THE COST OF MANAGING FOREST CARBON UNDER REDD+ INITIATIVES: A CASE OF KOLO HILLS FOREST IN KONDOA DISTRICT DODOMA, TANZANIA.

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FORESTRY, SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

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ABSTRACT

There is no doubt that REDD+ payments can do many activities that lead to deforestation and forest degradation less attractive. However, countries considering participating in REDD+ mechanism, need information on what it would cost them to reduce emissions from deforestation and forest degradation. This study was delimited to estimate transaction costs of REDD+ project with the Advancing REDD+ in Kolo Hill pilot project in Kondoa District as a case study. Socio-economic and biophysical data regarding routine, non-routine activities, their associated transaction costs and carbon stock were collected. The socio-economic data were collected through interviewing 40 households in Mnenia village while 39 sample plots were systematically established in the Mnenia forest. The qualitative data from structured questionnaires were analysed using the Statistical Package for Social Science (SPSS) while the quantitative data such as costs were analysed using Microsoft excel spreadsheet. The carbon stock were analysed using locally allometric equation that estimated the biomass and converted into carbon by multiplying biomass by 0.49. The routine and non- routine identifed were boundary making and attending the village meetings among others. The average total cost incurred in setting up and running by project stakeholders was US76.06ha^{-1}$ while the average carbondioxide stored was 72.48tCO_2eha^{-1}. The average costs incurred by managing the forest in relation to a tCO_2 stored was 1.0485tCO_2e^{-1}ha^{-1}$. Estimates suggest that abatement transaction cost in Non-Annex I countries ranges between 0 - 3.48 US$$tCO_2e^{-1}ha^{-1}$ for projects. According to the available carbon stock and costs incurred, the project was found to be economically profitable at 5%, 10%, 15% and 25% discount rates with NPVs of about US$19021.92, US$9061.366, US$5426.22, US$3754.257 and US$2838.799 respectively. Although the estimates suggest that abatement costs observed was between the ranges on the estimates in Non-Annex I countries more investigation should be done to other forest ecosystems so as to establish abatement cost in Tanzania.

DECLARATION

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

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LIST OF ABBREVIATION AND ACRONYMS

AGB	Above ground biomass
AIJ	Activities Implemented Jointly project
ARKFor	Advancing REDD+ in Kolo Hills Forest
ATC	Average Total Cost
AWF	African Wildlife Foundation
C	Carbon
C/ha	Cabon per Hectare
CAMCO	Certified Association Management Company
CAR	Climate Action Reserve
CCIAM	Climate Change Initiative, Adaption and Mitigation
CDM A/R	Clean Development Mechanism through Aforestation and Refforestation
CDM	Clean Development Mechanism
CEDERENA	Ecological Corporation for the Development of Renewable Natural Resources
CERs	Certified Emission Reductions
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP	Conference of the Parties
DBH	Diameter at breast height
DD	Deforestation and forest degradation
DED	District Executive Director
DFO	District Forest officer
FAO	Food and Agriculture Organization of the United Nations

FBD	Forest and Beekeeping Division
FITI	Forest Industries Training Institute
FPIC	Free and prior informed consent
G	Basal area
G	Basal area per ha
GHG's	Green House Gases
GPS	Golbal Positioning System
Ha	Hectare
Ha^{-1}	Hectare per Units
HADO	Hifadhi Ardhi Dodoma
IIED	International Institute for Environment and Development
IPCC	Inter-governmental Panel on Climate Change
IRA	Institute of Resource assessment
JFM	Joint Forest Management
KTFR	Kitulangalo Training Forest reserve
MNRT	Ministry of Natural Resources and Tourism
MRV	Monitoring , Reporting and verification
MSHL	Masai steppe heartland
n	Number of sample plots
NGO's	Non- governmental organizations
NOK	Norwegian Kroner
NPS	U.S National Park Service
PES	Payment for Ecosystem Services
PROFAFOR	Programa Face de Forestación del Ecuador
Ps	Plot size
REDD	Reducing Emmission from Deforestation and forest degradation

REDD+	Reducing Emissions from Deforestation and forest Degradation plus conservation and sustainable management of forests and the enhancement of forest carbon stocks
SARI	Selian Agricultural Research Institute
Si	Sampling intensity
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
TA	Total area of the forest
TANAPA	Tanzania National Park Authority
tCO_2	Tonne of carbon dioxide
U.S. EPA	United States Environmental Protection Agency
UCSUSA	Union of Concerned Scientist of United States of America
UMB	Norwegian University of Life Sciences
UN REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nation Framework Convention on Climate Change
URT	United Republic of Tanzania
US$	United States of America dollar
V+C	Verification and certification
VCS	Verified Carbon Standard former “Voluntary”
VNRC	Village Natural Resource Commetee
VPO	Vice President’s Office

$/tCO_2/h	United States of America Dollar per metric tonne of carbon dioxide per hectare
$/tCO_2	United states of America Dollar per metric tonne of carbon dioxide

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Forests are the largest terrestrial reservoir for atmospheric carbon dioxide (Alexandrov, 2007). Tropical forests for example were estimated to store more than 320 billion tons of carbon (Gibbs *et al.,* 2007). Tanzania has about 33.4 million hectares of forests and woodlands (FAO, 2010). Out of this total area, almost two thirds consist of woodlands on un-reserved land, which lack proper management (URT, 1998). Forest resources on the un-reserved land is under enormous pressure, from expansion of agricultural activities, livestock grazing, fires and other human activities. About 13 million hectares of the total forest areas in Tanzania have been gazetted as forest reserves of which 1.6 million ha is under natural forests for water catchment and about 80,000 ha are under industrial forest plantation (URT, 1998).

In the tropical region where also Tanzania lies, deforestation and forest degradation has been occurring on a large scale, playing a critical role in the carbon cycle, with implications for climate and biological diversity (Forester-Kibuga and Samweli, 2010). Deforestation is the conversion of forested areas to non-forest land use such as arable land, urban use, logged area or wasteland (Tejaswi, 2007; FAO, 1998). Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. Degradation on the other hand involves reduced forest quality , density and structure of the trees, the ecological services supplied, the biomass of plants and animals, the species diversity and the genetic diversity (Tejaswi, 2007).

Globally, emissions from current tropical deforestation and forest degradation have been estimated at 20% of total CO_2 emissions (IPCC, 2007; Proffernberger *et al.,* 2009; URT, 2009). Reducing forest loss is therefore of utmost importance for climate change mitigation, and this is reflected in the commitment to include Reduced Emissions from Deforestation and forest Degradation plus sustainable forest management, enhancement of carbon stock and conservation (REDD+) in the post-2012 agreements of the United Nation Framework Convention on Climate Change (UNFCCC[1]) (Campbell *et al.,* 2008; Obersteiner *et al.,* 2009). In Tanzania, forest deforestation and degradation rates are higher around 403,000 ha annually equivalent to 1.16% of the forest estate, hence the country is an important source of Green House Gases (GHG's[2]) emissions (FAO, 2010).

REDD+ is a concept that has been gaining momentum in climate change policy negotiations at both the international and national levels. Hence a number of funds have been established to support REDD+ activities, such as; the Australian Forest and Climate Initiative, the German Climate Protection Program and the Norwegian government's fund. Also a number of developing countries announced initiatives to address emissions from deforestation and degradation. At the same time, conservation organizations, project developers and governments were beginning to implement voluntary market-based REDD+ pilot activities on the ground in some developing countries. Tanzania REDD+ initiative is part of government's effort to address the global changing climate through reduction of emission of Green House Gases from the forestry sector. The Vice

[1] The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at the United Nations Conference on Environment and development (UNCED) held in Rio de Janeiro in 1992. The objective of the treaty is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. www.unfccc.int

[2] Green House Gases (GHGs) are natural and industrial gases that trap heat from the Earth and warm the surface.The Kyoto Protocol restricts emissions of six greenhouse gases: natural (carbon dioxide, nitrous oxide, and methane) and industrial (perfluorocarbons, hydrofluorocarbons, and sulphur hexafluoride).

president's Office oversees and coordinates all REDD+ related activities. The Initiative receives significant financial support from the Kingdom of Norway through a letter of intent signed in 2008. At the inception phase, a National REDD+ Framework was put in place to guide the process (URT,2013).

Currently, 16 countries including Tanzania that are piloting the REDD+ projects. In Tanzania there are nine (9) REDD+ pilot projects being implemented in different ecosystems by non- governmental organizations (NGO's) in collaboration with central and local government, academic institutions and the private sector (URT, 2009) (Fig. 1). Among of those projects is the advancing REDD+ in Kolo Hills Forest (ARKFor) under African Wildlife Foundation (AWF) (URT, 2009). The potential of REDD+ pilot projects as part of a post-2012 climate change regime remains uncertain, in part, due to lack of detailed information on the likely costs associated with forest carbon projects and REDD+ programmes in particular (Olsen and Bishop, 2009).

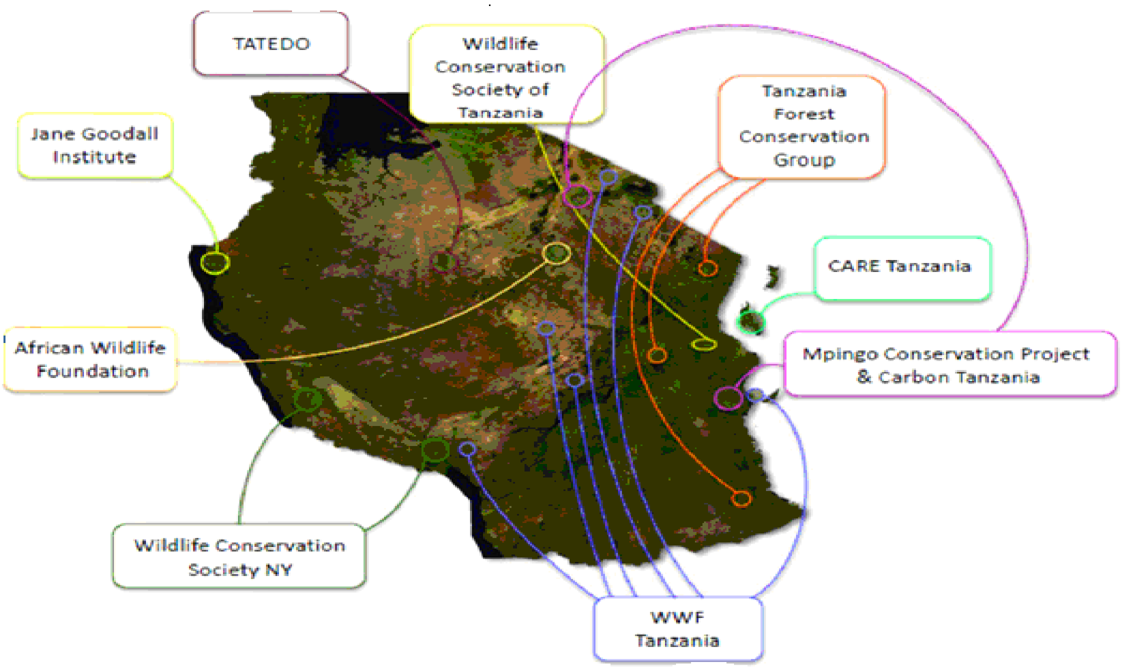

Figure 1: Map of Tanzania showing REDD+ pilot project

Source: UN-REDD Tanzania, (2010a)

1.2 Problem statement and justification

There is no doubt that REDD+ payments can do many activities that lead to deforestation and degradation less attractive (Angelsen *et al.*, 2012). However, countries considering participating in a REDD+ mechanism, need information on what it would cost them to reduce emissions from deforestation and forest degradation (Pagiola and Bosquet, 2009). Therefore, as Tanzania prepares to embark on REDD+, it needs information on the future costs and benefits of these programmes. This is because it will remain difficult to implement REDD+ activities without empirical evidences of the costs and benefits of deforestation and degradation and the avoidance of such activities. Meanwhile, several studies e.g. Wertz-Kanounnikoff (2008); Lobowski (2008), have tried to develop models and estimated several costs associated to REDD+ at global level. The costs include the opportunity costs, the transaction costs and the management costs, among others. But according to Pagiola and Bosquets (2009) these estimates provide very little guidance in this regard; as in addition to the inevitable crude approximations that must be made in any such large-scale exercise, conditions within any given country (such as Tanzania), will differ substantially from any international, and indeed any non-Annex 1 country conditions. Also, Wertz-Kanounnikoff (2008), argued that information on the transaction costs of REDD+ schemes remains limited.

This study was delimited to estimate transaction costs of REDD+ project with the advancing REDD+ in Kolo Hill pilot project as a case study. Understanding and minimizing the transaction costs are critical for reducing tropical forest losses (Alston and Andersson, 2011). The results will help in identifying costs per specific areas in the course of implementing REDD+ project. This due to the fact that more attention to transaction costs would benefit the institutional design of a new global program intended to combat tropical deforestation in developing countries and provide information on how emission reductions might potentially be able to ‘sell’ to a REDD+ mechanism at a given price . Also, it will contribute to policy makers and planners for initiating cost-effective future REDD+ activities.

1.3 Objective of study

1.3.1 Overall objective

The overall objective of this study was to estimate the cost of managing forest carbon under REDD+ initiatives with Kolo hills forest in Kondoa District as a case study.

1.3.2 Specific objectives

The specific objectives of this study were to:-

i. Identify routine and non routine activities in establishing and running the project.

ii. Estimate their associated transaction costs incurred in establishing and runnig the project.

iii. Estimate carbon stock in Kolo Hill forest under REDD+ Project.

1.3.3 Research questions

This research was guided by the following key questions:

i. What were the routine and non-routine activities undertaken by the stakeholders in carbon management?

ii. What was the unit cost of the activities incurred by stakeholders?

iii. How much carbon was stored in the forest?

iv. What was the transaction costs incurred by the stakeholders in managing the forest?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 An overview

This chapter presents a review of literature on areas of forest management in Tanzania. It includes the review on the global history of REDD+ policy as the new initiative adopted in Tanzania in managing forests for carbon sink. The reviews on the type of management cost under REDD+ initiative. Lastly, for the purpose of this study biophysical information on Miombo woodland ecosystem are also presented.

2.2 Forest management in Tanzania

Management of forests in Tanzania was the responsibility of the central government and local governments where much of the attention was to protect forest resources through the so called "policing" system. However, it was realized that both central and local governments have failed to provide adequate protection and management of the forest estates, a condition which led to increased deforestation and degradation of state controlled forests at an alarming rate (Kajembe and Mgoo, 1999*)*. The major reasons behind the negative state of management where the declining government capacity to protect the forests in terms of finances, low human resources due to retrenchment policy and general negative attitude of the communities towards state properties as they regarded them as not theirs.

Since the early 1990s, Tanzania has been formulating and implementing strategies and policies towards improving the management of its forest resources. These policies and strategies could be considered for a REDD strategy design and implementation (Mwakalobo *et al.,* 2011). It was reported by Vatn *et al.,* (2009) that introducing a new policy like REDD demands good insights on present forest and to some extent the more general national policies. In the international climate change regimes, the main objective of REDD policy is to encourage countries to undertake measures to minimize existing rates of deforestation and forest degradation through a payment mechanism (Mwakalobo *et al*., 2011). The REDD policy recognises the role of the forests as an essential component of the global climate system. It also emphasises the involvement of local communities because of the far-reaching implications it has for their livelihoods (Mwakalobo *et al.,* 2011).

2.3 The history of REDD+

According to the Stern (2006) review, reducing deforestation is the "single largest opportunity for cost-effective and immediate reductions of carbon emissions" (Hollowa and Giandomenico, 2009). This is where REDD comes in (Hollway and Giandomenico, 2009) and recently agreed REDD+ is the original concept of REDD, plus the sustainable management of forests and the conservation and enhancement of forest carbon stocks (Burgess *et al.,* 2010). The proposed REDD+ mechanism forms part of an international move to include emissions from habitat change (especially the loss of carbon-rich ecosystems such as forests) in a more comprehensive agreement under the UNFCCC (Burgess *et al.,* 2010). Also, it is a suite of policies, institutional reforms and programs that provide developing countries with financial incentives to reduce greenhouse gas emissions and to enhance economic growth by preventing the destruction of their forests (UNFCCC, 2009; Holloway and Giandomenico, 2009). (Fig.1) is a summary of the History of REDD Policy, from its roots in the Kyoto Protocol (Holloway and Giandomenico, 2009) and to the meetings of COP17 held in Durban, December 2011. Existing UNFCCC decisions on REDD+ encourage developing countries like Tanzania to prepare for an eventual agreement on the topic and developed countries to support them in doing so (Burgess *et al*., 2010).

