United Nations
Economic Commission for Africa

An Assessment of Agricultural Sector Policies and Climate Change in Kenya:

Nexus between Climate Change Related Policies, Research and Practice

Final Report

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ACRONYMS

ADB	Africa Development Bank
AgGDP	Agricultural Gross Domestic Product
AI	Artificial Insemination
ASCU	Agriculture Sector Coordination Unit
ASDS	Agriculture Sector Development Strategy
AUC	Africa Union Commission
CAADP	Comprehensive Africa Agriculture Development Programme
CAIS	Central Artificial Insemination Station
CBO	Community Based Organization
CCAFS	Climate Change, Agriculture and Food Security
CCCU	Climate Change Coordination Unit
CDM	Clean Development Mechanism
CGIAR	Consultative Group in Agricultural Research
DVO	District Veterinary Officer
EADD	East Africa Dairy Development
EfD-K	Environment for Development Initiative in Kenya
FAO	Food and Agriculture Organization
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
GHGs	Greenhouse gases
GoK	Government of Kenya
HIV	Human Immuno-deficiency Virus
HPI	Heifer Project International
HYV	High Yielding Varieties
IFPRI	International Food Policy Research Institute
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forest Research Institute
KEPHIS	Kenya Plant Health Inspection Service
KIPPRA	Kenya Institute for Public Policy Research and Analysis

KNAIS	Kenya National Artificial Insemination Station
MDG	Millennium Development Goal
MEMR	Ministry of Environment and Mineral Resources
MoA	Ministry of Agriculture
MoLD	Ministry of Livestock Development
MTP	Medium Term Plan
NARS	National Agricultural Research System
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
NPBM	National Performance and Benefit Measurement
PRI	Policy Research Institutes
R&D	Research and Development
ROP	Rural Outreach Programme
SDCP	Smallholder Dairy Commercialization Programme
SRA	Strategy for Revitalizing Agriculture
SRES	Special Report on Emission Scenarios
SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
WTO	World Trade Organization

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Executive Summary

Agriculture is essential to the economy of Kenya. Kenya's agricultural system faces a rapidly growing challenge: the need to protect food security and agricultural resources from the negative impacts of climate change. Already food systems are being affected by extreme weather events including historic droughts which are leading to threats to livelihoods of smallholders. Farming is dominated by smallholders reliant on rainfall. Sluggish growth in the agricultural productivity translates to slow overall growth and generally low per capita income levels. Ensuring an expanding and secure food supply capable of meeting the challenges of climate change requires more resilient crops and agricultural production systems.

Unfortunately, agricultural resilience policies are plagued with several inadequacies. Kenya's Agricultural Development Strategy has included climate adaptation as a priority, but the agricultural components of the NCCRS provide more details on prioritized activities. The NCCRS recognizes that current government institutions are inadequate to handle complex challenges of climate change needs including research. To meet the needs of climate change a Climate Change Secretariat has been established within the MEMR to coordinate climate change activities across sectors. In addition Climate Change Units have been established within the relevant government ministries, including the Ministry of agriculture (MoA). The mandate of the MoA Climate Change Unit is to act as a knowledge broker to support the mainstreaming of climate change into all of the Ministry's projects and programs. The unit will also be involved in the development and implementation of policy on climate change in agriculture, the development of programs and projects, coordination and partnership building with relevant stakeholders and the mobilization of resources for these 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. 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 programmes. Arguably, existing technologies are adequate if uniformly diffused and applied and if socio economic obstacles such

as poverty are overcome. But even in the most ideal circumstances, diffusing existing technologies and practices is not enough to address the challenges faced by the country.

With the on-going climate change and climate variability, Kenya must adopt policies and strategies that will make agriculture sector climate resilient, more productive and sustainable. In light of this, we propose several solutions. In particular, we argue that the critical game-changing solutions for building agricultural resilience will come from expanding innovation and the adoption of next generation crops and agricultural practices. We need new and improved crop varieties that use less water, deliver increased yields, improved nutrition and withstand extreme heat and drought.

Our key findings are summarized as follows:

The agricultural sector in Kenya is highly exposed to climate change and climate variability, as farming activities directly depend on climatic conditions. Effective policies that balance between increased productivity, while taking into account that agriculture is dominated by the poor are required.

Although the playing field for inclusivity has expanded, there is still a lack of coherence in national policy framework on climate change research giving room to powerful private sector actors to dictate agricultural innovation agenda in the country.

Most of the research in agriculture focuses on technical fixes to increase output and crisis management solutions to climate change in the agricultural sector.

Many actors in the sector are strategically placing themselves as climate change champions in order to benefit from the anticipated climate funds.

There are several potential adaptation and mitigation strategic interventions to address gaps in agricultural production largely from international NGOs. These include:

- Promotion of the creation of weather based insurance scheme for crop and livestock production;
- Promotion of conservation agriculture to ensure efficient use of water resources through drip irrigation, water recycling, and reuse, mulching and appropriate land-use techniques etc,;

- Promotion of appropriate irrigation technologies suitable for different agro-climatic regions and sensitive to ecological systems;
- Facilitation of the enhancement of farming systems that encourage crop diversification, including the cultivation of more drought-tolerant food crops such as millet, sorghum and sweet potatoes.
- Beyond the above "quick fixes", Kenya needs advanced agricultural innovation, including the development of and deployment of next generation transgenics to meet the growing challenges of food security and climate change. Advanced crop varieties are needed to meet these challenges by creating improved crops with greater resilience to climate change and climate variability.

Finally, we outline some specific policies that should be implemented domestically in order to create a more robust agricultural innovation ecosystem capable of producing next generation crop technologies needed for food security and meet climate change and climate variability challenges. These policies are:

Increased public investment in advanced agriculture innovation

Over time, private investments in agricultural innovation have increased, while public investments have either declined or stagnated. As a result agricultural research has shifted to near end product development ignoring early stage research capable of generating new technology platforms. The government needs to reverse this trend.

Reform regulatory research environment

Policy changes must be made to improve the efficiency of agricultural research. Regarding the types of regulatory reforms needed to boost innovation and accelerate much needed breakthrough crops into the markets.

Strengthen centres of Agricultural Innovation Excellence

Regional cooperation is needed to advance and deploy innovative and adaptable agricultural technologies. Agricultural stakeholders must work together to speed the development and deployment of next generation crop and animal production technologies.

1.0 Introduction and Objectives

Since *Thomas Malthus' 'An Essay on the Principle of Population'*, policy makers have debated the challenges of feeding a growing and changing global population, (Ola Linner 2003). Climate change and climate variability are the latest challenge, and potentially the most dangerous. According to the United Nations (UN) and Food and Agriculture Organization (FAO) and the World Bank, the goal of modern agriculture policy is to produce a global state of food security, (Schmidhub and Tubiello, 2007). This is already a great challenge. Global climate change is set to further destabilize the global food security situation, demanding new policy frameworks that directly address all aspects of the problem.

Agriculture is the most important sector in sub Saharan Africa (SSA) and it is set to be hit hardest by climate change. Climate change, with its effects on temperature and precipitation, threatens this important economic activity. Small-scale farmers that dominate the sector and derive their livelihoods from agriculture are reliant on rainfall. These farmers face the challenges of land degradation, poor soil fertility management, and continuous cropping. Sluggish growth in agricultural productivity translates into slow overall growth and general low per capita income levels. Kenya is one of the SSA countries in which agriculture is the backbone of the economy. The adverse impacts of climate change on agriculture are unmistakable in Kenya. Hence the performance of the sector has a significant effect on national output and corresponding income and poverty levels. The sector is vital to the country's socio-economic security. Climate change and climate variability will cause substantial welfare losses, especially for small holders whose only source of livelihood is agriculture. There is need for the nation to neutralize the potential adverse effects of climate change if welfare losses to this vulnerable segment of society are to be avoided.

Taking cognizance of the challenge posed by climate change, the United Nations Economic Commission for Africa (UNECA) in collaboration with Africa Union Commission (AUC) and the Africa Development Bank (ADB) commissioned this study under the ClimDev-Africa program. The ClimDev-Africa program supports Africa's response to climate change and climate variability by building technical capacities and providing policy support. The programme conducts policy reviews and policy analysis in key sectors with a view to identify opportunities

for climate resilient development as a result of climate change and climate variability. In particular the nexus between agricultural policies, research and practice is a key determinant of resilience of the sector to climate change and variability. With the on-going climate change and associated climate variability, African countries must adopt policies and strategies that will make agriculture sector climate resilient, more productive and sustainable.

This report summarizes the findings of a recent study that focused on the links between agricultural research and climate change as documented in the policy arena in Kenya. The overall objective of the study was to assess the extent to which the agricultural sector policy integrates with climate related agricultural research to influence agricultural practices in Kenya. Assessment also focused on the effectiveness of policy to mobilize resources for both domestic as well as resources available under various international climate financing.

Specific sub –objectives of the study included the following:

- Document the macro and micro economic aspects of the agricultural sector, particularly contribution to GDP and economic growth, trade and foreign exchange balance, national food security, poverty reduction and improvement of livelihoods;
- Assess qualitatively the country's climate change policy in the agricultural sector and how the policy development process is informed;
- Analyze the extent to which agricultural research influences climate change policy and vice versa? In particular whether agricultural research addresses aspects of climate change and climate resilience for the agricultural sector;
- Document how agricultural stakeholders (small holders, NGOs, private sector) inform and influence agricultural policy. Does the country have a mechanism to address issues of climate change that links policy, research and practice; and
- Draw lessons that may be useful in the design and implementation of future climate change research policy coherence in the agricultural sector.

This report traced the role of the agricultural sector both at the macro and micro-level; reviewed climate change policies in the country and how they specifically related to the agriculture sector and the extent to which current research agenda in the agriculture sector

incorporated the challenges posed by climate change and climate variability. The report also reviewed the extent to which agricultural policies in Kenya were informed by climate change related research and vice versa and consequently the extent to which these policies influenced practice on the ground. Finally, the report addressed the implications of the findings for the future and attainment of the goals of low carbon climate resilient agriculture.

We identify the following key findings:

The agricultural sector in Kenya is highly exposed to climate change and climate variability, as farming activities directly depend on climatic conditions. In addition the sector also contributes to the release of GHGs to the atmosphere. Effective policies that balance between increased productivity and reduction of GHGs, while taking into account that agriculture is dominated by the poor are required.

Although the playing field for inclusivity has expanded, there is still a lack of coherence in national policy framework on climate change research giving room to powerful actors to influence and direct climate change agriculture agenda in the country.

Most of the research in agriculture focuses on technical fixes to increase output and crisis management solutions to climate change in the agricultural sector.

Many actors in the sector are strategically placing themselves as climate change champions in order to benefit from the anticipated climate funds.

There are several potential adaptation and mitigation strategic interventions to address gaps in agricultural production largely from international NGOs. These include:

Promotion of the creation of weather based insurance scheme for crop and livestock production;

Promotion of conservation agriculture to ensure efficient use of water resources through drip irrigation, water recycling, and reuse, mulching and appropriate land-use techniques etc,;

Promotion of appropriate irrigation technologies suitable for different agro-climatic regions and sensitive to ecological systems;

Facilitation of the enhancement of farming systems that encourage crop diversification, including the cultivation of more drought-tolerant food crops such as millet, sorghum and sweet potatoes.

