



AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

KENYA

AGRICULTURAL SECTOR RISK ASSESSMENT

Stephen P. D'Alessandro, Jorge Caballero,
John Lichte, and Simon Simpkin

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2. Man with livestock—Curt Carnemark/World Bank.
3. Irrigating fields near Mount Kenya—Neil Palmer (CIAT).
4. A farmer in the Kibirichia area of Mount Kenya—Neil Palmer (CIAT).

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ACRONYMS AND ABBREVIATIONS

ACCI	Adaptation to Climate Change and Insurance Programme
AIDP	Agriculture Insurance Development Program
ASAL	Arid and Semi-arid Land
ASDS	Agricultural Sector Development Strategy
CAADP	Comprehensive Africa Agriculture Development Programme
CBD	Coffee berry disease
CBK	Coffee Board of Kenya
CBOK	Central Bank of Kenya
CBPP	Contagious bovine pleuropneumonia
CFA	Cash-for-Assets
CIAT	Information Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CLR	Coffee leaf rust
COMESA	Common market for Eastern and Southern Africa
CSAE	Centre for the Study of African Economies
CV	Coefficient of variation
DAP	Diammonium phosphate
DTMA	Drought Tolerant Maize for Africa
EAC	East African Community
ECF	East Coast fever
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Corporate Statistical Database
FFA	Food-for-Assets
FHH	Female-headed household
FMD	Foot and mouth disease
FPEAK	Fresh Produce and Exporters Association of Kenya
GCM	General circulation model
GDP	Gross domestic product
GM	Genetically modified
GoK	Government of Kenya
ha	Hectare
HCDA	Horticultural Crops Development Authority
HDI	Human Development Index
HSNP	Hunger Safety Net Program

IBLI	Index Based Livestock Insurance
ICT	information and communication technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
ITCZ	Inter-Tropical Convergence Zone
KARI	Kenya Agricultural Research Institute
KCC	Kenya Cooperative Creameries
KCPTA	Kenya Coffee Producers and Traders Association
KEPHIS	Kenya Plant Health Inspectorate Services
KESREF	Kenya Sugar Research Foundation
kg	Kilogram
KNBS	Kenya National Bureau of Statistics
KRA	Kenya Rainwater Association
K Sh	Kenyan shillings
KTDA	Kenya Tea Development Authority
LGP	Length of the growing period
LMD	Livestock Marketing Division
MDTF	Multi Donor Trust Fund
MHH	Male-headed household
MLND	Maize lethal necrosis disease
mm	Millimeters
MoA	Ministry of Agriculture
MoALF	Ministry of Agriculture, Livestock and Fisheries
MT	Metric ton
MTP-I	Medium Term Plan I
MTP-II	Medium Term Plan II
NASEP	Kenya's National Agricultural Sector Extension Policy
NCCRS	National Climate Change Response Strategy
NCPB	National Cereals and Produce Board
NDDCF	National Drought and Disaster Contingency Fund
NDMA	National Drought Management Authority

NDVI	Normalized Difference Vegetation Index
NERICA	New Rice for Africa
NGO	Nongovernmental organization
NIB	National Irrigation Board
NSNP	National Safety Nets Programme
OIE	World Organization for Animal Health
PFS	Probability of a failed season
PPP	Public-private partnership
PPR	<i>Peste des petits ruminants</i>
RPLRP	Regional Pastoral Livelihoods Resilience Project

SACCO	Savings and Credit Cooperative
SDL	State Department of Livestock
SECO	Swiss Secretariat of Economic Affairs
TBK	Tea Board of Kenya
TOT	Terms of trade
USAID	U.S. Agency for International Development
WDI	World Development Indicators
WFP	World Food Programme
WHFSP	Water Harvesting for Food Security Programme

Note. All dollar amounts are U.S. dollars unless otherwise indicated.

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EXECUTIVE SUMMARY

Agriculture remains vital to Kenya's economic growth. It is also vital to the country's food security and poverty reduction efforts. Because the vast majority of Kenya's poor depend on smallholder agriculture for their livelihood, increasing their productivity can contribute at once to improving food availability, increasing rural incomes, lowering poverty rates, and growing the economy. Putting more and better seeds, fertilizers, and other inputs into the hands of farmers and pastoralists and finding ways to link them more directly to markets are among the key thrusts of current sector development policies. More broadly, Kenya's *Vision 2030* aims in part to transform the country's agriculture from subsistence to a more competitive and commercially oriented sector, one that can meet the country's food needs, expand exports, and become a key engine for forward growth.