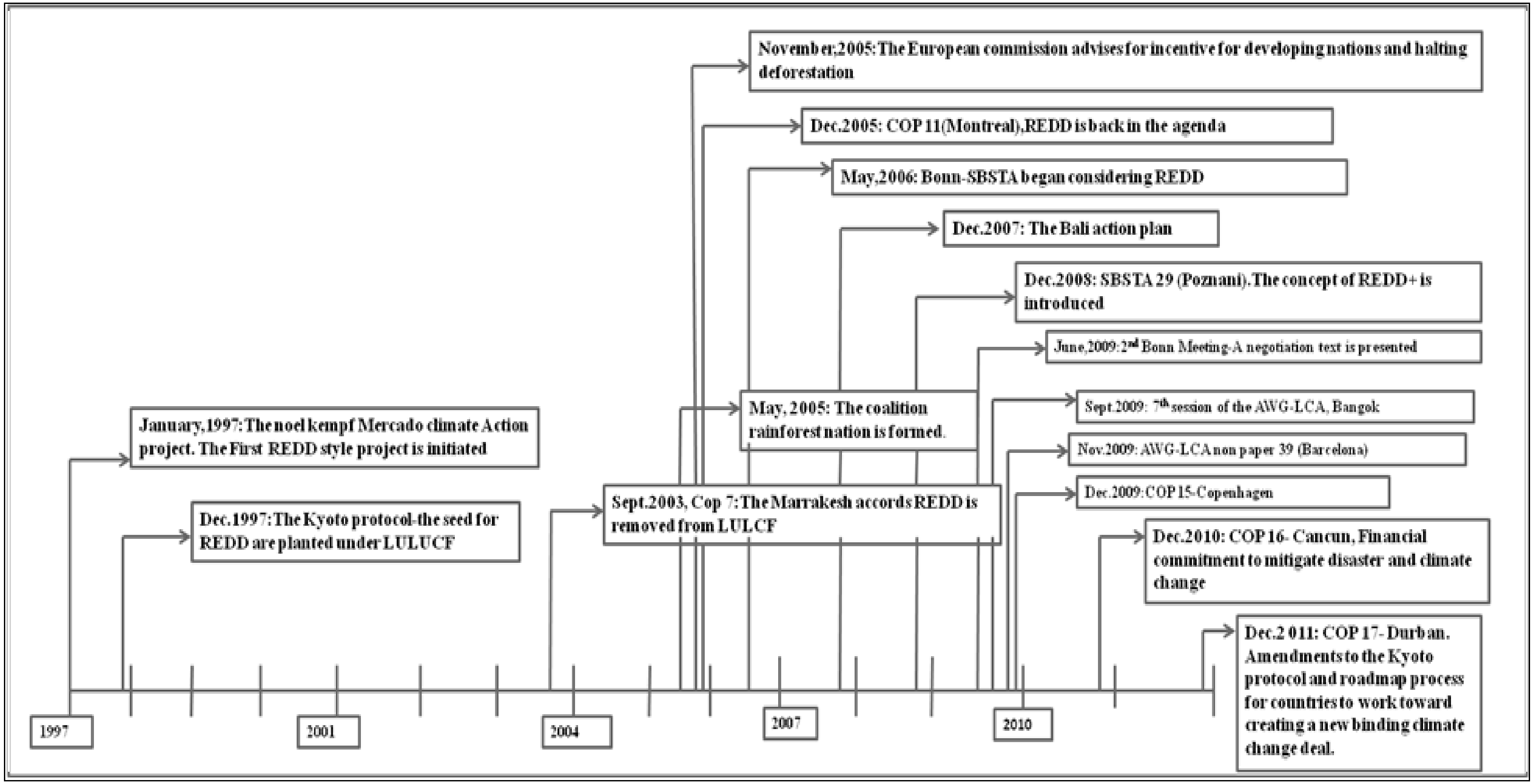

Figure 2: Global history of REDD+

Source: Holloway and Giandomenico, (2009)

2.4 REDD+ Initiatives in Tanzania

Tanzania has the potential to design and execute a REDD strategy and other related activities, and has already prepared a National Framework for REDD (Mwakalobo *et al.*, 2011). It is currently benefiting from donor funding that helped to establish REDD+ actions in the country. The funding included a 100 million NOK (USD$ 80 million) commitment from the Government of Norway to support national REDD strategy development, National and sub-national pilot projects, research and capacity building, investments in measuring, reporting and verification, private sector engagement, and the establishment and piloting of a Trust Fund (Milledge, 2009 and Burgess *et al*., 2010).

Tanzania is also receiving USD 4.28 million from the UN-REDD Programme, which is also largely funded by Norway, which is a collaborative partnership between three UN agencies. These agencies are the Food and Agriculture Organization (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP) (Burgess *et al*., 2010).

Further, in Tanzania there were various initiatives introduced to support management of forest. These initiatives includes the Vice President's Office (VPO) strategy, integrated coastal management, participatory forest management, private sector involvement in establishment and management of forest plantations, law enforcement and surveillance improvements, payment for environmental services (carbon, water, biodiversity, and so on), sector-wide approach planning for the forestry (Vatn, *et al.*, 2009; Lawuo, 2008). Therefore, according to Burgess *et al.*, (2010) the national activities to prepare for REDD+ may involve building of institutional commitment and capacity, design and planning of REDD+ programmes and pilot activities to test the effectiveness of REDD+ measures.

2.5 National REDD+ pilot projects

REDD+ appears to be a win-win solution as developing countries receive payments to preserve their forests and donor countries receive carbon credits and praise for "doing something" about climate change (Wertz-Kunounnikoff, 2008; Alston and Andersson, 2011). As reported earlier, there are nine (9) REDD+ pilot projects in Tanzania (Fig.2). These projects seek to build on the participatory forest management experience and to test ways to transfer benefits from the national government to communities managing forests (Burgess *et al*., 2010).

The lessons learned will be critical with regard to designing, implementing and challenges of REDD+ in Tanzania and other developing countries (Murdiyarso and Skutsch, 2006; Chatre and Agrawal, 2009). REDD project activities are expected to reduce GHG by slowing or stopping the conversion of forest to non-forest land and/or reducing the degradation of forest land where forest biomass is being reduced. To act against deforestation and degradation, these projects implement conservation activities and/or activities to counter the causes of the deforestation and degradation. Further, it seek to mitigate climate change by addressing the core underlying problems of tropical forest loss and the social costs of tropical deforestation.

2.6 Challenges facing REDD+ in Tanzania

Despite their potential, participatory forest management and forest policy are not without some obstacles that need to be addressed in order for a REDD strategy to survive in Tanzania (Mwakalobo *et al.,* 2011). According to URT (2011) REDD+ face challenges on clarification of land tenure, indigenous land rights (considering the assignment of use and not ownership) and the presentation of progress made to the native populations and indigenous communities. Lack of regular, reliable, specific and accurate data for computing baseline emissions, and therefore expensive survey work, Leakage has also become very challenging in the implementation of REDD initiative, because local projects, albeit successful, might fail to deliver any net emission reductions from reduced deforestation in the aggregate., very high deforestation rates make large scale implementation critical.

Kilawe *et al.,* (2008); URT, (2011) further reported that land tenure issues relating to the titling and property rights, this affects the security and entry of local people, particularly smallholder farmers, to participate in REDD. Reported by Kilawe *et al.*, (2008), that challenge and uncertainties that might affect the REDD carbon market in Tanzania among others, include, Regulatory issues related to rules and regulations under the CDM A/R: these are restrictive and strenuous, keeping transaction costs high and leading to large areas of degraded land being ineligible to generate Certified Emission Reductions (CERs). Therefore, concerning market problems, with respect to benefit-sharing and bargaining power between developed countries and developing countries. Most of the benefits will be reaped by the developed countries given their strong bargaining power, as compared to weak bargaining power of the developing countries in the international markets (Mwakalobo *et al.,* 2011; URT, 2011).

Further, other challenges are estimating the cost of managing REDD project, these cost are variable and limited. Greig-Gran (2009) found that there has been little field data from real-world projects to inform policy dialogue over the cost of REDD+. Therefore, these costs ranges from opportunity costs to those for actual implementation, and for transactions such as contract negotiation with carbon buyers.

Opportunity costs resulting from the forgone benefits that deforestation would have generated for livelihoods and the national economy. According to Pagiola and Bosquets, (2009) deforestation for all its negative impacts could also bring benefits. Timber can be used for construction and cleared land can be used for crops or as pasture. Reducing deforestation means foregoing these benefits. Similarly, forest degradation because of selective logging, fuel wood collection, or grazing of animals also brings benefits, and avoiding this degradation foregoes these benefits. Hence, these costs of foregone benefits are known as “opportunity costs”. (Greig-Gran, 2009) showed that published estimates are based largely on the so-called ‘opportunity costs’ of refraining from expanding farming or other uses of forest land, rather than on money actually spent in communities to protect.

In addition to opportunity costs, there are also costs involved in implementing a REDD program. These are the costs directly associated with the actions leading to reduced deforestation, and hence to reduce emissions (Pagiola and Bosquets, 2009). These costs according to Lubowski, 2008; Pagiola and Bosquets, 2008 are the costs of implementing REDD policies that comprise upfront costs of capacity building, ongoing administrative costs of monitoring, enforcement and other activities needed to run a REDD programme.

Pagiola and Bosquets (2009) showed that besides the above opportunity and implementation cost, REDD also involves specific transaction costs, which are the costs that are necessary for the parties to a transaction involving a REDD payment (the buyer and seller, or donor and recipient). These costs are separate from implementation costs, as by themselves they do not reduce deforestation or forest degradation. They are nevertheless necessary to the transparency and credibility of the REDD program and thus add value to the whole process. Further, Lubowski (2008) showed that most estimates are based on opportunity costs without considering the costs of developing institutional capacities and actually implementing and transacting a REDD programme. Pagiola and Bosquets, (2009) showed that an important aspect of the transaction is they are likely to be largely fixed rather than variable. Therefore, Olsen and Bishop, (2009) stated that identifying the distribution of transaction costs assists in understanding incentives to deforest or degrade forest and thus may provide critical guidance in developing policies to reduce deforestation and forest degradation.

2.7 Transaction costs

Transaction costs were first discussed by Coase (1937). He introduced the term in his economic analysis of the optimal size of an undertaking and showed that market transactions come with costs (Krey, 2004). Since then various definitions of transaction costs have emerged by which the Michaelowa *et al.,* (2003); Pagiola and Bosquets, (2009) defined transaction costs as the costs of information gathering, contracting and controlling contracts. Furubotn and Richter (2010) subdivide transaction costs into market transaction costs, corporate transaction costs and political transaction costs.

Stavins (1995) showed that these costs play a pivotal role in markets as their most obvious impact is that they increase the costs to each participant of the prospective exchange. The participants, among other activities must find one another, need to communicate and exchange information (Stavins, 1995). If the participants are economically rational transaction costs can even prevent an exchange from happening once the transaction costs exceed a participant’s benefit from the exchange (Coase, 1960). Transaction costs increase the buyers cost and/or lower the suppliers (net) price and result in a shift of the demand and supply curves. The resulting quantity traded will be lower than it would be in the absence of transaction costs (Dudek and Weiner, 1996).

According to fig. 2 the curves S and D represent the supply and demand in a market without transaction costs. The market clears at a quantity of Qopt. If either or both parties to the transaction bear transaction costs (illustrated by the adjusted curves STAC and DTAC) the quantity traded will always be lower than Qopt. The shape of the curves STAC and DTAC (that e.g. Varies with the relation between transaction costs and total quantity traded) determine the specific relation between the traded quantities Q1, Q2 and Q3. Generally, the higher the transaction costs the lower the traded quantity and the higher the price will be.

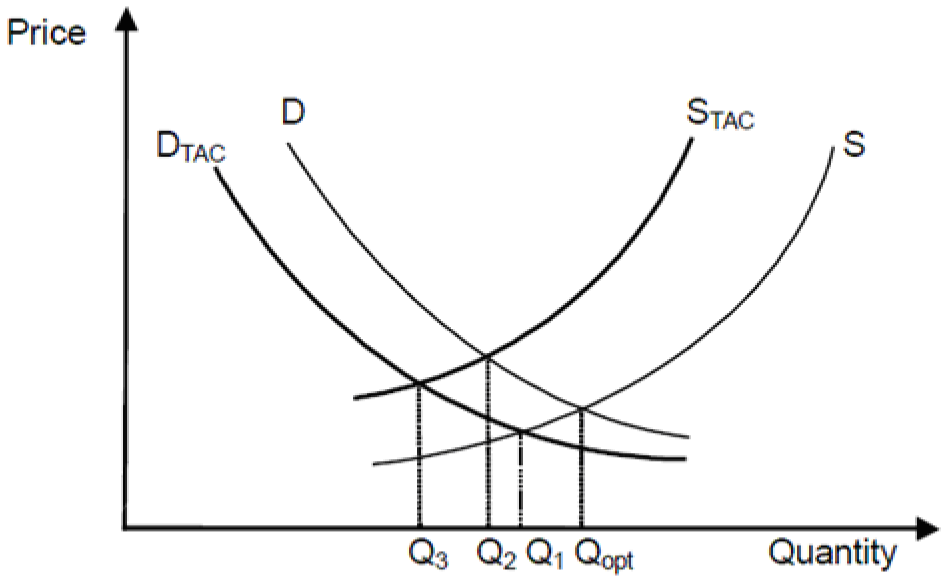

Figure 3: Supply and demand in the presence of transaction costs

Source: Dudek and Weiner (1996)

Therefore, according to Dudek and Weiner, (1996) there are several components of transaction cost that are search costs, negotiation costs, Approval costs, Monitoring costs, Insurance costs and Enforcement costs.

2.8 Component of transaction costs

According to Dudek and Wiener (1996); McCann and Easter (1999) these costs are categorised into the following; search costs, approval costs, monitoring costs, enforcement costs and insurance costs (Table. 1) provides an overview of the categories used and examples for each which such forms costs can accrue.

Table 1. Transaction costs categories

Cost category	Types of costs
Search costs	-Costs of finding interested partners to the transaction (e.g. Advertisements and brokers) -Costs for communication (e.g. Expenses for telephone ad sales representative) -Costs for price information and quality control (e.g. Agents/consultants)
Negotiation costs	-Costs for coming to an agreement (e.g. Time, visits and drafting of contracts)
Approval costs	Costs that arise when the trade must be approved by a government agency (e.g. Modifications)
Monitoring costs	Costs to observe the transactions and verify adherence to the terms of contracts (e.g. Hiring verification services)
Insurance costs	Costs of insurance policy (e.g. For compensation in the event of loss of goods)
Enforcement costs	Costs to insist on compliance once divergence from contracts is detected (e.g. Suing the seller in the court)

Source: Dudek and Weiner, (1996)

Therefore, under REDD+ initiative, there are various types of cost that are categorized as establishing and running the project.

2.9 Transaction costs in REDD+ projects

The creation of REDD+ implies establishing and running a set of new systems. REDD+ is from one perspective a system of goals – reducing deforestation and forest degradation. To obtain the goals, however, a specific governance system has to be established (Vatn, 2011). This implies the involvement of the existing actors in new tasks, the creation of new actors in the form of organizations, committees. The costs of setting up, maintaining and using a governance system under REDD+ are normally termed transaction costs (Vatn, 2011).

Transaction costs in REDD+ may be categorized due to the level at which they occur and the type of costs. Hence costs can be categorized according to the following level; - international level, national level, sub-national levels. These levels are divided into various types of costs that are; costs of setting up and costs of running REDD+ governance systems/architectures, costs related to various functions or tasks (e.g., Costs related to negotiating contracts, planning, administration), types of resources used (budget categories) (e.g., Personnel or labours (time/wages), occupancies/offices, consumables, transport), who carry the costs - costs per actor or actor group (Vatn, 2011).