Beyond the above ”necessary options”, Kenya needs advanced agricultural innovation, including the development of and deployment of next generation transgenic to meet the growing challenges of food security and climate change. Advanced crop varieties are needed to meet these challenges by creating improved crops with greater resilience to climate change and climate variability.

This report is structured as follows. Section 2 details the methodology followed in the production of this report. The role of the agricultural sector to the Kenyan economy is documented in section 3. Section 4 reviews the literature on various policy documents on climate change and agriculture. The section also analyzes the extent to which climate change is integrated in these policy documents. We then highlight the agricultural research environment, including the impediments to innovative agricultural development in section5. Section 6 explores existing technologies in the agricultural sector and how those are translated into practice and action. Finally, Section 7 concludes and draws implications.

In essence, to effectively deal with the challenge of climate change, research evidence has to influence agricultural policies to come up with the appropriate adaptation strategies. Conversely, agricultural policies require mainstreaming of Climate Change in the implementation of programs within the sector. Furthermore to make real impact on the lives of smallholder farmers, the said national agricultural policies must influence practice on the ground.

2.0 Approach and Methodology

The study was carried out in four phases: -

(i) Phase I: Literature review
(ii) Phase II: Inception;
(iii) Phase II: Data Collection and Synthesis
(iv) Phase III: Feedback and Finalization.

Under each phase several activities were undertaken and outputs generated as summarized in Appendix 1.

To understand the progress made thus far and the challenges experienced in tackling climate change in Kenya's agricultural sector, as a first step we undertook a review of existing literature on climate change in Kenya. The literature served the following purposes:

- To identify the key actors working on agriculture and climate change in Kenya expound on their roles for the selection of key actors for interviews;
- It provided information on the current policy initiatives on climate change as well as understand the policy context and the main drivers; and
- Identify the key themes and narratives shaping the discourse on climate change and agriculture in Kenya.

2.1Inception phase

An inception meeting was held with the representative of UNECA/ADB to discuss the assignment and responsibilities of the EfD-K/KIPPRA team. Discussions were also held on the survey tools and approaches to be used in implementing the study. The key actors and institutions in the climate change and agriculture realm were identified and agreed upon based on the literature review.

2.2 Data collection and synthesis phase

Qualitative/quantitative approaches were applied in collecting and collating data. A further literature review was also undertaken to synthesize information available from various policy documents and research. The technique used in each approach is summarized in Table 1 below:

Table 1: Survey methods techniques

Approach	**Techniques**
Literature review research	Review of policy documents and other relevant materials.
Qualitative/quantitative Research	In depth interviews with various institutions dealing with agriculture and climate change at the national level and in four regions in the country; coast, central, eastern and western Kenya

Source: Authors, 2013

The survey tool that was used for the study is shown in appendix 2. The survey tool was used to collect information from a wide range of institutional experts (see list of individuals interviewed and their institutional affiliation in Appendix 3). The literature survey constituted reviewing current and past documents related to climate change and climate variability in Kenya.

The qualitative research phase involved the use of in-depth interviews using the survey tool. In-depth interviews entailed one-on-one discussions with institutional respondents. The information generated from the interviews was recorded. Every effort was made to ensure that the key stakeholders were covered during the study in particular those involved in actual implementation of agricultural programs.

Analysis was conducted based on the interviews and the results were documented as the first draft of this report. The findings were used as a basis for discussion with stakeholders in a validation workshop that was held in Nairobi, in November 2013. The objective was to validate and offer key stakeholders in the agricultural sector working with climate change opportunity to contest the findings, and to discuss the implications for policy and practice of the findings. The key actors were in agreement with the broad thrust of the findings. Where there were disagreements, clarifications, these were noted and have been incorporated in this report[1].

[1] For instance, during the prior literature review there was no discussion of the 2nd Medium Term Plan 2013-2017.

3.0 Role of Agricultural Sector in the Economy

Agriculture is a central sector of the Kenya's economy. The sector contributes about 25 percent of the Gross Domestic Product (GDP) and another 25 percent indirectly (GoK, 2010). The sector is the main contributor to Kenyan exports accounting for about 65 per cent of Kenya's total exports. It is therefore a major foreign exchange earner for the country. The sector also provides employment to a large section of the Kenya's population. According the Agricultural Sector Development Strategy (ASDS) agriculture sector and provides more than 18 per cent of formal employment and more than 70 per cent of informal employment is in the rural areas (GoK, 2010).

The agricultural sector comprises six subsectors that include; industrial crops, food crops, horticulture, livestock, fisheries and forestry. According to GoK (2010), the industrial crops contribute 17 per cent of the AgGDP and 55 per cent of agricultural exports. Horticulture, is currently the largest subsector, contributing 33 per cent of the AgGDP and 38 per cent of export earnings. Food crops contribute 32 per cent of the AgGDP but only 0.5 per cent of exports, while the livestock subsector contributes 17 per cent of the AgGDP and 7 per cent of exports. In general the full potential of the agricultural sector remains underutilized. In particular, the livestock and fisheries subsectors have huge potential for growth that has not been exploited.

The agriculture sector is the primer for industrialization; it supplies the raw materials for industries, for instance timber for the paper manufacturing industry, skin and hides for the leather industries, raw food stuff for the food processing industry etc. Furthermore, the sector is also a market for the industrial goods such as machinery, equipment, fertilizer and other agro-chemicals that are used in the farming process. The sector has strong backward and forward linkages to the rest of the economy. It promotes and creates many off-farm service activities such as transportation and supply chains for agricultural inputs. It provides many employment opportunities along the various value chains; from production, processing, wholesaling, and retailing to final consumption.

In addition, the sector generates foreign currency through export process of agricultural products. It creates a source of employment to the population through farming, business, industrial processing and research activities. The purchasing power of the population is

improved through income generation, hence creating a market for industrial products.

3.1 Agriculture and economic growth

Agricultural sector is the major driver of the overall economic growth in Kenya. Available statistics clearly show that growth of the national economy is highly correlated to growth and development in agriculture (See Figure 1). During the first two decades after independence, the sector and in turn the whole economy recorded high and impressive levels of growth. On average, the agriculture sector grew at average of 6 percent per annum while the overall economic growth averaged 7 percent.

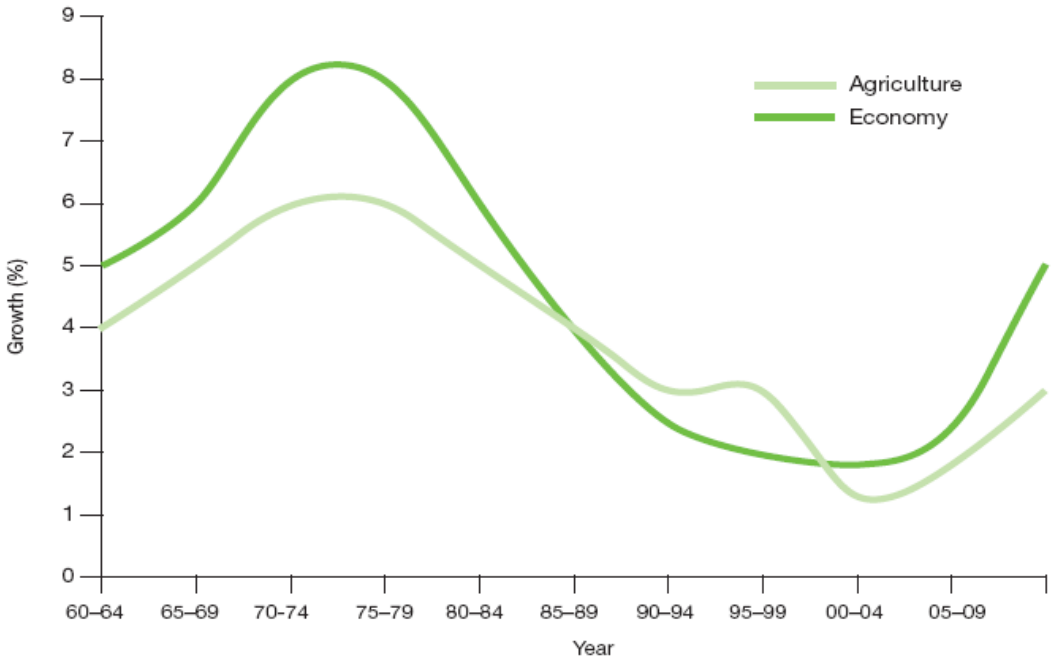


Figure 1: Trends in Agricultural and Economic growth (1960-2008)

Source: Adopted from the Agricultural Sector Development Strategy (ASDS), Gok, 2010

Since the late 1970's to late 1990's the agriculture sector experienced a declining growth. Correspondingly, the overall economic growth also took a downward turn. A clear reversal of the declining trend has been evident since the early 2000's; the agriculture sector and the overall economy have recorded positive growth. Based on the evidence from the last five decades, it is very clear that Kenya's overall economic growth is intertwined with the growth of

the agricultural sector; indeed it is not a *cliché* to say that agriculture is the engine of economic growth in Kenya.

Given such critical role of the sector in generating economic benefits, accelerated growth in agriculture should have the potential to stimulate wider economic growth and reduce poverty significantly. As noted in the agricultural sector development strategy (ASDS 2010-2020), sustained agricultural growth is critical to uplifting the living standards of our people as well as generating rapid economic growth. The ASDS set the following targets to be achieved by 2015:

- Reduced number of people living below absolute poverty lines to less than 25 per cent, to achieve the first MDG (Millennium Development Goal).
- Reduced food insecurity by 30 per cent to surpass the MDGs.
- Increased contribution of agriculture to the GDP by more than KES 80 billion per year as set out in Vision 2030.

The critical role of the agricultural sector in national development and poverty reduction efforts is very clearly demonstrated in the ASDS and other government policy documents.

3.2 Agriculture and Food security

The achievement of national food security is to be a key objective of the agricultural sector. Agriculture ensures a constant food supply and food security for the population, which is essential for a healthy and energetic population to drive the economy. It also saves the country funds that would have rather been used in the importing of food from other countries this in turn has a positive effect on the country's balance of payments and there is surplus money to invest in other areas of the economy such as social overheads; roads, hospitals.

In general, the agricultural sector in Kenya, supplies food for the population but for several commodities such as maize, rice and sugar, local production is not sufficient to meet the local food demand. The deficits are closed through importation. According to the Kenya Food Security Steering Group, the country has been facing higher frequencies of severe food shortages in the recent times especially due to higher frequency of extreme weather that are related to climate change and climate variability. Official estimates indicate over 10 million people are food insecure with majority of them living on food relief. Households are also

incurring huge food bills due to the high food prices. Maize being staple food due to the food preferences is often in short supply and most households have limited choices of other food stuffs.

