………} \quad (1)$$

Where; N = stem density per hectare; n_i = stem counts in the i^{th} plot; a_i = area of the i^{th} plot in hectares, n= number of plots

ii. Basal Area (BA) and Tree Volume

Tree DBH and heights of sample trees were used to fit a height DBH equation that was used to estimate heights of trees not measured in the field. The DBH height model fitted was.

$$H = a + b \times DBH \quad \text{……………………………………………………………} \quad (2)$$

(i.e. H= 6.3249+0.3596*DBH with R^2 = 0.5863 for 2009 and H= 0.5439 + 0.7337*DBH with R^2=0.8592 for, 2013).

$$V_i = 0.58Gh_i \quad \text{……………………………………………………………………} \quad (3)$$

Where, V_i = the volume of the i^{th} tree (m^3); G = the tree basal area (m^2); h_i = the total height of the i^{th} tree (m) and 0.58 = the tree form factor. For natural forests in Tanzania, tree form factor of 0.5 is recommended without distinction of the vegetation type involved (Haule and Munyuki, 1994).

Basal area was estimated using the general formula for calculating basal area of trees.

$g_i = \pi DBH^2\ 4$; $G=(\ g_i A \times n)$……………………………………………………………....(4)

Where, g_i=Basal area of a tree (m^2), G=basal area of the i^{th} plot (m^2/ha), A = Plot area (ha), n= number of plots

Tree volume was estimated using the formula:

iii. Estimation of biomass

Local allometric equations were used to compute stand biomass as average sum of trees' biomass in the plots. The use of local allometric equations for areas with similar geographical and vegetation type is recommended in the literature (de Gier, 1999; Brown, 2003; IPCC, 2003). Individual tree biomass was obtained by multiplying tree volume with average tree basic density. Average tree basic density of 0.58 gcm^{-3} for montane forest was used (Munishi and Shear, 2004). Carbon was estimated by multiplying tree biomass with a biomass-carbon ratio of 0.49 (MacDicken, 1997; Brown, 2003). Distribution of number of stems/ha (Nha^{-1}), basal area (m^2ha^{-1}) and stand volume (m^3ha^{-1}) for the year 2009 and 2013 were assessed to describe the presence of human disturbances inside the forest Reserve. Biomass (tha^{-1}) for various tree species suitable for different uses was also assessed.

Changes that occurred in biomass (tha^{-1}) in relation to the trees harvested due to different uses between 2009 and 2013 were considered as the predictor values for forest degradation in the study area.

3.2.3.4 Spatial correlation between forest degradation and human activities in MNR

The land use map developed (Fig. 3) was used in spatial analyses, where shape files for roads were changed into points (i.e. all roads were changed from segments to points using ILWIS software). Since, each point has a coordinate X, Y and each sample plot has its centre point with coordinate X, Y, the distance from plots to all road points were calculated in MS Excel, using a distance formula (Equation 5).

$$\text{Distance }(d) = \left((x_1 - x_2)^2 + (y_1 - y_2)^2\right)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

From $point_1$ (X_1, Y_1) and $point_2$ (X_2, Y_2)

Distances from each plot to all points were calculated, and the shortest distances from all calculated distances for each plot were taken to represent distance from the centre of plots to main road. Then the distance from the centre of each plot to the village centres was calculated using the same formula. These exercises were carried out for each plot to existing major roads using ILWIS software and Excel spread sheet. The average distances from the sampling plots to the main roads and village centres together with number of people engaged in different activities found in each studied village were used in regression analysis to find the correlation between the distance from major road and village centre with human activities (Appendix 8).

After finding the correlation these distances were then employed in regression analyses as a function of human activities to determine the spatial correlation between the forest degradation and human activities by multiple regression analysis (Equation 6).

$$\acute{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_N + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(6)}$$

Where;

$\acute{Y}$= Changes in biomass in tha^{-1} due to human activities.

β = the coefficients determined from the sample data.

$X_1 - X_n$ = the predictor variables (e.g. distance from village centre, distance from major road to sample plots as a function of human activities) and

ε = residual/error.

The regression analyses were performed using SPSS, in which the degradation indicator i.e. changes in biomass in tha^{-1} due to different land uses, was taken as the dependent variable (Ý) while the degradation predictors (i.e. distance from village centres and distance from main road) were the independent variables ($X_1 - X_n$).

CHAPTER FOUR

4.0 RESULTS

4.1 Dominant Human Activities Associated With Utilization of Forest Products in the Study Area

The results present various human activities among the interviewed households in the villages surrounding Magamba Nature Reserve. The most common human activities related to utilisation of forest products are firewood collection for commercial and household use, collection of medicinal plants, illegal timber harvesting, animal grazing, cutting trees for building poles and Charcoal burning. The intensity for these activities on the studied villages of Magamba, Mavumo and Ndabwa differ from village to village as presented in Table 1.

Table 1: Most common human activities in the villages near Magamba Nature Reserve

	VILLAGES		
HUMAN ACTIVITIES	Mavumo%	Ndabwa%	Magamba%
Firewood collection	22	27	21
Medicinal plants	19	14	15
Illegal timber harvesting	13	12	7
Animal grazing	11	13	7
Building poles	3	4	8
Charcoal burning	1	0	1
Animal Husbandry	9	9	11
Honey Harvesting	2	4	4
Agriculture Activities	12	9	4
Business	6	5	14
Employment	2	3	8

4.2 Magnitude of Forest Degradation in Magamba Nature Reserve (MNR)

4.2.1 Stem density of standing trees (N)

Figure 2 presents the mean tree density distribution for Magamba Nature Reserve. The results show a reversed trend, for both measured transects with decrease in number of stems per hectare as DBH classes increases. In Ndabwa village, the mean tree density distribution was found highest in DBH class 5 - 9.9 cm with about 116 $stemsha^{-1}$ and lowest in DBH class ≥ 50 cm with about 1 $stemha^{-1}$. In Mavumo village the mean tree density distribution was highest in DBH class 5 - 9.9 cm with 114 $stemsha^{-1}$and lowest in DBH class 40 - 49.9 cm with 1 $stemha^{-1}$. In Magamba village also the highest mean tree density distribution was found in DBH class 5 - 9.9 cm with 178 $stemsha^{-1}$ and the lowest in DBH class ≥ 50 cm with 3 $stemsha^{-1}$.

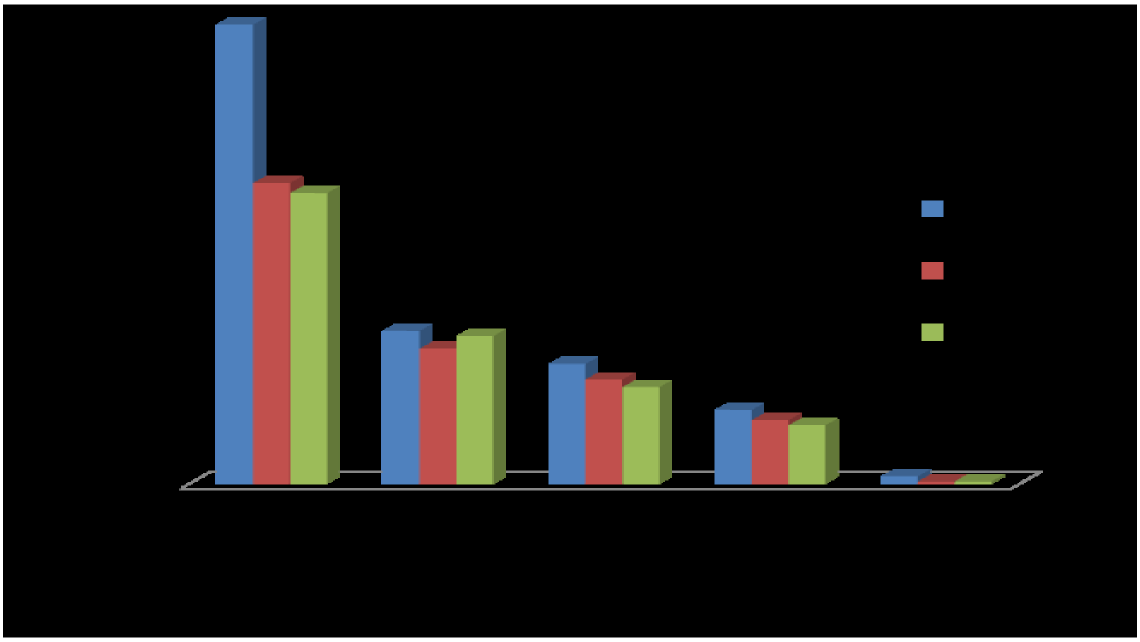

Figure 2: Mean tree density distribution (number of stems per hectare (Nha^{-1}) of stand trees by diameter classes in MNR for the transects in the proximity of Magamba, Ndabwa and Mavumo villages

4.2.2 Basal area per hectare (G)

Distribution of basal area per hectare (m^2ha^{-1}) of stand trees by diameter classes in MNR for the transects in the proximity of Magamba, Ndabwa and Mavumo villages is presented in Fig. 3. The results for basal area (G) for transects near Ndabwa and Magamba villages show an increasing trend, with highest basal area per hectare in DBH class ≥ 40 cm and lowest in DBH class 5 - 9.9 cm. In Mavumo village the results do not obey the J-shaped trend. The trend shows an increase in basal area per hectare with increasing DBH class up to 31 - 40 cm but, decrease with increase in DBH at DBH class ≥ 40 cm as shown in Fig. 3.

