Investigating the viability of carbon financing for climate smart agriculture for a small holder farming in western Kenya

BY

GEOFFREY ODHIAMBO ONYANGO

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DEPARTMENT OF METEOROLOGY

SCHOOL OF PHYSICAL SCIENCES

UNIVERSITY OF NAIROBI

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Declaration

I declare that the work I am submitting for assessment contains no section copied in whole or in part from any other source unless explicitly identified in quotation marks and with detailed, complete and accurate referencing.

Signature:…………………………………….   Date:……………………….

Geoffrey Odhiambo Onyango
P. O. BOX 2302 – 01000

THIKA, KENYA

This project has been submitted with our approval as University Supervisors;

Signature:……………………………………………   Date: …………………………………………….

Professor Mutua, Francis M.

Department of Meteorology

University of Nairobi

P. O. BOX 30197

Nairobi.

Signature:………………………………………………   Date:………………………………………………..

Dr. Kinama, Josiah M

Department of Plant Science and Crop Protection, Faculty of Agriculture

University of Nairobi

P. O. BOX 30197

Nairobi.

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Last but not least I give Thanks to Almighty God who gave me life and this opportunity to study, providing for all my needs during this period. May your Name be Exalted, Honored and Glorified?

May all of you who supported me be blessed!

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List of acronyms

AFOLU	Agriculture, Forestry and Other Land Use
BND	Boundary planting
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organization
CCAFS	Climate Change Agriculture and Food Security
UNFCCC	United Nation Framework on Convention for Climate Change
LEIT	Low External Input Technology
KFSSG	Kenya Food Security Steering Group
CGIAR	Consultative Group on International Agricultural Research
IFAD	International Fund for Agricultural Development
tCO_2-eq	Tones of carbon dioxide equivalent
tC	Tones of carbon
CO_2	Carbon dioxide
DNA	Designated National Authority
DBH	Diameter at breast height
Ha	hectares
GHG	Green House Gas
CDM	Clean development Mechanism
ICRAF	International Centre for Research in Agriculture and Forestry
M	Meters
AR	Afforestation and Re-affforestation
MICCA	Mitigation for Climate Change in Agriculture
NAMA	National Appropriate Mitigation Action
WDL	Woodlot

Dedication

I dedicate this study to my Mother, Yunia Auma Onyango. She has been the reason I took my Master of science studies. If you want to do something, Do it now! Was my mother's advice as I kept postponing my studies?

Abstract

In the recent past, climate change has been a big problem in the world causing a lot of disaster. The world has adopted a system of reducing the greenhouse gases (GHG) through mitigation aspects and a reward given to those able to reduce their emission below the set caps through a system known as carbon financing.

This study sought to investigate whether Carbon financing through implementation of climate smart agriculture practices would help solve food insecurity challenges in poor and developing countries through adaptation of climate smart agriculture. Climate smart agriculture is an agriculture strategy that helps farmers adapt to climate change and simultaneously reduce greenhouse gas emissions or sequester carbon while sustainably increasing agricultural productivity hence food security. The carbon models to help understand the ex-ante sink from agroforestry system which l determined how much would be paid to the farmers was developed from above and below ground tree biomass from the two agroforestry trees of Causorinas and Gravillea robusta. This two tree species were selected because they were the most popular with the communities. The biomass baseline within the research area was determined from landsat images of the last 15 years which was again affirmed by ground truthing. This baseline carbon was finally deducted from the created sink as the afforestation reafforestation Clean Development mechanism (CDM) methodology requires. Verified carbon standards (VCS) methodologies borrow quite heavily from CDM methodologies reason why you will keep noticing references to CDM. Carbon prices were also determined from the carbon market trends. The net revenue from carbon was determined by multiplying carbon dioxide figures by carbon price less the cost of implementing these activities.

The study showed that around 7000ha of land must be planted with both or either of the agroforestry trees in the same year for the climate smart agriculture to be viable at a carbon price of USD6/TCO2-eq after year 10. This will only be able to meet the cost of implementation but will not include any payment to the farmer. If any payment to the farmers is required then more than 7000ha of land needs to be covered in this programme. The data also showed that carbon finance alone was not enough to make climate smart agriculture sustainable. There will be need for other sources of funding especially climate funds. But since this programme focus on both adaptation and mitigation then there was need to consider both adaptation and mitigation funds to finance this kind of activities.

Chapter 1: Introduction

Climate smart agriculture (CSA) is a farming system that is famously called triple "win" by both the World Bank (WB) and Food and Agriculture Organization (FAO). FAO 2010 has defined CSA as agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes Greenhouse gases (GHGs) (mitigation), and enhances achievement of national food security and development goals. There is growing acknowledgement that agriculture and food systems need to change, regardless of any climate change impacts. However, climate change impacts combined with high population growth rates, unsustainable agricultural practices, and high levels of land-use change, among others require significant changes in farming practices to increase productivity and, at the same time, use natural resources more efficiently and sustainably. Examples of these practices include, shifts to new crops and varieties, water and soil conservation measures and planting trees on farms. While none of these practices are new, the way in which they are framed is evolving. Ideally, agricultural production systems managed in a climate-smart way emit fewer greenhouse gases, sequester carbon, and at the same time become more productive and resilient in the face of a changing climate.

Although adaptation and mitigation have been developed as two distinct responses to climate change, the two are often applied in concert. In fact, agriculture strategies that help farmers adapt to climate change may simultaneously reduce greenhouse gas emissions or sequester carbon. Strategies that achieve both aims, while sustainably increasing agricultural productivity, are the essence of the concept of climate-smart agriculture. These world organizations think that Carbon financing through implementation of this system will help solve food insecurity in poor and developing countries. This study therefore is to look at the possibility of carbon financing making climate smart agriculture (CSA) work for the smallholder farmer in western Kenya and the viable scale.

CSA is now attracting a great deal of interest from policy-makers (as demonstrated by the recent call to action issued by African Agricultural Ministers), major donors, and international research and development agencies (e.g. World Bank, FAO, CGIAR-CCAFS). This is because of the increasing recognition of the substantial synergies between the three themes of CSA which are adaptation, mitigation and agriculture production.

The strong emphasis of some major CSA actors on mitigation (notably the World Bank) has resulted in many civil society actors, and southern governments fearing that CSA will be overly influenced by carbon markets, and therefore rejecting the term CSA. For this reason some civil society and southern governments uses varied terms to mean the same thing, emphasizing that the climate-change mitigation theme of CSA is secondary to the productivity and resilience themes, (i.e. mitigation is a "co-benefit" in United Nation Framework on Convention for Climate Change (UNFCCC) terminology), and, from a small-holder farmer perspective, primarily an opportunity to access carbon finance to support efforts to increase productivity and resilience. Other major agencies such as International Fund for Agriculture Development (IFAD) have also adopted the term Climate Change Smallholder Agriculture (CCSHA) for similar reasons.

Adopting CSA has been necessitated by the fact that area and production under crops has been declining over time as a result developing and poor countries like Kenya have suffered many years of food insecurity relying on food aid (Kenya Food Security Steering Group (KFSSG)-report 2010). Combating food insecurity in Kenya in the context of rapidly growing populations as well as climate change requires not only efforts to arrest and reverse the decline in land productivity but also initiatives to diversify livelihoods. Climate change will have increasingly negative impacts on agricultural activities through fluctuations and in western Kenya regions a permanent reduction – in crop yields. Through their direct dependence on agriculture, small-scale farmers in these regions are hit particularly hard by this development. In this respect, innovations in Agroforestry and agriculture, combined with appropriate business development and/or microfinance services, can also make a major contribution.

1.1. Problem statement

The research problem is to investigate the ability of carbon financing to support CSA work for the smallholder farmer in western Kenya and at viable scale. As food production continues to decline due to land size, increased soil degradation and climate change, the World Bank and other partners like FAO have suggested the use of climate smart agriculture as a possible solution to this problem (Seeberg 2010). The argument here is that farmers implementing CSA technology will be able to benefit from carbon financing to help sustain and incentify them to continue using the said technology.

This study considered the extent to which carbon financing was able to support this initiative, the sustainability and scale to which the CSA was considered viable. A lot of promise has been raised through the availability of carbon financing to an extend where the smallholder farmers perceive the funds as avenue for pulling them out of poverty and hence food insecurity. The southern governments and various international civil organization have embraced it as a possible solution to food insecurity but the question remains, how viable is it and at what scale.

1.2. Justification

Discussion of the constraints to improvement of small-holder agriculture has historically focused mainly on inputs and technology. However the failure of so many efforts in this arena, particularly in Africa, and especially the failure to deliver benefits for poorer farmers in more marginal areas, is leading to a growing realization that there are some serious systemic constraints to progress in this sector, and some strong political agendas around CSA, that must be recognized and addressed if CSA is to succeed (Robbins, 2011). These are best analysed through a political economy lens.

The political economy of climate-smart agriculture is characterised by an international agenda that involves debates at the United Nations Framework Convention on Climate Change (UNFCCC), as well as promotion by large international organizations such as the United Nations Food and Agriculture Organisation (FAO), World Bank, Consultative Group on International Agricultural Research (CGIAR), International Fund for Agricultural Development (IFAD) among others.

Debates on agriculture at the UNFCCC have had little progress in the last several years. Discussions are complicated especially by the divisive issue of carbon markets, as well as disagreements about the relative priority of climate change adaptation or mitigation objectives. Some actors, including many international organizations, tend to argue that increased climate change mitigation, adaptation and food security can be achieved in synergy. According to this account, scaling up adoption of 'sustainable agricultural' practices, including low external input technology (LEIT) such as agroforestry or conservation agriculture, could be the primary means of achieving this CSA synergy.

Agricultural technologies, including LEIT, are not uniformly beneficial, but have varying distributions of costs and benefits depending on context, given the diverse agro-ecological and socio-cultural environments of Sub-Saharan Africa (SSA). For this reason, an institutionalized approach to technology adoption based on ideas of technology transfer has only limited value for small-holders.

It would be more valuable for CSA to feed into the creation of an institutionalized (not minor and project-based) system of support for small-holder agriculture which uses farmer participatory and agro-ecological approaches, so that agricultural technologies could be better tailored to the complex, diverse and risky environments where farming takes place in SSA.

Farmer participatory approaches to agricultural development are not new, however, and some of the reasons why these approaches to small-holder agriculture have not gained more traction include:

- Neglect of the agricultural sector in SSA among governments and development partners in recent decades, and corresponding lack of institutional capacity in many countries.
- Dominant narratives stressing economic growth and the value of a narrow range of technologies associated with the Green Revolution, which has value primarily for more

commercially oriented farmers in more productive regions, leading to the neglect of farming in more 'marginal' areas.
- Lack of effective demand from small-holders for more effective agricultural services, which is linked to small-holders' marginalization and lack of power or voice.

This is not a complete list. Mind-sets, for example, are a key factor – many people do not see beyond ideas associated with technology transfer, and also fail to recognize the value in investing to support small-holder agriculture.

These are some positive ways to address these issues within the context of CSA (Christina and Alashiya, 2012):

- If CSA becomes a prominent issue, then this may help to address the historical neglect of agriculture and help to build relevant institutional capacity.
- CSA's focus on LEIT provides an opportunity to push forward the agenda on small-holder agriculture specifically, stressing the adaptation needs of poorer farmers who are more vulnerable to climate change impacts (to encourage a shift away from institutional pre-occupation with more productive and commercial areas).
- Farmers' organizations, which are not currently prominently represented in the debate on CSA, could be supported (helping create effective demand for agricultural services that meet small-holders' needs).

There is a danger that CSA becomes associated with a linear transfer of technology approach, where agricultural practices are assumed beneficial, adaptation is framed as a technical response to well-defined impacts, and technology adoption is facilitated with problematic examples of carbon trading, paying little heed to the priorities of small-holders.

On the other hand, if CSA is promoted in SSA with more focus on concepts such as 'adaptive capacity' and 'resilience', coupled with prioritization of the most vulnerable, and perhaps integrating some carefully designed mechanisms for carbon finance, then climate-smart agriculture could provide an entry point that assists in the creation and strengthening of institutions that support the welfare of small-holders farmers.

The purpose of this study is to understand whether carbon financing can be able to make climate smart agriculture work for the smallholder farmer or is it shifting the responsibility of mitigation to the poor communities and countries by international policies. Most African countries and some civil society have been against the idea of mitigation in agriculture especially in developing and poor countries calling it unnecessary burden to the poor communities and countries. The reason given is that mitigation shouldn't be the responsibility of these smallholder farmers who are mostly poor and not the major contributors to GHGs why the unnecessarily burden them (Chung and Billingsley, 2012). They are for the idea of adopting adaptation measures without incorporating mitigation in agriculture.

Those in support of the said carbon financing through mitigation reason that this is the only sure way to support the adoption of conservation agriculture (adaptation and mitigation) and agroforestry (mitigation) with the aim of improving crop yields hence food security for this poor smallholder farmers (World Bank, Climate Change Agriculture and Food security Network (CCAF) and FAO (FAO, 2011). This research would like to look at the possibility of carbon finance supporting these activities and whether it's worth pursuing and at what scale will it be viable to implement. The research will also look at the sustainability of financing this kind of projects as being promoted by those in support.

1.3. Objective of the study

The overall objective of this study was to determine whether carbon financing is a viable option for implementing CSA for a smallholder farmer in western Kenya.

1.3.1. Specific objectives

The specific objectives of the study were to;

I. Identify the barriers to implementing CSA and whether carbon financing will be able break those barriers
II. Determine the scale where carbon financing under CSA is viable especially for smallholder farmers.
III. Determine whether Climate funds benefits are able to make CSA sustainable.
IV. Determine whether small scale farmers will be able to get Cash incentives as envisaged by promoters of CSA.

1.4. The research questions

The study will help answer the following questions: –

a. At what scale is carbon financing viable to support CSA especially with smallholder farmer and is it worth the effort?
b. What barriers will the funds help break?

1.5. Hypothesis

It is hypothesized that CSA is only viable at very large scale in a place like Nyando basin with the support of carbon finance.

1.5.1. The project activities

Nyando Basin has had many years of degradation through poor farming practices and deforestation. This study intends to reduce this GHG emission and eventually create a carbon sink as well. Therefore, this study uses;

i. Conservation agriculture which is suppose to reduce emission through reduction minimum soil disturbance and retaining farm residue in the field as opposed to current trend where they are picked up and burned resulting into emission,
ii. Agroforestry systems creates a carbon sink through taking up CO2 in the atmosphere and using it for photosynthesis resulting into storage of those carbon within its systems,
iii. Soil and water conservation methods is a method that reduces soil disturbance hence retaining of soil carbon which could have been lost,
iv. Adoptive crops to cope with the changing climate and improvement of yields in this case crops like trees used CO2 for photosynthesis and finally retaining it acting as a carbon sink. The higher the yield, the more carbon is sank by a crop therefore a higher yielding crop will be better as a carbon sink than a low yielding crop reason for using a higher yielding crop in this case as a way of reducing emission,
v. Managed grazing as opposed to current free range grazing system which has resulted into over grazing in most parts of the basin. Animals have been known to cause soil disturbance especially when it comes to overgrazing. An overgrazed land result into loosening of soils therefore exposing it for erosion resulting into soil carbon lose, and
vi. Planting of fodder crops as a way of creating sink or reducing GHG emission.

Chapter 2: Literature review

Following recent global spikes in food prices and the food crisis of 2008-09, there has been a growing revival of interest and investment in agriculture, nutrition and food security, and rural development. In the past, attention focused more on short-term inputs and productivity increases through innovations in agricultural technology, very often lacking well-thought out scaling up strategies (Robbins, 2011). Fragmentation of international aid and political incentives reinforced this thinking. While scaling up remains the biggest challenge, there is growing evidence on lessons learned and best practices along with harmonization efforts of actors. This renewed interest also coincides with the growth of climate change as an international development theme in its own right. There is a growing consensus that climate change is transforming the context for rural development, changing physical and socio-economic landscapes, increasing variability, uncertainty, vulnerability and the way in which rural communities, especially farmers, interact with the environment to ensure food security and productive livelihoods (Chung and Billingsley, 2012).

2.1 Changes in global agricultural production and food security

Projections based on population growth and food consumption patterns indicate that agricultural production will need to increase by at least 70% to meet demands by 2050 (FAO, 2010). In recent Rio +20 conference discussions, there was a consensus that agricultural production will significantly increase in the Northern hemisphere while being negatively impacted in many countries of the South where most estimates indicate that climate change is likely to reduce agricultural productivity, production stability and incomes in some areas that already have high levels of food insecurity (FAO, 2010). Food production might increase substantially in the global North, but the need for southern regions to develop adaptive measures to continue levels of self-sufficiency and cushion against future risks of food insecurity will remain imperative.

Therefore, the impact of climate change on food systems as a whole is widespread, complex, geographically and temporally variable, and profoundly influenced by pre-existing and emerging social and economic conditions. It is difficult to distinguish climate change from other key drivers of food system change. Impacts of climate change on livelihoods are likely to be just as important, if not more important at least in the short-term, than impacts on total crop production in determining future outcomes for food security. A complex range of factors, including behavioral economics, national aspirations and socio-political goals, governance, civil and political rights and literacy, economic well-being and stability, demographic structure, global interconnectivity, institutional stability and well-being, and natural resource dependence, are all emerging as powerful determinants of vulnerability and the capacity to adapt to climate change. Such determinants permeate through food systems to impact on food security at multiple levels (Kristjanson & Neufeldt, 2011).

This has called for more adverse technology and research to support the adoption of those technologies and one such technology in set up is CSA. CSA has been pioneered in a number of countries to evaluate its workability. A number of research works has been done on this area but focusing on the emissions associated with agriculture, how to reduce those emissions, tools for monitoring and accounting for the emissions, the impact on food security but nothing has been done on the area of variability of the carbon funding to sustainably support this technology.

Henry Neufeldt of ICRAF has done a research on the challenges in making climate-smart agricultural production work for the poor, who will be the most vulnerable to climate impacts. The research offered recommendations on how to overcome constraints, as even small management changes can have significant income and livelihood benefits but nothing to show on how the carbon finance will be viable and at what scale will it work for the small holder farmer (Neufeldt, 2011). The research looked at the contrains in adoption of CSA and suggested recommendations for future improvement in implementation of the technology.

The other area where a lot of research has been carried is how carbon can be sequestered in agriculture and especially how to get organic carbon stored in the soil, where it is expected to remain in the terrestial pool all the year round. This was meant to recommend management practices to build up carbon stocks in the soil and basiccally those that increase the input of organic matter to the soil and/or decrease the rates of soil organic matter decomposition. These practices will generally include a combination of the following: tillage methods and residue/stubble management; soil fertility and nutrient management; erosion control; water management; and crop selection and rotation (Robbins, 2011). This looked at how erosion and soil degradation does affect the soil texture hence carbon loss. If this is reduced then, there is likelihood of controlling carbon loss into the atmosphere and even sink more of it underground.

The other aspect that the Robbin looked at is the Biochar. Although Biochar has raised more questions than answers because of the limited research in its mitigation aspect, it still remains a key activity to consider for mitigation in agriculture. Biochar is concerned with pyrolysis that is to say, the heating of biomass in an environment that is free or nearly free of oxygen. This is the same way charcoal is made and feedstock is whatever biomass is available. The main incentive of biochar systems for mitigation of climate change is to increase the stability of organic matter or biomass. This stability is achieved by the conversion of fresh organic materials, which mineralize comparatively quickly, into biochar, which mineralizes much more slowly. The difference between the mineralization of uncharred and charred material results in a greater amount of carbon storage in soils and a lower amount of carbon dioxide, the major greenhouse gas, in the atmosphere (Robbins, 2011).

The Mitigation of Climate Change in Agriculture (MICCA) Programme builds the knowledge base on climate change mitigation in agriculture by conducting life cycle analyses of agricultural production chains, analyzing global mitigation potentials and costs, and reviewing opportunities and obstacles for mitigation at the farm level. It also supports decision-making by analyzing policy options and farmer decision-making processes, and by supplying information to the UNFCCC negotiations. MICCA also generates reliable data by addressing the large variations and gaps in data related to greenhouse gas emissions from agriculture and forestry and strengthen countries' capacity to carry out their annual greenhouse gas inventories. In addition, the Programme carries out pilot projects to produce quantifiable evidence that climate-smart agriculture practices can mitigate climate change, improve farmer livelihoods and make local communities better able to adapt to climate change. More information is available at and makes local communities better able to adapt to climate change (Christina & Alashiya, 2012).

On the other hand ICRAF and CCAF conclude in their work that Smallholder farmers can contribute significantly to climate change mitigation but will need incentives to adapt their practices. Incentives from selling carbon credits are limited by low returns to farmers, high transaction costs, and the need for farmers to invest in mitigation activities long before they receive payments. Improved food security, economic benefits and adaptation to climate change are more fundamental incentives that should accompany mitigation. Designing agricultural investment and policy to provide up-front finance and longer term rewards for mitigation practices will help reach larger numbers of farmers than specialized mitigation interventions (Wollenberg, et al., 2012). This does not address the fundamental issue of the viability of CSA to generate carbon finance and the scale.

Kenya has responded to major challenges of climate change by becoming a leader in climate change policy development. With three quarters of Kenya's population dependent on agriculture for their livelihoods, it is a country in need of climate-smart agriculture. In addition to increasing average temperatures, Kenyan farmers face more prevalent droughts and floods, crop failures, rising rates of climate-related disease such as malaria, and the conversion of medium and high potential land to arid and semi-arid land (GoK, 2010b). Kenya's National Climate Change Response Strategy (NCCRS) was developed as a framework for integrating climate concerns into development priorities, government planning and budgeting. The NCCRS development process, led by the Ministry of Environment and Mineral Resources (MEMR), ran from May 2009 to April 2010 (GoK, 2010a). Kenya's Agricultural Sector Development Strategy has included climate adaptation as a priority, but the agricultural components of the NCCRS provide more details on prioritized activities. On adaptation, it calls for accelerated investment in weather information systems, research on drought tolerant crop varieties, soil and water conservation, water harvesting, and strengthening integrated pest management systems, among others (GoK, 2010a). Kenya has already established itself as a leader in agricultural mitigation by hosting a variety of innovative land-based carbon projects, including Vi Agroforestry's Agricultural Carbon Project which turns sustainable agricultural practices into carbon credits, as well as biogas development programs. Kenya plans to build on this experience and others in mitigation by prioritizing activities such as proper management of agricultural waste, organic farming, mulching, agroforestry, and selected application of biotechnology (GoK, 2010). Although many adaptation and mitigation activities overlap, actions plans for implementation will be developed separately through the National Adaptation Strategy and the NAMA, respectively. In addition to the NCCRS, Kenya's national policy to support water catchment management approaches, now under development, could help to facilitate the kind of multi-objective landscape-scale planning that could deliver climate-smart agriculture.

In Western Kenya, World Bank together with Swedish non-government organisation Vi Agroforestry is rolling out the first CSA programme of its kind in Africa to encourage smallholder farmers in the country to adopt improved farming techniques and boost productivity in ways that will also see them earn carbon credits. The soil carbon methodology has been approved by the Verified Carbon Standard. It represents a new approach for sustainable agricultural land management (SALM) practices. Kenya is rolling out the first programme of its kind in Africa to encourage smallholder farmers in the country to adopt improved farming techniques and boost productivity in ways that will also see them earn carbon credits. The project focuses on helping farmers adopt practices that increase the amount of carbon in soil and biomass on agricultural lands. As these practices build up the soil's organic matter, they increase resilience to climate change effects and help store more carbon in the soil (Robert, 2011).

In Rift Valley, Nandi County of Kenya, FAO together with ICRAF and ILRI are working on a programme to reducing carbon emission in the area of livestock production through planting of fodder and managing waste to act as both carbon capture and storage. This is another CSA pilot in Kenya with focus on livestock. The two pilot projects have been on the ground for the last 5 years (FAO, 2010).

2.2 Carbon Markets

Under the Kyoto protocol, projects and developing and poor countries were required to sell their emission reductions or storages to the annex 1 countries or developed counties or those unable to reduce emissions to the required level. This kind of market is called compliant carbon markets and because most of the projects were unable to meet the requirement for the compliant market, the market developed another alternative market called voluntary market. In this market, companies and countries buy this carbon as means of social responsibility and the methodologies are relax. The procedure for qualifying for this market and carbon prices discussed below are for voluntary carbon markets.

2.2.1. Carbon Prices.

It is estimated that reforestation of only 1% of eligible tropical land could give rise to $5 billion in carbon credits. Each year US $8 billion worth of carbon (valued at US $5 per ton) is emitted due to deforestation partly caused by poor agricultural practices (Seeberg, 2010). Thus the ability for afforestation/reafforestation (A/R) to contribute to reducing GHG is significant. However, if forests are to be replanted, stabilized, or deforestation avoided, the developers of such mitigating activities will need expertise, capital, and technical support to bring credible mitigating activity to market and to implement them. It is also possible that other ecosystem credits including water quality, biodiversity and poverty reduction can attract additional buyers and higher value for bundled co-benefits (Seeberg, 2010).

The supply of credits from Agriculture Forestry and Other Land Use (AFOLU) mitigation activities will be linked to the availability of funding, standards and technical expertise to developer's mitigating activities. Bringing AFOLU mitigating activities to market is a complex matter. Such mitigating activities have multiple stakeholders and require contributions and coordination across countries, technical skill sets that are not readily available in many developing countries, and a high degree of motivation on the part of local participants.