3.3 Agriculture and poverty

Approximately 80 percent of the Kenya's population live in rural areas and relies on agriculture for its livelihood. According to the World Bank Development Indicators for 2005, poverty is still high in Kenya. The poverty headcount ratio for the country is estimated at 45.9%. The rural economy is dominated by the smallholder subsistence farmers who produce about 75% of the total agricultural output. The areas with high potential for agriculture and located in the central highlands and highlands to the west of the Rift Valley where population density and population to land ratios are very high. The poorest communities in the country are located in the sparsely populated arid zones mainly to the north of the country. Among the rural poor in Kenya are the following categories; smallholder producers, pastoralists, farm labourers, unskilled and semi-skilled workers, women-headed households, people with disabilities and orphans.

Available evidence shows that that agriculture-led growth in Kenya is more than twice as effective in reducing poverty as growth led by industry (Mabiso, Pauw and Benin, 2012). The analysis undertaken by Mabiso, Pauw and Benin (2012) indicate that if Kenya were to achieve the CAADP target of 6% for the agriculture sector, levels of poverty would fall to 24% by 2020. To achieve this level of growth, substantial investments would have to be committed to sub-sectors such as cereals, roots, pulses, fruits and tea. These sub-sectors would have to growth at over 6% per annum. In the semi-arid areas of the country, investment in irrigation and infrastructure offer the best potential to reduce poverty significantly. In general, the transformative process of the agricultural sector would have bigger multiplier effects in other sectors of the economy which would absorb more and more labour. The population that would remain in the agriculture sector would have higher productivity and high levels of income. The key to better performance in agriculture lies in boosting smallholder productivity and developing non-farm activities.

3.4 Impact of climate change on agriculture

Existing literature demonstrates that climate change and climate variability are indeed a reality in Kenya. This is manifested in increasing frequency and intensity of extreme weather events. Drought occurrence over a period of 123 years illustrates this (Table 2).

Table 2: Frequency of drought occurrence in Kenya

Year	Regions Affected	Populations threatened
1883	Coast	
1889/90	Coast	
1894/95	Coast	
1896-1900	Most of East Africa	
1907-1911	Lake Victoria basin; Machakos; Kitui; Coast	
1913-1919	Kamba lands; Coast; Ethiopia	
1921	Coast	
1925	Kerio valley; Coast	
1933/34	Coast; Central	
1942-1944	Kenya & Uganda	
1947-1950	Central; Coast	
1952-1955	Kitui	
1969-1971	Rift Valley; Machakos; Kitui	
1981	Eastern province	
1983	Coast; Machakos; Kitui; Kakamega; Nyanza	
1984	Countrywide	
1997	Countrywide	2 million
2000	Countrywide	4 million
2004	Countrywide	2.3 million
2005	Northern Kenya	2.5 million
2008	Countrywide	4 million
2009	Countrywide	4 million

Source: Karina and Mwaniki (2011)

It is evident that the frequency of droughts has increased over the years, but most prominently over the past decade. Moreover, their effects have been experienced on national rather than local scales.

Other indicators of climate change include changing precipitation patterns, i.e., rainfall variability, speed of wind, temperature differentials on both land and water surfaces, increased prevalence of certain pests and diseases, and changing crop production conditions.

These manifestations were clear to the communities and the experts that were interviewed in this study. Indeed the effects of declining soil fertility, increasing pest and diseases and soil erosion arising from extreme weather episodes were already being manifested in recurrent food insecurity among most of the communities we interacted with. The key concerns were whether the existing climate change policy in the sector was adequate, extent to which it was informed by research and how much it was being translated into action on the ground.

4.0 Climate change and agricultural policies in Kenya

4.1 National Climate Change Response Strategy (NCCRS) and National Climate Change Action Plan (NCCAP)

Climate change is a relatively new entrant on the policy agenda in Kenya, (Maina *et al* 2013). The National Climate Change Response Strategy (NCCRS), (GoK 2010b) is the framework that guides the integration of climate concerns into development priorities, government planning and budgeting. NCCRS highlights various measures for adaptation and mitigation to the impacts of climate change on agriculture (GoK 2010b). These include use of a range of innovative technologies such as irrigation; early maturing and high yielding crop varieties as well as drought and pest resistant crop varieties and disease-resistant livestock. The NCCRS also advocates diversification of livelihoods; adaptation of agricultural technologies from analogue environments; and enhancing early warning systems with drought monitoring and seasonal forecasts with respect to food security.

The NCCRS includes indicative budgets and plans for line ministries. The implementation of the full strategy is estimated to cost US$3 billion annually over the next 20 years, and roughly US$100 million per year would be needed for adaptation and mitigation activities in agriculture (GoK 2010b). This would require nearly 20% of Kenyan government expenditures planned for agriculture and rural lands for the 2012-2013 fiscal year (Kenya National Assembly 2012).

NCCRS is meant to guide the government in all activities and interventions aimed at addressing issues related to climate change. That is, it will consolidate all the national efforts and focus on climate change adaptation and mitigation. The processes of formulating the NCCRS and its implementation action plan were participatory and consultative, and all the key sectors of the economy were addressed - climate change was viewed as a challenge that cuts across all the sectors and segments of the society in Kenya hence the need to have inputs from diverse stakeholders and players. The stakeholders comprised of development partners, representatives from the private and public sector as well as, parliamentary committee dealing with climate change.

Though the Agricultural Sector Development Strategy has included climate adaptation as a priority (GoK 2010a), the agricultural components of the NCCRS provide more details on

prioritized activities. With regard to adaptation, the NCCRS 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. On the mitigation front, 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.

To operationalize the NCCRS, the government in March 2013 finalized the development of the National Climate Change Action Plan (NCCAP). This was developed through a consultative process that engaged actors across government, the private sector and civil society. NCCAP is meant to operationalize NCCRS by providing the analysis and enabling mechanisms to make implementation successful. It will also support efforts towards the implementation of the Kenya Constitution 2010 and the attainment of Vision 2030; and encourages people-centred development, ensuring that climate change actions help the country move toward its long-term development goals. In particular, the NCCAP sets out a vision for a low carbon climate resilient development pathway; summarises analysis of mitigation and adaptation options and recommended actions; recommends an enabling policy and regulatory framework; and sets out next steps for knowledge management and capacity development, technology requirements, a financial mechanism, and a national performance and benefit measurement system (NPBM) (GoK 2013). Due to lack of a clear policy document on climate change and agriculture in Kenya, NCCRS (a government strategy and not policy) and the NCCAP have received much attention and can be taken as de facto policy documents for the country.

4.2 Agricultural Sector Development Strategy (ASDS)

In 2010, the Kenyan government adopted the Agriculture Sector Development Strategy (ASDS) Policy replacing the Strategy for Revitalization of Agriculture, 2004. ASDS 2010-2020 sets out a detailed plan to 'position' the agricultural sector as a key driver for delivering the 10 percent annual economic growth rate envisaged under the economic pillar of Vision 2030. The vision of

the document is 'a food secure and prosperous nation' and the strategy aims to increase productivity, commercialization and competitiveness of agricultural commodities and enterprises; and develop and manage key factors of production (ASDS, 2010a). However, the realization of such economic growth is likely to be hampered by the impacts of climate change.

The ASDS Policy proposes the establishment of a national irrigation framework to: (i) reduce the vulnerability of the agricultural sector to drought as it predominately practices rain-fed agriculture; (ii) enable rehabilitation of forests and water catchment areas; and (iii) improve food security, as well as address desertification. In addition, the policy also promotes the development of arid areas, including Northern Kenya, measures which are further elaborated under the National Policy for the Sustainable Development of Arid and Semi-Arid Lands (Heinrich Böll Stiftung, 2013). ASDS recognizes that reforms in the agricultural sector require drastic actions to take into account the existing and emerging concerns about sustainable agriculture and climate change adaptation in Kenya.

4.3 The Vision 2030

Vision 2030 does make reference to climate change adaptation in the context of building capacity as part of the Environment. The vision also does state as a specific goal under environmental management, the aim of attracting at least 5 Clean Development Mechanisms (CDM) projects per year in the next five years. The Water Catchment Management Initiative is a relevant environmental flagship project. In addition, the Vision 2030 has also captured the following climate change goals and strategies;

i. expansion and intensification of irrigation,
ii. improvement of seed quality and livestock productivity (e.g. through seeding ranches and rangelands and enriched fodder),
iii. better management of water quality (increased water storage and harvesting),
iv. conservation of forests through rehabilitation of degraded water catchment areas,
v. implementation of compensation for environmental services to include carbon markets and use of biotechnology,
vi. integration of climate change into development planning,

vii. promotion of adaptation activities in high risk disaster zones,

4.4 The Second Medium Term Plan 2013-2017 (MTP)

The government launched the Second Medium Term Plan 2013-2017 (MTP) which identifies key policy actions, reforms, programmes and projects to be implemented in the 2013-2017 period in line with government priorities, the Kenya 2010 constitution and the long-term objective of Vision 2030. Accordingly, the theme of this MTP is *Transforming Kenya: Pathway to Devolution, Socio-Economic Development, Equity and National Unity*. The MTP gives priority to devolution as spelt out in the constitution and to more rapid socio-economic development with equity as a tool for building national unity. The Second MTP also aims to build on the successes of the first MTP (2008-2012), particularly in increasing the scale and pace of economic transformation through infrastructure development, and strategic emphasis on priority sectors under the economic and social pillars of Vision 2030.

Under the MTP (2013-2017), transformation of the economy is pegged on rapid economic growth on a stable macro-economic environment, modernization of infrastructure, diversification and commercialization of agriculture, food security, a higher contribution of manufacturing to the GDP, wider access to African and global markets, wider access for Kenyans to better quality education and health care, job creation targeting unemployed youth, provision of better housing and provision of improved water sources and sanitation to Kenyan households that presently lack these. To cap it all, Kenya will pay full attention to securing its environment and building its resilience to climate change. Much of this will be done in collaboration with county governments and new urban management boards as provided for under the constitution and its laws. The flagship projects under the social pillar of the MTP, which will help build resilience against climate change, include strengthening environmental governance; waste management and pollution control; rehabilitation of urban rivers; land reclamation; irrigation and drainage infrastructure installation; water harvesting and storage programme; rehabilitation and protection of water towers among others.

4.5 The nexus between agriculture and climate change policies/strategies in Kenya

NCCRS 2010, Vision 2030 and the 2nd medium term plan (2013-2017), have underscored and manifested themselves in the ASDS. In fact, ASDS has highlighted implementation of NCCRS as

one of the surest ways to curb climate change and variability in Kenya[2]. For instance, ASDS notes the need for local communities to be encouraged to document knowledge and practices that provide early warning systems and help mitigate some of these changes within their environments for adoption and customization. Maina *et al* 2013 however observes that there is no clear linkage between NCCRS and the agricultural sector ministries. The agricultural policy in Kenya does not mention climate change explicitly. Agricultural sector goals revolve around increasing productivity and income growth, especially for smallholders; enhanced food security and equity, emphasis on irrigation to introduce stability in agricultural output, commercialisation and intensification of production especially among small scale farmers; appropriate and participatory policy formulation and environmental sustainability.