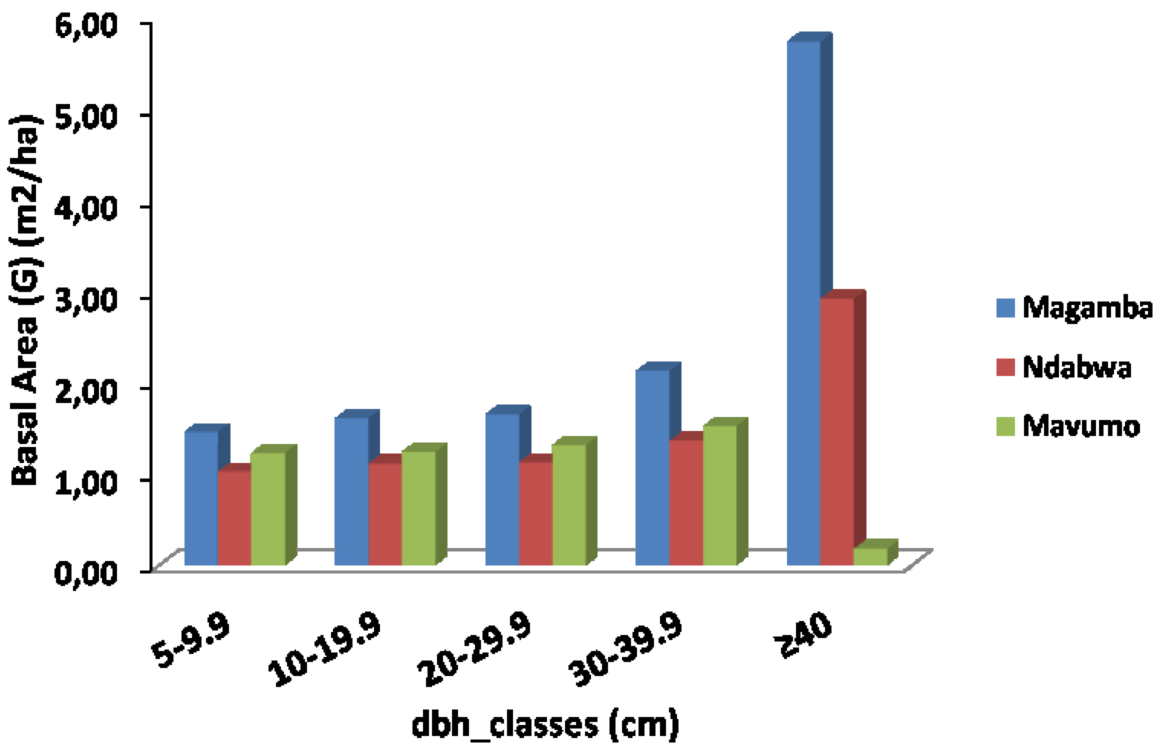

Figure 3: Distribution of basal area per hectare (m^2ha^{-1}) of stand trees by diameter classes in MNR for the transects in the proximity to Magamba, Ndabwa and Mavumo villages

4.2.3 Stand volume per hectare (V)

Figure 4 presents the distribution of stand volume (m^3ha^{-1}) of stand trees by diameter classes in MNR for transects in the proximity of Magamba, Ndabwa and Mavumo villages. The results for stand volume (V) (m^3ha^{-1}) for transects near Ndabwa and Magamba villages show a J-shaped trend, with highest stand volume per hectare in DBH class ≥ 40 cm and lowest in DBH class 5 - 9.9 cm. In Mavumo village the results do not follow a J-shaped trend. The trend shows an increase in stand volume per hectare with increasing DBH class up to 31- 40 cm but, decrease with increase in DBH at DBH class ≥ 40 cm as shown in (Fig. 4).

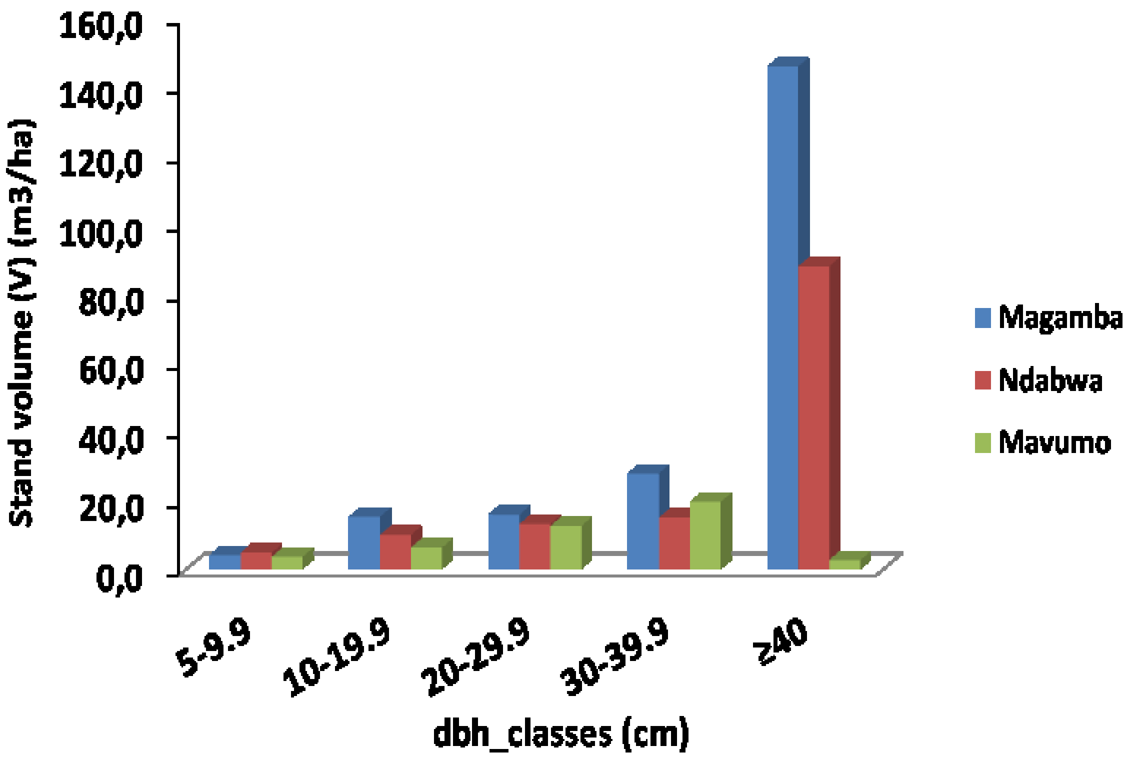

Figure 4: Distribution of stand volume (m^3ha^{-1}) of stand trees by diameter classes in MNR for the transects in the proximity of Magamba, Ndabwa and Mavumo villages

4.2.4 Change in biomass (tha^{-1}) between 2009 and 2013 due to different human activities

Table 3 show the results of change in biomass due to different human activities and Figs. 5, 6, 7 and 8 show the spatial distribution of the biomass change occurred between 2009 and 2013 in Magamba Nature Reserve.

Table 2: Changes biomass (tha^{-1}) occured between 2009 and 2013 due to diffareant human activities

	BIOMASS (tha^{-1})						Change in biomass (tha^{-1}) (2009-2013)		
	MAGAMBA		NDABWA		MAVUMO				
Human activities	2009	2013	2009	2013	2009	2013	Magamba	Ndabwa	Mavumo
Illegal Timber harvesting	9.66 ± 13.15 (89)	16.9 ± 28.8 (111)	8.75 ± 9.55 (64)	8.08 ± 12.75 (93)	3.60 ± 3.07 (83)	4.65 ± 4.30 (90)	7.27	-0.67	1.05
Firewood collection	14.33 ± 22.06 (174)	2.11 ± 2.45 (131)	4.76 ± 3.69 (62)	2.09 ± 3.01 (115)	2.72 ± 3.09 (65)	2.64 ± 0.67 (127)	-0.05	-2.67	-0.08
Building poles extractions	2.20 ± 0.93 (48)	1.09 ± 0.96 (127)	2.62 ± 2.55 (95)	2.57 ± 1.99 (76)	1.42 ± 0.30 (20)	0.73 ± 1.14 (152)	-1.11	-0.05	-1.09
Extractions of traditional medicines	N/A	N/A	9.04 ± 6.70 (83)	6.30 ± 5.46 (136)	1.93 ± 0.36 (20)	1.47 ± 1.77 (136)	N/A	- 0.40	- 0.46
Not yet established	3.60 ± 4.79 (130)	3.34 ± 2.87 (149)	10.74 ± 33.32 (111)	5.70 ± 9.68 (92)	2.32 ± 1.68 (50)	1.62 ± 2.61 (111)	-0.26	-5.04	-0.70

Note. Numbers after +/- are products of Standard Errors of the Mean and t-value at 95% confidence level.
The figures in bracketsm indicate precision levels of estimate i.e. confidence intervals as percentage of mean.
N/A indicates that no species was found to have been extracted by respective human activity in the area.
Negative sign indicate the reduction in biomass and positive sign indicate the increase in biomass.

