A Bottom-Up Approach in Climate Change Response in Kenya: Assessing the Benefits of Community Based Projects in Kirikoini Village, Kandara Division

By

Mercy Kariuki-McGee

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By

Mercy Kariuki-McGee

has been approved for

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By

Laurence Geri, D.P.A
Member of the Faculty

ABSTRACT

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Eastern Africa has been experiencing an intensifying dipole rainfall pattern on the decadal time-scale. The dipole is characterized by increasing rainfall over the northern sector of this region and declining amounts over the southern sector. Kenya, in Eastern Africa, will be facing the impacts of this dipole rainfall pattern. Kenya's economy is largely supported by agriculture. An unpredictable rainfall and changes in temperatures have major impacts on food production. Climate change impacts are accelerated by the factors of poverty, health issues, rapid immigration, population growth, and increased demand for food and viable sources of water.

This thesis research examines how rural communities in Kenya are dealing with these expected changes in climate by exploring the impacts on Kandara. Kandara is an agriculturally productive area. The majority of the residents in this area engage in subsistence farming which is conducted on the river banks and along several creeks running through the sloped terrain. The average farm holdings range from 2 to 10 acres.

The author of this thesis conducted an assessment of Kirikoini Village located in Kandara Sub-location regarding how small-holder farmers are coping with this rainfall dipole. A survey of 50 randomly selected farm households was conducted June 2010. All respondents indicated farming has been extremely affected by the unpredictable rainfall. Some of the respondents indicated they have shifted their farming practices to cope with the changing climate. Lack of economic stability (74%) affects the majority of the farmers who are unable to adapt.

The research further assesses potential benefits that exist for a bottom-up approach in climate change adaptation within rural communities. This assessment identifies and recommends rural community-based biogas project that would carry positive socio-economic impacts and help mitigate the effects of climate change while increasing farm productivity and reducing poverty.

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List of Acronyms and Abbreviations

AREED	African Rural Energy Enterprise Development
AFOLU	Agriculture, Forestry, and Land Use
BSP	Biogas Support Programme
CDCF	Community Development Carbon Fund
CDM	Clean Development Mechanism
CH4	Methane
CO2	Carbon Dioxide
DNA	Designated National Authority
DRC	Democratic Republic of Congo
ER	Emission Reduction
FACE	Forest Absorbing Carbon Emissions
GDP	Gross Domestic Product
GEF	Global Environmental Facility (World Bank Initiative)
GWP	Global Warming Potential
GOK	Government of Kenya
IPCC	Intergovernmental Panel on Climate Change
KES	Kenya Shillings
KIPPRA	The Kenya Institute for Public Policy Research and Analysis
MDG	Millennium Development Goals
REDD	Reducing Emissions from Deforestation and Forest Degradation
REP	Rural Electrification Programme
SDFA	Sustainable Development for All

SLM	Sustainable Land Management
SREP	Scaling Up Renewable Program
UNEP	United Nations Environment Program
UNDP	United Nations Development Program
USAID	United States Agency for International Development

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Chapter 1

1.1Introduction

According to The Intergovernmental Panel on Climate Change (IPCC), further warming of the global climate would induce many changes in the global climate system through 2100. Changes in wind patterns, precipitation, weather extremes, and sea ice will be evident. The IPCC further states that a global temperature rise of more than 2 °C compared to pre-industrial levels might result in abrupt or irreversible changes as indicated in their Emission Scenario "B1" section 3.5.3 (IPCC, 2007).

In recent decades, Eastern Africa has been experiencing an intensifying dipole rainfall pattern on the decadal time-scale (IPCC, 2007). The dipole is characterized by increasing rainfall over the eastern sector and declining amounts over the southern sector. Interannual variability of the African climate is determined by several factors. The most dominant perturbation factor causing interannual climate variability is the El Niño[1]-Southern Oscillation (ENSO) (Nicholson and Entekhapi, 1986). Eastern Africa is in phase with warm ENSO episodes, whereas southern Africa is negatively correlated with these events (Nicholson and Kim, 1997). IPCC also notes that the 1997–1998 ENSO events

[1] El Niño/La Niña
The El Niño/La Niña pattern is an irregular climate oscillation that arises from the interaction between atmospheric and ocean temperatures in the east Pacific, but that can affect temperatures and rainfall in many parts of the world.

resulted in extreme wet conditions over eastern Africa (see Appendix..10-1 and 10-2 (IPCC), and the 1999–2000 La Niña may have caused devastating floods in places like Mozambique. IPCC Modeling exercises indicate that climate change may increase the frequency of ENSO warm phases - increased warm pool in the tropical western

Pacific or reduce the efficiency of heat loss (Trenberth and Hoar, 1997; Timmerman et al., 1999).

1.1.1 Recent Historical Record

IPCC observational records show that the continent of Africa is warmer than it was 100 years ago (IPCC, 1996). Records show warming through the 20th century has been at the rate of about 0.05°C per decade with slightly larger warming in the June, July, August (JJA) and September–November seasons than in December, January, February (DJF) and March–May (Hulme et al., 2001). With the 5 warmest years in Africa all occurred since 1988 - 1988 and 1995 being the two warmest years. Records show that this rate of warming is not dissimilar to that experienced globally, and the periods of most rapid warming—the 1910s to 1930s and the post-1970s—occur simultaneously (IPCC, 2007).

According to the IPCC, a decrease in vegetation density, for example, has been suggested to result in a year-round cooling of 0.8°C in the tropics, including tropical areas of Africa. Complex feedback mechanisms mainly due to deforestation/land-cover change and changes in atmospheric dust loadings also play a role in climate variability, particularly for drought persistence in the Sahel and its surrounding areas (IPCC, 2007).

Kenya is an Eastern African country and, will face the impacts of this dipole rainfall pattern. Kenya's economy is largely supported by agriculture including crops such as coffee, tea, rice, and produce, and so is highly sensitive to elements of climate change (FAO, 2010). This is evident when examining tea and coffee farming for the export market as well as the wealth of crops grown on small-scale farms and sold in local markets for consumption throughout the country. Kenya's lack of economic development and institutional capacity makes the country among the most vulnerable (IPCC, 2007). Climate change impacts will be accelerated by the factors of poverty, health issues, rapid immigration, population growth, and increased demand for food and viable sources of water. For many generations, African indigenous people relied on indigenous knowledge to predict weather patterns. This was the basis for forming local-level decision-making in many rural communities. Such knowledge has value not only when viewed culturally, but also for emerging science and planning scenarios that can help improve conditions in rural localities. Incorporating indigenous knowledge into climate-change effective mitigation policies can help lead to the development of beneficial adaptation strategies that are cost-effective, participatory, and sustainable (Nyong et.al, 2007).

Mitigating and adapting to the impacts of climate change in Kenya demands a bottom-up approach that emphasizes reducing the vulnerability of local communities. Local communities have relied on knowledge of traditional farming and natural cycles to deal with climatic variations throughout the region, yet with predicted climatic patterns this knowledge may not be sufficient. Successful local/rural development and adaptation to climate change will require an integrated approach that considers small-scale community projects. Mitigation strategies should take into account the reduction of poverty, water/soil management, forestation/reforestation, and green-energy projects for smallholder farms.

1.2 The National Dialogue

Africa is among the continent's most vulnerable to climate change and faces a very low capacity to adapt to its impacts. There has been great consideration of impacts that will affect poor communities - such as: flood control, irrigation infrastructure, and diversification of water sources. It has been noted that climate change impacts will especially affect the Sub-Saharan region due to widespread poverty and the unique geographic climate. Climate change simulations for Africa have indicated that Africa is likely to experience (IPCC, 2007):

- Stress on agricultural and natural ecosystems due to temperature rise
- Less rainfall in certain regions which will result to shorter growing seasons

- Higher rainfall in certain regions which will increase the flood frequency
- Sea level rise in the coastal and delta regions, and
- More severe and frequent hydrological disasters – cyclones

As global initiatives on climate change continue, African countries have come together to reaffirm their stand on global climate change impacts. In 2009, the African Ministers of Environment met in Nairobi, Kenya for a special session on climate change during the African Ministerial Conference on the Environment, at this session they reaffirmed their position on global climate change policy. Africa is especially vulnerable to drought, flooding and financial crisis and it is important to set strategies to deal with the impacts of climate change. Africa's climate change priority is to implement policies that increase food security and alleviate poverty while attaining the Millennium Development Goals (MDG)[2]

In the Nairobi Declaration of 2008, the Ministers of Environment from various African countries reaffirmed the African Union's adaptation of the Algiers Declaration on Climate Change of 19 November 2008. This was in the form of a common African position and the need to speak with one voice in the negotiations process for the new legally binding global climate change regime. They

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2 The Millennium Development Goals (MDGs) are the world's time-bound and quantified targets for addressing extreme poverty in its many dimensions-income poverty, hunger, disease, lack of adequate shelter, and exclusion-while promoting gender equality, education, and environmental sustainability. They are also basic human rights-the rights of each person on the planet to health, education, shelter, and security. (i.e. eradicate extreme hunger and poverty; achieve universal primary education, promote general equality and empower women, reduce child mortality, improve maternal health, combat HIV/Aids, malaria and other diseases, ensure environmental sustainability and develop global partnership for development)

expressed concern about the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, and in particular as it relates to the social, economic, and environmental impacts of climate change in Africa. They noted that Africa contributes the least to the increasing concentration of greenhouse gases in the atmosphere, yet is the most vulnerable continent to the impacts of climate change and has the least capacity to adapt (Ministry of Environment, Kenya, 2010). They further stressed the urgent need for all countries to take action, including more stringent and legally binding emissions reduction by the developed countries. This declaration stresses the implementation of climate change programs that focus on mitigation and adaptation – with achievable sustainable development that alleviates poverty and attains the MDG.

1.3 Geography of Kenya

Kenya has an estimated 39 million people, 32.3% of the population live in urban area and 67.7% in rural areas (Kenya Census, 2009). Kenya is found on the Equator in the eastern part of Africa. Kenya covers about 582650 Km2 with 11,230 km2 of water. It lies approximately between 5 degree north and 5 degrees south and between latitudes 34 degrees and 42 degrees in the east of Africa, with the equator bisecting the country in two halves. Kenya has a unique landscape which varies across the country. It lies from sea level to approximately 5000 meters above sea level. With 2% of the landscape covered by lakes and 16% by agricultural land, 72% of the landscape is arid and semi-arid. Kenya is classified as a dry land country with less than 20% of humid environment and over 80% of dry land. Land distribution is as follows: savanna (8%), semi arid areas (14%), arid areas (36%) and very arid areas (22%). Kenya has high and medium potential areas, in the humid zone which is suitable for rained agriculture and is dominated by crop and dairy farming, occupying 31% and 30%, respectively.

Chapter 2

Literature Review

2. Analysis of commonly applied response strategies

2.1 Sustainable agriculture and Sustainable Land Management (SLM)

Climate change may pose a threat to many African countries, but it also provides a new opportunity for implementation of productive and sustainable land management practices. For many years, non-profit organizations have been working with communities in Africa to educate and implement reforestation, water resource, land management, and soil management projects. These efforts now have become more important with the predicted climate change and will help improve the economic status of many countries. Countries can now be involved in new sustainable practices such as reforestation, improved water management, integrated soil fertility management, conservation agriculture, agro-forestry, and improved rangeland management.

IPCC estimates that about 50 million additional people will be at risk of hunger by 2050 due to climate change, and they predict that these numbers could rise to 132 million additional people by 2050 and 266 million by 2080 (Actionaid, 2009).

Besides the increased human suffering this would create the cost to countries and donors in hunger management, health, sanitation, and housing would be significant. It is important to develop tools and knowledge that can help communities adapt to climate change and minimize such costs. To aid in this, IPCC have developed a framework in which SLM can be used to mitigate global emissions of greenhouse gases (GHG), especially in the sub-Saharan region. Under IPCC Agriculture, Forestry and Land Use (AFOLU) practices, Sub-Saharan Africa can play a major role in mitigating GHG emissions by sequestering carbon in vegetation, litter and soils. IPCC estimates that improved cropland and grazing land management, restoration of peaty soils, and restoration of degraded land could reduce GHG emissions by 265 Mt CO_2e per year by 2030. Afforestation in Africa could sequester 665 Mc CO_2 per year, while reduced deforestation and forest degradation (REDD) could reduce emissions by 1260 Mt CO_2e in 2030. This alone may not be the ultimate answer but it has the possibility of reducing about 6.5 percent of global GHG emissions ((based on year 2000), TerrAfrica, 2009).