The government has used a "systems approach" to the agriculture sector. Agriculture sector ministries are viewed as components whose synergistic functions should lead to attainment of the objectives set out in the agricultural sector. The argument is that when each of the sector ministries aligns its operations to the tenets of the NCCRS and NCCAP, then the agricultural sector will respond effectively to the challenges of climate change and climate variability. NCCAP has outlined how agriculture sector ministries are expected to align their climate change activities and plans to the NCCRS. Maina *et al 2013,* however note that this will only take care of the upstream interests at national, regional and international levels, while the downstream may be neglected. Implementation of the NCCRS through the NCCAP strategies is in its formative stages and remains at the level of mainstreaming into government plans and development of implementation strategies.

4.6 Policy actors, processes and incoherence

The foregoing review suggests that policy formulation process in the agricultural and climate change spheres in Kenya involves multifarious actors defined by politics, geographical settings, interests, gender and financial resources, since it constitutes the foundation upon which the economy is built. The actors include Government ministries and institutions such as the Ministry of Environment and Mineral Resources (MEMR), Ministry of Agriculture, Ministry of Forestry and Wildlife, the National Environmental Management Authority (NEMA), the Climate

[2] Both NCCRS and the NCCAP view agriculture, as the most weather dependent sector of the Kenyan economy,and one that will bear the largest brunt of climate change.

Change Coordination Unit (CCCU), and several government parastatals and departments; international Non-Governmental Organizations (NGOs), United Nations (UN) and related bodies; regional NGOs and corporations; national NGOs and Community Based Organizations (CBOs); development partners; the private sector; civil society organizations; and research and academic institutions.

The decisions that influence agricultural and climate change policy formulation and implementation are made by these actors interactively, which imply that policy formulation processes are becoming more systematic, transparent and inclusive. This has led to a process of sharing information among the actors, leading to ownership not only of the processes but the products. This is intended to have each institution using the same tool to inform its target audience, which will have a synergetic influence in the sectors development towards climate change proofing.

Policy formulation, particularly among agriculture-related agencies like the ministries is inclining towards evidence-based findings from research undertakings of local consultants, uuniversities and policy research institutes (PRIs), an approach which had been overlooked in the past. The importance of policy based on evidence has grown with the establishment of PRIs like the Kenya Institute for Public Policy Research and Analysis (KIPPRA), Kenya Agricultural Research Institute (KARI), Institute for Development Studies (IDS) of the University of Nairobi and Egerton University-based Tegemeo Institute of Agricultural Policy and Development, among others.

Although an all-inclusive and transparent landscape emerges from the above, there is lack of coordinated climate change adaptation planning by the actors. There are efforts to establish climate change units within different agencies- MoA and KARI have both set up units/departments dealing solely with issues of climate change. It would have been thought that being a new niche in Kenya, coordinated efforts would have been encouraged so as to share experiences and emerging knowledge within the new units through communities of practice. Indeed shaped by the actors' mandate area, salient policy issues on climate change adaptation can be synthesized and analyzed by the agricultural research institutions for wider sharing and informing national level policy processes.

There are multiple pieces of legislations and regulations, and draft policies in Kenya, directly and/or indirectly linked to agriculture and climate change. Notably, the various policy and institutional frameworks have led to weak coordination in basic approaches to the sector and overlapping jurisdictions. The policy incoherence identified at a national level is that while Kenya is remarkably committed to tackling challenges posed by climate change, coordination and management of strategic activities is fragmented between the different actors. This poses the threat of interfering with institutional frameworks and possibilities of leading to weak enforcement of policies and legislations.

5.0 Agricultural Research, Climate change in Kenya

5.1 Agricultural Research Institutional Framework

There are over 130 pieces of legislations in Kenya, that are both directly and indirectly linked to agriculture. In addition there are various other draft policies that affect the agricultural sector such as the National Land Use Policy; National Seed Policy; National Irrigation Policy; National Horticultural Policy; Livestock Policy and the National Agriculture Research System among others. Notably, the various policy and institutional frameworks lead to overlapping jurisdictions and mandates. For instance, many experiments require prior approval from an institutional review board. Field trials almost always need permits from several institutions including Kenya Plant Health Inspection Service (KEPHIS).

To enhance coordination, of the agricultural sector in Kenya the government established the Agriculture Sector Coordination Unit(ASCU), which together with its thematic working groups was mandated to review and make recommendations on the development of legal, regulatory and institutional reforms. Regulatory and institutional reforms are focused on climate change, sustainable land practices and natural resource management. A cautious, regulatory and policy making approach was appropriate during the dawn of modern biotechnology. Since then, researcher, regulators, and policymakers have accrued a vast body of experience around the world.Taken together these delays in setting up a regulatory framework obviate benefits from agricultural research. According to one field scientist- "*while regulation to ensure the safety of new crop varieties is essential, in a country facing burgeoning demands on agriculture, from economic growth and climate change, overregulation and lack of coordination is an indulgence we can ill afford*".

Kenya's Agricultural 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. It has already been noted that Kenya has is pioneering a number of agricultural mitigation activities including 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 programmes.

The NCCRS recognizes that current government institutions are inadequate to handle complex challenges of climate change needs including research. To meet the needs of climate change a Climate Change Secretariat has been established within the MEMR to coordinate climate change activities across sectors. In addition Climate Change Units have been established within the relevant government ministries, including the ministry of agriculture (MoA). The mandate of the MoA Climate Change Unit is to act as a knowledge broker to support the mainstreaming of climate change into all of the Ministry's projects and programs. The unit will also be involved in the development and implementation of policy on climate change in agriculture, the development of programs and projects, coordination and partnership building with relevant stakeholders and the mobilization of resources for these activities.

5.3 What is needed to address agricultural research challenges?

There are two practical ways to increase agricultural output in Kenya: expand cultivated land area or increase yields on existing lands. The prospects for the former are limited. Though there is some scope for expanding agricultural land area, doing so would involve either using land that is only marginally productive for agriculture or using lands that provide ecosystem services of national and global significance. It is therefore essential to increase yields on existing lands, regardless of whether cultivated land expands.

The most successful methods for improving crop yields are through improved agronomic practices and seed genetics. Advances in both these areas were at the heart of the 20th century Green Revolution. In Kenya this role is played by the Kenya Agricultural Research Institute (KARI). However, while these advanced technologies and practices hold significant potential in Kenya, they cannot deliver enough productivity enhancements to meet the anticipated need. If Kenya is to meet projected growth in food demand, the KARI has to develop and employ more efficient, productive next generation biotechnologies. According to KARI field staff, one example of the kind of innovation needed is TALENs, or Transcription Activator-Like Effector Nucleases. TALENs with the help of computer algorithms, make it feasible for the first time to work with new traits in short time frames (years rather than decades or centuries). This technology is important for many reasons. Many of the traits needed to improve in crops and livestock to increase yields and resilience to the stresses exacerbated by climate change are polygenic. Some of the most important traits, like drought tolerance, are impacted by hundreds

of genes working together in complex and poorly understood ways. TALENs provide a breakthrough research pathway for unlocking these traits and building more resilient crops and livestock. Whilst other scientists are working on this path breaking research, Kenya has yet to agree on a National Bio-safety Bill to guide this research. The uncertainty created by lack of regulation in research greatly affects the agriculture sector by delaying the production of climate resilient crops.

5.4 Weak Agricultural Innovation Policy

The dramatic productivity increases in major commodity crops resulting from the Green Revolution began to taper off in the 1980s. The Green Revolution's successes were largely the result of increasing yields through genetic modification by age old breeding techniques to change simple traits controlled by one or a few genes. While similar approaches can still be used to benefit minor crops, future yield increases and climate resilience will have to come from new techniques and technologies that can be used to improve more complex traits controlled by many genes, as in the example of water use efficiency. Unfortunately, the agricultural innovation system comprised of universities, government institutions, non profit institutions and private industry is currently ill equipped to produce the advanced innovations required.

Agricultural sector scientists rely on the Intergovernmental Panel on Climate Change – Special Report on Emissions Scenarios (SRES) to provide plausible future scenarios that can be used to anticipate the potential impacts of climate change and compare the outcomes of different policy approaches. A typical agricultural assessment models the future effects of climate change on crop productivity (e.g. soil conditions, temperature, crop quality, crop yields and precipitation) using each of the scenarios presented in SRES. Though the SRES scenarios are carefully constructed in view of the best available scientific evidence, they make overly optimistic assumptions about the "baseline" agricultural innovations that obscure the scale of the agricultural production challenge and the importance of a concerted, innovation centric response.

The problem with these assumptions is that they posit significant future agricultural without specifying where these improvements will come from. In assuming that such improvements will appear absent of policy changes, these analyses suppress a critical discussion on how the

country will increase crop productivity and climate resilience. Considerable policy changes, resources, technological innovation and growth are needed to create this improved system. Creating the necessary improvements in agricultural production systems will require strategic, evidence based policy and investment decisions.

5.5 Government under Investment in Agricultural Innovation

Over the last several years, a variety of support systems for agricultural research have evolved at the national and international level. Kenya, like other nations directly dependent on agriculture has established some type of national agricultural research system (NARS) units such as KARI, KEFRI etc. Historically, these institutions have managed a significant percentage of total global agricultural research and development (R&D), driven by domestic economic imperatives and sustained public investment. Countries such as the United Kingdom, USA have risen to particular prominence, wielding influence and exerting impacts on what research is to be conducted beyond their national interest.

In addition, a number of international bodies have been active in conducting agricultural research and coordinating efforts to support agricultural growth in Kenya as part of larger economic development agendas, including the Consultative Group International Agricultural Research (CGIAR), the United Nations Food and Agriculture Organization (FAO), and the United Nations Development Programme (UNDP), among others. Private philanthropic groups have also played significant roles. For example the Rockefeller Foundation, Bill and Melinda Gates Foundations' agricultural work have become increasingly prominent.

While the number of institutions supporting agricultural research has expanded over time, public expenditure and investments in agricultural innovation have not been sufficient to maintain the levels of annual growth in crop yields and conduct research in climate resilience agriculture. Respondents argued that the government has significantly scaled back support for agriculture R&D at a time when innovation is most needed in crop and livestock production systems. Increased private funding has helped pick up a fraction of the slack, leading to commercialization of higher yielding varieties of a handful of major crops. This shift away from a public and non profit system, and the corresponding slowdown in the growth of public research funding, has serious consequences on traditional crop varieties that may offer climate resilience.

Presently, in Kenya the major private sector players dominating agricultural innovation ecosystem are large multinational companies that have active historically in agricultural chemicals. These include Monsanto, BASF, Bayer Crop Science, Syngenta, and Dow AgroSciences[3]. However, as research investments have shifted from public funded projects to industry labs controlled by private interests, so too has the character and focus of that research. Industry research is aimed, for the most part, not at basic or fundamental science, but rather at adding recoverable value to seeds by imparting to them the ability to overcome specific problems like disease, pests or weeds. Industry research is focused on major crop species (maize, cotton and potatoes) whose seeds are sold in sufficient quantity to provide industry the opportunity to recoup significant R&D costs through sales. And despite this, other major crops such as wheat and rice have received much less emphasis. This is because, amidst the dearth of public sector funding, they have not attracted the support of next generation private sector product developers, primarily because of regulatory barriers and financially risky long research time horizons.

