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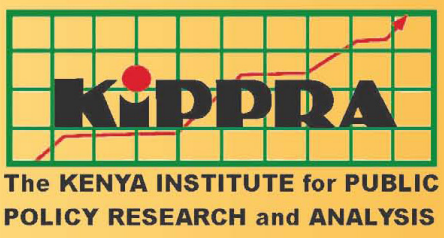

An Assessment of Agricultural Sector Policies and Climate Change in Kenya: Nexus between Climate Change Related Policies, Research and Practice

Wilfred Nyangena
Paul Guthiga
Maurice Ogada
Geophrey Sikei

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

AND

UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA (UNECA)

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The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

ECA

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Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

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Foreword

Climate change and climate change variability is a threat to food production patterns, thus exacerbating food and nutrition insecurity across Africa. Therefore, tackling poverty, hunger and food security is a priority for the Africa Union Agenda 2063 which underscores the right of Africans to live healthy and productive lifes. Further, the African Union has set a target to eliminate hunger and food insecurity by 2025 towards achieving the Sustainable Development Goal (SDG) 2 on ending hunger, achieving food security and improving nutrition. Unfortunately, Africa is not on track in meeting these targets mainly because the region is not producing enough food due to climate change and low adoption of technology. However, climate change has variable impacts on food production, with both production losses and gains across the region. As a result, regional trade is critical for facilitating the distribution of agricultural products to enhance food security in the region.

The East Africa Community (EAC) region is particularly vulnerable to climate change. The region is already experiencing increased climate change impacts, including extreme weather conditions, persistent drought, floods, and landslides and rising sea level which threaten food security and efforts to eradicate poverty. Despite the huge potential to produce enough food, the agricultural production system in the region is mainly rainfed, which consequently leads to high food and nutrition insecurity.

Finding solutions to perennial food security challenges in the EAC is crucial and urgent as climate change impacts intensify in frequency and severity. Looking beyond just agricultural production systems is thus critical in tackling this peril. Thus, there is need to apply other approaches such as the nexus approach which allows for evaluating integrative systems where, for instance, trade facilitates food security in a changing climate environment. Although agriculture production is vulnerable to climate change, food security is not necessary a result of low production but a combination of other factors such as poor food distribution caused by perverse subsidies and other trade barriers. The EAC has been able to attain a common market status, which could facilitate trade in the region and thus mitigate food shortages.

Despite the various measures and programmes adopted in EAC, some parts of the region continue to face food deficits due to restrictive trade policies and barriers to trade. Opportunities exist for adopting existing policy frameworks by member countries to address food security needs.

Preface

The project on Regional Assessment of Climate Change, Agricultural Production, Trade in Agricultural Production and Food Security in East African Community (EAC) was carried with support from the ACPC-CLIMDEV Work Programme. The ClimDev-Africa Programme is an initiative of the African Union Commission (AUC), the United Nations Economic Commission for Africa (UNECA) and the African Development Bank (AfDB). It is mandated at the highest level by African leaders (AU Summit of Heads of State and Government). The Programme was established to create a solid foundation for Africa's response to climate change and works closely with other African and non-African institutions and partners specialized in climate and development.

Over the last few years, our understanding and certainty about how climate is changing and the possible impacts this could have has grown immensely. This notwithstanding, agricultural production systems in the EAC region are highly vulnerable to climate change, consequently affecting food and nutrition security. The region is the most developed regional economic community (REC) in Africa, and cross border trade plays a critical role in facilitating food security. In response, the United Nations Economic Commission for Africa–African Climate Policy Centre (ACPC) is increasing its efforts to improve the capacity of EAC member states for mainstreaming climate change impacts in development policies, frameworks and plans.

The three-year project was launched in May 2014 covering Burundi, Kenya, Rwanda, Tanzania and Uganda. The activities carried in this study were linked to the ClimDev-Africa Programme work stream II, which focuses on solid policy analysis for decision support, and was spearheaded by the Kenya Institute for Public Policy Research Analysis (KIPPRA). The overall objective of the project was to assess whether or not agricultural production systems and trade policies in EAC can be adjusted to alleviate the impact of climate change on food security, and promote sustainable development. The project outputs include pre-project report, country scoping studies, indepth EAC studies on climate change, crop production model, economic policy and trade and finally a comprehensive regional report.