For many years communities have relied on local knowledge to sustain their land, but climate change has brought new challenges. Using sustainable land management, farmers can develop techniques to both deal with the impact of climate change and adapt to projected changes in the climate. According to a report by TerrAfrica (2009), investing in soil and water conservation efforts can help deal with the impact of declining rainfall and can increase soil organic carbon. SLM practices reduce variability of agricultural production, for example, soil and water conservation, and organic agricultural practices that improve moisture holding capacity, integrated pest management, and other practices that help diversify agricultural income.

Agricultural practices contribute nearly 4% of greenhouse gas emissions annually while land use changes such as deforestation (to increase agricultural land) contributes another 19% (Actionaid, 2009). The largest contributor of agricultural induced greenhouse gas emissions are industrial agricultural practices caused by the use of pesticides and chemicals, deforestation and the burning of biomass. Since most agricultural land in Africa is owned by small scale farmers, this may not be a major concern for Africa. But the role of the African farmer is important in dealing with climate change. About 450 million smallholder farms produce 80% of the world's food and play a major role in the world's food system (Actionaid, 2009). The dipole rainfall being experienced in most parts of Africa will have a major impact on their agricultural practices. Currently there is very little attention worldwide directed to these smallholder farmers. Helping them adapt to climate change will have a global benefit in the world's food market and in curbing global emissions. Also with this premise, we cannot forget that smallholder families make up 75% of the world's poor. Developing sustainable agriculture practices with a focus towards promoting local food supply and organic-grown produce that promotes a healthy biodiversity will have a substantial climate change mitigation benefit. Effective land management tools would boost agriculture in Africa. Enabling access to water storage facilities, better sanitation, diversifying production to reduce reliance on a single crop and building community self-sufficiency through the use of seed banks, limiting the use of fertilizers and taking advantage of the rich biodiversity that surrounds these environments will increase resilience.

One of Africa's problems is lack of knowledge of potential climate change impacts. The impacts are expected to be most severe where current climate change information is the poorest, technological change has been the slowest, and the domestic economies depend heavily on agriculture. It is evident that African farmers have adapted to a certain degree of climate variability, but climate change may force large regions of marginal agriculture out of production. The agriculture sector is a major contributor to the current economy of most African countries, averaging 21% and ranging from 10% to 70% of the Growth Domestic Product (GDP) (Mandelsohn et al., 2000). Future development is likely to reduce agriculture's share of GDP. With an optimistic forecast of future development, agriculture's share of GDP could shrink to as little as 4% by 2100. Even with this scenario, several countries will still have large agricultural sectors of over 10% of GDP (Mandelsohn, et. al. 2000).

Even without climate change, there are serious concerns about agriculture in Africa because of water supply variability, soil degradation, and recurring drought events. A number of countries face semi-arid conditions that make agriculture challenging. Further, development efforts have been particularly difficult to sustain. African agriculture has the slowest record of productivity increase in the world. It is important to understand the substantial threat that climate change poses to agriculture and create an approved understanding of how to respond to agricultural impacts from climate change. There is very little research on tropical countries, and the damage of climate change is still to be known. Climate change will cause warming rapidly and beyond the understanding of African farmers. They may not have the knowledge on how to deal with these rapid changes in temperatures. Although farmers have adapted to climate change variability to a certain degree, climate change may still be catastrophic. Regions of marginal agriculture areas may be forced out of production. Large populations in Africa live in rural areas and depend on agriculture for their livelihood and are faced with possible loss of food supply due to intense climate change.

A recent study by Burke et.al (2009) examined likely shifts in crop climates in Sub-Saharan Africa under the climate change scenario for 2040. The study explored the implications of agricultural adaptation with a focus on identifying priorities in crop breeding and the conservation of crop genetic resources. Using historical climate data, maps of crops, and climate model from recent IPCC and present data, they investigated how crops will change across the African Continent. The study focused on three rain-fed cereals – maize, sorghum and pearl millet. These provide at least 30% of calories consumed in most part of Africa (FAO, 2008). The results of the studies demonstrate the importance of international cooperation on genetic resources conservation, as crucial in helping

African farmers adapt to imminent threats of climate change.

2.2. Carbon Sequestration

Carbon sequestration projects are likely to have economic and development benefits for Africa. Under the Kyoto Protocol, Clean Development Mechanism (CDM) carbon sequestration is one of the solutions that will benefit the continent of Africa; however land ownership patterns in Africa could be a huge barrier (Berninger et.al, 2009). Project tenure security is crucial and creates a barrier in Africa since a piece of land could have multiple tenures for different land use purposes, making it difficult to invest in carbon projects. Currently, the World Bank's BioCarbon Fund is the leading investor of carbon sequestration projects in Africa. Others include Global Environmental Facility (GEF), the United States Agency for International Development (USAID), the Forest Absorbing Carbon Emissions (FACE) Foundation and the European Union. Currently there are over 19 carbon sequestration projects in Africa and seven of these projects are located in East Africa (Kenya, Uganda and Tanzania). This is a good indication that investors are willing to invest in projects in Africa. Projects are located in different agro-ecological zones and have different land uses. Projects vary from rangelands, dense forests, to lake basins. Many of these projects are capable of sequestering approximately 35 million tons of CO2, and they will be able to generate carbon offsets under the provisions of the Kyoto Protocol. These carbon credit projects are worth millions of dollars and some of these projects are already selling carbon credits in international markets.

Carbon sequestration provides global benefits to the local communities and to the project investors. One of the Kyoto stipulations is that any CDM projects should achieve sustainable development within the country they are located in (Earth Trend, 2009). One of the benefits is the increase of timber and non-timber products. These provide dependable income for households while promoting environment conservation as well. One of the major problems for Africa is the loss of biodiversity due to deforestation. Implementing carbon sequestration projects will help address this concern. By investing in afforestation and reforestation projects Africa can benefit from improved water quality, decreased soil erosion, and improved land management. It is, however, noted that converting land into large plantations can have some hydrological effects on the ecosystem, according to a global study by Farely et al. According to the study, runoff reductions are greater than 75% in 1/5 of the water catchment.

Fig.1 (a) Foliage (*Source: Farley et. al 2005: Changing Runoff with plantation age)*

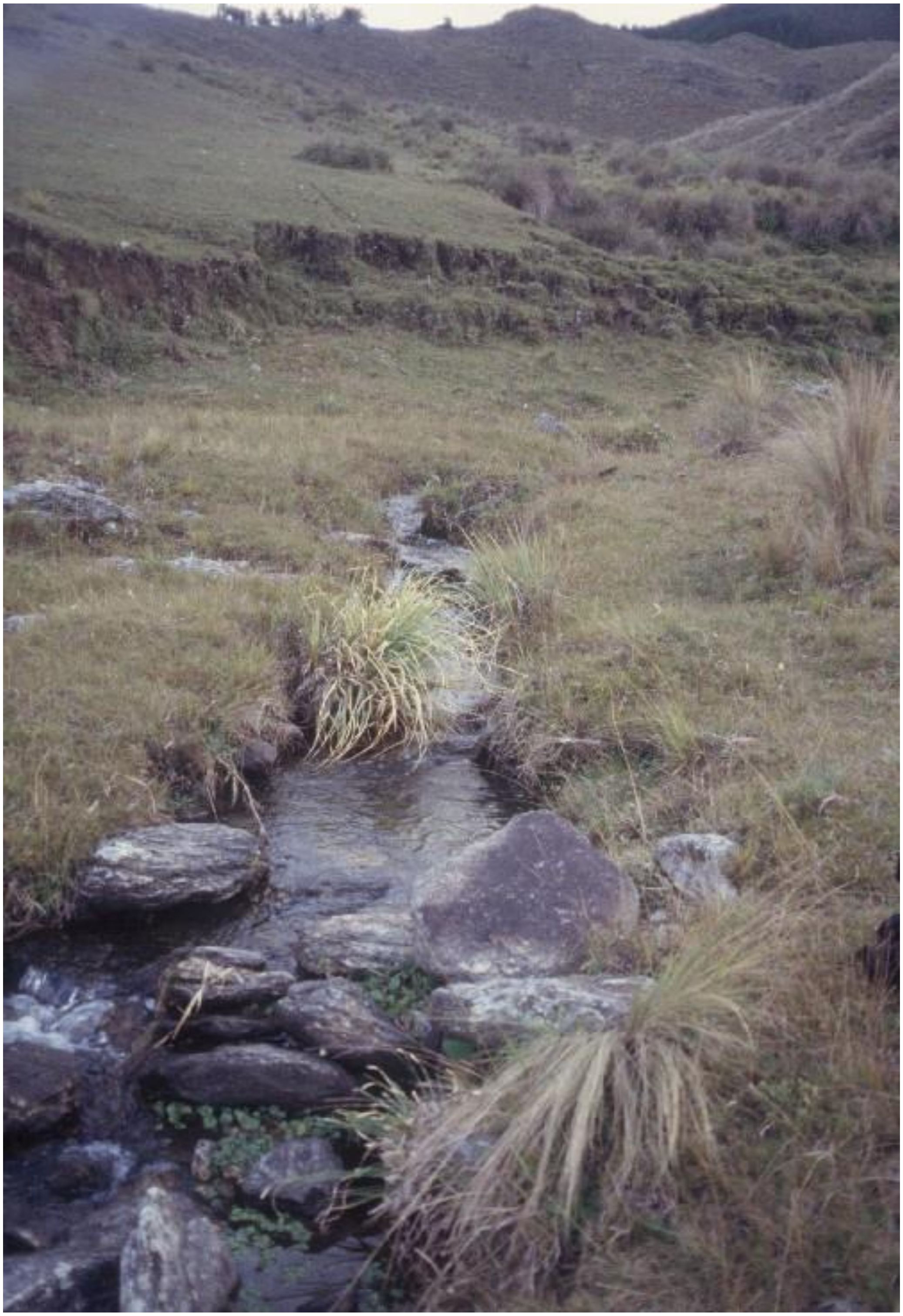

Fig. 1(b)) Source: Farley et. al 2005: Changing Runoff with plantation age

2.2.1 The cost of investing in Carbon Sequestration in Africa

Carbon sequestration projects come with high transaction costs usually from the negotiations, implementation, and monitoring of small-scale projects compared to larger projects. The cost of carbon sequestration increases when there are multiple parties involved. This is the case for most land ownership in Africa. Although most of the rural land is owned by small landholders, there are large-scale privately or government held lands that present opportunities for carbon sequestration in Africa. Carbon sequestration projects are expected to benefit the poor communities and any sustainable development should give an opportunity to the rural communities to benefit. Any carbon sequestration projects that aim to have sustainable development should involve small landowners despite the financial constraints involved. To help alleviate the high transaction cost barrier, CDM guidelines have been revised to allow the participation of small-scale carbon sequestration projects that target and benefit poor communities while still generating emissions reductions of less than 8000 tons CO2 per annum (UNEP, 2004)

Governance and institutional capacity building is important to any project implementation. Many international non-profit organizations have dedicated time and money to institutional capacity building. UNEP has made this a top priority and has initiated capacity building projects to help Africa manage and mitigate climate change impacts. UNEP's capacity building includes training government staff to be able to identify, design, and implement carbon projects. One of the

Kyoto requirements is that developing countries establish a Designated National Authority (DNA)[3] in order to promote carbon projects that align with its national development priorities that benefit local communities and support sustainable development. This has placed pressure on African governments to integrate capacity building. The political volatility of most Africa countries makes investing in carbon sequestration a risky effort for many investors. But in many cases there has been substantial improvement in economic development and skilled leadership. Through international support, many regional efforts have led to better collaboration among African countries.

2.3 Carbon Finance – A New Trend

The World Bank is always exploring new ways to help developing countries and is currently exploring innovative approaches to agricultural carbon. The World Bank BioCarbon Fund is the newest approach in mitigating global climate change. Since the year 2000, the BioCarbon Fund has directed its effort to projects that sequester or conserve carbon in forest and agro-ecosystems. This public/private initiative that is administered by World Bank, aims to deliver cost-effective emission reductions, while promoting biodiversity conservation and poverty alleviation. The Fund has two Tranches: tranche One has invested a total

[3] Source UNFCC - A *designated national authority* (DNA) is the body granted responsibility by a Party to authorize and approve participation in CDM projects. Establishment of a DNA is one of the requirements for participation by a Party in the CDM. The main task of the DNA is to assess potential CDM projects to determine whether they will assist the host country in achieving its sustainable development goals and to provide a letter of approval to project participants in CDM projects. This letter of approval must confirm that the project activity contributes to sustainable development in the country. It is then submitted to CDM Executive Board to support the registration of the project

capital of $53.8 million and tranche two invested a total capital of $36.6 million. This BioCarbon Fund purchases carbon from a variety of land use and forestry projects. The Carbon Fund portfolio includes afforestation and reforestation, and reducing emissions from deforestation and degradation.