In-country technical expertise to manage the implementation and monitoring of the mitigating activities requires local level capacity to ensure successful outcomes (Seeberg ,2010).

Often mitigation requires up-front funding to support startup costs for mitigation development and carbon measurement. Having such funding in place early allows for a better chance of mitigating activities success. In addition, it must be established who is the legal owner of the credits, and how the transaction can be structured to ensure that credits are only sold once and that a viable counterparty can sign the emissions reduction purchase agreement with buyers. In many countries, it is unclear as to who owns the carbon credits, whether it is actually the land owner, long term land tenants and/or implementer of the mitigating activities. Thus agreements between potential credit owners need to be put in place to ensure that rights to credits are clear between all parties.

Finally, to ensure that income streams can flow fairly to multiple participants, including local communities, revenue flows need to be accurately predicted and mechanisms put in place to distribute carbon benefits. This means that all financial aspects of the mitigating activities need to be thoroughly planned and monitored effectively, so all costs and revenues can be accounted for and payments made in a timely and routine fashion.

2.2.2 Carbon Markets and Climate Change

There are many ways and efforts underway to reduce carbon emissions and promote activities which help to store and remove carbon. This has made carbon a valuable economic commodity. To find a common unit for this commodity, all GHGs are converted to CO2equivalents (CO2-eq). The CO2-eqs are traded on carbon markets. The markets work in a similar way to financial markets. The currency used on these markets is carbon credits.

Carbon trade in simple terms entails an agreement between a buyer and a seller of carbon credits. Those who reduce emissions or sequester carbon receive payments and those who have to reduce emissions can buy carbon credits to offset their emissions. "

Carbon offsetting" means to compensate emissions which cannot be avoided by paying someone else to save – sequester - GHGs. The prices which are received for one ton of CO2 vary a lot and depend on the type of market and the type of carbon offset project. Over the last few years several financial instruments, mechanisms and markets have emerged during 2012, the prices ranged from $2.5 to $17 per ton of CO2-eq (Michael and Durschinger, 2013).

How is the carbon price determined?

Carbon Units prices are determined through negotiation between buyers and sellers, and based largely on an evaluation of the risk factors involved in a mitigation activity, as well as prevailing market factors. Carbon prices are also affected by the supply and demand balance of the market, and resulting pricing dynamics.

2.2.3. What factors will influence the price of carbon units?

The price reflects market supply and demand dynamics, transaction costs and any other social or environmental benefits that the mitigating activity may deliver. It is important to note that the prices for carbon units are not fixed. The market price which can be obtained for carbon units are determined by the volume of supply and expected demand. Discrepancies in market prices for land use carbon credits are common because they originate from different mitigating types and the motivations of buyer vary widely. Prices vary with respect to the regulatory framework and standards to which they have been submitted, and reflect the relative value and risks they represent to potential buyers. A recent survey of the voluntary market by Ecosystems Marketplace noted the following prices for voluntary market transactions per ton of CO2 based on means of carbon capture and storage:

- A/R plantation/mono crop - $8.20 per ton
- A/R restoration of native species -$ 6.20 per ton
- Avoided deforestation - $4.80 per ton
- Agricultural soil - $3.90 per ton

Buyers often focus on two issues beyond the importance they place on accurate carbon accounting. The first one is permanence. This is based on the notion that the offsets created and sold from a mitigating activity will not be reversed by natural or man-made events that release the project's previously sequestered carbon. The second one is additionality, confirming that the mitigating activity resulted in lower green house gas emissions than what would have occurred under a 'business as usual' scenario. Currently, five categories of buyers exit in the market. These include:

i. Regulatory compliance buyers who need to purchase offsets to meet their regulatory caps;
ii. Companies who purchase credits to meet objectives of environmental responsibility;
iii. Pre-compliance or early action buyers from corporate entities who will eventually have to comply with a standard;
iv. Speculators or investors who want to take advantage of possible future price increases; and
v. Retail buyers who want to take personal action to offset their carbon footprints.

While each of these buyers has different motivations and pricing objectives, they all need to rely on transparent standards for carbon accounting and the ability to understand the risk related to their carbon offsets purchases.

The current carbon prices trends (Marcacci, 2013) are as shown in the figure 1 1 below as per the World Bank records;

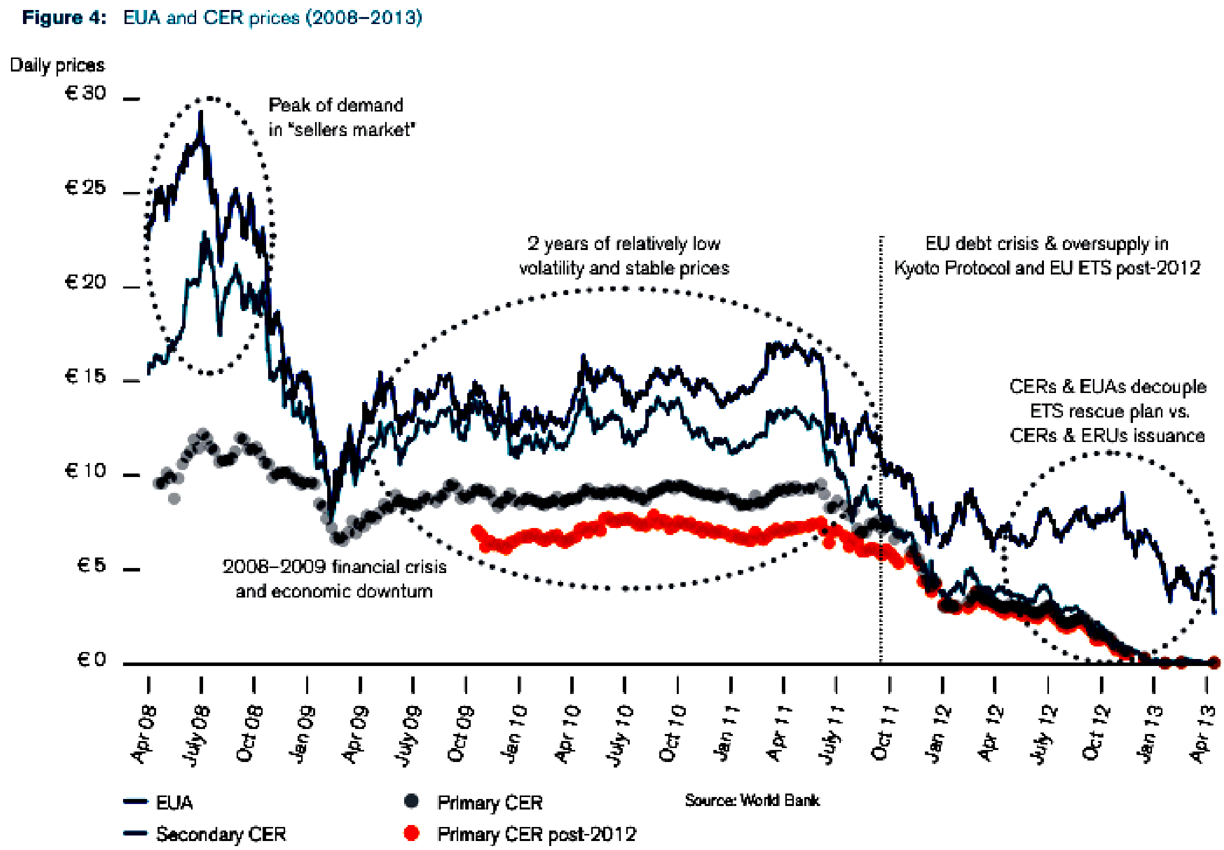

Figure 1 1: Current Carbon Prices (Source: World Bank 2013)

According to the report by the World Bank on the downward trend of the carbon prices, this was necessitated by the economic recession but now factors like the emitters allowed in deciding the price of carbon has also played hand in the suppressed carbon prices. It is common knowledge that once the carbon prices has been left to the market forces then the big buyers, who are also the leading emitters, have been allowed to decide on the prices of their activities. This definitely will work against the carbon prices.

Chapter 3: Material and methods

This study focused on agroforestry system for calculating carbon sink created through the adoption of the CSA activities as outline in section 1.5.1. soil carbon was not part of this study for it was considered to be beyond the scope of the study because it requires a completely different methodology. And even within the agroforestry system, the most common trees promoted within the basin were the ones considered for the carbon storage and that includes casuarinas and Gravellea robusta. Other agroforestry trees like Lusina have been planted as a fodder crop but have become very unpopular because of its invasive nature therefore not considered in the calculation. The carbon calculation has been based on the sink created by the two agroforestry trees mentioned above and basically considering their below and above ground biomass. The crop residues, liters and other agricultural crops were also not considered for this calculation as they are considered under soil carbon calculation which is beyond the scope of this study.

The planting system in use is either boundary planting or woodlots. Boundary planting is the planting of a double line or single line along the farm boundary and the woodlot planting is the planting of trees in a plantation format on a piece of land.

The VCS methodology considered for this study given the project areas as describe below was AR-AMS0007. This methodology needs to be implemented in grassland and cropland as describe in section 3.2.2. sub section 1c and the following definitions apply to cropland and grassland according to the methodology;

> **Cropland.** Arable and tillage land that contains annual and/or perennial crops and/or woody vegetation that does not impair its eligibility for AR CDM project activities.

> **Grassland.** Rangeland/pasture-land subjected to any kind of anthropogenic exploitation that may include systems with woody vegetation that does not impair eligibility of the land for A/R CDM project activities.

3.1 Study area

The study was conducted in the lower and mid Nyando River basin, a land area that encompasses more than 115,000 households. The Nyando River basin is located in western Kenya in parts of Kisumu, Nandi and Kericho Counties, confined within latitudes 0°25’ S and 0°10’N and longitudes 34°50’ E and 35°50’ E (Raburu, Odada and Olago 2006)(Figure 1 2). In recent years this area has been subject to increasing environmental degradation and is affected by droughts and floods that are a function of both the physical characteristics of the area and human influence on the land, both of which are outlined in the following section.

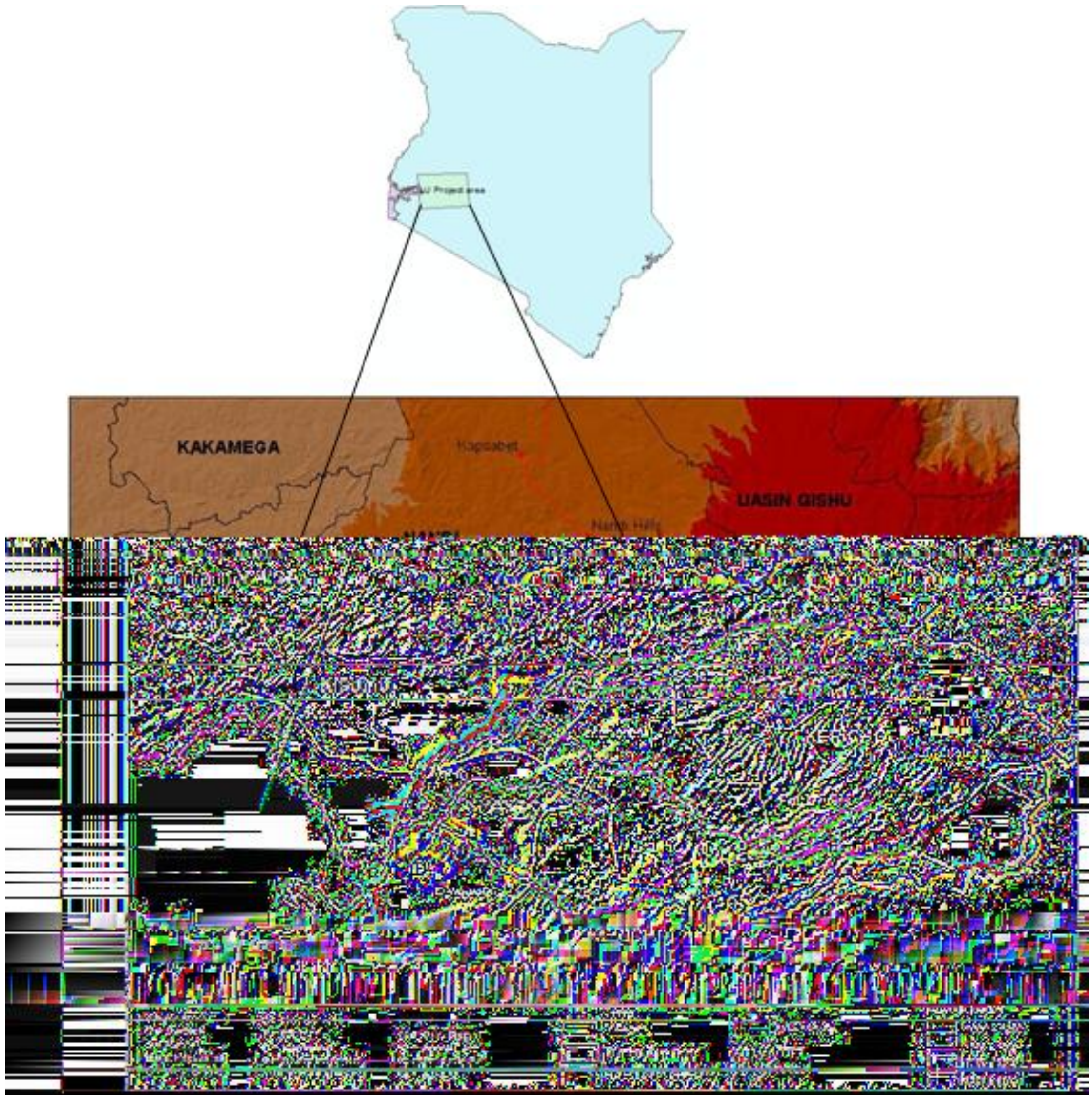

Figure 1 2. The Nyando catchment in relation to Kenya and the surrounding Counties (adapted from Onyango *et a*l, 2005)

3.1.1. Topography and Catchment Description

The research area falls within the Lake Victoria Lowlands and Floodplains Region and is surrounded by Lake Victoria to the west, the Tinderet Hills to the east, the Nandi Escarpment to the north and Kisii Hills to the south. The lowlands are found at an approximate elevation of 1,100 masl and have a relatively flat topography, which gradually grades to steep slopes with an elevation of ~3,000 m in the north-eastern and southern areas that constitute the upper reaches of the Nyando catchment (Sang, 2005).

The Nyando River basin encompasses the Kisumu, Nandi and Kericho counties, and drains into Winam Gulf of Lake Victoria. The basin has a total area of 3,550km and a main river course of 153km (Olang and Furst, 2010). Even though it is an important source of water for the people in the region, the Nyando River frequently floods during periods of heavy seasonal rainfall, causing damage to homesteads and farmlands. Sondu Miriu River is the second largest in the area and a hydroelectric power plant has been constructed on the lower reaches of the river. Aside from the two major arterial rivers, several streams including Awach Kano, Asawo, Nyaidho and Ombeyi also drain from the project area into Lake Victoria.

3.1.2. Climate and Hydrology

The research area has a tropical climate with a bi-modal pattern of rainfall occurring mainly between March – April and October – November. Two dry seasons occur in the intervening periods and hence rainfall is distributed unevenly on an annual scale. Average annual precipitation in the Nyando basin ranges between 900 – 1,600 mm and annual temperatures typically range from 20 - 35°c (Verchot, Straaten and Zomer, 2007). Climate change related modifications to the regional climatic regime have had far reaching effects on agricultural production within the project area. Frequent long dry spells that are characteristic of tropical climates may hinder AR activities and drought conditions are becoming increasingly common (Ongwenyi, 1993).

High rates of human population growth in the region mean that the implications of erratic water flow regimes will be felt by more people. A recent flooding event in 2002 affected 175,000 people and disturbed thousands of hectares of cultivated land in the Nyando basin and surrounding catchments (ICRAF, 2006). The effects of flooding and drought events are exacerbated by improper land use and deforestation, both of which are contributing to the most severe problems of agricultural stagnation and environmental degradation found anywhere in Kenya (Swallow, Onyango and Meinzen-Dick, 2006).

3.1.3. Soils

The study area comprises of soil types ranging from soils with a high content of silt and clay such as *Ferrasols, Nitisols, Cambisols* and *Acricsols,* predominant in the upland areas of the basin to *Luvisol, Vertisol, Planosol, Cambisol* and *Solonetz* soil profiles from Holocene sedimentary deposits in the lower basin (Andriesse and Pouw, 1985). The soils are typically well drained and moderately fertile, which is essential for the sustainability of agricultural practices in the area. Soils in the upper reaches of the project area are relatively shallow and are prone to sheet and rill erosion (Swallow, Onyango and Meinzen-Dick 2006). In the lower reaches of the Nyando basin pedological profiles are comprised of deep, sodic soils which are prone to gully formation (Swallow, Onyango and Meinzen-Dick, 2006). Changes to climate and land use have resulted in increased rates of soil erosion across the project area, with greatest losses recorded in the lower Nyando (Figure 1.2) shows the extent of soil erosionin some location within the lower river basin.

Figure 1 2. Soil erosion documented during field studies in the Lower Nyando

Soil erosion has severe implications for agricultural productivity in the area and the Nyando River Basin is considered to be a soil erosion hotspot, with some of the most severe erosion on the African continent contributing to the widespread degradation of previously productive agricultural land. Loss of land to soil erosion at rates of >40 Mg/ha/yr (Yanda et al., 2001) may hinder the implementation of AR activities, particularly in the more susceptible gully-forming soils of the lower Nyando.

The process of soil erosion has led to the influx of sediment laden water with nutrients such as phosphorus and nitrogen from the project area into Lake Victoria (Ntiba, Kudoja and Mukasa 2001). Nutrient leaching from cultivated soils has led to depletion of soil fertility in the Nyando catchment and subsequent eutrophication in Lake Victoria. Eutrophication has a negative impact on fish stocks for local fisherman as it promotes plant growth in the lake, which in turn removes large volumes of oxygen from the water. This demonstrates the downstream environmental and economic implications of increasing rates of soil erosion in the lower and mid Nyando basin.

3.1.4. Types and Condition of the Vegetation in the Project Area

The agricultural productivity of the research areas has been affected by the land degradation. The land is generally bear after constant clearing of vegetation to give way for settlement, agriculture and to meet the people's energy needs.

Historical Vegetation Distribution

Historically the entire mid Nyando block was covered in equatorial forest. The native forest vegetation consisted of evergreen broadleaf forest, where the most ubiquitous tree species were *Croton megalocarpus, Diospyrus abyssinica, Funtumia latifolia, Olea welwitschii, Dombeya spp* and *Dovyalis abyssinica* (Tobella 2009). At lower altitudes in the lower block (<1400m), forest vegetation graded into perennial grasslands comprised of species such as *Themeda triandra, Hypairhenia hirta, Panicum spp* and*Eragrostis spp.* Grasslands were typically interspersed with evergreen and semi-deciduous bushlands including *Dodonea angustifolia, Carissa edulis, Rhus natalensis, Rhus vulgaris* and *Euclea divinorum* (Tobella, 2009). In the inland valleys of the Nyando basin and at the river mouth, *Cyperus spp.* wetlands and riparian vegetation constituted the main native vegetation communities (Tobella, 2009).

The vegetation distribution described above is representative of conditions in the Nyando basin prior to 1960. Since 1960 large scale land use changes have significantly disturbed the native vegetation communities (Olang and Furst, 2010)(Figure 1.3) and the resultant distribution is a function of several key factors.

1. Post-independence (1963) severe flooding around Lake Victoria created a large resettlement scheme into Tinderet Forest, which now forms part of the research area in mid Nyando. This resulted in the clearance of large forest areas for settlement, after which time the population more or less stabilised. Again the flooded areas were converted to rice paddy scheme.
2. Following the post-election clashes in 1992 squatters arrived in to the area, many of whom resorted to charcoal making which resulted in massive deforestation (Olaka n.d. 2002)
3. In the 1940s, large portion of Tinderet forest were cleared to give way to large scale agriculture production which resulted into the introduction of sugarbelt areas.

Levels of deforestation in the project area have been investigated using increasingly available remotely sensed data, which provides high resolution imagery with extensive spatial and temporal coverage. A study by Ogutu *et al.* (2005) has shown that encroachment on forest reserves and wetlands and transformation of farm lands from perennial to annual cropping systems characterize the major changes in vegetation in the Nyando basin. The details of vegetation changes are as shown in figure 1 3 below.

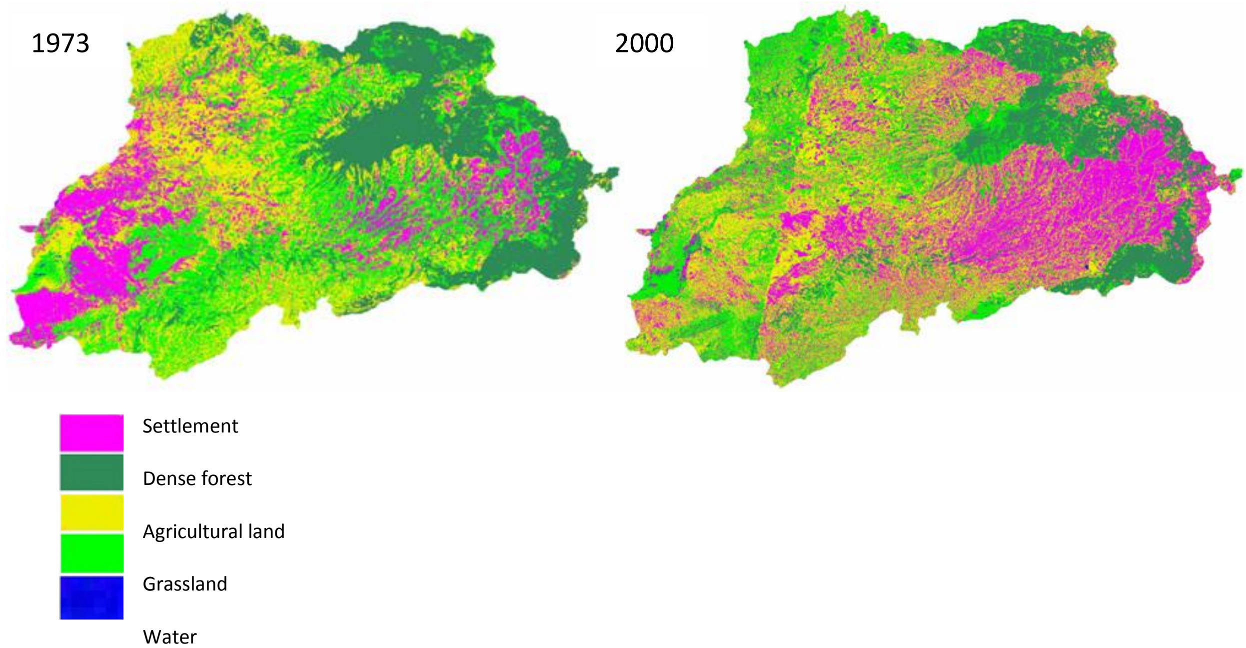

Figure 1 3. Landsat imagery used to show large scale vegetation and land use changes in the Nyando basin between 1973 -2000 (Source: Olaka 2002)

Current Vegetation Distribution

In order to support an increasing population, the mid Nyando basin now comprises significant areas of cultivated arable land used for agricultural production involving both crop cultivation and raising of livestock. Within the cultivated areas a mixed cropping system is used, where cereals (*Zea mais,Sorghum bicolor,* and *Panicum milaiceum*), pulses (*Vigna radiata*) and root vegetables (*Manihot esculenta,Maranta arundinacea,*and *Ipomoea batatas*) are typically grown (Verchot 2007). Dominant agricultural land-uses in lowland areas are maize (*Zea mais*), sorghum (*Sorghum bicolor*), sugarcane (*Saccharum officinarum*), irrigated rice (*Oryza sativa)* and communal pasture. The lower basin is flood-prone and annual flooding near the delta leaves rich alluvial deposits that are cultivated and yield good harvests (Onyango 2005).

There are two remaining forest areas, Tinderet and Mau forests, that are currently being heavily deforested due to charcoal burning and illegal farming. Unsustainable agricultural practices have resulted in widespread areas of fallow and bush land, comprised of sparsely distributed species such as *Dodonea angustifolia, Carissa edulis, Rhus natalensis, Rhus vulgaris* and *Euclea divinorum* (Tobella 2009). An increasing area of land in the project area is unable to support vegetation communities as the previously fertile soil is degraded by erosive forces.

The influx of eroded soil into Lake Victoria has led to the widespread colonisation of *Eichhornia crassipes:* a non-native species of water hyacinth. *Eichhornia crassipes*was introduced to Africa as recently as the 1980s, yet now covers a total lake area of 5,000 ha (Mailu 2000). This invasive water based plant dominates the lower Nyando River, at its point of entry into Lake Victoria in the Winam Gulf. Abundant nutrients derived from agricultural soils and warm water temperatures mean that the plant continues to spread prolifically across the lake, resulting in decreased lacustrine productivity and significantly reduced fish stocks (Mailu 2000).This is compromising the Lake Victoria fishery and eroding a keystone in local livelihoods, as fishing is one of the few sources of income that is not directly linked to agriculture.