These costs are expressed in terms of cost per ton CO_2e. Transaction costs, on the other hand, are likely to be more fixed than variable. According to Alston and Andersson, (2011), many of these transaction costs are hard to quantify, but REDD architects need to take steps to minimize them in order to create a market for conservation. Similar studies can be found in the local PES schemes in (Table.2).The transaction costs of REDD+ projects are additional costs to be paid by the parties (buyers, sellers, donors, recipients) to a transaction involving a REDD payment, as well as external parties such as market regulators or payment system administrators to ensure a certain amount of emissions reduction has been achieved (Pagiola and Bosquet, 2009). Subsequently, consideration of the distribution of costs is important to understand potential impacts on stakeholders, particularly vulnerable groups (Olsen and Bishop, 2009). Further, it depicts transaction costs that accrue to project suppliers or sellers of CERs as an increase in abatement costs (Krey, 2004).

Table 2: Non-exhaustive list of studies on transaction costs associated with REDD schemes

Studies	Coverage	Cost category	Data source	Cost [$/tCO$_2$Eq]
Kindermann *et al*., (2008)	Global	Transaction costs	CDM projects	0.3 - 4.05
Antinori and Sathaye (2007)	11 forestry projects	Transaction costs	Climate projects	0.66 - 16.4
Cacho *et al*., (2005)	6 projects (tropical countries)	Transaction costs	AIJ*projects. 0.14-1.07	0.14-1.07

Source: Wertz-Kanounnikoff (2008)

2.9.1 Component of transaction cost in REDD+ pilot projects

For the purpose of transaction costs, arising from the REDD+ project are subdivided into setting-up and running transaction costs according to functions, types of resources used (budgetary costs) and according to actors. These are once again subdivided into smaller components.

2.9.1.1 Costs of setting-up and running the project

Under this section various components of setting-up and running transaction costs of the pilot project were reviewed. The review based on setting-up and running cost according to function, budget and actors in the pilot project. Among of these cost components are negotiating contracts, planning the setting of the project, decision-making, cost of establishing institutions for REDD+ and cost of establishing an MRV system of the project.

2.9.1.2 Negotiating contracts

Negotiating contracts for the pilot to get funded, the responsible in establishing a pilot project has made contracts with a national authority or an international donor to raise the necessary resources. Negotiating contracts defined as two or more parties discussing points of a potential partnership arrangement (www.businessdictonary.com). The goal is for an agreement to be made that is beneficial to all involved parties. Discussions may go back and forth between parties until all points have been agreed upon. The end goal is an arrangement that is both fair and equitable to each party. Under REDD+ initiatives in Tanzania in establishing a pilot project, the negotiation contracts may be reached between villagers, district or national level surrounding the forest and the investor depending on the ownership of the land. Hence, the cost incurred by all parties in this activity during discussion may be analysed.

Itoh and Morita, (2006) argued that contracts contingent upon investment-related information could protect the seller or buyer, but this is often difficult in reality. So, without adequate contractual protection, the seller's anticipation of the buyer's opportunistic behaviour results in a less than socially optimal level of investment. Salas (2010) pointed out that designing REDD contracts involve not only properly rewarding those who reduce emissions from deforestation and forest degradation (DD) but must also consider technical issues such as the permanence of carbon offsets and equitable distribution of payments as well as financial and institutional issues including delegation, verification and enforcement of contracts. Negotiation costs will arise in the form of time spent to conclude the negotiations, communication and travel costs and possibly a fee for specialised consultants in legal or financial matters (Dudek and Wiener,1996).

2.9.1.3 Cost of planning

Planning refers to the process of deciding what to do and how to do it. Planning occurs at many levels, from day-to-day decisions made by individuals and families, to complex decisions made by businesses and governments (Litman, 2013). It is done to increase the likelihood that a project will be implemented efficiently, effectively and successfully. Planning of REDD+ project cost accrued by project developers based on time and resources spent by stakeholders in day to day activities in establishing the pilot project. According to UNFCC (2009) planning and design efforts should take into account existing data sources and information, and should assess their usefulness for project setting-up.

2.9.1.4 Cost of decision -making

Decision making, refers to as the process of identifying and choosing alternatives based on the values and preferences of the decision maker (Harris, 2012). Making a decision implies that there are alternative choices to be considered, and in such a case need not only to identify as many of these alternatives as possible but to choose the one that has the highest probability of success or effectiveness and best fits with our goals, desires, lifestyle, values, and so on. Under REDD+ pilot projects, cost of decision-making accrued by project developers based on time and resources spent in field visits, collecting of specific information, internal and external meeting with stakeholders.

2.9.1.5 The cost of organizing information and communication programs

Organising information refers to as a collection of data that has been verified to be accurate and timely, specific and organized for a purpose, presented within a context that gives it meaning and relevance, and that can lead to an increase in understanding and decrease in uncertainty (www.businessdictionary.com). The value of information lies solely in its ability to affect a behaviour, decision, or outcome. A piece of information is considered valueless if, after receiving it, things remain unchanged (www.bussinessdictonary.com). Vatn (2011) showed that in order to introduce REDD+ in an area, the NGO may run a specific program for local communities and maybe also local authorities. It concerns on the process of engaging local communities. Further, tt is the process of ensuring free and prior informed consent (FPIC). Therefore, organizing information and communication programs cost will accrue to the project developer inform of time and resource spent in field visits, production and dissemination of brochures and leaflets for REDD+ sensitization in the local area.

2.9.1.6 Cost of establishing institution basis

Institutions are the conventions, norms and legal rules that form the actors and regulate the relationships between them (Vatn, 2005). They provide expectations, stability and meaning essential to human existence and coordination. Institutions regularize life, support values and protect and produce interest (Vatn, 2006). Actors are both individuals and organisations (e.g., Firms, NGOs, state-level and local-level decision and administrative bodies). Institutions define who has access to which resources and the power to make decisions (Vatn and Angelsen, 2009). Further, Institutions have been described as governance structures regulating rationally constrained agents and being created from the need of minimizing transaction costs. Institutions arise due to the demand for protection in societies where free riding is increasing and the cost of punishing the defectors is too high because of their increasing numbers. From the economic interaction point of view, institutions are created from the necessity of reducing uncertainty in human exchange. They are responsible for structuring the interactions among the actors (North, 1991). Together with the technology employed they also determine the cost of transactions.

Throughout history, institutions have been devised by human beings to create order and reduce uncertainty in exchange. Together with the standard constraints of economics they define the choice set and therefore determine transaction and production costs and hence the profitability and feasibility of engaging in economic activity (North, 1991). These are costs accrued by project developers in establishing institution under REDD+ based on the cost involved in establishing an institutional basis for making REDD+ work at local level. This may concern the cost of defining necessary land rights, establishing new organizations or committees at e.g., Village level, developing the program for payments (Vatn, 2011).

2.9.1.7 Cost of monitoring, reporting and verification (MRV)

Monitoring costs are defined as the costs that arise from the setting-up and implementation of the monitoring plan, the periodic monitoring activities and the periodic submission of the monitoring report. Monitoring costs can be sub-divided into initial and periodic costs. The monitoring plan involves the purchase and installation of monitoring equipment as well as data processing and archiving equipment that allows for monitoring, processing and archiving of data as required in the monitoring plan. The latter costs accrue periodically. Costs for the monitoring report for compilation of the data also arise periodically. As the monitoring report is the basis for verification and certification it depends on the preferences of the project developer how frequently the costs for the monitoring report will accrue.

Verification and certification (V+C) costs are defined as the costs that the project developer has to pay to the verifier. V+C costs are considered as a single transaction cost component because the project developer will usually pay a single fee to the verifier for both verification and certification (de Gouvello and Coto, 2003).

2.9.1.8 Cost of finance and general administration

The word 'administration' refers to the organization and management of collective human efforts in the pursuit of a conscious objective (Hubpages, 2012). The word 'finance' refers to monetary resource. Finance and administration refer to a set of activities which are related to making available money to the various branches of an organization to enable it to carry out its objective. Whether it is a family, business or a government department, its day to day activities depend on the availability of funds with which financial administration is concerned. Finance and administration include all the activities which generate, regulate and distribute monetary resources needed for the sustenance and growth of the members of a political community (Hubpages, 2012). Administrative expenses include expenses associated with the general administration of the business. Examples include the salaries and fringe benefits, human resource personnel, accounting, information technology, the depreciation expense for equipment and space used in administration, as well as supplies and utilities (Acountingcoach, 2012). The finance and administration cost accrued by REDD+ project developers based on benefits, hiring personnel, accounting information technology, salaries and fringe benefits of stakeholders.

Therefore these costs required to be estimated. Their importance lies in determining the effective price faced by a buyer or seller, where effective price includes both the “sticker” price of a good and the hidden costs that the buyer and seller face to transfer ownership of the good (Antinori and Sathaye, 2007). Transaction costs can lower the effective price a seller receives and raise the effective price a buyer pays.

2.9.2 Experiences on transaction costs of REDD+

Transaction costs are reported either in the form of total costs or as a percent-share of the entire budget (Wertz-Kunounnikoff, 2008). No consistent methodology for collecting data on transaction costs could be found. This makes it difficult to compare values across projects or regions. According to Wertz-Kunounnkoff (2008) insights from PES and CDM schemes suggest that transaction costs tend to be particularly high in the early stages of a scheme (startup costs), and when the size of the scheme is small. Cacho *et al.*, (2005), for example, show that for four carbon projects in Indonesia the startup costs can be quite large whereas running costs tend to be more manageable. One general observation is that existing information on transaction costs is limited. Good estimates are rarely available and their generally intangible nature makes them hard to estimate in relation to the carbon stored in the forest (Wertz-Kunounnkoff, 2008). According to Wunder and Alban, (2008), on the study conducted in Pimampiro and PROFAFOR project in Ecuador (Table 3) showed the average costs estimated in establishing and running the project.

Table 3: Start-up and operational expenses 2000-2005, Pimampiro project, Ecuador

Expenses	2000	2001	2002	2003	2004	2005
Start-up costs	37,800	-	-	-	-	-
Administration costs	-	360	360	360	360	360
Monitoring costs	-	504	504	504	504	504
Payments to participants	-	4,219	3,500	4,271	4,173	4,704
Total costs	$37,800	$5,083	$4,364	$5,135	$5,037	$5,568

Source: Wunder and Alban, (2008).

2.10 Forest carbon stock

The stock is the amount of a substance in a particular place. The total stock of carbon in all tropical forests (roughly 300 billion tons). Each year, about 1.5 billion tons of stored carbon are converted by deforestation into about 6 billion tons of carbon dioxide, and emitted into the atmosphere. Thus, although the stock of tropical forest carbon is very large, and only about 0.5 percent of it flows from the forest to the atmosphere annually (1.5 billion/300 billion), this flow into the atmosphere is what matters for global warming (Gibbs *et al*., 2007).

Currently, there appears to be a consensus that the issue of deforestation and forest degradation must be effectively tackled as it would otherwise limit the options available to reduce greenhouse gas emissions, greenhouse gas concentrations and increases in temperature to acceptable levels. Any reduction in the rate of deforestation and forest degradation has the benefit of avoiding a significant source of carbon emissions and reducing other environmental and social problems associated with deforestation (FCPF, 2012). The fundamental goal of REDD programs is to reduce those emissions. Thus, REDD pays, either directly or indirectly, for reductions in the flows, measured as tons of carbon dioxide emitted.

Countries that demonstrate emissions reductions may be able to sell those carbon credits on the international carbon market or elsewhere (Gibbs *et al*., 2007). These emissions reductions could simultaneously combat climate change, conserve biodiversity and protect other ecosystem goods and services. Implementation of climate policies aimed at reducing carbon emissions from deforestation will require resolution of scientific challenges. Foremost among these challenges is identifying feasible approaches to assess national-level carbon emissions from deforestation and degradation in developing countries. Therefore to estimate emissions, we need to know the area of cleared forest and the amount of carbon that was stored in those forests (Gibbs *et al.,* 2007). Hence, stakeholders involved in managing the forest should consider carbon stock dynamic, management options and estimation models in regard to the certainty of the ecosystem so as to ensure the forest managed in cost effective.

2.10.1 Forest carbon stock dynamics

About one-half the dry weight of wood is carbon. Carbon is also contained in the bark, branches, roots, and leaves of trees, and within forest litter and soils. In the growth process trees capture carbon dioxide from the atmosphere, combine it with water drawn from the ground, and produce sugars that are then converted into wood. Oxygen is released as a byproduct (Bowyer *et al*., 2011b). This carbon remains stored within the wood products even as new carbon is captured as the forest re-grows. Carbon makes up a considerable proportion of wood volume, amounting to about 50% of the moisture-free weight. In 2005–2010, some 24 to 25 billion metric tonnes (t) of carbon were stored in standing trees, forest litter, and other woody debris in U.S. forests, and another 20 to 21 billion tonnes of carbon were stored in forest soils and roots (Bowyer, 2011a). Good forest management planning and practices are essential for the success of REDD+ and must be addressed from the outset and will be fundamental to the successful implementation of national REDD+ strategies (FAO, 2010).

2.10.2 Management of Forest carbon under REDD+

According to FAO, (2010), forests can be net sinks or net sources of carbon, depending on their age, health and susceptibility to wildfires and other disturbances, as well as on how they are managed. Forest management interventions that result in carbon emission reductions or increased carbon sequestration could potentially be rewarded by REDD+ (FAO, 2010). Thus far, REDD+ negotiations and national preparations have mainly focused on defining transparent monitoring, reporting and verification (MRV) systems, and on forest governance and national policies and strategies for REDD+. While these are key pillars for REDD+ construction, improving forest management practices will also be of fundamental importance to reach the desired objective of curbing emissions from deforestation and forest degradation and to conserve and enhance forest carbon stocks on the ground.

Therefore estimates of carbon stock vary between various types of ecosystems e.g Carbon contents in miombo woodland may differ substantially with other ecosystems and there could be different parameters based on those ecosystems. Magnussen and Reed, (2004) found that many variables of interest in forest inventory and monitoring applications cannot be measured directly. Examples include such basic quantities as stem volume where diameters and heights are measured on individual trees and a table or an equation (collectively referred to as a model) is used to estimate the associated volume. There are types of models available for estimating quantities like wood volume, biomass, and carbon content.

2.10.3 Forest carbon stock estimation in miombo woodland ecosystem

2.10.3.1 The Miombo Woodland

The Miombo is a vernacular word that has been adopted by ecologists to describe those woodland ecosystems dominated by trees in the genera *Brachystegia, Julbernardia and Isoberlinia (Leguminosae, sub-family Caesalpinioideae) (Abdullah and Monela, 2007).* Miombo woodlands are the most extensive tropical seasonal woodland and dry forest formation in Africa. Miombo woodlands cover about 2.4 million km² southern Africa including Angola, Zimbabwe, Zambia, Malawi, Mozambique and Tanzania, and most of the southern part of the Democratic Republic of Congo (Frost, 1996).

Figure 4: Map showing distribution of miombo woodlands in the southern part of Africa.

Source: Abdallah and Monela (2007)

2.10.3.2 Miombo woodland in Tanzania

In Tanzania, miombo woodland make up about 90% of all forested land in Tanzania, equivalent to 44.6 million ha, out of which 54% is under general lands (URT, 2001). The main concentrations of this formation in the country are found in the western zone (Tabora, Rukwa and Kigoma regions) and the southern zone (Iringa, Lindi, Mtwara and Ruvuma regions) (Fig. 5). This ecosystem composed with different tree species, number of stems, basal area, biomass and carbon contents. The major species are *Brachystegia* and *Jubernardia*. Other species commonly found in this group are Pterocarpus angolensis (Mninga), Albizia Sp. and *Afzelia quanzesis* (Abdullah and Monela, 2007).