2.4 Community Development Carbon Fund (CDCF)

The CDCF is a World Bank Carbon Fund initiative that provides carbon finance to projects in the poorer areas of the developing world. The Fund is a public/private initiative designed in cooperation with the International Emissions Trading Association and the United Nations Framework Convention on Climate Change and became operational in March 2003. This fund has two tranches and in the first tranche, CDCF capitalized $128.6 million with nine governments and 16 corporations/organizations participating in it .The CDCF supports projects that combine community development that are attributed with emission reductions to create "development plus carbon" credits, and can significantly improve the lives of the poor and their local environment. In return contributors to the CDCF support projects receive verified Kyoto-compliant emission reductions (ER) from these projects. World Bank uses parallel resources from donors to mobilize technical support assistance, capacity building, and project preparation in CDCF countries. Since these projects are directed to the developing countries, there is difficulty in attracting carbon finance due to the financial risk associated with political stability of these countries. The World Bank continues to mitigate this process to make it viable. The CDCF Fund is a good example of a bottom-up approach in mitigating climate change.

The World Bank also has funded agricultural-based carbon finance project in Kenya – one of the first of the CDCF projects. The project is based in Nyanza Province and Western Province of Kenya, with an approximately 45,000 ha of land. The projects engage small-holder farmers at a grassroots level to adapt sustainable agricultural land management practices which result in increased crop yields, farm productivity and soil carbon sequestration, as well as above-ground carbon sequestration. A second CDCF project has been initiated in the Democratic Republic of Congo (DRC). DRC utilizes the CDCF funds to replant degraded forest. The Carbon Sink Plantation project is located in Ibi village on the Bateke Plateau located 150 kilometers from the DRC capital, Kinshasa. Funds generated from the carbon sinks are used to educate children as well as provide basic health care services. The Ibi Bateke reforestation project covers over 4,200 hectares of degraded land and is estimated to absorb 2.4 million tons of carbon dioxide over the next 30 years (World Bank, 2008). These projects align with the World Bank strategy for Africa and benefit communities by improving health access, agricultural practices, education, and increased food security.

2.5 Financing and Investing in Climate Change

Although African countries contribute less than four percent of total global greenhouse gas emissions, climate change is a great challenge for Africa and voluntary contributions will not meet the demand that will be caused by the impacts of climate change. According to UNDP report (2007), adaptation costs vary with funding, World Bank's estimated to $86 billion per year in 2015, with around US$100 - $200 billion dedicated to climate change mitigation (World Bank, 2009).

African governments have made a commitment to improve the economic welfare of their countries, and have developed a framework to assist nations to end poverty and increase their economic statuses through a climate change mitigation framework. Financing sustainable practices in Africa is important and was a core discussion topic in climate change talks in Copenhagen in 2010 and continues to be a critical discussion in Durban, South Africa climate change talk in 2011.
The Kyoto Protocol included the Clean Development Mechanism (CDM) option to fund climate change mitigation projects in developing countries. Under the Kyoto Protocol countries wishing to reduce their emissions can do so through the CDM option. They can also use such projects to earn saleable emission-reduction credits that can be used to meet the Kyoto targets. CDM goals are to stimulate sustainable development while giving developed countries flexibility to reduce their emission targets, but unfortunately, it is not clear if it encourages good behavior. One problem is that it does not support primary forest protection, it only supports reforestation and afforestation – a basic concept – clear the forests and replant so you can benefit from a CDM. The projects should fund forest protection efforts such educating communities and those involved in the timber

industry why it is important to keep old forests. With the possibilities of carbon sequestration a key opportunity for African countries, this should be a primary requirement for qualifying projects but the CDM option has placed some limitation on qualifying projects.

One such limitation is the lack of a CDM option accepting projects that invest in the expansion of the electricity grid for clean energy. Since most African countries get their electricity from hydropower, solar power and biomass for electricity this creates a great opportunity for Africa. Combining the different available sources of green energy, such sources could meet 80 percent of the continent's electricity needs (IPCC, 2007). In Europe's Climate Change Action plan, they have considered taking advantage of these abundant resources and generating electricity with solar thermal technology in Northern Africa, which will mean importing it and connecting it to their grid (EIA Climate Action Plan, 2009) fortunately due to the limitation of the CDM option Africa is unlikely to be able to take advantage of such a technology. Other uncovered projects are the support of capturing methane from biomass feeds and wind power. Farmers may be able to take advantage of this growing technology, but bio-fuel has severe limitations under CDM. Plant oil only qualifies if is to be used for transportation fuel. Unfortunately, a large population in Africa does not own a car nor take any means of oil-fueled transportation. Traditionally fuel usage in Africa is largely for household energy needs such as cooking, lighting or running water pumps. Africa's priority now is to be able to meet basic human needs, which is about one tenth of the per capita energy use in the developed world. Africa needs advanced sustainable technologies such as renewable energy and efficient-clean energy saving fuel technologies to meet the growing demand for energy and especially in rural communities. The CDM option should adjust the requirement to allow the investments of such technology that meets basic human needs in Africa.

Financing climate change in Africa is a complex undertaking that requires involvement at all levels of policy making and the cooperation of the local communities. International non-profit organizations and World Bank have initiated different strategies to help finance climate change projects. And to do so local communities have to be engaged and have to have the understanding of climate change impacts. Financial institutions may not be willing to invest in projects that have high costs to prepare and administer, and are more willing to finance projects that already exist. In many developing countries investing and developing clean energy means early engagement of those who will rely on the energy or technology.

Investment barriers, political risks, and government bureaucracy may keep Africa from climate change mitigation and it may require refocusing the financing tool. United Nations Environmental Programme's (UNEP) core focus is to remove investment barriers and develop markets for renewable energy and energy efficiency – sustainable energy. UNEP sustainable energy financing is part of their overall approach to strengthen the finance element needed to carry clean energy ideas and technologies from project conception to commercial investment. UNEP is a humanitarian organization and does not finance projects but their goal is to work with banks and other financial institutions to increase their support for clean energy projects. They work on building capacities and awareness that the banks need in order to invest in sustainable energy projects. Their work compliments major sustainable energy investors such as the World Bank and GEF. It engages to create awareness and develop ways to finance sustainable energy projects. UNEP's Africa Rural Energy Enterprise Development (AREED), combines enterprise development services and seed capital to promise clean energy services and products to rural and peri-urban communities. AREED has invested $9.4 million in five countries in West, East and Southern Africa. With the World Bank taking a lead on carbon finance in Africa, there is much hope of financing climate change while boosting livelihoods and reducing poverty among rural communities.

To-date, the World Bank has initiated funding for a number of climate change projects – 19 in total - and has made Africa an integral part of their development and business strategy. In their African Action Plan, they have included the following climate change goals in these key areas:

1. *Adaptation and climate risk management* – this will focus on energy, disaster risk reduction, sustainable management of land, water and forests, coastal and urban development, agricultural productivity, and health and

social issues.

2. *Mitigation* – Most communities in Africa depend on wood for fuel, therefore it makes sense to link any mitigation opportunities with sustainable land and forest management, energy consumption and innovative development, and urban transportation. There is a huge opportunity for Africa to develop clean energy that is accessible by local communities.

3. *Knowledge and capacity development* – Uncertainties about climate change impact make policy decisions complex and magnify any trade-offs. To prepare Africa for climate change impacts, the World Bank is investing in technologies that will lead to improved weather forecasting, water resource monitoring, land use information, disaster preparedness, and technology development. The bank is committed to building capacity for risk management, planning, and coordination.

2.6 Practical Application: Analysis of a bottom-up approach of community-based project

2.6.1 Sustainable Development for All-Kenya (SDFA)

Sustainable Development for All-Kenya (SDFA) is a non-profit organization based in Kenya. It was founded in Kenya by Evans Wadongo, a recipient of CNN Heroes top ten 2010, Mikhail Gorbachev Award – "The Man Who Changed the World", and a Schwab Fellow of the World Economic Forum. SDFA focuses on rural development, renewable energy, health and education for all. SDFA created a LED solar lantern out of scrap metal that transformed the way rural community light their homes (SDFA, 2010). Solar lantern development is focused on youth and women who spend their time in their rural homes. According to SDFA 60% of rural households’ income in the sub-Sahara Africa is spent on paraffin or kerosene. Paraffin and kerosene has adverse effects on health and in particular eyesight when used under prolonged periods of time. Children in the majority of Africa households use paraffin or kerosene wiki lamps to study after dark. SDFA Solar lantern introduction in these rural households has boosted the learning experience for many children and helped initiate business ventures that benefit an entire community such bee keeping, raising poultry, fish farming and water projects. Other benefits are increased health for those vulnerable.

GHG reduction from SDFA solar lanterns project in Kenya

Table 1: SDFA Solar Lantern Total GHG reduction. Source: SDFA estimates.

Name of village	Number of lamps distributed per household	Total annual kerosene consumption per village	CO2 reduction per HH (savings)	*CO2 emission reduction per Village	CO2 reduction by 2016
Chebwai	372	678,900	4,636	1,724,406	3,207,395,160
Msalaba	463	844,975	4,636	2,146,237	4,968,537,498
Makutano	60	109,500	4,636	278,130	83,439,000
Mwamzugha	138	251,850	4,636	639,699	441,392,310
Maralal	86	156,950	4,636	398,653	171,420,790
Mwangeni	103	187,975	4,636	477,457	245,890,098
Sitian	428	781,100	4,636	1,983,994	4,245,747,160
mauche	123	224,475	4,636	570,167	350,652,398
Mukhonje	347	633,275	4,636	1,608,519	2,790,779,598
Bukhakunga	138	251,850	4,636	639,699	441,392,310
Nyaobe	122	222,650	4,636	565,531	344,973,910
Chiliva	149	271,925	4,636	690,690	514,563,678
Kaptilit	345	629,625	4,636	1,599,248	2,758,701,938
Amorii	232	423,400	4,636	1,075,436	1,247,505,760
Serem	49	89,425	4,636	227,140	55,649,178
Gisambai	34	62,050	4,636	157,607	26,793,190
Chulaimbo	78	142,350	4,636	361,569	141,011,910
Nzaikoni	123	224,475	4,636	570,167	350,652,398
Narok	129	235,425	4,636	597,980	385,696,778
Total	**3519**	**6,422,175**	**88,075**	**16,312,325**	**22,772,195,058**

*Emission factor = 2.54 kgs CO2 per liter of kerosene
Assumption- 1 lamp per family, therefore # of lamps per village = # of HHs per village
5x365=1825 litres per yr per family
1825x# of lamps = litres/yr
Total emissions of CO2 for village = total # of liters x 2.54 (emission factor)

SDFA has distributed 3,519 solar lanterns to households in 19 villages (SDFA, 2010). Total annual consumption of kerosene is 6,422,175 liters with a total of 16,312,325 tones of CO_2e emissions for all villages in the absence of solar lanterns. As shown in Table 1, based on 3519 solar lanterns supplied to rural household, the program will deliver GHG reductions of approximately 22 million tons of CO2e by 2016.

Kerosene-based lamps are the leading source of lighting for a majority of Kenyan households - 79%. In rural areas, 87% rely on kerosene-based lamps; 55% of urban residents rely on such lamps while 42% rely on electricity (GoK, 2007). The SDFA solar lamp has contributed to the elimination of kerosene-based lamps in the rural areas. The lack of electricity for lighting has serious gender-related dimensions and the continued exposure to kerosene fumes in the kitchen while cooking leads to disproportionate vulnerability of women to associated indoor pollution (GoK, 2007).

2.6.2 Nepal Biogas Support Partnership, (BSP-Nepal)

BSP-Nepal was established as a non-profit organization in 2003 to take over the implementation responsibility of BSP. BSP's key objective is to develop a donor-supported biogas program for commercial use integrated with carbon revenue to serve the Nepali rural populations. This program was formerly managed by the Netherlands Development Organization. The program is part of the Nepali government's biogas project and the first of the CDM projects in Nepal. By its fourth phase BSP has disseminated a total of 111,395 biogas plants. BSP's goal is to install a total of 200,000 small biogas digesters in Nepal (UNFCC accessed August, 20 2011). All activities registered under the CDM are renewable energy projects registered under category 1.C. Thermal Energy for the User of the Small-

Scale CDM Project (UNFCC, 2007).

The project targeted areas where households had a higher cooking fuel consumption which is determined through a household survey. Another criterion for project participation was the geographic location where households could not afford to buy firewood for fuel use in the absence of a biodigester installation. Figure 2 below shows the common design used for the BSP-Nepal Biogas plants.