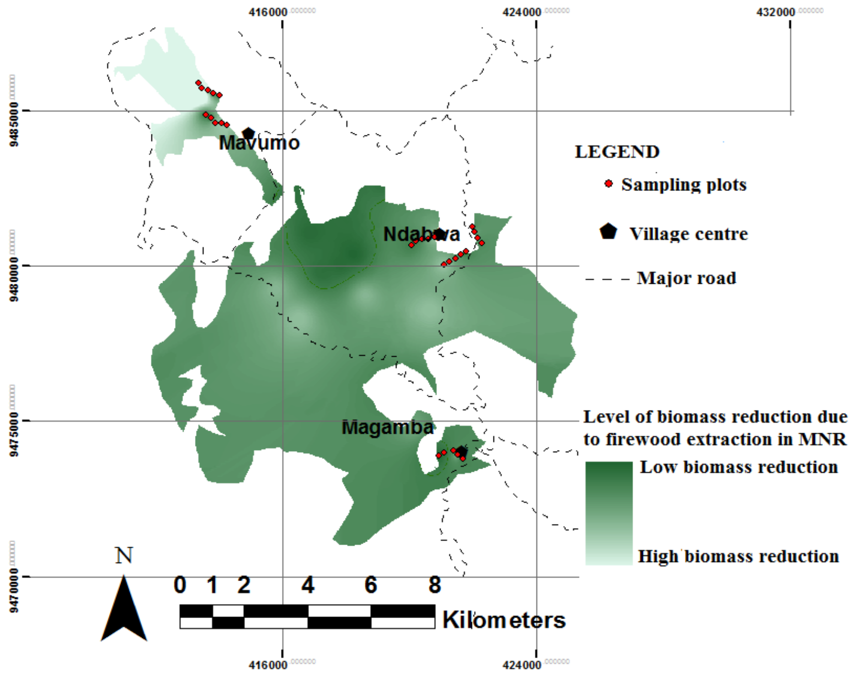

Figure 5: Spatial distribution of biomass change due to firewood collection in MNR between 2009 and 2013

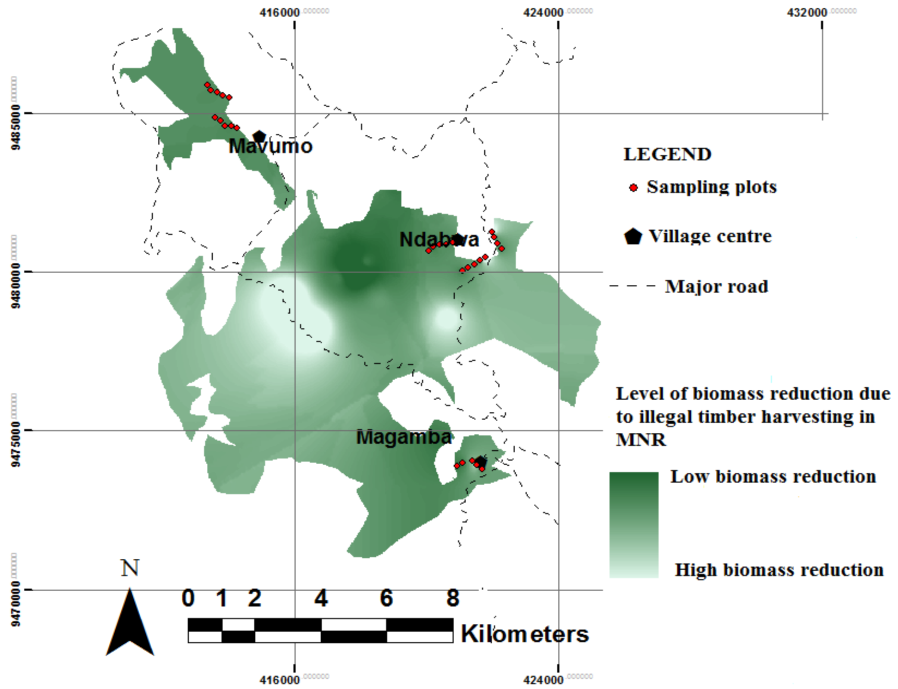

Figure 6: Spatial distribution of biomass change due to illegal timber harvesting in MNR between 2009 and 2013

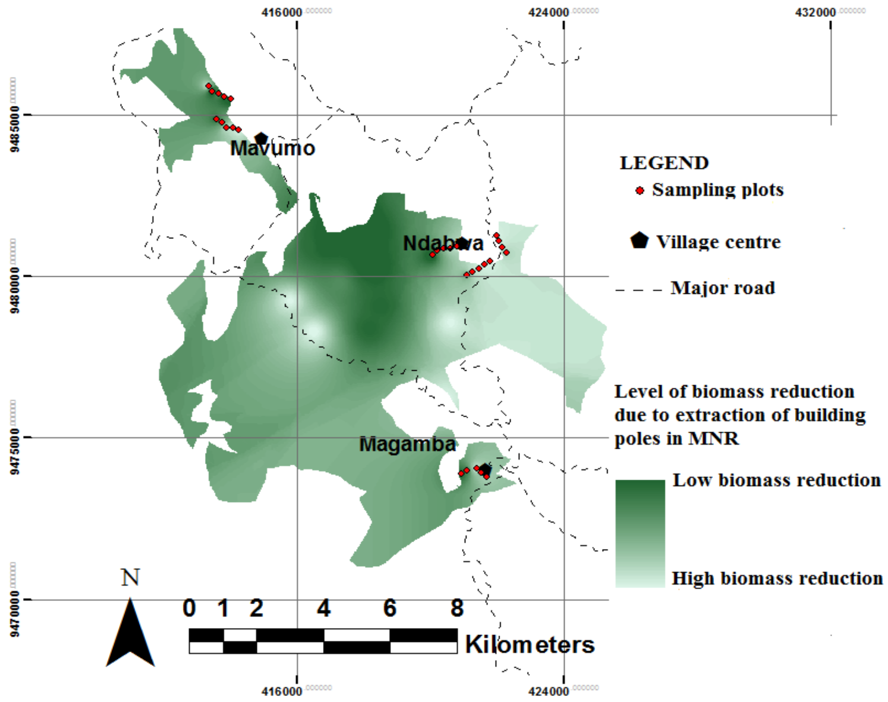

Figure 7: Spatial distribution of biomass change due to extractions of building poles in MNR between 2009 and 2013

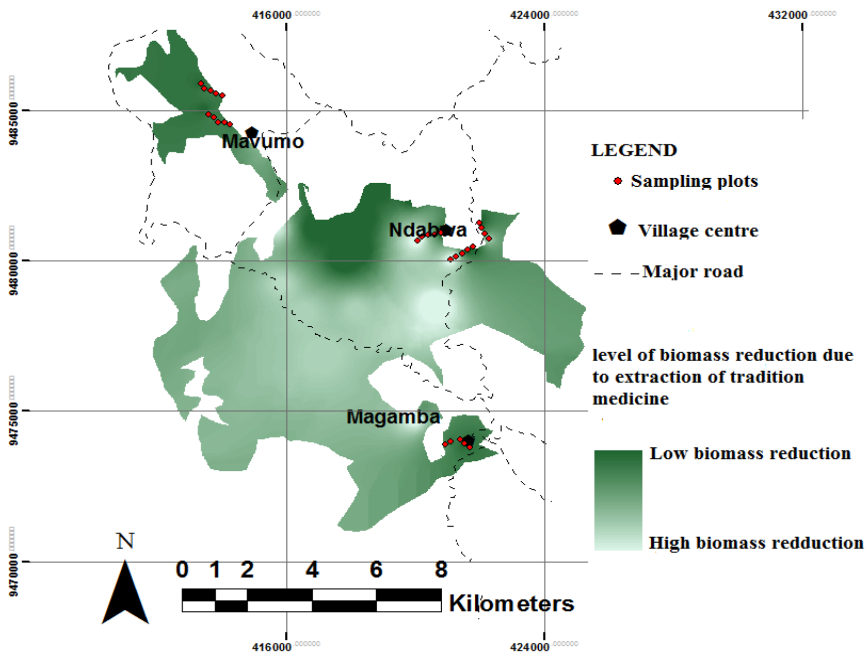

Figure 8: Spatial distribution of biomass change due to extractions of traditiona medicines in MNR between 2009 and 2013

4.3 Spatial Correlation between the Extent of Forest Degradation and Human Activities in the Study Area

4.3.1 Correlation between forest degradation associated with firewood collection and distance from village centre and from nearby major road

Results showed a positive correlation between forest degradation, due to firewood collection, with distance from village centre ($R^2 = 0.706$) (Table 3 and Fig. 9). Results also showed positive correlation between forest degradation, due to firewood collection, with distance from major road ($R^2 = 0.651$) (Table 3 and Fig.10). As you move away from village centre and nearby major road biomass increases by about 71 % and 65 % respectively.