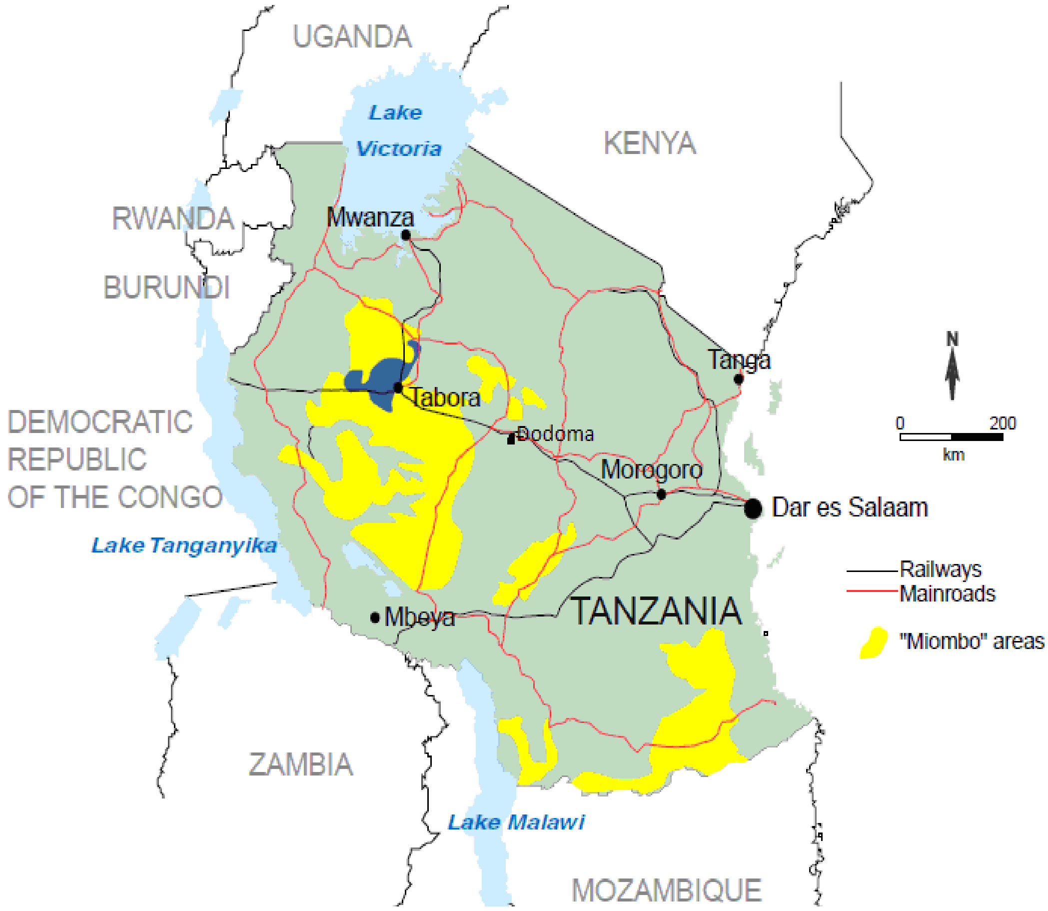

Figure 5: Map showing distribution of miombo woodland in Tanzania

Source: Monela and Abdallah (2007)

2.10.3.3 Tree species composition

Tree species compositions are the assemblage of plant species that characterize the vegetations (Isango, 2007). Miombo woodlands are extremely rich in plant species despite of their apparent uniformity in structure and composition over large areas (Kusaga, 2010). The composition and structure of Miombo Woodland appear superficially to be relatively uniform over large regions, suggesting a broad similarity in key environmental conditions (Giliba, 2011). Also miombo woodland species diversity in the country differs from place to place (Abdallah and Monela, 2007). According to Isango (2007) species diversity in miombo in Tanzania ranges from 79 to 95 and occasionally reaches 102 species. From studies in eastern arc mountain done by Shirima *et al.*, (2011) found that the plots contained an average of 20 tree species ha^{-1} that ranging from 11–29 trees ha^{-1}. Also, Giliba *et al.,* (2011) reported that Bereku forest contained a total of 110 tree and shrub species were identified, out of these trees constituted 75% while shrubs were 25%.

2.10.3.4 Number of stems per hectare (N)

Number of stems in the forest Number of stems per hectare shows the degree of rowdiness of stems in a specified area (Husch *et al.*, 1982) as cited by Kusaga, (2010). A result from studies done elsewhere in miombo woodland shows that stems per ha varies in forest. A study done at the Bereku forest reserve by Gilliba *et al.,* (2011) showed that average stems number was 616 in the forest. Other studies done in Eastern Arc mountain by Shirima *et al.*, (2011) found that the average number of stems was 344stems ha^{-1} ranging from 281-282 stems ha^{-1}. Also other studies done by Kusaga (2010), reported that number of stems Ha-^{1} in Mihumo and Ngongowele dry Miombo forest was 870 ± 119 (SE) and 731 ± 138 (SE) respectively. Further studies done by Zahabu (2008) and

Chamshama (2004), shows that the average number of stems Ha^{-1} ranges between 628 – 694 and 1027 at the Kitulangalo Training Forest reserve (KTFR) respectively.

2.10.3.5 Basal area (G)

The basal area of the forest defined as the cross section area of the stem or stems of a plant or of all plants in a stand, generally expressed as square units per unit area. The tree basal area is used to determine percent stocking. For shrubs and herbs it is used to determine Phytomass. In the case of natural forests, basal area is a good measure of site potential (Philips, 1983). According to Zahabu (2008) showed that basal area in the Kitulangalo Sokoine University of Agriculture training forest reserve (KSUATFR) are $10.2M^2/Ha$ and $7.9\text{-}99M^2/Ha$ respectively. Also Kusaga, (2010) reported that the basal area of Mihumo, Ngongowele and Ngunja forest reserve was 9.8 ± 0.78 (SE), 11.37 ± 0.98 (SE) and 9.82 ± 0.92 (SE) respectively.

2.10.3.6 Forest biomass and carbon stock

The main C pools in tropical forest ecosystems are the living biomass of trees, understory vegetation and dead mass of litter, woody debris and soil organic matter. The C stored in the aboveground living biomass of trees is typically the largest pool and the most directly impacted by deforestation and degradation (Gibbs *et al*., 2007). Knowledge of the living AGB density is useful in determining the amount of C stored through photosynthesis in the forest stands. The living AGB is also an excellent indicator of plant growth, condition and yield potential. Thus, estimating living AGB is the most important step in quantifying forest C-stocks and monitoring the changes (Krisnawati and Imanuddin 2011).

According to (Garrett and Ekakoro, 2010) the C-stock in the Kolo hills pilot project ranged from $17tCha^{-1}$ - $24tCha^{-1}$ and Shirima (2009) showed that eastern Miombo woodlands in Tanzania have been shown to have C storage potential of between 25 and 80 $tCha^{-1}$. Also Zahabu (2008), found that at KTFR the C-stock was 17.6 – 22.9$tCha^{-1}$. Further studies done in southern highland of Tanzania by Munishi *et al.*, (2010) found that mean above ground carbon density of the miombo ecosystem was 19.2t ha^{-1} and Shirima *et al*., (2011) found that estimates suggest that eastern arc mountain miombo woodlands store a range of 13–30 Mg ha^{-1} of carbon

CHAPTER THREE

3.0 MATERIAL AND METHODS

This section contains the description of materials and methodology used for socio-economic and biophysical data collection in the village and the forest reserve of Mnenia respectively as the part of the ARKFor pilot project.

3.1 Study area location, area and status

This study was conducted in Mnenia Forest which is a part of Kolo hills Forest and the surrounding village of Mnenia in Kondoa district (Fig.7). The Mnenia forest, in which the study conducted, composed of five (5) hills namely Singe, Chemchemi, Kwachondo, Rest-house and Maliwi with an estimated are of 5500ha. The forest is located 30km East – South of Kondoa district at 4° 41' 0" South and 35° 52' 0" East. The average altitude of an area ranges from 1650-2000 m above sea level. The forest is under central governments which managed by Kondoa district council, AWF and adjacent local communities.

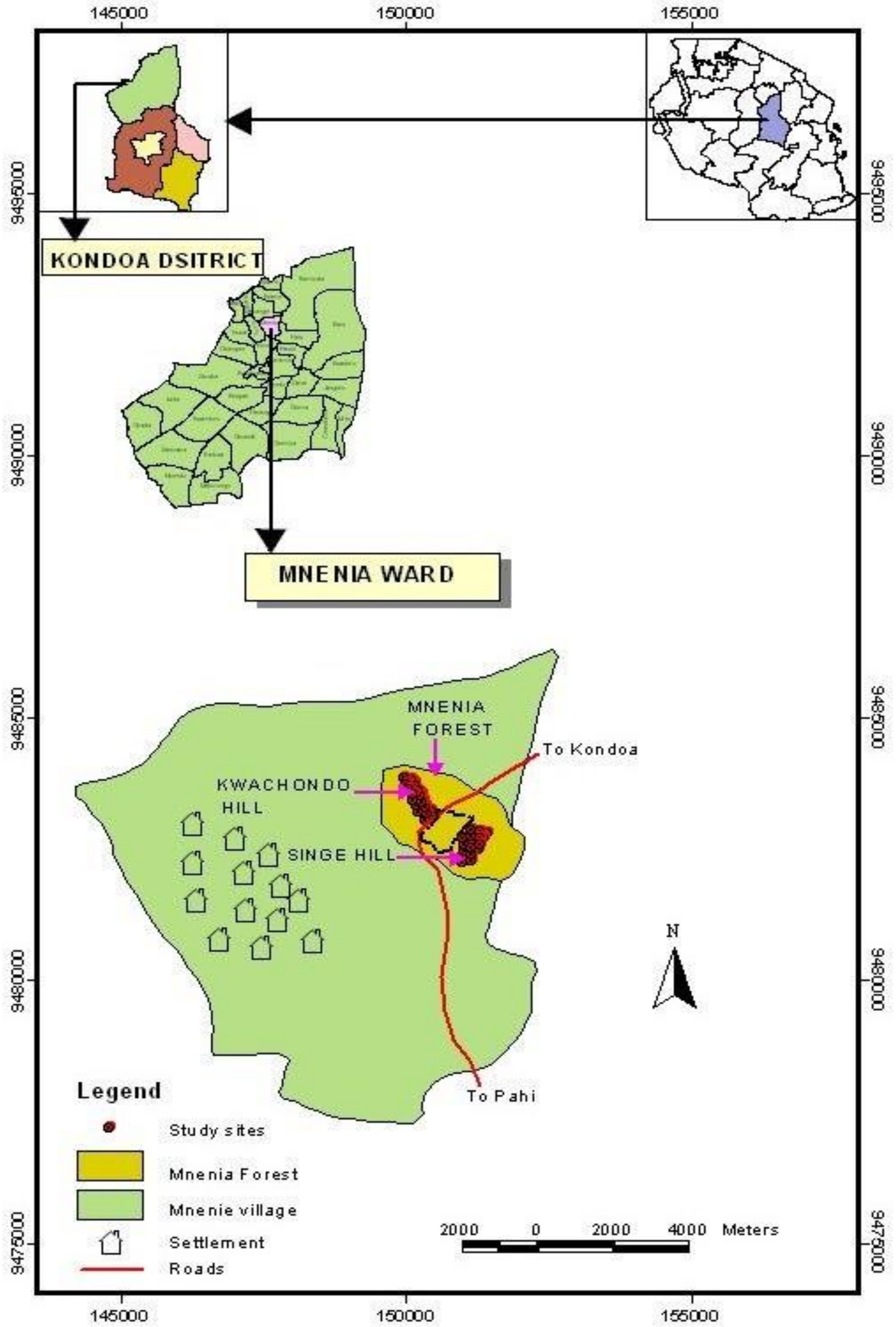

Figure 6: Map of Kondoa district showing study area

3.1.2 The ARKFor REDD+ Pilot project

The ARKFor project began in January 2010 with funding from the Government of Norway for three years. The project partners are African Wildlife Foundation, Kondoa District Council, CAMCO, Selian Agricultural Research Institute (SARI), Institute of Resources Assessment (IRA) at the University of Dar Es Salaam, and at least 15 local communities adjacent the forest (Planet-action, 2010).

Therefore, the project objective was to test and learn lessons about REDD which may be used as a mechanism to finance the protection of threatened forests through the sale of carbon offsets (emission reductions) (Garrett and Ekakoro, 2010). More specifically, it aims in mitigating climate change by conserving Kolo Hills Forests as well as to reduce poverty among the targeted communities in the project area. Lastly, the project also strive to prepare the local stakeholders to enter the carbon trading successfully (URT, 2010).

3.1.3 Vegetation and climate

The hills and escarpment are dominated by Miombo woodlands species. The topography is characterised by two distinct physical features, vast plains and the Kondoa Irangi Hills, known as Kolo Hills. The average annual rainfall ranging between 800-900mm while the mean maximum and minimum temperatures are 29° C and 16° C respectively (Garrett and Ekakoro, 2010). The soils are moderately fertile red sandy loams and clays that are suitable for the growth of short rotational crops e.g. maize varieties, sorghum, beans and finger millet.

3.1.4 Economic activities and populations

The main economic activities in the area are crop cultivation (nearly 70%) and agro-pastoralist (nearly 27%). The estimated population of the project area is approximately 62

000 while households are about 14 000 (Garrett and Ekakoro, 2010). The population of the Mnenia village was estimated to be 3360 while households were 715. However, the Kolo Hills Forest is the Headwaters for the Tarangire River, which is the main source of dry season water for wildlife inside Tarangire National Park. Further, when the river flow decrease would cause negative impacts on aquatic, riparian habitat and wildlife in the area. Therefore, it is a part of the larger conservation complex that forms the Masai steppe heartland (MSHL) and the northern Tanzanian tourism circuit**.**

3.2 Sampling procedures

3.2.1 Sampling for socio-economic survey

The sampling unit of the study was households. However in this study a household is a defined as a group of people who eat in a common pot and usually share a dwelling house and may cultivate same land. In addition to that they recognize the authority of one person, the household head who is the ultimate decision-maker for the household. Therefore, Mnenia village was selected purposefully based on the accessibility, potentiality and proximity to the forest reserve. Further, it was under the REDD+ pilot project and had been sampled by the CCIAM-SUA project. Hence in the village, households were obtained from the village registers. The respondents were selected by matching their numbers in the register with the first three numbers in the table of random numbers.

Therefore, five percent (5%) of households in the village was sampled randomly resulting into 35 households. According to Boyd *et al*. (1981), a recommended and reasonable representative sample size of particular populations under the study should be at least 5%. Further, other key informants were selected purposefully, including village chairman, members of village natural resource committees and project coordinator of ARKHFor at Kondoa.

3.2.2 Sampling for biophysical survey

Forest inventory was conducted in Mnenia Forest which is part of the Kolo Hill forest Reserve with an an area of 5 500ha. The aim of selecting this portion of the project was based on limited time and resources to cover the whole project area of 18 000ha during forest inventory. Further, information obtained from the forest was extrapolated to cover the whole area due to the fact that the ARKFor project covers the same ecosystem. In addition to that Mnenia forest was under joint forest management strategy introduced by the project in the area, hence information on forest carbon stock in relation to the cost accrued by stakeholders assumed to be similar in other forest blocks of the project.

In order to cover the whole area of the forest, systematic sampling design was adopted. The number of sample plots was determined using the equation below;

$$N = \left(\frac{TA * Si}{Ps * 100} \right) \qquad (1)$$

Where; N = number of sample plots

TA = Total area of the forest

Si = sampling intensity

Ps= Plot size.

In addition to that the sampling intensity of 0.05% was adopted whereby a total of 39 circular plots (0.07ha) was laid out on 8 transects. The distance and distribution of plots between transect was 250 m and 200 m between plots. Further, GPS was used to locate and marking of each plot during the inventory. This is because the coordinates obtained can help in revisting the plots for monitoring changes in the area.

3.3 Data collection

Both primary and secondary data were collected. A cross-sectional design was employed in this study. The design allows collection of information at one point in time according to (Kothari, 2004). The study was conducted in three phases. In phase one reconnaissance survey was conducted to provide a general picture of the research area through a rapid assessment whereby the questionnaires were also pre-tested. Phase two involved collection of socio -economic informations while phase three involved of biophysical information.

3.3.1 Primary data

These primary data were for socio -economic and biophysical information.