Decreasing land productivity has resulted in the adoption of agroforestry by some land owners in the project area. The trees planted in agroforestry initiatives are of multiple purpose and type providing a wide range of benefits including fuel wood production, wind breaks, Timber production, Fruit production, Food production, soil fertility, medicinal product production, Fodder production, Aesthetics and soil conservation.

In the Nyando study area farmers retain a small number of naturally occurring species such as *Terminalia brownii* and *Acacia spp* for agroforestry purposes. However the practice has led to the introduction of exotic species, in favour of native species outlined previously. The most commonly used exotic species are *Grevillea robusta, Casuarina equesetifolia* and *Eucalyptus camaldulensis.* Indigenous species across the designated research area are increasingly being replaced by exotic species on the homestead scale.

3.1.5. Community Description

The study area consist of two communities with varied customs, the Luos and the Kalenjins. The Luos are mainly on the Lower Nyando and parts of mid –Nyando and the Kalenjins occupy the Mid Nyando.

Basic Parameters

The entire study area is densely populated due to numerous resettlement schemes dating back to the 1960's and a growing population. The population changes over time is as shown in figure 1 4 below.

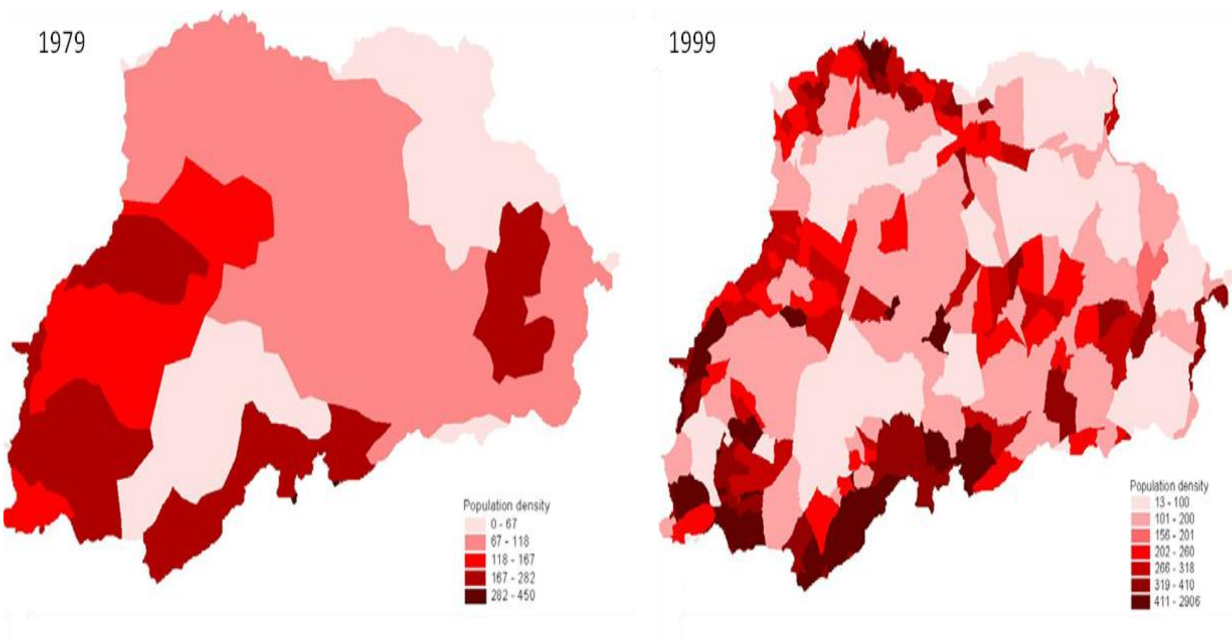

Figure 1 4. Population change in the Nyando basin between 1979 -1999 (Source: Olaka 2002)

The study area contains three constituencies in their entirety; Muhoroni, Nyando and Nyakach with 93,204 households according to the 2009 census (see Table 1). Parts of the Kisumu East, Tinderet and Kipkelion constituencies are also located inside the research area though it is not clear what proportion of the population live within the boundaries of the project area. It is estimated that there are up to 115,000 households living within the project area that may be considered for the research with a total estimated population of more than 500,000 people. This figure includes population from parts of Kisumu East, Tinderet and Kipkelion, although these constituencies are not included in their entirety within the Nyando basin area.

The population of the Nyando basin is mostly young, with 42.7% of the population between the ages of 0-15 years (KIHBS - Basic Report). The population is comprised of 51.3% females and 48.7% males (KIHBS – Basic Report), although high rates of population increase may invalidate these figures, which were collected in 2009.

Table 1: Population Density projections in the Nyando basin by Division

Constituency	**2009**	
	Population	**No. of HH**
Muhoroni	145,764	33,551
Nyando	141,037	30,439
Nyakach	133,041	29,214
Kisumu East	264,227	67,291
Tinderet	199,514	42,860
Kipkelion	206,590	42,310
Total area	**1,090,173**	**245,665**

Source: population censure 2009 (KARI, 2007)

The population in the Nyando Basin is among the poorest in Kenya, 65% of the homes are poor in comparison to 52% for Kenya on average (KARI, 2007). Poverty is less prevalent in the rural areas at 61% compared to urban areas, where it stands at 72% (KARI 2007). Poverty is rife in the project area due to a combination of social, economic and environmental factors, some of which are identified below:

- Degradation of land used for crop cultivation
- Frequency of drought and flood events
- Gender disparity
- Lack of title deeds

- Low literacy rates
- Land conflicts

In addition to the above, Western Kenya is also characterized by high levels of disease and destitution. Recent studies in the area indicate a high prevalence of malaria, HIV/AIDS (29.4% infection rate), tuberculosis and water associated diseases, and limited access to healthcare serves to increase the poverty in the area (FAO 2006).

Basic household parameters used to indicate poverty consistently show that the lower and mid Nyando basin is poor relative to the provincial average (Table 2).

Table 2: A comparison of basic household parameters across different data sets to evaluate the similarity of sample used for analysis.

Basic Indicator	**Lower Nyando**	**Mid Nyando**	**Nyanza province**
Male-headed household (male=1.0)	0.68	0.92	0.60
Hold title to land (yes=1.0)	0.93	0.61	-
Farm size (acres)	2.32	3	-
Household education - None	0.32	0.16	0.18
Household education – primary	0.5	0.59	0.60
Household education – secondary	0.13	0.15	0.19
Household education – post secondary	0.3	0	0.3

The vast majority of stakeholders within the study area belong to one major language and ethnic group: the Luo, who settled in the lower and middle watershed, although there is a significant presence of a second group: the Kalenjin (comprising the Nandi and Kipsigis sub-groups), who live in upstream areas. Resettlement of the large farms in the upper catchment has led to the coexistence of distinct clusters of Kalenjin and people from other ethnic groups. This was one of the factors that contributed to politically motivated "tribal clashes" in 1992, 1994 and 1997 (FAO, 2006).

Both the Luo and the Kalenjin rely on agriculture as a primary source of income. About 60% of the population are employed in agricultural activities, which contribute 52% of household earnings. Despite heavy reliance on agriculture, less than 20% of Kenyan land is suitable for cultivation and of this only 20% is classified as being of high or medium potential. The lack of alternative sources of income has forced communities into poverty and output from the agricultural sector is low due to the poor use of modern agricultural technology, lack of proper storage, erratic and unreliable rainfall, and lack of credit facilities, high costs of seed and other inputs, and poor road networks. In the 2009/2010 drought year farm productivity, decreased by an average of 50% across the lower and mid Nyando basin (Thorlakson, 2011) and agricultural productivity is likely to worsen in light of high levels of land degradation and increasing frequency of floods and droughts across the research area.

3.1.6. Gender Roles

Agricultural and agroforestry activities are typically male-dominated, although women are generally the primary users of timber products in the study area. Households with female heads have lower food security, as they tend to own smaller and less productive farms (Thorlakson, 2011), and gender roles in communities across the study area are such that females do not generally have control over income-generating activities. Previous studies have confirmed strong gender differentiation in household roles across the Nyando basin, with women bearing most responsibility for household water supply (Crow, 2009).

3.1.7. Current Land Use

The main land uses observed within the study area are:

- **Subsistence farming**. Most farmers practice subsistence farming. There are numerous limitations to commercial agriculture, including lack of resources for investment and small land sizes especially in lower Nyando where the population is fairly dense and the average land holding per household is less than 1 hectare.
- **Settlement**. The lower Nyando study area has attracted a lot of settlers especially from the flood prone areas, thereby increasing its population considerably.
- **Grazing.** Livestock is a major asset to the community living in these areas. The number of livestock has continued to grow resulting in overgrazing in most parts of the research area. The typical practice in Lower Nyando is free grazing.
- **Sugarcane.** This is a perennial plant that is harvested up to four times over a 6 year period (Lindell, 2011) and is used in the lower and mid Nyando basin as a cash crop. Sugar cane production is associated with burning of land prior to harvesting which contributes to land degradation in the area.
- **Rice.** Farming of rice has become increasingly common in the lower Nyando catchment, where both the Nyando River and Lake Victoria provide sufficient irrigation for crop cultivation.

3.1.8. Noted Land use change

Remote sensing analyses of the study area indicate that a large proportion of the land is degraded or degrading agricultural land, which historically would have been forested. The result of the large increases in fallow land and grassland combined with the decline in tree cover is increasing competition between land use types; a problem which is further exacerbated by soil infertility that prevents over-cultivation of cropland. The predominant land use changes occurring are:

1. Community bush land is under increasing pressure from grazing by livestock and encroachment for agricultural cultivation, the majority of which appears to be relatively recent. In the past, exploitation of the bush land was intense for firewood, charcoal, construction timber, clearance for settlement and agriculture. This has decreased recently because community bush has become increasingly scarce.
2. Farming. The community has been practising farming without proper technical knowledge. Poor farming practises have resulted in erosion and exhaustion of soils necessitating shifting agriculture. A lot of land has been left fallow and bushland has been cleared to give room for more agricultural land.
3. Settlement. There has been an increase in the number of homes although some extensive bare areas of land still remain and tree cover throughout the region is negligible with the exception of sporadic trees located around homesteads.

3.1.9. History of tree planting

Tree planting activities to date in the study areas have been limited, with a survey conducted in the study area identifying approximately 2,000 farmers to have participated in AR activities. There is however increasing awareness of the need for tree planting after exhausting the trees which were naturally available. Consultation with local communities has revealed that people want to plant trees but have limited knowledge as to the appropriate species to use in planting schemes, and generally have insufficient financial capacity to make such an investment. There is a need for extension services and farmer support to develop tree planting programmes and CSA practices. This study presents an opportunity for financial barriers to be surmounted and carbon finance schemes are likely to result in the widespread adoption of AR activities in the lower and mid Nyando basin, if they prove adequate to meet these needs. The figure 1 6 below gives an indication of the level of degradation and the need for more tree planting as indicated in the various matrix in both uplands and lowlands of the basin. It means that tree planting although possible, is very low due varied reasons ranging from technology, cultural and financial barriers among others.

Figure 1 5. Valid land use covers for tree planting

Bush	**Grassland**
	
Lowland matrix	**Lowland matrix**
	
Upland matrix	**Forest edge**
	

3.1.10. Boundaries of the Project Area

The AR activities to be supported will extend to ~115,000 households over a total research area of 208,185ha within the lower and mid Nyando River basin (Figure 1 6). Agroforestry initiatives will be implemented on the homestead scale, on land which is privately owned. Land adjudication has been completed in the communities and allotment numbers have been issued to individuals. Allotment numbers give tenants the right to a title deed; however farmers do not typically have title deeds because of the high cost of survey of KSH 15,000 per farm (approx. USD, 200) associated with the process.

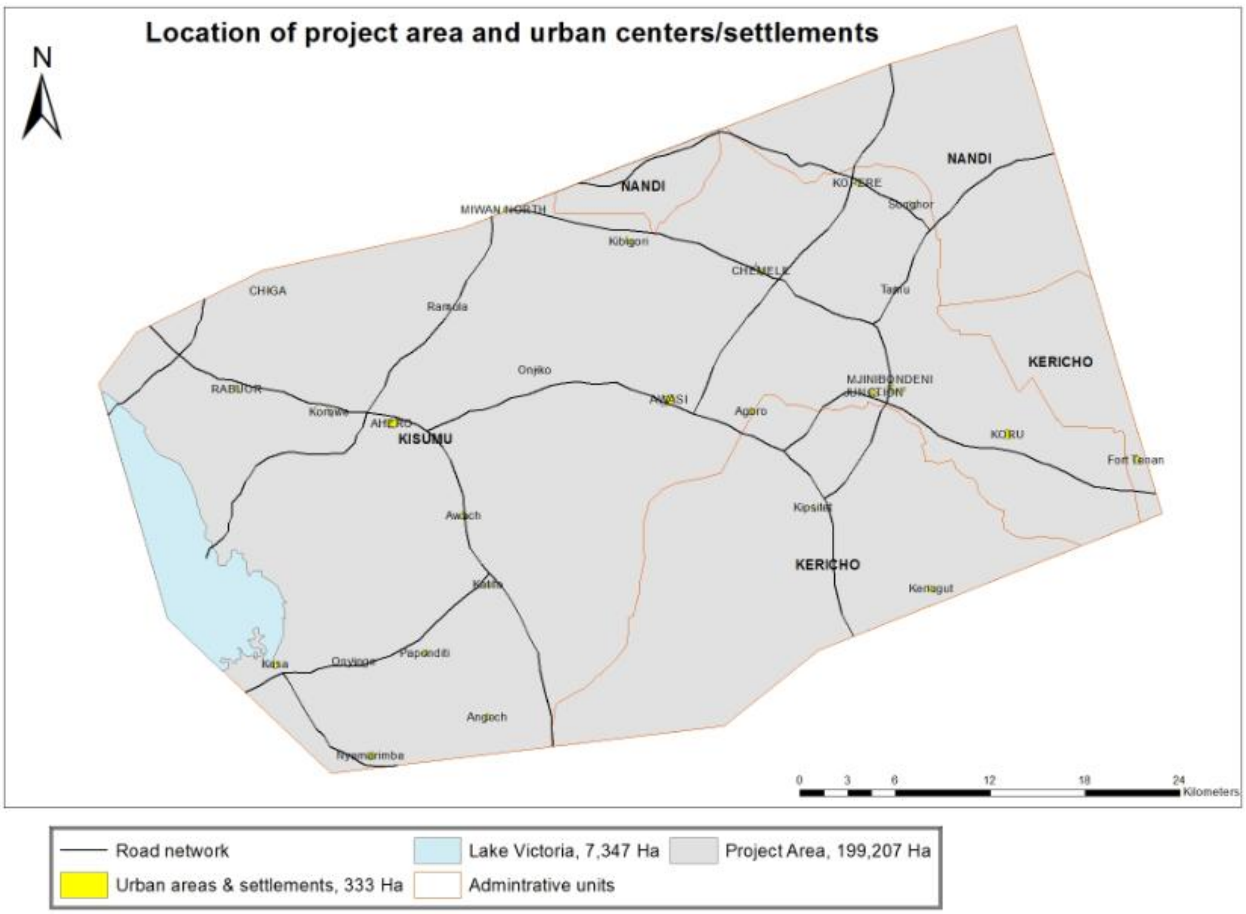

Figure 1 6. Study Area (map adopted from CARE project 2011)

Remote sensing (Landsat at 30m resolution) has been used to produce maps that provide clear differentiation between the eligible and ineligible areas within the project zone. Ineligible areas encompass the following land uses:

- Forest (at any point in time series 2000, 2003, 2006 or 2011)
- Sugar cane production area – referred to as the sugar belt

- Irrigated rice production area – referred to as the rice belt
- Other wetland
- Settlement
- Water
- Other land uses which includes roads, quarries and airstrips

Within the remaining eligible areas AR mitigating activity instances will be made up of many discrete areas of land, each of which will be mapped using GPS and assigned a unique geographical identification. The research intends to build upon existing AR activities in the lower and mid Nyando basin by using carbon finance to extend these activities to other eligible areas within the River basin.

No further geographical sub-division within the research area was required to determine the baseline, for the demonstration of additionality, the non-permanence risk analysis or for the assessment of activity shifting and market leakage. The eligibility criteria for all new instances of mitigating activity are:

- New mitigating activity instances must be located within the research boundaries delineated
- No forest cover between 2000 – present (forest as defined by DNA with more than 30% canopy cover and larger area than 0.25 ha)
- No sugar cane areas are eligible
- No rice growing areas are eligible
- No wetland areas are eligible
- Need to apply same technology i.e. the technical specifications in Annex 1.

A map which delineates the study area and all eligible land areas within the area is displayed figure 1 7 below.

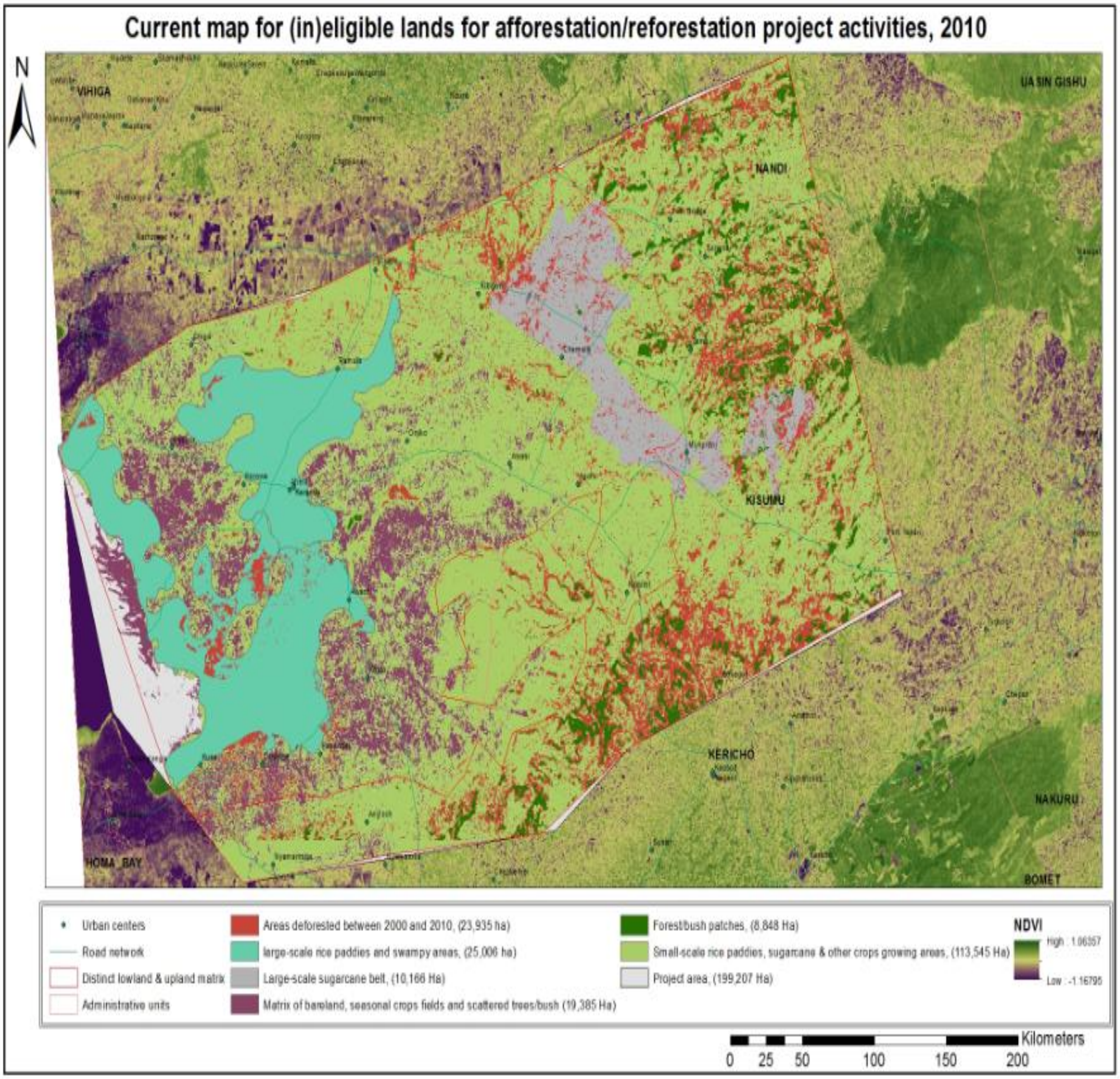

Figure 1 7 Current ineligible and eligible lands for AR project activities, 2010 (Map was adopted from CARE project 2011)

Eligible areas account for 132,629 ha of the project area and ineligible account for 75,556 ha. Of the eligible lands, 58,902 ha are in the upland areas (>1,300m a.s.l) and 73,727 ha are in the lowland areas (<1,300m a.s.l).

3.2. Methodology 1: Additionality

The first step in VCS mitigation projects is to determine whether the study area qualifies as afforestation/reafforestation mitigation areas and its viability. This process is known as additionality testing where the activities are tested whether they have significant carbon storage or avoidance capacity.

3.2.1. Additionality Procedure:

The steps below are keys to proving mitigation additionality for land use activities**.**

Step (i)

This 2 step serves to identify alternative land use scenarios to the proposed VCS AR mitigation activity(s) that could be the baseline scenario, through the following 3 sub-steps:

***Sub-step A**.*

The identified credible land use scenarios for the land within the study areas in the absence of the mitigation activities are:

1. Continuation and escalation (given population increase) of deforestation and degradation of the land as a result of unsustainable harvesting of timber products and overgrazing in line with historical trends.

2. Afforestation / reforestation of the land within the study boundary cannot be performed without registration as a VCS mitigation and support of carbon funds.

3. Significant need for development of alternative livelihood activities and new employment opportunities.

Sub-step A contains more than one land use scenario and therefore the mitigation can be considered additional at this stage.

Sub-step B

The list of plausible alternative land use scenarios to the mitigation activity is in full compliance with mandatory legislation and regulations, taking into account their enforcement across the country. The scenarios are developed as a function of behavioral changes that might take place within the research area that would be in line with Kenyan law.

Sub-step C.

The historical trends regarding land use and land use change in the lower and mid Nyando basin indicate that deforestation and land degradation is the most likely scenario for the land within the research's boundary. There have been small scale AR projects implemented in the research area previously, yet these are limited due to insufficient financial and technological capacity of the local population. Diversification of employment opportunities is not expected in a rural area where agriculture is the primary income source and fishing operations in the lower Nyando are threatened due to depleted fish stocks in Lake Victoria. Statistics show that livestock numbers are decreasing across the research area, due to the need to sell animals during drought and flood events and shifting cultural habits. Finally it is unlikely that pressure will be taken away from existing timber sources, as the local population requires them for wood fuel and charcoal making activities on the homestead scale.

Step (ii)

The second step is to consider how this proposed study activities fit within any of the VCS methodologies. Therefore, this study also tries to look at the potential of carbon dioxide mitigation in a land use activities and VCS has set up methodologies to be used in determining such sink or avoided emission. Therefore, the applicable VCS methodology for this research is AR-AMS0001 v06 'Simplified baseline and monitoring methodologies for small-scale Afforestation/reafforestation Verified carbon standard (AR VCS) study activities implemented on grasslands or croplands with limited displacement of pre-project activities"

This methodology has been selected for the following reasons:

Project activities are implemented on grasslands or croplands;	✓
Mitigating activities are implemented on lands where the area of the cropland within the research boundary displaced due to the mitigating activity is less than 50 per cent of the total research area;	✓
Mitigating activities are implemented on lands where the number of displaced grazing animals is less than 50 per cent of the average grazing capacity[1] of the research area;	✓
Mitigating activities are implemented on lands where ≤ 10% of the total surface research area is disturbed as result of soil preparation for planting.	✓

The estimation of carbon stocks and projection of future changes in carbon stocks are based on the CDM methodology AR-AMS0001 v06. Following this method, estimation of carbon stocks include detailed and statistically determined field sampling and Remote Sensing/GIS-based systems of land-use and management activity data, which will also be integrated for future Monitoring, Reporting and Verification. The basic elements involved can be summarised as:

- Identifying significant land use and/or management activities
- Identifying significant land use categories
- Identifying significant carbon pools
- Identifying significant CO_2 emissions or removals by sinks from various carbon pools
- Identifying significant non-CO_2 (if any) gases and from what categories.

3.3 Methodology 2

3.3.1. Stratification and baseline

To determine the mitigation capacity of the CSA in the research area, the first step involved undertaking a baseline survey. The research area comprised of heterogeneous land uses and hence stratification was carried out to improve the accuracy and the precision of biomass estimates. Different stratifications are required for the baseline and project scenarios in order to achieve optimal accuracy of the estimates of net GHG removal by sinks. The procedure involved is described on the following 5 stages:

Sub-step 1: Assess the Key Factors

The key factors that influence carbon stocks in the above- and below-ground tree biomass pools within the project zone were identified as soil features, local climate, landform, forest type, dominant tree species and mitigation actions.

Sub-step 2: Collect Maps of Key Factors

The map below demonstrates how indigenous forest resources are subject to degradation, in a continual shift of land use to low yielding agricultural land (Figure 1 8).

