FAO Characterisation of Global Heritage Agroforestry Systems in Tanzania and Kenya

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Kihamba system a traditional Agroforestry system, Shimbwe Juu Kilimanjaro region:
Photo by David Boerma.

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Greener landscapes, healthier ecosystems, better life for all.

Contents

List of Tables.

List of Figures.

Acronyms and Abbreviations

AIDS	Artificially Induced Deficiency Syndrome
ASAL	Arid and Semi-Arid Lands
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection - German
CAADP	Comprehensive African Agricultural Development Programme
CBD	Coffee Berry Disease
CLK	Coffee Leaf Rust
CSD	Commission on Sustainable Development
DDC	District Development Committees
DRC	Democratic Republic of Congo
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environmental Facility
GIAHS	Globally Important Agricultural Heritage System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
HASHI	Hifadhi Aridhi Shinyanga (Soil Conservation Project – Shinyanga Region)
ICIPE	International Centre for Insect and Pest Epidemiology
ICRAF	International Centre for Research in Agroforestry (now World Agroforestry Centre)
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Phytosanitary Inspectorate Service
KFS	Kenya Forest Service
KNCU	Kilimanjaro Native Cooperative Union
KWAP	Kenya Woodfuel and Agroforestry Programme
NGOs	Non Governmental Organizations
REDD	Reduced Emissions from Degradation and forest Degradation
SIDA	Swedish International Development Agency
TACRI	Tanzania Coffee Research Institute

UNEP	United National Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
WSSD	World Summit on Sustainable Development

1. Introduction

1.1 Globally Important Agricultural Heritage Systems (GIAHS)

The dynamic conservation of Globally Important Agricultural Heritage Systems (GIAHS) was conceptualized and introduced during the World Summit on Sustainable Development (WSSD) in 2002. It was later registered by the Partnerships for Sustainable Development that operates under the Commission on Sustainable Development (CSD) in 2004. The overall goal of the partnership is to identify, support and safeguard Globally Important Agricultural Heritage Systems and their agricultural systems and associated biodiversity, knowledge systems, landscapes and cultures, through catalysing and establishing a long-term programme to support such systems and enhance global, national and local benefits derived through their dynamic conservation, sustainable management and enhanced viability.

The salient features of GIAHS are their high degree of biodiversity. FAO 2002 defined GIAHs as “Remarkable Land Use Systems and landscapes which are rich in biological diversity evolving from the co-adaptation of a rural community/population with its environment and its needs and aspirations for sustainable development”. Five main criteria are used in identifying GIAHs namely:

- Food and livelihood security: contributing to food and livelihood security of local communities (often indigenous), representing the majority of their livelihood provisions.
- Biodiversity and ecosystem function: Endowed with globally (or nationally) significance biodiversity and genetic resources for food and agriculture (e.g. endemic, rare, endangered species of crops and animals)
- Knowledge systems and adapted technologies:
- Cultures, values systems and social organisation
- Remarkable landscapes and water resource management

In 2008, with financial support from the Federal Ministry for Agriculture, Food Security and Consumer Protection of the Government of Germany (BMELV), FAO initiated the project “Supporting Food Security and Reducing Poverty in Kenya and Tanzania through Dynamic Conservation of Globally Important Agricultural Heritage Systems (GIAHS)". Two years running, in 2008 the project identified the Maasai pastoral systems and Upland Agro-forestry systems as the most creative form of livelihoods that have withstood the test of time and deserving recognition as heritage agricultural systems of global importance and hence requiring support. This recognition was followed by a pilot site selection mission led by the Project Facilitating Team, which targeted three main agro-systems namely; the Chagga home gardens, the Pare Ndiva system and the Matengo pit system. The evaluation team ended up ranking the Uru-Shimbwe Juu site within the Chagga home gardens as the most integral Upland agrosystem, in which all the critical heritage features are represented and associated with this system. Probably of much relevance in the GIAHS concept here is the fact that the Chagga home gardens represent one of the highly recognised traditional agroforestry systems.

In 2011, the Project Facilitating Team recommended commissioning of a study to undertake characterisation of the agroforestry systems of Tanzania and Kenya, to support the East Africa GIAHs project in two main areas:

- Implementation of the action plan for the dynamic conservation of the selected project area and the mainstreaming of GIAHS goals and principles into national policy.
- Implementation of recommendation 5 of the 2011 project Independent External Evaluation, which reads:

“in order to contribute to the up scaling of the GIAHS concept, it is recommended that a structured review of pastoralist and agroforestry systems in eastern Africa be carried out so that the globally important features identified by the project in Kenya and Tanzania can be placed in the broader context of the region. In addition, it is recommended that the project develops both spatially-explicit and feature specific contextualisation of the selected sites, which can be used to better describe and document the relevance, impacts and sustainability of GIAHS and the selected systems”.

This paper addresses one of the components highlighted by the Independent Evaluation team, i.e. agroforestry with emphasis on upland agroforestry. The pastoral system as a potential GIAHS will be addressed in a parallel study.

1.2 Traditional Agroforestry in GIAHS concept

Agroforestry practice is an age old land use practice defined as land use systems in which woody perennials (trees, shrubs, palms, bamboo etc.) are grown on the same piece of land with herbaceous plants and/or animals, either in spatial arrangement or in time sequence and in which there are both ecological and economic interactions between the trees and non-tree components (Beets, 1989). A more recent definition embracing the global twin challenges of poverty and environmental degradation define agroforestry as a dynamic, ecologically based, natural resource management system that, through integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Leakey, 1996).

The diversified agroforestry systems help in sustaining agricultural production, improve household food security and incomes. They also contribute towards environmental and social benefits. Traditional agroforestry systems at some sites contain 50–80% of the plant species diversity found in comparable natural forests while providing most of the products needed by local families (Huang et al 2002). From a territorial point of view, an agroforestry system is a unit of interdependence between a community and its environment, where social and spatial boundaries ideally coincide. A territory typically embodies all the necessary environmental and socio-cultural elements and processes to constitute it as an integral unit for site selection and for ensuring its dynamic conservation. The concepts of territory and integrity thus guide the site delineation and some of the criteria used in site delineation include: outstanding biodiversity, landscape and socio-cultural characteristics, social-environmental balance and resilience, historical and contemporary relevance, being representative or unique in nature.

Traditional agroforestry systems support a high degree of plant diversity in form of crops, tree and fodder species. The underlining strategy of planting several species and varieties of crops is to maximize risks and stabilize yields over the long term, promote diet diversity and maximizes returns even with low levels of technology and limited resources (Harwood 1979).to minimize risk. Traditional agroforestry systems are very common on the East African landscapes spreading in most parts of the highlands of Kenya, Uganda, Tanzania, Rwanda and Burundi. All of them have common characteristic of plant diversity carefully selected and arranged in layers (comparable to different flats in a storey building); a system that minimizes competition between different plant species and optimizes land productivity.

Important to note that traditional agroforestry systems vary in their characteristics and challenges; therefore each of them requires specific interventions. They are irreplaceable, support biodiversity and have been proven to be environmentally sustainable. For centuries, the systems have supported not only the livelihoods of practicing communities but also a significant population along the value chain of the products and services emanating from them. There is evidence that these systems contribute tremendously towards the mainstream national economies. A conservative estimate of international trade of agroforestry products gave a whopping figure of UAD140billion in 2009 (Place et. al. 2009). Furthermore agroforestry systems assist farmers to spread risks and their cumulative benefits are likely to be much higher than alternative systems. These systems also contribute towards climate change adaptation and mitigation through carbon sequestration by the trees and other perennials in the system. Table 1 describe the main attributes of agroforestry systems within the GIAHS criteria and World Heritage Standards.

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Table 1 Attributes of agroforestry systems within the GIAHS criteria and World Heritage Standards.

GIAHS criteria	Agroforestry products and services
Peoples livelihoods and Food Security	Tree products in AF systems such as coffee, fruits and tree nuts contribute significantly to livelihoods of millions of low income people. Well managed Af systems maintain soil fertility and thus contributing to increased food production.
Conservation and sustainable use of fauna and flora	Most traditional agroforestry systems are reach in fauna and flora. The Chagga home gardens described in more details below is reported to carry over hundred plant species in farms ranging from 0. 2-1.2 ha. The Chagga home gardens also carry high diversity of birds and insects.
Provision of habitats for wild biodiversity	Micro-climate created by agroforestry provide a conducive environment for wild biodiversity
Repository of local/indigenous knowledge on crop and animal husbandry	Agroforestry systems maintained through inter-generational transfer of knowledge and experience
Provision of ecosystem services and contribution to ecosystem health and capacity to adapt and mitigate climate change	The high ground cover of agroforestry systems sustains soil health through improved soil and water conservation, thus reducing crop failure risks from water stress.

1.3 The Scope of Work

The study specifically involved:

- Characterization of heritage agroforestry systems in Tanzania and Kenya
- Highlight of geographical locations of heritage agroforestry systems in the two countries

- Presentation of the findings to national policy workshops in Kenya and in Tanzania
- Production and submission of the final report including inputs from the policy workshops.

1.4 Study Approach

The study involved review of project documents and related literature on agroforestry practices and particularly in the project selected sites in the two. It also included consultations with key informants such as the community elders and agroforestry experts in the government and NGOs who have decades of experience promoting agroforestry practices in the countries. A checklist was developed to guide the collection of information from key informants. The key areas of focus included; socio-cultural and biodiversity characteristics of the traditional systems, environmental sustainability and relevance to the ecosystem, economic relevance and resilience to climate change. The study involved field visits and meeting the local communities. Personal observation of current agroforestry practices guided the "face-to-face interviews". The local community provided valuable inputs. The preliminary findings were presented in the national policy workshops held at UNEP headquarters in Nairobi, Kenya 4 – 5th December 2012 and the Ubungo Plaza in Dar es Salaam 6 – 7th December 2012. Feedback from the workshop participants helped in the synthesis and compilation of the final report. Personal experience and field observations was also handy in understanding the concept of traditional agroforestry systems. Spatial mapping of the traditional agroforestry systems was guided by the information gathered from key informants and the literature review.

2.0 Traditional Agroforestry systems in Tanzania

2.1 General Overview

In Tanzania the GIAHS Project Facilitating Team identified three farming systems as potential sites for heritage agricultural systems;

- Kihamba sytem, popularly known as Chagga home gardens
- Pare Ndiva system

- Ngoro or the Matengo pits in Mbinga district.

Review of literature suggested other potential sites such as spice agroforestry systems in the Eastern Arc Mountains and Zanzibar, the Maize-Faidherbia system in Southern Tanzania, as well as the traditional silvipastoral system "Ngitili" in Western Tanzania (Figure 1). The Kihamba system or the Chagga home gardens can be described as a multi-strata system, which is found in High plains and Mountain blocks as well as the Volcanoes & rift depressions ecological zones. The multi-strata agroforestry systems overlap with the spice agroforestry systems mostly in the highlands of Tanzania (Fig 1). The Nyarubanja system in Kagera region fall within the multi-strata system.

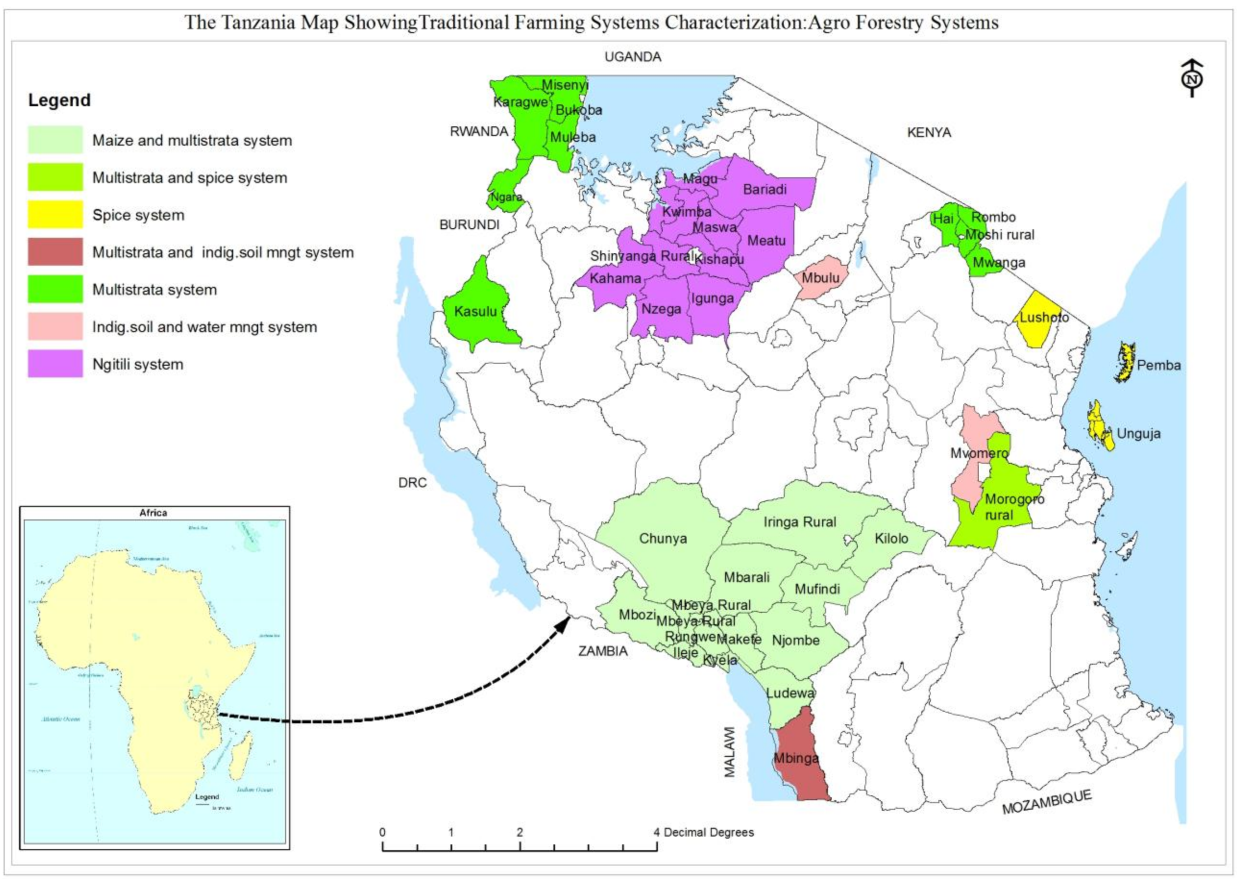

Figure 1: Potential sites for traditional agroforestry systems in Tanzania

While the Kihamba system or the home gardens is characterised by more forest features with multi-layered vegetation structure, the uniqueness of the “ndiva” system is the traditional water harvesting system and for the matengo pits is a combination of soil and water management. Since the present study focuses on upland agroforestry systems, a detailed description of the Chagga home gardens, the pilot area for the East Africa GIAHS project, is presented. For the other GIAHS systems highlights on geographical location, structural features and economic importance are presented.

2.2 Chagga Home Garden System in Northern Tanzania

Historical Perspectives and geographical location of Chagga Home gardens

Humans have continuously inhabited the slopes of Mt. Kilimanjaro for the last 2000 years. However, during the last decades the human population increased dramatically and it is estimated that the population on the mountain has multiplied 10 times within 90 years, from 1913 to 2002 (Hemp and Hemp, 2008). Most of the population is concentrated at an altitude between 1000 and 1800 meters, with densities varying from 500 to 1000 people per km^2 in some areas. Over the years, the inhabitants of the highlands in Kilimanjaro region have traditionally developed and refined a most unique farming system well suited to the local conditions. The system is known as the Chagga home garden or the *Kihamba* system (Fernandes et al., 1984). It is believed that the first home gardens and traditional water canals existed already in the 12th century. This old land use system has formed the identity of the Chagga, who are of multi-ethnic origin, despite the fact that they belong to the Bantu people (Hemp and Hemp, 2008).

By 1984, the Chagga home gardens were estimated to cover 120,000 ha on the southern and eastern slopes of Mt. Kilimanjaro mainly between 900 and 1800 m above sea level, stretching on the climatically most favourable zone of the southern and south-eastern slopes (Figure. 2). The home garden has been sustaining natural resources and the livelihoods of people on the mountain Kilimanjaro for many years. However, recently the sustainability of this system has been greatly affected by the increasing population pressure, lower economic returns of coffee once the backbone of the household economy, , eroding traditions; and ageing farming communities and climate change.