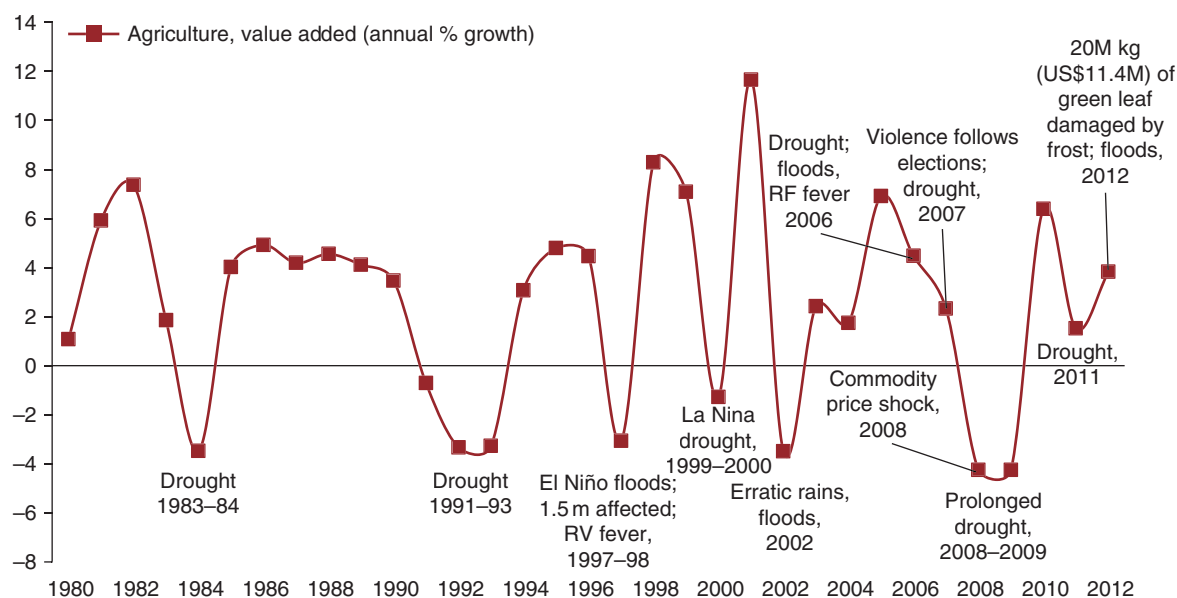
Despite Kenya's strong commitment to agriculture, sectoral growth remains well below the 6 percent target, and meaningful gains in productivity and in rolling back rural poverty have been slow in coming. The *Economic Survey 2014* shows that the agriculture sector grew by a mere 2.9 percent in 2013, down from 4.2 percent a year earlier. Moreover, Kenya continues to rely heavily on imports to feed its growing population¹ amid a widening structural imbalance in key food staples.

Key constraints limiting sector growth are well documented, as are associated response measures. Less well understood is how risk dynamics associated with production, markets, and policy adversely impact sector performance, in terms of both influencing ex ante decision making among farmers, traders, and other sector stakeholders and causing ex post losses to crops, livestock, and incomes—destabilizing livelihoods and jeopardizing the country's food security.

The present study was commissioned in part to bridge this knowledge gap. It is the first step in a multiphase process designed to integrate a stronger risk focus into sector planning and development programs. It seeks to learn from and build on a range of

¹ At 2.7 percent, Kenya has one of the highest rates of population growth in the world, according to *World Development Indicators* (WDI). The country's population has tripled in the past 35 years.

FIGURE ES.1. HISTORICAL TIMELINE OF MAJOR AGRICULTURAL PRODUCTION SHOCKS IN KENYA, 1980–2012



Source: WDI; authors' calculations.

broad initiatives by the government of Kenya (GoK) and its development partners purposed to enhance Kenya's resilience and response to natural disasters. The ultimate objective is implementation of a holistic and systematic risk management system that will reduce the vulnerability and strengthen the resiliency of Kenya's agricultural supply chains, and the livelihoods that depend on them. This sector risk assessment is the primary output of Phase One. The study's main objective is to identify, assess, and prioritize principal risks facing Kenya's agriculture sector by analyzing their impacts via quantitative² and qualitative measures. Based on this prioritization, the study identifies key intervention areas for improved risk management. The review encompasses the 33-year period 1980–2012.