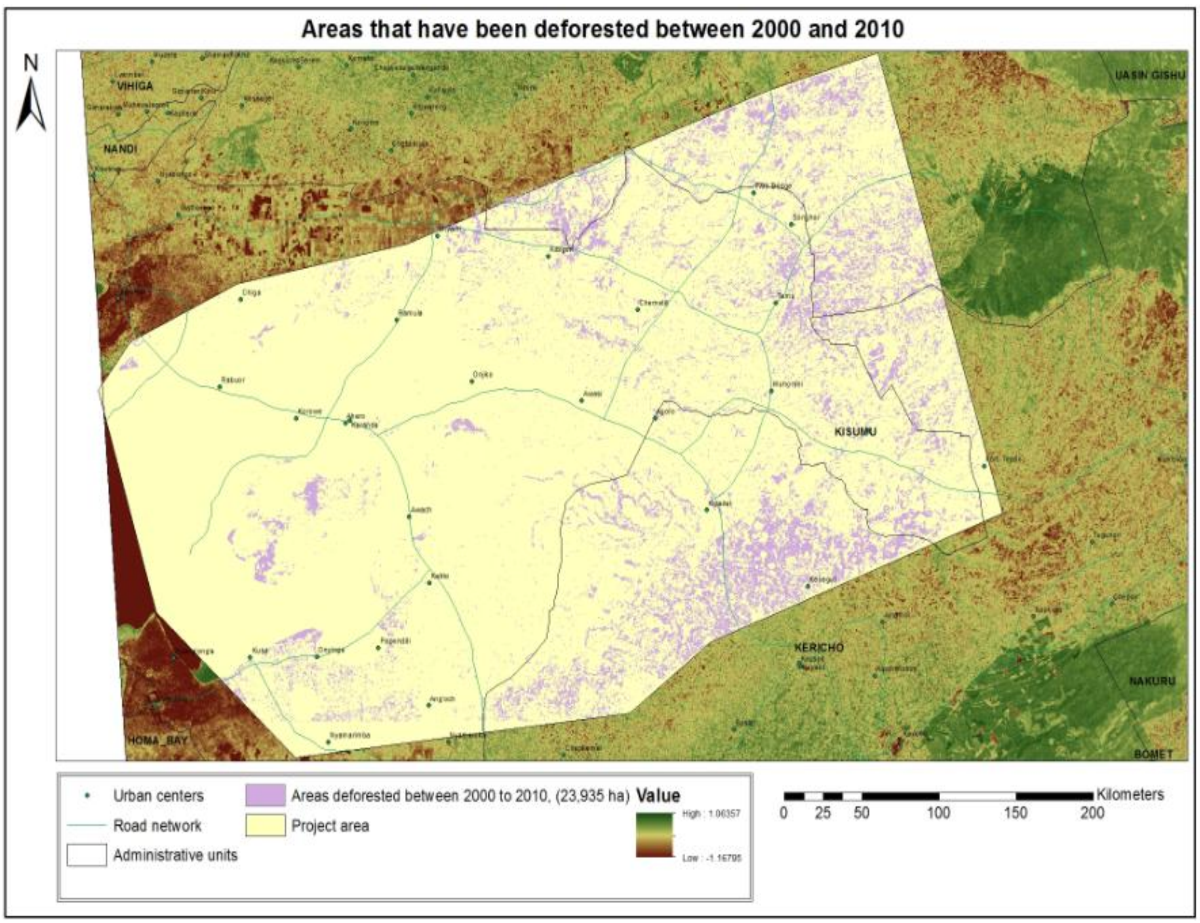

Figure 1 8. Conversion of forested areas to other land uses from 2000 -2010

Sub-step 3: Preliminary Stratification

Stratification is important to ensure accuracy and precision of data collected. Stratification involves dividing the study area into sub-populations (strata) that form relatively homogeneous units. Stratification is based on satellite imagery, aerial photographs and maps of vegetation, soils and/or topography. The results of remote sensing were validated through ground truthing by field survey. The initial unsupervised land cover classification, which was based upon field observation, identified the strata as shown in Table 3

Table 3: Land use stratification (2011)	
Land use classification and description	Eligible / ineligible
Forest (at any point in time series 2000, 2003, 2006 or 2010)	Ineligible
Sugar cane production area	Ineligible
Irrigated rice production area	Ineligible
Other wetland	Ineligible
Lowland matrix of cultivated trees combined with other sporadic on farm vegetation	Eligible
Upland matrix of cultivated trees combined with other sporadic on farm vegetation	Eligible
Bush	Eligible
Grassland	Eligible
Barren	Eligible
Settlement	Ineligible
Water	Ineligible
Settlements	Ineligible
Other land uses including roads, quarries, airstrips	Ineligible

Sub-step 4: Field Survey

The field survey was undertaken in two phases during the baseline determination in 2011. During the first phase upland and lowland agricultural strata were further divided for greater accuracy in estimation of baseline carbon stocks (Table 4)

Table 4: Land use stratification

Preliminary land use classification and description (1)	Preliminary land use classification and description (2)	Eligibility
Forest (at any point in time series 2000, 2003, 2006 or 2010)	Unchanged	Ineligible
Sugar cane production area	Unchanged	Ineligible
Irrigated rice production area	Unchanged	Ineligible
Other wetland	Unchanged	Ineligible
Lowland matrix of cultivated trees combined with other sporadic on farm vegetation	Ag10	Eligible
	Ag20	Eligible
	Ag60	Eligible
Upland matrix of cultivated trees combined with other sporadic on farm vegetation	Ag10	Eligible
	Ag20	Eligible
	Ag60	Eligible
Bush	Unchanged	Eligible
Grassland	Unchanged	Eligible
Barren	Unchanged	Eligible
Settlement	Unchanged	Ineligible
Water	Unchanged	Ineligible
Settlements	Unchanged	Ineligible
Other land uses including roads, quarries, airstrips	Unchanged	Ineligible

Biomass data from a minimum of six randomly located 0.1 hectare sample plots in each of the eligible land use strata was collected. After analysis of the data from the preliminary sampling, it was established that the baseline carbon stocks for all of the 44 plots sampled was less than four tons of carbon dioxide per hectare with a standard deviation of 2.64 tCO_2e. Baseline carbon stocks in the different strata sampled were shown to be low (<4tCO_2/ha) with relatively low variation between samples. It therefore made sense to merge all the initial strata into one single matrix to cover all of the upland and lowland all of the eligible project area. The Winrock sample calculation tool (2007) was used to calculate that 225 additional 0.1 hectare sample plots were required located based on a matrix across all the eligible project areas in order to achieve a precision level of 10% and a confidence level of 95% of baseline carbon stocks within the eligible project areas. A single baseline carbon value will therefore apply to all new mitigation activity instances within the study area delineated within this document.

Sub-step 5: Final Stratification

The final stratification merged all the agricultural strata (excluding rice and sugarcane) together with the grassland, barren and bush strata to form a single baseline stratum which is eligible for new mitigation activity instances within the study area (see Flow Chart 1) in both lowland and upland areas. This baseline stratification is in line with the methodology applicability conditions, namely those mitigation activities are implemented on grasslands or croplands.

These definitions of cropland and grassland are assumed to be the same for all the study areas.

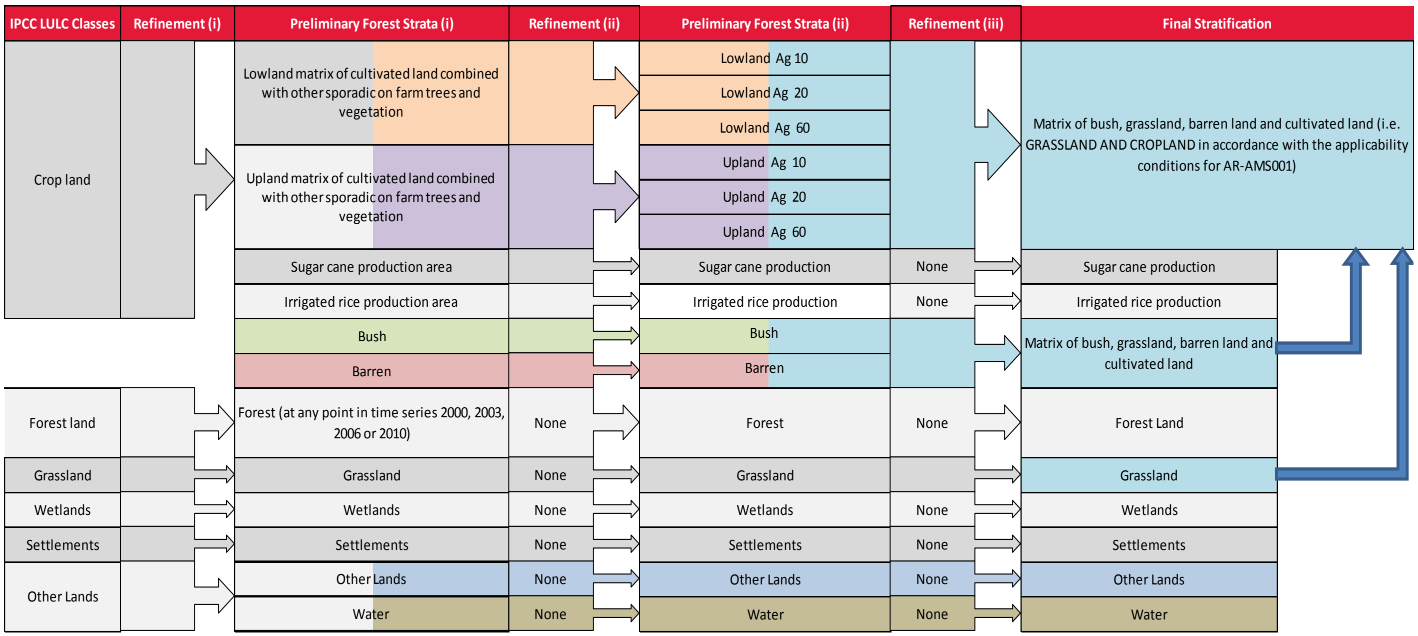

Figure 1 9. Stratification process

3.4. Methodology 3–Determination of Baseline Carbon Stocks

The CDM Tool 10 "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in AR CDM project activities" has been used to measure the baseline carbon in the study area.

3.4.1. Sampling Methodology

To determine the carbon stock in the area prior study, 225 sample plots were analysed. Vegetation in these plots was measured for the following parameters:

- Diameter of tree at breast height (cm)
- Height (m)
- Stem volume (m^3)
- Dry wood density (tons/m^3)

These data were used in a number of equations in section 3.5, using carbon content variables and conversion factors, to determine the following outputs:

- Stem dry biomass (tons/stem)
- Total dry biomass (tons/stem)
- Carbon/tree (tC/tree)
- Carbon density (tC/ha)

These outputs are necessary to determine the total baseline carbon stock and this was measured for each land type identified in the stratification process.

3.4.2. Above Ground tree Biomass Measurements

Stem volume is a critical parameter required for equation 4. There is no information concerning the growth characteristics of the trees to be planted through the study area. The study enumerators therefore collected data on tree growth rates from within the study area in order to determine stem volume (SV). The following methods were used to determine the SV potential of the tree species recommended in the 2 different planting systems at different points in time:

a. Field data collection

i. Tree selection

Trees of different ages and sizes throughout the range of interest (1-50 years old) were selected from the locality of the study area. Selected trees must be of a known age. Tree age was established through face to face discussion with the farmer. Ideally, a minimum of 10 trees in each age class (i.e. 1 – 10years, 11 – 20 years, etc.) should be measured for each species. If there is a lot of variation among individual trees, larger sample sizes may be necessary.

ii. Measurement

A separate data sheet was used for each farm visited. For each farm visited the following data were obtained:

- Location of measurement;
- Geographical coordinates of the site
- Elevation in m.a.s.l.;
- Soil type.

For each tree species, the parameters were determined and recorded in a datasheet as in annex 3

- The species;
- The diameter of the stem 1.3 m above ground level (a stick marked at 1.3 m can be useful for determining the correct height to make the measurements). Be aware of the correct way to measure trees with non-standard stems (see Figure 1 10 on page 43). Record the value in cm to one decimal place (i.e. 10.2 cm);
- The height of the tree, measured directly for smaller trees, or with a clinometer for larger trees. Record the value in m to one decimal place (i.e. 3.4 m);
- crown position (1-5; see Figure 1 11 on page 44);
- crown form (1-5; see Figure 1 12 on page 45);
- whether the tree is planted or grew naturally;
- age of the tree; and
- Any signs or details of management (e.g. coppicing or pruning).

An example datasheet for recording these measurements is provided as an Annex 3.

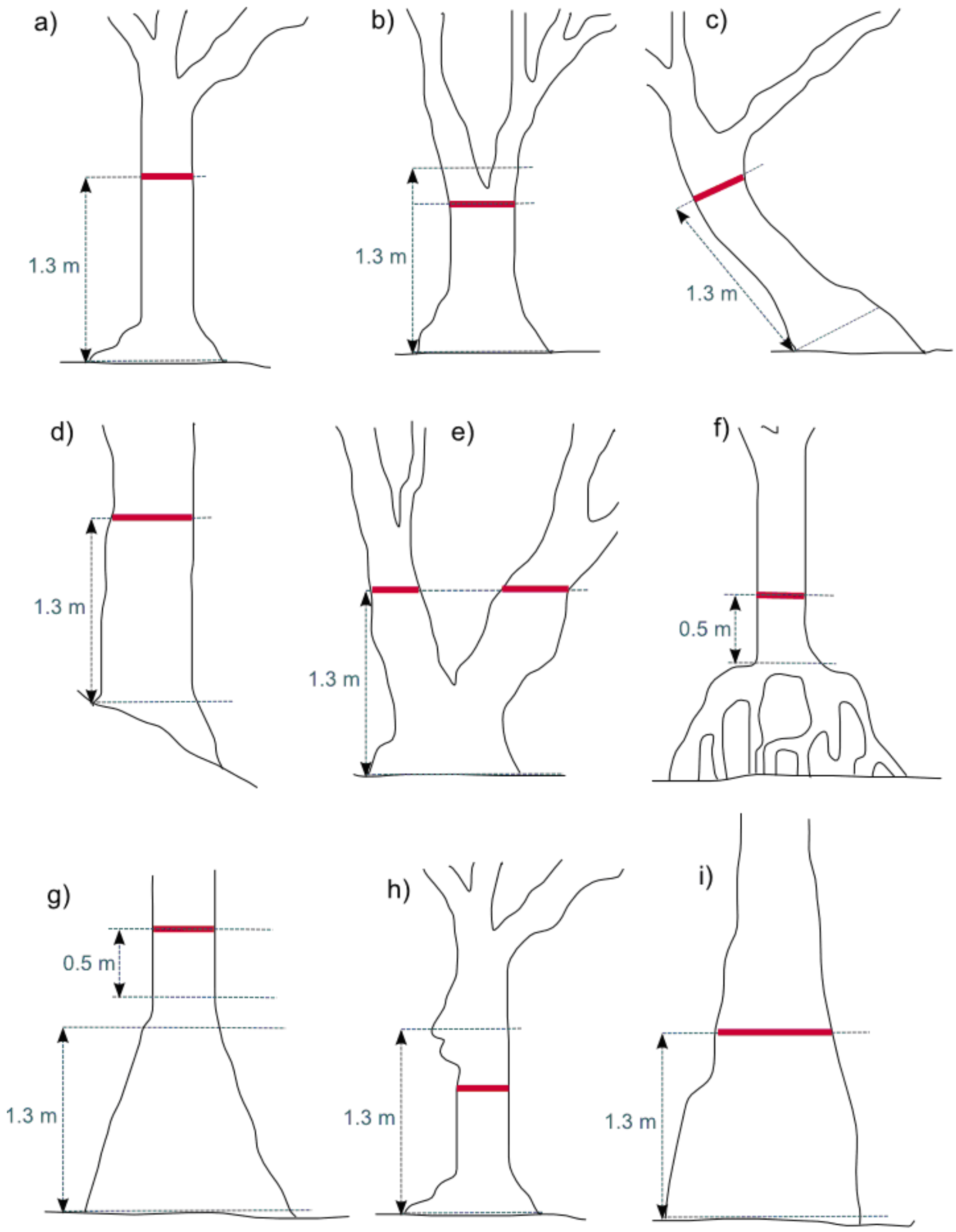

Figure 1 10. Height of measurement of stem diameter by stem type:

a) Whenever possible record DBH at 1.3 m height

b) If the tree is forked at or below 1.3 m, measure just below the fork point;

c) If the tree is leaning, make sure the tape measure is wrapped around the tree according the tree's natural angle (instead of parallel to the ground);

d) If the tree is on a slope measure record measure 1.3 m on the uphill side;

e) If it is not possible to measure below the fork point, measure as two trees;

f) If the tree has stilt roots, measure 50 cm above the highest stilt root;

g) If the tree is buttressed at 1.3 m, measure 50 cm above the top of the buttress;

h) If the tree is deformed at 1.3 m, measure 2 cm below the deformity;

i) If the tree is fluted for its entire height, measure at 1.3 m If the tree has fallen but is still alive (if there are green leaves present) measure the DBH as if it was standing). Pass the tape under any vines or roots on the stem.

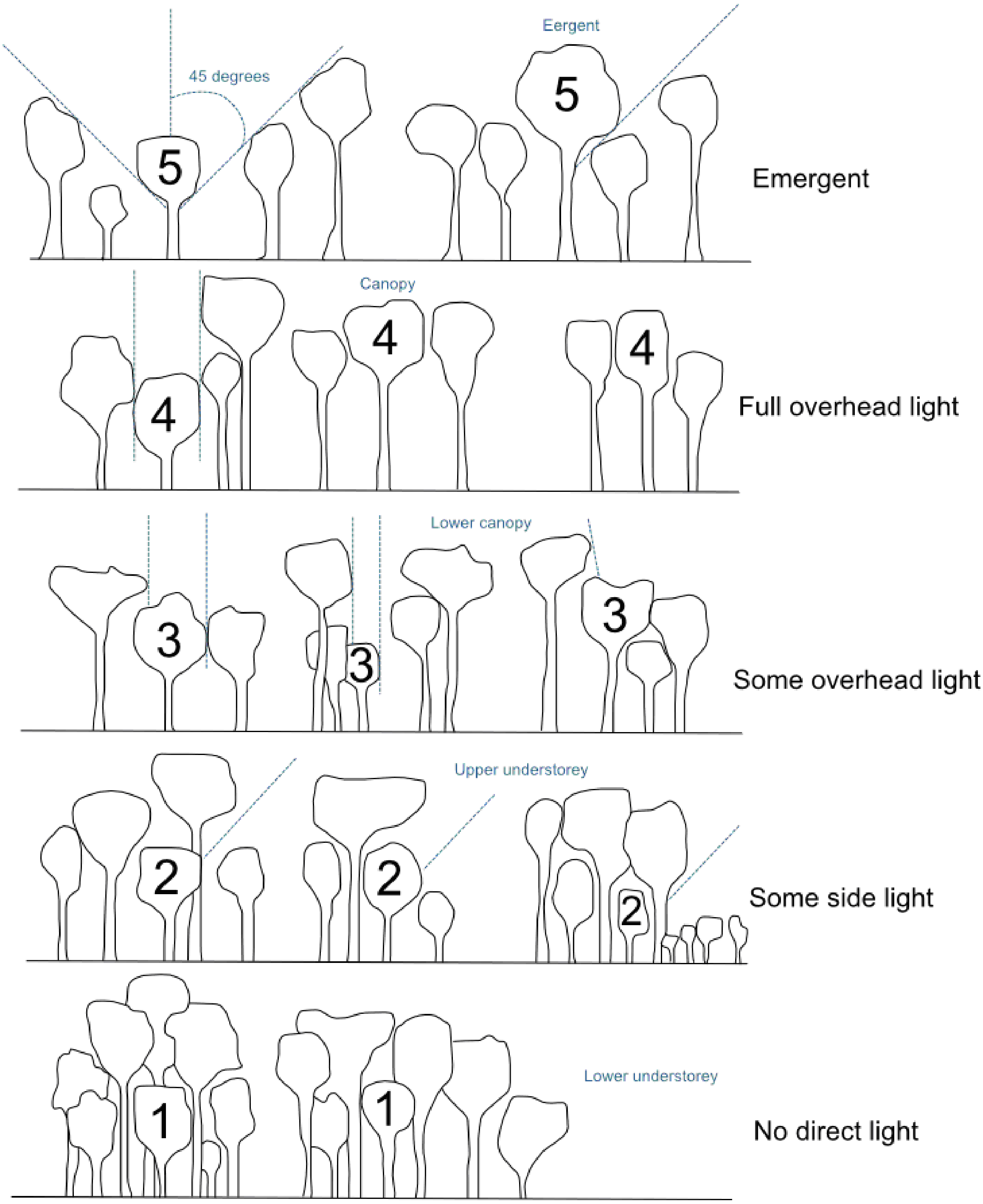

Figure 1 11: Crown position index (CPI; trees are classified on a scale from 1 to 5 depending on light received by the crown of the tree.

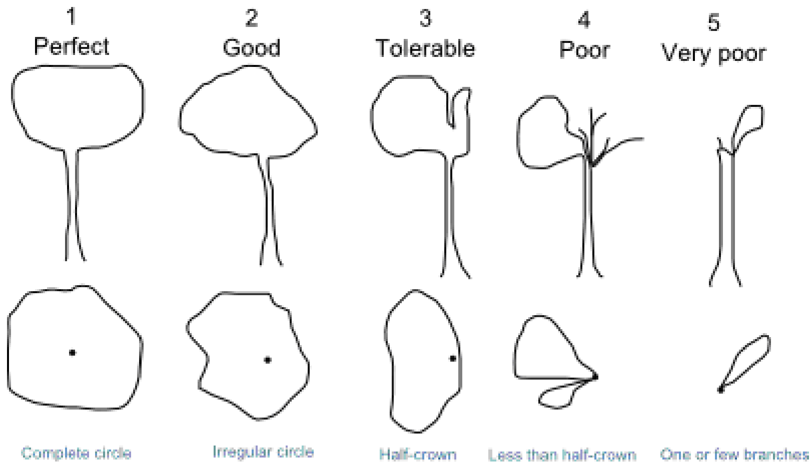

Figure 1 12: Crown form index (CFI); trees are classified on a scale from 1 to 5 depending on the condition of the crown.

The actual number of tree measured within each age class is shown in Tables 5 and 6. Where the minimum target of 10 trees has not been achieved this is due to the non-availability of suitable trees to measure within the research area.

Table 5: Trees and Minimum number of trees measured in lowland areas

Tree species	1 – 10 years	10 – 20 years	20 – 30 years	>30 years
Casuarina equisetifolia	24	7	10	
Grevillea robusta	23	18	4	12

Table 6: Trees and minimum number of trees measured in highland areas

Tree species	1 – 10 years	10 – 20 years	20 – 30 years	>30 years
Casuarina equisetifolia	24	10	10	12
Grevillea robusta	26	19	8	4

3.5. Methodology 4: Carbon sink/removal calculation

This methodology gives the possible amount of carbon dioxide equivalent removed from the atmosphere or avoided through the proposed CSA activities.

3.5.1. Carbon Stock Changes (projection)

This projection will help determine the future carbon sink or avoided emission created through this mitigation activities

3.5.1.1. Research Emissions

Study emissions are considered insignificant and therefore neglected.

3.5.1.2. Ex ante actual net GHG removal by sinks

Ex ante actual net GHG removal by sinks was estimated in accordance with the methods presented in CDM AR-AMS0001 using equations 1, 2, 3, 4, 5, 6 and 7 below.

The carbon stocks for the mitigation scenario at the starting date of the mitigating activity (Olang and Furst 2010) (*t*=0) was considered to be the same as the baseline stocks of carbon at the starting date of the study (*t*=0). Hence:

$N_{(t=0)} = B_{(t=0)}$ ....(1)

For all other years, the carbon stocks within the study boundary ($N_{(t)}$) at time *t* shall be calculated using equation 2:

$N_{(t)} = \sum_{i=1} (N_{A(t)\,i} + N_{B(t)\,i}) * A_i$ ....(2)

where:

$N_{(t)}$ Total carbon stocks in tree biomass at time t under the mitigation scenario (t C)

$N_{A(t)\,i}$ Carbon stocks in above-ground tree biomass at time t of stratum *i* under the mitigation scenario (t C/ha)

$N_{B(t)\,i}$ Carbon stocks in below-ground tree biomass at time t of stratum i under the project scenario (t C/ha)

A_i Study area of stratum *i* (ha)

i Stratum *i* (I = total number of strata)

3.5.1.3. Determination of Above-ground tree biomass

For Above-ground tree biomass $N_{A(t)\,i}$ was calculated per stratum *i* using equation 3:

$N_{A(t)\,i} = T_{(t)i} * 0.5$ ………………………………………………………….(3)

where:

$N_{A(t)\,i}$ Carbon stocks in above-ground tree biomass at time t under the mitigation scenario (t C/ha)

$T_{(t)i}$ Above-ground tree biomass at time t under the mitigation scenario (t d.m./ha)

0.5 Carbon fraction of dry matter (t C/t d.m.)

1. If biomass tables or equations are available then these were used to estimate $T_{(t)i}$ per stratum *i.* If volume table or equations are used then:

$T_{(t)i} = SV_{(t)i} * BEF * WD$ ....(4)

where:

$T_{(t)i}$ Above-ground tree biomass at time *t* under the mitigation scenario (t d.m./ha)

$SV_{(t)i}$ Stem volume at time t for the mitigation scenario (m^3/ha)

BEF Biomass expansion factor (over bark) from stem to total above-ground biomass (dimensionless)

WD Basic wood density (t d.m./m^3)

Values for $SV_{(t)i}$ were obtained from national sources (based on field data collection from within the project). Values for *BEF* were obtained from table 3A.1.10 of the IPCC good practice guidance for LULUCF. Values for wood density have been obtained from Table 3A.1.9 of the *IPCC good practice guidance* for LULUCF.