Table 3: Change in biomass (tha^{-1}) due to firewood collection and distance from village centre and major road

Predictor (Z-Score)	Model	ANOVA F	Total df	Level of significance	R^2
Distance form village centre	Y= 0.083+0.02X	11.545	9	0.009	0.706
Distance from major road	Y= 4.434 - 0.011X	7.235	4	0.074	0.651

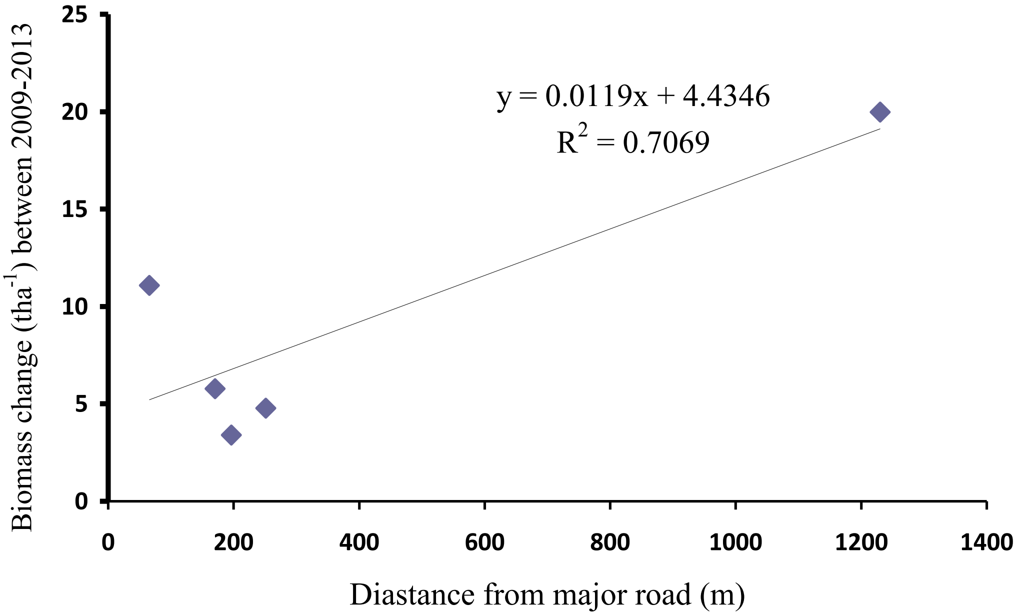

Figure 9: Correlation between change in biomass (tha^{-1}) due to firewood collection and distance from village centres

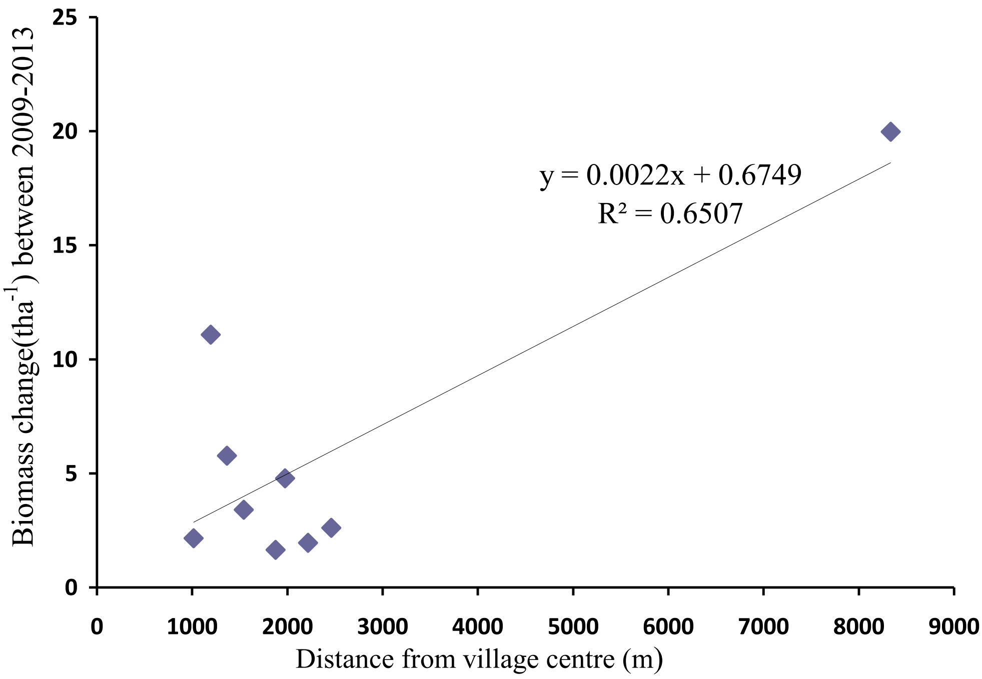

Figure 10: Correlation between biomass change (tha^{-1}) due to firewood collection and distance from the major road

4.3.2 Correlation between forest degradation due to illegal timber harvesting, extraction of building poles and traditional medicines with distance from village centres and distance from nearby major road

Results for forest degradation due to illegal timber harvesting, extraction of building poles and traditional medicines with distance from village centres and distance from nearby major road are presented in Tables 4, 5 and 6. These results show weak correlation between change in biomass for the period 2009 and 2013 with distance from village centre and from a nearby major road.

Table 4: Change in biomass (tha^{-1}) due to timber harvesting with distance from village centre and major road

Predictor (Z-Score)	Model	ANOVA F	Total df	Level of significance	R^2
Distance form village centre	Y= 9.43+0.001X	0.546	17	0.47	0.033
Distance from major road	Y= -21.87-0.012X	5.660	17	0.030	0.261

Table 5: Change in biomass (tha^{-1}) due to building poles harvests and distance from village centre and major road

Predictor (Z-Score)	Model	ANOVA F	Total df	Level of significance	R^2
Distance form village centre	Y= - 2.74+0.001X	2.890	6	0.167	0.026
Distance from major road	Y = -1.651+0.0004X	1.637	6	0.257	0.247

Table 6: Change in biomass (tha^{-1}) due traditional medicines harvest and distance from village centres and major road

Predictor (Z-Score)	Model	ANOVA F	Total df	Level of significance	R^2
Distance form village centre	Y= -6.576+0.0004X	0.847	9	0.384	0.096
Distance from major road	Y= -8.739-0.01X	0.421	9	0.770	0.013

CHAPTER FIVE

5.0 DISCUSSION

The purpose of this study was to examine forest degradation in Magamba Nature Reserve associated with the most common human activities in the surrounding villages. Firewood collection is the most important human activity associated with forest degradation in Magamba Nature Reserve. Although firewood collection is prohibited in the Nature Reserve and people are aware of the rules and regulations, but still a number of them are engaged in the activity. This could be explained by various factors including increasing demand for firewood due rapid population growth and lack of alternative sources of energy in most rural areas (Campbell, 1996). According to FBD (2006) firewood collection in Nature Reserves could result in serious ecological destruction including, removal of dead wood, which provides food and shelter to a wide range of animal and fungal species hence loss of biodiversity. Firewood collection creates tracks and footpaths in the forest Reserves which results in changes in the micro-environment such as increasing openness of the forest, and soil erosion.

Dependence of communities from the studied villages on medicinal plants is high in the Magamba Nature Reserve (Table 1). This could be attributed to poverty and poor accessibility to proper medical services in the area (Overgaard *et al*., 2012). Collection of medicinal plants is associated with forest degradation as the process is destructive in the sense that it involves uprooting plants, root cutting, and tree ring debarking (FBD, 2006). Such human activities in the forest Reserves hamper regeneration of tree plants and lead to loss of important tree species (Kimaro and Lulandala, 2013). Illegal timber harvesting in MNR by communities around the Nature Reserve is a lucrative business providing income and employment opportunities in the area. High demands of timber in domestic and crossborder markets pose significant threat to sustainable management of forests (Milledge and Elibariki, 2004). These demands enhance destruction of forest resources, biodiversity and forest services such as water and climate (Kishor and Damania, 2006; Tacconi, 2007). Networks of corruption, crime, and trafficking are other undesirable outcomes associated with illegal timber harvesting (Smith *et al*., 2003; Tacconi, 2007).

Low cost housing in and around the study area is sustained mainly by building poles harvested from forest and forest reserves including MNR. Field observations show that long and straight building poles and of good diameter are commonly harvested for house construction in the villages surrounding Magamba Nature Reserve. This activity is associated with destruction of the existing tree species and also retards plant regeneration process (Ahrends, 2005). Animal grazing and charcoal burning are other human activities taking place in Magamba Nature Reserve. Grazing in forest reserves destroys young tree seedlings and impairing natural regeneration of trees (Holtmeier, 2012). Charcoal burning seems to be relatively low when compared with other human activities (Table 1), but its contribution to forest degradation can be significant (Zahabu, 2008). The growing population of Lushoto town and other rural market centres is likely to increase the demand for charcoal as a major source of energy for households (Clarke and Dickinson, 1995; CEPF, 2003). The human activities reported in this study as drivers of forest degradation in Magamba Nature Reserve could largely be attributed to population growth in the district and the expanding urbanization (URT, 2013). According to NBS (2013), population size of Lushoto District for the year 2002 was 419 970 and 492 441 for the year 2012 which is an increase of 17 % over a period of 10 years. Population size and density are reported to have major consequences for the intensity of forest resource use (FAO, 2003) including extraction of forest products and services (Mitinje *et al.,* 2007). The extent of human activities in forest reserves differs according to geographical proximity to forest Reserves and socio-economic setup of the surrounding communities. For practical reduction of Carbon emission, active participation of communities around forest Reserves has to be given high consideration in Tanzanian REDD+ initiatives and strategic interventions.