Figure ES.1 depicts a historical timeline of the most notable risk events to adversely impact sector performance during the period under review. The study's main findings highlight an agriculture sector increasingly vulnerable to extreme weather variability. An analysis of cumulative annual rainfall during the period 1980–2011 indicates

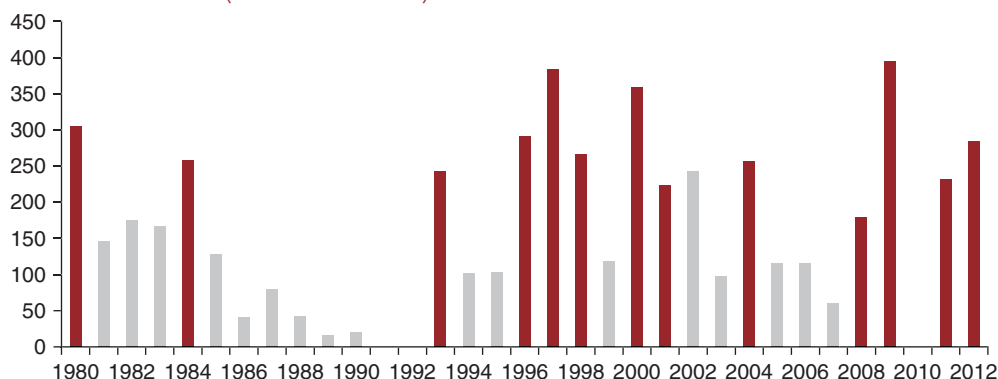
that Kenya has experienced an extreme rainfall event during two of every three years on average. It also suggests the increasing frequency of severe droughts affecting large swaths of the country in the last decade and rising levels of year-on-year rainfall variability. The combination of frequent severe droughts, high dependence on rainfed agriculture, and high poverty rates among smallholder farmers and pastoralists makes Kenya particularly vulnerable to the effects of droughts. Erratic rainfall, punctuated by severe droughts, is the biggest risk facing Kenya's agriculture sector, with profound impacts on both crop and livestock production. In addition to extreme weather events, the global financial and economic crisis, high food and fuel prices, and a tense and at times uncertain political environment in recent years have repeatedly disrupted agricultural supply chains and markets, jeopardizing growth and the sector's ability to provide food security and reduce poverty. Other key findings of the assessment are presented below.

CROP AND LIVESTOCK PRODUCTION RISKS

Extensive livestock systems and pastoralists in Kenya's northern rangelands are particularly vulnerable to the effects of drought. Estimated losses to livestock

² A more extensive quantification of risk impacts was hampered by notable inconsistencies and gaps in production, weather, and other time-series data, underlining the need for future investments in improved data collection, management, and dissemination.

FIGURE ES.2. ESTIMATED LOSSES TO AGGREGATE CROP PRODUCTION FROM RISK EVENTS, 1980–2012 (US\$, millions)



Source: FAOSTAT; authors' calculations.

populations from droughts that have occurred within the most recent decade alone amount to more than \$1.08 billion. Ancillary losses related to production assets and future income and the costs of ex post response measures are likely several times that figure. The increased incidence of droughts across Kenya's arid and semiarid lands (ASALs) in recent years means that affected communities have less time to recover and rebuild their assets. This has weakened traditional coping mechanisms, handicapping household resilience against future shocks.

Key select crops in Kenya experienced significant production losses³ in 13 years as a result of adverse risk events during the period 1980–2012, or once every three years on average (figure ES.2). All of these crop loss events resulted in a drop in agricultural gross domestic product (GDP) of 2 percent or more. Losses ranging from 3 to 4.2 percent occurred in six years. Indicative losses were substantial for these events, totaling nearly \$5.10 billion, or roughly \$154.5 million on an average annual basis, during the 33-year period. Maize accrued by far the biggest losses measured in production value over the period, accounting for nearly one-fifth (19.8 percent) of total indicative losses. Coffee, tea,

banana, and dry beans also experienced notable losses over the period. Sugarcane represented for nearly half (46 percent) of aggregate indicative losses by volume but less than 6 percent by value (figure ES.2).

Relative to most other crops, maize is highly susceptible to moisture stress. Kenya's strong reliance on rainfed maize production in meeting its food needs and growing consolidation of production toward maize (and dry beans) has rendered the country increasingly vulnerable to supply disruptions and food shortages. Amid declining yields, productivity gains have come largely through land expansion into marginal areas that receive lower and more variable rainfall. This trend coupled with Kenya's increasingly erratic rainfall has made the country's maize production more susceptible to moisture stress and year-on-year yield variability, with significant implications for the country's food security.