3.5.1.4. Determination of Below-ground Tree biomass

For below-ground tree biomass, $N_{B(t)}$ was calculated per stratum *i* using equestion 5:

$N_{B(t)\,i} = T_{(t)} * R * 0.5$..(5)

where:

$N_{B(t)\,i}$ Carbon stocks in below-ground tree biomass at time t under the mitigation scenario (t C/ha)

$T_{(t)}$ Above-ground biomass at time *t* under the mitigation scenario (t d.m./ha)

R Root to shoot ratio (t d.m./ t d.m.)

0.5 Carbon fraction of dry matter (t C/t d.m.)

The removal component of actual net GHG removals by sinks was calculated using equestion 6:

$\Delta C_{PROJ,t} = (N_t - N_{t-1})*(44/12)/Dt$……………………………………………………………(6)

where:

$\Delta C_{PROJ,t}$	Removal component of actual net GHG removals by sinks per annum (t CO_2-e/year)
$N_{(t)}$	Total carbon stocks in biomass at time *t* under the mitigation scenario (t C)
Dt	Time increment = 1 (year)

2. Study emissions were considered insignificant if:

$GHG_{PROJ,t} = 0$

where:

$GHG_{PROJ,t}$	Study emissions (t CO_2-e/year)

The net anthropogenic GHG removals by sinks for each year during the first crediting period were calculated using equation 7,

$ER_{AR\ CDM,t} = \Delta C_{PROJ,t} - \Delta C_{BSL,t} - GHG_{PROJ,t} - L_t$…………………………………………………………(7)

where:

$ER_{AR\ CDM,t}$	Net anthropogenic GHG removals by sinks (t CO_2-e/year)
$\Delta C_{PROJ,t}$	Project GHG removals by sinks at time t (t CO_2-e/year)
$\Delta C_{BSL,t}$	Baseline net GHG removals by sinks (t CO_2-e/year)
$GHG_{PROJ,t}$	Study emissions (t CO_2-e/year)
L_t	Leakage attributable to the project activity at time t (t CO_2-e / year)

To improve the accuracy of the estimation of carbon sinks, the study area was stratified into Upland (between 1300 and 1800m above sea level) and Lowland (between 1120 m and 1300 m above sea level) zones, and carbon models developed for each technical specification (i.e. planting plan) based on the tree species proposed for each specification. The results of GHG removals by sinks are therefore presented for each of the four strata. The strata are listed in Table 7.

Table 7: Study planting plan stratification		
	Region within the basin	Planting regime
1	Lowland	Woodlot
2		Boundary planting
3	uplands	Woodlot
4		Boundary planting

3.6. Methodology 5: Social Survey

3.6.1. Social economic survey

The social assessment was carried out in 2011 during the field data collection in four villages which were chosen by my study team which included me and enumerators. I was the lead team leader supported by 4 other enumerators. The enumerators are people who have either worked in the area for a long time or residence within the community. The enumerators help in selection of the villages. The villages' criteria for selection was based on at least 2 villages each from lower and Mid Nyando basin, the villages must have been involved previously in tree planting or conservation agriculture practices and atleast one which has never been involved in any of the activities. All the 4 villages must not neighbor each other. This was meant to give a picture of barriers to adoption of the study activities and which the climate funds are meant to break. Eventually, Kamula and Kawiti Villages in Nyakach, Lower Nyando Basin and Murram and Kagai Villages In Muhoroni and Fort Ternan respectively in mid Nyando basin were selected. The program of activities during the survey is as shown in annex 1.

After the villages' selection, a day was spending with each of the villages which started with a reconnaissance survey. During these sessions, the objectives were introduced to the community, the process of the assessment outlined and the community members to participate in the focused group discussions elected.

The following participatory tools were used to collect data during the focused group discussions in each of the villages

i. Access and control profile. Each village was to give natural resources level of access and control per gender especially to do with land, agricultural products and trees. Is it a barrier to adopting the study activities?
ii. Benefit Analysis. The villages here were required to give details of benefits sharing of natural resources per gender.

iii. Constraints and opportunities. What could be the possible constrains and what could be possible opportunities in adopting the study activities. How the constrains could be overcome and how can the opportunities be used in helping the adoption of study activities.
iv. Economic, Social and Cultural Impact tool. The villages were required to give a picture on how economic, social and cultural status of individuals' impact on the study activities adoption.
v. Trend lines on land use. The villages were to give trend lines in the recent past of land use and land use changes

All participating villages were encouraged to speak freely by asking individuals questions directly and their suggestions sort.

3.6.2. Focus Group Discussions

Focus group discussions serve as fora for addressing a particular issue and provide an opportunity for cross-checking information concerning the issue at hand as a cross section of the group are well represented. In the selection of the focus groups, care was taken to that the people involved had similar general characteristics and concerns in order to improve the outcome of the exercise. The discussions were guided by a series of questions prepared in advance to address areas of concern. Responses given by the participants are indicated in annex 1. During each of the 4 FGD, one of the enumerators was tasked with taking notes (this role was rotational in all the 4 FGD among the 4 enumerators) and I was leading in the discussions. The FGD was basically a question and answer kind of model. The focus groups in each village comprised of, 5 men, 5 women, 8 youth 4 girls and 4 boys and 2 disabled persons.

Chapter 4: Results and discussion

The result and discussions have been grouped into four titles as below;

4.1. The scale where carbon financing under CSA is viable especially for smallholder farmers

This was done by first proving the study activities' additionality and then calculating the possible ex-ante carbon sink expected to be created which finally gave us the expected revenues. These revenues were then compared with cost to determine the point where cost and revenue cancel each other. This point is considered the viability point.

4.1.1. Additionality

The study found out that the most likely land use in the lower and mid Nyando basin is a continuation of pre-study activities, involving overgrazing and unsustainable harvesting of timber products primarily for use as wood fuel, which will result in on-going deforestation and widespread land degradation. This is a sign of declining carbon baseline in the study site. Continuation of pre-study activities will exacerbate environmental issues of soil erosion and eutrophication of aquatic ecosystems. Population increases combined with a lack of alternative livelihood opportunities, decreasing timber resources in the project zone and insufficient capacity to protect the remaining vegetation resources clearly provide evidence that the pre-research condition, characterized by escalating use and resource extraction, is the most likely future land use.

Figure 1 8 on page 34 demonstrates that although most of the deforestation in the study area took place prior to the 1980s, there is still pressure on timber resources in the area. Deforestation and degradation are still taking place and this is supporting evidence of the unsustainable nature of the pre-study activities.

The drivers of GHG emissions, namely overgrazing, burning of crop land, inefficient and unsustainable use of fuelwood (firewood and charcoal), are issues that are expected to continue if no interventions are put in place.

The proposed mitigation activities represent a significant excursion from the baseline scenario for the lower and mid Nyando basin and hence the mitigation is considered to be highly additional.

The approval and implementation of the mitigation activities will overcome institutional barriers, technological barriers, barriers related to local tradition, barriers due to prevailing practice, barriers due to local ecological conditions and barriers due to social conditions and land-use practices. Hence the mitigation activities will provide numerous benefits including:

1. Prevention of carbon emissions to the atmosphere, that would occur as a result of the land use activities prevalent in the alternative scenarios.
2. Influence other regional, national, and international stakeholders who can see this as a testing ground for future carbon finance activities related to CSA activities and are expected to be motivated to participate in a "learning by doing" exercise regarding carbon monitoring, verification, certification, trading, and carbon reduction/removal development in general.

3. Close interaction between individuals, communities, government, and carbon markets to intensify the institutional capacity to link networks for environmental products and services.
4. Improvement of land productivity across the research area and increased sustainability of soil resources for future agricultural activities.
5. Empowerment of poor members of society and women through their inclusion in AR activities.
6. Increased financial capacity of the targeted poor section of society from the benefits of carbon finance.

4.1.2. Carbon financing estimate section

This was done by analyzing the Ex-ante carbon sink and carbon sale prices trends.

4.1.3. Estimation of Ex ante carbon

The tree measurement data (height and DBH) was used to calculate current annual volume increment (CAI) for different tree species (m^3/ha/yr) and standing volume at different points in time (as required for equation 4 of AR-AMS0001): Figure 1 13 (a, b, c, & d) give us DBH/Height relationship for C. equisetifolia and G. robusta for both the lowland and upland regions.

Figure 1 13: Estimate DBH:height relationship (plotted DBH vs height and calculated best fit line)

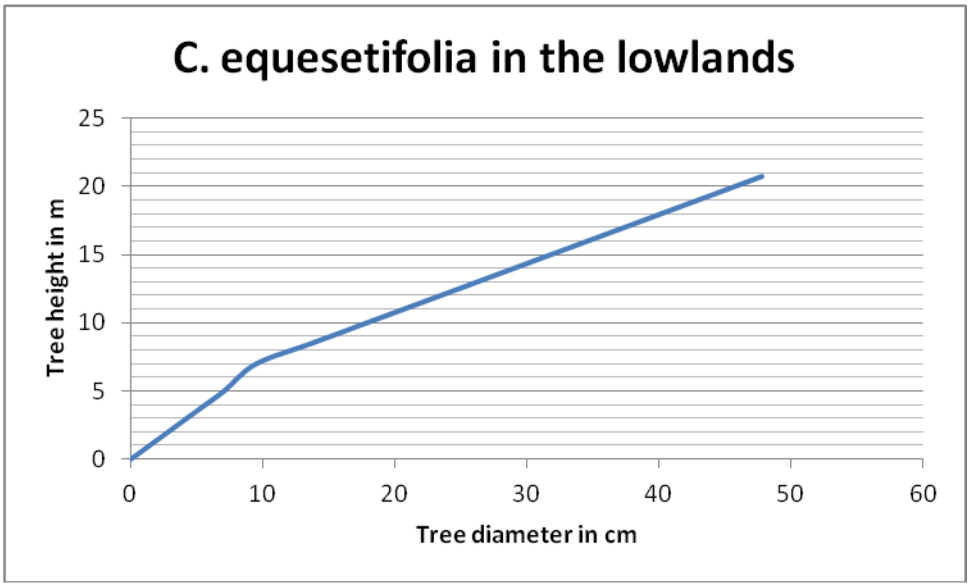

Figure 1 13a

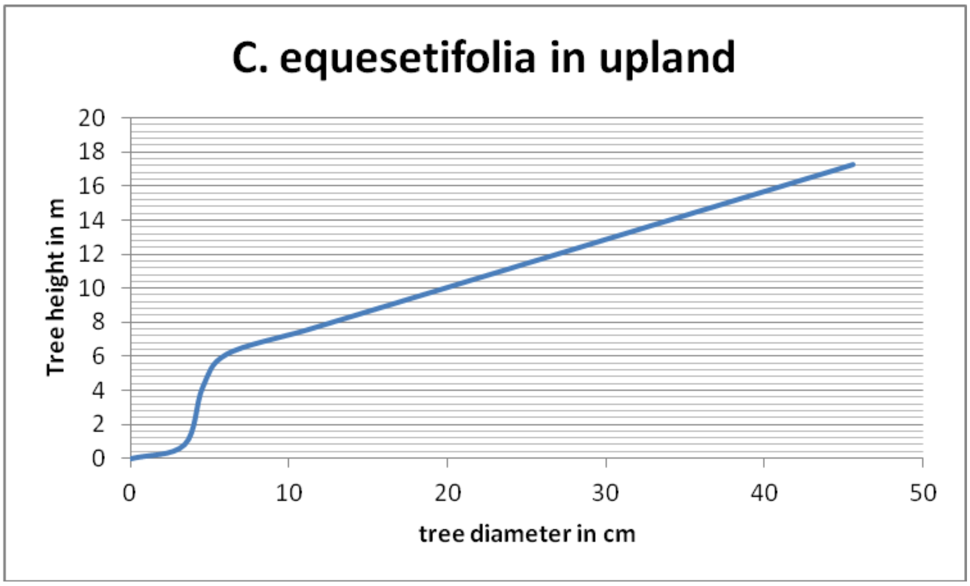

Figure 1 13b

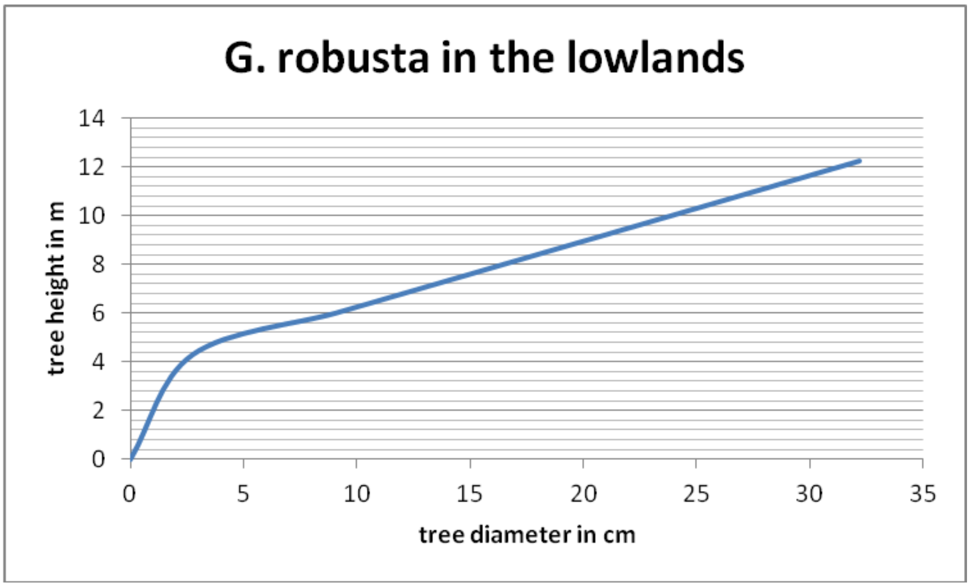

Figure 1 13c

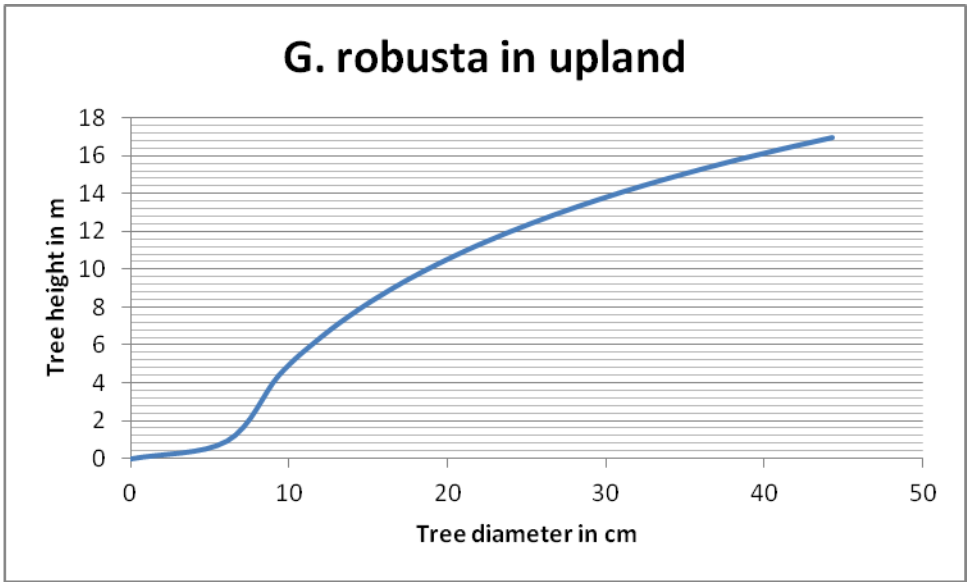

Figure 1 13d

DBH/Age relations of both the tree species and region of growth

The graphs below gives the estimated tree DBH growth in relation to Age which is helpful in projection of tree volume over time. Therefore, Figure 1 14 (a, b, c & d) below is meant to help in calculating the ex-ante tree volume vis-a – vis biomass.

Figure 1 14: Estimate DBH/age relationship (plotted age vs DBH and calculated best fit line)

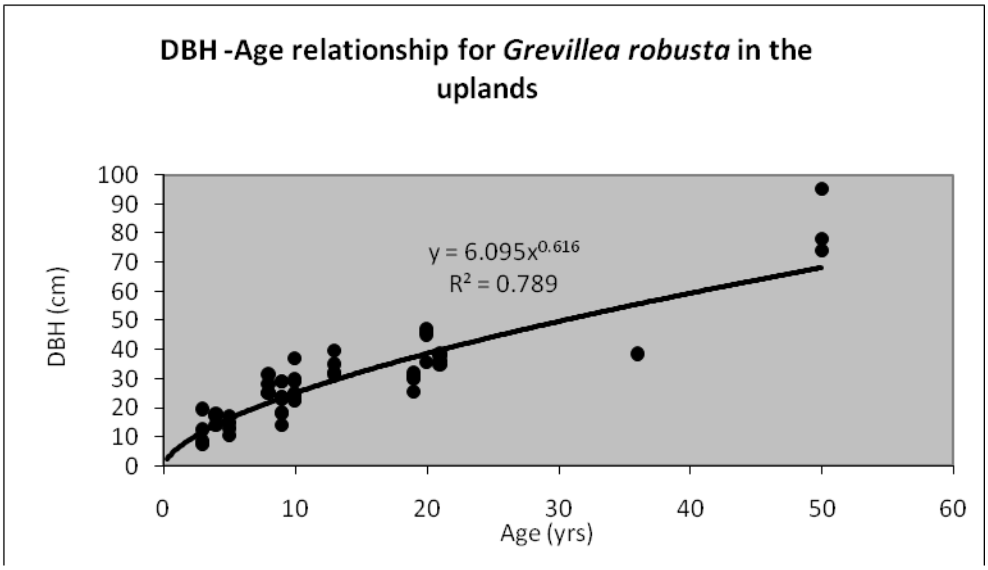

Figure 1 14a

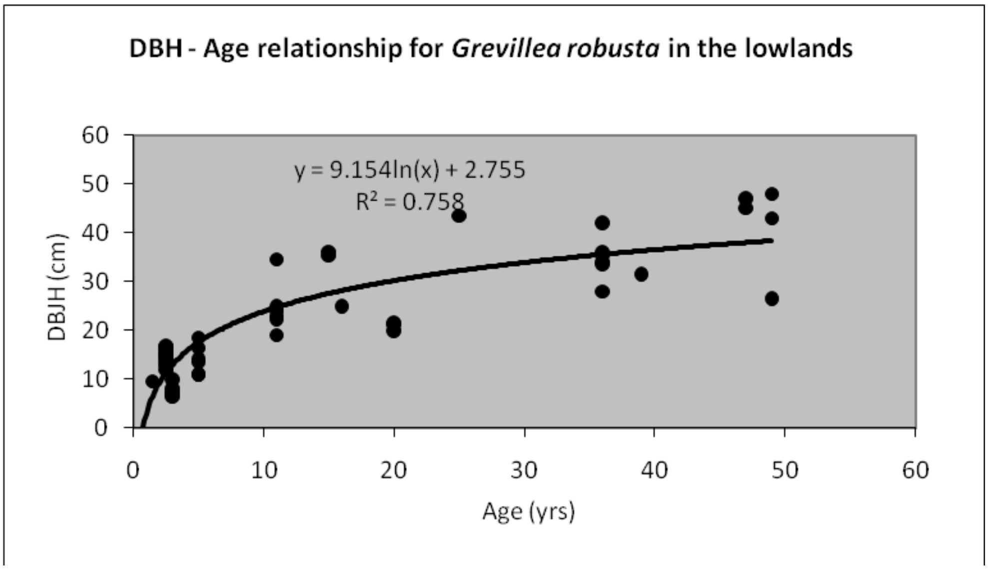

Figure 1 14b

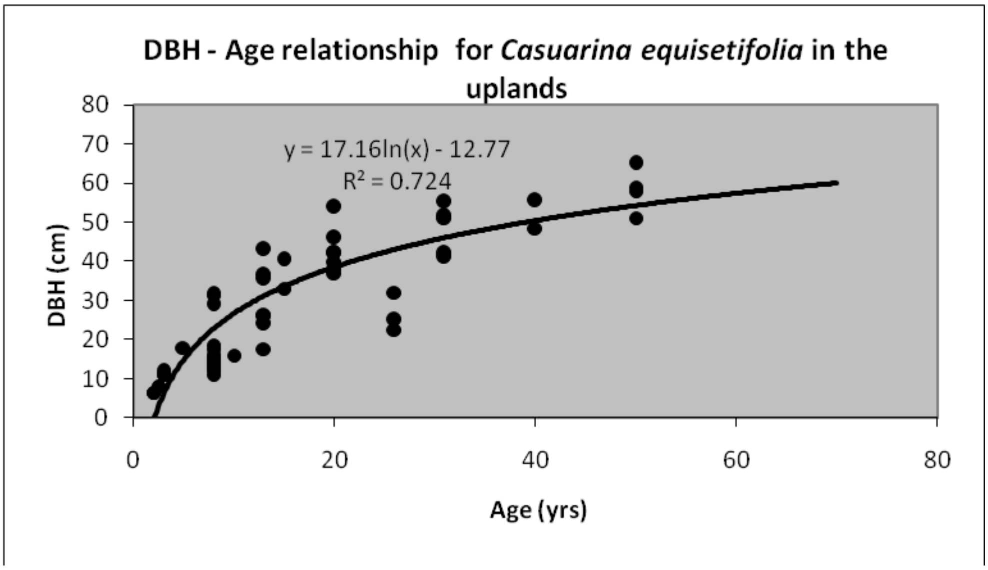

Figure 1 14c

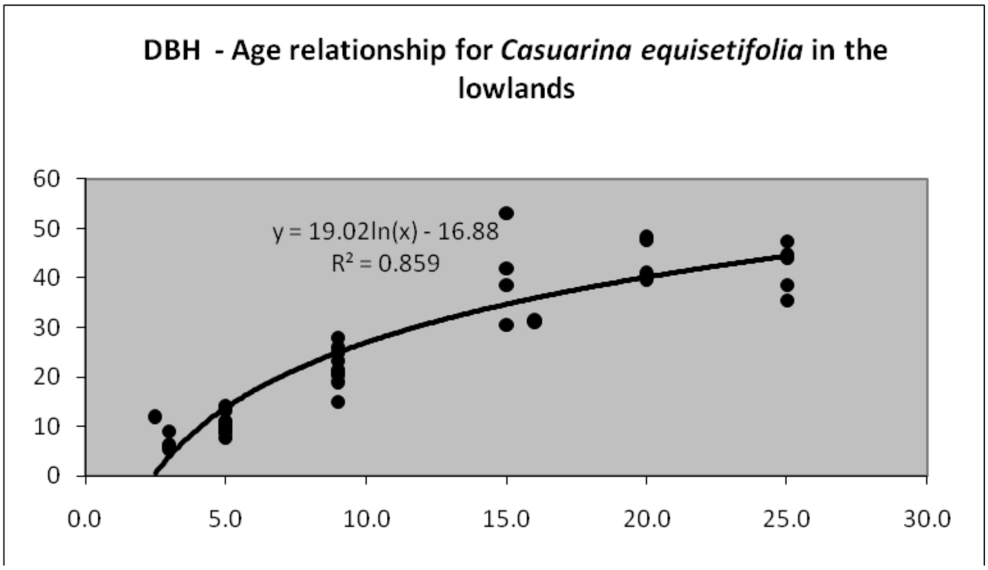

Figure 1 14d

Height/Age relationship

The best line was drawn from the points plotted from the data relating to tree height of known ages as shown in Figure 1 15 (a, b, c & d). This relationship helps in Ex-ante carbon calculation as per the equation 4 of AR-AMS0001 VCS methodology

Figure 1 15: Estimate height:age relationship (plotted height vs age and calculated best fit line)