Acknowledgements

The study was conceptualized and commissioned by the African Climate Policy Centre (ACPC), United Nations Economic Commission for Africa (UNECA), under the leadership of Dr Fatima Denton, Director of the Special Initiative Division, UNECA. Dr Tom Owiyo and Dr Johnson Nkem, senior experts at ACPC, guided the conceptual framing and provided oversight during implementation. Regular technical support was provided by ACPC researchers, Dr Wifran Moufouma Okia, Mr Nassirou Ba, Dr Habtamou Adessou, and research fellows Yosef Amha and Rivaldo.

The study was conducted as a part of the activities of the Climate Change and Development in Africa (ClimDev-Africa) Programme supported by the UK Department for International Development (DfID), European Union Commission, Norway, Sweden, France, Nordic Development Fund, and the United States Agency for International Development (USAID).

The Executive of KIPPRA and the Executive Secretary of UNECA would like to acknowledge the KIPPRA technical team comprising Nancy Laibuni (Project Coordinator), Dr August Muluvi, Dr Christopher Onyango, Mr John Nyangena, Mr Simon Githuku, and Mr Nixon Murathi; and the project consultants Dr Richard Mulwa, Dr Miriam Omolo, Dr Wilfred Nyangena, Prof. Caleb Mireri, and Dr Wellington Mulinge. In addition, we appreciate the Eastern and Southern Africa Region Office of the World Metrological Organization, led by Dr Elijah Mukhala and the consultants, Mr Nicholas Maingi and Dr Joshua Ngaina for their contributions to the project.

The regional Partner Institutions included Economic Policy Research Centre (EPRC)–Uganda team lead by Dr Isaac Shinyekwa, Sokoine University–Tanzania team led by Prof. Siza Tumbo, University of Burundi team led by Dr Alex Ndayiragije, and Kigali Independent University team led by Mr Paul Muzungu. The participation of the stakeholders in various stages of the preparation of the report was highly valuable in enriching the report.

The Economic Commission for Africa and KIPPRA would like to express their appreciation to all the government Ministries, State Departments and Agencies in Burundi, Kenya, Rwanda, Tanzania and Uganda for their active participation and providing the data and information used in preparing the report.

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 National Climate Change Response Strategy (NCCRS) provide more details on prioritized activities. The NCCRS recognizes that current government institutions are inadequate to handle complex challenges of climate change's needs including research. To meet the needs of climate change, a Climate Change Secretariat has been established within the Ministry of Environment and Mineral Resources (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 programs. 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 agricultural sector climate resilient, more productive and sustainable. In light of this, this paper proposes several solutions. In particular, it is argued 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. New and improved crop varieties are needed, that use less water, deliver increased yields, improved nutrition and withstand extreme heat and drought.

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 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.*

Finally, outlined are 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:

i. *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.*

ii. *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.*

iii. *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.*

Abbreviations and Acronyms

ADB	Africa Development Bank
AgGDP	Agricultural Gross Domestic Product
AI	Artificial Insemination
ASCU	Agricultural sector Coordination Unit
ASDS	Agricultural 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
FOKO	Friends of Katuk Odeyo
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GoK	Government of Kenya
HIV	Human Immuno-deficiency Virus
HPI	Heifer Project International
HYV	High Yielding Varieties
IBR	Institute of Biotechnology Research
IDS	Institute for Development Studies
IFPRI	International Food Policy Research Institute
ISAAA	International Service for the Acquisition of Agri-biotech Applications

JKUAT	Jomo Kenyatta University of Agriculture and Technology
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
LDP	Livestock Development Programme
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
TALENs	Transcription Activator-Like Effector Nucleases
UN	United Nations
UNDP	United Nations Development Program
UNECA	United Nations Economic Commission for Africa
WTO	World Trade Organization

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1. Introduction

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), Food and Agriculture Organization (FAO) and the World Bank, the goal of modern agriculture policy is to produce a global state of food security (Schmidhuber 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. Therefore, the performance of the sector has a significant effect on national output and corresponding income and poverty levels. The sector is also vital to the country's socio-economic security. Climate change and climate variability will cause substantial welfare losses, especially for smallholders 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 programme. The ClimDev-Africa programme 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 identifying 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 ongoing climate change and associated climate variability, African countries must adopt policies and strategies that will make the agricultural 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 microeconomic aspects of the agricultural sector, particularly its contribution to Gross Domestic Product (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 (smallholders, 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, and reviewed climate change policies in the country and how they specifically related to the agricultural sector and the extent to which current research agenda in the agricultural 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.