Distribution of stem density observed in MNR with respect to human activities for the studied villages of Ndabwa, Mavumo and Magamba shows the decreasing trend of stem density as expected. This indicates that the Magamba Nature Reserve was over exploited in the past due to unabated exploitation of trees with larger diameter classes probably for commercial timber extraction, charcoal making, and for harvesting building materials (Zahabu, 2008). The presence of many small diameter trees and few large diameter trees also is an indication of high regeneration likely to be the result of past disturbances as attributed to harvesting of timber and building poles, wild fires and forest encroachment for various uses including farming (Zahabu, 2008). The results for the distribution patterns of basal area (m^2ha^{-1}), and stand volume (m^3ha^{-1}) of stand trees in MNR close to the studied villages of Ndabwa and Mavumo, shows the increasing trend with increase in DBH class (Figs. 4 and 5). This is a normal feature for naturally grown forests (Mbwambo *et al.,* 2012), although there are obvious discontinuities between classes, which indicate past over-exploitation of some preferred trees. In Mavumo village the distribution pattern of observed parameters in DBH classes showed a curved–shape trend with increase in DBH classes, which is contrary to the expected normal increasing trend for basal area and volume for natural forest. This trend could be attributed to over exploitation of forest resources that removed large valuable tree species in the area (Zahabu, 2008).

The forest area near Magamba and Ndabwa villages has good recovering rate from degradation when compared with regeneration in Mavumo village, where tree harvesting especially for trees of 40 cm DBH and above disturbed the regeneration trend. The forest area near Mavumo village seems to be more affected by human activities such as firewood collection, extraction of building poles, extraction of traditional medicines and illegal timber harvesting. The forest disturbance is further influenced by location relative to forest management surveillance control points compared with the forest area near Magamba and Ndabwa villages.

The results for biomass (tha^{-1}) show a considerable decrease in forest quality due to different human activities including firewood collection, extraction of building poles and traditional medicines and illegal timber harvesting (Kimaro and Lulandala, 2013). The losses in forest quality include decrease in number of tree species such *as Albizia gummifera* (*J.F.Gmel*) *C.A.sm; Clausena anisata* (*Wild*) *Benth; Cussonia spicata Thunb and Memecyclone deminutum Brean*. On the other hand the decrease in forest biomass between 2009 and 2013 is another significant indicator of forest degradation in Magamba Nature Reserve. The observed trend is probably attributed to forest disturbances by human activities including illegal timber harvesting and building poles extraction (Table 2). Another plausible explanation is that the change in status of forest management regime of Magamba Forest Reserve into Magamba Nature Reserve (UNESCO, 2010) was not well received by the people living around Magamba who foresee limited benefits from the new forest management regime (Mbwambo *et al.*, 2012). Illegal firewood collection by the adjacent communities also seems to contribute much to the forest degradation in the area (Table 2; Fig. 5). In the forest area near Magamba village, biomass reduction due to firewood collection is higher compared with Mavumo and Ndabwa villages (Table 2). This could be explained by increased population in Magamba village and proximity of the area to Lushoto town.

Forest degradation in the study area is also attributed to harvesting of building poles which selectively affect tree species *like Dasylepis integra warb; Drypetes usambarica* (*Pax*) *Hutch; Memecyclon deminutum Brean and Turraea floribunda Hochst* (Fig.7). The reduction in biomass due to extraction of building poles seems to be higher in Magamba and Mavumo villages compared with Ndabwa village (Table 2). Forest area near Magamba village seems to be more disturbed due to the extraction of building poles despite of being close to forest management and surveillance centre unlike forest area around Mavumo village which is far away from management surveillance control.

Tree harvesting for traditional medicines is also among the human activities which can pose forest degradation (Table 2) in the study area. Dominant tree species suitable for medicines such as *Clausen anisata* (*Wild*) *Benth; Dracaena usambarensis Engl; Ficus thonningii Bl* and *Warbugia ugandensis Sprague* are mainly found in forest area near Ndabwa and Mavumo villages. The biomass in this area shows a considerable change between 2009 and 2013 (Table 2). In the forest area near Magamba village such tree species were less prominent. It is clear from this study that the reduction in biomass due to extraction of traditional medicinal plants in Mavumo and Ndabwa villages is significant (Table 2; Fig. 8). Human activities inside the forest Reserve, like animal grazing and charcoal burning are also common as observed in this study (Table 1).

In this study a strong correlation was observed between forest degradation due to firewood collection and distance from the village centres and from near major roads. Results indicate further that distance from village centres and from major roads are good predictors of forest degradation (Table 3). The results suggest that forest degradation increases near village centres and major road (Fig.10) This finding was unexpected, as firewood collection is generally associated with subsistence use and / or small local markets (CEPF, 2003).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In conclusion, this study has demonstrated the possibility to relate outdoor human activities to the spatial distribution of the degradation of Montane forest in Magamba Nature Reserve in Tanzania. It has been demonstrated that firewood collection is the most important human activity associated with Montane forest degradation in Magamba Nature Reserve. In this study a strong correlation was observed between forest degradation due to firewood collection and distance from village centres and from nearby major roads. Rapid population growth and lack of alternative source of energy are the major factors contributing to this human activity.

Collection of medicinal plants is linked to forest degradation in MNR as it is associated with human activities involving uprooting of plants, root cutting, and tree ring debarking which hamper regeneration of tree plants and loss of important tree species in the study area such as *Warbugia ugandensis Sprague; Clausena anisata* (*Wild*) *Benth* and *Dracaena usambarensis Engl*.

In the study area, low cost housing using poles harvested from forests and forest Reserves selectively affect tree types and size which is also associated with destruction of the existing tree species and retardation of plant regeneration process. The study has demonstrated further that the extent of forest degradation in the forest Reserves associated with human activities differs according to geographical proximity and socio-economic setup of the surrounding communities.

The presence of relatively many small diameter trees and the decrease in forest biomass over time are significant indicators of forest degradation in Magamba Nature Reserve associated with human activities such as harvesting of timber and building poles, illegal firewood collection, harvesting for traditional medicinal plants, animal grazing and charcoal burning.

These results suggest that forest degradation is higher near major roads and village centres. Distance from major roads and village centres can thus be taken as predictors of forest degradation.

6.2 Recommendations

The findings of this study make a significant contribution on the possible outdoor human activities that are common drivers of Montane forest degradation in space and time. Future efforts to predict and map spatial and temporal forest degradation at landscape scale should consider the role played by communities, distance from the village centres to forest Reserves and nearness to road networks.

There is also a need for a broad methodological approach to understand and value forest degradation from ecosystem services perspectives for subsistence economy, poverty levels and communities adjacent to forest reserves that depends on ecosystem services for their livelihood. The extent of human activities in forest reserves differs according to geographical proximity to forest Reserves and socio-economic setup of the surrounding communities. Therefore, for practical reduction of Carbon emission, active participation of communities around forest Reserves has to be given high consideration in Tanzanian REDD+ initiatives and other strategic interventions.

The authorities should consider supplying the affordable electrical energy and use alternative energies like solar and wind to the rural community. This can reduce tension on deforestation and forest degradation; hence, contribute to climate change adaptations and mitigations.

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APPENDICES

Appendix 1: Household questionnaire

<u>QUESTIONNAIRE FOR VILLAGERS</u>

<u>General:</u>

Questionnaire. No. .... Date........................... Village name ……………........

<u>Instructions:</u>

1) This questionnaire intended to collect data about human activities which may influence the degradation of Montane forest in Magamba Nature Reserve.

2) Do not write your name and circle the right answer.

<u>Household socio-economic characteristics</u>

Question 1. Gender: Male …………….. Female………………………….

Question 2. Age: a) 20-24……… b) 25-29……. c) 30-34…….. d) 35-44……. e) 45-54……… f) 55-64…….. g) > 65…………..

Question 3. Marital status: a) Married b) Single c) Widowed d) Divorced

Question 4. Level of education: a) Illiterate …….b) Primary School……………… c) Secondary school…………..d) Post-secondary education………

Question 5. What is your family's main source of household income?

a) Farming……………. b) Business ………… c) Employment …………….……… d) both (a) and (b)………… e). Others……

Question 6.Mention all activities you normally do in your household and their frequency.

s/n	Activity	Frequency (per month/ year)	Since when?
1			
2			
3			
4			
5			

Land tenure and environment

Question 7. Do you own Land? a) Yes…. b).No……

Question 8. If yes how did you acquire land?

a) Inheritance b) Bought c) Renting d) Clearing of forest e) Others (mention)

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………….

Question 9. How far is your land from your home?

Question 10. What is the average size of your land? ………… (acre).

Question 11. Is it possible to get more land?

Question 12. If yes how...

Question 13. Do you utilize that land for farming? a) Yes…. b) No…..

Question 14. How much land is cultivated? (In acres)…………………..