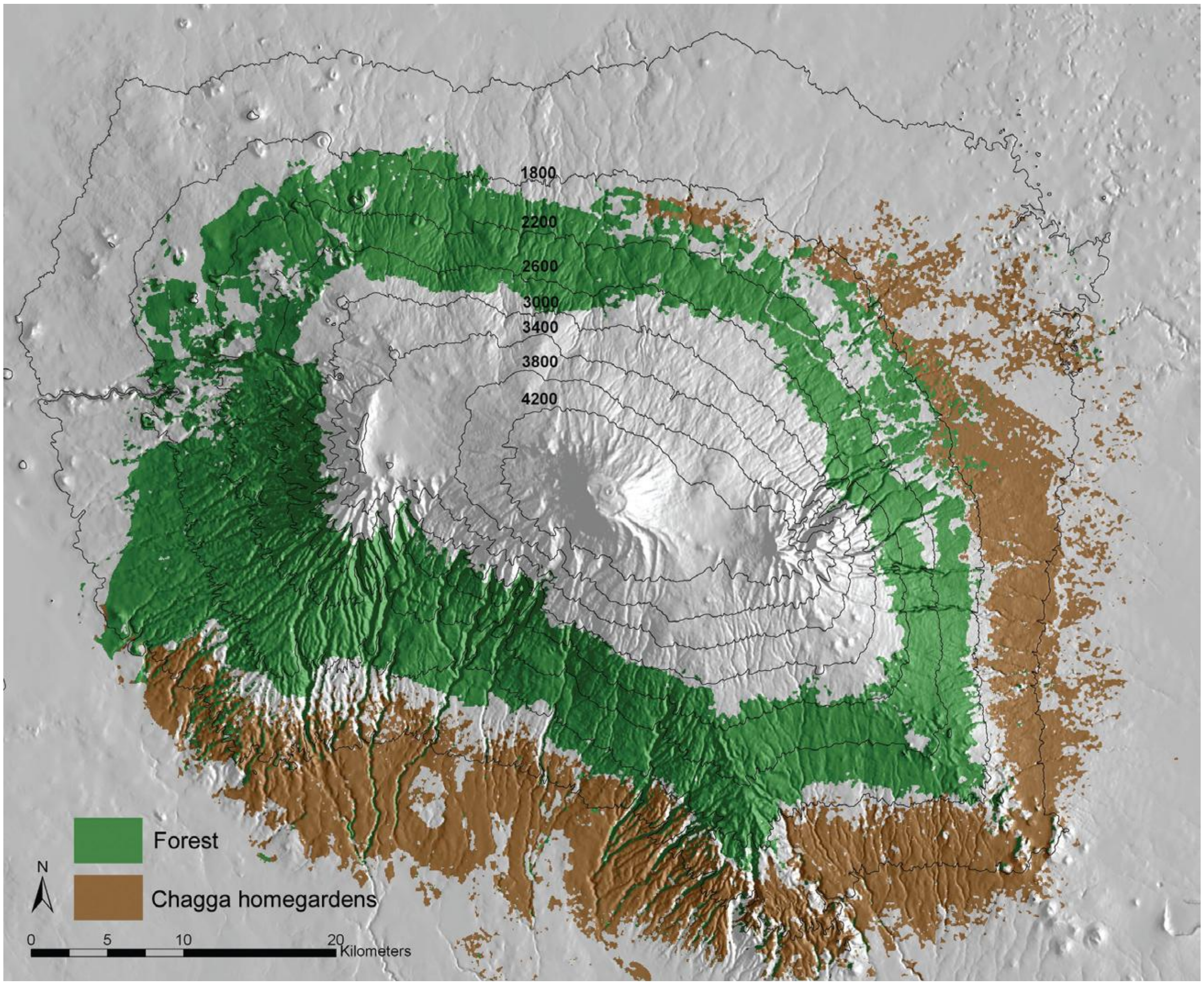

Figure 2: Distribution of the Chagga home gardens on Kilimanjaro based on a supervised classification of Landsat ETM images taken on 29 January and 21 February 2000 (Hemp and Hemp, 2008)

Structural features of the Chagga Home garden

The word home garden has been used loosely to describe diverse practices, from growing vegetables behind houses to complex multi-storied systems of trees/shrubs, crops and/or livestock (Bekele-Tesemma, 2007). The term is used here to refer to an intensive cropping system that involves the integration of several multi-purpose trees and shrubs with food and cash crops and livestock on the same unit of land. These components are managed as a single unit (system) using the family labour. Within the cropping system, several agro-forestry practices can be identified, including the use of multipurpose trees and shrubs to provide shade for coffee, fodder, timber and firewood and as live fences.

The chagga home garden is a typical agrisilvicultural system characterized by a multilayered vegetation structure similar to a tropical montane forest with trees, shrubs, lianas, epiphytes and herbs (Figure 3 and Figure 4). This forest-like structural arrangement of plants mainly consists of the shade trees, the major cash crops coffee (*Coffea arabica*) and banana grown for food and sale. In order to meet their shade requirements, these agricultural crops are intimately intermixed in a complex arrangement with a higher canopy of indigenous or planted multipurpose trees. There is also a middle canopy of fruit and multipurpose trees/shrubs; followed by a lower ground cover of food crops, medicinal plants and annual fodder plants (OK'tingati and Kessy, 1991). Apparently, the vertical stratification of home garden as noted here provides a gradient in light and relative humidity, which creates different niches for enabling various species groups to exploit them. Obviously, shade tolerant crops constitute the lower stratum, shade intolerant trees the top layer, and species with varying degrees of shade tolerance in the intermediate strata (Kumar and Nair, 2004).

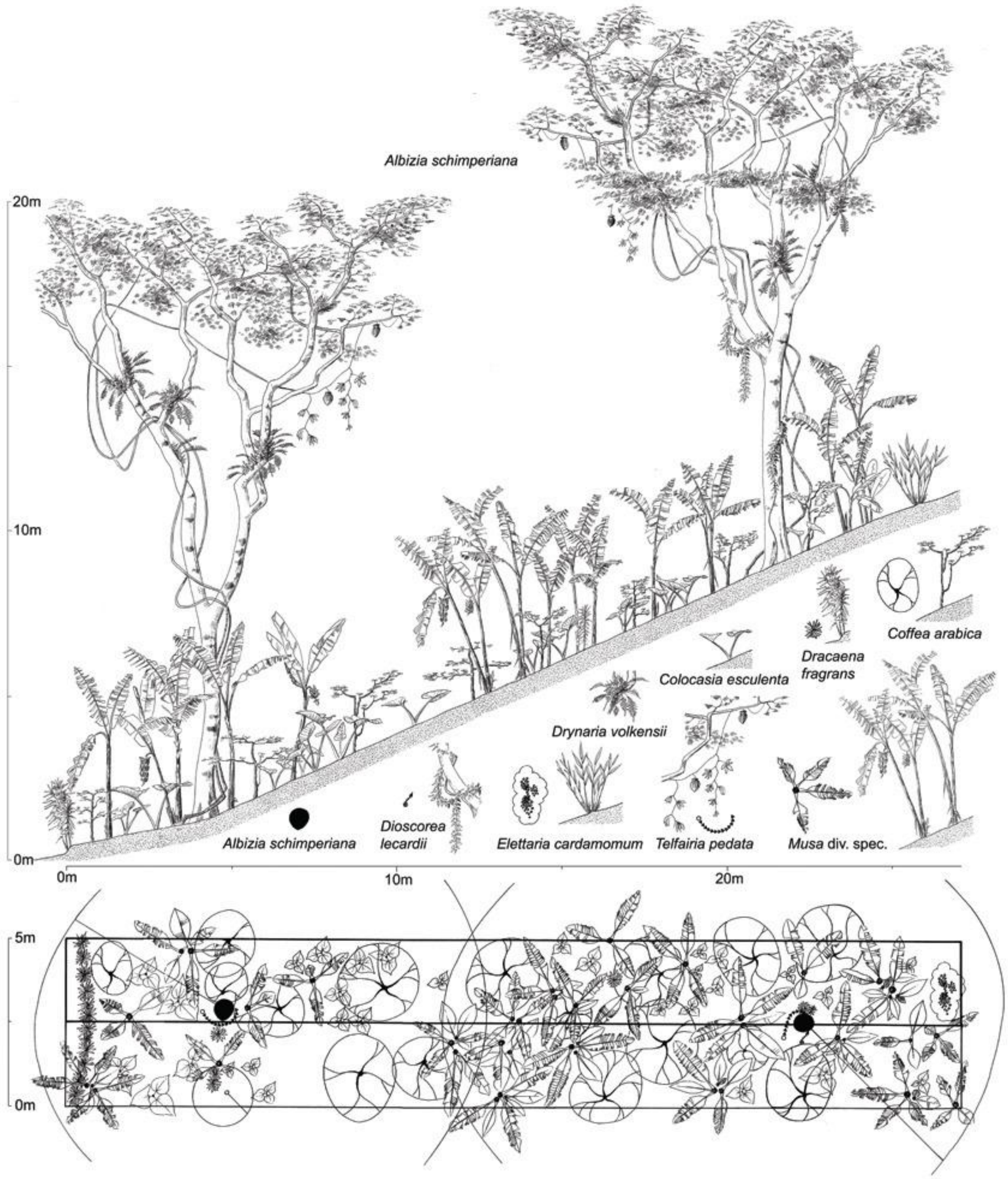

Figure 3: Vegetation Profile (Top 27 x 2.5 m) and ground plan (27 x 5 m; bold lines indicate the area used for the profile) of a typical Chagga home garden in Kidia area in Old Moshi at 1400 m asl. at 1400 m a.s.l.

An open light upper canopy is formed by *Albizia schimperiana* var. *amaniensis*, on which epiphytes such as the fern *Drynaria volkensii* and *Telphairia pedata*, a liana with oil containing seeds, find habitats. Bananas form a dense upper shrub layer of 4–6 m height, coffee trees a lower shrub layer of 1.5–2 m, intermingled with 1–1.5 m high Coco Yam (*Colocasia esculenta*). The lower side of the banana field borders a road; here *Dracaena fragans* is planted as a hedge. (Hemp, 2006).

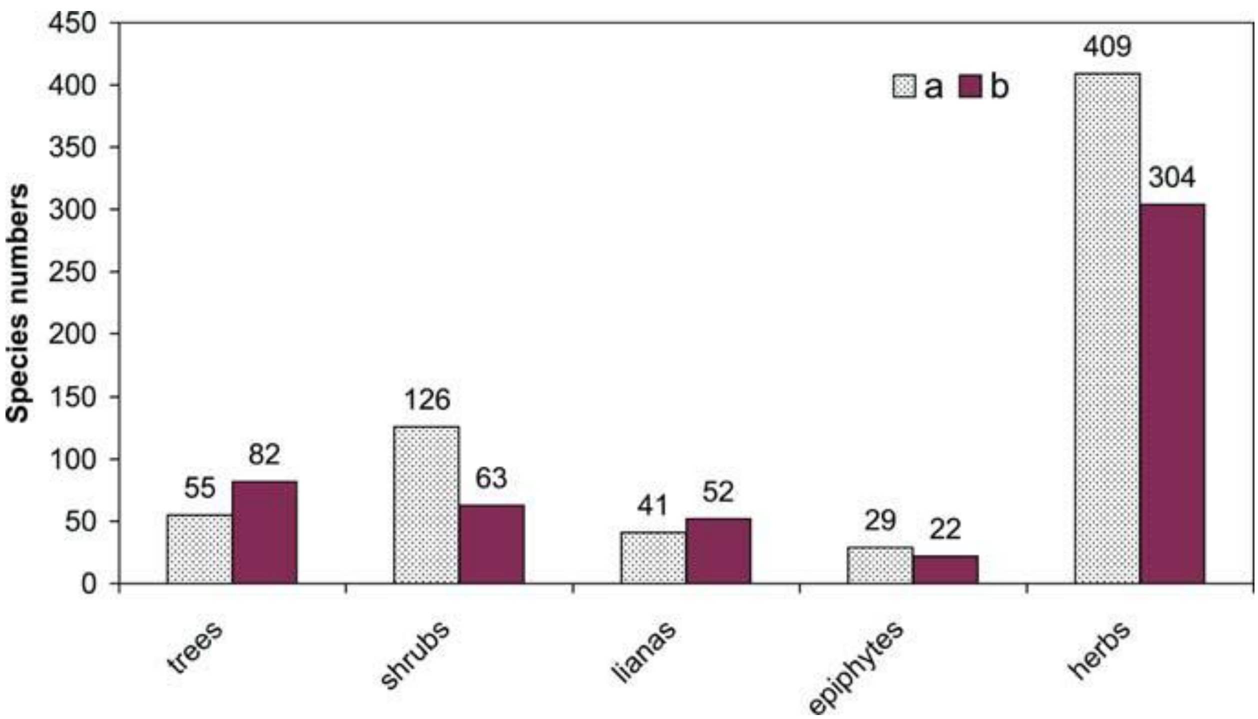

Figure 4: **Growth form spectrum of the Chagga home gardens; (a) species number of the respective stratum in the vegetation plots; (b) species number of all representatives of a growth form, e.g. of trees including young trees occurring in the shrub and herb layer or e.g. of herbs excluding young trees etc. (Hemp, 2006)**

Agro-biodiversity conservation in Chagga home gardens

Although highly influenced by human habitation, tropical home gardens are important repositories of high diversity of plant and animal species in farmlands (Agrobiodiversity). Recent studies (Hemp, 2006; Hemp and Hemp, 2008) indicate that most plant species in the home garden are forest species, followed by ruderal species (i.e. species on road sides, waste places and fallow arable land) and cultivated species (Fig. 5a). Overall indigenous species contribute over 70% of the species found in the home garden (Fig 5b). It is estimated that forest species in home garden contribute about 17% of the forest plants of Kilimanjaro, demonstrating high conservation value of home gardens. Some forest plants (e.g. *Pilea tetraphylla*) were only found in the home garden highlighting the important conserving function for species at risk of extinction. Forest related tree species common in the home garden include remnants of the former forest cover like *Albizia schimperiana, Rauvolfia caffra, Cordia africana, Commiphora eminii* and *Margaritaria discoidea.* There are also introduced timber trees such as *Grevellia robusta* and *Cupressus lusitanica* and fruit tree species such as *Persea americana, Mangifera indica* and *Syzygium cumini*.

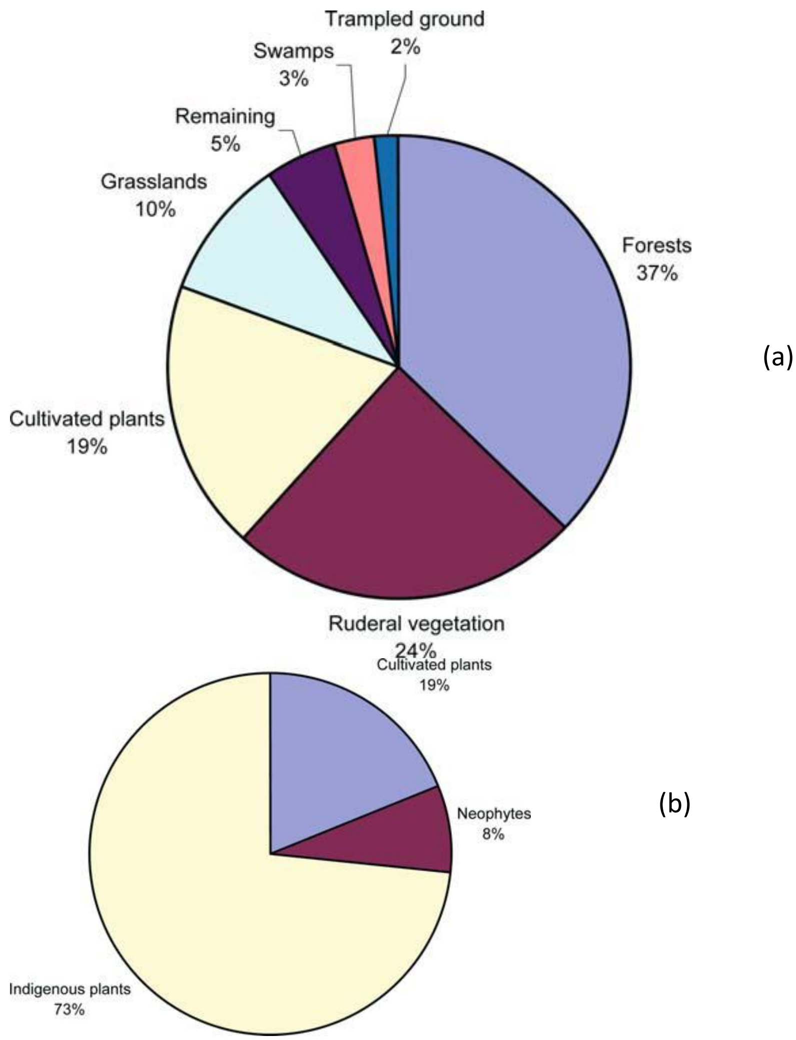

Figure 5: a) Floristic composition of the banana fields in respect of the different vegetation formations on Kilimanjaro; b) share of cultivated, neophytic and indigenous plants in the Chagga home gardens. (Hemp, 2006)

The Chagga home gardens also are an important habitat for animal species. Saltatoria is one of the widely studies fauna species in the Chagga home garden. It is estimated that 52 species, about a quarter of the whole Saltatoria fauna in Kilimanjaro Mountain, are found in the home garden (Hemp, 2006; Hemp and Hemp, 2008). Over 70% of the Saltatoria species found in the Chagga home gardens originate from forest communities and the remainder are open land forms; this indicate that home garden are also a refuge of animal species. Apparently high diversity of plant and animal species in Chagga home gardens reflect a variety of habitats like, cultivated areas, forest patches and river gorges found in this system. Similarly various studies elsewhere affirms that diversity indexes in home gardens are comparable with that of adjacent forest formations and plays a key role in sustainability and provision of ecosystem services, such as food, fodder and firewood; fertilize soil, carbon sequestration, etc. (Kumar and Nair, 2004).