The following key findings were identified:

- 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 Greenhouse Gases (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 mitigations 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;
- Promotion of appropriate irrigation technologies suitable for different agro-climatic regions and sensitive to ecological systems; and
- 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 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. Section 5 highlights the agricultural research environment, including the impediments to innovative agricultural development. 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 programmes 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. Methodology

This study was carried out in four phases:

- Phase I: Literature review
- Phase II: Inception
- Phase II: Data collection and synthesis
- Phase III: Feedback and finalization

Under each phase, several activities were undertaken and outputs generated. To understand the progress made thus far and the challenges experienced in tackling climate change in Kenya's agricultural sector, as a first step, a review of existing literature on climate change in Kenya was undertaken. The literature served the following purposes:

- It identified the key actors working on agriculture and climate change in Kenya and helped 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 helped understand the policy context and the main drivers; and
- Identified the key themes and narratives shaping the discourse on climate change and agriculture in Kenya.

2.1 Inception Phase

An inception meeting was held with the representative of United Nations Economic Commission for Africa/Africa Development Bank (UNECA/ADB) to discuss the assignment and responsibilities of the Environment for Development Initiative in Kenya/Kenya Institute for Public Policy Research and Analysis (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 2.1:

Table 2.1: Survey methods techniques

Approach	Techniques
Literature review research	Review of policy documents and other relevant materials.
Qualitative/ quantitative research	Indepth 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

A survey tool was used to collect information from a wide range of institutional experts. 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 indepth interviews using the survey tool. Indepth 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 programmes.

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. Disagreements and clarifications were noted and have been incorporated in this report.

3. Role of Agricultural Sector in the Economy

Agriculture is a central sector of Kenya's economy. It contributes about 25 per cent of the Gross Domestic Product (GDP) and another 25 per cent indirectly (Government of Kenya, 2010a). 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 Kenya's population. According to the Agricultural Sector Development Strategy (ASDS), the agricultural sector provides more than 18 per cent of formal employment and more than 70 per cent of informal employment in the rural areas (Government of Kenya, 2010).

The agricultural sector comprises six sub-sectors 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 sub-sectors have huge potential for growth that has not been exploited.

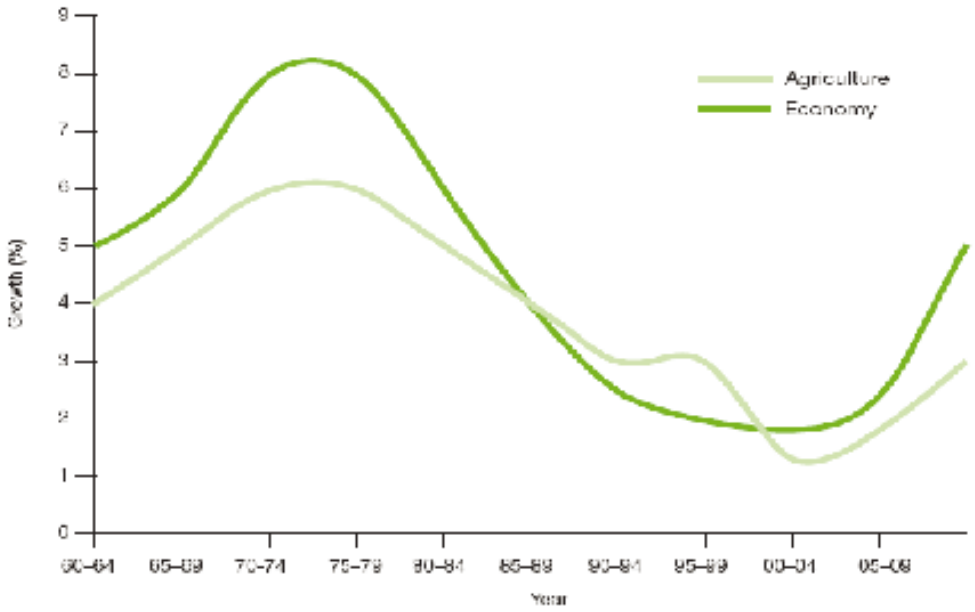
The agricultural sector is the primer for industrialization; it supplies the raw materials for industries, for instance timber for the paper manufacturing industry, skin and hides for the leather industries, raw food stuff for the food processing industry, etc. Furthermore, the sector is also a market 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

Agriculture 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 (Figure 3.1). 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 agricultural sector grew at an average of 6 per cent per annum while the overall economic growth averaged 7 per cent.