Agricultural research in general has also suffered from the slowing of public funding for early-stage agricultural R&D. Many fundamental areas of research such as plant breeding, plant pathology, and entomology which often have very long time scales to lead to any impacts have lost ground dramatically as funding has shifted toward research aimed at commercializing near-term products. Traditionally, private sector companies have not invested significantly in these areas, as they are high in risk and it is not always clear how basic scientific research will lead to commercially viable technology, or on what timescale. Consequently, many new crop varieties coming from the private sector may only be delivering marginal incremental gains, not the breakthrough leaps in crop productivity and climate resilience the country urgently needs.

In conclusion, climate change is increasing the severity and volatility of weather patterns and environmental constraints. Increasing crop productivity is not enough. Building climate resilient agriculture in addition to doubling crop productivity is one of the key social, economic and technological challenges facing the country. The country's agricultural innovation ecosystem is currently ill prepared to quickly and properly meet this challenge. The robust system of agricultural innovation that produced the high yielding varieties (HYVs) of the 70s which

[3] Although there are other smaller companies that have produced valuable innovations, these companies have produced the most commercial agricultural innovations and possess their innovative intellectual property rights.

drastically reduced starvation is marred by underfunded research budgets, regulatory barriers, and a lack of vision for next generation innovations.

6.0 Translating Kenya's Agricultural Policy into Practice and Actions

Under the old Constitution, Kenya's agriculture was managed under about 10 different sub-sectors: food and industrial crops, horticulture, livestock, fisheries, land, water, cooperatives and marketing, environment and natural resources, regional development, and development of arid and semi-arid lands. Other initiatives were also carried out in the Office of the President under the Ministry of Special Programmes. This indicates the complexity of the sector's interaction with other sectors, and multiplicity of channels through which it touches the lives and livelihoods of Kenyans. In this report agriculture as a sector is interpreted within the context of Comprehensive Africa Agriculture Development Programme (CAADP). Thus, agricultural policies are not restricted to those documented in agricultural policy documents but also other related sector and national development documents. We, however, restrict the discussion to those policies geared towards climate change adaptation or mitigation.

Climate change response policies in Kenya are captured in the Vision 2030, NCCRS (2010), NCCAP and National Development Plan 2002-2008. They are also manifested in the agriculture sector strategies such as ASDS (2010-2020) and Strategy for Revitalizing Agriculture (SRA) (2004-2014). Among the issues covered in the SRA include the following:

a. Promotion of on-farm water harvesting and management technologies (roof catchment, pans, dams, water holes, etc.);
b. Introduction of water-saving technologies such as canal lining and drip irrigation;
c. Increasing national forest cover through afforestation and agroforestry (e.g. through supply of seeds of fast growing trees);
d. Control of floods in Nyanza and Western Provinces;
e. Improving and developing breeds of non-traditional livestock and animal species such as camels, ostrich and other wildlife through game cropping and sanctuary operations; and
f. Diversification of production to include game ranching, bee-keeping, growing of tree crops and medicinal plants, and crop and forage production.

ASDS also identifies improvement of livestock breeds, development of pastures and forage, reducing livestock pests and diseases, improvement of water harvesting and management techniques, protection, conservation and sustainable management of forest resources and

rehabilitation of water towers as among the key climate change response strategies for the agriculture sector.

Using information from our field survey and literature, we explored how far these strategies have been implemented. This is documented in the next sub-sections.

6.1 Interventions in crop production

Activities and strategies related to climate change adaptation and mitigation that have been identified for the crops sub-sector include: use of crop varieties suited for the changes in moisture and temperature; switching to farming practices that conserve soil moisture and nutrients; controlling soil erosion and improving water uptake by crops; use of seasonal forecasts; forestry and agroforestry; small scale irrigation; disease and pest control; and conservation agriculture and micro-dosing. Elements of these strategies have been implemented to varying degrees. We explore a few below.

6.1.1 Drip irrigation technology

Due to extreme weather fluctuations, rain-fed agriculture is unreliable. But the country is also water scarce such that irrigation has to be water-efficient. Thus, drip irrigation is viewed as a viable option in response to increased frequency and intensity of drought. Water use efficiency of drip irrigation is estimated at 90% compared to 60% in surface irrigation and 75% in sprinkler irrigation (Quezada et al., 2012). It is therefore an appropriate climate change adaptation strategy especially for areas already receiving and those projected to receive low and erratic rainfall.

The initial capital required for implementing the technology is, however, higher than what is required for the other irrigation technologies. A wide range of components of this technology are available in different parts of the country, supplied mainly by Kenya agricultural Research Institute (KARI). The use is, however, restricted to farmers who are fairly better off in terms of finances. A few farmers have also adopted improvised drip irrigation technologies made from plastic buckets. These improvised versions are much cheaper and could be enhanced more easily. Their use was, however, limited as noted from our survey.

6.1.2 Use of drought-tolerant sorghum

Sorghum grows well even under arid and semi-arid areas which constitute about 80% of the country's land area. Areas suitable for sorghum growing include parts of Eastern province, parts of Rift Valley, and parts of Nyanza and Western Provinces. Extension agents and NGOs are promoting adoption of drought-tolerant sorghum for food security and beer brewing. Super sorghum, a high-yielding drought-tolerant sorghum being promoted in Western Kenya, and Sila sorghum which has been identified by Kenya Breweries as an alternative to barley in beer making are typical examples (see Khamsin, 2011 for details).

We noted from our interviews with farmer groups in lower Eastern that, although sorghum is not widely cultivated in terms of land area, 50% of the groups adopted improved varieties - Serena, Gadam, Mtama-1, and Seredo. Gadam and Serena had been grown in the area for about 10 years. The major adoption constraint to adoption of sorghum was bird attacks. Another key hindrance to adoption of sorghum is the importance of maize in the diet of Kenyans. Many farmers are stuck to maize growing even in areas less suited for the crop. This is because they find sorghum less palatable and also because market for sorghum is not well developed except in areas where Kenya Breweries has entered into contract with the farmers.

6.1.3 Minimum Tillage

This is a system of land preparation where only planting holes or furrows are made while the rest of the land remains undisturbed. The technology is able to increase crop production while, at the same time, conserving water and soil, and protecting the environment (Quezada et al., 2012). The system is being promoted by KARI Kisii and Marsabit stations. During our field survey, we were able to witness its adoption in Nyando and Kisii although our key informants revealed that it has also been adopted in other areas as Nandi, Transmara and Marsabit districts.

The system is cheap and leads to saving in fuel that would otherwise be used in land cultivation. However, we learnt that a number of farmers were quite skeptical about its ability to enhance yields. This is a manifestation of weak extension system in the area of climate change adaptation and mitigation. More investment is, thus, required in this area to help upscale adoption of useful and affordable technologies like this.

6.1.4 Tissue Culture Banana

Tissue culture banana is a product of biotechnology. The cultivars include the Cavendish group, Williams hybrid, Gold finger, Lacatan, Valgy and Paz. The technology is promoted by KARI, University of Nairobi, Jomo Kenyatta University of Agriculture and Technology (JKUAT) and Institute of Biotechnology Research (IBR), Thika Horticultural Research Centre, Kitui Development Centre and International Service for the Acquisition of Agri-biotech Applications (ISAAA).

Tissue culture bananas have been widely adopted in Kisii, Meru, Embu and parts of Central province. The yields have been noted to be 4-5 times higher than what is realized from suckers. Perhaps this explains the good adoption levels in the areas where the technology has been disseminated. KARI has attempted to add value to the technology by introducing and disseminating banana ripening chamber technology which is already gaining currency in Kisii.

6.1.5 Early Warning for Crop Production

This involves disseminating meteorological forecast to farmers. Among the critical elements of the forecast are the rainfall amount and pattern (onset and cessation), length of the growing season, temperature and droughts. The aim is to enable farmers to plan their farm activities and choose crop varieties to plant. Our interview with meteorological department in Kisumu revealed that weather information is widely communicated through appropriate radio channels and where applicable caution is sounded on impending floods to prepare people to move to safer grounds.

For flood prone areas like Budalangi, weather forecast is communicated in real time. Meteorological station in Busia has even gone a step further to integrate scientific forecasts with indigenous knowledge derived from the Nganyi community. The meteorologists compare their forecasts with the predictions of the traditional experts before organizing village level meetings to advise farmers on way forward with respect to the cropping season. Such meetings are addressed not only by the meteorologists but also by the traditional experts. This way, they have been able to effectively influence the activities of the farmers. Earlier, interactions between the meteorologists and the Nganyi rain-makers were characterized by mutual skepticism (Guthiga and Newsham, 2011). When the two groups negotiated modalities of working

together, they have successfully showed good convergence. This underscores the usefulness of indigenous knowledge in dealing with climate change.

6.2 Interventions in Livestock Production

Most dairy activities in Kenya are concentrated in the high-to-medium altitude areas, mostly in Rift Valley and Central Kenya. Rift Valley has the largest number of dairy cows although Central Kenya has the highest concentration of dairy cattle per square kilometer. Other regions that can benefit from experiences of Central and Rift Valley are the Western and Nyanza provinces.

Among the important climate change response interventions identified for the sub-sector are participatory breeding of the local breeds, establishment of fodder banks, replanting rangelands, and diversification of livestock enterprises. We trace the progress in the implementation of these interventions below.

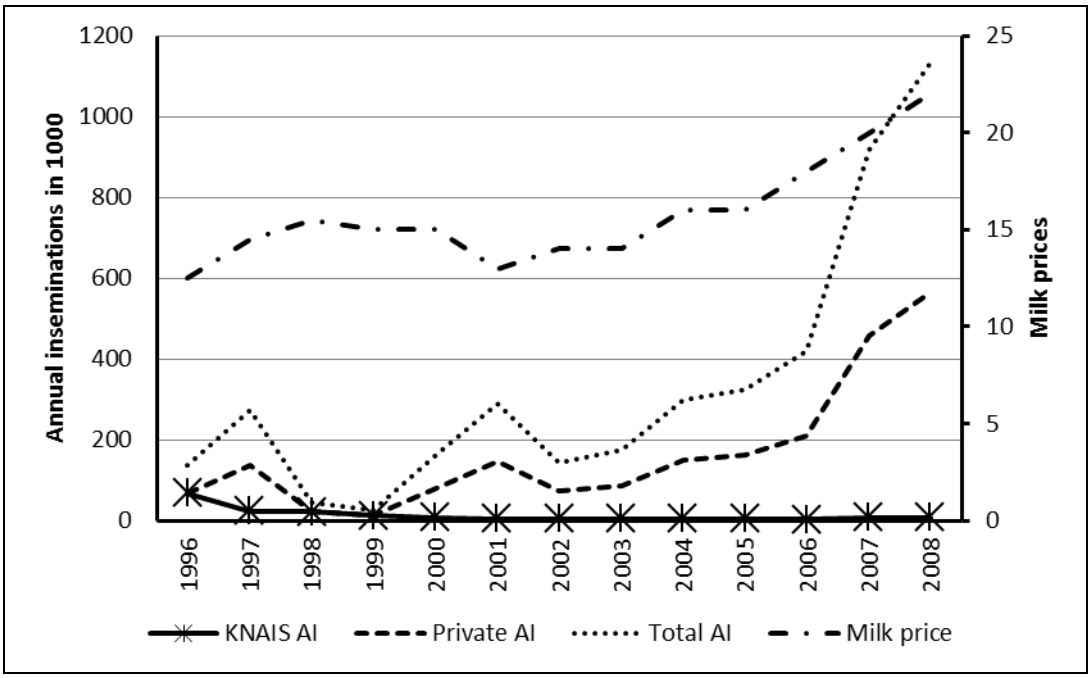
6.2.1 Dairy cattle breeding technologies

Livestock breeding programs in Kenya aim at improving dairy productivity, shortening calving intervals and enhancing herd fertility (Rege, 2001). No explicit breeding policy exists in the country but various generic policy statements guide breeding programs (Staal, Nin Pratt and Jabbar, 2008). The policy statements aim at increasing dairy productivity through breeding and selection implemented via wider use of AI and bull camps. A further goal is the production of high-yielding and diseases resistant cattle types. The objective is therefore not to eliminate the indigenous gene but to integrate exotic gene to improve productivity while retaining the disease resistance and local adaptability traits of the indigenous gene.