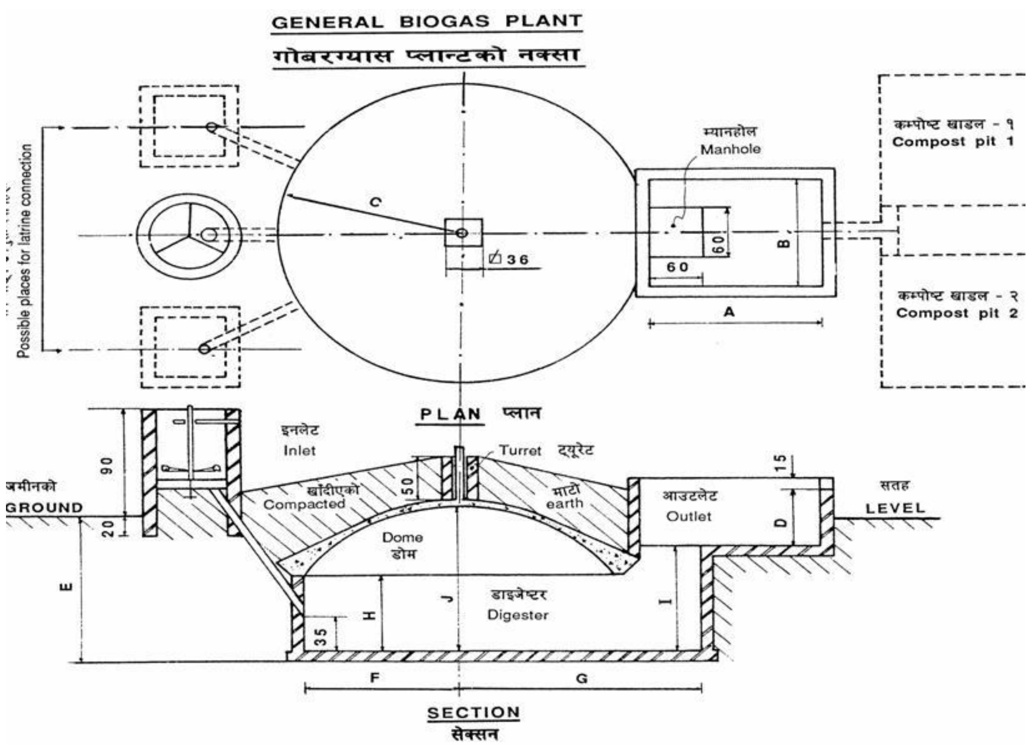

Figure 2: General Biogas Plant. Source: BSP-Nepal.

2.6.2.1 Project commissioning, Monitoring, and Registering the CDM Project

All projects were constructed and commissioned right away. First feeding of biodigester was done on large quantity of cattle dung mixed with water and feeding was done every day for constant gas production for cooking and lighting. For quality control, monitoring and After Sales Service (ASS) was done within one or two years of commissioning the plants. Monitoring of the plants is done to check the quality and functionality of the biogas plant before it is classified as a CDM project. The monitoring project is based on a random sampling of existing biogas plants database and follows a 4-tier system with 15 clusters based on 5 development regions and 3 categories of districts, Terai, Hill and remote Hill (these are geographical area). The survey was based on samples of households from these 3 geographic areas.

2.6.2.2 Specification of Baseline

The project follows a 5-step process to determine the net emissions as specified in appendix B of the simplified M & P for small scale CDM project activities.

1) Identification of baseline and project emissions sources. Table 2 shows emission sources

   determined for the project.

Table 2: Emission Source

Source: http://cdm.unfccc.int/Projects/DB/DNV-CUK1132671435.09/view

Emission Source	Baseline	Project
Fuel Use	Co2 emissions from kerosene	None
	CO2 emissions from burning unsustainable fuel wood	None
	CH4 emissions from burning of fuel wood	None
Fugitive emissions		Biogas (CH4) leaks from digester and incomplete combustion

2) Identification of emission factors

The project utilizes the IPCC tier 1[4] approach to calculate CO2 emissions from source (Kerosene, firewood and charcoal usage). After identifying the source, the next step taken is to aggregate emissions per source into standardized emission reduction factor per biogas plant per region (see BSP CDM Activity 1, pg 31-2006)

3) Identification of activities per sources

4) Calculation of emissions per sources and;

5) Calculation of emission reduction factor per plant per region

[4] A Tier 1 method follows the approach in the *IPCC Guidelines*, Section 5.2.3 (Forest and Grassland Conversion) where the amount of aboveground biomass that is removed is estimated by multiplying the forest
area converted annually to other land by the average annual carbon content of biomass in the land prior to conversion. It is assumed that the entire biomass is removed in the year of conversion. The recommended default
assumption for the Tier 1 calculation is that all carbon in biomass is released to the atmosphere through decay processes either on- or off-site.

2.6.2.3 Emission Reduction Calculation

In Project Activity 2 monitoring period August 1, 05 to July 31, 06, using an ER factor of 4.99, the projects total ER claimed for the crediting period was 46854.07 TCO2e for a total of 9,688[5] operating plants (See below). ER calculation formulas were adopted form the established CDM monitoring guideline (CDM-UNFCC Version 2, 2006) and it was based on number of plants in operation. Table 3 shows total annual reduction from project activity 2 for each geographical area.

Table 3: Total number of Plants with Different Sizes and Constructed in Different Ecological Regions in the CDM project (Project Activity 2)

Total Plants Registered under CDM					
Project Activity 2 (6/16/2004-4/6/2005					
Location	4m3	6m3	8m3	10m3	Total
Hill	1168	2961	134	91	4272
Remote Hill	42	41	1	0	84
Terrai	216	4178	847	91	5332
Total	**1426**	**7180**	**982**	**100**	**9688**

Source: Annual Emission Report for Project Activity 2 of CDM Project in Biogas Support Program of Nepal (Monitoring Period: 08/01/2005-10/19/2006)

5 For the biogas digester, ER is calculated using a standardized method for a household size biogas digester measuring minimum $3m^3$, $6m^3$, $8\ m^3$, and $10m^3$.

Table 4: Details of Emission Reduction Calculation for Project Activity 2)
(Source: BSP-Nepal Monitoring Report, 2006)

Emission Reduction Calculation for Project Activity 2							
A	**Annual Performance**						
	Crediting Period				1		
	Fiscal Year		6/1/06				
	Total Number of Existing Plants			9688			
	Annual Performance Rate			98.70%			
B	**Annual Emission Reduction Factor**						
	Annual Weighted ER Factor			8.9975			
	Applied ER Factor				4.99		
C	Emission Reduction from Augst1, 2005-31-July, 2006						
	Size/Region	Unit	Total				
	(Terai/Hills)						
	4m3 Hill	TCO2e				5842.25	
	4m3 Terai	TCO2e				1044.64	
	4m3 Total	**TCO2e**	**Total**				**6886.89**
	6m3 Hill	TCO2e				14528.25	
	6m3 Terai	TCO2e				20206.06	
	6m3 Total	**TCO2e**	**Total**				**4734.31**
	8m3 Hill	TCO2e				652.9	
	8m3 Hill	TCO2e				4096.25	
	8m3 Total	**TCO2e**	**Total**				**4749.25**
	10m3 Hill	TCO2e				43.53	
	10m3 Terai	TCO2e				440.1	
	10m3 Total	TCO2e	Total			**483.63**	483.63
	Annual ER	**TCO2e**	**Total**				**46854.0 8**

Source: Annual Emission reduction Report for Project Activity 2 of CDM Project in Biogas Support Program of Nepal CDM Project Reference No,0139 (Monitoring Period 1st August 2005 to 19th October 2006)

Based on 2008/2009 Biogas User Survey (BUS) Monitoring period 1 August 2006 to 31 July, 2009, a total ER of 95652 $TCO2e$[6] was claimed. The Nepal project showed a 20-year Financial Internal Rate of Return (FIRR) [7] of 21 percent in the Hills and 16 percent in the Terrai for and average 6^{m3} biogas system. However, the FIRR is very sensitive to the price of fuel wood.

The BSP-Nepal now it's in fourth phase has revised its target for Phase-IV to 135,000 plants (BSP-Nepal, 2010). In addition to these financial and emissions benefits, BSP-IV Phase[8] projects are expected to generate substantial other positive outcomes as shown in Table 5 and 6.

Table 5: Annual savings due to non-burning of unsustainable fuels

	Annual Reduction tons/plant	Annual savings per/litre	Annual Total GHG emission reduction
Fuel wood	345, 716		
Agricultural waster	60,500		
Dung Cake	103,700		
Kerosene		5.83 million	
Total Annual GHG emissions reduction			**1,210,000**

Table 6: Other Associated benefits

	# of household	Annual production
Bio-slurry/bio-compost	127,900	302,500
Improved sanitation	112,400	
Improved indoor air pollution	135,000	
Employment		12,000

[6] UNFCC/CCNUCC Monitoring Report Version 01 dated 01/12/2010 EB 54 Report Annex 34 page 32 biogas Support Program – Nepal (BSP-Nepal) Activity 2 – 2nd Monitoring Report (01/08/2006-31/07/2009).

[7] The FIRR is an indicator to measure the financial return on investment of an income generation project and is used to make the investment decision.

[8] Source: http://www.bspnepal.org.np/objectives

The project overall direct benefits to the farmers are:

- Improved agriculture yields and reduced use of chemical fertilizers.
- Reduced incidence of illness and expenses on health
- Avoided cost of firewood, kerosene and charcoal for house use.
- Avoided purchase of inorganic fertilizer as a result of use of the biogas slurry (bio-slurry).

Chapter 3

3. Research Objective and Methodology

Two questions are driving this research:

1) Is a bottom-up approach a viable way to mitigate the effects of climate change in rural communities?
2) How are rural communities in eastern Kenya adapting to the changing climate?

To answer these questions, the researcher first conducted the above literature review to quantify the benefits of community-based climate change mitigation. The review highlights the effectiveness, efficiency, risk, and uncertainty of environmental mitigation projects under the Kyoto Protocol Clean Development Mechanism (CDM). To examine the effectiveness of a bottom-up approach, the researcher analyzed two community projects, in Kenya and Nepal respectively. The Nepal project data were obtained from a previously published case study (UNFCC, 2010).

A random survey of fifty households in the Kirikoini Village of Kandara Township was conducted. Each household was asked a series of climate change, farming practices, and adaptability questions. The survey was conducted by two research assistants who are familiar with the area and possess knowledge of farming in Kandara Township. The survey instrument and letter of intent are attached (see Appendix 2(a) (b) (c)).

Data from the survey were analyzed to understand how the farmers are dealing with the changing climate. 50 respondents were asked a series of ten related questions as shown in the survey instrument. The answers had a degree of similarity. These answers were sorted according to the response and categorized into four groups: 1) Climate change effects on farming 2) Farmers efforts to adapt, 3) Economic stability, 4) Factors affecting farmers' ability to adapt. Data were then entered into a data sheet, and the responses analyzed to show climate change effects.

The responses from the survey have similarities and demonstrate the farm holders' reactions to the effects of climate change in rural communities in Kenya. The survey findings are broadly applicable to other communities with similar challenges in mitigating the effects of climate change. The results of this survey may be limited due to the relatively small number of households surveyed and the particular characteristics of the study area. Increasing the number of households and size of the study area would increase the validity and reliability of the data, and thus yield better results. Future surveys that target different geographic areas with a larger sample would be necessary to fully quantify benefits of a bottom-up approach to climate change mitigation.

The data gathered from the survey were analyzed and will be used to recommend sustainable mitigation projects that carry both economic and social benefits to the farmers. The results of the survey are also analyzed to determine if they satisfy the Millennium Development Goals (MDG) for Kenya.

3.1 Study area

Kirikoini Village in Kandara Division was chosen for this research because it has a great opportunity for a community carbon finance project. It is an agricultural area and the majority of residents rely on subsistence farming to support family needs, such as health, education, energy, etc. Some farmers engage in small-scale coffee farming, growing fruits and vegetables, and animal rearing. The majority of the farms are less than 5 acres. And, in most cases women and children tend the land while the men perform labor or professional work in the cities. In Kirikoini village, there is no government supplied electricity or running tap water. Communities rely on kerosene, charcoal and fuel wood for cooking and lighting needs. Water is either collected in rain barrels or fetched by women and children from the nearby river/creek. Based on the survey results, it is evident that this area has experienced unpredictable rainfall resulting in prolonged drought with fluctuating temperatures (KEMET, 2010).