Beyond weather risks, the analysis highlights the important threat that pests and diseases pose to Kenya's farmers. Left unchecked, crop pest and diseases regularly cause considerable pre- and postharvest losses that dampen yields and incomes. The most common crop threats are armyworms, thrips, aphids, mealybugs, and nematodes, which are all a permanent fixture of Kenya's agricultural landscape, as elsewhere. Parasitic weeds such as *Striga* are another common threat, affecting large swaths of Kenya's prime cropland. Maize is particularly susceptible to a range of fungal (e.g., rust,

³ Measured in terms of gross agricultural value, or the total value of volume of production for each crop multiplied by the producer price. Crops covered in the analysis include maize, wheat, paddy rice, sorghum, Irish potatoes (1980–2006), cowpea, dry beans, tea (1988–2012), coffee, sugarcane, bananas, and green beans.

spot, blight, smut) and viral diseases (e.g., maize streak virus). The most noteworthy is maize lethal necrosis disease (MLND), which is considered the greatest threat to maize production as no definitive or resistant varieties have yet to emerge from research since the disease was first detected in June 2011. Incidence in the field ranges from 40 to 100 percent of the crop, and crop losses of over 80 percent have been reported. Among Kenya's industrial crops, coffee is particularly susceptible to coffee berry disease (CBD) and coffee leaf rust (CLR), two major diseases of Arabica coffee that, left untreated, can cause up to 50–80 percent losses. Chronically low—farm-gate prices offer poor incentives to farmers to invest in control measures for these diseases, aggravating their impact.

Tea production in Kenya has long benefitted from favorable growing conditions that limit pest and disease threats. Good crop husbandry is also an enabling factor. For the period 1988–2012, tea yield variability was by far the lowest among the crops analyzed. However, given the high market value of tea, even small yield drops can amount to considerable dollar losses, as happened in 2009, 2011, and 2012, when aggregate losses for the three years totaled \$376.7 million. Although it remains unclear from the analysis, the factors that may be driving higher levels of observed yield volatility of late, some industry officials cited the effects of shifts in rainfall and temperature patterns, with extended dry periods possibly linked to climate change. In addition, farmer groups interviewed for this study highlighted increased incidences of frost. Notably, 20 million kg (\$11.4 million) of green leaf was reportedly damaged by frost in January 2012.

For Kenyan livestock, diseases pose a significant threat, though due to a paucity of data, related impacts are difficult to measure. East Coast fever (ECF) is perhaps the most noteworthy threat. Tick-borne, ECF can kill large numbers of calves in pastoralist herds. The presence of ECF in neighboring countries severely handicaps effective control. Rift Valley fever in Kenya is similarly hard to control but is more predictable due to its positive correlation with heavy rainfall and flooding. During outbreaks, animal losses are often high, as treatment by vaccination frequently leads to abortion in pregnant animals. Foot and mouth disease (FMD) is endemic in Kenya and can cause

high mortality rates, especially in improved breeds. Vaccination is effective, but existing coverage is limited (roughly 10 percent). Widespread outbreaks were recorded every third year on average during the review period. One severe FMD flare-up in the early 1980s resulted in losses valued at an estimated K Sh 230 million. Other notable diseases include small ruminant pest (PPR [*Peste des petits ruminants*]), contagious bovine pleuropneumonia (CBPP), and catarrhal fever. The risk associated with animal disease is especially acute during drought when even common day-to-day levels of infection or internal or external parasites can be fatal.

MARKET RISKS

At the market level, the analysis highlights price volatility as the most significant risk. Producer prices in Kenya for key crops are subject to moderate to high levels of inter-annual price variability. Rice paddy, coffee, sorghum, and to a lesser extent, cowpea exhibit the highest levels of year-on-year producer price volatility. In the case of rice and coffee, this suggests that domestic price fluctuations are influenced by imports and/or changes in international market prices. It also suggests that rice and coffee producers in Kenya are exposed to significant swings in farm-gate prices from one year to the next.

Although public support programs manage to keep producer prices for maize relatively stable, wholesale prices are among the most volatile, a critical issue for the GoK given maize's importance to household consumption and food security. Sharp increases during 2008–2009 and then again in 2011 and 2012 coincided with domestic and external shocks. For example, maize prices jumped by 145 percent during the first six months of 2011 following a sharp increase (39 percent) in the commodity food price index and a near doubling of U.S. maize prices in 2010.⁴ In general, domestic maize prices tend to be more volatile than international maize prices, as domestic prices are highly sensitive to uncertainty and constant speculation in projected and real annual output. The GoK's active role in cereal markets, while designed to increase productivity, stabilize prices, and ensure food availability, can also discourage private

⁴ According to Index Mundi at indexmundi.com. Data accessed May 2014.

sector investment in input supply, storage, and other services due to the added uncertainty over the timing and scale of public interventions.