Question 15. How is the trend of cultivated land? a) Decreasing...b) Increasing. .c) same...

Question 16. If yes, mention all activities you normally do on farm and their frequency.

s/n	Activity	Frequency (per month/ year)	Since when?
1			
2			
3			
4			
5			

<u>Factors influencing forest degradation</u>

Question 17. Do you know Montane forest?

a) Yes….. b) No…….

Question 18. If Yes,

1. Since when? …………………
2. How far is the forest from your home? (In Km)……………………..

Question 19. How many tree species of Montane forest do you know? ....

Question 20. What are the user right regulations in Montane forest?

a) Free space b) Village permits c) ministry permits d) Other (mention)…………

Question 21. Are there any restrictions on use of particular species? a) Yes b) No

Question 22. If yes, mention.

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………

Question 23. Mention all activities you normally do in montane forests and their frequency.

s/n	Activity	Frequency (per month/year)	Since when?
1			
2			
3			
4			
5			

Question 24. What products/Services do you get from the montane forest? Tell us how frequent do you obtain the products.

s/n	Product/service	Frequency (per month/year)	Since when?
1			
2			
3			
4			
5			

Question 25. Do you think this community can survive, without Montane forest?

a) Yes   b) No

Question 26. If not, why?

Question 27. Are you aware of what will happen to the community if Montane forest degraded? a) Yes … b) No……

Question 28. If yes, explain.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………

Question 29. How do you see the status of Montane forest now with comparison to the past 10 years?

a) Highly degraded

b) Degraded

c) Not degraded/ remain the same.

Question 30. If your answer is (a) or/and (b), answer the following questions.

1) What differences have you observed between that periods?

....

....

....

2) What species of Montane forest you think are more degraded?

....

....

....

3). What are the common uses for that species?

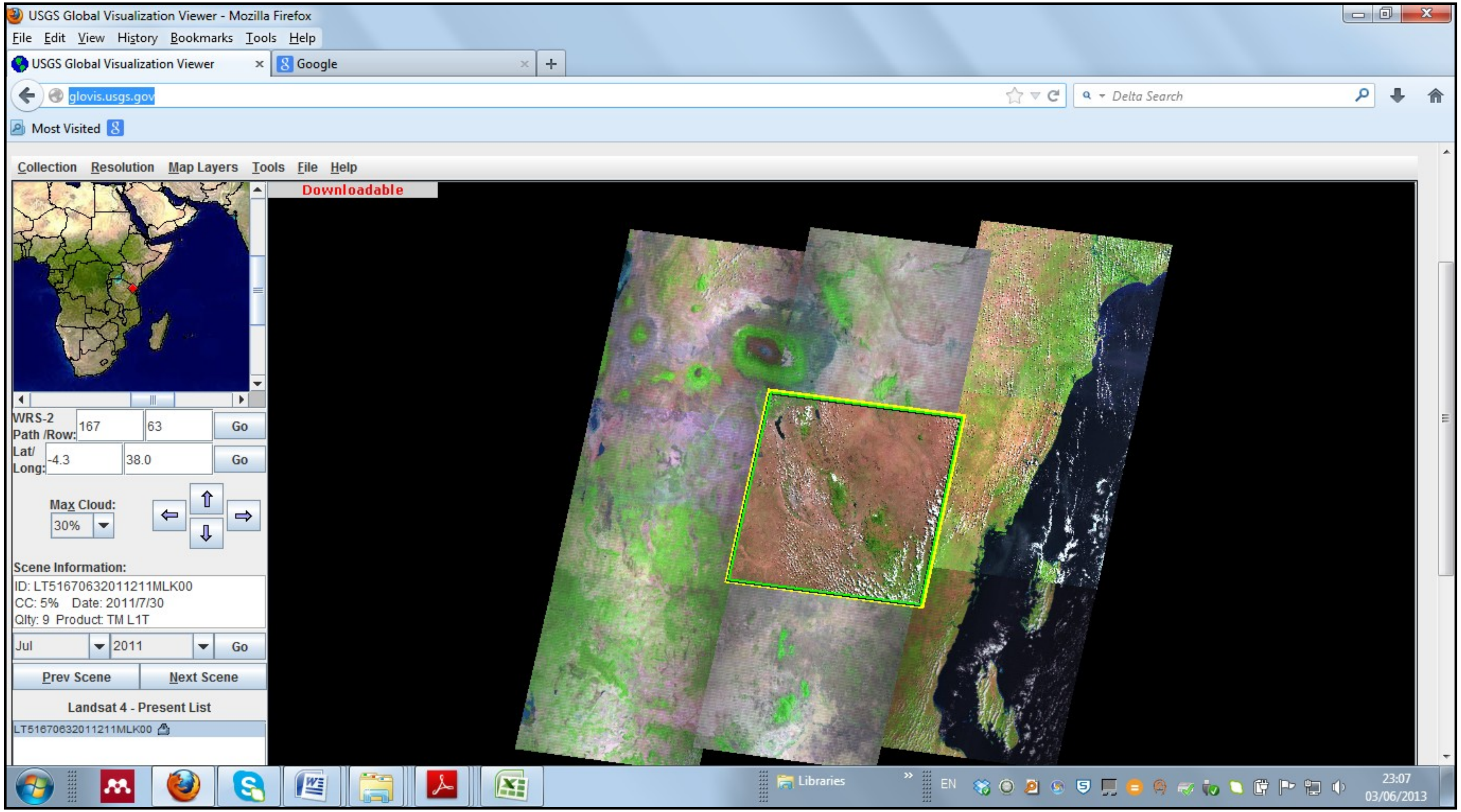
....

....

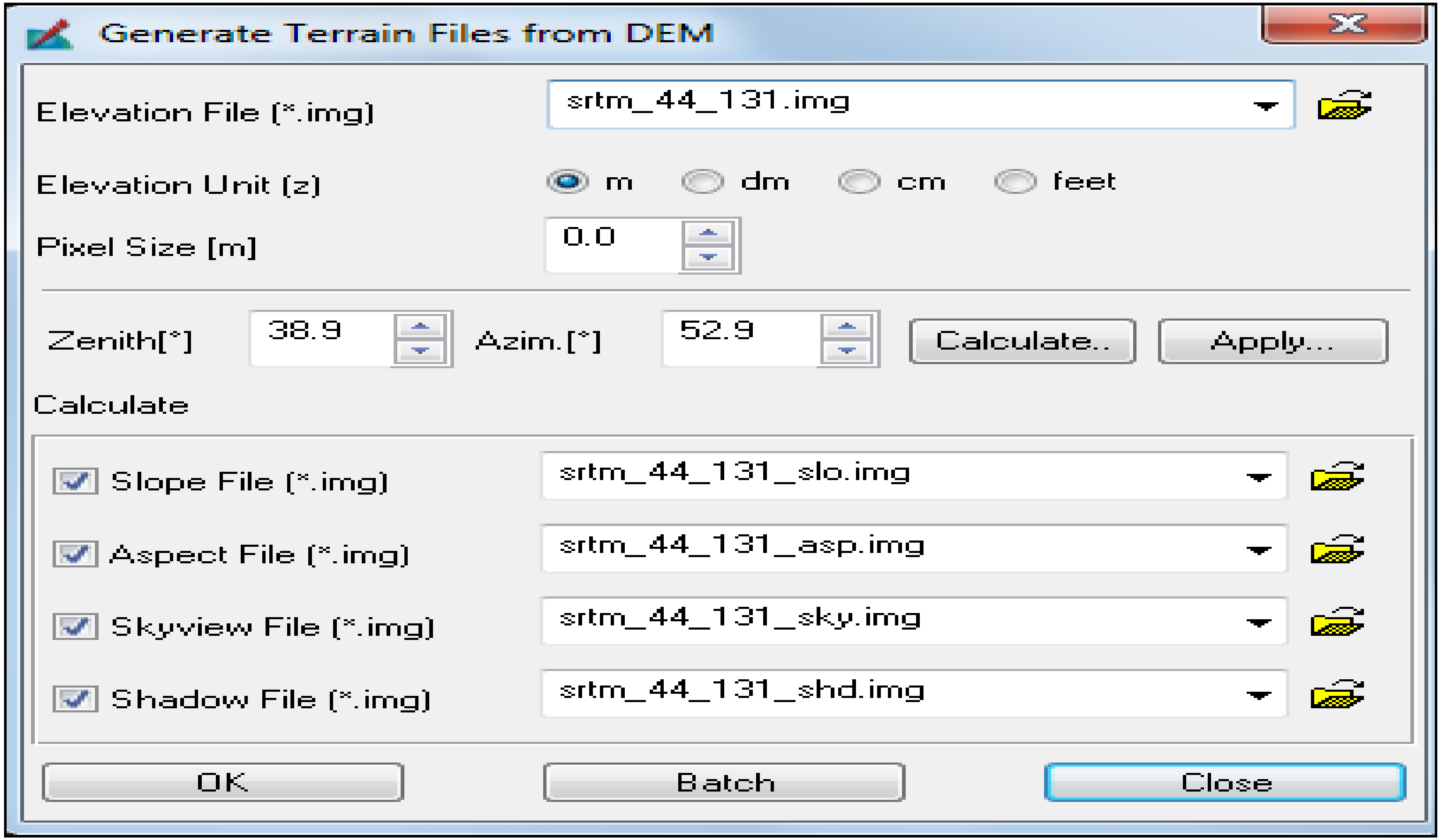
....