Household Food and Income Securities from Chagga Home gardens

Operationally, tropical home garden are mainly subsistent, except for those with cash crops like coffee and cocoa; hence their primary function is food production. Food crops and fruits trees, especially, banana (Musa spp), guava and avocado are an important component of Chagga home garden providing food throughout the year, minimizing the need to store food for a long period where there is also the risk of post-harvesting losses. Beside food supply, different crops and livestock such as sheep, goats, cattle etc., from home garden, contribute to improved households nutrition. Diversified planting and harvesting time of food crops and fruits trees are the key elements for home garden's contributions to household food and nutrition security. Limited information is available on the nutritional value of Chagga home gardens. However, experiences from other places suggests, that home gardens hold high potential to provide 3 to 44% of total calories and 4 to 32% of total protein intake. Even though home gardens may seldom meet the entire basic-staple-food needs of the family in any given area, at best, they are complementary to other food sources (Kumar and Nair, 2004). Beside crop production, the tree layers provides people with fire wood, fodder and timber and sustain soil productivity through nutrient recycling processes and by reducing soil erosion and the impacts of other degrading factors.

Surplus food production can be sold to generate income and thus contributing to the household income security. The net income generated from home gardens is very variable and depends on species composition. For example, percent contribution of home garden to total family income ranged from 7% to 56 % of the total income household income in Indonesia and Vietnam (Trinh et al. 2003; Kumar and Nair, 2004). For many years coffee and banana have been sustaining the livelihoods of farmers in northern Tanzania, making Kilimanjaro region one of the richest and well educated regions in the country until 1990s when the trend reversed for reasons discussed below.

Wood Supply and Mitigation and Adaptation benefits of Chagga home gardens

While there are many reports on food and nutritional security, relatively few workers have addressed questions relating to wood production and its utilization in the home gardens. Indeed this seems to be an unrecognized value of many tropical home gardens including the Chagga home gardens. Local communities over the years have almost entirely relied on home garden for household cooking energy supply from trees planted or naturally regenerated in this system. It is estimated that a Chagga home garden supplies 1/4 to 1/3 of the fuelwood requirements of a family (Fernandes et al. 1984). Apart from indigenous shade trees, *Grevillea robusta*, is a one of the classical example of an exotic tree introduced for productions of timber and poles in Chagga home gardens. On-farm wood production has great potential to offset carbon emissions through avoided deforestation and if financing mechanisms to account for this carbon are well developed, this practice could help farmers to actively participate in climate change mitigation while generating income to adapt to the impacts of climate change and reducing land degradation (Kimaro et al., 2011; Robiglio et al., 2011). Understanding on-farm wood (fuelwood, timber, poles etc.) production capacity of Chagga home garden and household consumption patterns is a critically needed to assess the impacts of this on carbon sequestration and reducing harvesting pressure on native forests (Kimaro et al., 2011; Robiglio et al., 2011).

The forest-like structure of Chagga home garden discussed earlier presents a unique opportunity for carbon sequestration, while maintaining food crop and wood harvesting requirements of individual farmers. Traditionally this has been done through selective wood harvesting that do not involves complete removal of tree cover largely satisfying conditions of carbon leakage and permanence for carbon offset projects.. But comprehensive policy and regulations which consider landscape based carbon accounting approaches are needed to promote carbon as a value-added product for improving climate change adaptive capacity of farmers, while reducing degradation of coffee agroforests and enhancing food crop production.

Threats and opportunities of Chagga Home gardens

It was established in the previous sections that Chagga home gardens provide various human needs including income, food, energy, and construction materials. The complimentarity in subsistence and cash crops, and the diversity of the food crops enhance food and nutrition security and household income, contributing to socioeconomic sustainability of this system. Shade and fruits trees also increase family income from products like fruits, fuelwood, timber, and medicine. They also contribute to ecological sustainability of Chagga home gardens thorough efficient nutrient cycling and microclimate (soil moisture and relative humidity) modifications (Kumar and Nair, 2004). However, changes in biophysical and socio-economic conditions in Chagga home gardens over the years are endangering the sustainability of this system. These changes include decreasing farm size resulting from population growth and introduced alternative cash and food crops due to dwindling coffee prices (Hemp, 2006).

Cash and food crops like vanilla, maize and vegetables are gradually replacing the coffee-banana systems in Tanzania. As noted here, changes in socio-economic and biophysical conditions lead to the decline in composition and density of keystone species (i.e., shade trees coffee, and banana,), affecting food production, people's livelihood, and the environmental sustainability of the Chagga home garden system as a whole. This is because density and composition of keystone species determine the ability of multistrata systems to recycle nutrients and modify microclimate and soil moisture conditions to influence crop production as well as supply of food and other products discussed earlier. Hence, we conducted a field visit to discuss trends, threats and opportunities of Chagga home garden with key informants and farmers in Moshi rural districts. The field reported was complimented with literature review to understand the major threats of home garden over the years and opportunities for reviving this system to sustain its cultural and ecological heritage as detailed in this section

Farmers Perspectives on the threats of Chagga home gardens

Income- Poverty is increasing due to the decline in productivity and profitability of coffee-home gardens. It was explained that the collapse of coffee production system in northern Tanzania in the 1990s was associated with a number of factors, including the dwindling coffee price in the world market, climate change, and the disorganized inputs supply system. Farmers report declining coffee production but according to NAPA report climate change scenarios in Tanzania predict a 16% increase in coffee production (URT, 2009), which may be associated with the projected increase in the length of the growing seasons in African highlands, especially Ethiopia. Such is increase is attributed to a combination of factors, including the increased temperature and rainfall changes (Boko et al., 2007). Thus climate change impacts on coffee production as noted by farmers could be associated with a combination of local level factors including increasing drought and water shortages in traditional furrows that were used to irrigate the home garden.

The main impacts of decreased productivity and profitability of Chagga home garden is reflected in the livelihood of the Kilimanjaro region inhabitants to the extent that income per capita in the region is currently one of the lowest in Tanzania. To cope with this situation, it was learnt during the visit that farmers are adopting alternative livelihood options including, clearing of shade trees for sale of timber, cultivation of alternative cash crops like Vanilla, organic coffee farming, introduction of high-yielding sun-tolerant coffee variety, and increased rural-urban migrations by the youth to engage in off-farm income generating activities. Because of the frustration of the collapse of the coffee industry and increasing household expenditure one respondent indicated that "*people are doing things that they know they should not do*"; meaning that income poverty has caused people to cut down old trees in order to sell timber. Even valuable indigenous trees like mruka (*Albizia schimperiana*) which have very low propagative rate and fruits trees like mparachichi (*Persea Americana*) are cleared for timber production. Some sites in Shimbwe Juu village shows the effect of unsustainable tree harvesting and poor land management (Figure 6). In order to sustain the traditional and ecological value of Chagga home gardens and reduce the harvesting pressure on the native forests, it is necessary, to support the tree planting in the home gardens and increase environmental programmes. This can partly be advocated and funded via the carbon marketing schemes highlighted earlier and through effective government agricultural support programme.

Figure 6 Poor land management a threat to the Chagga home gardens. Shimbwe juu upland farming

Threats to productivity and sustainability of the Chagga Home Gardens

Shortage of a household farm labour:

As noted earlier, Chagga home gardens are managed mainly by using family labour. Family labour in northern Tanzania is lately a major problem due to higher proportion of ageing farming communities. The high rural-urban migration rate by youth and diseases epidemic, especially AIDS, which also affect the most productive age groups remaining in the village are among the major causes of reduced farm labour. One respondent emphasized that "Old people are the ones left in the villages; most of the young people have moved to either Moshi town or other parts of the country and do other economic activities. Many young people left in the villages are hopeless and engage in destructive activities like drunkenness. This trend has affected even other community development activities commonly done by villagers, e.g., maintenance village roads or traditional irrigation system, are not working well anymore because of high scarcity of the working force in the villages". The farm plots (*vihambas*) left behind are either managed using a hired labour which is not effective to keep them well productive or in the worst case scenario, abandoned because of the lack of family labour.

Land degradation: The cultivated area has been heavy fragmented as a result of increased population pressure. Furthermore agricultural intensification in response to the decreased farm sizes have resulted to heavy nutrient mining without replenishment. Increased population pressure has also led to cultivation in ravines, reduced fallow system in the low land and as noted above, induced change in cultivation and livelihood patterns all adding to land degradation problems in the Chagga home garden. During our visit we were informed that during the 1950s and 1970s, people used to put up terraces on the steep slopes and this practice was embedded in their farming operations. Farmers used to have songs and slogan encouraging each other to make terraces. It is a tradition among Chagga people to conserve the soil and sources of water like springs, rivers etc. No one was allowed to cut a tree and trees like *Ficus* spp., which grown close or along these water sources and in catchment areas. However, the new generation does not recognize the value of land and keep this tradition. People are not putting the bench terrace anymore; they just plant on steep slopes leading serious soil erosion and land degradation problems. There are by-laws from all levels of government too on good soil and water conservation practices, but nowadays they are not followed.

Cultural erosion: The Moshi Rural District Crop Production Officer Mrs. Joyce Kessy had the opinion that the major problem in the management of the *Kihamba* system is the eroding culture or attitude towards good agricultural practices as highlighted above. She noted that in the context of this system in Kilimanjaro the changes in people's attitudes, culture, and behavior could have more negative effects than climate change. This analysis or perspective could suggest negative attitude may constraint behavioral changes to adopt climate smart practices being advocated or revert to sustainable traditions which have sustained the Chagga home garden system over the years

Opportunities and policy recommendations to revive Chagga home gardens

Key informants and farmers indicated the following opportunities and recommendations to revive the Chagga home garden so as to sustain this traditional system in the context of challenges discussed in this report.

Organic coffee farming

a) Organic soil fertility improvement procedures

Farmers are encouraged to improve coffee production using available resources around their homesteads. They encourage proper manure management for soil fertility. This is done by mixing the manure available from their livestock, crop residues and kitchen wastes. This mixture is then buried down on the ground and covered well since rain and sun have negative effects on the manure nutrients. Organic coffee fetch higher prices in the global market which in turn a farmer is paid the better price compared to the conventional Market. This is adding value to what farmers have already in their field because most of them have failed to secure inputs and equipment for proper coffee management.

b) Organic control of pests and diseases

Farmers have indigenous knowledge of controlling pests and diseases. The local pesticide is made from utupa (*Tephrosia vogelii*) or muarobaini (*Azadirachta indica*) and is used to repel stem borer, berry borer and other pests. What they do is to tell farmers the proper measurements of the ingredients. For example in order to get effective pesticide one should prepare Ikg of fresh leaves of *Tephrosia spp* or *A. indica* mashed, mixed with 1lt of water and they are left settle for the whole night. The following day the solution is diluted with water to 20lts and it is good for control of several pests and diseases. There is on-going research at Tanzania Coffee Research Institute (TaCRI) on natural pesticides and biological control of the berry borers, stem borrer and other coffee pests and diseases which then will improve the control of coffee pests and diseases in a more economical and environmental friendly manner.

<u>Introduction of high value crops</u>.

Introduction of high value crops is one of the interventions in the Chagga homegardens to address the problem of low household income caused by the failing of the coffee industry. Vegetable crops including tomatoes and cabbages have replaced a number of coffee trees in the system. However, such crops have had a negative effect, because they require more light and therefore indigenous trees in the multi-strata system are cut down. Introduction of spices such as Vanilla, which is one of the intervention introduced by the GIAHS project is probably more environment friendly (Figure..). However, during the field visit farmers indicated that there is need for more research on the husbandry, markets and marketing of this crop. Potential for other spices such as cardamom as well as high value fruits and nuts are some of the other opportunities.

Figure 7 Vanilla plants in Chagga homegardens in Shimbwe Juu: Photo by David Boerma - FAO GIAHS project

Policy recommendations

1. Laws and regulations about soil and water conservation should be revisited and enforced. For examples, everyone with corrugated iron sheet roof should have a plan to collect the water in order to minimize soil erosion.
2. Soil and water conservation unit should be emphasized and be placed under president office. Right now is under the ministry of agriculture but it has not received the required attention.
3. The number of indigenous trees in a given area should be well defined in order to give guidance and inform farmers on its importance. This can be achieved by conducting research and establishing indigenous tree nurseries.
4. Follow up of laws and by laws should be done to ensure trees are planted and maintained, also protection of the recommended distances from water bodies and water catchment areas.
5. Women visibility should be raised in coffee production and *Kihamba* systems need to be increased as currently coffee is still a men dominated cash crop. KNCU is currently advocating on gender sensitive polies and guideline e.g. having female chairperson in the primary societies.
6. Laws on cutting and planting trees in the farms, around water sources should be put clear and emphasized
7. There should be a law for owners of *vihamba* living outside the villages to take care of their *vihamba* if not consequences will follow
8. Beacons or any mark should be used to mark water sources as it is done for road reserves.

2.3 MATENGO NGORO-PIT SYSTEM

Geographical location

The Livingstone Mountains are on the east coast of Lake Malawi, southern Tanzania. The western part of the mountainous area in the Mbinga District, Ruvuma region is called the Matengo Highlands (Fig 6), and is characterized by steep slopes ranging from

1,300-2,000m above sea level (asl). The indigenous vegetation of the Matengo Highlands is primarily evergreen montane forest, with annual precipitation of 500-1,200mm (JICA, 1998).

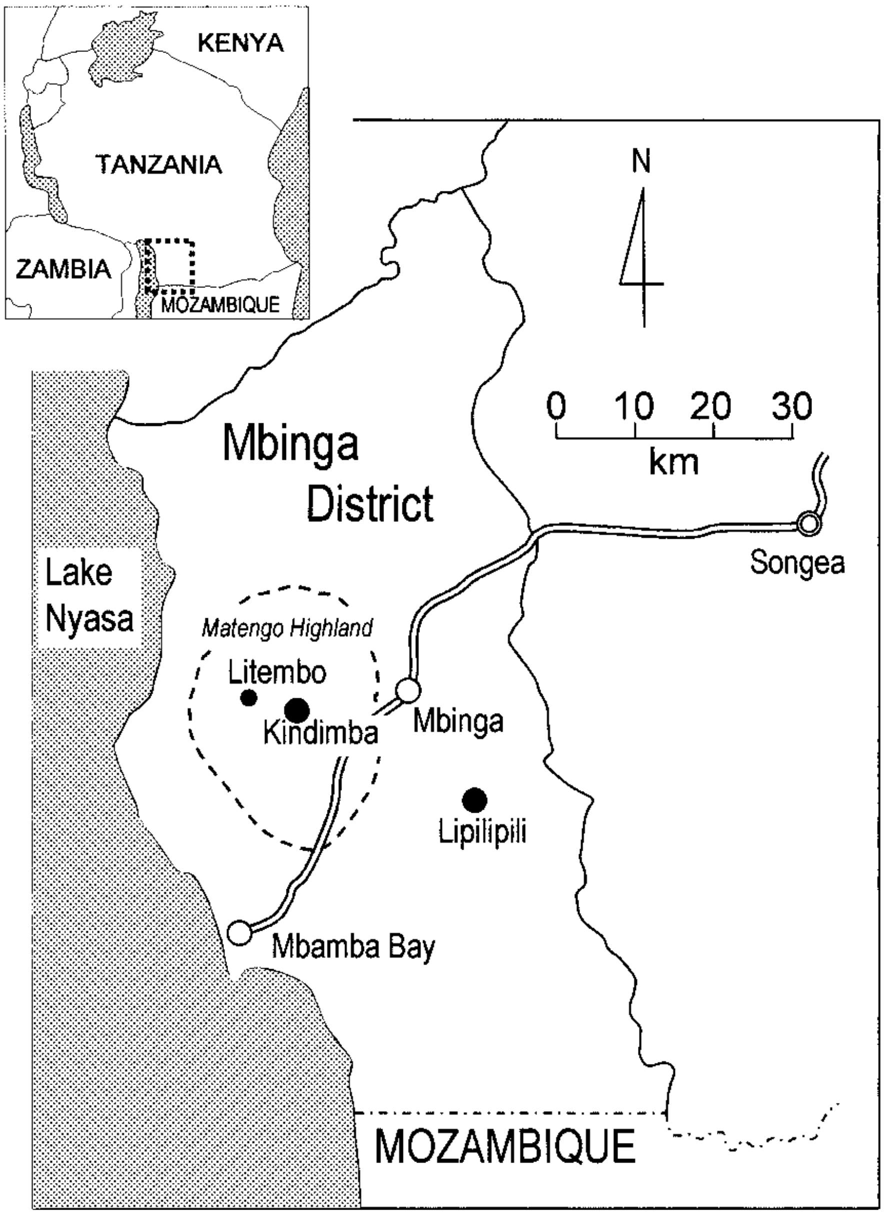

Figure 8 Map showing Mbinga District

The History of Matengo and Ngoro cultivation

The Matengo people have lived in the mountainous lands for more than a century and a half, because of conflict with the Ngoni people who migrated from southern Africa to east of Matengo Highlands, now called Songea, in the middle of the nineteenth century (Willis,1966; Shillington, 1989). They were obliged to stay only on the upper areas of mountains.