ENABLING ENVIRONMENT RISKS

Among notable risks within the sector's enabling environment are Kenya's growing cereal imports, which bring added uncertainty to the country's food security situation. Imports today make up a much higher proportion (37 percent) than they did a decade ago. This exposes the country to external pressures that can adversely impact domestic food prices, availability, and access. Moreover, amid recurrent maize shortages, uncertainty exists about whether rising Kenya maize imports will be able to fill the gap in light of Kenya's 50 percent *ad valorem* tariff for non-COMESA (common market for Eastern and Southern Africa) sourced maize, its import ban on genetically modified (GM) maize, and inadequate supplies of non-GM exportable maize in the COMESA region. This is especially true in light of episodic export bans for maize in Tanzania, Malawi, and Zambia during production shortfalls. Supply markets have also thinned out due to the growing attractiveness of the South Sudan market and of markets in the Democratic Republic of Congo for Ugandan and Tanzanian maize exports.

The increasing frequency of shocks and the country's growing dependence on emergency aid are also noteworthy. In addition to an estimated half million Somalian and Sudanese refugees in Kenya's Dadaab and Kakuma camps, an estimated 1.5 million Kenyans are chronically food insecure and in need of assistance, according to the World Food Programme (WFP). In drought years, that number can grow exponentially, as it did in 2011 when 4 million Kenyans in the northern rangelands needed food aid. During 2006–11, Kenya received \$1.92 billion in emergency aid, up from \$150 million during the prior five-year period (2000–04). As evidenced elsewhere, frequent crises coupled with an overreliance on food aid can lead to a breakdown of household resilience. Although emergency food aid can help address immediate food needs, it does little to help rebuild household resilience and may induce higher rates of dependency and chronic malnutrition. As such, it also can increase the cost of managing future crises.

With regard to Kenya's sugar industry, the unpredictability of current policy⁵ related to import regulations and ongoing exceptions to the COMESA rules pose considerable risk to mills, cane producers, and other stakeholders. Unpredictability also impedes investments and needed industry reforms, including the planned privatization of remaining government-owned mills. Sizable unrecorded imports of refined sugar from outside the region pose additional risks to the industry. Prices can fall precipitously when the market becomes saturated and mills are unable to compete, as happened in 2002 when industry assumed massive debts. A more recent surge in sanctioned and unsanctioned imports in 2013 resulted in sizable government payouts to a number of mills to stave off their bankruptcy.

Finally, the political uncertainty and associated insecurity that have disrupted agricultural production and markets in recent years have declined markedly since the new constitution was enacted in 2010. Moving forward, the restructuring, consolidation, and reorganization of the sector's legal and regulatory frameworks and ministerial functions and the devolution of policy planning, decision making, and administration to the county level will continue to have major consequences for the sector. Such seismic change imparts uncertainty and significant and myriad institutional risks in the short to medium term. These include potential for increased inefficiencies, disruptions, and breakdown of critical public services such as extension, data collection, and management information systems (MIS) and higher volatility of producer, wholesale, and retail prices.

MANAGING AGRICULTURAL RISKS

While hindering growth, unmanaged risks are also a significant factor contributing to chronic poverty in Kenya. Shocks to agricultural production and markets adversely impact household well-being in a variety of ways: by limiting food availability, weakening food access, and negatively affecting future livelihoods through income disruption and depletion of productive assets.

⁵ In February 2014, COMESA approved the extension for a further year of Kenya's special safeguard arrangement for sugar, thus allowing Kenya to maintain a 350,000-ton ceiling on duty-free sugar imports from COMESA.

Chronically vulnerable groups with high exposure to risks experience a disproportionately large impact from adverse events and typically lack coping mechanisms available to other groups. Understanding these and other risk dynamics is key to developing appropriate risk management responses that can help reduce production volatility, safeguard livelihoods, and put the sector and the broader economy on a firmer footing for growth. Effective strategies can also make a meaningful contribution to poverty reduction efforts.

Management of agricultural risk is not new to Kenya, and the GoK has a long track record of investment in risk mitigation, transfer, and coping mechanisms. Moving forward, Kenya's *Vision 2030* recognizes the need to strengthen existing risk management systems, and the GoK has launched a range of new initiatives to confront the most severe threats facing the country. In 2011, it established the Drought Risk Management Authority to better coordinate preparedness and speed up response measures. It also launched the Disaster Risk Reduction Program, the National Climate Change Action Plan, and the National Hunger Safety Net Program. These and other initiatives by the GoK and its development partners are already helping to safeguard livelihoods, promote adaptation, and strengthen resilience against impacts from natural disasters and a changing climate. Yet as revealed in this report, Kenya's agricultural supply chains remain highly vulnerable to myriad risks that disrupt the country's economic growth, cripple poverty reduction efforts, and undermine food security. The current study highlights the need for a more targeted and systematic approach to agricultural risk management in Kenya.