3.3.1.1 Socio-economic data collection

The socio-economic information's was collected through structured questionnaires (open and close ended), focus group discussion and participant observation. According to Kajembe and Luoga (1996) as cited by Haule (2007) focus group discussion and participant observation used in order to triangulate information given through questionnaires, to cross check respondent's answers and to obtain information that may not be covered by the questionnaire. This survey was conducted to collect information with regard to socio-economic aspects of the communities surrounding the Mnenia forest. This involved solicit routine, non-routine activities conducted by stakeholders and cost accrued in managing the forest. However, among of the data collected was a time and resources used by local people in the REDD+ project set-up, costs involved in institutional basis for making REDD+ (cost for defining land rights and establishing new village committees and costs of start-up information programme e.g. Number of meeting and people involved).

The closed and open-ended questions for collecting data from the households (Appendix 1) wes pre-tested during the reconnaissance survey stage to check if the respondents understand them well and they address issues under investigation. Most questions were responded well and little modification was made to the original questionnaire. Further, a checklist was used to guide discussions with key informants (or focused group) (Appendix 2) . According to Haule (2007) a key informant's is an individual who is accessible, willing to talk and has a great depth of knowledge about the issues questions. Therefore under this study, discussions were conducted with ARKFor project management, district forest officer, village Environmental committee members, Ward and village executive officers.

Lastly under participant observation, the participant observer seeks to go beyond outward appearance and probe the perceptions, motives, belief, values and attitudes of the people involved. The researcher tries to be part of the community being studied (Kajembe and Luoga, 1996). The technique was thus used as an initial medium for learning about social and physical environment interrelationships. Therefore, the process of participant observations has greatly help in interpretations and linkage of data obtained from all other methods involved in the study.

3.3.1.2 Biophysical data collection

Forest inventory was conducted as to collect information on biophysical data of the Mnenia forest and recorded in the inventory form (Appendix 3). Circular sample plots with 2m, 5m, 10m and 15m radius were used in this study because they are easy to lay out and counting errors during inventory of border trees are minimised as observed also by Nduwamungu (1996); URT (2010b). Further a circular plot when subdivided ensures that small trees are measured in small plots and large trees (which constitute most of the biomass per unit area) are measured in large plots and therefore normality of forests can be measured. In each plots along the transect line the data recorded were diameter at breast height (DBH) of all trees with DBH greater than 5cm (Plate 1). A tree was defined as any standing woody plant with a straight stem of at least 3m and with a diameter greater than 5cm and below 4cm was counted as regenerates. The measurement from concentric plots was taken as in Fig.8 below ;

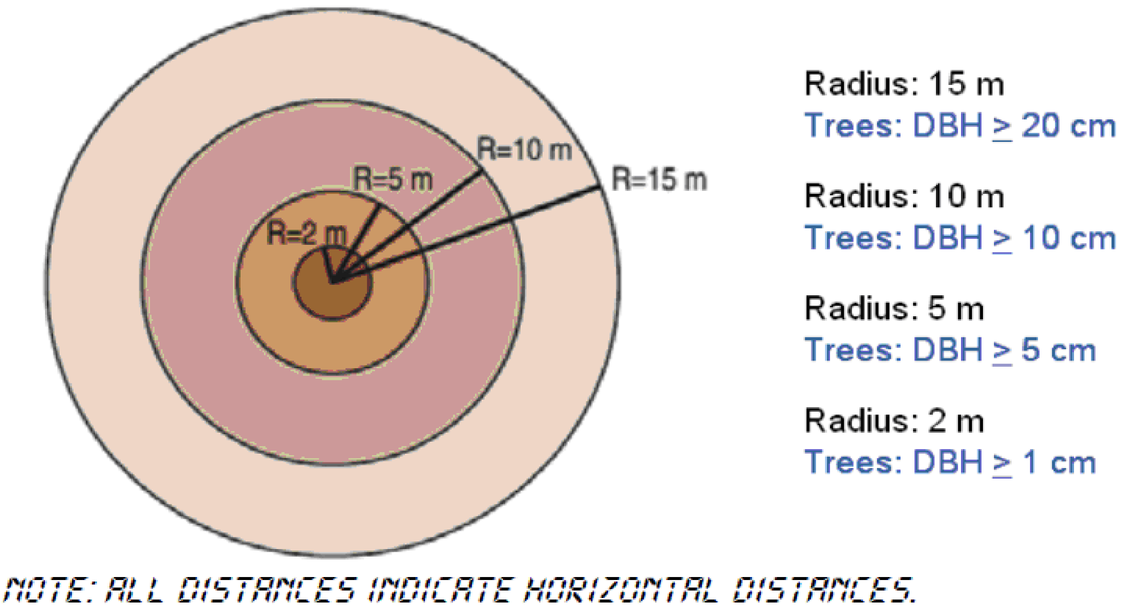

Figure 7: A simple diagram showing concentric plot and measurements taken in the forest

Source: URT, (2010b)

Furthermore tropical natural forests are characterized by having negative exponential diameter distribution such that there are several small size trees and the number of trees decreases with increasing tree sizes (URT, 2010b). The plots were located systematically running from the forest border with the first starting point selected randomly. In addition to that the plots were measured using a measuring tape and all plot coordinates (Appendix 4) of each transect were Geo-referenced using a GPS and the direction of the transect line determined using compass to allow transect to be relocated in the future (Plate 1).

A team of six people was involved in the forest inventory. These six people were divided into two groups of three persons. Each group has one measuring tape, one GPS, one calliper and recording forms. One group consists with three people conducted survey in singe hills and other group conducted a survey in the rest house hill. This was done due to limited resources and time of the study. The species names (vernacular and botanical) of all measured trees were recorded in each plot. The local people assisted in identifying the tree species in local names and translated into botanical names using a checklist and literatures.

Plate 1: Establishment of plots and data recording in the forest

3.3.2 Secondary data collection

These data were obtained from various research findings and experience from different case studies related to the transaction cost analysis and carbon stock estimation. The data on transaction cost category were collected from pilot project coordinating office in Kondoa and AWF headquarter in Arusha by using existing annual reports and relevant records for two years (January, 2010 to December, 2011. Further, other data obtained from different publications, journals and visiting websites to form an overview and identify information gaps.

3.4 Data processing and analysis

The qualitative data were analysed using Statistical Package for Social Science (SPSS) and Microsoft excel spreadsheet was used to analyse quantitative data such costs and biophyscal data.

2.4.1 Socio -economic data

The collected data was first coded into meaningful computer language to assist in the analysis using SPSS and Microsoft excel spreadsheet. The analysis included the determination of descriptive statistics such as (central tendency and dispersion of responses) was presented as percentage, means and frequency tables. Data on routine and non-routine activities were analysed through multiple response domain while data on cost (resources) from the local level and reports for ARKFor project were analysed using Microsoft excel spreadsheet to generate information on the total cost accrued by the villagers and an NGO (AWF). It was assumed that pay per day for local community was equivalent to $3.3 when an exchange rate of $1 was equal to 1500Tsh that depends on the prevailing average farm labours in the study site.

3.4.2 Forest carbon stock data

Data collected from the forest was analysed using the Microsoft excel spreadsheet so as to obtain forest carbon stock in terms of tons of biomass and carbon per hectare and other stand parameters including stand density in terms of the number of stems per ha (N), basal area (G, m^2 /ha) and volume (V, m^3/ha).

The allometric equation (2) developed by Chamsahama *et al.*, (2004) for estimation of biomass because was used to estimate biomass in this forest and later changed into carbon.

$$Biomass = 0.0625D^{2.553} \text{ ......} \quad (2)$$

Where;

Biomass = tree biomass (kg/ha),

D = tree diameter at breast height (cm).

Further, the use of local allometric equations for areas with similar vegetation type is recommended in the literature (Brown, 2003; IPCC, 2003). The allometric equation has R^2 of 0.97 making it reliable for the estimation of biomass. It includes trees from 1 cm diameter at breast height (dbh) and it has the advantage of requiring only Dbh as a variable.

Furthermore, forest average biomasses were obtained by dividing the obtained biomass per plot by area (ha) of each cycle, Biomass (kg/ha) = Biomass (kg) /Area (ha). Then, the average above ground biomass (AGB) values across all measured plots were calculated using the equation 3 below.

$$AGB = \frac{\sum_{pl=1}^{p} Bpl}{Npl} \text{ ......} (3)$$

Where;

Bpl = Total biomass of all plots

Npl = Total number of plots in the study forest

The average biomass per hectare (Kg/ha) obtained was converted to carbon using a biomass-carbon ratio of 0.49 (MacDicken, 1997; Brown, 2003). Therefore the average carbon stock estimated to be obtained per hectare was converted into tonne per ha by equation 4 below.

$$tC = \frac{C\left(\frac{kg}{ha}\right)}{1000Kg} \quad \text{......(4)}$$

Where;

tC = Tonne of carbon and C (Kg/ha) = Carbon (Kg) per hectare

The cost per tonne of carbon dioxide stored per ha in the forest was obtained by using equation 5 below.

$$Cost \quad per \quad tonne \quad of \quad CO_2 = \frac{ATC}{tCO_2} \quad \text{......(5)}$$

Where;

ATC = Average total cost

$AtCO_2$ = Average total carbon stored in the forest

It was assumed that the average conversion factor of 3.66 equal to $1tCO_2$ stored in the forest.

3.4.3 Cost Benefit Analysis (CBA)

CBA is most widely used approach in project appraising and it was the one used in Mnenia forest Project a part of the ARKFor pilot project. The aim of doing CBA in this study was to determine whether managing Mnenia forest was economically profitable by using Net Present Value (NPV) as a decision criterion. The formula used for NPV was:-

$$NPV = \sum_{t=1}^{n} \frac{Bt - Ct}{(1+r)^t} \quad \text{......(6)}$$

Where

NPV = Net Present Value

B_t = Project Benefit in year t

C_t = Project Costs in year t

r = Discount rate

n = Number of years in the planning horizon

According to this criterion, an investment is profitable only if the NPV is greater than zero. In this evaluation two alternatives were considered, that was with project alternative and without project alternative, the latter being the do nothing alternative. According to Kessy (1993) with such mutually exclusive alternatives NPV is the best criterion compared to internal rate of return and benefit /cost ratio because the last two criteria may be misleading as they do not show the monetary magnitude of the return.

The costs considered in this analysis was estimated amount of cost per tonne of carbon dioxide per ha ($\$/tCO_2ha^{-1}$) incurred in managing the forest. The benefit component considered included the estimated value that was assumed will be obtained through trading carbon stored in the forest. The analysis considered the estimated project life span of 40 years (Garrett and Ekakoro, 2010) and the average sequestration rate of $5.3tCO_2ha^{-1}yr^{-1}$ as reported by Zahabu (2008). The market price considered in this study was based on the Verified Carbon Standards (VCS) for “Voluntary” of $\$8.5tCO_2e$ (Diaz *et al.*, 2011). The discount rates of 5%, 10%, 15%, 20% and 25% were used in the analysis to obtain the Net Present Value of the project.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents the findings and discussion of this study. The first section presents results on the socio-economic characteristics of the community that include age, sex, education level and main occupation. The second section presents results of the routine, non routine activities incurred by local community and costs accrued by stakeholders in managing the forest. Lastly, the results of adjacent forest based on parameters that includes tree species composition, number of stems, stem basal area, forest biomass and carbon stock are presented.

4.1 Socio -economic characteristics

4.1.1 Age distribution

The results showed that 40% of the sampled population were aged between 36-46 years with a few falling below 18 and above 61 years of age (Table 4). This implies that the majority of the interviewed respondents were in the working group. Haule (2007) found that increase in the age of the household's head increases the chance of reducing the forest disturbance as they have the sense of ownership and feel responsible for the sustainable conservation and management of resources.

Table 4: Socio-economic characteristics of the respondents in Mnenia village Kondoa District, Dodoma, Tanzania

Household characteristics	Study village Mnenia *Frequency*	*Percent*
Age distribution		
0-18	1	2.5
18-35	5	12.5
36-46	16	40.0
47-60	14	35.0
61-Above	4	10.0
Gender		
Male	28	70.0
Female	12	30.0
Education level		
Informal education	4	10.0
Formal education	36	90
Main occupation		
Farmers	29	72.5
Livestock keeping	9	22.5
Traders	2	5.0

4.1.2 Education level

The results showed that about 90% of all people had attended formal education (Table 4). This could have a direct effect on how the community perceives in establishing and running the ARKFor pilot project in the area. Education is one of a number of tools that contributes to the overall outcome of a conservation project (Howe, 2009). Both formal and informal education is widely used as a conservation intervention in order to develop positive attitudes, and it is often assumed that formal education will automatically lead to environmentally responsible behaviour (Howe, 2009; Dobson, 2007). For example, studies by Alix-Garcia, (2007) and Carr, (2005) have shown a reduction in deforestation around homesteads with additional schooling of the household head. Thus, according to

Kingazi (2002) education has a positive and direct influence on community in participating and adopting new technologies.

4.1.3 Main occupation of respondent

The findings showed that 72.5% of the sampled population engaged in agriculture (Table 4). This was possibly due to the presence of an established irrigation scheme in the area. The main crops cultivated included maize, beans, tomatoes, onions and cabbages. In addition, it was observed that despite such a favourable condition for cultivation yet there were those who practised shifting cultivation. In this case encroachment was observed in the forest (Plate 2). This may have repercussions to carbon loss that may affect the current REDD+ initiatives that are ongoing in the study area. Forest extension services could be enhanced to restrain pressure on forests.

Plate 2: Part of the Mnenia forest showing an open areas as a result of enchroachment by the communities, Kondoa, Tanzania.

4.2 Community awareness of REDD+ initiative in the area

The findings showed that 90% of the local community in the village surrounding the forest were aware of the REDD+ initiative being initiated in the area (Table 5). This awareness created might have been greatly contributed by the presence of the AWF initiative in ARKFor project. Therefore, awareness realized in the area might influence local person's involvement in managing the forest under the REDD+ initiative. According to URT (2003) for a new project intervention to be successful in an area, it is necessary to create awareness for the purpose of introducing the new concept and assessing the communities' willingness to participate in project activities. It was learned further that the villagers was eager to know what will be the impact of REDD+ following the experience obtained from HADO conservation measures taken in the past. This is because the HADO conservation mechanism involved policing in enforcing management of the forest and displacing local community from their native areas. Thus this experience possible influences local community to be aware of the REDD+ initiative that have been introduced into their environment.

Table 5: Community awareness on REDD+ initiative in the area

Local awareness on REDD+	*Frequency*	*Percent*
Not aware of REDD+ initiative	4	10.0
Aware of REDD+ initiative	36	90.0
Total	40	100.0

4.3 Community involvement in management of the forest

Findings showed that 95% of local people were involved in forest management activities under the REDD+ initiative (Table 6). This could be a result of incentives they might be receiving through the activities being undertaken by ARKFor project. It was learned that local people were eager to know what will be the benefit of this initiative in their areas especially the direct incentives which would influence them to manage the forest. Kusaga (2010) reported that interest of villagers to participate in the REDD initiative is stimulated by the expected incentives.

Table 6: Community involvement in management of the forest

Local involvement in managing the forest	*Frequency*	*Percent*
Not involved in managing the forest	2	5.0
Involved in managing the forest	38	95.0
Total	40	100.0

4.4 Activities conducted by community as part of orest management under REDD+

The findings showed that 14.8% and 23.8% of the community attended the REDD+ meeting as a routine and non routine activities respectively (Table 7). This could be possibly that they have realised on the importance of the surrounding forest in their livelihood. Kugonza *et al.*, (2009) stated that a wide range of socio-economic factor influence local community participation in managing the forest as they realise the importance of forestry on their livelihood strategies.

Table 7: Community activities in managing the Mnenia forest under REDD+

Routine and non Routine activities		*Responses*	
		Frequency	*Percent*
Routine activities	Tree planting	29	12.6%
	Forest patrolling	29	12.6%
	Forest boundary making	25	10.9%
	Forest land management	29	12.6%
	Land use planning	21	9.1%
	Attending REDD+ meeting	34	14.8%
	Attending seminar of forest management under REDD+ initiative	25	10.9%
	Selected as a focal farmer	12	5.2%
	Another alternative source of income (Apiary and server stove making)	26	11.3%
Non-routine activities	Attending the REDD+ meeting	31	23.8%
	Forest fire protection	26	20.0%
	Forest supervision	26	20.0%
	Demarcating forest boundary	22	16.9%
	Preventing keeping livestock in the forest	25	19.2%

The costs incurred by local community were calculated based on the days or time spent monthly in undertaking those activities for the purpose of managing the forest.