Due to high population pressure in those days they needed to increase yield per unit area in order to obtain enough food. Under these social constraints to survive in the highlands, the matengo invented intensified cultivation system with a unique soil conservation features especially for food production. The system is called *ngoro*. Literally translated, *ngoro* means "pit" in the Matengo language. Since a *ngoro* field has many pits, the system has been referred to in the literature as "Matengo pit cultivation" (Kato, 2001). The Ngoro system has sustained land productivity for many years and it is estimated to start between 1700-1750 BC and covers an area of 18,000ha. The population in the highlands is still high According to the 1957 census, the population density of the Matengo Highlands was about 70 individuals/km2 (Tanganyika, 1963), and in 1997 it was more than 100 individuals/km2 (JICA, 1998). This density is considerably higher than the average 26 individuals/km2 in Tanzania in 1988 (Tanzania, 1989).

Description of the Ngoro farming system

The plot is slashed and the grass including the crop residues are left to dry for about two to three weeks. Then they are arranged in square shaped lines of about 2 m by 2 m sizes. This job is done by men. The women job is to dig the pits, whereby the soil is dug in the middle to cover the grasses and thus forming a series of ridges with pits in the middle. This forms a honey comb like structure. Beans, wheat, finger millet, cowpeas and maize are grown on the ridges surrounding the pits (Fig 7).

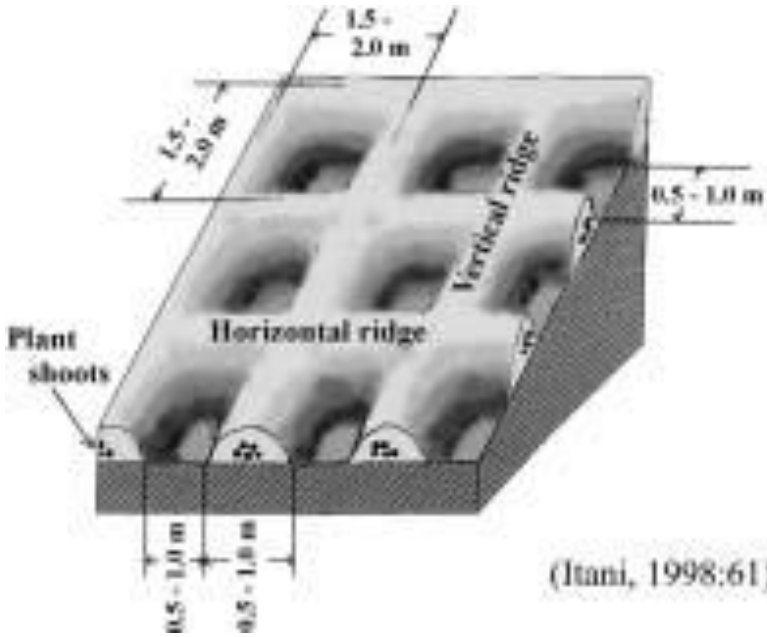

Figure 9 A profile of Ngoro ridges

The fertility of a *ngoro* field can be sustained by long fallow periods, as well as by short fallow periods every two years. However, because of the high population density the farmers must continue to cultivate their fields for a long time and in order to continue getting high yields, they apply chemical fertilizers to grow maize (Kato, 2001).

Significance of the System

Economy and food security: The *ngoro* system is the most important way for the Matengo to acquire food, and many of the farmers do not sell products from their *ngoro* fields. Food production from ngoro farming is relatively higher Allan, 1965 mention of an experiment which indicated that maize yields in *ngoro* were 3 times more than those of a bench-terracing system. Most of the income in the Matengo economy is acquired through coffee production. In 1926, coffee was introduced to the Matengo Highlands and gradually spread throughout the area (Iliffe, 1979). Coffee is suited to the cool and moist conditions of Mbinga. There is a close relationship between coffee production and food crop production in Matengo highlands. Since coffee is the major cash crop the income from coffee is used to buy fertilizer and other inputs for food production

Social-cultural: Ngoro cultivation has very deep roots in Matengo culture, especially when it comes to marriage. Women must master the techniques of making the ideal and perfect *ngoro*. They are aware that the skill of cultivating the *ngoro* is an index of their socio-cultural status and recognition, particularly for unmarried women. Thus, the *ngoro* cultivation system has also been maintained by the common recognition of women's labour and integrity. Division of labour in ngoro cultivation is strictly based on gender. If either gender fails to perform its duty, the cultivation of *ngoro* may commence late or be abandoned altogether. It is almost impossible to exchange labour between sexes in *ngoro* cultivation, because men and women have mastered only one technique. (Kato, 2001)

Environment

Soil and water conservation: The system is very effective in controlling soil erosion; the effects are comparable to bench terraces and more effective than ridges or bare practices. The pits are very effective in collecting runoff water during the rain and to be effectively utilized by crops grown on the ridges. Moisture conservation facilitated by the ngoro pits creates a microclimate which allows beans planted towards the end of the rains (March/April) to be cropped on residual moisture (Table 2)

Table 2. Effects of conservation practices and slope on seasonal soil loss at Tukuzi, Mbinga District

Site	Slope (degree)	Conservation practice	Soil loss (tons/ha) 1994/95	Soil loss (tons/ha) 1995/96
A	9	Bare	39.0	38.6
		Ridge	7.3	3.0
		Ngoro	2.4	1.2
B	21	Bare	55.7	80.6
		Ridge	14.3	10.6
		Ngoro	5.8	1.4

Source: Jica, 1998

The buried grasses and the crop residues on the ridges decompose to release nutrients to the soil and subsequently to the grown crops.

During the rainy season, the ridges begin to collapse gradually and the pits are filled with sediment by the middle of the rainy season. This is probably caused by a lack of subsurface drainage due to decomposition of grass and crop residues on the ridges. The decrease in permeability of water into the ridges may be ascribed to soil compaction. During the season, erodible surface soils are deposited in the bottom of the pit. Even if the size of one pit is small, the number of pits formed all over the field may enhance soil sedimentation capacity by minimizing soil loss with run-off water. (Itani, 1998). The position of the pits is shifted for each new cultivation . New pits are placed where the previous ridges intersected. By changing the position of the pits during each preparation, the top and sub-soils as well as dry grasses are mixed or turned over (JICA, 1998). This process matures the soil. Although the function of soil and water conservation attracts the most notice in the *ngorongoro* system, soil maturing is also quite important to maintaining high productivity levels.

Land Utilization on the Highlands

Matengo have a unique land tenure system called *ntambo w*hereby families own pieces of land from top of the mountain down to the valley. The elevation ranges from 100-600 m and the size of the *ntambo can* range from 10-70 ha. (Kato, 2001). *Kitengo* is the upper parts of the mountains which is often a forest cover. The place is used for firewood collection, grazing of animals, or collecting wild plants for herbal remedies.

People build houses on any flat site within their ntambo. This place is called *nnduwi*. Is around this area where Matengo establish their home gardens (Fig 8). They plant vegetables like tomatoes, onions, amaranth, sweet potatoes, sunflowers, pumpkins, and other vegetables. Coffee trees are usually cultivated in bench terraces on the slopes around this area. Coffee is grown on farms that are close to homesteads as it needs close supervision and operations like pruning, spraying, picking and processing of the ripe berries would be difficulty if farms were far. Trees such as Grevillea, Eucalyptus, Cypress and fruit trees are interplant with coffee to form home garden agroforestry system. (Nhira et al 2008).*Uheleu*, is the steep slope area in the ntambo, that's where the ngorongoro cultivation is done to grow the major food crops, maize and beans.

Kijungu and libindi fields are located down on the valleys on narrow, flat, elongated plain along the streams. This area remains wet throughout the year and is used to grow some vegetables and coffee seedlings. Perennial crops such as sugar cane, banana and taro are grown here too. Plains are utilized for pasture during the dry season. Some farmers do aquaculture on this place too.Thus, the Matengo use the *ntambo* effectively to suit various ecological conditions.

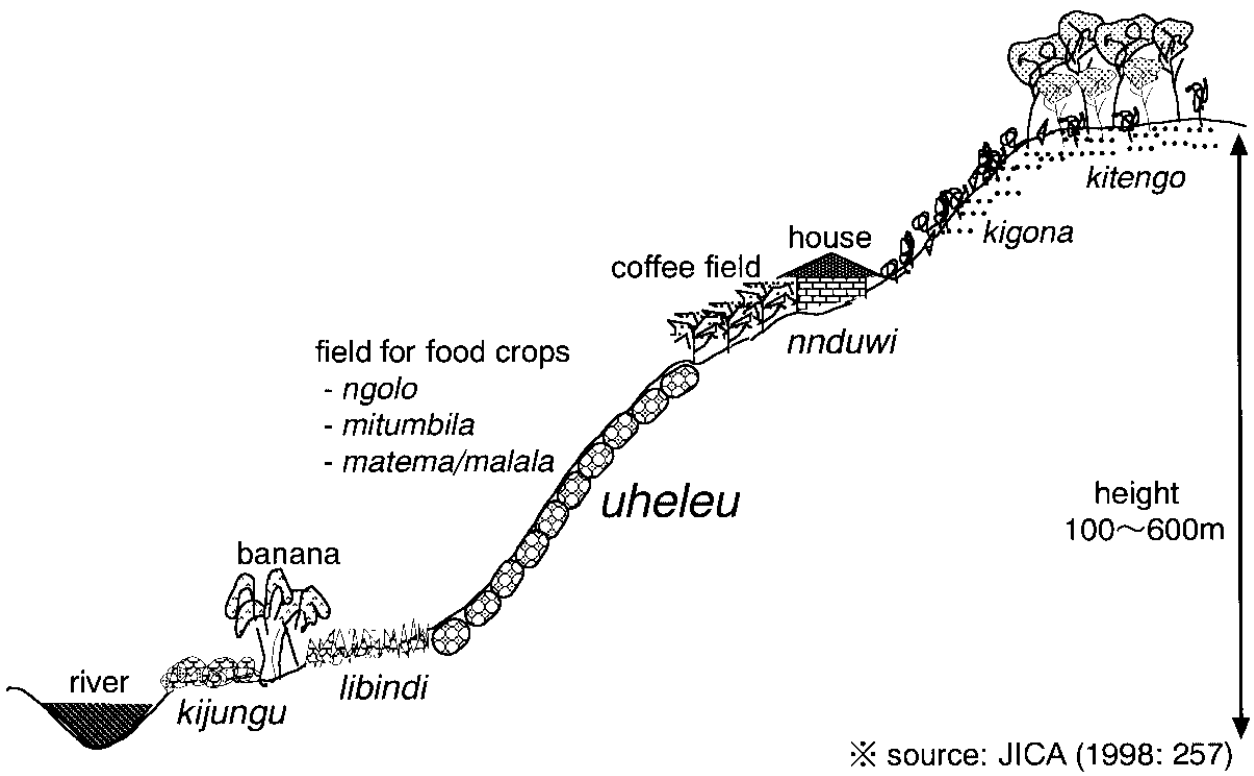

Figure 10 A cross section of a typical Ntambo agroforestry system along the catena.

<u>Challenges and Opportunities</u>

Threats: The system is labour intensive for women. Denser population and competing land uses with coffee production and settlement expansion, shortage of labour, drought, and climate change are the major constraints to sustainability of ngorongoro farming. For instance shortage of family labour lead to the use of hired labour, which sometimes do not make good pits and hence the system becomes ineffective.

Climate change its impact and adaption: Nindi S. and Mhando D.(2012) did a study on the climate change and variability in Matengo highland and come up with the following results. The study was done on two Matengo villages of Kindimba and Kitanda, the following were noted as indicators for climate change, recurrent droughts, El nino rains of 1997-1998, change of rainfall seasons (onset, offset, durations, increasing dry spells) crop failures, increasing temperatures, outbreak of unusual pests and diseases such as maize leaf rust in 1990s, declining soil fertility that forced replacement of maize with cassava.

Their adaptive strategies include the following: working in farmers groups in order to enhance intergrated resource management in activities like fish farming, beekeeping, tree planting. Other strategies include rural –rural migration, adoption to improved cooking stoves in order to cut down firewood consumption, intensive valley bottom cultivation and change in eating habits. Others include intensification of agroforestry, adoption of new coffee clones, cultivation of drought resistant crops like cassava and engagement in other non-farm activities like poultry, pig, cattle husbandry and hydromill machine. The stricking feature is the organization of farmers groups although adaption at household level is practiced too. The farmers are enganged in other cash generating activities like selling of fingerlings, fish vegetables and honey. The hydromill which is owned under the farmers umbrella group generate revenues which are used for other development activities in the village. Establishment of SACCOS (Saving and credit Co-operative Societies) which helps farmers to access financial services and acquire loans which helps to improve their livelihood.

Collapse of Coffee production

The collapse of the coffee market has negatively impacted the Matengo farmers. The income from coffee was used to acquire chemical fertilizer which supported crop production. Mhando (2005) noted that the tumbling of coffee production and it's marketing system led to the vast and abrupt creation of new farms on virgin lands on the rolling hills where use of agro-chemicals was not necessary. This influx of immigrants from the mountainous areas caused land degradation in the rolling hills since in the new land farmers practiced slash and burn agriculture on such steep and rugged slopes and cause intensive soil erosion and sediment run off to valleys Nindi. (2004) and deforestation is another problem.

2.4 Ngitili agroforestry system in Western Tanzania

Geographical location and structural features

The Ngitili,is a traditional silvopastoral pastoral system of the Sukuma tribe in western Tanzania, especially in Shinyanga region. The Ngitili is system comprises livestock and trees/vegetation components which are both managed together to generate social-economic and environmental benefits. Under the Ngitili, communities set apart grazing areas to serve as a reserve for supplying fodder during the dry season when supply is limited. The Ngitili also provides wood and non wood products, medicines and food for the households (Otsyina et al. 1997, Monela 2005).

The Ngitili System integrates livestock and crop production. Although the Ngitili agropastoral system originated and mostly documented in Shinyanga, variations of the Ngitili system are practiced by the Wanyaturu in Singida and parts of Tabora. Shinyanga Region is situated in northwestern part of Tanzania, South of Lake Victoria at about latitude 2 - 5^0 South and longitude 31 - 35^0 East. Mwanza, Kagera and Mara regions to the North, Arusha Region to the East, Singida and Tabora regions to the South and Kigoma Region to the West border the region.

The Region has eight administrative districts (Shinyanga Rural, Shinyanga Urban, Maswa, Meatu, Kahama, Bukombe, Bariadi and Kishapu (Figure 10). Shinyanga Region covers an area of 50,764 km^2 of which 31,140 km^2 is arable land, 12,079 km^2 grazable land and 7,544 km^2 forest reserves (HASHI, 2002). Altitude varies between 1000 masl in the southeast to 1500 m asl in the north-east. Ecologically the region falls under the unimodal plateau. Mean annual rainfall is about 700 mm and it ranges from 600 mm in the east to 1200 mm in the west (HASHI, 2002). Rains begin in November and end in April/May. Rainfall is poorly distributed with high variability within and between seasons. Monthly temperatures vary between 27.6^{0}C to 30.2^{0}C maximum and 15^{0}C and 18.3^{0}C minimum. On hilltops, soils are moderately well drained greyish brown and sandy (ferric acrisols and oxisols). Moderately deep well drained, greyish brown sand loams (ferric luvisols) occur on the slopes. On the low-lying bottom lands, are the poorly drained black clays (cambisols and vertisols). Vertic soils are very extensive covering 47% of all soil types in the region. Natural vegetation was originally woodland and bushland with species such as *Acacia, Brachystegia, Albizia, Commiphora* and *Dalbergia* (HASHI-ICRAF, 1997).

Social-cultural characteristics

Shinyanga Region is dominated by WaSukuma, an agropastoral community. Lesser populated groups include WaSumbwa, and minorities from neighbouring Mara and Kagera Regions. The region is experiencing a fairly high population growth that has increased from 1,772,549 people in 1988 to 2,805,580 people in 2002 at a growth rate of 2.9% per annum (National Population Census, 2002). Mixed farming is practiced whereby cultivation is the major livelihood activity, followed by livestock keeping. Major cash crops are cotton and tobacco. Other crops such as paddy, cassava and maize serve both purposes of food and cash income.