3.2 Data Collection and Analysis

i) Solar lantern and biogas data

The amount of kerosene displaced by solar lanterns was based on the number of lamps supplied by Sustainable Development For All-Kenya in 2010 and daily assumption per household (Appendix 3). Annual base emissions reduction and kerosene/fuel wood saving calculations are adopted from IPCC 2007 emission factors. ER for this project is projected for a six year period. See below:

ii) Fuel Baseline calculation

a) Kerosene emission factors = 2.41 kgCo22/litre kerosene

Kerosene savings in liters per day*365*2.41 kgCO2/litre

b) Fuel wood emission factor = 1.83 kgCo2/kg of fuel wood

Calculations = fuel wood savings in kg per day* of unsustainable fuel wood consumption per hh*365*1.83 kgCO2/kg of fuel wood

3.3 Research Limitations

Conducting the quantitative research for this project in Kandara was extremely difficult. The researcher was not able to travel to Kenya to conduct the quantitative research in person. However, efforts were made to gather the data used in analyzing the effects of climate change in Kandara using reliable local resources and knowledge. These included the GOK, and other UN-funded non-profit organization analyses for current status on climate change and sustainable efforts in Kenya. The best available data on climate change impacts on Eastern Kenya are from the IPCC and other published reports. This inhibited the ability to analyze climate data specific to Kandara Township for 1997-2010, which were the years that all respondents expressed as having prolonged lack of rainfall and drought as was experienced in most parts of Kenya. The data analyzed here are based on best knowledge of the researcher and current studies/reports published. Overall, the data from the survey show that drought conditions during this period in the Kandara area were consistent with the IPCC data on the region as a whole. Still, the lack of more specific data may lead to some inaccuracy in data interpretation.

Chapter 4

4. Analysis of Climate Change effects on farming in Kandara

4.1 Background

Kandara is located in Murang´a District, Central Province of Kenya. It is one of the oldest towns in the central province, built during the colonial period, and sits on top of a hill. Kandara has a population of 274,000 (2009 census). It has a cooler climate than the rest of the country due to the higher altitude. There are two main wet seasons: long rain season (March, April and May) and short rain season (October, November). The rainfall has been unpredictable and the area has experienced climate change - shorter or no rain period during the long rainy season and prolonged rainfall in the short rain season. One of the social-economic impacts of climate change in Kandara is the lack of work for the youth due to reduced farm production which is compounded by the high rising cost of living in rural areas. Kandara, like many townships in Murang´a District, has experienced a high rate of unemployment (MDSP, 2005). Poverty caused by poor farm production and rising cost of basic living commodities and has forced young residents to migrate to the cities in search for work (MDSP, 2005)

As part of the implementation of The National Population Policy for Sustainable Development in Maragua Districts Strategic Plan (MDSP) for 2005-2010, the government identified some key issues/problems to address within the district. Some of these key goals identified are:

- Integrated population and environment concerns into all aspects of the development process
- Enhance environment, population and development
- Enhance the rights of children and their basic needs
- Improve employment opportunities for youth
- Reduce deforestation
- Reduce the rate of school dropouts

There are some disparities between females and males which creates restrictions on opportunities in this area. This disparity is very common in many African societies. Opportunities are commonly laid out in the societies' values and norms within the community. Women constitute 52% of the population and contribute 70% to 80% of the total agriculture work done and yet property ownership for women is very limited (Maragua Strategic Plan 2005-2010). These disparities are also evident in the provision of social services such as school enrollment, employment and general access to available services. There is a lack of equal gender involvement in the district in the development process of sustainable development. Women could play a major role in a bottom-up development approach.

Kandara is an agriculturally productive area and primarily contributes to the production of coffee on a small-scale for export. There are also even smaller tea and fruit plantations. The majority of the residents in this area engage in subsistence farming which is conducted along the river banks and several creeks along the sloppy terrain. The average farm holdings range from 2 to 10 acres.

The Kandara region until recently was covered with natural habitat, including dense forest land where wild animals roamed and native trees and plants survived. Like many other parts of Central Kenya, Kandara has faced a degree of desertification over the last 30 years mainly due to deforestation, overgrazing, and bad irrigation practices. These causes undermine the land's fertility and contribute to poverty in the region.

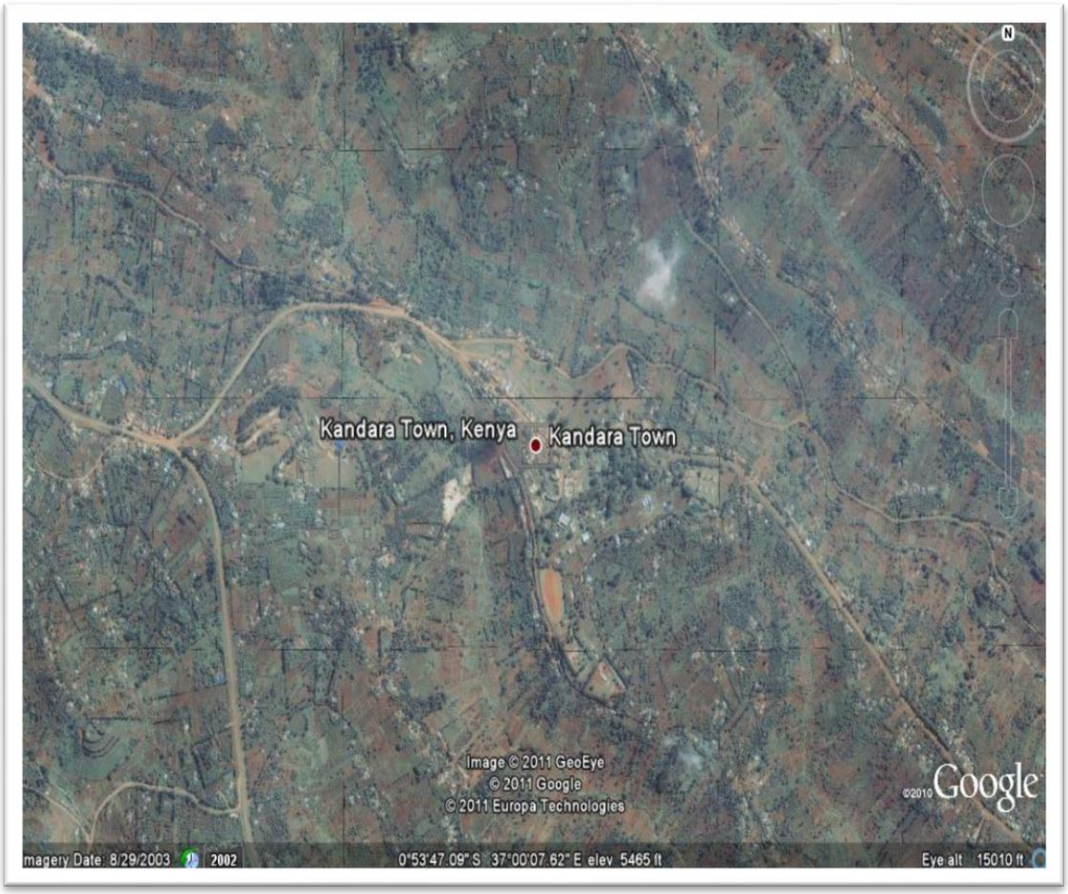

Figure 3 (a): Aerial Map of Kandara Township showing hilly terrain

Figure 3(b): Hilly Landscape

4.2 Climate Change Effect on Agricultural Farming

All 50 respondents to the project survey expressed that farming has been extremely affected by unpredictable rainfall and prolonged drought like in many other parts of the country. The unpredictable rainfall caused low food production due to early or no crop maturity. 35% of the respondents experienced livestock death due to prolonged drought in the country, while 35% have shifted to short-term and hybrid crops. Chart 1 and 2 below show the effects on agriculture and how farmers are coping with the changes in this region.

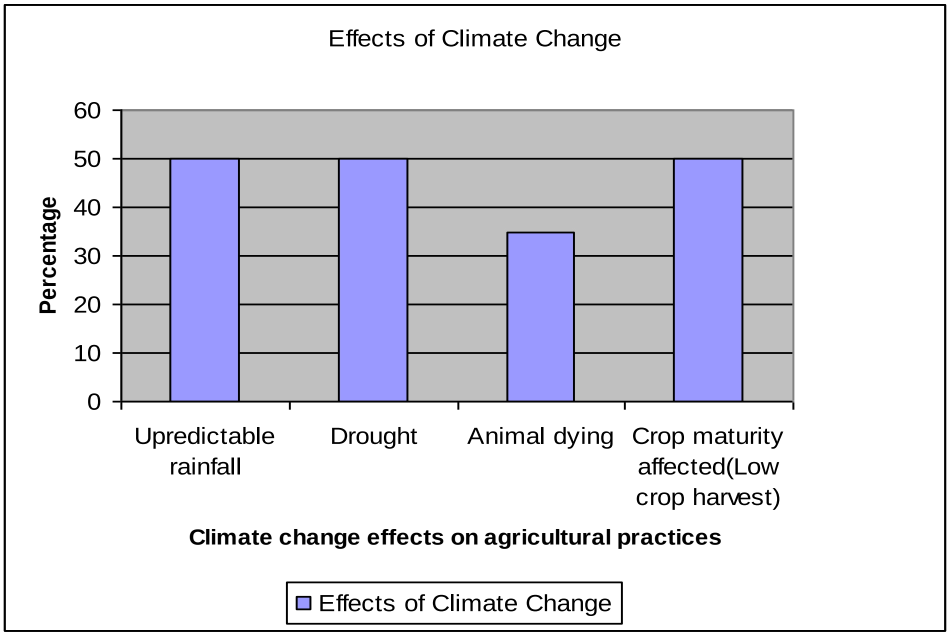

Chart.1 Climate Change Effects on Agricultural Practices. (Source: survey data).

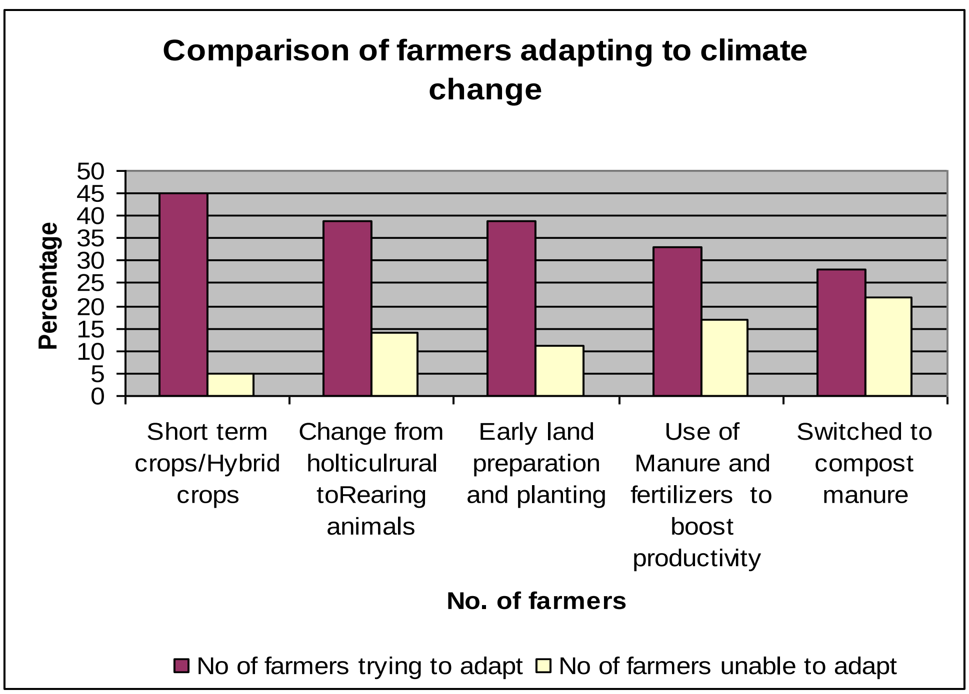

Chart 2: Comparison of farmer's adaptation method to climate change. Source: survey data.

4.3 Economic stability

74% of the respondents expressed that economic instability has major effects on their ability to adapt to the changing climate. The high price of seeds also limits farmers' ability to switch to more adaptable seed such hybrid-Crop or short-term crops. Survey data show that only 26 % can afford to do so. 43% face a shortage of land to expand their farms due to limited land space and the growing population in the area. This limits farmers' ability to cultivate new land to increase productivity of the farm.

The majority of the farmers expressed that they lacked the finances to practice sustainable farming. All farmers in Kirikoini village depend on subsistence agriculture with some small dairy farming used to generate family income. It is evident from the survey that most farmers have taken alternative steps to deal with the unpredictable climate. Although lack of finance is a big problem, 45% indicated that due to unpredictable rainfall (2004-2008) they have adapted to new farming practices to increase food production.

4.4 Recommended Community Development Project

As per the 2009 Kenyan Census, Kandara township is densely populated, and the development of friendly and affordable sustainable programs, such as renewable energy, afforestation and water resource management would help meet the district's strategic development (MDSP, 2010) Kandara rural communities rely heavily on fuel wood, kerosene, and charcoal for cooking and other energy use.