4.4.1 Time spent and amount paid in performing the activities

Finding showed that 40% of the community were involved in the forest management activities (Table 8). This was possibly due to the presence of various human activities in the forest like cultivation, charcoal making and other activities that may cause forest degradation and deforestation. There were forest guards who involved in patrolling the forest to ensure no encroachment for shifting cultivation and other human activities like livestock grazing in the forest. This resulted to a higher number of days (Table 7) that lead to much cost incurred in managing the forest.

Table 8: Estimated days for involving in forest management

Range of days	Frequency	Percent
<5	16	40.0
5-10	13	32.5
10-15	3	7.5
>15	8	20.0
Total	40	100

Furthermore, findings showed that 45% of the community members was paid for participating in various activities (Table 9). This was due to the presence of support from AWF as an NGO involved in administering the ARKFor pilot project. It was also learned that some members of the community were participating in forest activities voluntarily. This was possibly either due to the community realisation of the importance of the forests to their livelihood.

Table 9: Estimated time spent and amount paid to local community per month

		An allowance given to the community		
	Time/Amount	NO	YES	**Total**
The time spent in involving the activities per month	3hours/month	27.5%	0%	27.5%
	3-6hours/month	27.5%	0%	27.5%
Amount paid during participating in forestry activities	1000-5000	0%	37.5%	37.5%
	>5000	0%	7.5%	7.5%

4.4.2 Estimated community cost of managing Mnenia forest

Findings in Table 10 showed that the amount accrued in forest patrolling was 17 382.62$US. This could be possibly due to the presence of various human activities like crop cultivation in the forest as shifting cultivation and cut down the trees for charcoal making, buildings and firewoods, hence patrolling activities accrue much time or costs than other activities in the area. In addition to that it was learned that in the village there were forest guard trained by AWF and VNRC members who were involved in the forest patrolling activity. However, it was noted that the established institution in community faces a range of challenges like lack of forest patrolling equipments but devoted much of their time in the managing the forests. This is because Mnenia forest was the source of water for irrigation and domestic purposes, other forest products such as honey and fuel wood obtained from that forest. (2006) reported that in a situation in which forestry is just one of many livelihood activities, costs as a proportion of total costs can be significantly higher up to and sometimes above 20% of the cost.

Table 10: Cost incurred by local community by taking part in management of Mnenia Forest

Routine and non Routine activities	Estimated days and costs				
	Freque	*Per day ($US)*	*Number of days per*	*Number of days*	*Costs ($US)*

		nc y		month	per year	
Routine activities	Tree planting	29	3.33[3*]	-	1	96.57
	Forest patrolling	29	3.33*	15	180	17 382.60
	Forest boundary making	25	3.33*	-	1	83.25
	Land use planning	21	3.33*	-	5	349.65
	Attending seminar	25	3.33*	-	5	416.25
	Selected as a focal farmer	12	3.33*	5	60	2397.60
	Making server stoves	12	3.33*	5	60	2397.60
	Conducting beekeeping activities	14	3.33*	15	210	9790.20
Non routine activities	Attending the village meeting	31	3.33*	-	2	206.46
	Forest fire protection	26	3.33*	-	15	1298.70
	Demarcating forest boundary	22	3.33*	-	1	73.26
	Preventing keeping livestock in the forest	25	3.33*	-	15	1248.75
Total						**35 667.63**

In addition to the estimated cost incurred by the forest adjacent communities , other costs incurred by an AWF and other partners were estimated in order to estimate the total costs incurred in managing the forest. It involved the actual cost incurred in setup and running the ARKFor project based on function, actors and budget of the project.

4.5 The direct cost incurred in setting up and running the project by AWF

This section presents results on cost incurred by AWF and partners engaged in managing the ARKFor project. It was noted that the ARKFor project began in January 2010 with funding from the Government of Norway for three years (CAMCO, 2010). It was learned that the main actors in the project were AWF involving in setting-up and running the pilot project. While the other partners were the Institute of Resource Assessment (IRA) of the

* Pay per day was equivalent to $3.3 when an exchange rate of $1 was equal to 1500Tsh that depends on the prevailing average farm labours in the study site.

University of Dar Es Salaam (UDSM), Selian Agricultural Research Institute (SARI) and CAMCO were involved in executing various activities in the area.

4.5.1 Set-up costs according to function and actors

Results showed that the actual expenditure incurred in negotiating contracts, planning, decision making, management and finances was 84.01% (Table 11). This implies that negotiation costs, planning, decision making and administration arise due to time and resources spent to wrap up the negotiations, planning, communication and travel costs. In addition to that as the project was in the initial stage this tends to incur much cost possibly because as the foundation of the project lay properly then the project could be thriving. Dudek and Wiener (1996) stated that negotiation costs will arise in the form of time spent to conclude the negotiations, communication and travel costs and possibly a fee for specialised consultants in legal or financial matters.

Table 11: Set-up costs according to function and actors of the project

Cost centres	NGO (AWF-Arusha & Kondoa)	Partner	Consultancy	Monitoring body	Verifications	Villages and villagers	Total
Negotiating contracts, planning, decision making, administration and finances.	$150 107	-	$192 132	-	-	-	$342 239 (84.01%)
Developing institutions	$1625	$2383	$125	-	-	-	$4133 (1.01%)
Information programs and payment programs/communication	$4908	-	$4146				$9054 (2.2%)
MRV systems	$48 514	-	$3451	-	-	-	$51 965 (12.76%)
Total							**407 391**

Source: ARKFor financial report (January-December, 2010)

4.5.2 Set-up costs for paying personnel and purchasing assets of the project

Results showed that cost incurred in purchasing of capital assets was 49.68% of setup cost (Table 12). This could be due to the fact that the project was in the establishment stage then things like vehicles and other important assets must be purchased for proper management of the project. Milne (1999) stated that procurement, scheme design and negotiation are important categories of transaction costs during establishment of REDD projects. Bond *et al.,* (2009) stated that some of these costs are borne by the buyers and sellers, while some are incurred by the authorities implementing a scheme.

Table 12: Set-up costs for paying personnel and purchasing assets of the project

COST CENTERS	NGO main office (AWF-Arusha)	NGO local office (AWF-Kondoa)	Partner	Consultancy	Monitoring body	Verifications	Villages and villagers	**TOTAL**
Personnel cost	$12 290	$42 255	-	-	$66	-	-	$54 611 (36.41%)
Office costs	-	$20 832	-	-	-	-	-	$20 832 (13.39%)
Capital assets	-	$74 511	-	-	-	-	-	$74 511 (49.68%)
Total								**149 954**

Source: ARKFor financial report (January-December, 2010)

4.5.3 Running cost according to function and actors of the project

Results show that costs incurred in running the developed institution (such as the established JFM in the village, plan, training communities and register JFM and conducting training to communities) was 62.12% (Table 13). This was possible that more attention was given to each village adjacent the forest involved in managing the ARKFor pilot project have a credible management institution that will oversee all the activity in the community.

It was learned that in running the developed institution in the village, training of local communities was undertaken to ensure its sustainability. The high cost incurred in developing an institution for example in Tanzania involve in establishing a joint management plan and development of agreement between local communities surrounding the forest. Further, it requires much time and resources in completing. Bond *et al.*, (2009) argued that realising REDD projects or schemes in weak governance settings is likely to imply higher transaction costs than in settings or running where institutions and rights are well defined and well functioning.

Table 13: Running cost according to function and actors of the project

COST CENTERS	NGO main office (AWF-Arusha)	NGO local office (AWF- Kondoa)	Partner	Consultancy	Monitoring body	Verifications	Villages and villagers	TOTAL
Negotiating contracts, planning, decision making, administration and finances.	$110 225	-	-	$64 638	-	-	-	$174 863 (33.30%)
Developing institutions	$223 313	-	$2314	$53 885	-	-	$46 274	$325 786 (62.12%)
Information programs and payment programs/communication	$788	-	-	$38 582	-	-	-	$39 370 (7.51%)
MRV systems	$185	-	-	$11 201	-	-	-	$11 386 (2.17%)
Total								**524 405**

Source: ARKFor financial report (January-December, 2011)

4.5.4 Running costs for paying personnel and purchasing assets for the project

Findings showed that personnel cost such as salaries and fringe benefit of the staff project was 62.56% (Table 14). This was possibly due to the initial stage of the project that requires more personnel who will make sure that the established activities in the area are properly managed like project coordinator and other supporting staff. Further, it was learned that the project provides a contract for conducting baseline on establishing an MRV system in the area that lead in employing various people, hence more resource were spent for paying personnel and execute administrative activities.

Table 14: Estimated running cost of forest in according to budget categories and actors

Cost centres	NGO main office (AWF-Arusha)	NGO local office (AWF-Kondoa)	Partner	Consultancy	Monitoring body	Verifications	Villages and villagers	Total
Personnel cost	$26 388	$58 183	-	-	$5310	-	-	$89 881 (62.56%)
Office costs, include consumables, travelling costs and miscellaneous.	$27 986	$2500	$3600	$3500	-	-	$14 770	$52 356 (36.44%)
Capital assets	-	$1426	-	-	-	-	-	$1426 (0.99%)
Total								**143 663**

Source: ARKFor financial report (January-December, 2011)

4.6 The cost of managing Mnenia forest a part of the ARKFor REDD+ pilot project

The findings showed that the actual costs accrued by AWF, an NGO involved in setting up and running the ARKFor project in Kondoa from January, 2010 to December, 2011 as shown in Table 10, 11, 12 and 13 were 407 391, $149 954, $524 405 and $143 663 respectively that makes a total of $1 252 413 for two years. Further, it was assumed that the total cost of $1 252 413 spent by AWF in managing the forest covers the whole area of the ARKFor pilot project estimated to be 18 000ha. Consequently as the Mnenia forest (part of the ARKFor project) covers estimated areas of 5500ha then the cost estimated to manage the forest was $382 681.75.

However, the findings (Table 10) showed that the estimated total costs incurred by the community surrounding the Mnenia forest in managing the forest was $35 667.63. Subsequently, the total cost assumed to be accrued by stakeholders (AWF and Mnenia community) estimated to be $418 349.38 in managing the Mnenia forest. For that reason, the average estimated cost incurred in managing the Mnenia forest on a hectare basis by stakeholders (the AWF and the community) was $76.06/ha. This showed the costs that stakeholders incurred in order to obtain the desired reduction of deforestation and emission at Mnenia forest. Pagiola and Bosquets (2009) reported that the transaction costs are the costs incurred by the parties as a result of a REDD+ transaction and for the countries of the miombo region, many of these costs would be associated with verifying that the action taken has resulted in a reduction of emissions.

Therefore, the forest inventory work was done in the Mnenia forest in order to estimate the amount of carbon stored as a result of the cost accrued by AWF and local community in managing the forest.

4.7 Forest carbon stock

This section presents findings of forest stand parameters on tree species compositions, number of stems, basal area, biomass and carbon stock per ha in Mnenia forest part of the ARKFor pilot project.

4.7.1 Stand parameters

Findings on forest parameters (Appendix 7) such as number of stems, basal area, volume, biomass and carbon stock per hectare in Mnenia forest summarized in Table.15.

Table 15: Stand parameters

	STAND PARAMETERS			
	No. of stems ha^{-1}	**Basal area (m²/ha**	**Biomass (t/ha)**	**Carbon (t/ha)**
Mean	852	10.83	40.31	19.75
SE	110.25	0.81	3.55	1.74

4.7.2 Tree species composition

A total of 62 tree species was identified in the Mnenia forest (Appendix 5). The number of tree species identified in this study is consistent with previous studies elsewhere in Tanzania conducted in miombo woodland (e.g. Abdallah, 2001; Dondeyne *et al*., 2004; Backeus *et al*., 2006; Isango, 2007).

4.7.2.1 The number of stems per ha

Table 15 shows the average number of stems present in the forest. The findings are comparable to other studies done in miombo woodland elsewhere in Tanzania. According to Kusaga (2010), reported that number of stems Ha^{-1} in Mihumo and Ngongowele dry miombo forest was 870 ± 119 (SE) and 731 ± 138 (SE) respectively. Also Zahabu (2008) and Chamshama (2004), shows that the average number of stems Ha^{-1} ranges between 628 – 694 and 1027 at Kitulangalo Training forest respectively. Further it was observed that they were more number of stems of trees with the low Dbh class of (1-4cm) than tree with the higher Dbh class in the forest.

Therefore the observed distribution of the number of stems (Appendix 6) in the forest follows an inverse '*J*'-shaped trend (Fig.9) which is common in natural forests with active regeneration and recruitment according to (Phillip, 1983). On the other hand, Kusaga (2010) reported that this trend could happen due to previous disturbances from logging, charcoal burning or wildfires that opened the woodland canopy and made way for more regeneration. This is because Miombo woodland colonizes faster and denser after disturbances because the woodland floor exposed to sunlight and competition among woody plants is minimized (Campbell, 1996).

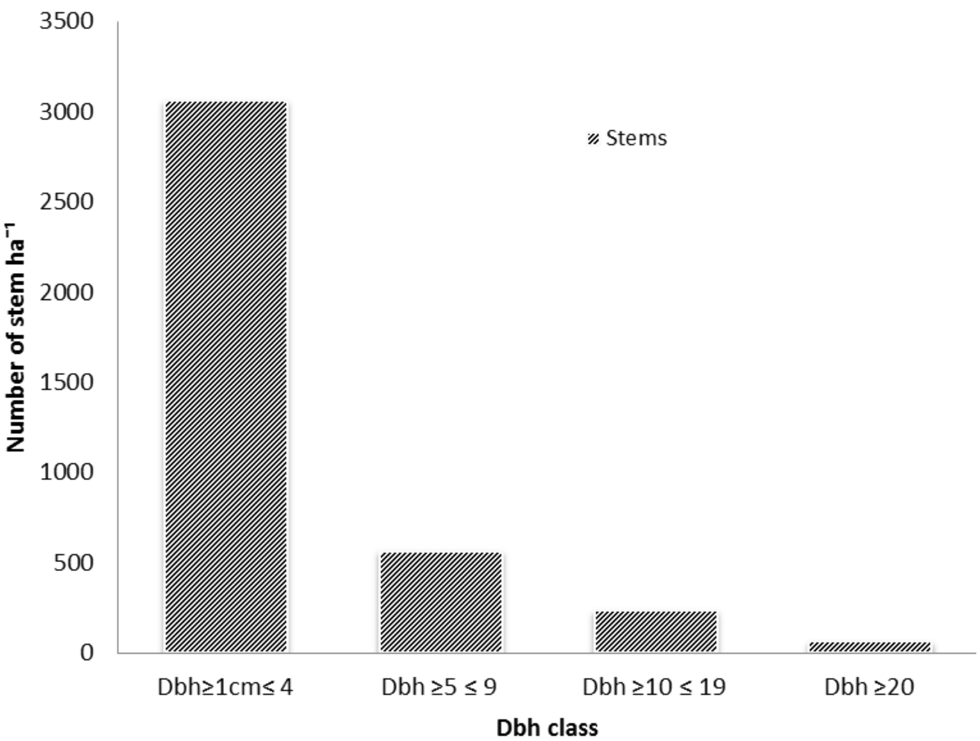

Figure 8: Distribution of number of stems by diameter classes in Mnenia Forest Kondoa, Tanzania

4.7.2.2 The basal area of stems in the forest

The result in (Table.15) shows the average basal area of stems in the forest. The observed basal area is comparable with other research done elsewhere in Tanzania because it is from the same ecosystem of miombo woodland. For example, according to Zahabu (2008) the basal area in Kitulangalo forest was 10.2m²/ha and 7.9-9.9m²/ha respectively. Kusaga (2010) showed that the basal area of Mihumo, Ngongowele and Ngunja forest reserve was 9.8 ± 0.78 (SE), 11.37 ± 0.98 (SE) and 9.82 ± 0.92 (SE) respectively.