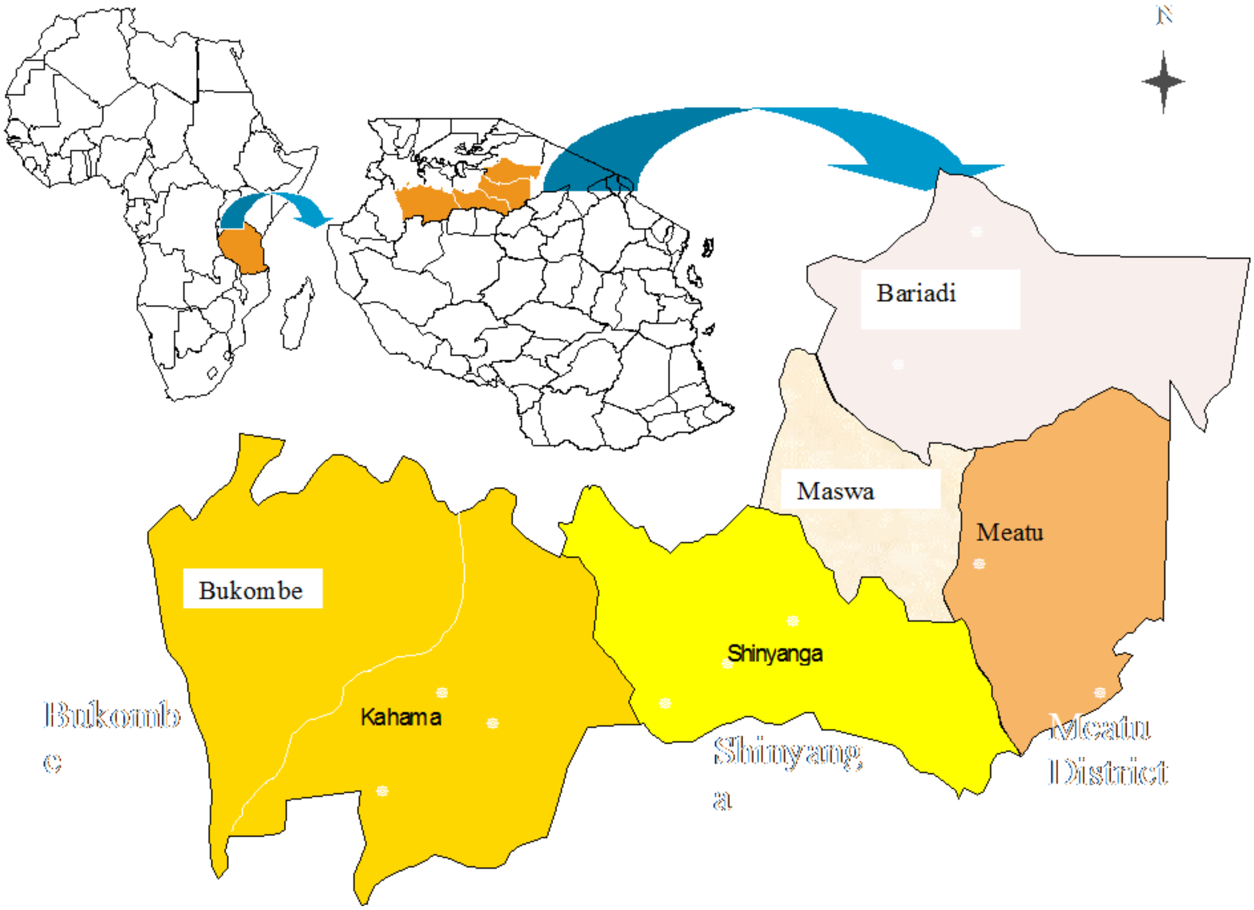

Figure 11 The Map of Africa and Tanzania inset showing the distrcits of Shinyanga Region

Livestock keeping is very prominent and according to National estimates (2002) Shinyanga region possesses the largest number of cattle head among all regions in Tanzania. It is estimated that between 20-30% of the livestock population in the country is found in Shinyanga (Machanya et al, 2003:4). Cattle are the traditional symbol of wealth and status, are assets that can be converted to money, food and farm implements, used for bride price, and source of family wealth and income' (Shinyanga, 1998). Livestock wealth is thus a central component in maintaining people's lifestyles. A small percentage of people also practice artisanal and small scale mining. Despite having much production potential, Shinyanga region was consistently identified as poorer than the national average in terms of income poverty.

Structure, composition and biodiversity

The Ngitilis concept is based on conservation of natural resources for food security, supply of wood and non wood resources as well as other household needs. Ngitilis comprise trees forming the upper layer while grasses mixed with forbs form the other lower layers. A great diversity in composition and will as sizes exists from district to district depending on land availability, usage and climatic differences. Ngitilis in Kahama are the most diverse. Dominant trees found on Ngitilis in each district are indicated in the figure 11 below. Dominant tree species found on Ngitilis include, *Acacia tanganyikensis, Acacia polyacantha, Afzilia quanzensis, Brachystegia species, Commiphora Africana, combretum zayeri and Dalbrgia melanoxylon.*

Recent survey results (Monela 2005) have documented over 152 different trees, shrub and climber species in Ngitili forests and many bird species and insect eaters have re-colonized habitats that were destroyed. Ngitilis also provide homes for small and medium sized mammals. However, large mammals like elephant, buffalo, zebra that require larger home ranges have disappeared in all districts except in protected areas. In addition, Ngitili and woodlots provide fodder for livestock grazing during the dry season. This simplifies the living standards of the livestock keepers because the pastures are now nearby them, hence save time for other activities.

Management of the Ngitili system

The system is managed through careful grazing resource management and crop husbandry practices. The Sukuma have developed ecologically based grazing management practices to ensure sustainability of fodder and food throughout the year. Some of these practices include controlled and deferred grazing of Ngitilis, adherence to optimum stocking levels and times of grazing at specific areas. For example, wetlands or **Mbuga** areas were reserved for grazing during the dry seasons. On crop lands, the Sukuma practiced crop rotations, fallowing and specific crop mixtures to maintain soil fertility and productivity as well and minimize disease incidences. The Ngitili management systems were controlled and monitored by village and sub village by-laws which were enforced by the Sungusungu or community police.

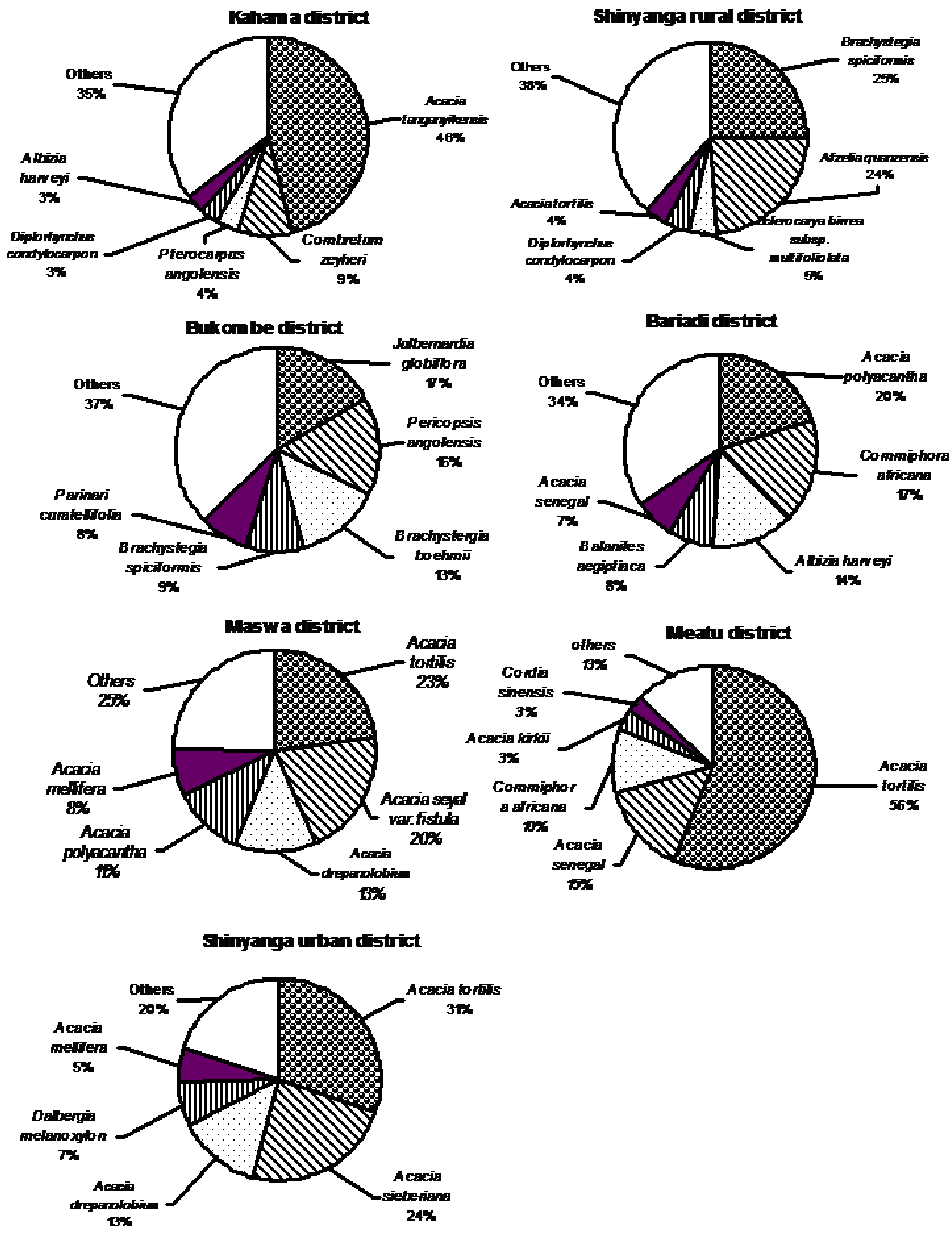

Figure 12 Tree composition of Ngitilis from various districts in Shinyanga.

Institutions and organizations

The wealth in indigenous institutions, knowledge and practices related to natural resource management in Shinyanga has been well documented (Mlenge, 2002, Minja and Machanya 2010). The strength of these institutions is still apparent today although policy influences and changing socio-economic reality have influenced the evolvement of institutional arrangements. Currently, most traditional systems of resource management try to synchronize with modern challenges and demands on natural resources in order to maintain a healthy resource base. Resource management is organized and directed by informal traditional structures such as **Baraza la Wazee**, that has significant clout in institutionalisation and enforcement of local rules and regulations regarding Ngitili management. The local rules ensure that the valuable natural resources for livestock and agriculture are not degraded but sustained. This traditional knowledge is passed on to the younger generations.

Land use, ownership and tenure rights

The Tanzania Land Law and Policy recognizes customary land tenure arrangements. Thus land use patterns in the region are strongly influenced by Sukuma cultures and traditions. These have established rights of access to resources, land use practices such as bush fallow, and the predominance of livestock keeping. Women, who may not automatically have ownership rights to the land, do at least have full control of low-income crops while men control cash crops such as cotton, despite the shared labour between the couples (op. cit, 2003:43). Traditional land use patterns are, however, increasingly challenged by pressure on land because of increased livestock populations, and human population increases leading to increased fragmentation. Decreasing soil fertility is making farming unproductive but the farmers are not used to apply manure despite its availability (Machanya, et al, 2003).

Economic activities

The types of economic activities carried out in Shinyanga region are dependent on climate and the existing natural resource base. Livestock keeping is second to crop husbandry, the predominant economic activity in the region. More than 90 per cent of the region’s population live in the rural areas and practice agro-pastoralism. The people in Shinyanga region earn their living through a diverse range of activities. Subsistence farming for food and cash crops as well as livestock keeping rank high as main occupations in the region. Cotton and tobacco are the main cash crops while sorghum and maize are the staple crops. In addition, such crops as paddy rice, sweet potatoes, cassava, beans, finger millets and groundnuts are cultivated on varying scales. Other activities include: mining, casual labour, petty trading, beekeeping, lumbering and charcoal making and formal employment for government staff working in villages. Gender, norms, customs, individual wealth and access to resources have to a large extent influenced economic activities in the region.

Figure 13 Traditional bee hives in Ngitili system

Cultural Importance of Ngitili: The traditional institutions such as the Council of elders and the Sungusungu played key roles in the management of the system. The Dagashida was involved in decision making to ensure sustainable use of the resources as well as the welfare of the people. For example the elders of both the families and the clans determined which areas were set aside for grading during the wet and dry seasons and for how long the Ngitilis were grazed. The council has its own rules and regulations enforced through a system of fines and other social sanctions. The council of elders, exists at two levels, at hamlet, where they can be more than one council depending on the size of the hamlet in terms of area and at village level. The hamlet council is composed of a chair and members, all elders. A village level council of elders is formed by the heads of each hamlet council of elders.

The Sungusungu or traditional police are the implementation arms of the Council of Elders or Dagashida. The role of the Sungusungu is to keep law and order and to ensure implementation of bylaws. They are also responsible for protection of the communities against invaders. Heavy fines are levied on culprits who break the laws. The Sunsungu are powerful and well respected in the communities but not legally recognized in the central and local government structures. The traditional institutions still exist and functional in Sukuma land, however, with the introduction of modern local government systems after independence in 1970, the powers of the Elders and the Sungusungu has been reduced considerably (Minja and Machanya 2010). The system was further disturbed by the introduction of the Ujamaa system in 1970. The ujamaa forced communities to move from traditional villages to new villages and communities so as to access modern services. Communities on the move left their Ngitilis behind and moved on. This has led to increased degradation of the natural resources and social conflicts which threaten the existence of the Ngitili system. By 1984, the Ngitili system was on the verge of collapse, Shinyanga was very badly degraded resulting in serious erosion of the top soils, fuelwood and fodder became a scarce and communities faced severe food security problems (Otsyina et al 1997).

Socio-economic and Environmental benefits of Ngitilis

This section details major products of Ngitilis, which include timber, fuelwood, fodder, poles for construction, water, honey, wild animals and insects, medicinal plants, wild fuits, mashrooms, thatching material, charcoal and wild vegetables. Other benefits include carbon sequestration and storage. Monela et al. 2005 estimated economic importance of Ngitili for Shinyanga region, which showed that the Ngitili products listed above generated an average household annual income of USD163.7, 152.6 and 493.19 for Shinyanga Urban, Shinyanga Rural and Meatu, respectively The environmental and ecological value of the Ngitili system can be assessed through its impacts on carbon sequestration and climate change impacts.

a) **Monetary value of Ngitilis in terms of avoided deforestation and degradation:** It is estimated that over 500,000 hectares of Ngitili are being managed under the system today. Other associated systems such as woodlots are also being established to mimic the Ngitili system. At present a total biomass of 23,214,752 tons of dry matter is currently standing in the main conservation areas. This translates to about 11,607,376 tons of carbon and 42,599,070 tones of carbon dioxide gas. When converted at current voluntary carbon market rates at USD 5.0 per ton of carbon dioxide, about USD **212,995,350** is saved from degradation avoided deforestation and degradation (Otsyina et al. 2008).

b) **Potential for carbon trading in Shinyanga: A**lthough significant progress has been made in slowing down the deforestation and degradation process, a lot still needs to be done to sustain the benefits of the system and to increase coverage under conservation in Shinyanga. Investments in forest carbon trading as an additional incentive would promote management of Ngitilis and improvements in the livelihoods of the communities in Shinyanga while contributing to the global climate change agenda.

Due to the potential value of the Ngitili system in conservation, food security and income generation for communities in Shinyanga, a national REDD+ pilot project has been initiated in Shinyanga to address the key drivers of deforestation and forest degradation. The aim of the project is to assist 6000 Ngitili owners in 10 villages of Shinyanga rural and Kahama districts to establish a robust local institutional framework that effectively manage the restores Ngitilis to capture the benefit arising from REDD (TaTEDO 2009). In order to prepare the communities to befit from the carbon trade, the project plans to formalize and capacitate institutional framework for REDD implementation, establish baselines for potential carbon sources, develop and assess different measures for addressing key drivers of degradation and forest deforestation. Key approaches and interventions adopted by the project include, introduction and scaling up use of alternative and efficient energy technologies for domestic, institutional and small and medium enterprises to reduce forest deforestation and degradation, sustainable management of natural resources, introduction of sustainable agricultural intensification activities to increase productivity, training of agro-pastoralists to plan and manage livestock and Ngitili resources on a sustainable basis. In addition, the project will train communities and government leaders to address governance issues in natural resources management.

Introduction of the REDD+ pilot project has raised considerable interest and enthusiasm among the leadership and local communities in Shinyanga. It is seen as means of safeguarding the valuable Ngitilis and woodlots from further degradation while providing monetary benefits and improving the fragile environment and improving livelihoods. Lessons and experiences from Shinyanga will be scaled up to other degraded areas.