Figure 3.1: Trends in agricultural and economic growth (1960-2008)



Source: Adopted from the Agricultural Sector Development Strategy (ASDS), Government of Kenya (2010)

Since the late 1970s to late 1990s the agricultural sector experienced a declining growth. At the same time, the overall economic growth also took a downward turn. A clear reversal of the declining trend has been evident since the early 2000s; the agricultural 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 a 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 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 Millennium Development Goal (MDG).
- Reduced food insecurity by 30 per cent to surpass the MDGs.
- Increased contribution of agriculture to the GDP by more than Ksh 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 been used in importing food from other countries which 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 roads, hospitals, etc.

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 deficit is 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 high food prices. Maize, being the staple food, is often in short supply and most households have limited choices of other food stuffs.

3.3 Agriculture and Poverty

Approximately 80 per cent of 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 head count ratio for the country is estimated at 45.9 per cent. The rural economy is dominated by the smallholder subsistence farmers who produce about 75 per cent of the total agricultural output. The areas with high potential for agriculture are 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 agriculture-led growth in Kenya is more than twice as effective in reducing poverty as growth led by industry (Mabiso et al., 2012). The analysis undertaken by Mabiso et al. (2012) indicates that if Kenya were to achieve the Comprehensive Africa Agriculture Development Programme (CAADP) target of 6 per cent for the agricultural sector, levels of poverty would fall to 24 per cent 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 grow at over 6 per cent per annum. In the semi-arid areas of the country, investment in irrigation and infrastructure offer the best potential to significantly reduce poverty. In general, the transformative process of the agricultural sector would have bigger multiplier effects in other sectors of the economy that would absorb more and more labour. The population that would remain in the agricultural 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 3.1).

Table 3.1: 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	
1921	Coast	
1925	Kerio Valley, Coast	

1933/34	Coast, Central	
1942-1944	Countrywide	
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. 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 was being translated into action on the ground.

4. 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 for 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 (Government of Kenya, 2010b). This would require nearly 20 per cent 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 the parliamentary committee dealing with climate change.

Though the Agricultural Sector Development Strategy has included climate adaptation as a priority (Government of Kenya, 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 programmes. 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 encourage 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 the next steps for knowledge management and capacity development, technology requirements, a financial mechanism, and a National Performance and Benefit Measurement System–NPBM (Government of Kenya, 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 Agricultural Sector Development Strategy (ASDS), 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 per cent 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. 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 Vision 2030

Vision 2030 makes reference to climate change adaptation in the context of building capacity as part of the environment. The Vision also states as a specific goal under environmental management, the aim of attracting at least five 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, 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; and

(vii) promotion of adaptation activities in high risk disaster zones.

4.4 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 macroeconomic 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 Nexus between Agriculture and Climate Change Policies/ Strategies in Kenya

NCCRS 2010, Vision 2030 and the Second MTP (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 . 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 observe 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; and appropriate and participatory policy formulation and environmental sustainability.

The government has used a "systems approach" to the agricultural sector. Agricultural 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 agricultural 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, National Environmental Management Authority (NEMA), Climate 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 sector's development towards climate change proofing.

Policy formulation, particularly among agriculture-related agencies such as the ministries is inclining towards evidence-based findings from research undertakings of local consultants, universities 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 such as 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. The Ministry of Agriculture 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 leading to weak enforcement of policies and legislations.

5. Agricultural Research 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 Agricultural 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 policy makers 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 Sector Development Strategy has included climate adaptation as a priority, but the agricultural components of the NCCRS provide more details on prioritized activities. On adaptation, it calls for accelerated investment in weather information systems, research on drought tolerant crop varieties, soil and water conservation, water harvesting and strengthening integrated pest management systems, among others. It has already been noted that Kenya 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, 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 programmes. The unit will also be involved in the development and implementation of policy on climate change in agriculture, the development of programmes and projects, coordination and partnership building with relevant stakeholders, and mobilization of resources for these activities.

5.3 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, 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 Transcription Activator-Like Effector Nucleases (TALENs). TALENs with the help of computer algorithms makes 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 such as drought tolerance, are impacted by hundreds of genes working together in complex, but poorly understood ways. TALENs provide a breakthrough research pathway for unlocking these traits and building more resilient crops and livestock. While 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 agricultural 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 that are 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 improvements 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 that directly depends 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 and 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 agenda, 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 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 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, the major private sector players dominating agricultural innovation ecosystem are large multinational companies that are active historically in agricultural chemicals. These include Monsanto, BASF, Bayer Crop Science, Syngenta, and Dow AgroSciences . 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 such as 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 to 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 1970s which drastically reduced starvation is marred by underfunded research budgets, regulatory barriers, and a lack of vision for next generation innovations.