4.7.2.3 Estimated forest biomass and carbon stock

A result in (Table.15) above shows the estimated forest biomass and carbon stock of the forest. The observed forest biomass and carbon stock was comparable with other studies done in miombo woodland elsewhere in Tanzania. According to (Garrett and Ekakoro, 2010) the carbon stock in the Kolo Hills Forest was about $17tCha^{-1}$ - $24tCha^{-1}$. Further, Shirima (2009) showed that eastern Miombo woodlands in Tanzania have C storage potential of between 25 and 80 $tCha^{-1}$. In addition, Zahabu (2008), found that KSUATFR the C stock was 17.6 – $22.9tCha^{-1}$.

Therefore, the distribution of forest parameters (biomass and carbon) by DBH class portray a normal ‘*J*’-shaped trend as expected for natural forest (Fig.10) with good growth and regeneration potential. It was observed that trees with small DBH have low biomass and carbon stock content while trees with higher BDH have high amount of biomass and carbon stock.

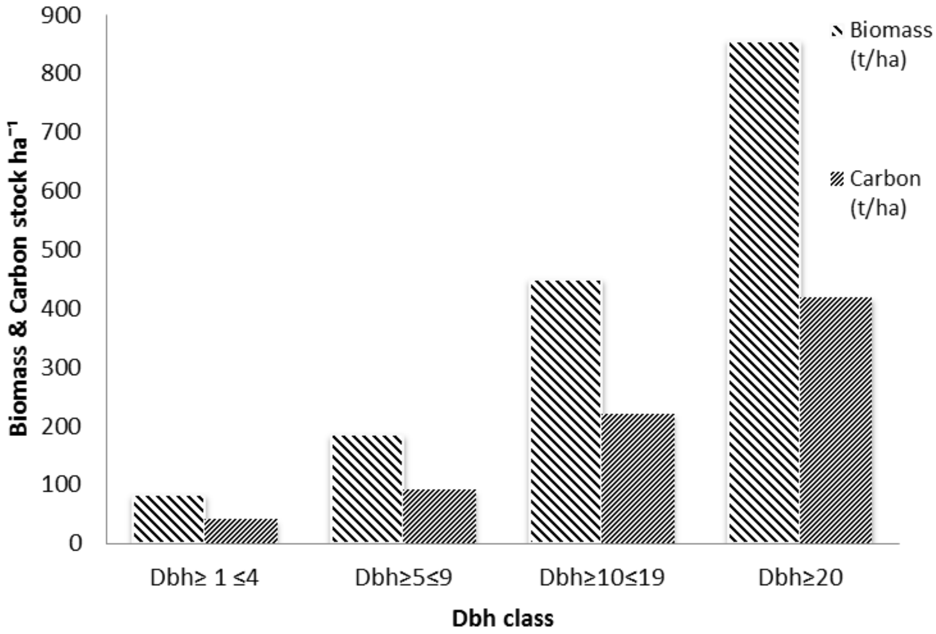

Figure 9: Distribution of forest biomass and carbon stock by Dbh classes in Mnenia Forest Kondoa, Tanzania

Further, results showed that seven species out of 62 that were found in the forest account for about 68% of total forest biomass in the forest. Meanwhile, seven species was represented 69% of the total forest carbon stock (Figure 11). The tree species that contribute the most of the standard parameters was *Brachystegia brusii* (37%), *Terminalia brownii* (12%), *Brachystegia spiciformis* (6%), *Pterocarpus angolensis* (4%), *Cordia monoica* (4%), *Combretum molle* (3%) and *Acacia xanthophlea* (3%). Other species were represent 31% of the total forest biomass at the Kolo hills forest reserve.

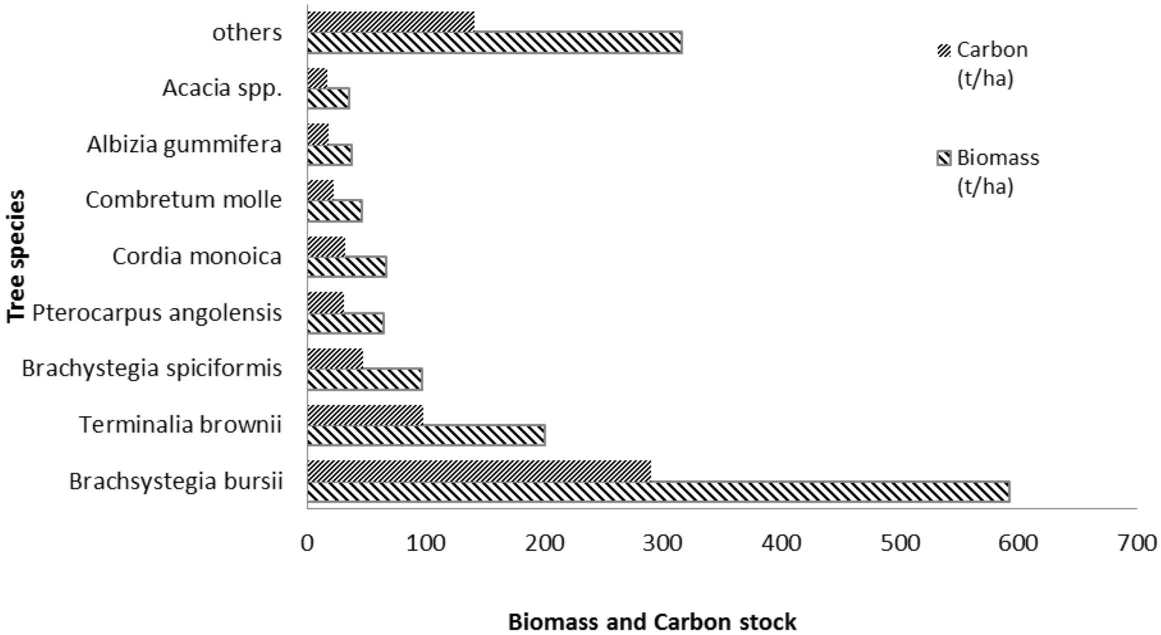

Figure 10: Contribution of tree species in term of biomass and carbon storage

4.8 Costs per tone of carbon dioxide and profitability of managing the forest

The average tone of carbon dioxide (tCO_2) stored in the forest was $72.48tCO_2eha^{-1}$. This observation was in line with other studies done elsewhere in miombo woodland ecosystems. For example, Nhantumbo and Izidine (2009) showed that carbon stock for Mozambique miombo woodlands contain $19.0tCha^{-1}$ with an estimated amount of $69.73tCO_2ha^{-1}$and Zahabu (2008) found that in KSUATFR the C stock was 17.6 – $22.9tCha^{-1}$ equivalent to $64.59tCO_2ha^{-1}$ and $84.04tCO_2ha^{-1}$ respectively.

The average costs incurred by AWF and local community in managing the forest in relation to a tCO_2 by the forest was $\$1.0485tCO_2e^{-1}ha^{-1}$. The observed transaction cost found to be comparable to other studies done elsewhere. For example a study by Michaelowa and Jotzo (2005) showed that transaction costs can vary from US$1.48 per tCO_2 for large projects to as high as US$14.78 per tCO_2 for small projects. Further, Moomaw *et al.* (2001) showed that abatement transaction cost estimates in Non-Annex I countries ranges between 0 - 3.66 \$US/t CO_2e and 0 - 3.48 US/tCO_2e for very large and large projects respectively.

The profitability of the project was determined by considering the sequestration rate studies done in miombo woodland. Zahabu (2008) reported that the average rate of biomass increment for the miombo woodland forest of KSUATFR was 2.8$tCha^{-1}yr^{-1}$ which was equivalent to CO_2 sequestration of 5.3 $tCO_2ha^{-1}yr^{-1}$. Currently the carbon markets only apply to carbon sequestration (i.e., the additional storage of carbon over time). Globaly as there are several emerging markets for carbon based on both regulation and voluntary market demand. The ARKFor project observed to trade emissions under the centralized markets of voluntary carbon offsets. Diaz *et al.,* (2011) reported that Verified Carbon Standard former “Voluntary” (VCS) showed a volume-weighted average price per tCO_2e of 8.5\$US.

The obtained Net Present Value (NPV) for Mnenia forest with an estimated net benefit of \$540.02 for the proposed life span of 40 years at the discount rate of 5%, 10%, 15%, 20% and 25% was \$19021.92, \$9061.366, \$5426.22, \$3754.257 and \$2838.799 respectively (Appendix 8). The World Bank (WB, 2005) recommends 15% discount rate in project evaluation of development projects with external funding whereas the Bank of Tanzania charges an interest of about 20.6 % (BOT, 2007) for investments including investment in forestry and carbon projects. This result was comparable to other studies done elsewhere in miombo woodlands. Nhantumbo and Izidine (2009) reported that Nambita forest project in Mozambique with 19$tCha^{-1}$ equivalent to 69.73tCO_2ha^{-1} at a price of \$4tCO_2^{-1} and a net benefit of \$476 was feasible and profitable at discount rate of 10%.

CHAPTER FIVE

5.0 CONCLUSION AND RECCOMENDATIONS

5.1 Conclusion

5.1.1 General observations

This study provides information on the estimated amount of costs incurred by stakeholders in managing the ARKFor pilot project and an estimated average tonne of C stored in the pilot project. The information was therefore used to estimate average amount of transaction cost incurred in managing the forest in relation to the amount of carbon stored in the pilot project.

It has been observed that local communities in the villages are willing to participate in a REDD initiative. The willingness of the villagers to participate in REDD+ initiative is motivated mainly by the expected income they will receive from carbon trading and their perception of the negative effects that climate change will have on their environment. The overall observation showed that most of the activities conducted as part of protecting the forest were done by AWF through the support secured from the Government of Norway for three (3) years from January, 2010, adjacent communities and Government of Tanzania. Therefore when the fund will be over then most of local people will not be able to participate in managing the forest this because in the long run, the actual participation of villagers in a REDD+ project will depend on the availability of conservation fund of carbon project and a timely flow of carbon payments to the participating communities at project level.

5.1.2 Estimated average transaction costs and benefit from the project

Findings showed that the average transaction cost incurred by stakeholders in managing the pilot project was $76.06ha^{-1}. The average start-up and running costs incurred by the community and the AWF in managing the Mnenia forest as part of the ARKFor pilot project was 418 349.38$US. The analysis showed that higher cost were on planning, administration , procurement various assets during project setup. Other areas that accrued higher cost were on running the developed institution in the community and payment made to personnel. Further it was concluded that the project was found to be economically feasible at 5%, 10%, 15% and 25% discount rates with NPVs of about $19021.92, $9061.366, $5426.22, $3754.257 and $2838.799 respectively.

5.1.3 Parameters of the forest

Findings from this study show that stems density of the ARKFor pilot project was good because stem density portrayed an inverse 'J' shape, which is the common shape of natural forests with active regeneration and recruitment. Therefore this forest expects to ensure sustainability of carbon stock and sequestration for carbon trading in future for the ARKFor pilot project and community surrounding the forest.

Also, findings revealed that the case study of ARKFor store biomass and carbon stock per hectare similar to other Miombo forests in Tanzania. On average the biomass and carbon stock in ARKFor pilot project were estimated to be 40.31t/ha and 19.75tC/ha. Therefore, the distribution of forest parameters (biomass and carbon) by DBH class portray a normal 'J'-shaped trend as was expected for natural forest (Fig.5). The tree species that contributeed the higher stand parameters were *Brachystegia brusii* (37%), *Terminalia brownii* (12%), *Brachystegia spiciformis* (6%), *Pterocarpus angolensis* (4%), *Cordia* *monoica* (4%), *Combretum molle* (3%), *Acacia xanthophlea* (3%) and other species accounted for 31% of the total forest biomass at the Kolo hills forest reserve.

5.2 Recommendations

Based on the finding from the current study, the following recommendations are proposed as strategies to minimize REDD+ project costs for sustainable conservation of the forest.

- Local communities should be sensitised on the role of conservation through extension services that will restrain from shifting cultivation observed in the area and reduce pressure on the forest. This will lead to decreased in local involvement in forest patrolling the forests and in turn decrease in the cost of managing these forests.
- Community based structure such as Village Natural Resource Committee (VNRC) should be strengthened with a view to assuming responsibility for ARKFor project administration (after three years),to ensure that project ownership belongs to the participating villages and reduce cost of managing the forest
- In order to ensure sustainability of REDD+ projects the carbon rights and benefit sharing mechanisms all need to be clarified particularly in respect of current introduction of REDD+ as the forest management approach in the area by policy makers.
- Although the estimates suggest that abatement costs observed was between the ranges on the estimates in Non-Annex I countries more studies should be done to other forest ecosystems so as to explore and establish abatement cost in Tanzania.

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APPENDICIES

Appendix 1: Questionnaire form for household survey

A. IDENTIFICATION VARIABLE

Questionnaire No: ………………

Sex of respondent: ……………..

Age of respondent: …………….

Household size: …………………..

Ward Name: ....

Division: ....

District: ....

B. Routine and Non- Routine Activities.

1. Are you aware on REDD+ initiative at Kolo Hill forest?
   Codes: (0=No; 1=Yes)
2. Do you know the NGO involved in managing the forest under REDD+ initiative?
   Code: (0=No; 1=Yes)
3. Are there any other initiatives in this area that work on forest related issue?
   Codes: (0=No; 1=Yes)
4. Are there any activities done by household in managing the forest under REDD+ initiative?
   Code: (0= No; 1= Yes)
5. What are the types of activities done by household in managing the forest under REDD+ initiative?
   Code: (1= fire fighting; 2= boundary marking; 3= management plan preparation; 4= forest patrolling;
   5= others)

B. TRANSACTION COSTS

1. Are you or any member of your household involved in a group involved in managing the forest?

Code: (0=No; 1= Yes)

2. If yes, how many people involved in the activity?

Code: (1= <2; 2= 2-5; 3= >5)

3. What is the number of days involved in the activities per month?

Code: (1= <5; 2=5-10; 3= 10-15; 4= >15)

4. Is there any allowance given to you for participate in the activities?

Code: (0=No; 1=Yes)

5. If yes, what is the amount per day paid during participating in forest activities?

Code: (1= <1000; 2= 1000-5000; 3= >5000)

6. If no, what is the time you spent in involving the activities per month?

Code: (1=3hour/month; 2= 3-6hours/month; 3= >6 hours/month)

7. What is the amount you think you could get when performing other activities?

Code: (0=None; 1= <1000; 2= 1000-5000; 3=>5000)

C. GENERAL QUESTIONS

1. Are you satisfied with the current management approach of forest?
   Code: (0=No; 1=Yes)
2. Do you think that cost of managing forest under REDD+ initiative is higher/lower than that incurred during traditional method approach?
3. What is your suggestion on the best way of reducing such cost of managing forest under REDD+ initiative?

Appendix 2: Checklist for VNRC and key informants from the NGO

I. Checklist survey for Village Natural Resource Committee (VNRC)

A. IDENTIFICATION VARIABLES.

Questionnaires No………………......

Sex of respondent: ....

Age of respondent: ....

Village Name: ....

Ward Name: ....

Division: ....

District: ....

B. Routine and Non- Routine Activities.

1. Are you aware on REDD+ initiative at Kolo Hill forest?
   Codes: (0=No; 1=Yes)
2. Do you know the NGO involved in managing the forest under REDD+ initiative?
   Code: (0=No; 1=Yes)
3. Are there any other initiatives in this area that work on forest related issue?
   Codes: (0=No; 1=Yes)
4. Are there any activities done by local people in managing the forest under REDD+ initiative?
   Code: (0= No; 1= Yes)
5. What are the types of activities done by local people in managing the forest under REDD+ initiative?
   Code: (1= fire fighting; 2= boundary marking; 3= management plan preparation; 4= forest patrolling;
   5= others)

C. Transaction Cost.

D.