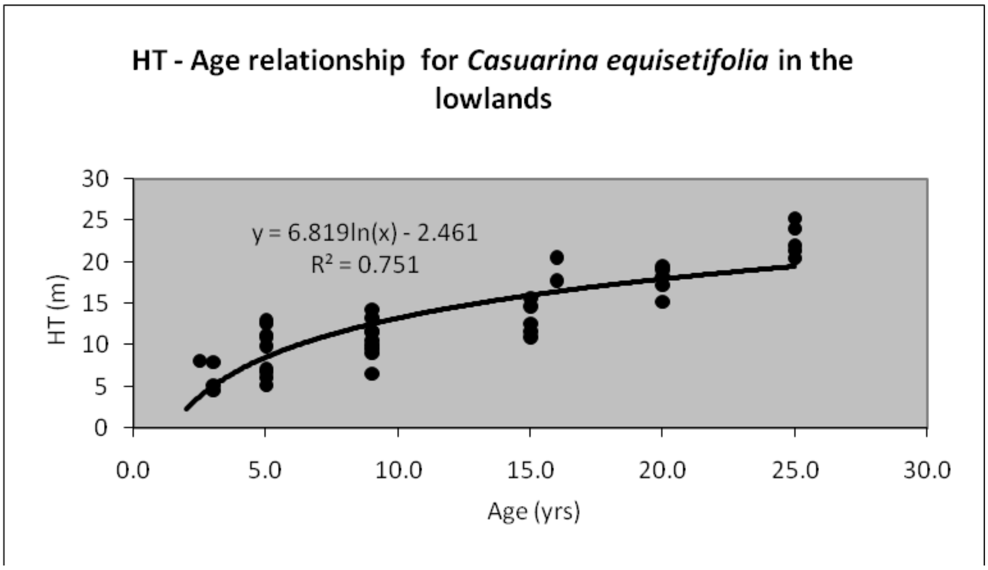

Figure 1 15a

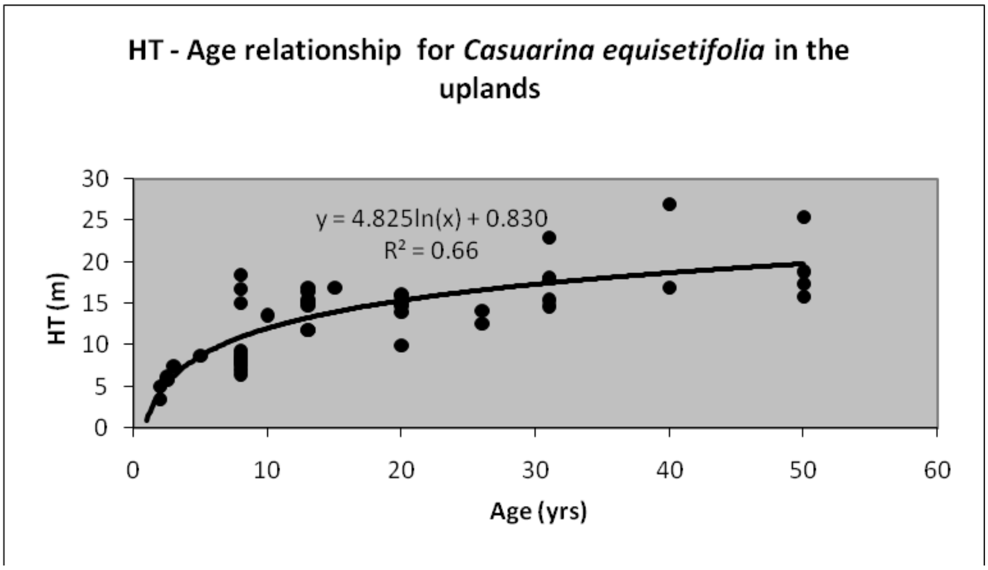

Figure 1 15b

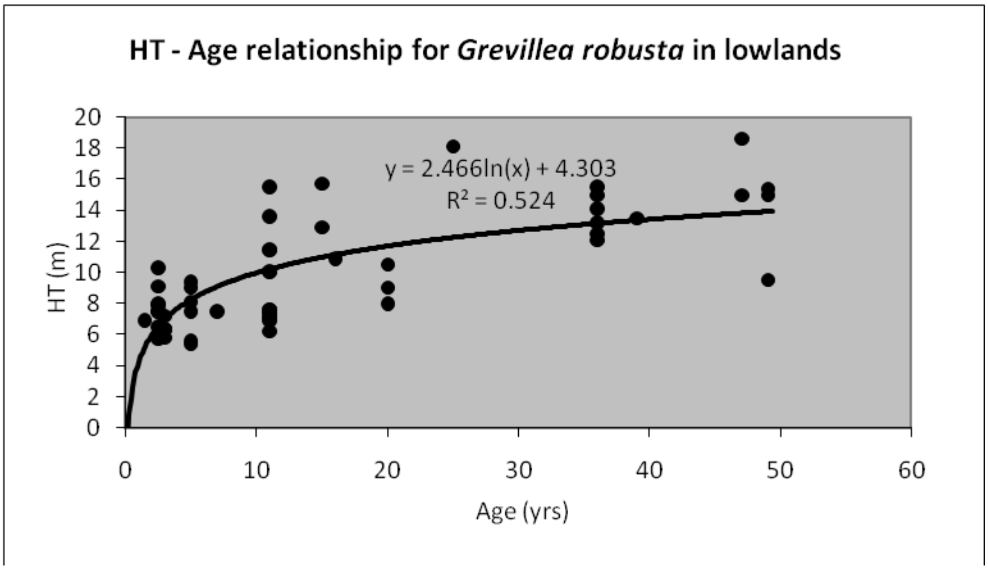

Figure 1 15c

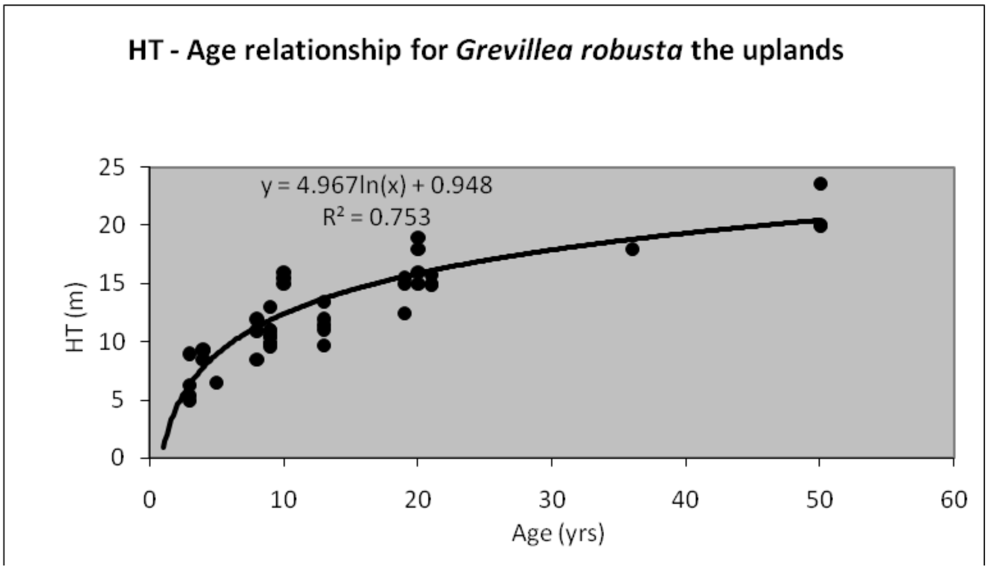

Figure 1 15d

Individual tree stem volume in (m^3) was calculated using the predicted DBH and heights from trees of age 1, 2, 3, ...5…20, etc. predicted stem volume of the tree at ages 1, 2, 3, ...5…20, etc. based on the volume of a cone using the Huber formula below:

$$v_i = \frac{\pi\left(\frac{d_i}{200}\right)^2 h_i}{\rho}$$

Where ρ = form factor (a form factor of 3 has been used for all tree species) (Olang and Furst, 2010). The factor 200 is used to convert the cross-sectional area units from cm^2 to m^2.

Calculate annual increment per tree at age in successive years from planting to harvesting as the increase in volume between the two ages (e.g. volume at age 15 minus volume at age 10) divided by 5 (years)

Multiply the CAI per tree by the number of trees in the technical specification (refer to the establishment and maintenance plan) to annual volume increment per hectare (m^3/ha).

A forecast of individual tree stem volume for the species growing in lowland and upland conditions (stratum) is presented in Tables 8 and 9.

Table 8: Tree stem volume (m^3)in lowland stratum		
Year	*Casuarina equisetifolia*	*Grevillea robusta*
1	0.00118684	0.0008546
2	0.00281325	0.01302009
3	0.00666844	0.03009655
4	0.01647795	0.04816455
5	0.04203215	0.06614585
6	0.07557325	0.08368698
7	0.11469058	0.10067377
8	0.15771007	0.11708272
9	0.20346988	0.13292684
10	0.25115137	0.14823365
11	0.30016747	0.16303556
12	0.35009007	0.17736562
13	0.40060243	0.19125556
14	0.45146725	0.204735
15	0.50250498	0.21783126
16	0.55357862	0.2305693
17	0.60458304	0.24297187
18	0.65543719	0.2550597
19	0.70607852	0.26685167
20	0.75645873	0.27836499
21	0.80654064	0.28961539
22	0.85629581	0.30061727
23	0.9057027	0.31138382
24	0.95474524	0.32192719
25	1.00341175	0.33225854

Table 9: Tree stem volume (m^3)in highland stratum		
Year	*Casuarina equisetifolia*	*Grevillea robusta*
1	0.00025421	0.00092152
2	0.00227294	0.0100257
3	0.00593452	0.0240999
4	0.02388749	0.04201477
5	0.0495855	0.06313429
6	0.08012229	0.08703854
7	0.11371334	0.11342493
8	0.14923907	0.14206279
9	0.18597419	0.17276923
10	0.22343501	0.20539494
11	0.26129111	0.2398152
12	0.29931251	0.27592399
13	0.33733685	0.31362979
14	0.37524839	0.35285268
15	0.41296415	0.3935221
16	0.45042464	0.43557522
17	0.48758738	0.47895568
18	0.52442238	0.52361253
19	0.56090895	0.56949948
20	0.59703331	0.61657426
21	0.63278691	0.66479804
22	0.66816515	0.71413505
23	0.70316641	0.76455217
24	0.73779135	0.81601866
25	0.77204233	0.86850588

The choice of trees species, tree numbers planted and thinning regime is the same in lowland and highland locations. The choice of popular agroforestry was arrived at during focus group discussion. The tree species that will be planted according to each one of the planting plans (technical specifications) is presented in Table 10.

Table 10: Number of trees to plant

Planting plan	*Casuarina equisetifolia*	*Grevillea robusta*	Total
Woodlot (per hectare)	800	800	1600
Boundary planting(per 400 metres)	100	100	200

The proposed thinning regime for each one of the planting plans (technical specifications) is shown in Tables 11 and 12

Table 11: *WDL thinning regime (Number of trees remaining per Hectare)*			
Year	*Casuarina equisetifolia*	*Grevillea robusta*	*Total*
1	800	800	1600
2	800	800	1600
3	800	800	1600
4	800	800	1600
5	800	800	1600
6	800	400	1200
7	800	400	1200
8	800	400	1200
9	400	400	800
10	400	400	800
11	400	400	800
12	400	400	800
13	400	200	600
14	400	200	600
15	400	200	600
16	400	200	600
17	200	200	400
18	200	200	400
19	200	200	400
20	200	200	400
21	200	200	400
22	200	200	400
23	200	200	400
24	200	200	400
25	200	200	400

Table 12: BND thinning regime (number of trees remaining per 400m planted)			
Year	*Casuarina equisetifolia*	*Grevillea robusta*	Total
1	*100*	100	200
2	100	100	200
3	100	100	200
4	100	100	200
5	100	100	200
6	100	50	150
7	100	50	150
8	100	50	150
9	100	50	150
10	50	50	100
11	50	50	100
12	50	50	100
13	50	50	100
14	50	50	100
15	50	50	100
16	50	50	100
17	50	50	100
18	50	50	100
19	50	50	100
20	50	50	100
21	50	50	100
22	50	50	100
23	50	50	100
24	50	50	100
25	50	50	100

Above ground biomass at time t under the project scenario is calculated using **equation 4** on page 47.

BEF value of 1.25

Basic wood density (t.d.m./m3) values obtained from ICRAF database and refer to the medium value (Table 13)

Table 13: Basic wood density values (t.d.m./m3)		
Tree species	*Casuarina equisetifolia*	*Grevillea robusta*
Density	0.92	0.62

Carbon stocks in above-ground tree biomass under the research scenario (at time *t*) are calculated based on **Equation 3 on page 46**.

The value for carbon fraction of dry matter (t C/t.d.m.) is 0.5.

Carbon stocks in below-ground tree biomass at time *t* under the research scenario (tC / ha) are calculated using **equation 5 on page 47**.

The root to shoot ratio (t.d.m./ t.d.m.) applied was 0.25

The value for carbon fraction of dry matter (t C/t.d.m.) is 0.5.

Carbon stocks in tree biomass at time t under the research scenario (t C/ha) are the sum of carbon stocks in above-ground biomass and below-ground biomass (see **equation 2 on page 46**). The table 14 and 15 below gives an Ex ante tree carbon available at given time.

Table 14: Carbon stocks in tree biomass at time t under the study scenario (t C/ha) – lowland stratum		
Year	*WDL*	BND
0	0	0
1	1.0	0.1
2	6.4	0.8
3	14.9	1.9
4	27.0	3.4
5	47.8	6.0
6	72.8	9.1
7	100.8	12.6
8	130.6	16.3
9	80.9	10.1
10	96.9	12.1
11	113.2	14.1
12	129.6	16.2
13	73.1	18.3
14	81.3	20.3
15	89.6	22.4
16	97.8	24.5
17	106.0	26.5
18	114.2	28.5
19	122.3	30.6
20	130.3	32.6
21	138.2	34.6
22	146.1	36.5
23	153.9	38.5
24	161.7	40.4
25	169.4	42.3

Table 15: Carbon stocks in tree biomass at time t under the study scenario (tC/ha)- highland stratum		
Year	*WDL*	BND
0	0	0
1	0.5	0.1
2	5.0	0.6
3	12.2	1.5
4	28.8	3.6
5	50.9	6.4
6	76.6	9.6
7	105.0	13.1
8	135.2	16.9
9	83.5	10.4
10	99.9	12.5
11	116.7	14.6
12	133.9	16.7
13	75.7	18.9
14	84.6	21.1
15	93.6	23.4
16	102.7	25.7
17	111.8	28.0
18	121.1	30.3
19	130.4	32.6
20	139.7	34.9
21	149.2	37.3
22	158.6	39.7
23	168.1	42.0
24	177.7	44.4
25	187.3	46.8

Baseline carbon stocks are forecast to remain constant at the current (year 0) level throughout the mitigation crediting period. The carbon stocks for the research scenario at the starting date of the mitigation activity are the same as the baseline stocks (**see equation 1 on page 46**). The GHG removals have been calculated as the difference between the baseline carbon stocks and the project carbon stocks over the entire mitigation period.

The results of this calculation (i.e. additional carbon sequestration above baseline) for the two planting scenarios in both lowland and highland strata (t C/ha) are presented in Tables 16 and 17.

Table 16: Net GHG removals by sinks (t CO2-e/ ha) – lowland stratum

Year	*WDL*	BND
0	-6.3	-0.6
1	-2.8	-0.2
2	17.1	2.3
3	48.2	6.2
4	92.7	11.7
5	169.0	21.3
6	260.8	32.8
7	363.1	45.5
8	472.6	59.2
9	290.2	36.4
10	348.9	43.8
11	408.6	51.2
12	468.9	58.8
13	261.6	66.3
14	291.9	73.9
15	322.2	81.5
16	352.4	89.1
17	382.4	96.6
18	412.3	104.0
19	441.9	111.4
20	471.4	118.8
21	500.5	126.1
22	529.5	133.3
23	558.1	140.5
24	586.6	147.6
25	614.7	154.6

Table 17: Net GHG removals by sinks (t CO2-e/ ha) – highland stratum

Year	*WDL*	BND
0	-6.3	-0.6
1	-4.6	-0.4
2	12.0	1.7
3	38.6	5.0
4	99.3	12.6
5	180.2	22.7
6	274.6	34.5
7	378.5	47.5
8	489.5	61.3
9	299.7	37.6
10	359.9	45.1
11	421.7	52.9
12	484.8	60.8
13	271.3	68.8
14	303.9	76.9
15	336.8	85.2
16	370.1	93.5
17	403.7	101.9
18	437.6	110.3
19	471.7	118.9
20	506.0	127.5
21	540.6	136.1
22	575.3	144.8
23	610.2	153.5
24	645.3	162.3
25	680.5	171.1

4.1.4. Results of Carbon Stock Calculation

Table 18 below shows the result of the computation of the carbon baseline stock. This table demonstrates that for a matrix of cultivated trees combined with other sporadic on farm vegetation, bush and bare land, the average carbon stock was 3.45tCO_2/ha as.

Table 18: Total biomass carbon stock in research area

Land use stratum	Area (ha) within study area	tCO_2/ha	Carbon stock (tCO_2)
Matrix of bush, grassland, barren land and cultivated land	154,989	3.45	534,712
Sugarcane production	11,578	110.00	1,273,580
Irrigated rice production and wetland area	25,108	18.33	460,313
Forest land	8,830	537.00	4,741,710
Settlements	333	0.00	0
Other lands (including water bodies)	7,347	0.00	0
TOTAL	208,185		7,010,315

From the table 18 above, it is readily seen that the total baseline biomass carbon stock (tCO_2) in the study area was estimated to be 7,010,315 tCO_2 eq.

It was found that the difference between carbon stocks for this land use type in upland and lowland areas was negligible (<5%). Average baseline biomass (above and below ground for woody perennials and below ground for grasses) based on the 127 samples taken from within the study area is 2.48 tonnes with standard deviation of 5.57 tonnes of biomass per hectare. A conservative estimate of baseline biomass is 3.45 tonnes per hectare with a confidence level of 95% which was equivalent to 1.73 tonnes of carbon per hectare.

Values for tree biomass carbon stocks in other land use stratum within the study area were presented in Table 19. The calculations for carbon storage in sugarcane, rice paddies and forests were all based on IPCC values (report, 1999). These areas were not eligible to participate in mitigation AR activities and no changes are expected to carbon stocks within these stratums as a direct or indirect result of any mitigation activities.

4.1.5. Capping

The crediting period for each instance of mitigating activity is 25 years although the mitigation longevity is expected to extend 10 years beyond the end of the crediting period. All two systems involve thinning whereas the woodlot and boundary planting systems are also expected to include harvesting at some point beyond the end of the crediting period. According to the AFOLU requirements, where harvesting is included the maximum number of GHG credits available shall not exceed the long term average GHG benefit as shown in Table 19.

Table 19: Long term average GHG benefit (t CO_2 / ha)

Planting regime	Rotational harvest	Capping	
		Lowland	Highland
Woodlots	>25 years	333	353.1
Boundary planting	>25 years	69.7	74.3

Figure 1 16 on page 88 and 89 below are graphs indicating ex-ante carbon emissions related to various land use with capping incorporated. The capping gives us the picture of a long term average of carbon removal if harvesting is expected like in the case of most on farm tree plantings. The study therefore incorporates that idea in the calculations per planting regime and in various regions within the basin as in figure 1 16 below;

Figure 1 16: Ex-ante removal with capping for various planting regimes at various regions

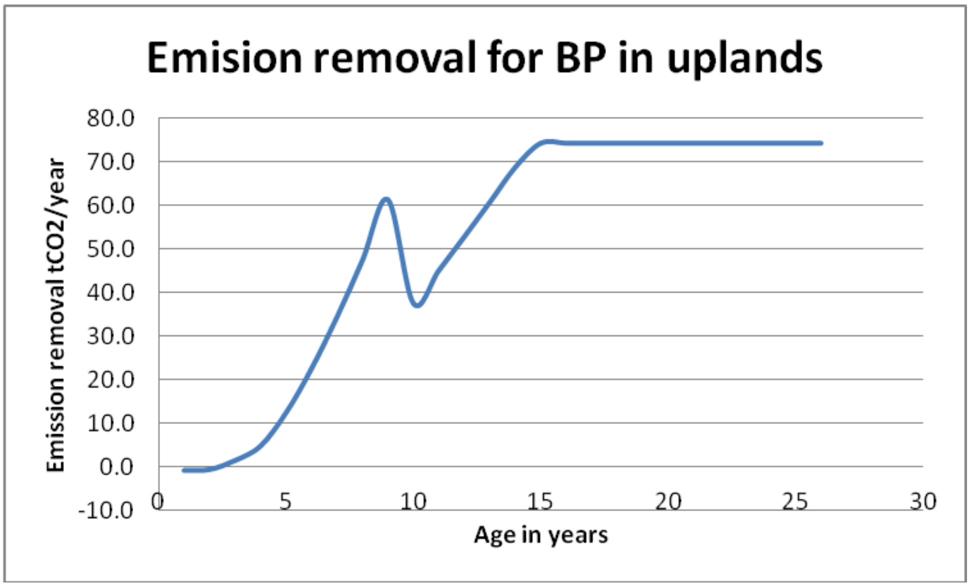

Figure 1 16a

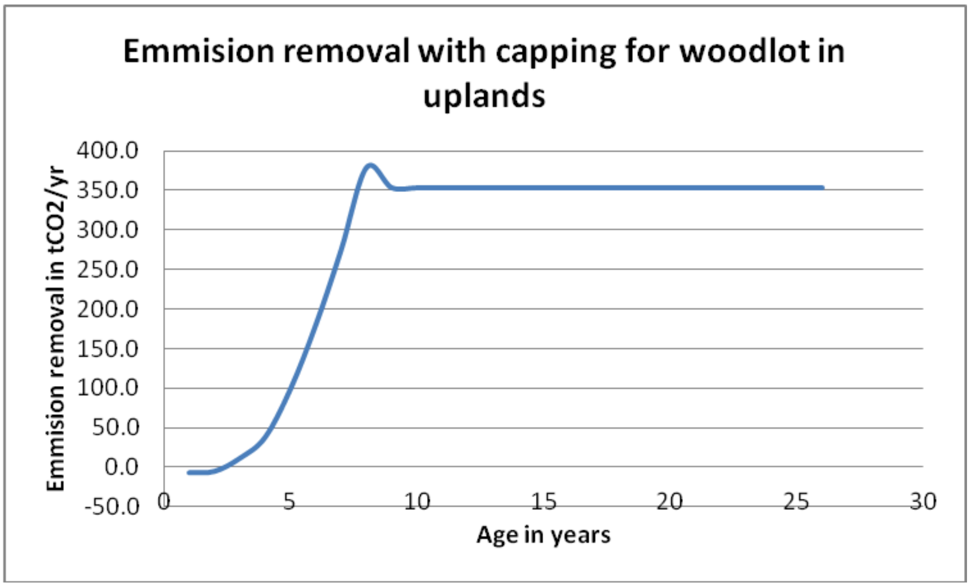

Figure 1 16b

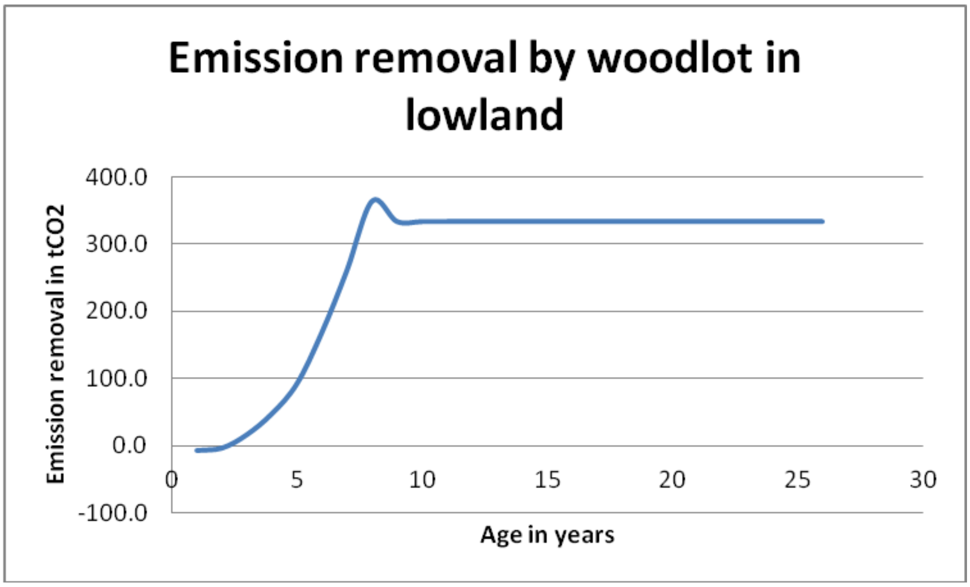

Figure 1 16c

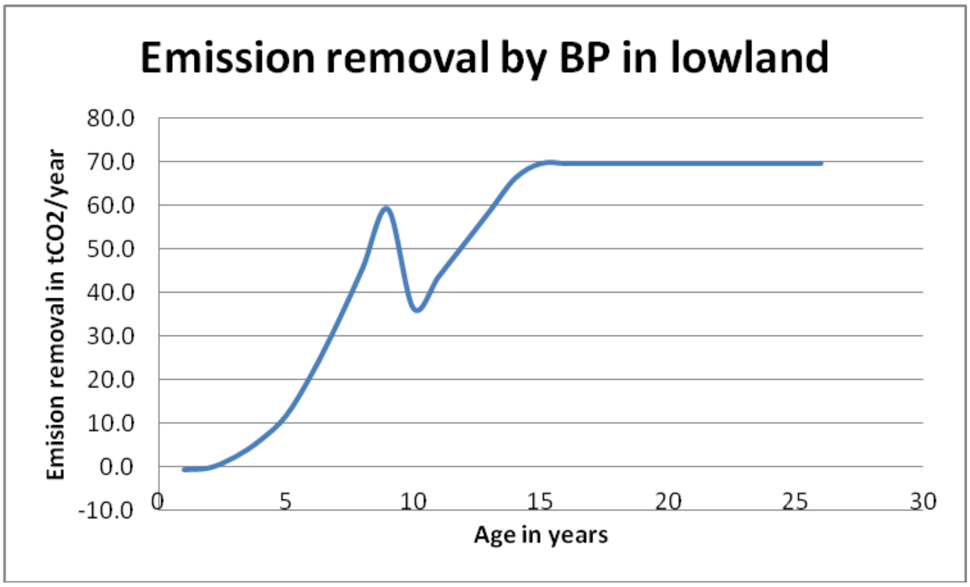

Figure 1 16d

4.1.6. Leakage and mitigation activities risk

The VCS Tool for AFOLU Non-permanence Risk Analysis and Buffer Determination v3.0 has been used as a basis for determining mitigation risk. In line with this tool, the following steps have been applied to assess likely internal, external and natural risks associated with the mitigation activities.