....

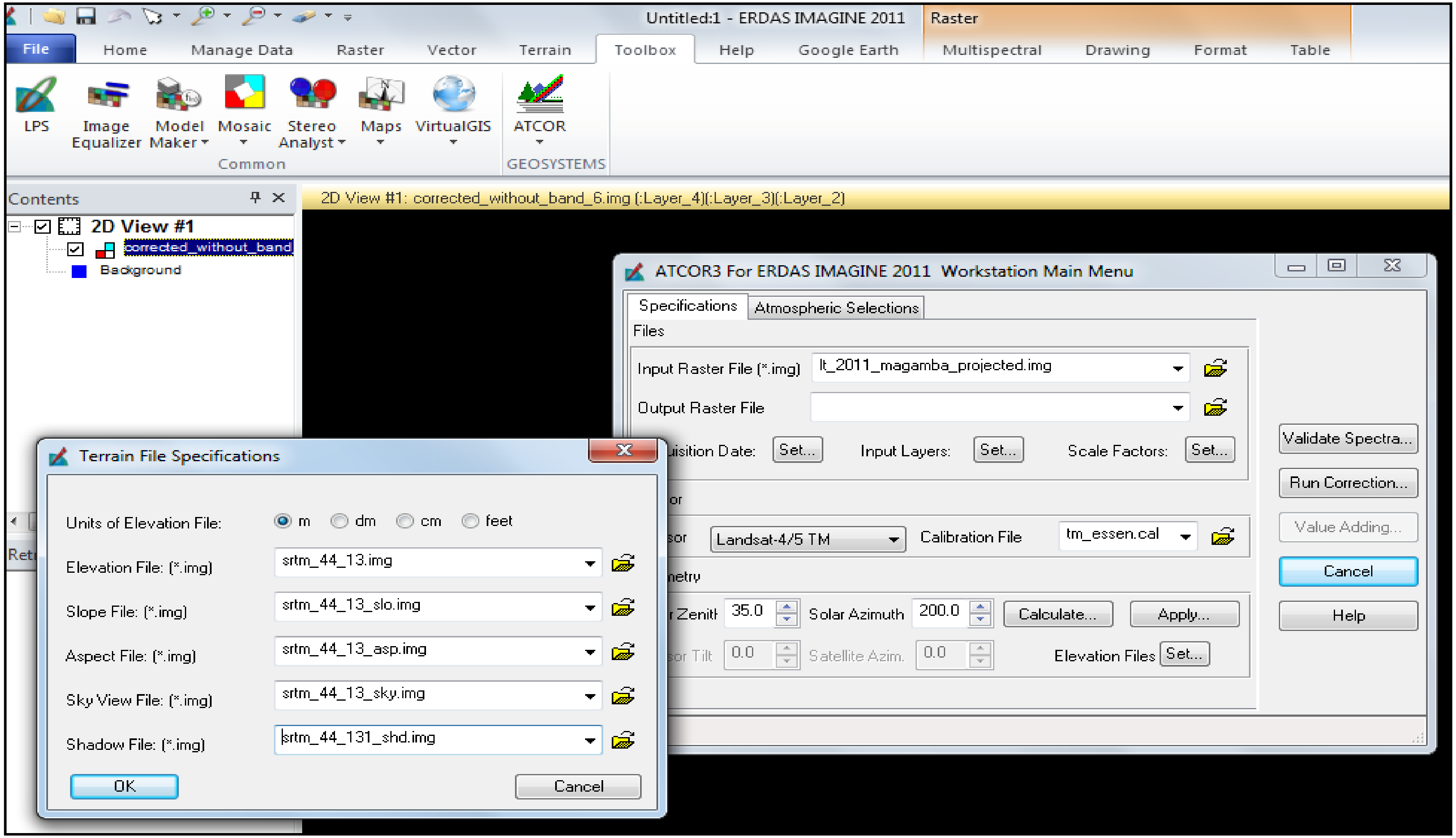
Appendix 2: Satellite image downloading from USGS website



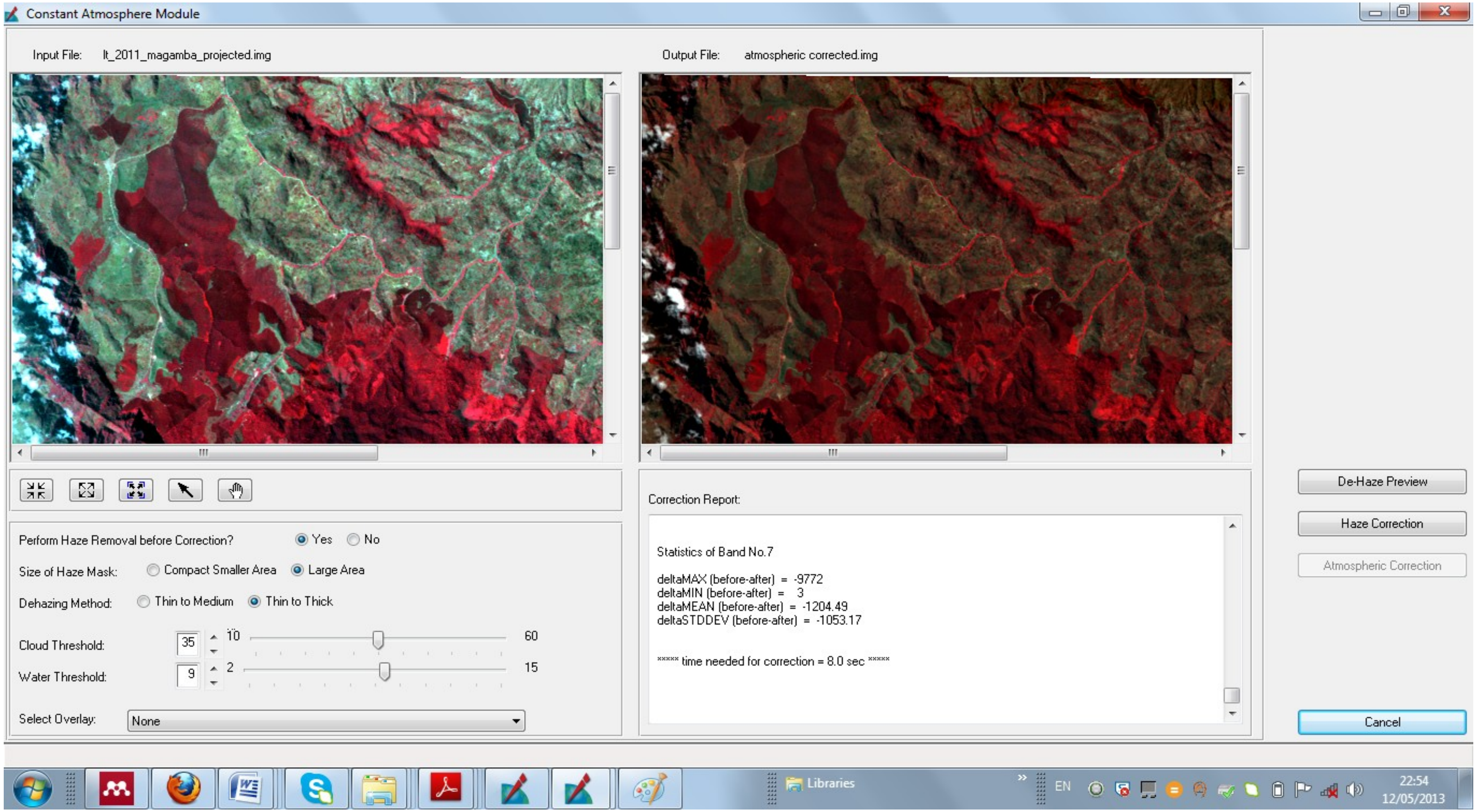
Appendix 3: Developing files from Lushoto DEM to be used in a radiometric image correction