1. Is there any meeting that conducted to discuss about management of forest under REDD+?
   Codes: (1=Yes; 0=No).

2. If yes, what number of local people participating in the meeting?
   Codes: (0=Never; 1= All (>50 people); 2=few (<50 people)

3. Is there any allowances provided to them in attending the meeting?
   Codes: (0=No; 1=Yes)

4. If yes, what was the amount per day?
   Codes: (0=Never; 1=<1000Tsh; 2=1000-5000Tsh; 3=>5000)

5. Is there any meeting conducted in discussing management forest plan with local people?
   Codes: (0=No; Yes=1)

6. What is the number of local people participated in the meeting?
   Codes: (0=None; 1=<10; 2=10-20; 3=>20)

7. Is there any meeting conducted in order to formulate forest management by laws?
   Codes: (0= None; 1=Yes)

8. If yes, what is the number of meeting conducted per month?
   Codes: (0= none; 1= < 2/Month; 2=2-5/month; 3= >5/Month)

9. What is the number of local people participated in formulation of forest by laws?
   Code: (0=None; 1= <10; 2=10-20; 3= >20)

10. What is the amount paid to local people per meeting?
    Codes: (0= None; 1=<1000; 2=1000-5000; 3=>5000)

E. General questions.

1. Are you satisfied with the current management approach of forest?
   Code: (0=No; 1=Yes)

2. Do you think that cost of managing forest under REDD+ initiative is higher than that incurred during traditional method approach?
3. What is your suggestion on the best way of reducing such cost of managing forest under REDD+ initiative?

II. CHEKLIST FOR KEY INFORMANTS FROM THE NGO

A. Identification Variables

Questionnaires No: ....

Date of Interview: ………………………………….

Title of Respondent: ………………………........

Sex of respondent: ....

B. Routine and Non- Routine Activities.

1. Are you aware on REDD+ initiative at Kolo Hill forest?

   Codes: (0=No; 1=Yes)

2. Do you know the NGO involved in managing the forest under REDD+ initiative?

   Code: (0=No; 1=Yes)

3. Are there any other initiatives in this area that work on forest related issue?

   Codes: (0=No; 1=Yes)

4. Are there any activities done by local people in managing the forest under REDD+ initiative?

   Code: (0= No; 1= Yes)

5. What are the types of activities done by local people in managing the forest under REDD+ initiative?

   Code: (1= fire fighting; 2= boundary marking; 3= management plan preparation; 4= forest patrolling;
   5= others)

C. Transaction Cost:

1. Is there any local committee established to manage the forest?

   Code: (0=No; 1=Yes)

2. If yes, how many local committees established to manage the forest?

Code: (1=<2; 2= > 2)

3. What is the number of local people involved in the committee?

Code: (1= <5; 2= 5-10; 3=10-15; 4=>15)

4. What is the number of days in which the committee participate in forest activities per month?

Code: (1= <5; 2= 5-10; 3=10-15; 4= 15-20; 5= >20)

5. Is there any allowance given to the committee member when participating in forest activities?

Code: (0= No; 1= Yes)

6. If yes, what is the amount given per person per day?

Code: (1= < 1000; 2= 1000-5000; 3=>5000)

7. Is there any seminar conducted by the office in educating the committee how to manage the forest?

   Code: (0= No; 1= Yes)

8. If yes, how many times per month?

   Code: (1= <2; 2= 2-5; 3= >5)

9. If yes, what was the cost incurred in conducting such seminar per person?

   Code: (1= <1000; 2= 1000-5000; 3= >5000)

10. What is the type of seminar provided to local committee?

Code: (1= Fire fighting; 2= Forest carbon stock estimation; 3= forest patrolling; 4=others)

11. If it is fire fighting, is there any equipment provided to local people?

    Code: (0= No; 1=Yes)

12. If yes, mention them (a)……………… (b)………………………. (c)……………………

13. What was the cost incurred for purchasing those equipment?

    Code: (1= <20000; 2=20000-50000; 3= >50000)

14. Is there any management plan prepared for managing the forest reserve?

    Code: (0=No; 1=Yes)

15. If yes, what is the number of officials participated in the preparation?

    Code: (1= <2; 2= 2-5; 3=>5)

16. How many days do the activity taken to be completed?

    Code: (1=<2; 2=2-5; 3=>5)

17. Is there any allowances provided to the officials in preparing the management plan?

    Code: (0= No; 1=Yes)

18. How much amount per day?

    Code: (1= >10000; 2=10000-20000; 3=>20000)

19. Is there any sensitization activities conducted by NGO to local community on issue of REDD+?

Code: (0= No; 1= Yes)

20. What was the number of days in which local people involved in the activities per month?

Code: (1=<5; 2=5-10; 3= > 10)

21. Is there any allowance paid to the local community during attending sensitization process?

Code: (1= <1000; 2=1000-5000; 3=>5000)

D. General question

1. Do you think that cost of managing forest under REDD+ initiative is higher/lower than that incurred during traditional method approach?

   Code: (0= No; 1= Yes)

2. What is your suggestion on the best way of reducing such cost of managing forest under REDD+ approach?

Appendix 3: Biophysical informations recording form

About the Plot

Plot No..........................

Plot Location

GPS Y (Nothing's).........................

GPS X (Easting's).........................

Direction to plot centre.................

Distance to plot centre..................

Date .... /........ /........ (dd/mm/yy)

Start time.......................................

End time..

District name.................................

Division name................................

Ward name.....................................

Village name..................................

Forest/Area.....................................

About the trees DBH in the plot

Tree No.	**Species Name**	**Plot Radius/DBH**			
		2m, Dbh≥1cm	5m, Dbh≥5cm	10m, Dbh≥10cm	15m, Dbh≥20cm
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					

Appendix 4: Plot coordinates in Mnenia Forest

Plot No.	Easting's	Northing's
1	816472	9481652
2	816520	9481452
3	816643	9481286
4	816728	9481112
5	816783	9480917
6	816943	9480772
7	817028	9480600
8	816546	9480729
9	816518	9480932
10	816380	9481092
11	816793	9480486
12	816838	9480684
13	816758	9480868
14	816679	9481049
15	816626	9481245
16	816538	9481426
17	816439	9481599
18	816373	9481788
19	816121	9481823
20	816170	9481631
21	816312	9481488
22	816416	9481314
23	817890	9479107
24	817886	9479307
25	817925	9479502
26	817911	9479700
27	817855	9479892
28	818623	9480049
29	818512	9479883
30	818353	9479508
31	818143	9479153
32	818130	9479357
33	818124	9479565
34	818194	9479946
35	818121	9479946
36	818132	9480146
37	818376	9480092
38	818371	9479892
39	818389	9479692

Appendix 5: Trees/Shrubs found in Mnenia forest a part of ARKFor pilot project

S/N	**Tree Local Name**	**Tree Scientific Name**
1	Chawoda	
2	Ekijame (mpingo)	*Dalbergia melanoxylon*
3	Hembehembe	
4	Ibuibui	*Sterculia quinqueloba*
5	Idaka	*Commiphora africana*
6	Ijovya	*Commiphora africana*
7	Ikochokocho	*Bersama abyssinica*
8	Iperemeso	
9	Iteteko	
10	Itunene	*Markhamia obtusifolia*
11	Itunene	*Markhamia obtusifolia*
12	Iyarampimbi	*Pappea capensis*
13	Kichumbichumbi	*Erythrina abyssinica*
14	Kihunga	*Acacia sp.*
15	Kijame	*Acacia nilotica*
16	Kinkusa	*Indigofera swaziensis*
17	Kivambang'ombe	*Balanites aegyptiaca*
18	Mchachave	*Acacia hokii*
19	Mchakayi	*Dombeya rutundifolia*
20	Mchaoda	
21	Mchumbu	
22	Mdabiri	*Dichrostachys cinerea*
23	Mduwau	*Grewia bicolar*
24	Mfile	
25	Mfile (mpikichu)	
26	Mfiru	
27	Mfulofulo	
28	Mgiito	*Combertum molle*
29	Mhanagala	*Brachsystegia bursii*
30	Mhija	
31	Mhuluka	
32	Mhunga	
33	Mjengu	
34	Mkabaku	*Carisa edulis*
35	Mkakalulu	
36	Mkamki	
37	Mkirisi	
38	Mkunungu	
39	Mkuvu	
40	Mlama	
41	Mninga	*Pterocarpus angolensis*
42	Mnu	*Ekebergia capensis*
43	Mponde	*Podpcarpus falcutus*
44	Mriyamburi	
45	Msaamaji	*Albizia gummifera*
46	Msakawa	*Lannea schweinfurthii*
47	Msalanka	
48	Msasa	*Cordia monoica*
49	Mtalavanda	
50	Mtungulu	
51	Mukomu	
52	Muluka	
53	Mumu-muzura	*Ficus thoningii*
54	Muvare	*Lonchocarpus capassa*
55	Mvimuvimu	
56	Mviru	*Vangueria infausta*
57	Mwanya	*Terminalia brownie*
58	Mwerera	
59	Mwitelele	
60	Mwiwi	*Adansonia digitata*
61	Myombo	*Brachystegia spiciformis*
62	Ntohoni	

Appendix 6: Distribution of stems by DBH classes in Mnenia Forest part of ARKFor pilot project

Plot NO	2m DBH≥1cm≤ 4	5m DBH ≥5 ≤ 9	10m DBH ≥10 ≤ 19	15m DBH ≥20	Total
1	769.23	886.08	0.00	0.00	886.08
2	2307.69	1392.41	191.08	70.72	1654.21
3	0.00	1265.82	286.62	42.43	1594.88
4	4615.38	379.75	382.17	14.14	776.06
5	1538.46	886.08	159.24	84.87	1130.18
6	9230.77	379.75	191.08	42.43	613.26
7	1538.46	2025.32	159.24	28.29	2212.84
8	3076.92	886.08	286.62	113.15	1285.85
9	3076.92	759.49	382.17	99.01	1240.67
10	5384.62	506.33	414.01	84.87	1005.21
11	1538.46	1139.24	95.54	70.72	1305.50
12	4615.38	253.16	222.93	141.44	617.54
13	2307.69	1012.66	0.00	14.14	1026.80
14	1538.46	253.16	127.39	84.87	465.42
15	13076.92	632.91	318.47	42.43	993.82
16	8461.54	126.58	63.69	14.14	204.42
17	6153.85	126.58	63.69	42.43	232.71
18	14.14	0.00	0.00	0.00	0.00
19	769.23	379.75	31.85	155.59	567.18
20	769.23	126.58	31.85	127.30	285.73
21	4615.38	0.00	127.39	84.87	212.25
22	0.00	0.00	127.39	127.30	254.69
23	3846.15	0.00	95.54	99.01	194.55
24	4615.38	126.58	159.24	84.87	370.68
25	4615.38	126.58	95.54	70.72	292.85
26	0.00	0.00	95.54	42.43	137.97
27	0.00	253.16	0.00	28.29	281.45
28	1538.46	0.00	0.00	84.87	84.87
29	7692.31	0.00	63.69	70.72	134.42
30	2307.69	253.16	159.24	28.29	440.69
31	3846.15	379.75	605.10	14.14	998.99
32	1538.46	126.58	382.17	42.43	551.18
33	1538.46	1012.66	859.87	28.29	1900.82
34	1538.46	1518.99	1114.65	28.29	2661.93
35	2307.69	886.08	414.01	42.43	1342.52
36	0.00	379.75	445.86	28.29	853.90
37	5384.62	2025.32	159.24	0.00	2184.55
38	0.00	0.00	159.24	70.72	229.96
39	3076.92	1392.41	541.40	70.72	2004.53
Total	119244.91	21898.73	9012.74	2319.66	33231.13
Average	3057.561885	561.5060045	231.095868	59.478475	852.08

Appendix 7: Detailed forest parameters in Mnenia Forest part of ARKFor pilot project

Plot	Basal area	Carbon (t/ha)	Biomass (t/ha)
1	2.55	2.70	5.51
2	10.91	17.82	36.37
3	10.39	20.69	42.23
4	10.88	14.45	29.50
5	14.79	35.93	73.33
6	11.67	16.15	32.96
7	11.68	16.68	34.05
8	19.98	40.88	83.44
9	19.12	45.59	93.03
10	17.45	28.06	57.27
11	9.32	14.76	30.13
12	12.63	24.85	50.71
13	8.03	14.08	28.73
14	7.70	15.25	31.13
15	11.56	17.22	35.15
16	6.69	10.82	22.08
17	5.76	10.33	21.09
18	1.28	3.52	7.19
19	15.45	38.57	78.72
20	12.10	31.38	64.04
21	9.12	16.89	34.46
22	10.14	24.00	48.98
23	7.46	13.78	28.13
24	15.14	38.98	79.54
25	8.16	13.59	27.73
26	2.73	5.55	11.33
27	2.55	4.23	8.63
28	9.50	24.49	49.98
29	7.36	16.53	33.72
30	7.32	14.78	30.16
31	12.30	18.04	36.82
32	9.54	16.30	33.27
33	20.11	31.44	64.16
34	21.43	33.23	67.81
35	12.56	6.87	14.02
36	8.76	15.56	31.76
37	12.11	13.52	27.60
38	6.52	13.55	27.66
39	19.52	29.25	59.69
Total	422.26	770.32	1572.08
Mean	10.83	19.75	40.31
Standard error	0.81	1.74	3.55
Cofidence level (95%)	1.64	3.52	7.18
Standard Deviation	5.05	10.85	22.15

Appendix 8: Table showing NPV at various discount rate of 5%, 10%, 15%, 20% and 25%

Year (n)	**NET BENEFIT**	**r=5%**	**r=10%**	**r=15%**	**r=20%**	**r=25%**
1	540.02	514.30	490.9273	469.5826	450.0167	432.016
2	582.52	528.36	481.4215	440.4688	404.5278	372.8128
3	625.02	539.92	469.5868	410.9608	361.7014	320.0102
4	667.52	549.17	455.9251	381.6567	321.9136	273.4162
5	710.02	556.32	440.8666	353.0054	285.3411	232.6594
6	752.52	561.54	424.7779	325.3352	252.0174	197.2686
7	795.02	565.01	407.971	298.8775	221.8755	166.7278
8	837.52	566.87	390.7093	273.7868	194.7804	140.5125
9	880.02	567.27	373.2144	250.1566	170.5538	118.1143
10	922.52	566.35	355.6714	228.0328	148.9921	99.05483
11	965.02	564.23	338.2336	207.4245	129.8801	82.89459
12	1007.52	561.02	321.0269	188.3127	113.0001	69.23625
13	1050.02	556.85	304.1534	170.6576	98.13894	57.72546
14	1092.52	551.80	287.6947	154.4044	85.09263	48.04954
15	1135.02	545.96	271.7148	139.4877	73.66901	39.93497
16	1177.52	539.44	256.2627	125.8354	63.68958	33.14424
17	1220.02	532.29	241.3745	113.3714	54.99026	27.47241
18	1262.52	524.60	227.0753	102.0181	47.42156	22.74354
19	1305.02	516.44	213.3812	91.69765	40.84825	18.80732
20	1347.52	507.87	200.3003	82.33385	35.14878	15.53585
21	1390.02	498.94	187.8342	73.8527	30.21446	12.82067
22	1432.52	489.71	175.9793	66.18327	25.94856	10.57013
23	1475.02	480.22	164.7275	59.25808	22.26534	8.706981
24	1517.52	470.53	154.0671	53.01347	19.08906	7.166286
25	1560.02	460.68	143.9836	47.38972	16.35306	5.893589
26	1602.52	450.69	134.4602	42.33111	13.99881	4.84332
27	1645.02	440.62	125.4783	37.78588	11.97506	3.977414
28	1687.52	430.48	117.0183	33.70617	10.23703	3.264138
29	1730.02	420.30	109.0594	30.04787	8.745708	2.677076
30	1772.52	410.12	101.5806	26.77047	7.467131	2.194273
31	1815.02	399.96	94.56015	23.83682	6.37181	1.797509
32	1857.52	389.83	87.97668	21.21303	5.434175	1.471679
33	1900.02	379.76	81.80871	18.86816	4.632091	1.204281
34	1942.52	369.77	76.03511	16.77409	3.946418	0.984975
35	1985.02	359.86	70.63516	14.90529	3.360634	0.80522
36	2027.52	350.07	65.58862	13.23863	2.860489	0.657968
37	2070.02	340.39	60.87587	11.75315	2.433708	0.537408
38	2112.52	330.83	56.47793	10.42997	2.069729	0.438753
39	2155.02	321.42	52.37651	9.251998	1.759473	0.358064
40	2197.52	312.15	48.55405	8.203879	1.495144	0.292101
		19021.92	**9061.366**	**5426.22**	**3754.257**	**2838.799**