Based on an analysis of key agricultural risks, an evaluation of levels of vulnerability among various stakeholders, and the filtering of potential risk management measures, this assessment makes the following recommendations for the GoK's consideration. The proposed focus areas of intervention encompass a broad range of interrelated, mutually supportive investments that together—aligned with *Livelihoods Enhancement* goals within *Vision 2030*—hold strong scope to strengthen the resilience of vulnerable farming and pastoralist communities and the agricultural

systems on which their livelihoods and the country's food security depend:

- » To better **optimize rainfall** and **soil moisture** in marginalized production areas, promoting **community-driven investments** in **improved soil** and **water management** measures such as terracing, water harvesting pans, roof and rock catchment systems, subsurface dams, and micro-irrigation systems
- » To **curb soil erosion**, **increase soil fertility** and **water retention**, and **enhance** the **productivity**⁶ and **biodiversity** of smallholder systems across Kenya, **promoting** broader awareness and adoption (via farmer field schools and other participatory extension approaches) of **conservation agriculture** practices such as zero tillage, mulching, composting and use of organic fertilizers, crop diversification and rotation, intercropping, and integrated pest management (IPM)
- » To **strengthen certified seed** production and distribution **systems**, build their credibility, and stimulate demand for improved seeds and fertilizers by smallholders, investing in capacity building and training to **strengthen monitoring and enforcement** of quality standards and **reduce incidences** of **counterfeiting**, adulteration, and other abuses that dampen farmer demand and productivity
- » To **reverse degradation** of **water, soil, and vegetation cover**, **safeguard** the long-term **viability** of Kenya's arid and semiarid **range-land ecosystems**, and **ensure access** to **sufficient** grazing land, promoting: (1) use of contour erosion and fire barriers, cisterns for storing rainfall and runoff water, controlled/rotational grazing, grazing banks, homestead enclosures, residue/forage conservation, and other **sustainable land management** practices; and (2) innovative **rangeland comanagement** (state and local community) approaches that leverage customary

⁶ Conservation agriculture allows yields comparable with modern intensive agriculture but in a sustainable way and with lower production costs (time, labor, inputs). Yields tend to increase over the years with yield variations decreasing.

forms of collective action and economic instruments to reward sound pasture management

- » To **strengthen drought resilience** among vulnerable **pastoral communities** in target ASAL counties and better safeguard the viability of animal herds during shortages, supporting the development of **feed/fodder production and storage systems, animal health, market and weather information**, and other critical services
- » To mitigate growing pressures on rangelands in ASALs and increasing vulnerability of smaller livestock (<50 animals) owners, in particular, putting in place supportive policies and **livelihood development programs** (targeted credit schemes, skills training, public sector investments in labor-intensive infrastructure projects, cash for work) to facilitate their engagement **in alternative livelihood and income-generating activities**
- » To **strengthen fiscal management** and **reduce** the GoK's **budget volatility** (and diversion of development resources caused by ex post crisis response), better **safeguard rural livelihoods**, and **increase resilience**, deepening investments in agricultural insurance mechanisms and markets (in partnership with the private sector), with an initial focus on **asset protection** (via early warning triggers and expedited payouts) among **vulnerable pastoralist communities** and area yield index insurance for smallholder maize farmers
- » To facilitate **improved, evidence-based decision making** among farmers, pastoralists, and policy makers and to mitigate price volatility, investing in integrated **data and information systems build-out** for more **robust, cost-effective, and reliable collection, management, and dissemination** (via terrestrial surveying, geographic information systems [GIS], information and communications technology [ICT], short message service [SMS]) of crop production, agro-weather,

market prices (input/output), agricultural research and advice, and so on

- » To further objectives of the devolution process, promoting institutional and organizational **capacity building** and **technical training** at county and national levels to promote **standardized collection and management of agricultural data** (in line with recently developed national guidelines)

The purpose of this study was to help policy makers, Ministry of Agriculture, Livestock and Fisheries (MoALF) and other GoK officials, and the wider development community better understand the most important risks facing Kenya's agriculture sector. It is hoped that the study's findings will inform ongoing and future policy planning and programming to ensure sustainability of agricultural investments and enhanced agricultural resilience over time. It is also hoped that the findings will lead to improved decision making and successful implementation over time of a comprehensive, integrated, and ultimately responsive risk management framework for Kenya's agriculture sector.