An analysis of fuel types in Kenya by urban and rural areas showed that 80% relied on Kerosene, 60% on charcoal while 55% relied on fuel wood. Due to a lack of access, connectivity and knowledge only 37% use electricity and 21% use LPG (KIPPRA, 2010). Market penetration by renewable energy (solar, biogas and wind) is very low, only 3%, 0.2% and 0.1% respectively (KIPPRA, 2010). Rural access to electricity in rural areas is only 4 per cent compared to the national average of 15 per cent (Kamfor, 2002). The cost of connecting to a grid is approximately KES.35000 (US$422 at an exchange rate of 83) about 15 US cents equivalent per kWh of electricity service (GoK, 2011). Since 1973, the Government of Kenya has been working on rural energy access through the Rural Electrification Programme (REP). One of Kenya's Millennium Development Goals is to reduce the number of people who lack access to modern energy services and live in poverty by 2015. Kenya hopes to achieve this goal through Scaling-Up Renewable Energy Program (SREP) - part of Kenya's Vision 2030 plan.

In most cases, the biomass used for cooking is usually produced unsustainably and contributes to land degradation. Thus, this quality of biomass results in higher CO_2 emissions and indoor air pollution. 1.6 million deaths occur every year because of diseases caused by indoor air pollution (UNICEF, 2005). Biomass correctly managed can be an efficient source of energy that provides quality indoor air and other direct and indirect benefits to the rural communities.

<u>Figure 4: Example of Unsustainable biomass burning</u>
Source: FAO Forestry Department/CFU000334/R.Faidutti

Kandara community presents a great opportunity for climate change mitigation through the CDCF Fund. The social-economic status of the area indicates the need for grassroots level projects that would help generate income as well as help sustain farming. The unpredictable weather has forced the majority of the farmers to abandon their land or default to unsustainable farming methods. Farmers are looking for ways to improve food production. In the past, farmers relied on the local Kandara Farmers' Cooperative Union for support in farm management and education, fertilizer supply, seed supply, and secure options for selling their farm produce. However with poor management and lack of government funding, the local union cooperative is not able to sustain the same level of support to the farmers as has been evident in the past. Initiating community-based projects that are cost-effective will boost the economy, restore sustainable food production, and help alleviate poverty in the community.

4.4.1 Recommendation - Anaerobic Digestion Pilot Project in Kandara

4.4.1.1 Background

Anaerobic digestion is a series of biological processes in which microorganisms break down organic matter with little oxygen. This system can be used for industrial or domestic purposes to manage waste and/or to generate energy. During this process the system breaks down the manure in an oxygen-free environment, it then produces a natural product, “biogas” which contains between 60 to 70 percent methane, 30 to 40 percent carbon dioxide, and a few other gases, as shown in Figure 5 (EPA, 2002).

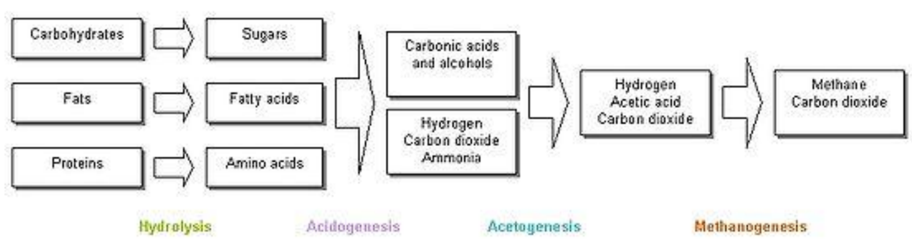

Figure 5: Anaerobic digestion: Source: http://en.wikipedia.org/wiki/Anaerobic_digestion

The system has four basic components: a digester, a gas-handling system, a gas-use device, and a manure storage tank or pond to hold the treated affluent prior to land-use application, as shown in Figure 6.

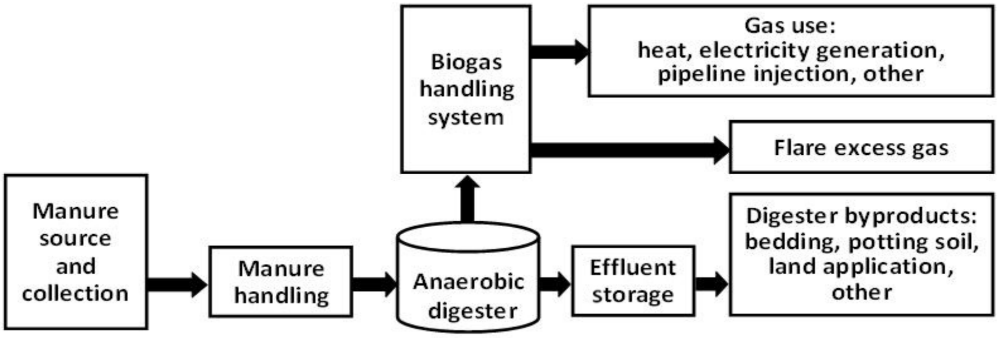

Figure 6: Stages of an anaerobic digestion system
(Source EPA 2010 - http://www.epa.gov/outreach/agstar/anaerobic/ad101/index.html)

Small Scale Biodigester

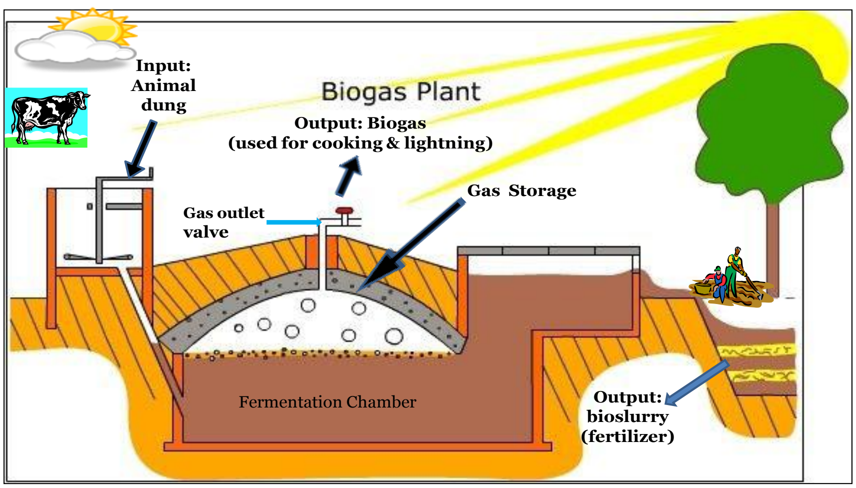

Figure 7: Sketch of Small Scale Biodigester

Anaerobic digesters reduce greenhouse gas emissions from direct methane emission reduction from the capture and burning of biogas. The graph below shows the United States biogas projects annual emission reductions, including both direct reductions and avoided emissions, resulting from anaerobic digesters *since 2000 (EPA, 2010). There are over 150 big scale biogas systems currently in operation in the United States.*

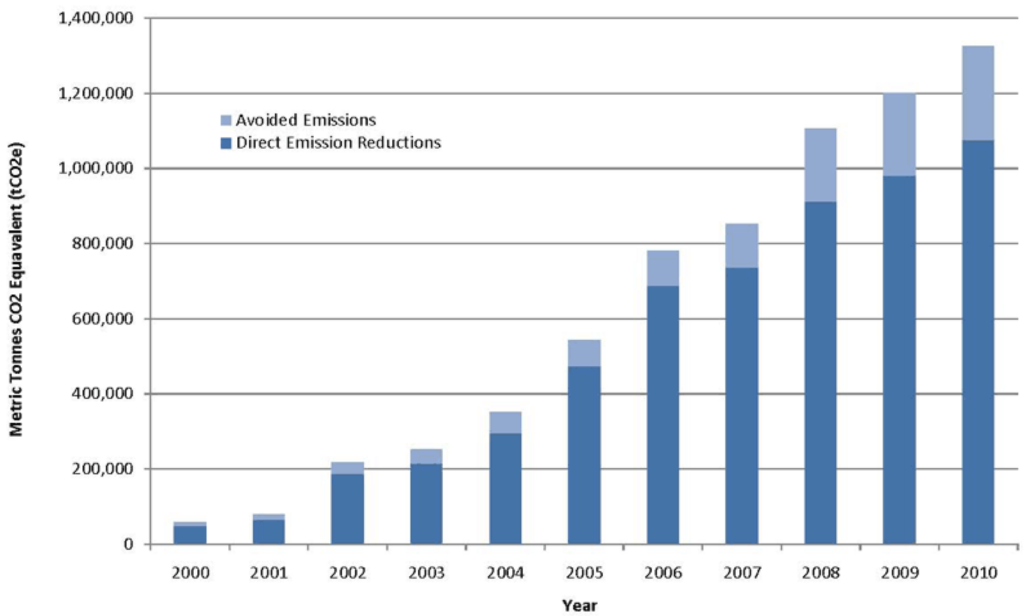

Chart 3: United States biogas projects annual emission reductions
Source: http://www.epa.gov/outreach/agstar/about-us/accomplish.html

Note: Avoided emissions calculated based on EPA eGRID national average emission rates for electricity projects and EPA's "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006" for non-electricity projects. EPA eGRID data unavailable for 2001, 2002, 2003, and 2006 so values were extrapolated based on a linear decrease from 2000 to 2004 and from 2005 to 2007. EPA eGRID data for 2007 and EPA greenhouse gas inventory data for 2006 were assumed for subsequent years as these are the most recent data available.

4.4.1.2 Estimated Emission Reduction

CO2 emission from fuel wood is calculated using the emission factors outlined under the CDM methodologies for small scale plant. CO2 emissions reduction was only considered for possible unsustainable fuel wood usage since this is the primary cooking and heating source in most families in this community.

- *Emission factors = 1.83 kgsCO2/kg of fuel wood*
- *Average daily fuel wood consumption = 6 kgs/365 days = 2190 kg per family*

- *Total emissions of CO_2 for plants = total # of kg x 1.83 (emission factor)*

Table 7: Emission Reduction for proposed Kandara Biogas project

Projected Number of biodigester to be distributed	***Total annual unsustainable fuel wood consumption kg per hh***	***CO_2 ER/ y*****	***CO_2 reduction per HH (savings)***	***Total CO_2 reduction per village by 2016***
50	*109,500*	*200,385*	*4,008*	*50,096,250*

*****1) Since the project is not implemented, the reduction is only derived from average consumption of fuel wood per day per household (in kg/day), and 2) Under real scenario, ER would be calculated using before and after installation data.***

Overall if all 50 households installed a biodigester, the estimated annual emissions reductions would be 200,385 t/CO_2e/yr.

4.4.1.3 Other gases with Global Warming Potentials (GPW) from the use of a biodigester

There are two major GHG pollutants indicated by the IPCC as significant amounts as a result of biodigester composting process:

- *Nitrous oxide (N_2O) emissions: According to the AM0025 methodology (UNFCCC 2009), two parts of the composting process are involved in emitting N_2O. During the storage of waste in collection containers as well as the application of compost, N_2O emissions have possibility for being produced and released.*
- *Methane (CH_4) emissions – Emissions are from physical leakage and incomplete*

combustion of biogas during fermentation and may be transportation of the gas.