Internal Risks

These are risks associated with implementation of the mitigation activities and involve four steps that include project management, financial viability, opportunity costs and project longevity. These steps are described in the sub-section that follows;

Sub-step a) Project Management. The risk rating given below indicates the level of risks related to mitigation activities. For example where the rating is non existence, the rating is zero where it is in existence then 2 where it shows indication of mitigation then -2.

Mitigation activities Management		**% Risk**
a)	Species planted (where applicable) associated with more than 25% of the stocks on which GHG credits have previously been issued are not native or proven to be adapted to the same or similar agro-ecological zone(s) in which the GHG removal is located.	0
b)	Ongoing enforcement to prevent encroachment by outside actors is required to protect more than 50% of stocks on which GHG credits have previously been issued.	0
c)	Management team does not include individuals with significant experience in all skills necessary to successfully undertake all project activities (ie, any area of required experience is not covered by at least one individual with at least 5 years experience in the area).	0
d)	Management team does not maintain a presence in the country or is located more than a day of travel from the study site, considering all parcels or polygons in the study area.	0
e)	***Mitigation***: Management team includes individuals with significant experience in AFOLU mitigation activity design and implementation, carbon accounting and reporting (eg, individuals who have successfully managed mitigation through validation, verification and issuance of GHG credits) under the CDM Program or other approved GHG programs.	−2
f)	***Mitigation***: *Adaptive management plan in place.*	0
Total Mitigation Management (PM) [as applicable, (a + b + c + d + e + f)]		-2

Sub-step b) Financial Viability. This is risk associated with financial viability of the project within the crediting period. It takes into consideration all project implementation costs and related incomes and determines whether the project is able to continue till end of crediting period. Zero indicates the risk is non existence and a figure of 1 to 10 indicates the level of risk.

Financial Viability		**Risk Rating**
a)	Mitigation activities cash flow breakeven point is greater than 10 years from the current risk assessment	0
b)	Mitigation activities cash flow breakeven point is between 7 and up to 10 years from the current risk assessment	0
c)	Mitigation activities cash flow breakeven point between 4 and up to 7 years from the current risk assessment	1
d)	Mitigation activities cash flow breakeven point is less than 4 years from the current risk assessment	0
e)	Mitigation activities (Research) has secured less than 15% of funding needed to cover the total cash out before the CSA reaches breakeven	0
f)	Research has secured 15% to less than 40% of funding needed to cover the total cash out required before the CSA reaches breakeven	0
g)	Research has secured 40% to less than 80% of funding needed to cover the total cash out required before the CSA reaches breakeven	1
h)	Research has secured 80% or more of funding needed to cover the total cash out before the CSA reaches breakeven	0
i)	***Mitigation***: *research has available as callable financial resources at least 50% of total cash out before CSA reaches breakeven*	0
Total Financial Viability (FV) [as applicable, ((a, b, c or d) + (e, f, g or h) + i)]		2

Sub-step c) Opportunity. This is the risk associated with forgone alternative opportunity. Again zero indicates it is non existence.

Opportunity Cost		**Risk Rating**
a)	Net present Value (NPV) from the most profitable alternative land use activity is expected to be at least 100% more than that associated with Mitigation activities; or where baseline activities are subsistence-driven, net positive community impacts are not demonstrated	0
b)	NPV from the most profitable alternative land use activity is expected to be between 50% and up to 100% more than from mitigation activities	0
c)	NPV from the most profitable alternative land use activity is expected to be between 20% and up to 50% more than from mitigation activities	0
d)	NPV from the most profitable alternative land use activity is expected to be between 20% more than and up to 20% less than from mitigation activities; or where baseline activities are subsistence-driven, net positive community impacts are demonstrated	0
e)	NPV from mitigation activities is expected to be between 20% and up to 50% more profitable than the most profitable alternative land use activity	0
f)	NPV from mitigation activities is expected to be at least 50% more profitable than the most profitable alternative land use activity	0
g)	***Mitigation***: Study proponent is a non-profit organization	-2
h)	***Mitigation***: Study is protected by legally binding commitment (see Section 2.2.4) to continue management practices that protect the credited carbon stocks over the length of the mitigation crediting period	0
i)	***Mitigation***: The mitigation proponent is protected by legally binding commitment (see Section 2.2.4) to continue management practices that protect the credited carbon stocks over at least 100 years	0
Total Opportunity Cost (OC) [as applicable, (a, b, c, d, e or f) + (g or h)]		0

Sub-step d) Project Longevity. This is a risk associated with the life of the CSA after the end crediting period. The longer the activities will continue after the crediting period the better it is.

Mitigation Longevity		**% Risk**
a)	Without legal agreement or requirement to continue the management practice	= 24 - (mitigation longevity/5)
b)	With legal agreement or requirement to continue the management practice	= 30 - (mitigation longevity/2)
Total		19

Grand Total of internal Risks

Internal Risk	**% Risk**
Total Internal Risk (PM + FV + OC + PL)	19

External Risks

These are risks which are not associated with the implementation activities but are external. They are determined using the following procedures below;

Sub-step a) Land Ownership and Resource Access/Use Rights. This are Risk associated with land ownership and user right. The land with unclear ownership or user rights is much risky in terms of possible sabotage from the competing partner. Negative sign is a strong indicator of ownership right and all ownership papers are well documented.

Land Ownership and Resource Access/Use Rights		Risk Rating
a)	Ownership and resource access/use rights are held by same entity(s)	0
b)	Ownership and resource access/use rights are held by different entity(s) (eg, land is government owned and the mitigation proponent holds a lease or concession)	0
c)	In more than 5% of the research area, there exist disputes over land tenure or ownership	0
d)	There exist disputes over access/use rights (or overlapping rights)	5
e)	***Mitigation***: research area is protected by legally binding commitment (eg, a conservation easement or protected area) to continue management practices that protect carbon stocks over the length of the mitigation crediting period	0
f)	***Mitigation***: Where disputes over land tenure, ownership or access/use rights exist, documented evidence is provided that mitigation proponent have implemented activities to resolve the disputes or clarify overlapping claims	-2
Total Land Tenure (LT) [as applicable, ((a or b) + c + d + e+ f)]		3

Sub-step b) Community Engagement. This is an area showing the involvement of the community papers both within and without the study area.

Community Engagement		% Risk
a)	Less than 50 percent of households living within the research area who are reliant on the research area, have been consulted	0
b)	Less than 20 percent of households living within 20 km of the research boundary outside the research area, and who are reliant on the research area, have been consulted	5
c)	***Mitigation***: The research generates net positive impacts on the social and economic well-being of the local communities who derive livelihoods from the research area	-5
Total Community Engagement (CE) [where applicable, (a+b+c)]		0

Sub-step c) Political Risk. This score determine the suitability of doing business in that particular country as per the World Bank governance scores rating.

Political Risk		% Risk
a)	Governance score of less than -0.79	6
b)	Governance score of -0.79 to less than -0.32	0
c)	Governance score of -0.32 to less than 0.19	0
d)	Governance score of 0.19 to less than 0.82	0
e)	Governance score of 0.82 or higher	0
f)	***Mitigation***: Country is implementing REDD+ Readiness or other activities, as set out in this Section 2.3.3.	-2
Total Political (PC) [as applicable ((a, b, c, d or e) + f)]		4

Total Grand External Risk

External Risk	% Risk
Total External Risk (LT + CE + PC)	7

Natural Risks. These are risks associated with both manmade and natural risk which likely to affect the project within its crediting period.

Significance	Likelihood				
	Less than every 10 years	Every 10 to less than 25 years	Every 25 to less than 50 years	Every 50 to less than 100 years	Once every 100 years or more, or risk is not applicable to the project area
Catastrophic (70% or more loss of carbon stocks)	0	0	0	0	0
Devastating (50% to less than 70% loss of carbon stocks)	0	0	0	0	0
Major (25% to less than 50% loss of carbon stocks)	0	0	0	0	0
Minor (5% to less than 25% loss of carbon stocks)	0	0	0	0	0
Insignificant (less than 5% loss of carbon stocks) or transient (full recovery of lost carbon stocks expected within 10 years of any event)	2	0	0	0	0
No Loss	0	0	0	0	0
LS Score	2				

Mitigation	% Risk
Prevention measures applicable to the risk factor are implemented	0
Mitigation proponent has proven history of effectively containing natural risk	0.50
Both of the above	0
None of the above	0
Score for each natural risk applicable to the mitigation (determined by (LS × M)	
Fire (F)	**2.5**
Pest and Disease Outbreaks (PD)	
Extreme Weather (W)	**2.5**
Geological Risk (G)	
Other natural risk (ON)	
Total Natural Risk (as applicable, F + PD + W + G + ON)	**5.0**

Overall Risk

Risk Category		Rating
a)	Internal Risk	19
b)	External Risk	7
c)	Natural Risk	5
Overall risk rating (a + b + c)		**31**

Where the overall risk rating is greater than 60%, mitigating activities risk is deemed unacceptably high and the GHG removal fails the entire risk analysis. The estimated risk for this study is 31% as in the Risk calculation above and hence is deemed acceptable when determined in line with the VCS procedure. The sum of risk ratings for each risk category is less than the thresholds designated in the risk tool above.

The risk rating can be used to determine the buffer credits that shall be deposited in the AFOLU pooled buffer account. The overall risk rating is converted into a percentage, which is then multiplied by the net change in the mitigation's carbon stocks. This totaled to 31% as indicated in Risk Category rating in the table above.

4.1.7 Summary of GHG Emission Reductions and Removals

The study emissions are assumed to be zero and are therefore not shown in any subsequent calculations. The emission associated with study is basically emission caused by the vehicle usage which is negligible and therefore omitted in this calculation. The final payable carbon removal in this study is summarized as in table 21 below which has factored in the risk buffer and capping.

The GHG emission reductions and removals forecast as a result of mitigations through this AR study activities implementation are shown in Table 20.

Table 20: Net GHG removals by sinks (t CO2-e/ ha)

Year	BND uplands	Woodlot uplands	*BND Lowland*	Woodlot lowland	Combine woodlot	Combined BND	TOTAL COMBINED
0	-0.6	-6.3	-0.6	-6.3	-6.3	-0.6	-1
1	-0.4	-4.6	-0.2	-2.8	-3.6	-0.3	-1
2	1.7	12	2.3	17.1	14.8	2.0	4
3	5	38.6	6.2	48.2	43.9	5.7	12
4	12.6	99.3	11.7	92.7	95.6	12.1	26
5	22.7	180.2	21.3	169	174.0	21.9	47
6	34.5	274.6	32.8	260.7	266.9	33.6	71
7	47.5	378.5	45.5	363.1	369.9	46.4	99
8	61.3	353.1	59.2	333	341.9	60.1	112
9	37.6	353.1	36.4	333	341.9	36.9	84
10	45.1	353.1	43.8	333	341.9	44.4	93
11	52.9	353.1	51.2	333	341.9	52.0	102
12	60.8	353.1	58.8	333	341.9	59.7	111
13	68.8	353.1	66.3	333	341.9	67.4	120
14	74.3	353.1	69.7	333	341.9	71.7	125
15	74.3	353.1	69.7	333	341.9	71.7	125
16	74.3	353.1	69.7	333	341.9	71.7	125
17	74.3	353.1	69.7	333	341.9	71.7	125
18	74.3	353.1	69.7	333	341.9	71.7	125
19	74.3	353.1	69.7	333	341.9	71.7	125
20	74.3	353.1	69.7	333	341.9	71.7	125
21	74.3	353.1	69.7	333	341.9	71.7	125
22	74.3	353.1	69.7	333	341.9	71.7	125
23	74.3	353.1	69.7	333	341.9	71.7	125
24	74.3	353.1	69.7	333	341.9	71.7	125
25	74.3	353.1	69.7	333	341.9	71.7	125

The combined total GHG emission reduction or removal were calculated with the assumption that 10% of the farmers will adopt woodlot planting, 70% boundary planting and 20% will be doing both. This was arrived at during the Focus Group Discussion. Farmers agreed that majority will be planting on the boundary and few of them will be planting woodlot in the highly degraded areas. Some large land owners also indicated adopting woodlot in portions of their lands.

Based on these planting parameters a summary of the potential GHG emission reductions and removals forecast as a result of research AR implementation activities has been demonstrated below graphically.

If only Boundary planting has been used then the graphically emission removal or reduction will look at shown in figure 1 17 below;

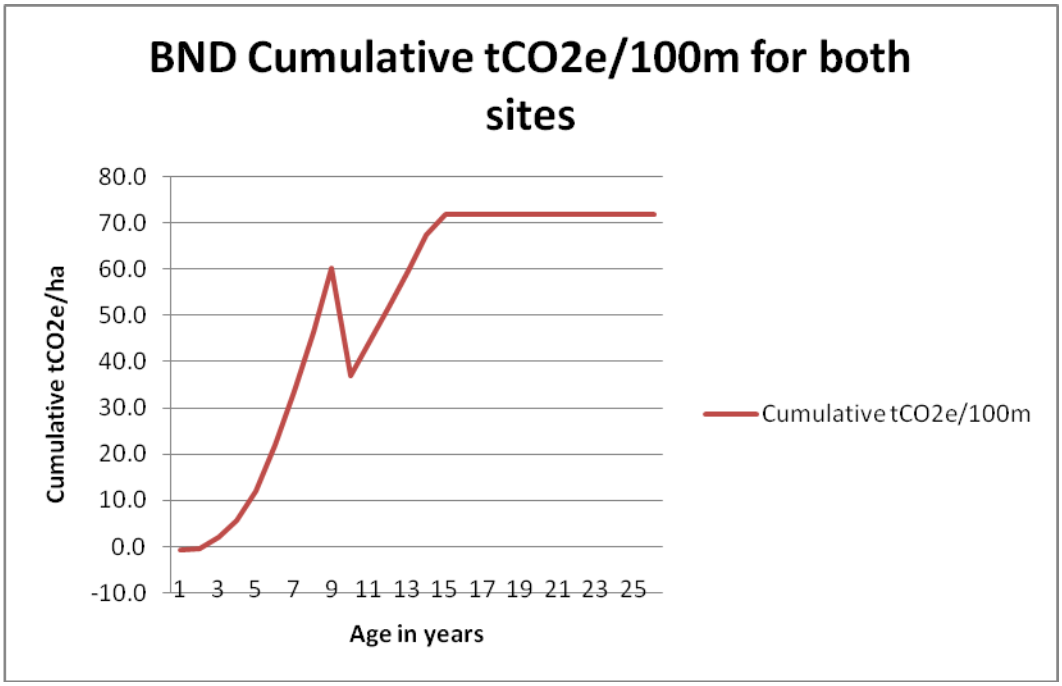

Figure 1 17: Emission removal/reduction by BND

If only woodlot was used then emission removal or reduction trend will be as shown in figure 1 18 in the graph below

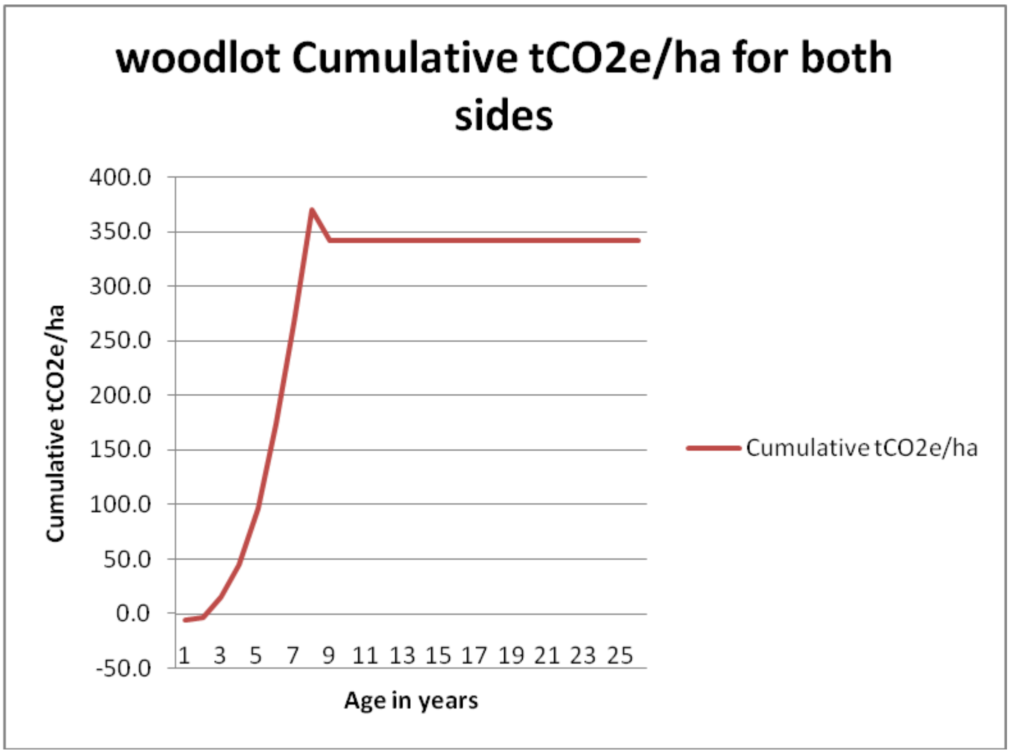

Figure 1 18: Emission removal/reduction by woodlot

This combined emission removal or reduction has used the planting combination as indicated below in figure 1 19.

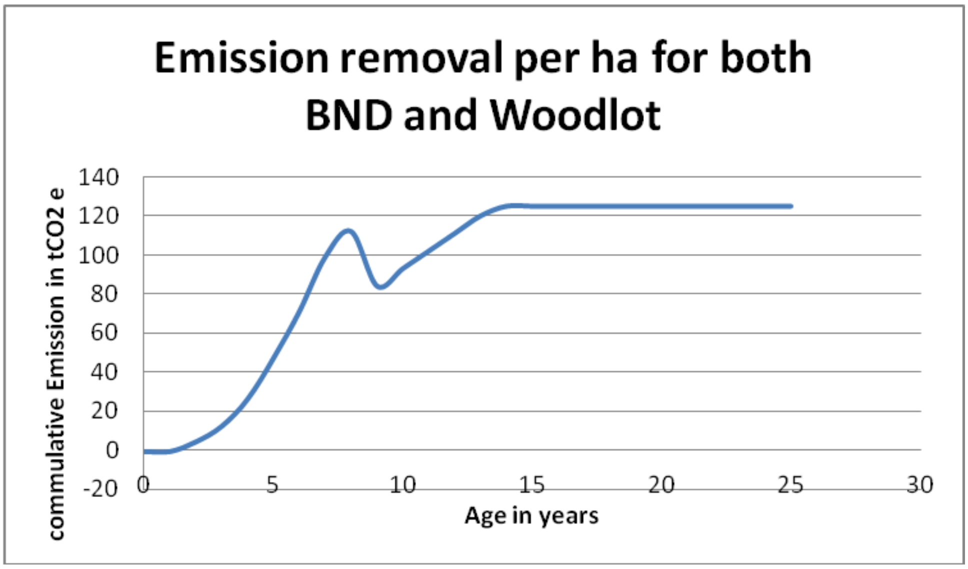

Figure 1 19: Emission removal of both BND and Woodlot in the study area

The table 21 below therefore gives the total emission removal/reduction as a result of the study activities over a period of 25 years and the available carbon credits for sale.

Table 21: GHG emission reductions and removals forecast to crediting period

Year	Cumulative CO_2	CO_2 gain pa	Period gain (tCO_2)	Buffer removed in period	Credits released from buffer	Remaining cumulative buffer	Credits for sale in period
0	-1	-1					
1	-1	0					
2	4	5					
3	12	8					
4	26	14					
5	47	21	26	8.06	0	17.94	17.94
6	71	24					
7	99	28					
8	112	13					
9	84	-28					
10	93	9	58	17.98	4.03	40.02	44.05
11	102	9					
12	111	9					
13	120	9					
14	125	5					
15	125	0	41	12.71	8.99	28.29	37.28
16	125	0					
17	125	0					
18	125	0					
19	125	0					
20	125	0	0	0	6.355	0	6.355
21	125	0					
22	125	0					
23	125	0					
24	125	0					
25	125	0	0	0	0	0	0
	TOTAL	125		38.75	19.375		105.625

The cumulative CO_2 is shown in Table 21 to start as negative value because of the baseline carbon stocks which are conservatively assumed to be removed at the time of implementation of AR activities. The cumulative CO_2 is shown as in table 22 steadily increase up to year 10 after which it starts to decreases because the crediting period for each project instance is 25 years and due to capping introduced to which requires that cumulative CO_2 does not exceed the long term average GHG benefit after which point we cease to include those carbon stocks in the accounting process. Therefore 105.625 tCO_2eq per ha will be available for sale according to this ex-ante calculation for this study area at the end of crediting period. The sale of this carbon credits can be spread throughout the mitigation crediting period or paid all by year 15 as carbon sales are not expected to exceed the long term average GHG benefits.

4.1.8. Carbon Financing

The study used the projections as discussed in chapter 2 of carbon prices in the market Environmental registry to arrive at an average carbon price of $6 per ton of CO2-eq. which have been used in the calculation of expected revenues. This is the carbon dioxide price used for the determination of the viable area needed for CSA to be considered sustainable. Now, if the carbon prices are $6, then the most viable area for this kind of CSA will be 7,000ha as indicated in figure 1 20 (Christina & Alashiya, 2012) for western Kenya. The viable area for CSA is dependable on the tree growth which is affected by weather patterns, soils and tree species. If these parameters changes, then there will be a change in viable land areas for sustainable CSA. Remember also the study relied mainly on two trees which appeared most popular with the community as agroforestry trees and these were G. robusta and C. equisetifolia, probably if other tree species are used then the viable land size might change.

Graph of revenue flow (USD) in relation to land size (Ha)

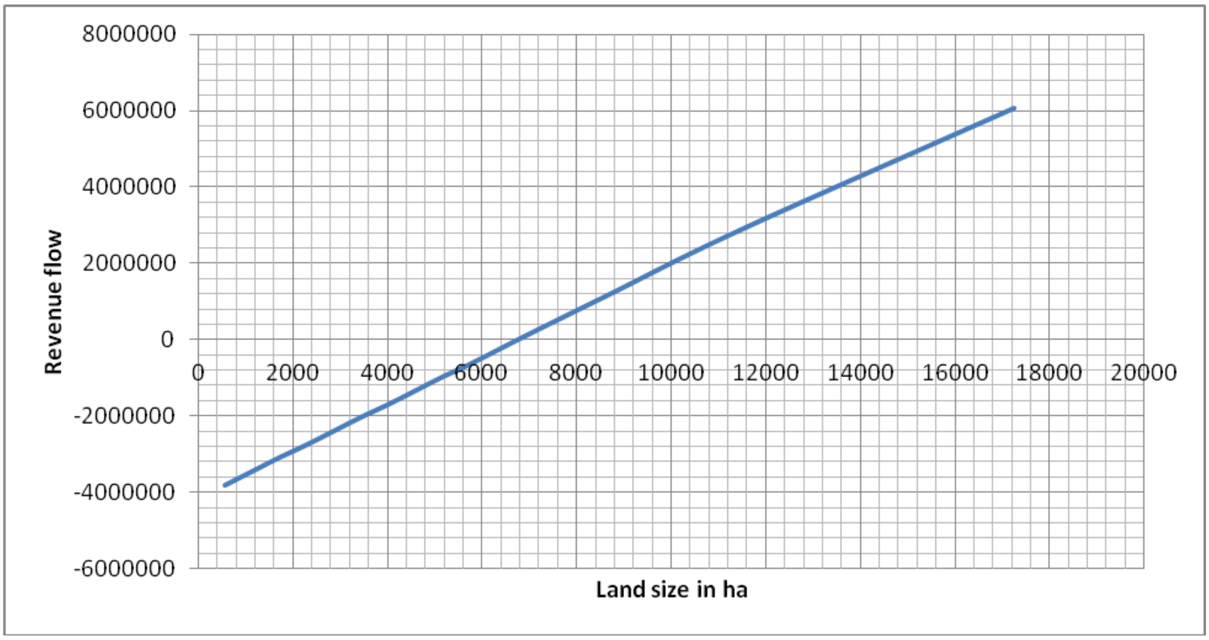

Figure 1 20: Shows the revenue flow (USD) in relation to land size (Ha)

From the figure 1 20 above, the breakeven point is where the revenue flow hits zero and that is at 7,000 ha.