2.5 Spice agroforestry system

Geographical location and structural features

Agroforestry systems provide conducive environment for spices, thus the high association of agroforestry and the spice industry. A typical example is found in Western Ghat of South India, the main spice producing region in the world, which is known for its rich ecological and environmental biodiversity (Korikanthimath 2033). In Tanzania mainland the spice farming belt is found within the Eastern Arc Mountain (EAM) an ecoregion of national and global importance for biodiversity conservation Eastern Arc Mountains is reported to have the highest ratio of endemic flora and fauna per 100 km2 of all biodiversity hotspots in the world (Myers et al 2000). Although the present study did not include Zanzibar it is important to note that spice farming in Zanzibar dates back to the 16th Century. In fact the island is famously known as spice island, which contribute greatly to the growth of the tourist industry

East Usambara is the main domain for spice farming in Tanzania mainland. However, spice farming is practiced in the other mountains within Eastern Arc such as Uluguru Mountains. Link between spice farming and agroforestry has gained more importance in recent years as a measure to combat problems of forest degradation. There is a global move to encourage using agroforestry methods for spice farming instead of converting natural forests to spice farms. In an experiments with intensive agroforestry in Emau Hill in the East Usambaras, where cardamom was intercropped with *Grevillea robusta* and black pepper Reyes et al. 2006 reported ten times higher production of cardamom in agroforestry farm than in a secondary forest. The multi-layered structure of agroforestry provide conducive environemnet for spice farming as seen in images captured in Zanzibar and East Usambara (Plates X – Xxx).

Spices cultivated in the EAM include: Cloves ("Karafuu" - *Eugenia caryophyllus*), Cardamon (Iliki - *Elettaria cardamomum* Maton),), cinnamon *(mdalasini - Cinnamomum zeylanicum*) and black paper (Pilipili manga – *Piper nigrum*). An informal survey in two villages in East Usambara, Kwezitu and Kiswani, revealed that spcies are highly valued crops inEast Usambara. All farmers (16) interviewed in these two villages reported that spices contribute most of their cash income. Reyes et al. 2006 reported that cardamon alone contribute over 50% of total cash income among households in East Usambara. The price of cardamom has increased from USD2.9 in 2001 to USD6.3 in 2012. Spice farming contributes to local and national economy through ecotourism.

Economic importance of Spice –agroforestry

An informal survey in two villages in East Usambara, Kwezitu and Kiswani, revealed that spices are highly valued crops in East Usambara. All farmers (16) interviewed in these two villages reported that spices contribute most of their cash income. Reyes et al. 2006 reported that cardamon alone contribute over 50% of total cash income among households in East Usambara. The price of cardamom has increased from USD2.9 in 2001 to USD6.3 in 2012. The high value of spices makes them better choice for complimentary crop in traditional coffee based agroforestry systems. The East Africa GIAHS project recommended vanilla as a complimentary crop in the Kihamba or Chagga home gardens. Other spices compatible with coffee include; cadamon, balck paper, and tree spices.

The importance of the spice farming is growing as more and more drastic measures are taken to protect the natural forest. An informal survey was conducted in two villages in East Usambara to study the importance of the system and assess its potential as a heritage agroforestry system.

Figure 14 Spice Agroforestry system in East Usambara Tanzania

Major observations from the field visit suggest that spice agroforestry has enormous potential to support communities living adjacent to natural forest especially with the emerging protection of natural forest. There is need for further studies on spice agroforestry system in the country, and its potential to protect natural forests.

3 Traditional Agroforestry Systems in Kenya

Figure 15 Smallholder farming system in Central Kenya Highlands

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3.1 Overview

In Kenya, there are several forms of agricultural heritage systems including agroforestry, livestock and fisheries production. Existing and potential values of agricultural heritage systems have not been well identified or recognized despite evidence that these systems have over time been proven to sustain the livelihoods of communities that practice them. The traditional systems are rich in natural resource, institutional management structures and have contributed to the outstanding landscapes associated with them. The systems have been tested over time and they are the outcomes of years of experimentation and validation by local communities. The systems have co-evolved with the people and the environment and in the process the practices have been perfected.

The focus of the study in Kenya was the upland traditional agroforestry systems examining the trends and impacts of the systems on household food security and incomes, environmental and ecosystems conservation. The study also looked at the historical and policy implications on the traditional systems. The GIAHS project team in Kenya identified seven traditional agricultural systems as shown on the map below. These are:

- The intensive agroforestry systems of the highlands of central Kenya
- Taita agricultural landscapes
- Ameru agroforestry system
- Ttraditional furrow irrigation system of the Marakwet,
- Amaya irrigation system in Samburu,
- Ngebotok irrigation system in Turkana County and
- The agro-pastoral and fishing systems of the Ilçhamus in Baringo County.

However, there is need to identify and document other existing traditional agricultural systems in the country.

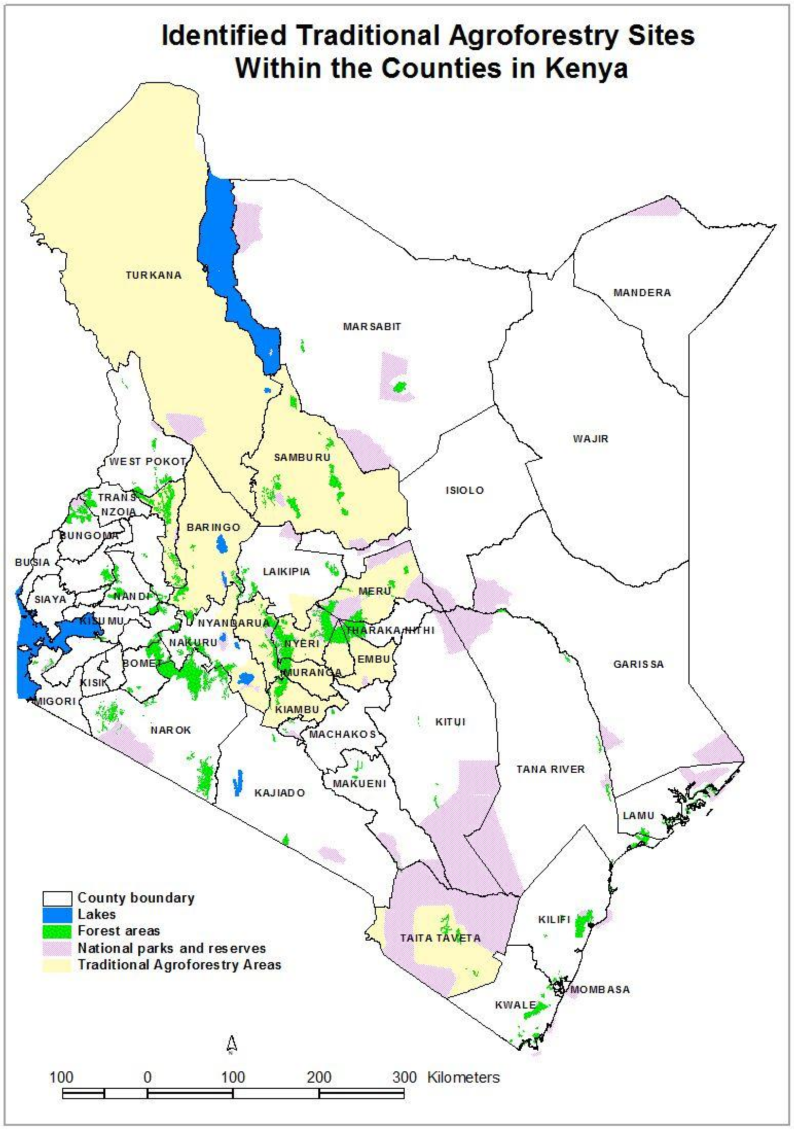

Figure 16 *A Map showing some of the Identified Traditional Agroforestry Systems in Kenya*

3.2 The Case Study of Central Kenya Highlands

The central Kenya highlands have a unique traditional agroforestry system that has been used by the local community to meet diverse needs and protect a fragile environment caused by the sloppy terrain and high population density. There is evidence that the local community has practiced agroforestry over generations. The survival of the community has depended on diversification of agricultural production and wide choice of foodstuffs consumed in the area.

Description of Central Kenya Highlands

The central Kenya highlands lie along the slopes of Mount Kenya and Aberdare Ranges and most of the area is in Central Province that has a total area of 13,173 km². Central Province has five counties namely Kiambu, Murang'a, Nyeri, Kirinyaga and Nyandarua. The geological conditions are more or less homogenous and therefore soils are less variable and are primarily nitosols of moderate to high fertility (Kenya Government, 2006). Central Kenya has the highest population density in the country ranging from 300 to more than 1,000 persons/km2. Most of the area is dominated by the populous Agikuyu (Kikuyu) community and neighbours the Meru and Embu communities in the east, Kamba in the south and south east, Maasai in the south, Samburu in the north and Kalenjin in the west (Figure 13)

According to the results of 2009 population and housing census the population of Central Province was 4.4 million, the number of households was 1,224,742 but the total population of the Agikuyu was reported to be about 6.7 million out of the total Kenyan population of 38.6 million (Government of Kenya, 2010). The Agikuyu community are sedentary farmers with tradition of practising mixed farming by keeping livestock, planting crops and trees on the same piece of land. Agroforesty is thus an old traditional practice of the Agikuyu community. The Embu and Meru communities share similar cultural and social orientations with the Agikuyu while the Masai, Samburu and Kalenjin are traditionally pastoralists.

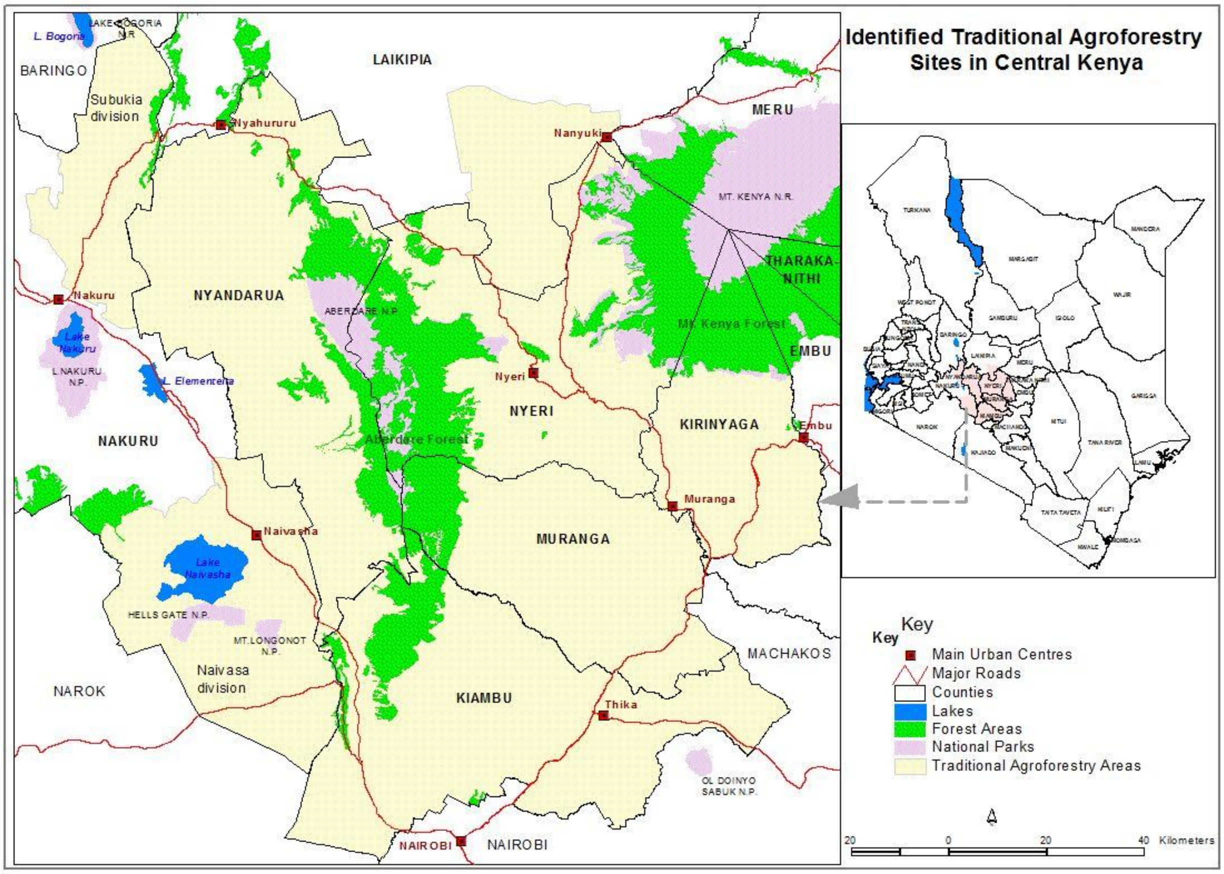

Figure 17. *A Map showing Traditional Agroforestry Systems in Central Kenya*

Land Use System

Land Tenure: Among the Agikuyu community, land was either owned privately or communally and its allocation was guided by community leadership and cultural laws. The forests were communally owned and protected. The community trusted its leadership on council of wise elders who determined all issues affecting the members. They did not leave leadership at the hands of one individual who can easily be biased or manipulated. The elders had the mandate to expedite justice to community members including convicting criminals such as passing of death sentences to murderers and violent robbers who were put in traditional bee hives and rolled down a steep slope.

The communal land was mainly used for grazing and families were encouraged to have small herd of livestock as a mechanism of ensuring that the communal pastures were not over-exploited. The communal land was protected by strict cultural laws that encouraged sustainable use of common resources. Prior consent from the elders was required to cut down a tree and permission was granted to persons who had serious justification for the need of tree products such as construction of a house. There were taboos that restricted indiscriminate and unnecessary cutting of trees and especially felling of valuable tree species like Mugumo tree. Commercial exploitation of natural resources such as forests was strictly forbidden in realization that natural resources belonged to the community and were not meant for exclusive use by an individual. This served as an inherent mechanism for protecting and conserving the biodiversity and environment. It also helped in protecting the common resources and circumvented the occurrences of the tragedy of the commons.

Practices and Management of Traditional Agroforestry Systems

Traditionally, crops, livestock and trees were deliberately incorporated onto the same piece of land since time Immemorial. The cropland is characterised by the upper layer being dominated by tall trees, the middle layer by shrubs, bananas and fodder shrubs while the ground layer is dominated by annual crops and grasses including maize, beans, Napier grass, root crops, etc. The crop associations and rotations are carefully chosen, arranged and monitored to reduce competition and to improve the total production. There are several tree species planted or conserved on cropland and pastures such as *Cordia africana*, *Grevillea robusta, Commiphora zimmermannii* and *Trema orientalis.* There are several niches for planting trees including boundary, cropland, grazing land, home compound, water courses, etc. The community has rich ethno-botanical knowledge about trees and over 400 species have been named and their uses are well known after centuries of experimentation and validation.

The resilience of traditional farming systems highly depended on diversification of crops and livestock enterprises. The tradition agricultural systems have inherent mechanisms for nutrient recycling and thus ensure sustainable land productivity through the maintenance of soil fertility and vegetation cover. The crops are planted together with trees scattered in the farm or arranged around the farm boundaries. Farmers produce mixed crops such as cassava, millet, sorghum, yams, sweet potatoes, bananas, pumpkin, arrowroots and early-maturing crop varieties such as composite maize and Irish potatoes.

The drought tolerant varieties include yams, cassava, sweet potatoes and *Dolichos lablab.* Most of these crops are easy to store for long periods after harvesting. Other crops are produced for both human and livestock feeds such as sweet potatoes, millet, sorghum and bananas.

Traditional tool for cultivation is known as “Muro” and resembles the hoe. Livestock feeds include planted fodder such as Napier grass, sweet potato vines, fodder shrubs and herbaceous legumes and are also supplemented by crop residuals. Fodder trees and shrubs are deliberately conserved on the farm *in-situ* to feed livestock when the need arises and especially during the dry season. Cut-and-carry feeding system ensures that fodder species and crops are protected from destruction by livestock. The community usually keeps small herd of livestock including cattle, sheep, goats and poultry. The diversification of farm enterprises and production of drought-tolerant crop varieties are strategies to improve and stabilize the household food security and economy. The survival of the community has for long depended on diversification of agricultural enterprises and conservation of the environment through the use of appropriate farming practices.

In the past, the traditional agroforestry systems involved shift cultivation practices where an exhausted piece of land was left fallow and the farmer opened another piece of land for cultivation. The land was left fallow to allow the regeneration of trees and rejuvenation of exhausted soils. Controlled grazing was allowed on fallow land. Selected tree species that have minimal negative effects on food crops in terms of competition for nutrients and water were allowed to grow together with the crops. Examples are *Cordia africana*, *Dombeya goatzinii, Grevillea robusta* and *Commiphora zimmermannii*. The presence of trees in the farm makes it easier for the farmer to take home firewood and fodder after cultivating the land. Thus, farmers and especially women are able to save on time and efforts required to fetch these products from the wild. Research has proved that agroforestry systems with crops, livestock and trees enable efficient recycling of soil nutrients.