6. Kenya's Agricultural Policy: Implementation and Practice

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 Vision 2030, NCCRS (2010), NCCAP and National Development Plan 2002-2008. They are also manifested in the agricultural 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:

1. Promotion of on-farm water harvesting and management technologies (roof catchment, pans, dams, water holes, etc);
2. Introduction of water-saving technologies such as canal lining and drip irrigation;
3. Increasing national forest cover through afforestation and agroforestry (e.g. through supply of seeds of fast growing trees);
4. Control of floods in Nyanza and Western regions;
5. 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
6. 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 agricultural sector.

Using information from field survey and literature, how far these strategies have been implemented has been explored. 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. A few of them have been explored 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 per cent compared to 60 per cent in surface irrigation and 75 per cent in sprinkler irrigation (Perez-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 the survey.

6.1.2 Use of drought-tolerant sorghum

Sorghum grows well even under arid and semi-arid areas, which constitute about 80 per cent of the country's land area. Areas suitable for sorghum growing include parts of Eastern Region, parts of Rift Valley, and parts of Nyanza and Western Regions. 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 (Khamsin, 2011).

It was noted from the interviews with farmer groups in lower Eastern that, although sorghum is not widely cultivated in terms of land area, 50 per cent 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 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 the 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 (Perez-Quezada et al., 2012). The system is being promoted by KARI, Kisii and Marsabit stations. During the field survey, its adoption was witnessed in Nyando and Kisii although the 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 fuel that would otherwise have been used in land cultivation. However, it was learnt that a number of farmers were quite skeptical about its ability to enhance yields. This is a manifestation of the 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 region. 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. The 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 such as Budalangi, weather forecast is communicated in real time. The 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). Modalities of working together 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 kilometre. Other regions that can benefit from experiences of Central and Rift Valley are the Western and Nyanza regions.

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. Progress in the implementation of these interventions has been traced below.

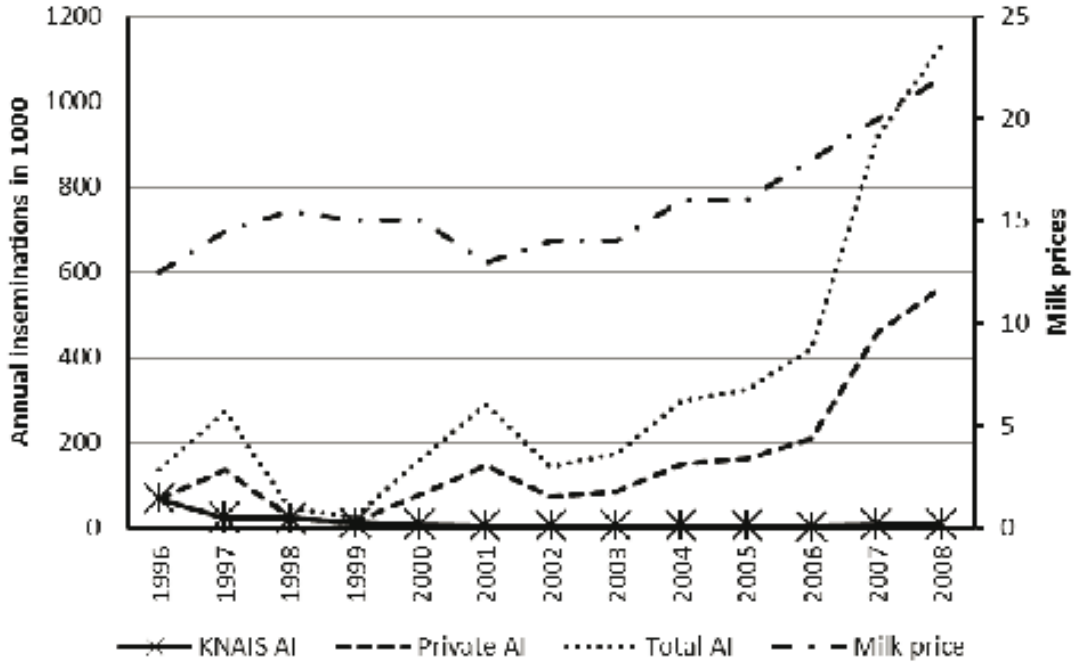
6.2.1 Dairy Cattle Breeding Technologies

Livestock breeding programmes 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 programmes (Staal et al., 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.