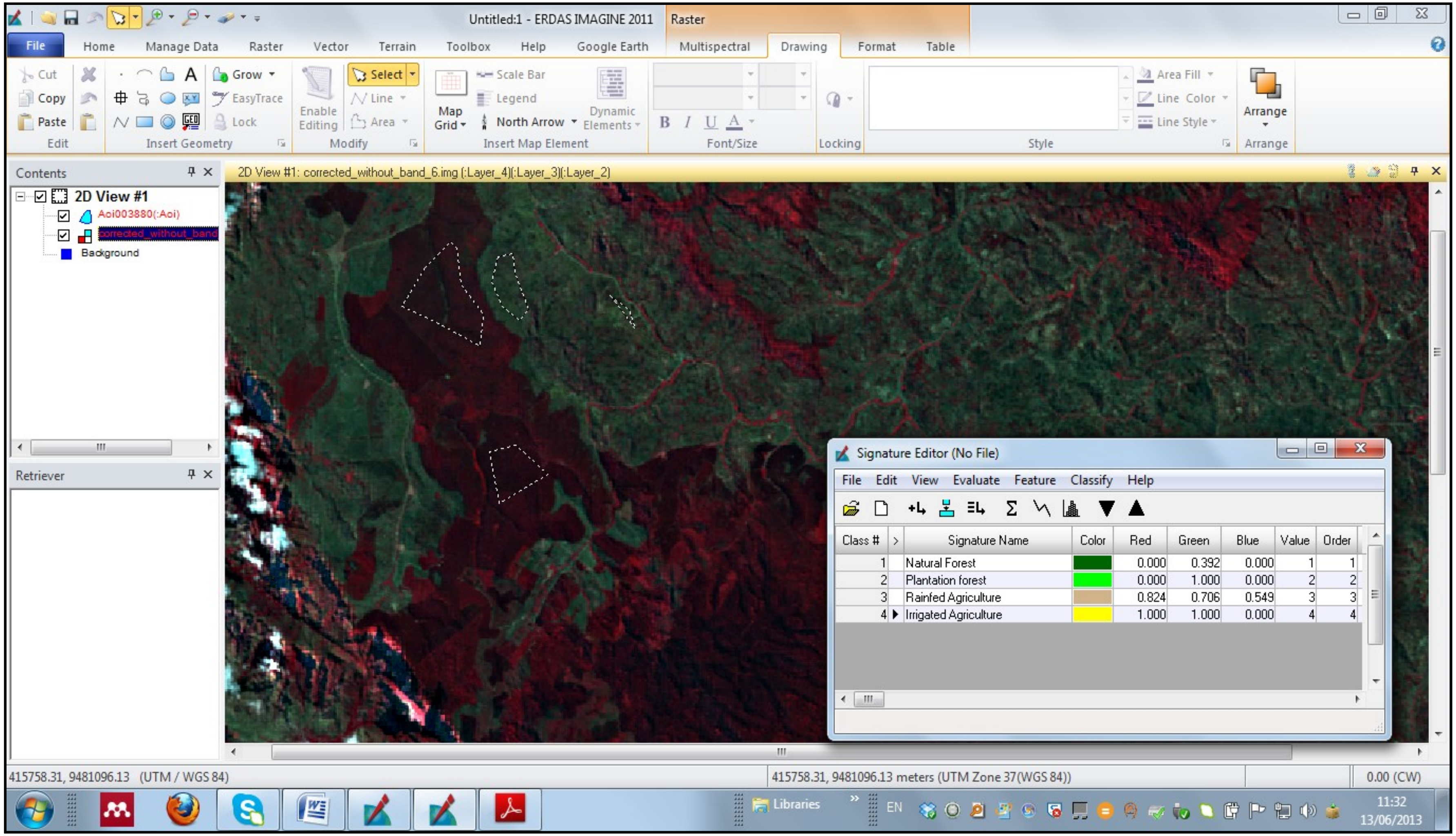
Appendix 4: Radiometric image correction in atcor 3 for Erdas imagine 2011



Appendix 5: Corrected image (right hand side) in atcor 3 for Erdas imagine 2011



Appendix 6: Supervised image classification using Erdas imagine 2011



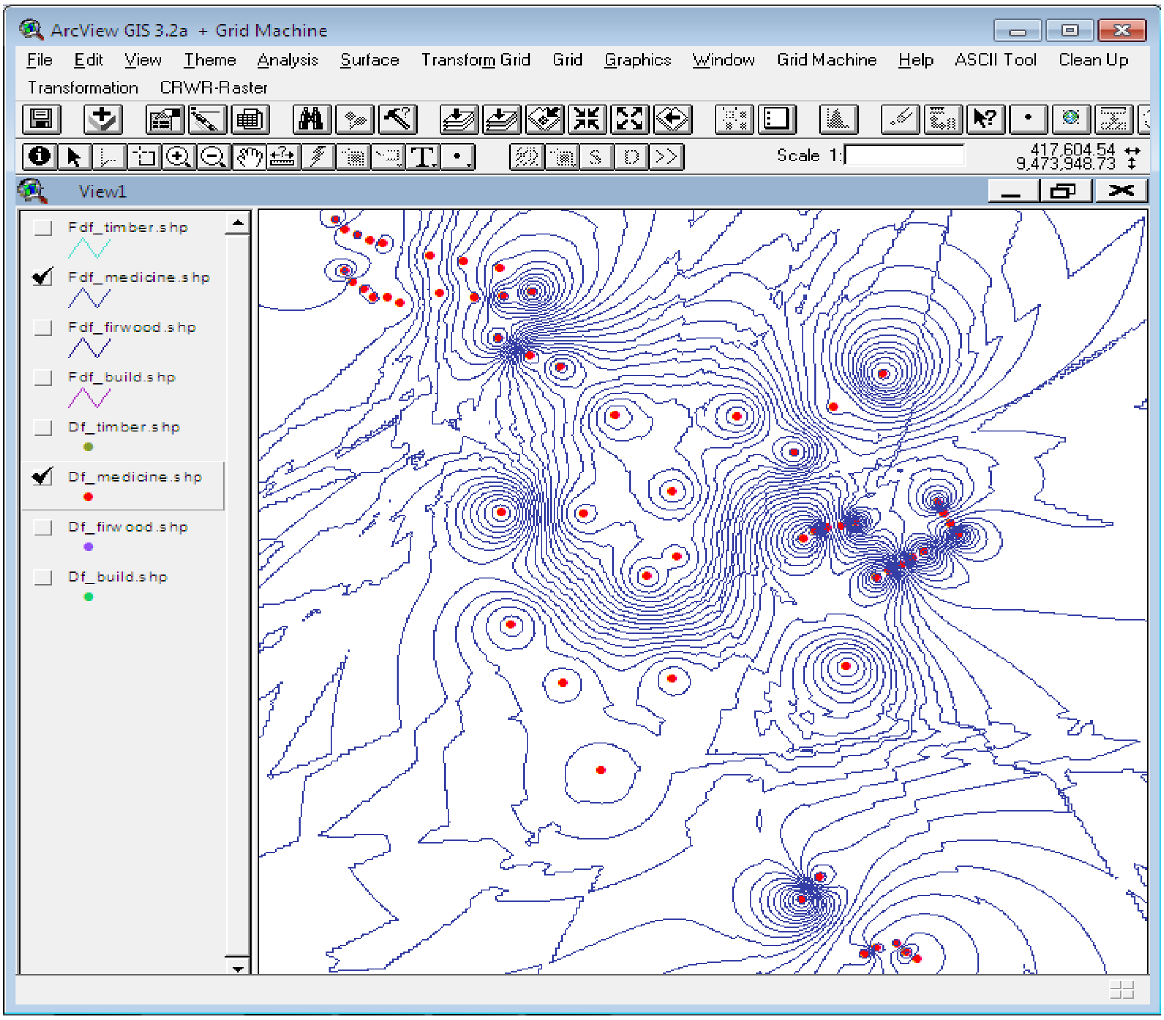
Appendix 7: A table consisting of coordinates for all points (plots) with values of respective changes of the biomass due to different land use

Plot_Number	Eastings	Northings	Df_Buildin	Df_Firewoo	Df_Medicin	Df_Timber
1	421783	9480440	0	0	5.666	-70.378
2	421613	9480342	-0.732	-4.778	0	1.718
3	421445	9480231	0	0	-4.55	-3.669
4	421265	9480139	0	0	0	-7.886
5	421102	9480023	0	0	0	7.574
6	420787	9480916	-5.166	0	0	1.884
7	420593	9480859	1.709	0	-6.699	0.807
8	420393	9480842	-3.974	-1.952	0	-0.531
9	420204	9480778	-0.17	-0.054	-19.611	11.512
10	420053	9480647	-1.574	0	0	-0.968
11	421981	9481249	0	-2.159	0	0
12	422059	9481065	0	-11.084	0	9.501
13	422159	9480894	-6.824	-5.774	0	0
14	422271	9480726	0	-3.398	0	0
15	421685	9473790	-0.829	0	-0.817	0
16	421517	9473900	0	0	0	0
17	421381	9474046	-1.167	0	-2.286	0
18	421093	9473968	0	0	-0.187	0
19	420935	9473890	0	7.217	-5.774	0
20	414027	9485473	0	2.213	-0.651	-1.362
21	413835	9485529	-0.251	-1.644	0	0
22	413657	9485622	0	0	-2.21	0
23	413477	9485708	-0.733	0	-1.857	2.643
24	413355	9485864	-0.467	-2.616	1.359	0
25	414265	9484499	-1.092	0	0	-0.333
26	414091	9484596	0	-19.982	0	5.022
27	413893	9484593	0.658	0	0	3.271
28	413750	9484733	1.647	0	0	0.381
29	413588	9484849	0	1.677	0	-0.492

Appendix 8: Relationship betwen human activitie and distance from village centres and from major road

Predictor (Z-Score)	Model	ANOVA F	Total df	Level of significance	R^2
Distance form Village centre	Y= -0.88 + 0.005X	2.924	2	0.471	0.745
Distance from major road	Y= 2.089 + 0.001X	1.201	2	0.337	0.546

Appendix 9: Lines maps (similar to contour maps) which shows noted changes for every point for each considered activity in the forest



Appendix 10: A raster map created from lines map, using ILWIS software