Traditional agroforestry system has been practiced by the community through generations and the community migrate with this tradition into new areas. A case in point is Kieni areas of Nyeri County that prior to settlement had Savannah type of vegetation but today people are practicing agroforestry systems bringing tremendous changes to the landscape. Despite the community's propensity to embrace new technologies, it has not abandoned several components of traditional agroforestry systems and instead they have been incorporated into today's farming practices. It is easy to distinguish the farms of the Agikuyu community by the characteristic presence of trees scattered in the homestead and cropland and a few animals in the farm. Common tree species on the farms include *Grevillea robusta* (Silk Oak) and *Croton megalocarpus* planted around the farm boundaries, *Cordia africana,* and *Dombeya goatzinii* scattered in the farm and Mugumo (Fig) tree left undisturbed. Fruit trees such as avocado, mango, citrus, loquats and macadamia are planted together with crops in warm areas while temperate fruits such as plums, peaches and apples are planted in cool areas of Limuru in Kiambu County, Kinangop and Kipipiri in Nyandarua County. Trees found in the cropland serve different purpose such as provision of fuelwood, timber, fodder, fruits, herbal medicine, bee forage, erosion control and other uses.

Figure 18 Intensive Multi-layer Traditional Agroforestry System at the slopes of Mount Kenya

3.3 Values and Benefits of Traditional Agroforestry Systems

Broadly, the values and benefits of traditional agroforestry systems can be categorized into household food security and incomes, environmental, social and cultural terms. These values and benefits have significant contribution towards the sustenance of people's livelihoods and the environmental resilience as highlighted below:

Household food security and incomes

Food security refers to a situation where people have access to sufficient food that meets their nutritional requirements at all times of the year (Kenya Government, 2011). The traditional agroforestry systems have inherent mechanisms that ensure people have adequate food at different times of the year from diverse products and benefits that include food crops, fruit trees, vegetables and livestock products. This enhances household food security, stabilize the incomes and cushion the families against production and market risks. The multiple products and benefits also increase the household income base, provide better returns to investment, improve the household nutrition and ensure food availability throughout the year. The overall benefit from an agroforestry system is improving the livelihoods of the people, reducing poverty levels and sustaining the system ecological stability. The system also provides safety measures for coping with drought incidences in situation where the system has drought tolerant crop varieties such as millet, sorghum, cassava, yams and *Dolicos lablab*. The post-harvest loses is reduced by constructing storage facilities using pest-repellent materials. Traditionally, fodder and medicinal trees and shrubs are usually conserved *in-situ* by allowing them to grow on the farm undisturbed and are only harvested in times of need.

Despite the fact that most traditional crops are drought tolerant and do not require hybrid seeds, their yields are low discouraging commercial seed companies to develop interest in their production. The research and extension services have a role to promote production and consumption of traditional crops up to the point when demand will justify the interest and participation of the private sector. The government through KARI and KEPHIS has to ensure that the genetic value and purity of released parental lines are sustained by supervising and educating the enlisted institutions and farmer groups charged with the responsibility of bulking, multiplication and distribution of certified planting materials.

Over 10 million Kenyans suffer from poor nutrition and chronic food insecurity and estimated 30% of Kenyan children are undernourished (Kenya Government, 2011). The government estimated that 2-4 million people are in constant need of emergency food assistance. The right to quality food is guaranteed in the Kenyan Constitution under the section of Economic and Social Rights (The Constitution of Kenya, 2010). The government has the duty and obligation to accord the Universal human rights to its citizens by ensuring that every person has access to quality and affordable food at all times of the year. The options to achieve this goal include diversification of food production, proper storage and efficient food distribution in the country. A lot of food is wasted every year from unhygienic handling and poor storage leading to contamination of food by pathogens such as aflatoxins and salmonella. Loss and wastage of food must be avoided and the government need to improve the strategic food reserves to cater for emergencies. This calls for development, enactment and enforcement of safety standards and guidelines for food handling and storage to make it safe for human consumption. Occasional loss of live and diseases resulting from food contamination has been reported in some parts of the country.

Some parts of central Kenya experience frequent and prolonged droughts making them to have high levels of food deficit and poverty. These include Kieni in Nyeri County, Ndeiya in Kiambu, Mwea in Kirinyaga, Ndaragwa in Nyandarua and Makuyu in Muranga. There is need for the government and development agencies to invest in research and promotion of drought-tolerant crop varieties with the aim of improving food security status and the livelihoods of the people.

Cultural and social values

The survival of the people has mainly depended on inherent knowledge of proper and efficient management of the ecosystem using the indigeneous knowledge. Dissemination of knowledge and skills on management of the ecosystem mainly depended on farmer-to-farmer mode of technology transfer. Indigenous knowledge and taboos had traditionally assisted in conservation of natural resources including rare tree species as well as in sustaining land productivity. For a long time, the local people have been aware that trees contribute tremendously towards the environmental services including the supply of clean air, water and medicine. The presence of multiple products in an agroforestry system ensures that the farmer saves on time and efforts required to fetch firewood, fodder and herbal medicine from the wild. It ensures sustainable exploitation of the biodiversity including herbal medicine, fodder, fruits, bee forage, fuelwood and construction materials. The traditional systems are embedded in community’s way of life making it easy to naturally pass the practices from one generation to another.

3.3.3 Environmental services

As part of the public goods, agroforestry systems have continuously provided environmental services such as contribution towards climate change adaptation and mitigation through carbon sequestration, watershed protection and conservation of the biodiversity. At private level, agroforestry benefit farmers through provision of products such as fruits, fodder, firewood, medicine and services such as improvement of soil fertility and reduction of soil erosion. It is easy for the farmers to perceive these benefits making it an impetus for adoption and expansion of agroforestry practices. However, external interventions may be necessary especially in provision of planting materials and managerial skills to catalyze the adoption process. The traditional agroforestry systems enhance environmental and biodiversity conservation, contribute towards ecosystem resilience and enhance ecological services including soil erosion control and increased water infiltration. The wood perennials assist in climate change adaptation and mitigation through carbon sequestration.

3.4 Contribution of Traditional Agroforestry Systems in Climate Change Adaptation and Mitigation

Climate change refers to the differences in the average weather condition for a certain period that may range from months to tens, thousands or millions of years (University of Philippines, 2009). The climate change has become a major concern in the agricultural sector due to its impacts on altering the cropping seasons and increased incidences of pests and diseases. This has direct effects on agricultural productivity and food security at local and global levels. Farmers have been forced to find mechanisms for coping and adapting to the challenges posed by the climate change. Evidence for climate change include increased average temperatures associated with increased emission of green house gasses, extreme climate variability, rise in sea level and increased frequency and intensity of typhoons. This has impacts on food availability and supply, increased incidences of pests and diseases and loss of living things that are unable to cope with changes in temperatures and humidity.

The tradition agroforestry practices encourage preservation of trees and other perennials; thus contribute towards absorption of green house gases like carbon dioxide. The systems are quite effective in preservation and conservation of biodiversity, reduction of soil erosion and improvement of soil fertility. Indigenous tree species along the water courses are usually conserved and this helps in increasing rain water infiltration, reduction of soil erosion, control of floods and protection of water channels by the tree root systems. Litter fall from layers of vegetation increase soil organic matter while leguminous species fix and add nitrogen to the soil. The deep root systems of trees help in nutrient recycling by extracting leached nutrients and bring them back to the soil surface through the litter fall. Most of the indigenous tree species in traditional agroforestry systems are deep rooted posing little competition to food crops.

3.5 The Value and Role of Some Indigenous Tree Species

The community highly value trees for meeting numerous needs including the provision of fuelwood, construction materials, fodder, fruits and herbal medicine. Trees are also valued for their environmental services such as soil erosion control and fertility improvement. The community has rich ethno-botanical knowledge about trees and it is documented that over 400 tree species have been named and their uses are well known. Several tree species are deliberately conserved or planted together with crops e.g. *Cordia africana*, *Grevillea robusta, Commiphora zimmermannii* and *Trema orientalis.* However, valuable knowledge and skills of tree propagation and utilization especially the indigenous species that have medicinal value have not been properly documented and archived for future use. The selective custodian and passage of this rare and vital knowledge has relied on word of mouth and it is likely that most of it may have been lost with the death of individuals who possessed it.

Mugumo or Fig tree *(Ficus thonningii* and *Ficus natalensis)* is a sacred tree with important religious value including traditional rituals and worship. There is an existing museum site with a huge Fig tree at Mukurwe-wa-Nyagathanga in Murang'a County where the community believes their first ancestral father Gikuyu and his wife Mumbi were sent to live by God (Gachathi, 1989). Many tree species provide herbal medicine for treatment of various human and livestock diseases. The medicine is extracted without destroying the trees. These include *Prunus africana* (Muiri), *Warbugia ugandensis* (Muthiga), *Croton macrostachyus* (Mukinduri), *Olea europaea* (Mutamaiyu), *Carisa edulis* (Mukawa), *Strychnos henningsii* (Muteta) and *Myrsine africana* (Mugaita). *Kigelia africana (*Muratina*)* was used for fermentation of traditional honey and sugarcane beer. Fruit trees included *Vangueria madagascarensis (*Mubiru*), Carissa edulis* (Mukawa), *Rhus natalensis (Muthigiu), Syzygium guineense (*Mukoe*)* and *Psidium guajava* (guava).

Indigenous species that are important in feeding livestock include *Trema orientalis* (Muhethu) and *Sesbania sesban* (Mwethia) but exotic species have also been adopted widely such as calliandra, leucaena and tagasaste (Wambugu, et.al, 2011). The fodder species are usually conserved in the cropland where the farmers use the "cut-and-curry" harvesting practices. *Crinum macowanii* (pyjama Lily or Gitoka), *Euphorbia tirucalli* (finger euphorbia) and *Croton megalocarpus* (Mukinduri) are used as boundary markers. *Syzygium guineense (*Mukoe*), Prunus africana* (Muiri), *Bridelia micrantha* (Mukoigo) and *Dombeya goatzennii* (Mukeu) are usually conserved along water courses.

3.6 Distraction of Traditional Agroforestry Systems

The disruption of traditional agricultural system was mainly caused by historical events such as colonization, population dynamics and enactment of conflicting land use policies and laws. The disruptions of these traditional systems had adverse effects on people's livelihoods, the resource base and the environment resulting to food insecurity, environmental degradation, ecological disturbances, economic decline and changes in the landscapes from loss of vegetation cover. Ultimately the effects were felt through increased soil erosion, decline in soil fertility, loss of biodiversity, decline in water levels including changes in river flows and the disappearance of some of the rivers and streams. These effects had also drastic impacts on food production. Some of the historical events and changes in land use policies and laws are highlighted below.

Kenya was declared a protectorate of the British government in 1895 and a colony in 1920. The colonial government passed the Crown Land Ordinance no. 21 of 1902 that gave the land commissioner powers to sell and distribute land to white settlers at the expense of the local communities. By 1914 over 5 Million acres of land had been taken away from the Africans (mostly the Maasai, Kikuyu and Nandi) and transferred to the white settlers. In 1910, the colonial administration introduced the “Shamba system” that has been practiced in Kenya for the last century as highlighted in a separate section below. The Registration of Title Ordinance of 1919 was introduced to supersede all previous land laws throughout the country. The ordinance legalized privatization of land ownership through issuance of land title deeds to the white settlers. This led to forceful acquisition and re-allocation of land to the white settlers by the colonial government. The white settlers put the land under mono-cropping of cash crops such as tea, coffee, sisal and pineapples. Some of the land was put under pastures for cattle and wool sheep. The impact of wide scale change of land use by colonial settlers was evident on the landscapes that lost most of the indigenous vegetation and the disruption of the traditional agroforestry systems.

Introduction of mono crop plantation systems

The locals were forced to resettle in restricted colonial villages (reserves) allowing them to cultivate scattered pieces of land. This disrupted the traditional agricultural systems and reduced the overall agricultural production by the local community. Some of the land was put under communal use but it was too little to meet their needs leading to its over-exploitation and subsequent degradation from overgrazing and continuous cultivation without addition of manure and fertilizers. The limited land availability resulted to unrestricted use of common resources such as the pastures because any person could freely increase the exploitation of the common resources to the point of its unsustainable utilization leading to the “tragedy of the commons”.

Prior to independence, in 1954 the colonial government set up the Swynnerton Commission that addressed land reforms in African reserves. It enacted a policy for land amalgamation and consolidation targeting the land under local communities. However, the land under colonial settlers was left intact and the land under the local community was too little to revert back to traditional agroforestry systems and also could not sustain the large population. Land scarcity and denial of civil rights became one of the reasons for the “Mau Mau revolt” in Kenya.

Figure 19 A large tract of land under coffee mono crop

The population increases between 1960s and 1980s led to land subdivision and fragmentation into uneconomical units that could not support agroforestry practices. Increased demand for tree products led to over-exploitation and destruction of tree vegetation including the indigenous species resulting to environmental degradation and loss of biodiversity. Land fragmentation necessitated intensive management of small land parcels in order to support the demands from a high population. In the 1980s several research and development agencies initiated agroforestry projects all over the country. The Ministry of Agriculture and SIDA supported a national-wide programme on soil and water conservation that included the promotion of agroforestry practices. It is under this project that a lot of awareness was raised on potential benefits that can be accrued from agroforestry practices. Currently, many agricultural projects in the country have agroforestry components and thus it is easy to incorporate traditional practices that enhance agricultural productivity and sustainability.

The "Shamba System"

The "Shamba system" was introduced in 1910 by the colonial government in some of the state-owned forests including Mount Kenya and Aberdare Forests in central Kenya region. It is a modified form of Taungya system that is practiced in South East Asia and involves establishment of forest plantations together with food crops. The main objective of the system was to benefit the landless by giving them opportunity to produce food in government forests and in return benefit the government by taking care of tree seedlings growing together with the food crops. The farmers tend the young trees for 2-3 years when the tree canopies close in and can no longer allow continued growth of crops. The farmers then shift to another site where the government intend to expand the afforestation programme. More or less the "Shamba system" is a form of silviculture shift cultivation.

Initially, resident forest workers were allocated freshly cleared forest areas to plant food crops followed by tree planting. This system enabled the government to establish forest plantations at minimal costs, ease pressure on natural forests and allow farmers to produce food crops on government land. The government aimed at meeting the increased wood demand for industrial and domestic use. A lot of revenue was generated from the sale of wood and non-wood products from the "Shamba system" when the system was working well. Some of the forests where the "Shamba system" was practised include Kereita and Kinale (Aberdare Forest) in Kiambu County, Kabage and Zaina (Aberdare Forest), Gathiuru and Kabaru (Mount Kenya Forest) in Nyeri County and Njukini West (Mount Kenya Forest) in Kirinyaga County.

From 1910 to 1975, the "Shamba system" resident workers employed by the Forest Department were allocated forest plots (*shambas)* and guaranteed employment for nine months per year. The produce from the shambas was considered to be part of the workers´ emolument (Kagombe and Gitonga, 2005) and compensated them for the remaining three months of unpaid salaries. The system was revised in 1975 and the resident workers were fully employed for twelve months of the year but they were now required to rent the shambas. The system also opened doors to non-forest workers leading to increased number of people who were benefitting from forest resources. This made the supervision problematic as newcomers did not understand how the system operated resulting to low survival rates of tree seedlings. The system was consequently banned by a presidential decree in 1987, and in 1988 all the forest residents were evicted (Kagombe and Gitonga, 2005). Unfortunately, prior to the banning decree, the government had not put in place alternative systems of establishing and managing forest plantations resulting to stagnation of reforestation programmes in the country. Less than 20% of clear-felled areas were replanted and about 80% of replanted areas were not weeded (Kagombe and Gitonga, 2005). The situation was aggravated in 1994 by civil service retrenchment programme, leading to an acute shortage of labour in forest stations. This led to decline in tree production and acute shortage of wood products forcing the country to import wood products from other countries such as Uganda and Democratic Republic of Congo (DRC).

In 1994, the government reintroduced the non-resident cultivation “Shamba system” in some districts under the management of District Development Committees (DDC). By 1997, the government expanded the programme to all major forests in the country. This involved policy changes shifting the management of the “Shamba system” to the District Development Committees (DDCs) that were dominated by politicians and provincial administration. The input from the technical personnel was often ignored resulting to indiscriminate clearing of areas that are unsuitable for cultivation such as the natural forests and river banks. The stakeholders were not adequately involved in decision making processes. The end result was failure to establish new plantations and in some cases destruction of natural forests leading to the banning of the “Shamba system” in 1986.

The acute shortage of raw materials for expanding the timber industry and pressures on the natural forests led the government to reinstate the “Shamba system” in 1994. It was re-designed into a non residential cultivation system. Unfortunately, the new system failed to deliver as expected leading to its banning in 2003. The banning of the system in addition to excision of forests for alternative land uses, including human settlement and expansion of agricultural activities reduced the forest plantations from 160,000 hectares in 1994 to 40,000 hectares by 1999 (Kagombe and Gitonga, 2005). The situation was worsened by unsustainable harvesting of trees, low replanting rates, shortage of labour, low levels of funding and extensive damage of forest plantations by fires, especially in the period between 1992 and 1999. In 1992, fire destroyed 6,170 ha of plantations; in 1997, a further 4,726 hectares were burned (Kagombe and Gitonga, 2005).