The 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:

i. *Artificial insemination (AI).* 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 replaced 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 (Figure 6.1). The sudden increase in uptake of AI technology after the increase in milk prices in 2007 is a clear testimony to this fact.

Figure 6.1: Annual inseminations against milk prices



Source: FAO (2011)

ii. *Gender selected/sexed semen*. This is an AI technology biased towards heifer production. Farmers can be about 90 per cent 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.

iii. *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.

iv. *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 programmes as the Livestock Development Programme (LDP), and 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.

v. *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 programmes such as Livestock Development programmes and the Millennium Development Goals (MDGs) have been implementing this initiative. Rural Outreach Programme (ROP) and Heifer Project International (HPI) are some of the NGOs which have been active in this intervention. The intervention has been implemented through farmer 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 programs 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. 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 Program (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 (Ministry of Livestock Development, 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 the 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 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 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. 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. The reasons for this were a matter of conjecture among 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 talked to in Western Kenya suggested that it would be preferable for the smallholders to start with cross-breed dairy cows and gradually upgrade the stock for optimum adaptability. Furthermore, the choice of cattle breeds supplied to farmers need to be carefully done. Most field extension staff interacted with indicated that some of the breeds provided by supporting NGOs do not fit farmers' needs and constraints. It was discovered 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 such as zero grazing and stall feeding are practised. Main feed sources in the smallholder system include forage, cultivated fodder and crop by-

products. Napier grass 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. It was noted from the 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:

(i) *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.

(ii) *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.

(iii) *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).

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

Survey in Western Kenya found a number of specific feed technologies being promoted. These are highlighted 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. It is also relatively more drought-tolerant and several high-yielding cultivars have been developed. Various government livestock extension programmes 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 per cent 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 per cent of farm households having legume trees. The second most important fodder tree was *caliandra*, planted by 22 per cent of households.

(iii) *Maintenance of grasses*. Use of natural grasses has been promoted especially in Nyamira by SDCP. 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. The 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 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 such as 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 to 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 per cent of farmers undertook tick control measures weekly. Another 17 per cent undertook tick control fortnightly while 13 per cent did so only occasionally. Specific technologies implemented include the following:

(i) *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.

(ii) *Hand spraying*. Due to the failure of dips, most farmers have turned to spraying for control of ticks. However, as noted from the survey, not all smallholders are able to buy spray pumps. In Western Kenya, it was noted that HPI has intervened to assist smallholders acquire spray pumps. A foot pump is provided to a group of two or three farmers that they support. 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.

(iii) *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 per cent of the farmers control ticks through dipping while 65 per cent use spraying (Waithaka et al., 2002). Tick infestation, however, remains high because of the irregularity with which dipping 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 (Mudavadi et al., 2001). Even the farmers who adopt the

tick control measure have the tendency to use low doses, rendering the exercise ineffective and in most cases ticks develop resistance. 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. It was alleged by field officers that the government has prioritized parts of the country for preferential treatment in administration of government vaccination programmes. For example, Western region is not among the 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, information gathered from a community-based organization in Nyando District, Western Kenya is used.

Nyando Basin is characterized by high poverty, HIV prevalence and heavy reliance on subsistence agriculture. From the interviews with CCAFS, poverty incidence here is estimated at 61 per cent for the rural areas and 72 per cent for the urban areas. HIV/AIDS infection is estimated at 29.4 per cent. 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. 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 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 per cent 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, including:

- 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

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 as providing farmers with seeds, fertilizer and financial and extension services to "sufficient options" such as 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 to 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 growth, the country needs myriad agriculture breakthroughs at 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 be 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 resilience to climate change.

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Kenya Institute for Public Policy Research and Analysis
Bishops Garden Towers, Bishops Road
P.O. Box 56445-200, Nairobi, Kenya
Tel: +254 20 2719933/4, 2714714/5, 2721654, 2721110
admin@kippra.or.ke

African Climate Policy Center
UN Economic Commission for Africa
Menelik II Ave.
P.O. Box 3001, Addis Ababa, Ethiopia
Tel: +251 11 544 5000
acpc@un.org