The figure 1 21 below shows the cash flow when 7,000ha of land size is adopting CSA for smallholder farmers. In the initial stages of the adoption of CSA, the trees were still young and therefore had very low Biomass and with time, this changes. After age 10 years, the cash flows start going down again as trees reach maturity and very little biomass changes is experienced coupled with the mitigation attaining long term average. At age 10 years, the cash flow is above the zero as in figure 1 21 showing positive cash flow making the CSA sustainable.

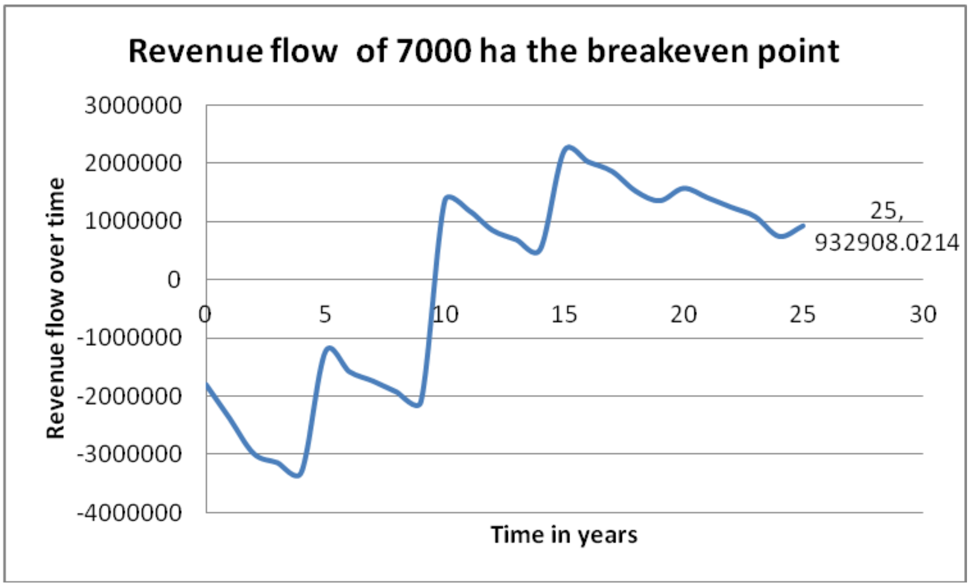

Figure 1 21: Revenue flow at 7,000 ha over time period

4.1.9. Limitation relating to carbon calculation

CSA covers the whole landscape and therefore carbon sinks related needs to cover the whole spectrum of the landscape. This study only covered the above and below ground tree biomass leaving out a number of other sinks like bushes, crops, improve fodder among others.

From the available land use methodology, the issue of capping is not very clear. As methodology discusses capping, they leave it quite open to interpretation of individual users for example a case where a programme developer envisages some harvesting but not very sure when, how can such a scenario be handle.

It is also noted that if carbon funds under such CSA programme can be viable after year 10 year, how then can this initial stage be financed? This needs further exploration.

4.2 Identification of Barriers

Barriers were analyzed on their impact on mitigation activities. This was done in two Steps

4.2.1. Barrier related to social issues.

A barrier analysis was performed in place of the investment analysis (Step 2). The following barriers were identified (barriers are not specific to the project or the project proponents):

Institutional barriers

There is limited guidance available at the grass-root scale in Kenya as to sustainable farming practices. Past government policy has included implementation of higher commodity prices in order to increase incentives to adopt soil conservation measures in agricultural activities. However studies have shown that there is no simple relationship between price distortions created by government policies and farmers' incentives to adopt conservation measures. Policy-induced price changes could lead to either more or less conservation, depending on site-specific conditions. In the Nyando basin, land degradation continues despite preventative governmental policy, as there is lack of knowledge about sustainable agricultural practices amongst some local communities.

Lack of extension services at sub-location and village level is also an important barrier to the mitigation activities has was noted in the study area. It is expected that Carbon finance will enable the mitigation activities to fund non-governmental staff to offer these extension services. Past mitigation activities demonstrates the significance of this barrier, as tree planting occurred once extension agents were in place and farmers were supported without any other incentives.
The main institutional barrier is poor leadership and lack of accountability in the management of land which leads to lack of trust. The strategies for dealing with these barriers include training and providing workshops on group formation, leadership, group dynamics and financial management by technical team financed by this carbon funds.

Technological barriers

There is currently a lack of access to planting materials and a shortage of modern equipment for agricultural activities in the lower and mid Nyando basin. During initial consultation with local communities these factors were outlined by many farmers as placing restrictions on the development of agroforestry practices in the research area. The issue of purchasing seeds was a particular area of concern, as high seed prices have forced some farmers into selling livestock to sustain their agricultural inputs (Pagiola 1996). The barrier associated with the purchase of planting materials and tools for agricultural activities can be overcome with carbon finance revenues.

Revenue from carbon finance can also be used for other domestic investment. For example the community of the lower and mid Nyando basin lacks access to household technologies, such as fuel efficient stoves. Carbon finance revenue can help the community access these efficient stoves, which in turn will place less reliance on existing forest resources to provide wood fuel. This is an example of positive feedback that might result from the mitigation activities to improve agricultural practices and yields, whilst alleviating poverty amongst local communities.

Barriers related to local tradition

The traditional Luo way of life is based around agriculture and pastoral herding. Typically communities in the lower and mid Nyando basin have not had opportunities to develop the skills required to establish sustainable planting and maintain trees over an extended period of time. Furthermore there are also a number of socio-cultural barriers and taboos, such as timing sowing as led by the eldest person in the community or household (*Golo kodhi)* prior to which no one else is allowed to plant amongst the Luo. For Kalenjins it is believed that the strength of a man is determined by the acreage of land under maize leading to delays in planting or cultivation of large areas that are unmanageable for the respective communities. These significant barriers can be overcome through the sale of carbon offsets and education of the local population as to the benefits of AR activities. The carbon finance resulting from AR activities will be used to develop awareness in sustainable planting techniques.

Local traditions dictate that livestock herds are kept for use as payment when debts need to be settled, as demonstrated by the use of livestock to purchase seeds (Thorlakson 2011). The presence of large herds (large herds are considered to be over 10) means that land in the lower and mid Nyando basin is under high pressure from grazing. The project will decrease grazing pressure, as famers will be able to access money through carbon finance and therefore will not be required to keep such large herds for use as emergency payment.

Barriers due to local environmental conditions

Unfavorable climate conditions such as droughts and flooding are becoming more frequent and damaging in the lower and mid Nyando basin. 2009 saw both natural disasters decrease farm productivity levels across the study area by ~50%, according to the local communities. Losses are typically greatest amongst smaller, poorer herders in the lower basin, who have fewer resources to take water to their livestock and crops during extreme dry periods. The lower basin tends to be affected by floods and droughts on a cyclical basis and hence the issues of land degradation and soil erosion are exacerbated relative to the mid Nyando basin. These mitigating activities are intended to deliver substantial climate adaptation benefits to farmers affected by adverse climate conditions across the research area, through the development of sustainable resource management plans and reduction in over-reliance on exploitation of natural resources.

The issue of food security will also be addressed by the mitigating activities by placing focus on sustainable farming practices across the research area and development of agroforestry systems to improve soil conservation. Over an extended period of time this could contribute to increased crop yields and hence improved food security for land owners in the lower and mid Nyando basin. It is hope the carbon financing could take care of this activities through employing extension staff to support farmers in implementing this technologies.

Barriers due to social conditions and land-use practices

The underlying causes of deforestation and land degradation are poverty amongst local land owners and an increasing population (Table 1 on page 25). The average annual income for people in Kenya is 720 USD (Nyakundi 2010) and hence many Kenyans, particularly those who make a living from agriculture, live in a state of poverty. The agents of deforestation and land degradation are primarily poor and are engaged in activities that result in land degradation to meet either subsistence or very low earning commercial agricultural activities.

Previous research has demonstrated that there is understanding amongst local farmers that crop diversification can be used to improve land condition (Thorlakson 2011). Furthermore it is understood that trees help to maintain soil stability and fertility (Thorlakson 2011), yet it is not always feasible for farmers to diversify crops or plant trees due to financial barriers, which include the high costs of seedlings and promotion of the cultivation of crops which can be sold for the greatest profits.

4.2.2. Barrier related to land use scenario.

The study **was** planned for Lower and Mid Nyando basin areas of western Kenya. In Nyando farm sizes were smaller (averaging around 1 ha) and agricultural potential is substantially lower, in particular due to lower and more erratic rainfall. Both areas have high levels of poverty and serious environmental degradation, including declining tree cover, serious soil erosion and declining soil fertility.

Proximate drivers of land degradation include poor farming techniques that deplete soil fertility and leave the soil highly vulnerable to erosion, removal or burning of crop residues and progressive loss of trees due to high demands for fuelwood and other wood products. Due to the progressive land degradation, the area of land under long fallows is increasing in many areas while the area of communal bush land is decreasing as this land is progressively converted to agriculture.

Land tenure is, by and large, not a major barrier to improved land use. Although most farmers do not have legal titles, a process of land allocation has been completed and is widely respected especially in the targeted research area of Nyando Basin.

The identified barriers would not prevent the implementation of at least one of the alternative land use scenarios. Table 22 below demonstrates this scenario.

Table 22: Barriers in relation to different land use scenarios

Barrier	Scenario: Continuation and escalation of land degradation	Scenario: Afforestation / reforestation of the land	Scenario: Development of alternative livelihood activities
Institutional	There is limited enforcement of environmental protection laws	Afforestation is promoted rather than prevented	There are no laws restricting people to certain jobs
Local tradition	This is the traditional norm in the Nyando catchment	2000 farmers have already taken part in afforestation	There is diversification of employment, as 27% of people are not employed in agriculture full time
Prevailing practice	This has been prevailing practice since the 1960s	Afforestation is not prevailing practice, but farmers are taking part in schemes	Diversification of employment opportunities means that alternative livelihoods could becoming prevailing practice
Environmental conditions	Environmental conditions will promote further degradation	Trees can be supported by the soils, even with poor environmental conditions	Environmental conditions may force people from agriculture into other livelihoods
Social conditions and land-use practices	Social conditions mean that some people are unaware of their impact on the land and hence will not change their practices to preserve it	Intervention from bodies such as ICRAF will lead to increased awareness that afforestation is a valuable land use practice	Agricultural land use practices do not provide high wages and people may want to increase their income through alternative livelihoods

Common practice analysis

Kenya has a long history of land degradation. National annual rates of deforestation between 1990 and 2010 are estimated to be 0.34% and soil erosion losses are increasing across the lower and mid Nyando basin. The prevention of land degradation is not considered to be common practice despite the long term benefits that would be observed in terms of increased agricultural yields and soil fertility. Most communities are unable to realize the economic value of timber resources in ways that do not involve deforestation and degradation and therefore, they have not adopted sustainable land use practices on a large scale across the study area.

There are agroforestry activities similar to the proposed mitigation activity previously implemented or currently underway in the lower and mid Nyando basin. However these are sparsely distributed across the research area and are limited to famers with sufficient investment power or third party funding to initiate such activities. Approximately 2,000 farmers in the research area are already involved in agroforestry activities, often initiated in association with the World Agroforestry Centre (ICRAF) and under the guidance of their staff (Thorlakson 2011). This however does not represent a significant proportion of the population, which has generally been shown to suffer from increasing poverty as a function of land degradation and population increases. Higher incidences of poverty leave the local population unable to engage in CSA activities, as they have insufficient financial and technological capacity to do so.

4.3. Is Climate funds benefits able to make CSA sustainable

The study indicates that if more than 7,000 ha of smallholder farms have been involved in this process, then CSA is considered sustainable. At this point the funds will only be used in meeting the cost of extension services which is a key component in making this programme work. The result of this study suggests that smallholder carbon projects are not financially viable without very substantial subsidies in the initial stages. More fundamentally, we found that the carbon mitigation designs based on financial incentives to adopt relatively tightly defined land use practices is not well adapted to the realities of poor smallholder farmers in our study area. However, this study noted that a more rigorous extension services will be more of benefit to the farmers and would help make it sustainable than giving cash incentive. Of course this process will cost more, but we can be confident that such an approach will lead to substantial increases in carbon stocks at a landscape scale which could help finance such a process. Modelling of this “climate-smart” approach in the context of our research in western Kenya suggests that carbon finance could potentially cover up to 50% of the cost of the whole initiative over a 10 year period and thereafter be able to take care of itself. But it needs to be a farmer-led approach which lets farmers manage the synergies and potential trade-offs. From a farmer perspective this will not, and should not, look like a carbon activity, but carbon finance could still make a substantial contribution to financing a climate-smart approach to smallholder agriculture at a landscape scale. The extension services offered to the farmer will help break the barriers making it possible to adopt the CSA and sustainably implement it.

The other advantage of this carbon finance is being able to help farmers organize themselves into some governance structure. This will be used by farmers to demand for services from their leaders, access markets and get some financial support either through loaning from financial institution or group saving and loans schemes. Therefore, strong community governance will give farmers a strong voice for bargaining and demanding for rights which is currently lacking.

4.3.1 Limitations of achieving the objectives

There were no adequate data on carbon prices to enable modelling future trends of carbon prices. This can help indicate what future trends will look like because the programme may look good now future drifting downwards of carbon prices may prove otherwise.

4.4. Whether small scale farmers will be able to get Cash incentives as envisaged by promoters of CSA.

As already discussed in chapter 4.1.6 above after more than 7,000 ha of smallholder farms have been involved in the programme then some cash incentives will be available for sharing. The research shows that when only 7,000 ha of smallholder farms are fully involved in the programmme then the carbon funds associated will only be able to meet the cost of extension services leaving nothing for sharing. This trend is likely to change as more land is introduced.

There will be many benefits associated with CSA carbon financed in the form of improved crop yields, Non timber forest products, timber products, and improved soil and water conservation.

4.4.1 Limitation of objective

There were no enough data to help objective give figures that could be shared out at various land sizes by the farmers and the other stakeholders.

There was no enough information to make conclusion on the impact of CSA on food security.

Chapter 5. Conclusion and recommendation

This chapter summarizes the conclusions that can be drawn from the results and discussions in chapter 4 and proposes several recommendations for future work.

5.1. Conclusion

It can be concluded from the results above, that CSA is a variable undertaking in western Kenya alone the Nyando Basin if atleast 7000 ha of land can adopt the technology. All this land must be able to adopt the programme within the first 2 years otherwise it will not be viable. The main purpose of these funds will be to break the barriers associated with negative adoptive capacity to CSA through supporting extension services. Therefore, with carbon finance, farmers will be able overcome barriers through acquiring new technologies and be able to develop their capacities to overcoming the effect of climate change on their food production.

It is also important to note that cash incentive can only be available after CSA has met its cost of implementation and the balance is then shared out between the stakeholders. Therefore cash incentives can only be available with more than 7000 ha of smallholder farm being involved in the adoption of the CSA otherwise the money available at 7000 ha adopting will only meet the cost of implementation. This is in line with what the western Kenya VI Agroforestry CSA project has been proposing that mitigation funds alone are not sufficient to make this kind of projects viable unless at a very high scale. Because of this need VI Agroforestry focus on using 60,000 households in their project. Similar results for China show that the opportunity costs for land are much higher for smallholder farmers than those with larger areas of land. Large-scale farmers took only 1 year after introducing improved grazing management practices to achieve net positive incomes. In contrast, small-scale farmers took 10 years to achieve similar results (Neufeldt, et al., 2011). Therefore the result is not surprising.

Finally, CSA in Nyando Basin of western Kenya is viable and sustainable if adopted at a scale of more than 7000 ha by the smallholder and it will be worth the effort. Remember, the whole of more than 7000 ha must be adopted within the first two years of the programme.

5.2. Recommendation

This analysis of the potential role of carbon finance as part of a financing package for smallholder agriculture is based on analysis of the carbon revenues that might be secured from generating carbon credits or accessing funds- based carbon finance (for example through NAMAs), the costs of providing the necessary extensions services to farmers, carbon monitoring and project management, and, last but not least, the value of the agroforestry practices beyond carbon to the participating smallholder farmers. Given that this kind of mitigation is not viable until after 10th year even with CSA activities covering over 7000ha means initial financing will have to be sourced. One such source will be tapping into adaptation funds which should be able to take care of the activities for the first 10 years before breakeven period. This is an area that needs to be explored otherwise CSA may not work without pre-financing mechanism. Since this research both mitigates and adapts in nature, there is need to look at the option of being financed by both funds. A single funding system may not be adequate as indicated in the calculation.

The prices of carbon are also too low especially from land use and therefore will require other sources of funding to make it financially stable.

There is need to explore whether CSA activities needs to be capped although there is a high risk associated with its activities and whether farmers will able to keep trees and other practices for a long period of time. This is still one grey area that needs to be explored. The standards are also very general and appear unclear on mitigating activities that will need capping. Without capping AFOLU activities in this kind of a programme will be viable as early as age five and farmers will keep enjoying cash flow throughout the crediting period. CSA is considered to be supporting both adaptation and mitigation according to the FAO definition therefore it should be considered for financing through mitigation and adaptation funds.

More research needs to be done to consider how both NAMAs and NAPAs can be incorporated while considering financing CSA activities.

There is also need to consider the other activities related to CSA which are also mitigating carbon emission generally referred to as soil carbon. The study was not able to consider soil carbon but it is an area worth considering in future related research.

The other area worth looking at is the impact of CSA on food security and in general the living standard of the people implementing such activities. It is currently assumed that CSA will be able to solve the problem of food security in developing countries. It should be proved through a research work whether such an assumption is true.

The research was also not able to determine the value of other benefits associated with CSA eg Timber from agroforestry, benefit from yields improvement etc. This needs to be considered in future.

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Chapter 7. Annexes

Annex-1

Table 2 gives a summary of the questions that were addressed during the focus group discussions and the relevant tools used to gather the information.

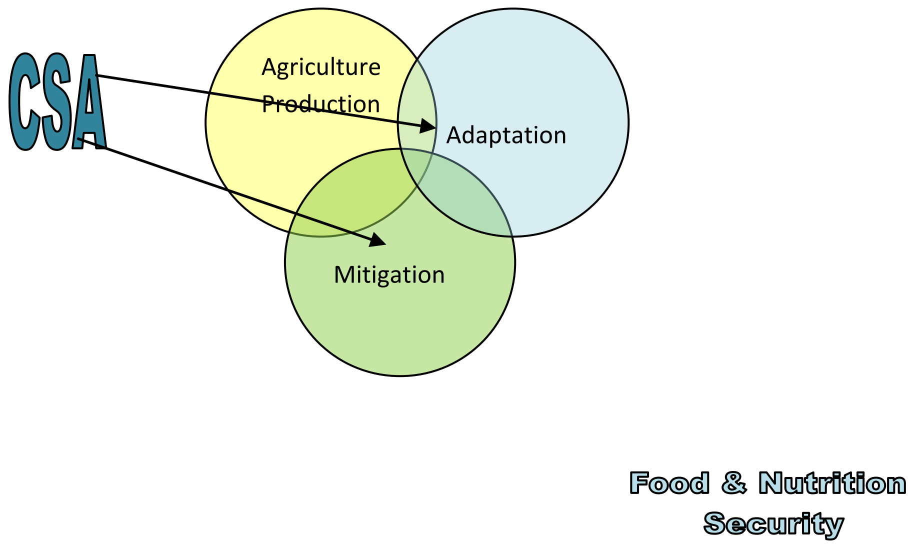
Table 2: Tools used during focus group discussions to collect information from the community members	
Questions	**Tools**
1. How are farmers rights to land defined under customary and/or statutory arrangements? What proportion of farmers land is borrowed/ rented as opposed to being owned by them and over what time period is this arrangement? Are there a significant number of conflicts over property rights, what is the nature of these conflicts, and what processes exist to resolve them (with examples of conflicts that have been successfully resolved in the last 10 years)?	Focus group discussions Trend lines
2. What are the positive social impacts that may be expected to result from this mitigation activity in the short, medium and longer term and to whom will these benefits accrue?	Economic, Social and Cultural Impact tool (Adapted from Benefits-Harms Handbook CARE)
3. What are the barriers that may limit the level of positive impacts/benefits accruing to poorer more vulnerable people, and in particular to women, and to what extent and through what strategies might these be reduced /overcome? The full of potential barriers should be explored including legal (e.g. resource tenure), political (e.g. influence over decision-making), cultural, social, financial etc.	Access and control profile Benefits analysis chart Constraints and opportunities profile
4. What other opportunities exist to enhance impacts for poorer more vulnerable people, and in particular to women	Constraints and opportunities profile
5. What are potential negative impacts/risks of this project, which social groups are likely to more affect and in what way?	Economic, Social and Cultural Impact tool (Adapted from Benefits-Harms Handbook CARE)
6. What strategies should the Research employ to avoid and/or mitigate potential risks to poorer more vulnerable groups?	Economic, Social and Cultural Decision tool (Adapted from Benefits-Harms Handbook CARE)

Annex 2

Definitions of key terms, concepts and variables

CSA mean agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes Greenhouse gases (GHGs) (mitigation), and enhances achievement of national food security and development goals (Food and Agriculture Organization (FAO)).

The increasing focus on agriculture and climate change in the development context has led to new ways of thinking. With both fields shifting from focusing on agricultural production to an expanded approach that focuses on resilient livelihoods and systems, the concept of 'Climate Smart Agriculture' (CSA) has appeared. FAO first outlined the concept in 2010, defining CSA as follows: agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes GHGs (mitigation), and enhances achievement of national food security and development goals (FAO, "Climate-Smart" Agriculture: Policies, Practices & Financing for Food Security, Adaptation & Mitigation, 2011). Figure 1 illustrates the current CSA conceptual framework.



There is growing acknowledgement that agriculture and food systems need to change, regardless of any climate change impacts. However, climate change impacts combined with high population growth rates, unsustainable agricultural practices, and high levels of land-use change, among others require significant changes in farming practices to increase productivity and, at the same time, use natural resources more efficiently and sustainably. Examples of these practices include, shifts to new crops and varieties, water and soil conservation measures and planting trees on farms. While none of these practices are new, the way in which they are framed is evolving. Ideally, agricultural production systems managed in a climate-smart way emit fewer greenhouse gases, sequester carbon, and at the same time become more productive and resilient in the face of a changing climate. CSA also advocates for a larger scale approach - expanding to a "landscape scale" where linkages within ecological systems (including linkages with human welfare) can be more effectively addressed. This expanded view also includes taking a more multi-sectoral approach. Instead of focusing on isolated issues and technologies, CSA is trying to integrate the dialogue and processes for more effective scaling up and overall landscape-level change.

Adaptation: In this expanded view, adaptation addresses not only the differential impacts of climate change but of all drivers that affect aspects of food security (availability, access, and utilisation **(storage and consumption)**), from the farmer to global level. Taking into account multiple risks and a broader scope, a focus on resilience and integration is emphasized. Adaptation is less about specific interventions/technology than it is about the appropriate process of identifying vulnerabilities and addressing them at the right levels. Within this process, adaptive capacity is the ability of a system or community to adjust to associated changes. By increasing adaptive capacity and reducing vulnerabilities, overall resilience to a rapidly changing environment defined by growing uncertainty is increased. Adaptation is therefore a process that addresses shifts in current vulnerability as well as anticipated longer-term changes and risk by increasing flexibility to manage change, uncertainty and diverse contexts, needs and priorities. Adaptation therefore implies fundamental shifts in the way institutions and actors interact, value and use different types of information, how they make decisions and evaluate and respond to risks and uncertainties.

Mitigation: There is an opportunity to access climate change mitigation finance, and specifically carbon finance, to support the scaling up of CSA. While funding is mostly from the public sector, it may, in some situations, include "market-based" carbon finance from sale of carbon credits. In large scale commercial agriculture the potential for CSA to generate carbon finance is substantial, but the same has not yet been demonstrated for small-holder agriculture where costs of accounting for carbon gains and managing carbon revenues will be higher, and there are substantial risks to farmers.

The ineligible areas are: (i) land deforested at any point in time between 2000 – 2010, (ii) large scale rice paddies and swampland (iii) large scale sugar cane belt.

According to AR-AMS0007[2] the following definitions apply to cropland and grassland:

Cropland. Arable and tillage land that contains annual and/or perennial crops and/or woody vegetation that does not impair its eligibility for AR CDM project activities.

[2] http://cdm.unfccc.int/methodologies/DB/1GB973D5DQ1XKYBG8V2R357T9RMVUI

Grassland. Rangeland/pasture-land subjected to any kind of anthropogenic exploitation that may include systems with woody vegetation that does not impair eligibility of the land for A/R CDM project activities.

Annex 3

Tree measurement data sheet

AGROFORESTRY BASELINE DATA SHEET - *START A NEW SHEET FOR EACH FIELD OR NON-CULTIVATED AREA SURVEYED*

Name:		Date:	
District:	Sector:	Farm:	
Field:		Area of field (ha):	
Survey method: plot / full survey	Plot size (if used): 0.01ha plot for all trees >7cm OR nested plots of 0.01, 0.05, and 0.1ha		
Planting system:	Elevation (m.a.s.l.):	Rainfall (mm/yr):	Soil type:
Would the area be planted without the CHDI project: yes / no	Longitude:	Latitude:	Management:
Landuse: cultivated / non-cultivated		Length of time since last cultivated (for non-cultivated areas):	

Plot number (if used)	Species	DBH (cm)	Height (m)	Planted or natural	Age of tree (if known)	Management (e.g. pruning/coppicing)	Notes