Main institutions in dairy cattle breeding include Kenya stud book (keeping animal breeding records); Dairy Recording Service (to keep milk performance data); Central Artificial Insemination Station (CAIS) (to produce semen); and Kenya National Artificial Insemination Services (KNAIS) (to distribute semen) (Conelly, 1998). In response to the goals of the breeding policies, various dairy breeding technologies and interventions have been introduced.

a) *Artificial insemination*. Until the mid-1980s, there had been a well-organized dairy cattle breeding system subsidized by the government. This contributed to growth of smallholder dairy farming system (FAO, 2011). Thus, AI was used effectively to upgrade local zebus to accelerate uptake of dairy farming. With liberalization of the economy

government involvement in breeding activities has been gradually replacement by private players. However, private AI services remain underdeveloped, probably due to perceived high cost of the service. This has increasingly led to use of bulls of unknown quality. Uptake of AI services has also been affected by a sluggish milk market (Figure1). The sudden increase in uptake of AI technology after the increase in milk prices in 2007 is a clear testimony to this fact.



Source: FAO (2011)

Figure 2: Annual inseminations against milk prices

b) *Gender selected/sexed semen*. This is an AI technology biased towards heifer production. Farmers can be about 90% certain of the gender of their calves if they use this technology. The technology, presents substantial opportunity for increasing population of heifers to address the shortage of heifers for increased milk production. However, the technology remains very expensive and adoption is restricted to large farms such as Brookside.

c) *Multiple ovulation and embryo transfer (ET).* Use of embryo transfer remains low. It is only common in stud herds where breeding bulls are produced to be sold to AI centres. The technology provides an avenue for importing genes from overseas while keeping down transport costs. It is slightly less expensive than live animal importations although this depends on the number of calves born per 100 embryos implanted.

d) *Bull Schemes*. Helping farmers upgrade their dairy animals through use of high grade bulls has been seen as an alternative to AI which is increasingly becoming more expensive. Bulls have been provided under such government programs as the Livestock Development Program (LDP), Heifer Project International (HPI). There are also non-governmental organizations (NGOs) promoting dairy activities in different parts of the country (Waithaka *et al*., 2000). Through sharing of bulls, individual farmers who are not able to rear their own bulls have easy access to genetic material for upgrading their stock and maintaining the quality of their dairy breeds.

e) *Dairy cattle stocking intervention*. Besides upgrading of indigenous breeds through AI and bull schemes, there have also been other interventions aimed at enabling farmers to quickly stock dairy cows. In Western Kenya, for instance, government programs such as Livestock Development programs and the Millennium Development Goals (MDG) have been implementing this initiative. Rural Outreach Program (ROP) and Heifer Project International (HPI) are some of the NGOs which have been active in this intervention. The intervention has been implemented through famer groups. Individual farmers get dairy cows through their groups. Group members decide who receives the first cow and then selected farmers begin preparation by first planting fodder and preparing sheds (Hall, 2006). Selected farmers sign contract which compels them to pass on the offspring of the provided cow to other group members. Through this program, HPI had by the year 2005 provided an initial stock of 309 dairy cows to various selected farmers (Hall, 2006).

As noted earlier, AI technology, under government subsidized programmes had significant impact on upgrading of indigenous breeds. The withdrawal of government support, however, has had a negative impact on the use of AI technology. Our interaction with field extension staff and farmers revealed substantial reversal to use of indigenous or low grade bulls as a result of poor coverage and high cost of AI services. On the contrary, in places like Nyamira district

where Smallholder Dairy Commercialization Programme (SDCP) supports AI technology uptake, success continues to be registered. Farmers interviewed in Nyamira district indicated that the SDCP has increased the number of AI service providers and ensured that the supported farmer groups have a dedicated service provider. AI services offered through the SDCP were cheaper (costing between Ksh. 600 and 800 per service compared to other schemes charging between Kshs 1,000 and 1,200 per service). As a result, many livestock farmers in Nyamira have switched from use of local bulls to AI technology. Consequently, monthly rate of AI services has been on the increase (MoLD, 2011). The bull schemes have, however, not been taken up well by farmers and is often used only as a last resort.

Dairy cattle stocking intervention has also contributed significantly to increasing population of dairy cattle especially in Western Kenya where HPI has actively been involved. Most of the breed upgrading and cattle stocking interventions are often accompanied by a sequence of training aimed at preparing farmers to sustainably and productively manage the dairy cows. Field staff we talked to indicated that this training is a major contributor to sustainable uptake of dairy cows. Indeed, providing dairy cows to farmers without the requisite training and preparation was blamed for failure of the MDG cattle stocking programme.

A number of factors were found to impede adoption of dairy technologies in the country. For the AI technology, the main hindrance as reported by the Ministry of Agriculture we interviewed especially in Western Kenya was the prohibitive high prices charged by the private providers of the service. Unreliable infrastructure for distribution of semen, inadequate facilitation of private AI service providers and lack of business skills among private AI service providers were identified as additional impediments. Indeed some agro-vets serving as distribution agents for CAIS in Western Kenya were reported to either employ unqualified staff or use sub-standard equipment to store semen. Consequently, some of the semen purchased by AI service providers is dead by the time the animal is served.

The bull scheme has also faced a myriad of challenges. Foremost, keeping a bull is very expensive yet the price per service is quite low. Thus, the overall return to the farmer is quite low especially when the frequency of service is low, which is often the case. As a result, farmers charged with the responsibility of maintaining the bulls on behalf of their groups had no option

but to dispose of the bulls. Our key informants further revealed that sharing of bulls among farmers leads to spread of reproductive diseases, which leads to productivity loss to farmers.

Dairy cattle stocking intervention has been associated with below capacity production. Reasons for this were a matter of conjectures among our key informants. Either the farmers do not have the capacity to exploit the genetic potential of provided cows or the cows supplied are of inferior quality. There was also a feeling that the high grade animals provided may not have been well adapted to local weather conditions in some cases. In fact, most field staff we talked to in Western Kenya suggested that it would be preferable for the smallholders to start with cross-bred dairy cows and gradually upgrade the stock for optimum adaptability. Furthermore, choice of cattle breeds supplied to farmers need to be carefully done. Most field extension staff we interacted with indicated that some of the breeds provided by supporting NGOs do not fit farmers' needs and constraints. We were informed that farmers in the western Kenya region have a preference for Aryshire breed of dairy cattle because of its low feed requirement, relative adaptability to local environment and higher butter fat content. However, NGOs working in the region have mainly supplied Friesian breed.

6.2.2 Feed Technologies

Most smallholder livestock systems rely on open grazing. Supplementary feeds are provided only occasionally except in areas of high population densities where intensive systems like zero grazing and stall feeding are practised. Main feed sources in the smallholder system include forage, cultivated fodder and crop by-products. Napier dominates the cultivated fodder. Other common feeds and forages include maize stovers, dried poultry waste, hay (purchased pure Lucerne, grass or Lucerne/grass mix), silage (by a few farmers), home-made rations of locally available grains and other ingredients, and grazing, which is the most common source of animal feed (FAO, 2011). Commercial feeds such as dairy meal, dairy cubes, calf pellets, maize germ, maize bran, molasses, cottonseed cake, wheat pollard, and wheat bran are also used on a limited scale among the smallholders. We, however, noted from our interviews with key informants that most commercial feeds were of poor quality.

Due to weather variability livestock farmers experience fluctuations in feed availability. This has necessitated development and dissemination of feed technologies to increase and stabilize feed supply. Some of the technologies being promoted in the country are discussed below.

a) *Planted Fodder, fodder legumes and fodder shrubs*. The major livestock feed in smallholder dairy production systems in Kenya are natural pastures and planted fodder, mainly Napier grass (Orodho, 2006). Various fodder legumes and fodder shrubs have also been introduced to farmers with varying degrees of success in increasing milk production. One of the most successful fodder crops is *caliandra* which has been widely and rapidly adopted by many farmers in the country as a protein supplement for their dairy cows (Franzel and Wambugu, 2007). It easily fits into existing farming systems, a quality that has made it attractive to many farm households. Other fodder crops that have been introduced include *desmodium,* Rhodes grass and Columbus grass.

b) *Crop residues*. Some farms also use crop residues for livestock feeds. Among the most popular crop residues are maize stover, wheat straw and sweet potatoes vines. Given the need to improve storability of feeds for use in dry seasons, crop residues have been promoted alongside processing technologies.

c) *Feed Conservation technologies*. For feeds to be available even in dry periods, it is important to have conservation technologies in place. The most common conservation methods that have been introduced to farmers are *silages*, so far adopted on limited scale and *haying*. An increasingly popular conservation technology is the pulverizer technology. There are also isolated cases where farmers are storing unprocessed crop residues. East Africa Dairy Development (EADD) programme has been behind the promotion of pulverizer and grass cutter technologies. About 480 pulverizers have been purchased by farmers across EADD sites (EADD, 2010).

d) *Home-made rations*. This involves formulation of feed rations from locally available grains and other ingredients (FAO, 2011).