4.4.1.4 Justification and Benefits of an Anaerobic Biodigester

A new report released by the United Nations Environment Program in collaboration with the World Meteorological Organization, proposes "a climate-change stopgap: controlling two noxious ground-level pollutants, black carbon (or soot) and ozone". The report concluded that reducing levels of these substances "will slow the rate of climate change in the first half of the 21st century," (New York Times, 2011). Black carbon or soot is from tiny black particles that come from burning fire and diesel vehicles. In developing countries the majorities of families prepare meals and heat their houses by burning wood, charcoal or kerosene. The smoke associated with burning of processed or non-processed biomass results in a high rate of respiratory disease. Small-scale anaerobic digesters can play an important role in reducing related greenhouse gas emissions from use of unsustainable fuel wood and improving human health while providing economic benefits for small scale farmers. Based on data from Kenya Bureau of National Statistics (KBS, 2010), the chart below saw the trend of respiratory sickness due to continued use of fuel wood as a source of energy in many rural and urban households. Chart 4below shows the distribution of respiratory illness by county. The average respiratory sickness in Kenya is 4.9% while in Murang'a District, where Kandara is located is at 6.3% (Kenya Open Data, accessed 2010)

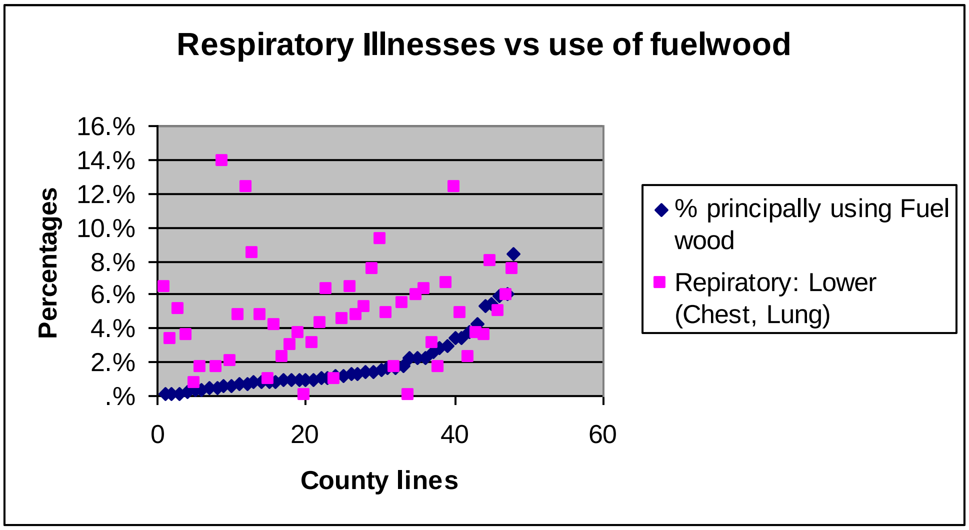

Chart 4: Respiratory Illness –vs- Use of Fuel Wood as a source of cooking
Source http://www.opendata.go.ke

Kandara is an excellent potential location for an anaerobic digester. Most farmers in Kandara own one or two cattle and engage in subsistence farming which is a prerequisite for running a biogas plant. Kerosene, charcoal, or firewood is the choice for cooking and heating the house, which makes a biogas an ideal replacement of these unsustainable fuel sources.

An Anaerobic digester would give farmers in Kandara several direct and indirect benefits.. The direct benefits are affordable renewable energy source for cooking, heating, electricity generation, and a healthier environment due to reduced emissions from these sources. The indirect benefit to the farmers will be the use of the residue that results from the fermentation process which can be used in the farm as an organic fertilizer. Other associated benefits are reduction on time and *workload of collecting fuel wood; and avoided deforestation from cutting trees for firewood or charcoal.*

4.4.1.5 Financial feasibility and acquisition of a biodigester

The survey results show that a majority of the farmers expressed financial hardships that will make it difficult to cope with any adaptation efforts or increase farm productivity. The penetration of a biodigester in the rural area will require the following:

- *upfront production costs of individual households.*
- *operation and maintenance costs of the biodigester.*
- *acquisition and handling of the substrate (feedstock), if feedstock is not located within the household compound.*
- *commitment to feeding and operating of the plant for best performance.*
- *supervision, maintenance, and repair of the plant.*
- *ability to manage storage and disposal of the slurry in sustainable way.*

The installation of the biodigester is expected to be funded fully or through partial purchase by the farmers through a micro-finance credit scheme. The cost of production needs to be determined, specifically who will bear the cost and is based on various factors:

- *location of the biogas plant and slurry storage (in most cases cows are located about 50 – 60 meters away from the house).*
- *model of the biogas plant to be introduced.*
- *biogas unit size and dimensions – for space allocation.*

- cost of materials to build the biodigester.
- labor input and wages.
- percentage of participation level and justification of benefits of associated benefits of a biodigester.

Chapter 5

5. Conclusion

Extreme weather effects – higher temperatures and variable precipitation continue to be evident throughout Kenya. This extreme weather is affecting food security. Since 1970, Kenya has observed 13 extreme weather effects (1970-2010) (GoK, 2011). Most of the farming is done in smallholder farms – 2 to5 ha, and cultivation is done using basic technology. Technology transfer and adoption will play a major role in enabling these smallholder farmers adapt to the effects of climate change. Potential land productivity will depend on good rainfall and fertile soils, but land degradation (caused by unsustainable fuel wood cultivation) coupled with unsustainable land use practices and climate change has had a major effect on food production. With 80% of the country classified as ASAL and agriculture remaining the most crucial sector in stimulating Kenya's economy, it is evident that more localized community based projects will be important to meeting Kenya's Millennium Development Goals. This paper recommends such a project, supporting investment in an anaerobic digester pilot program in Kandara, Central Province. Kenya is already preparing to invest in renewable energy (SREP, 2011). Considering a bottom-up approach will lead to successful mitigation of climate change. It will strengthen community involvement in sustainable development, allow knowledge and technology transfer in rural communities.

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Appendices

Appendix 1: IPCC - Working Group II: Impacts, Adaptation and Vulnerability: Chapter 10: Africa

Box 10-1. The 1997-1998 ENSO Event

ENSO appears to play a major role in east Africa, but it masks the perhaps more important role of the other oceans, particularly the Indian Ocean. The 1961-1962 rains were spectacularly manifested as rapid rises in the levels of east African lakes. Lake Victoria rose 2 m in little more than a year (Flohn and Nicholson, 1980). This was not an ENSO year, but exceedingly high sea-surface temperatures (SSTs) occurred in the nearby Indian Ocean as well as the Atlantic. Such high SSTs are associated with most ENSO events, and it is probably SSTs in these regions, rather than the Pacific ENSO (Nicholson and Kim, 1997), that have the largest influence on east African rainfall. In another example, the dipole pattern anticipated to occur during ENSO events did not occur during the 1997-1998 events. There was a tremendous increase in rainfall in east Africa, but intense drought conditions did not occur throughout southern Africa. The reason appears to be an unusual pattern of SST in the Indian Ocean.

Box 10-2. Drought Conditions in the Sahel

One of the most significant climatic variations has been the persistent decline in rainfall in the Sahel since the late 1960s. The trend was abruptly interrupted by a return of adequate rainfall conditions in 1994. This was considered to be the wettest year of the past 30 and was thought to perhaps indicate the end of the drought. However, by the standard of the whole century, rainfall in 1994 barely exceeded the long-term mean. Also, the 1994 rainy season was unusual in that the anomalously wet conditions occurred toward the end of the rainy season and in the months following. Unfortunately, dry conditions returned after 1994. The persistent drying trend has caused concern among development planners regarding how to cope with losses of food production, episodes of food insecurity, displacements of populations, lack of water resources, and constraints on hydroelectricity.

Appendix 2

(a) Letter to the participants

Thank you for agreeing to participate voluntarily in my research.

The purpose of this research is to understand how climate change has affected our area and the farming habits. This research will help me complete my studies in America. Please note this research is for the purpose of completion of my degree and I am not receiving any compensation for it. Any work that will be done on this research will help me get informed of the needs that exist in our community. I will be able to use the information collected to further understand how we can be more involved to ensuring that the community is able to deal with climate change effects.

Please note that I will not be offering any compensation for your participation and participation is voluntary. You do have a right not to participate and we will honor your request. If you do participate, I will share my findings with you upon the completion of my work.

I apologize that I cannot be here to talk to you directly. I have requested Euticuse Kamau, to be my research assistant with two other assistants to help me gather this information.

Your corporation is highly appreciated and I thank you for your willingness to help inform me and others of how weather has changed in Kandara.

Thank you,

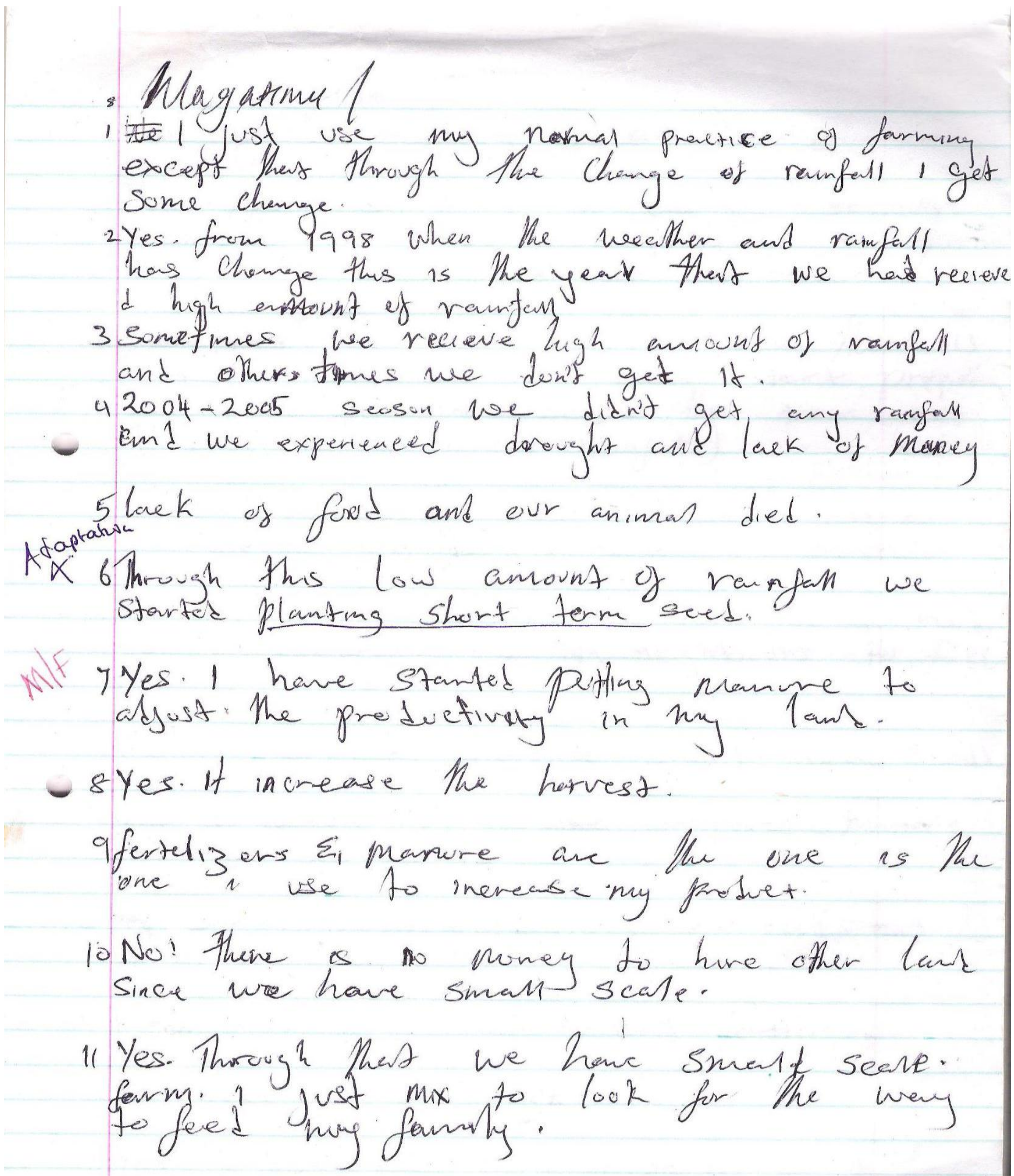
Mercy Kariuki-McGee
Graduate Student
Masters in Environment Studies
The Evergreen State College
Olympia, WA 98506
011-360-888-311

(b) Survey Questions

Questionnaires for the oral research

1) How can you describe your farming practices?
2) Have you seen changes in the amount of rainfall in the past five years?
3) Can you describe the kind of weather/rainfall that you have been receiving within the past five years?
4) What is the most severe weather you seen and when?
5) What damage have you experienced associated by the amount of rainfall or drought in recent years?
6) How have the changes in the weather affected your style of farming?
7) Have you changed the way you do things on your farm to adjust to the changing weather?
8) Have the adjustments improved your farming?
9) How do you increase productivity of the farm – do you use expensive fertilizer or do you use manure or compost?
10) Have you cultivated new land in order to increase crop yield to feed the family?
11) Do you know about mixed farming – have you been doing it?

(c) Example of farmer response


Magarimu 1

1 ~~He~~ I just use my normal practice of farming except that through the change of rainfall I get some change.

2 Yes. from 1998 when the weather and rainfall has change this is the year that we had recieve d high amount of rainfall

3 Sometimes we recieve high amount of rainfall and others times we don't get it.

4 2004-2005 season we didn't get any rainfall and we experienced drought and lack of money

5 lack of food and our animal died.

Adaptation X

6 Through this low amount of rainfall we started planting short term seed.

M/F

7 Yes. I have started putting manure to adjust the productivity in my land.

8 Yes. It increase the harvest.

9 fertelizers & manure are the one is the one i use to increase my product.