Some of the honey collectors carelessly started forest fires that ended up destroying the forests leading to substantial loss of biodiversity and destruction of the ecosystem. Abuse of the system by greedy people led to illegal and indiscriminate logging of indigenous tree species leading to loss of biodiversity and environmental degradation. Valuable timber trees including *Ocotea usambarensis* (Camphor), *Vitex keniensis* (Meru Oak) and *Prunus africana* (Red Stinkwood) now face extinction as a result of illegal and indiscriminate logging.The Forest Department increased the plantation hectarage in absence of the “Shamba system” but the results were quite shocking. The seedlings survival rates declined from 90% to 10% in some of the plantations due to lack of weeding (Kagombe and Gitonga, 2005).

Since the late 1980s, KEFRI conducted extensive investigations on alternative methods of establishing and managing forest plantations, including natural regeneration, slashing, spot-hoeing, slashing and total cultivation. Data generated from studies conducted at Uplands Forest Station in Kiambu County on costs of forest plantation establishment and management are as follows: The cost of plantation establishment per hectare for the first 3 years was as low as Ksh 6,000 for non cultivated sites and as high as Ksh 44,500 for total cultivation. The slashing costed Ksh 20,000 and slashing and spot-hoeing costed Ksh 25,000 (Kagombe and Gitonga, 2005). A plantation is considered to be well established after the third year, when the canopy closes in. Under the “Shamba system” most of the costs are borne by the farmer including site clearing, staking, planting and tending tree seedlings for a period of about three years. The system contributes towards higher tree survival rates, better protection from animal damage and reduced susceptibility to pests and diseases. In return, the farmer benefits from food production on government land. Total cultivation, though expensive, is the most appropriate method for forest plantation but in absence of adequate resources, the non-residential cultivation is the most viable method. If well-managed the “Shamba system has similar results to the total cultivation with the advantage of sharing the costs and benefits between the community and the Forest Department.

The “Shamba system” has many benefits to the local community in terms of employment creation, cash economy from sale of crops such as vegetables and Irish potatoes to major towns. It can suport the livelihoods of large population of landless people and those in the food value chain in terms of food provision and incomes. A study conducted in 1998 in Kiambu indicated that on average the net benefit to a farmer practicing “Shamba system” was Ksh 124,141 per hectare per year but benefits may vary from place to place depending on productivity, access to markets and crop management (Kagombe and Gitonga, 2005).

The banning of the “Shamba system” had drastic impacts on food security and the economy of the people residing in the central region of Kenya. The “Shamba system” of non resident cultivation remains the most viable option under the current funding scenario with improvements on its implementation strategies and approaches including: formation of inter-institutional supervisory committee with full involvement of the beneficiaries to monitor and guide its performance, zone and map areas appropriate for the reintroduction of the system to avoid opening up sensitive areas such as the riverbanks and indigenous forests, provide clear guidelines and regulations that should be strictly enforced to deter any abuse. There is need to work out modalities that allow participatory formulation of procedures for forest establishmant and management that ensure equitable sharing of costs and benefits between the farmers and the government. The lessons of past performance need to be incorporated so as to improve the implementation of the " Shamba system" in the country. Due to its benefits, many people today indicate that they would prefer the system to be reintroduced but with more strict rules that govern its operations to ensure sustainable exploitation of the forest resources. A well managed and supervised system has the potential to benefit the government, the farmers and other people who depend on forests for commercial extraction of wood and non-wood resources. There is need to institute mechanisms that ensure sustainable exploitation of forest resources, guarantees expansion of forest cover and conservation of both flora (plants) and fauna (animals). The communities that reside in the neighbourhood of the forests need to be sensitized and educated on the need to conserve and protect the forests and other natural resources. Appropriate policies and laws need to be enacted and strictly enforced to ensure effective and efficient conservation of natural resources.

Grazing of Livestock in State-owned Forests

Like in the case of the "Shamba system", the government allowed farmers to graze their livestock in the forests but at a small fee. Only cattle and sheep were allowed to be grazed. Goats were strictly prohibited from grazing in the forest due to their destructive nature. The system is still being practised in some of the government forests. Pastoral communities like the Maasai and Samburu are allowed to take their livestock to state forests during severe droughts to reduce livestock and human mortalities. Unfortunately, in the past heavy losses of livestock has been witnessed as a result of diseases and pests prevalent in high altitude areas. On the other hand, communities living near the forests also lose their livestock from pests and diseases transmitted by livestock belonging to pastoral communities. Livestock grazed in the forest also get affected by pests and diseases from wild animals including the tick-borne diseases.

3.7 The Current Trends in Promotion of Agroforestry Practices

The current agroforestry practices in central Kenya have borrowed many elements of the traditional agricultural systems. It could be a modification of an existing practice such as managing different tree species and crop varieties but managed in a familiar way. However, others are managed in a totally new way such as the improved fallows which is a completely new way of farming in most areas (Place, et.al, 2012). The FAO Forest Resources Assessment Report indicates that the total tree cover in Kenya outside the forests (mainly in agroforestry systems and trees in urban areas) is greater than tree cover within the forests. In addition the forest cover in Africa continues to decrease while the tree cover on the farms is increasing (FAO, 2003). The trend is likely to continue because of increased demand for tree products and services as human population increases. The importance of smallholder agroforestry systems is likely to be reinforced with increased attention and resources allocation to climate change adaptation and mitigation whereby more efforts are being made to protect forests and simultaneously expanding tree growing on farms (Place, et.al, 2012).

In the 1990s, various research and development agencies including SIDA, GTZ, KWAP and FAO, teamed up with government agencies to promote agroforestry practices. Agroforestry projects were initiated in several parts of the country and mainly focused on fast growing exotic tree species such as Grevillea, Leucaena, Calliandra and Casuarina. There was very little that was done to restore the indigenous tree species in the farmlands possibly because these species take a long time to mature. The Ministry of Agriculture in collaboration with SIDA had a nation-wide programme known as the “Catchment Approach” that focused on integrated farm management approach through soil and water conservation, fodder and fruit production. The programme aimed at increasing agricultural productivity and ecosystem conservation through reduction of soil erosion on sloppy areas and protection of water catchments in the country. This initiative yielded dividend since lots of awareness was created, lots of sloppy land was terraced and agroforestry trees were planted in the farms contributing to wide-scale changes on the landscapes.

Some of the research and development organizations focused on agroforestry systems that are geared towards production of specific commodities. ICRAF, KARI and KEFRI researched and promoted agroforestry systems that focused on soil fertility improvements, fruits and dairy production. ICIPE focused on agroforestry systems that deal with bee production (apiary) and silk worm production (sericulture). GEF, KEFRI, Green Belt Movement and KFS, promoted agroforestry systems that aimed at protecting and conserving Mount Kenya and Aberdare forests. The communities that live adjacent to these forests illegally rely on wood and non-wood products from state-owned forests and therefore are major contributors to the destruction of the forests. They need to be sensitised and educated on the need to incorporate agroforestry practices in their own farms to reduce the pressure they exert on forests. Currently, there are a number of national and international institutions such as KARI, KEFRI, KFS, Green Belt Movement, ICRAF and GEF that have agroforestry-based projects around the Aberdare and Mount Kenya forests. The projects include silviculture (trees with crops), silvo-pastoral (trees with pastures and livestock), apiculture (trees for honey production) sericulture (trees for silkworm production) and aquaculture (trees with fish). These projects aim at the restoration of the forest ecosystem. There is need to integrate other conservation measures such as the increased use of renewable energies like solar, wind and hydro energies to replace the use of wood energy. Production of charcoal and use of firewood has been quite detrimental to the environment and is associated with climate change as a result of emission of green house gases such as carbon dioxide. Tree species that produce high quality charcoal such as Olea and acacia face extinction due to over-exploitation.

Organizations that are promoting agroforestry practices often encourage incorporation of trees and shrubs into the farm as live fences, boundary markers, windbreaks, hedges for soil erosion control, fodder banks, wood lots, etc. Increased planting of trees and shrubs on the farms help in conservation and protection of natural forests as wood products and services can be obtained from the farms and thus reduce the pressures on exploitation of forest resources (Wambugu and Franzel, 2012). There is scientific evidence that some of the tree species can directly help in increasing land productivity and mitigate on climate change. Fodder shrubs can effectively replace some of the concentrates and part of the basal diet of dairy livestock leading to increased milk production per cow (Franzel and Wambugu, 2007). This may necessitate the reduction of the number of cattle in the farm and subsequently reduce the amount of methane emission at an individual farm

(Thornton & Herrero, 2010). In case of fodder production, only the leaves are harvested leaving behind the woody stems above the ground and the root systems below the ground and thus an immense contribution towards carbon sequestration (Wambugu and Franzel, 2012).

3.8 Challenges in Traditional Agroforestry Practices

The forest cover in Kenya is only 3% which is below the global recommendation of at least 10% of the total land in a country. The forest cover has been disappearing over time and on the contrary, the agroforestry practices outside state-owned forests have been on the increase. The farming community lack access to adequate and quality tree germplasm especially in the case of indigenous species. Many farmers do not have the knowledge and skills in germination and management of agroforestry tree species and traditional crop varieties that are better adapted to the local agro-ecological environment. The investment by the government and NGOs in germplasm multiplication and distribution is quite low and thus limiting the expansion of agroforestry practices. There is also need to invest in building the farmers' technical capacity in seed technology including seed collection, storage and propagation methods.

Involvement of the private sector has been hindered by free and subsidized germplasm supply by the government and NGOs and thus denying the private sector opportunity to invest in seed supply business ventures (Wambugu, et.al, 2011). Tree seed may be required only once in a person's lifetime making the demand to be quite low unlike the annual crops that a farmer has to buy every season (Place, et.al, 2012). This discourages the private entrepreneurs to venture into tree seed business. Seedlings distribution is hampered by the fact that they are delicate and bulky, thus limiting the distance and time period they can be transported. It is difficult to differentiate the quality of tree germplasm casually and this hampers the ability of suppliers to charge prices that commensurate with the quality of germplasm (Place, et.al, 2012).

The population increases in 1960s to 1980s led to over-exploitation and subsequent degradation of natural resources such as land, forests and water. It necessitated the expansion of agricultural land to forested and sloppy areas resulting to land degradation from soil erosion, deforestation and loss of biodiversity. Further increase in population led to continued land sub-division and fragmentation into uneconomical units that cannot support agroforestry practices. The population increase has led to the intensification of agricultural production in order to meet increased food demand.

Permanent cropping and lack of resources for replenishing soil nutrients is leading to serious soil degradation and exhaustion particularly in the smallholder farming areas (Place, et.al, 2012). Subsequently, the infertile soils lead to low yields and ultimately food insecurity. The eroded soils are deposited in water courses leading to the siltation of lakes and dams in the country. There is evidence that the siltation of Lake Naivasha and L. Olbolossat, Sasumua and Kindaruma dams are the consequences of deforestation and cultivation of the Aberdare slopes. The expansion cultivation land has not spared the wetlands either leading to loss of bio-diversity. As a result of human activities in forests and wetlands, important flora and fauna that have high environmental, economic and social values now face extinction. The impacts of climate change are unreliable and erratic rainfall, prolonged droughts and occurrence of floods which have adverse effects on agroforestry practices. It is no longer possible to predict the rains in the area unlike before when farmers could correctly predict the time for rain onset in preparation for a planting season. The impacts of climate change have presented big challenge to the agricultural production and food security in the area.

High potential agricultural land neighbouring urban areas are being converted into settlement sites leading to significant reduction in land under agricultural production. The trend of urbanization (settlement) of previously high potential agricultural lands has resulted to loss of land for production of crops, trees and livestock. High rise buildings have virtually replaced vegetation especially coffee plantations and forest cover in all areas neighbouring Nairobi Metropolitan. This trend should not be allowed to continue as it is threatening the survival of the people. Instead large population should be encouraged to settle in towns leaving agricultural land to few capable farmers to efficiently produce adequate food to support the urban population. This requires a refocus on the national land policy and laws so as to facilitate effective agricultural production by reducing land fragmentation, urbanization of agricultural lands and encroachment of forests. This demonstrates that there are a number of important policy constraints that hinder wider adoption of agroforestry systems among the smallholder farmers in developing countries, both at formulation and implementation levels (Place, et.al, 2012). Enactment of laws and policies that recognize agroforestry as an attractive investment in the agricultural sector is likely to lead to increased adoption of agroforestry practices in the country.

3.9 Opportunities in Traditional Agroforestry Systems

Most of the agricultural land in Kenya is under private ownership which is an incentive that encourages tree planting and management. In absence of secure land tenure, tree planting and management by farmers has been limited. The state has to work towards achieving and maintaining a tree cover of at least 10% of the land area of Kenya (The Constitution of Kenya, 21010). The agricultural policy reforms of 2009 that is anchored in Vision 2030 of the Kenya Government require that 10% of all farms be under tree cover as a solution for dealing with the effects of deforestation. The policy is likely to lead to increased agroforestry practices and subsequent huge demand for tree planting materials. The stakeholders in government and development agencies need to develop mechanisms for the supply of tree germplasm including the indigenous species.

There has been increased global attention on climate change adaptation and mitigation that has led to availability of more resources for advancement of agroforestry practices. This is in recognition of the role traditional agroforestry systems played in sustaining agricultural production and resilience to climate change and variability. The systems have higher efficiency in the use of resources and inputs for production as they contribute towards nutrient recycling processes. FAO is leading an initiative to develop agroforestry guidelines for policy makers, aiming at promotion of good agroforestry practices. FAO is also supporting the development of a framework for assessment of trees outside forests, including agroforestry systems, at national, regional, eco-regional and global levels (Place, et.al, 2012). This will be a key element in policy reforms to enable informed decision-making processes. There is greater policy recognition of the importance of agroforestry in the country and possibly address the policy barriers that have in the past hindered the recognition of agroforestry development.

Increased demand for forest products and the closure of state-owned forests makes agroforestry an attractive option for the communities that previously relied on government forests. Research has proven that agroforestry is a viable option for restoration of degraded lands and thus an incentive for its adoption. Linkages and collaboration among research and development agencies need to be established and strengthened for the advancement of agroforestry practices. This calls for public and private partnerships in addressing the challenges of advancing agroforestry development.

The practices of “climate smart agriculture” seems to have borrowed many of its elements from the traditional agroforestry practices such as the conservation agriculture, better management of manure and incorporation of perennials on smallholder farms. The impacts of population increase on the environment calls for increased adoption of agroforestry practices and conservation of the biodiversity so as to arrest the worsening situation caused by the climate change. Policies should be enacted to protect and increase the land under tree cover as well as conserving the wetlands. Farmers should be encouraged to plant trees on sloppy areas that are unfit for agricultural production and the wetlands should be protected by fencing them off. The state machinery should institute mechanisms for compensating farmers who convert private land that is unfit for food production into forest land. Research and development institutions should research and promote appropriate crop varieties and tree species that are well adapted to specific agro-ecological zones so as to optimize on land productivity. These institutions should develop strategies of availing planting materials of traditional crops and indigenous tree species. Since environmental conservation is by essence part of public goods, the international community need to develop effective systems of rewarding individuals and organizations that participate in ecosystem services such as tree planting, wetland conservation and promotion of biodiversity.

4. Conclusions and Recommendations

The traditional and heritage agroforestry systems need to be properly identified and documented. The 2003 UNESCO convention tools can be adapted to help in identification, validation, and valuation of traditional agricultural systems. The traditional systems can effectively complement the modern agricultural production systems. Specific studies are required to provide evidence of the contribution of traditional agricultural systems to the national economy and development. The studies should also establish the untapped potential values and importance of traditional systems including the contribution towards food security and environmental conservation. Projects and programmes need to be developed so as to facilitate dynamic conservation of traditional agricultural systems and develop frameworks for rewarding the maintenance of their values similar to the payments for ecosystem services.

The traditional agroforestry systems together with the rich indigenous ecological and management knowledge can provide solutions to many agricultural challenges that we face today including food insecurity and the impacts of climate change. Therefore, these systems should be promoted to tap the rich indigenous knowledge and skills that were used in balancing and sustaining agricultural production and environmental conservation. Since agroforestry generates significant public environmental services such as watershed protection, biodiversity, and carbon sequestration there is need for the government to provide incentives to the private sector to get involved in promotion of agroforestry practices.

Recognition of the values and importance of heritage agricultural systems including traditional agroforestry systems by the FAO as well as contribution of the GIAHS – East Africa project to the understanding of GIAHS concept and generation of knowledge on existing systems is highly commendable. Furthermore inputs and contributions from the GIAHS project national policy workshops held on 3-4th December 2012 and 6-7th

December 2012 in Nairobi and Dar es Salaam, respectively, provide a good basis for further development of this initiative nationally and at global level.

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