Our survey in Western Kenya found a number of specific feed technologies being promoted. We highlight these below.

i. *Napier grass establishment and management*. Napier is the most common fodder in smallholders dairy systems and it is preferred because of its high production per hectare in both dry matter and total digestible nutrients (Orodho, 1988). It is also relatively more drought-tolerant and several high-yielding cultivars have been developed. Various

government livestock extension programs and NGO projects have promoted the use of napier grass as fodder. Such interventions are accompanied by training on suitable planting methods such as the "tumbukiza" approach and improved husbandry practices. The "tumbukiza" technology aims at increasing and sustaining napier productivity for a longer period. The method is suitable for smallholders because it allows growing of more crops per unit area.

ii. *Fodder trees and legumes*. Waithaka et al. (2002) found that 25% of livestock keeping households in Western Kenya had legume trees. Nyamira and Vihiga districts were leading in this respect. Sesbania was the most commonly grown legume tree, planted by 41% of farm households having legume trees. The second most important fodder tree was caliandra, planted by 22% of households.

iii. *Maintenance of grasses*. Use of natural grasses has been promoted especially in Nyamira by SDCP is the use of natural grasses. Under the SDCP, farmers are trained on management of natural grasses through application of manure and control of weeds. Some of these grasses are cut and fed to cattle directly while others are used to produce hay.

iv. *Feed conservation*. Because of feed shortages and limited capacity for on-farm fodder production, initiatives aimed at conserving fodder for use during dry seasons have been promoted. Main feed conservation strategies that have been introduced in Western Kenya include tube silage, box haying and a pulverizer. Through the support of SDCP, some farmer groups have acquired pulverizers to process crop residues such as maize stover and beans husks.

v. *Home-made rations*. With rising prices of commercial feeds, many farmers have opted for home-made feeds. Farmers have been trained to formulate their own feed rations at home. This involves use of crop products and by-products and other purchased ingredients. Most of these activities are being promoted under the SDCP.

vi. *Establishment of feed seed bulking sites*. Under SDCP, farmer groups are facilitated to establish bulking sites as a way of improving access to planting materials. The seeds/planting materials are raised on a plot of a volunteer farmer where demonstration on management practices is conducted. Once the fodder is established vegetative planting materials or seeds from mature crop are harvested and used by other group

members as planting materials. This is a cheaper way of obtaining the seeds/planting materials.

vii. *The ICIPE "push-pull" intercropping technology*. This is a habitat management approach introduced by International Centre for Insect Physiology and Ecology (ICIPE) in collaboration with Kenya Agricultural Research Institute (KARI) and Rothamsed Research (UK) to control Striga weed in maize fields. It involves intercropping cereals with a repellant plant such as desmodium, and planting an attractive trap plant such as napier grass as a border crop around this intercrop. By doing this, stem borers are repelled and deterred away from the target food crop, maize. At the same time, they are attracted to the trap crop (pull), leaving the food crop protected. On the other hand, desmodium stimulates the germination of Striga weed and inhibits its growth after germination. This technology is useful in dairy production because it provides high-quality fodder. ICIPE is currently promoting the "push-pull" technology in Western Kenya in collaboration with HPI. Some farmers in the region have now adopted a one-to-one intercropping of desmodium with either maize or napier grass.

Adoption of feed technologies has been slowed down by a number of factors. For instance, feed conservation technology like tube silage requires abundance of fodder. However, because of small farm sizes, smallholders are not able to produce sufficient quantities to warrant the use of the technology. Pulverizer, which is fairly more popular, is expensive and may be out of reach of most of the smallholders unless it is heavily subsidized by the government or other sector actors.

Shortage of desmodium seeds and other grasses is the main hindrance to adoption of push-pull technology (Hassanali et al., 2008). Where desmodium is grown on a one-to-one basis with crops like maize, it has to be harvested at the end of the season in readiness for the next cropping season. This reduces the importance of desmodium as a long term source of fodder.

6.2.3 Livestock health technologies

Tick-borne diseases are the most common among the smallholder livestock famers (Waithaka et al., 2002). There are also cases of notifiable diseases, controllable through vaccination. Thus, livestock health care technologies mainly target tick control and vaccination. Tick control measures largely involve use of acaricides and treatment by means of antibiotics. Waithaka et al.

(2002) showed that, in Western Kenya, 55% of farmers undertook tick control measures weekly. Another 17% undertook tick control fortnightly while 13% did so only occasionally. Specific technologies implemented include the following:

a) *Communal or privately owned dips*. Tick-borne diseases in Kenya have conventionally been controlled through dipping. However, liberalization of the economy led to privatization of tick control with dip management becoming a responsibility of communities or private individuals. However, communal or privately owned dips remain few and under-utilized (Waithaka et al., 2000). As revealed by Veterinary and Livestock Officers during our survey most dips have been brought down by mismanagement and leadership wrangles. For instance, in Kakamega Central District, out of the 20 cattle dips that existed, only one was operational.
b) *Hand spraying*. Due to the failure of dips, most farmers have turned to spraying for control of ticks. However, as noted from our survey, not all smallholders are able to buy spray pumps. In Western Kenya, we noted that HPI has intervened to assist smallholders acquire spray pumps. A foot pump is provided to a group of 2 or 3 farmers that they supported. The supported farmers are trained on spraying techniques and funds are also allocated for demonstration to build the capacity of farmers on acaricides. Farmers are also advised to supervise and monitor each other to minimize tick infestation in their neighbourhoods. Since ticks can easily spread among neighbouring farms, group members have greater incentives to impress upon their neighbours to exercise tick control.
c) *Vaccination against notifiable diseases*. Among the most common notifiable diseases include Foot and Mouth Disease (FMD), lumpy skin and anthrax. These diseases are mostly controlled through vaccination and regulating livestock movement.

In all, it is estimated that only 25% of the farmers control ticks through dipping while 65% use spraying (Waithaka et al., 2002). Tick infestation, however, remains high because of the irregularity with which spraying and/or spraying are done, and the quality of acaricides management. Vaccination is still well utilized because of government involvement although this is highly likely to change if the government pulls out. On their own, the smallholders may be unable to meet the full cost of vaccination.

High cost of acaricides has been blamed for low adoption of dipping and spraying among the smallholders (see Mudavadi et al., 2001). Even the farmers who adopt have the tendency to use low doses, rendering the exercise ineffective, and in most cases ticks develop resistance. Our key informants also raised doubts about the quality of acaricides and livestock treatment drugs available to the smallholders because the smallholders largely rely on agro-vet dealers who, more often than not, lack the requisite training in livestock health and business ethics. Bundling input and output market may help smallholders overcome this problem. For instance, the acaricides could be acquired through the dairy cooperatives to ensure that farmers enjoy discounts on bulk-buying and also escape the trap of unscrupulous agro-vets.

Vaccination programmes are under-funded by the government. We were informed by field officers that the government has prioritized parts of the country for preferential treatment in administration of government vaccination programmes. For example, Western province is not among these priority regions. Since vaccines are expensive, this implies that many farmers will be left exposed to outbreaks of the notifiable diseases. SDCP initiative has recognized this challenge and put in place a revolving fund to overcome it. The initial funds are provided to the District Veterinary Officer (DVO) to purchase vaccines and conduct the vaccination exercise. Farmers pay a fee for the exercise and the generated revenue is deposited to a bank account belonging to the dairy group. This fund will then be available for subsequent rounds of vaccination.

6.3 Livelihood Diversification

With climate change, smallholder households are bound to suffer more immensely if they engage in specialized production. Diversification of livelihood systems among these vulnerable people is therefore an important adaptation strategy. To illustrate the effectiveness of this strategy, we use information gathered from a community-based organization in Nyando District, Western Kenya.

Nyando Basin is characterized by high poverty, HIV prevalence and heavy reliance on subsistence agriculture. From our interviews with CCAFS, poverty incidence here is estimated at 61% for the rural areas and 72% for the urban areas. HIV/AIDS infection is estimated at 29.4%. The community members formed themselves into 20 groups operating under an umbrella community-based organization called Friends of Katuk Odeyo (FOKO). The

organization is currently working with CCAFS, World Neighbors, Vi Agroforestry programme, KARI and the Ministry of Agriculture to test and implement a portfolio of promising climate change adaptation, mitigation and risk management intervention. Already the community has taken up bee-keeping, improved small livestock production and crop diversification with improved agronomic practices. The key lesson from this case is that farmers, researchers, development partners and extension service providers increase their benefits by uniting around common interests. Participatory processes which involve all stakeholders in identifying and prioritizing interventions empower community members to directly request and access information and services. This works well when the community operates under a properly structured organization for collective action.

7.0 Conclusions and policy implications

As the links between climate change and agriculture become better understood in the scientific community, public policy efforts to support agricultural adaptation and mitigation have intensified. Kenya has responded to the challenge by developing climate change policy development. This report has reviewed the process of Kenya's experiences and draws lessons for future national policy and institutional development in support of climate smart agriculture. The concept of climate smart agriculture describes agricultural systems that provide not only agricultural production, but also climate change adaptation and mitigation benefits, and improved watershed and ecosystem management. To support climate smart agriculture, policy and financing will need to adapt so that these multiple objectives adaptation and mitigation as well as rural development, food security and ecosystem services can be achieved simultaneously.

With three quarters of Kenya's population dependent on agriculture for their livelihoods, it is a country in need of climate smart agriculture. Kenya's NCCRS is the framework for integrating climate concerns into development priorities, government planning and budgeting. The NCCRS includes indicative budgets and plans for line ministries. The budget requires close to 20% of Kenyan government expenditures planned for agriculture annually for the next 20 years.

Technologies/innovations for adapting to and mitigating climate change are available and clearly articulated in the policy documents. Policy implementers, NGOs, research institutions and farm households are aware of them. A number of the interventions have been implemented by the smallholders, not as deliberate climate change adaptation and/or mitigation strategy but as normal routine livelihood system. More often than not, the interventions are undertaken on small farm-level scales. Complete and widespread adoption of these strategies and innovations are limited by a number of factors:

High cost of the technologies;

- Existence of counterfeit technologies and the inability of the farmers to draw distinctions;
- Small land sizes which make adoption of the technologies uneconomical;
- Lack of market for the products; and

- Lack of the requisite infrastructure for technology uptake.

7.1 Policy recommendations for the future

As policy makers in Kenya anticipate the country's economic prospects, they must consider climate change challenges and agricultural adaptation. A range of "necessary options" such providing farmers with seeds, fertilizer and financial and extension services to "sufficient options" such developing new agricultural technologies and research into climate resilient crop varieties, is possible. Those concerned with economic growth and food security should identify and pursue responses best adapted to the country.

Although, the NCCRS and NCCAP are important processes, there is need to develop adaptation and mitigation on different tracks, even in agriculture where many of the activities provide benefits for both. The separation of these processes is important for planning purposes and is necessary in order to access different streams of funding. Caution must however, be exercised to avoid inefficiencies due the promotion of similar activities.

The funds currently dedicated to climate change activities in agriculture are limited. Most of the ministry's activities that do support adaptation and mitigation are currently categorized as sustainable land management activities, as they have been in the past. While substantial climate change-specific funds have not begun to flow to Kenya-this is not the only case with agriculture-there have been a smattering of adaptation projects. Real work lies in innovative research developing new germplasms, Transcription Activator-Like Effector Nucleases (TALENs) for climate resilient crops.

As the Kenyan government responds to the devastating impacts of climate change, it faces a parallel challenge of building climate change institutions. There is tension and confusion between various institutions responsible for climate change. Confusion, overlapping mandates and perceived lack of consultation has the potential to delay beneficial projects and create mistrust and sub optimal coordination among agencies and stakeholders.

7.1.1 Increased public investments in Agricultural R&D

For agriculture to meet the challenges posed by climate change, food security and economic growththe country needs myriad agriculture breakthroughs on par with those of the Green Revolution. However, as discussed, public investments in agricultural innovation have not kept

pace with growth in GDP, and private sector investments fail to advance the sorts of high risk, high reward research that hold promise for building a truly resilient and plentiful agricultural system. A top priority of national and international policy makers should to reverse this trend by ensuring that innovations in the agricultural system is funded, staffed and supported adequately to a scale commensurate to the challenges faced. Arguably, given the growing agricultural challenges related to climate change such as worsening droughts and impacts of extreme floods, policy makers should increase investment to agricultural R&D including technologies for water use efficiency in the sector. This will provide scientists with ability to pursue multiple pathways to climate resilient crops that the private sector is not willing to invest in aggressively.