Several of the recommendations proposed in the report are already being considered or presently undergoing implementation. Some may well already constitute an integral part of existing risk management systems. Once the GoK has defined its priorities, Phase II will focus on identifying: (1) pathways for scaling-up successful interventions to encompass a greater number of beneficiaries and (2) existing gaps that need to be addressed. This will entail an in-depth review of Kenya's current risk management landscape to assess the effectiveness of various interventions, principal barriers, and challenges, and leverage points to enhance more stakeholders' access to risk management mechanisms. Phase II's anticipated outcome will be development and implementation of a risk management implementation and monitoring road map, one that will reduce the vulnerability and strengthen the resilience of Kenya's agriculture sector and the millions of households that depend on it for their livelihoods.

CHAPTER ONE

INTRODUCTION

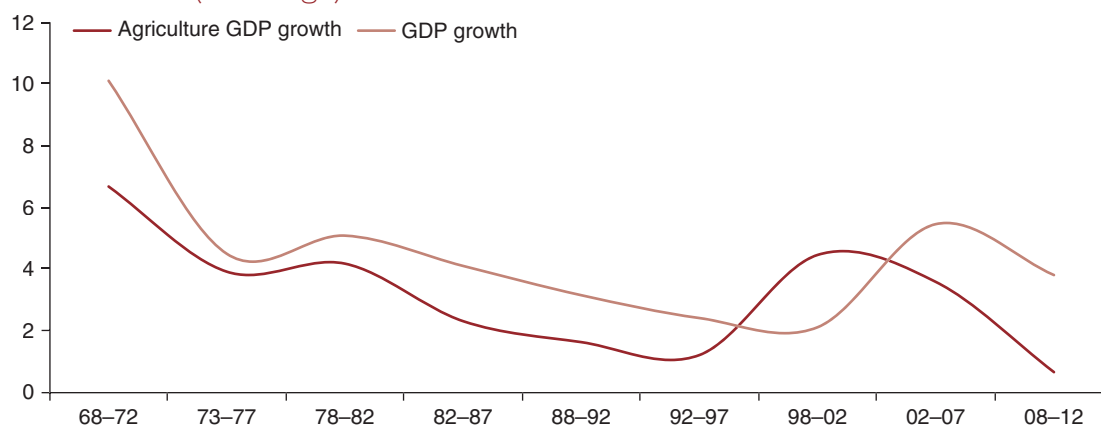
Despite myriad challenges, Kenya has emerged in recent years as one of Africa’s “frontier economies,” with headline growth in the most recent decade propelling the country toward middle-income status. Poverty rates have declined, while gross domestic product (GDP) per capita (\$943 in 2012) has more than doubled. Average real GDP growth was 5.1 percent during 2010–13. Spurred by its dynamic business community, strong communication and transport links, and relatively well-developed financial and services sectors, Kenya is today among the top five destinations for foreign direct investment in Sub-Saharan Africa.⁷ Yet despite recent gains, poverty remains a major challenge. Moving ahead, the Government of Kenya (GoK) has set ambitious economic growth and poverty reduction targets; the economy is expected to expand by 6.3–6.5 percent during 2014–16 (IMF 2014a). Achieving these targets will depend to a large extent on the future performance of Kenya’s agriculture sector.

A principal source of employment and major contributor to GDP, agriculture remains vital to the Kenyan economy. Nearly three in four Kenyans live in rural areas and are actively engaged in the production, processing, and marketing of crop, livestock, fish, and forest products. The sector accounts for an estimated 75 percent of informal employment and is the principal source of rural income and livelihoods. It also generates nearly two-thirds (65 percent) of merchandise exports and roughly 60 percent of foreign exchange earnings (World Bank 2013). In the five years ending in 2012, the sector’s annual contribution to GDP averaged 27.3 percent (29.9 percent in 2012). Not surprisingly, Kenya’s GDP growth is highly correlated with agriculture sector growth (figure 1.1).

Launched in 2008, Kenya’s *Vision 2030* strategy identifies agriculture as one of six priority sectors critical to delivering on the GoK’s economic growth target of 10 percent per annum. The second Medium Term Plan (MTP-II) of *Vision 2030* covers the period 2013–2017 and looks to build on successes achieved in MTP-I (2008–12). Under MTP-II, objectives include maintenance of a stable macroeconomic environment, modernization of infrastructure, and diversification and commercialization

⁷ Kenya was ranked as the fifth and fourth most popular destination for foreign direct investment in terms of new projects in 2011 and 2012, respectively, according to Ernst & Young (2013).