10 No! there is no money to hire other land since we have small scale.

11 Yes. Through that we have small scale farming. I just mix to look for the way to feed my family.

Appendix 3 - SDFA Number of lamps supplied in 2010

Name of village	Number Of lamps distribut-ed	Economic ventures set up	Number of beneficiaries	How long has SDFA-Kenya worked with them	Areas that have improved significantly	Direct beneficiaries
Chebwai	372	Fish farming Poultry keeping Crop farming	About 1,300 people have benefited with majority being schoo l going children	Since 2007	Education Income of people Environment Health	School going children Women Youth SDFA-Kenya
Msalaba	463	Bee keeping Crop farming	About 1,400 people have benefited from this program	Since 2007	Education Income of people Environment	SDFA-Kenya Women School children
Makutano	60	Dairy keeping		Since 2009	Income of people	Women SDFA-Kenya
mwamzugha	138	Fish farming Bee keeping		Since 2008	Education Income of people Environment	Youth Women SDFA-Kenya School children
Maralal	86	Goat keeping		Since 2010	Education	School children in the shepherd program Women
Mwangeni	103	Bee keeping Water project		Since 2008	Education Environment Income of people	Women SDFA-Kenya School children
Sitian	428	Dairy farming Crop farming		Since 2008	Education Environment Income of people Health	Women School children SDFA-Kenya Youth
mauche	123	Crop farming		2009	Education Environment	Women School children
Mukhonje	347	Poultry keeping Napier grass growing for commercial purposes		2008	Education Income of people Environment Health	Mukhonje community Women Youth School children SDFA-Kenya
Bukhakunga	138	Fish farming Dairy farming Tree nursery establishment		2008	Income of youth Environment	Youth SDFA-Kenya Community of Bukhakunga
Nyaobe	122			2010		
Chiliva	149	Sugarcane plantation		2009	Income of youth Education	Youth School children
Kaptilit	345	Dairy farming Goat keeping		2008	Income of people	Youth Kaptilit

					Education Environment	community SDFA-Kenya
Amorii	232	Fish farming Tree nursery establishment		2007	Income of women Education	Women SDFA-Kenya
Serem	49			2010		
Gisambai	34			2010		
Chulaimbo	78			2010		
Nzaikoni	123			2010		
Narok	129	Animal rearing for beef		2009	Education Environment	School children SDFA-Kenya
Manyatta**				2011		

Manyatta** we are partnering with Un-Habitat in Manyatta starting this April, where we are setting a community resource center/workshop for solar lantern assembling and other metal works for the youth in this region.

Appendix 4: Murang'a District Population Density

Area of the District by administrative units (km²). Division	Area (sq. km²)	Population	Density	Locations
Makuyu	195	58,695	299	3
Kandara	**234**	**157,141**	**672**	**6**
Kigumo	210	79,098	372	3
Maragua	200	93,666	468	5
Gatare Forest	226	-	-	-
Total	1,065	387,778	447	17

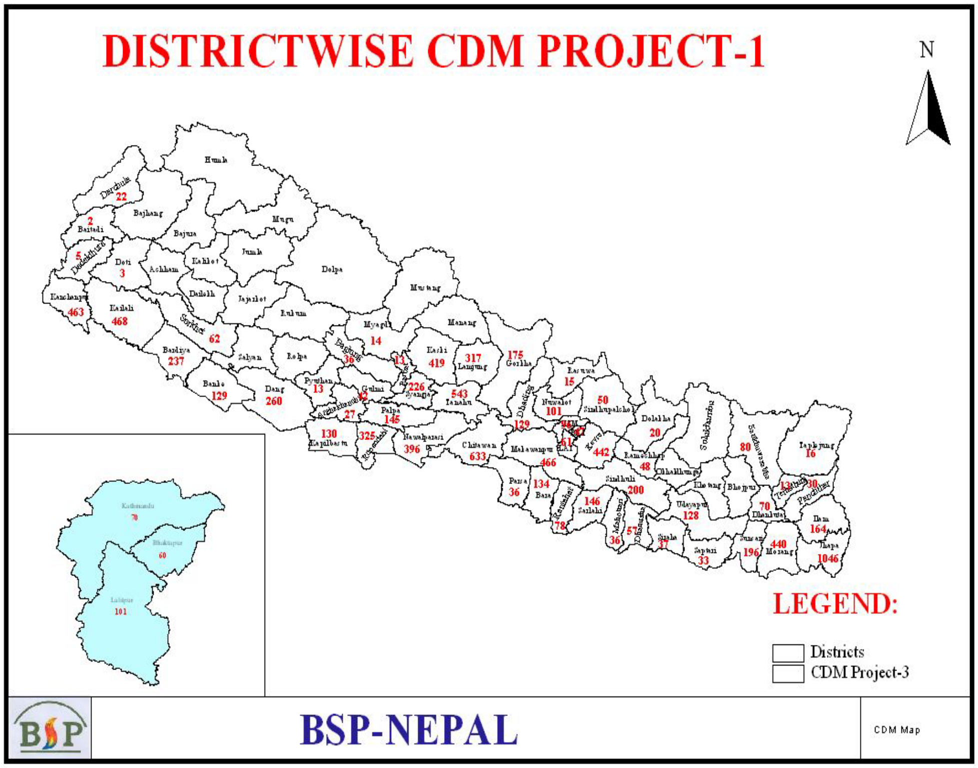
Source: District's Statistics Office, Maragua, 2001

Appendix 5:   Kenya Respiratory Illness –vs- Fuel Wood Use per county

County	% principally using Fuel wood	Respiratory: Lower (Chest, Lung)
Nairobi	0.10%	6.40%
Mombasa	0.14%	3.30%
Wajir	0.17%	5.10%
Mandera	0.23%	3.50%
Garissa	0.37%	0.70%
Busia	0.41%	1.70%
Bungoma	0.45%	4.50%
West Pokot	0.50%	1.70%
Kilifi	0.56%	13.90%
Vihiga	0.62%	2%
Kakamega	0.72%	4.80%
Turkana	0.77%	12.30%
Kiambu	0.79%	8.40%
Kwale	0.82%	4.80%
Migori	0.82%	0.90%
Trans Nzoia	0.85%	4.10%
Siaya	0.89%	2.20%
Kisii	0.94%	3%
Tana River	0.94%	3.70%
Nyamira	0.96%	0%
Kisumu	1.00%	3.10%
Homa Bay	1.01%	4.30%
Kajiado	1.05%	6.30%
Uasin Gishu	1.17%	1%
Marsabit	1.19%	4.50%
Nandi	1.25%	6.40%
Narok	1.36%	4.70%
Isiolo	1.37%	5.20%
Samburu	1.39%	7.50%
Elgeyo Marakwet	1.49%	9.30%
Kenya Average	**1.62%**	**4.90%**
Kericho	1.70%	1.70%
Baringo	1.72%	5.50%
Nakuru	2.26%	0%
Taita Taveta	2.30%	5.90%
Murang'a	**2.31%**	**6.30%**

Cont..d….Kenya Respiratory Illness –vs- Fuel Wood Use per county		
Machakos	2.64%	3.10%
Bomet	2.83%	1.70%
Kitui	2.92%	6.60%
Embu	3.43%	12.30%
Kirinyaga	3.47%	4.90%
Makueni	3.75%	2.20%
Nyeri	4.28%	3.70%
Lamu	5.29%	3.60%
Meru	5.50%	7.90%
Laikipia	5.94%	5%
Nyandarua	6.01%	5.90%
Tharaka nithi	8.42%	7.50%

MAPS



<u>Fig. 8 BSP-Nepal project Boundaries</u>
Source:
http://cdm.unfccc.int/filestorage/A/4/N/A4NYD8EXQY928HD61LHWHEIM82MBIN/PDD%20Nepal%20Biogas%20Project%20Activity-
1%2022%20%20NovemberFINAL%20SM.pdf?t=TGp8bHdsOG8xfDBQAPAOuDbysG3DVf8rhNDh

Figure 9: Map of Kenya
Source: http://www.state.gov/r/pa/ei/bgn/2962.htm

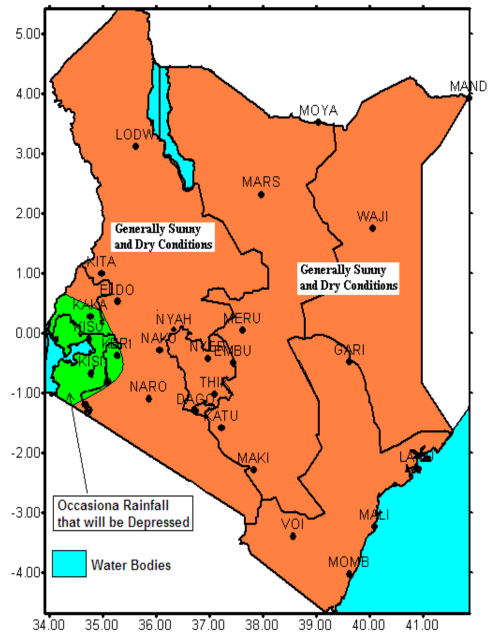
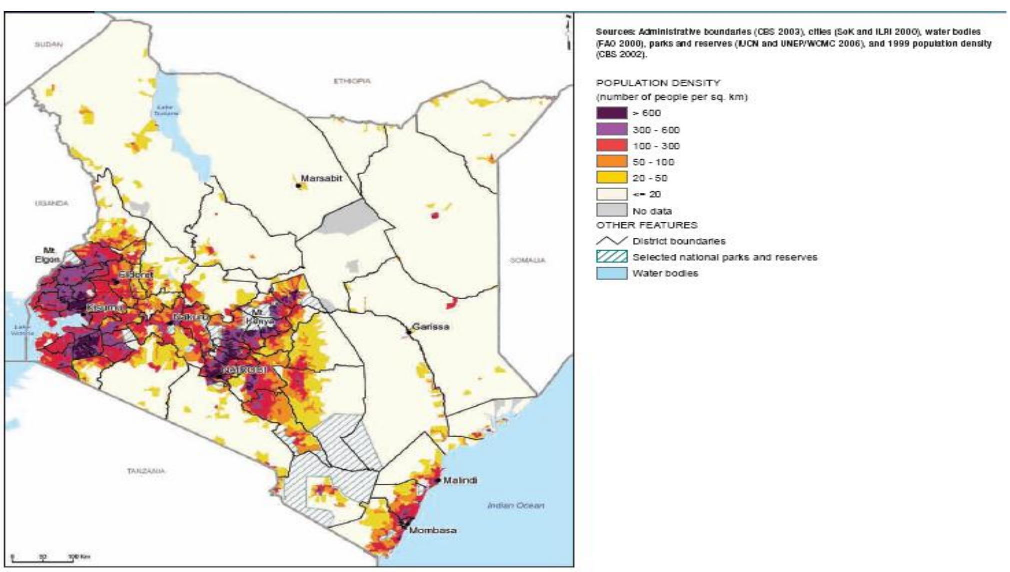
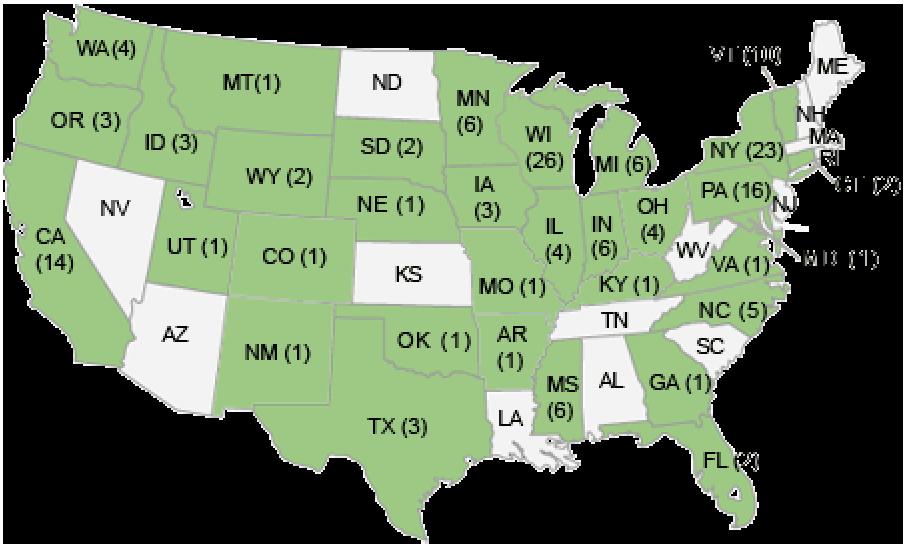


Figure 10: Kenya January-February, 2009 Rainfall Forecast
Source: KMET



<u>**Figure 11: The population density of Kenya (2002)**</u>
Source: http://www.unep-unctad.org/cbtf/publications/Integrated%20Assessment%20of%20the%20OA%20Sector%20in%20Kenya.pdf



<u>Figure 12: USA Biogas Projects</u>

Source: http://www.epa.gov/agstar/about-us/accomplish.html

(Total farm-scale projects: 152, Total regional/centralized projects: 10)