7.1.2 Reform regulatory agricultural research environment

Policy changes must be made to improve the efficiency of agricultural research. Regarding the types of regulatory reforms needed to boost innovation and accelerate much needed breakthrough crops into the markets, Kenya must follow other countries in adopting the rules codified under the World Trade Organization (WTO).

7.1.3 Strengthen Institutions to serve as Hubs for Agricultural Innovation

The research approaches used to boost crop productivity in the 1970s are vastly different from those needed to solve today's agricultural challenges. The proven solutions of yesteryears largely focused on using plant breeding to create improvements of traits controlled by only a few genes. These techniques are no longer sufficient. Today the traits that need to be improved-drought tolerance and water use efficiency, tolerance to extremes of heat and so on- are controlled by multiple genes. These traits are a dynamic interaction of several genes as part of a complex multivariate system. Consequently, these traits cannot be managed with the same approaches that were so fruitful in the last century, and research methods and techniques must change accordingly. In effect today research institutions such as KARI, KEFRI etc must become vehicles for coordinating reticulated networks, using many different disciplines and tools to solve complex biotechnology problems. Such a reform is critical to boost crop resiliency to climate change.

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9.0 APENDICES

Appendix 1: Summary of methodology

Inception	**Main Study**	**Feedback and Finalization**
Activities:	**Activities:**	**Activities**
• Preparatory planning meeting • Identification of stakeholders in agricultural sector. • Design of data collection instruments (quantitative and qualitative) • Comprehensive Desk review and initial Key Informant interviews • Drafting of inception report • Submission of inception Report	• Consultation of key informants • Preparation for field work • Key Informant Interviews with primary and secondary stakeholders • Policy analyses • Quantitative and qualitative data analysis • Preparation of Draft Report. • Feedback Meeting with client Submission of Draft Report	• Presentation of Draft Report to relevant partners • Dissemination of findings to stakeholders • Revision of Draft Report & • Submission of Final Report to partners
Outputs:	**Outputs:**	**Outputs**
• Proposal on methodology • Study Launch workshop • Study Instruments	• Draft Report	Dissemination Workshop Final Report

Source: Authors' compilation, 2013

Appendix 2: Survey tool

Interviewee…… Institution…….

Designation…… Contacts…….....

Interviewer …… Date……

BACKGROUND

- In 2010, Kenya adopted the Agricultural Sector Development Program (ASDP 2010-2020), as the over-arching policy document to guide/provide a road map for the sector for the period 2010-2020.
- ASDP recognize Climate Change and Climate Variability as key threats to the agriculture sector.
- The threat posed by climate change is recognized in various national development policy documents such as the *Vision 2030* and the National Climate Change Response Strategy (NCCRS). The Agricultural Sector Development Strategy (ASDP) considers the implementation of NCCRS as important in addressing climate change.
- NCCRS has been operationalized through the development of the National Climate change Action Plan (NCCAP) which provides a framework for dealing with climate change and climate variability.
- This study is being undertaken by KIPPRA in collaboration with UNECA with the aim of shedding light on the extent to which agriculture policies are informed by climate change related research and consequently the extent to which these policies influence practice on the ground.
- Given the critical role you and your institution plays in the agriculture sector (or climate change policies) you have been selected to for this interview.

This study aims at assessing the extent to which agricultural policies are informed by research and how policies are translated into actual practice on the ground.

PART I: GENERAL QUESTIONS (For all Interviewees)

1. Is the threat of climate change/climate variability recognised in the work of your institution? Yes [ ] No [ ] ***If yes go to 2, if No go to 3***
2. If yes in 1 above provide examples of activities undertaken by your institution to address the threat.

……

3. If no in 1 above, what are the reasons for the non-recognition of the threat of climate change?

……

4. In your own assessment, do existing agricultural policies adequately address the threat posed by climate change? Yes [ ] No [ ]
5. Explain your response in 4 above, showing the extent.

……

……

6. What policy gaps exits in addressing threat of climate change to agriculture?

……

……

7. To what extent are existing policies translated to actual practice on the ground?
   a. Not at all [ ] b. To some extent [ ] c. Fully [ ]

PART II: For policy makers only

8. Describe how the process of integrating climate change into agriculture policy has evolved over time in the last decade?

……

……

9. To what extent is the process of policy formulation informed by research evidence?
   a. Not at all [ ] b. To some extent [ ] c. Fully [ ]
10. Explain your response in question 9 above.

……

……..

11. To what extent is the National Climate Change Response Strategy (NCCRS) mainstreamed into agriculture sector climate change policies?

    a. Not at all [ ] b. To some extent [ ] c. Fully [ ]

12. Explain your response in question 11 above.

……

……..

13. Describe the mechanism that links research, policy and practice in climate change and agriculture

……

……..

14. From question 13 above, in your assessment, is the existing mechanism effective? Yes [ ] No [ ]
15. If no in question 14 above, what improvements are required to make the mechanism more effective?

    ……

    ……

16. Are there systems of monitoring and evaluating implementation of climate change related policies? Yes [ ] No [ ]
17. Does policy drive research on climate change? Yes [ ] No [ ]

PART III: For policy implementers

18. Are climate change policies mainstreamed in the work of your institution? Yes [ ] No [ ]
19. If yes in question 17 above, provide concrete examples (if any) of some climate change related programs or projects being undertaken by your institution

……

……

20. Are there budgets being allocated to specific climate change programs in your institution? Yes [ ] No [ ]
21. If yes in question 19 above, how do these budgets compare with others allocated to non-climate change programs?
    a. Comparable [ ] b. Higher [ ] c. Lower [ ]
22. What other institutions do you work with in implementing climate change programs in the area?

……

……

Part IV: For research Institutions

23. Does your institution carry out research related to climate change adaptation or mitigation? Yes [ ] No [ ]
24. If yes in question 22 above, provide examples

……

25. In your assessment, does the climate change research influence policy? Yes [ ] No [ ]
26. Explain your answer in question 24 above.

……

……

27. Are there specific examples in which research from your institution has influenced policy in reference to the following areas:-
    a. Land use efficiency (e.g. Agroforestry, intercropping, agronomic practices, fallowing, conservation agriculture, irrigation etc.)

……

    b. Input supply strategies (e.g. seed and fertilizers)

……

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<END>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

THANK YOU

Appendix 3: List of individuals and institutions interviewed

	Name	Designation	E-mail contacts	Telephone contacts
1	Judith Muricho	District Livestock Production Officer, Ugunja	judithmuricho@yahoo.com	254725859234
2	Obiero McAhadho	County Director of Livestock Production, Siaya	obieromcahadho@gmail.com	0727-577651 /0735387808
3	Betty Mulianga	Technical Advisory Committee Secretary		
4	J.A.N. Polo	County Director of Agriculture, Homabay		0726820232
5	Salome Okalo	Agriculture Officer, Kakamega		0722574801
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7	John Olwande	Research Fellow, Tegemeo Institute	jolwande@tegemeo.org	
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9	Charles Awich	DLPO, Ugenya District	dlpougenya@yahoo.com	0713705083
10	D.O. Ligeya	PRO, KARI		0722770108
11	Benjamin Bahati	Director, Meteorological Services, Busia		+254722225268
12	Likoko Jew	DLPO, Kisumu North		*0726646858*
13	Peter Oduko	DLPO, Maseno		0727498391
14	CCAFF-EA, Maren Radeny		m.radeny@cgiar.org	
15	Peter Omonyo	Livestock Devt Dept	vileldoret@yahoo.com	0721251065
16	Newton	Senior Research Officer, KARI		

		Kibos		
17	Millicent Kisia	MoA, Eldoret East		0720390424
18	V.O. Lala	CDE, NEMA	P.O. Box 9301, Eldoret	
19	Charles Makau	MoA, Eldoret		0716827493
20	Mark Obunde	Ministry of Forestry	P.O.Box 30100, Eldoret	
21	Kulecho Zakayo	MoA		0720814070
22	Ms. Grace Mureithi	INANDES Formation	Project Officer	0722535263
23	James Wandeto	Kenya Wildlife Services (Machakos)	Deputy Warden	0725859830
24	Isaac Kimitei	NEMA (Machakos)	Environmental Officer	0721541545
25	Francis Kikolya	CARITAS – Machakos	Development Coordinator	0725726780
26	Joel Atuti	World Vision (Machakos)	Project Officer	0725737290
27	Mr. Anthony Njiru	Department of Livestock (Machakos)	Livestock Production Officer	0720963894
28	Kathuli P.	KARI - Katumani	SRO	0726929889
29	Eunice Sakong	Department of Agriculture (Machakos)	Chief Agricultural Officer	0712117520
30	Lawrence Swanya	Department of Agriculture (Athi River)	Chief Agricultural Officer	0725658070
31	Mr. Nzombe	Department of Agriculture (Mbeere South)	DAO	0725980512
32	Ms. Cecilia	Department of Livestock (Athi River)	Livestock Officer	0727709806
33	Mr. Ng'ang'a	Min. of Agric	DAO – Meru Central	0738376383
34	Mr. Kinoti Kirinya	Kaguru A.T.C.-Meru	Principal	0723265115
35	Ms. Jane	Nyayo Tea Zone-Meru	Secretary	0721716198
36	Mr. Kiogora	Technoserve-Meru	Field	0721863274
37	Mr. Robert Gichunge	Caritas – Meru	Head of Program	0720645153 gichungerobert@yahoo.com
38	Mr. Mugambi	Former DLPO - Meru	Dep. County Rep.	0721896230
39	Ms. Martha	FH-Meru	Administration	0722223139

40	Finyange N. Pole	Horticulturalist, KARI Matuga	finyange@gmail.com	0733737794
41	Jeremiah Alukwe	Kenya Coconut Development Authority (KCDA)	jeremiah.alukwe@kcda.go.ke	0720204396
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45	Jeptum Linet	DFO	jeptumlinet@yahoo.com	0722345356
46	Arafa A. Amur	Field Tech., KEFRI-GEDE	ara.amur@gmail.com	0721119270
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48	Evans Ongijo	KeSREF, Bamburi	onginjoevans@yahoo.com	
49	Mcharo Mwaluga	Coast Development Authority	msmcharo@yahoo.com	0721403919
50	Martin Shimba	NEMA, Mombasa		
51	Pauline Ndiso	PAO, MoA Mombasa	daomombasa@yahoo.com	0722433228
52	Alfred Kiti	Field manager, KOMAZA Kenya	alfred.kiti@komaza.org	0725603609
53	Nicholas M Nkanda	County food for asset coordinator	nkanda06@yahoo.com	0721783976
54	Benjamin Muli	Head food crop programme, KARI		0722841390
55	Oras Murithi	Environment officer, NEMA Kilifi	orassteve@yahoo.com	0726967094
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57	Elizabeth Mukora	DAO, Kiambu		
58	Dr. Njiri	DLPO, Nyeri		0720615600
59	Mburu	DLPO		0720372411
60	Alice Nthenya	DAO, Nyeri		0721622981
61	NEMA-Kiambu			
62	Muteti	EO, NEMA-Nyeri		