FIGURE 1.1. AGRICULTURAL GDP VERSUS NATIONAL GDP GROWTH
(% change), 1968–2012



Source: WDI 2014 (<http://data.worldbank.org/data-catalog/world-development-indicators>).

Note: Based on five-year averages.

of agriculture. The five-year framework targets average annual real GDP growth of 8.2 percent between 2013 and 2017, with double-digit growth by 2017. Achieving these targets will require a significant acceleration in agricultural growth, which averaged 3.5 percent during 1997–2012 (IMF 2014a).

Considering the notable variability in year-on-year sector performance (figure 1.2), new and better ways must be found to strengthen agricultural supply chains and make them more resilient to downside risks. Extreme volatility characterized Kenya's agriculture sector's annual growth over the period 1980–2012, particularly during the most recent two decades. Shifting weather patterns, population growth, changing demographics, increasing market integration, political instability, and other domestic and external pressures are making Kenyan agriculture more vulnerable while exposing it to higher levels and incidences of risk. Adverse impacts from droughts, floods, pest, and disease outbreaks, and other shocks repeatedly disrupt sector activities, jeopardizing incomes, hobbling sector growth, and handicapping livelihoods. They also contribute to food deficits and diversion of development resources to ex post emergency response and recovery measures.

The GoK's Agricultural Sector Development Strategy (ASDS)⁸ incorporates the growth objectives of *Vision 2030* by seeking to transform Kenyan agriculture from sub-

sistence into a more competitive and commercially oriented sector. Covering the period 2010–20, the ASDS is anchored in two strategic thrusts: (1) increasing productivity, commercialization, and competitiveness of agricultural commodities and enterprises; and (2) developing and managing key factors of production (GoK 2010b). In addition to boosting growth, near-term targets include reducing the share of the population living below the absolute poverty line to less than 25 percent and cutting food insecurity by 30 percent. The ASDS calls for increased investments to, *inter alia*, promote the uptake of new technologies, exploit irrigation potential, undertake crucial sector policy reform, improve institutional governance, and ensure more sustainable management of natural resources.

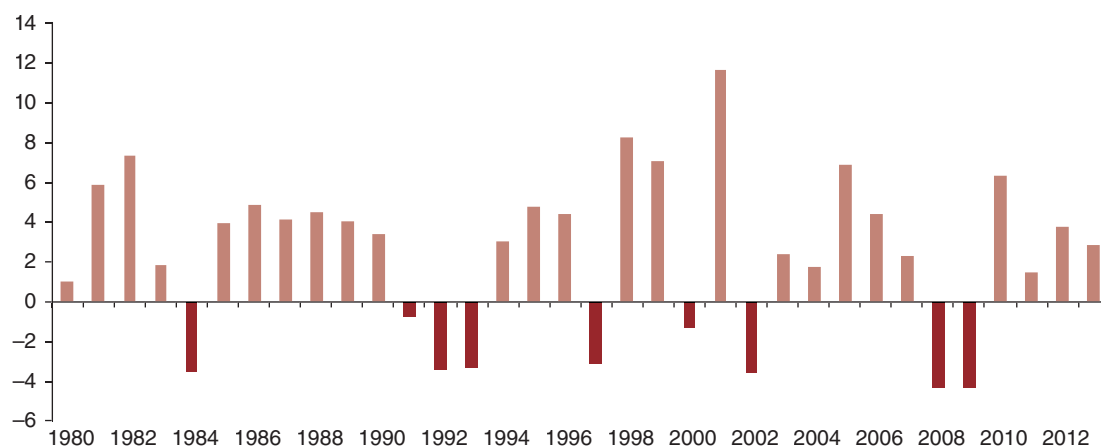
Between 2009 and 2013, Kenya allocated an average of 4.6 percent of its national budget to agriculture—less than half of the Maputo⁹ target. Looking ahead, MTE-II commits the GoK to increasing public spending on agriculture to 8 percent of the budget by 2020 (IMF 2014b). For the current fiscal year, the government scaled back its agriculture budget by 29 percent, or \$447 million versus \$627 for the previous year.¹⁰ A portion of this was to be

⁸ ASDS is a revision of the Strategy for Revitalizing Agriculture (2004–2015), incorporating *Vision 2030* objectives.

⁹ Within the framework of the Comprehensive Africa Agriculture Development Programme's (CAADP) Maputo Declaration, Kenya has committed to spending 10 percent of its national budget on agriculture.

¹⁰ See "Kenya falls short of Maputo Declaration on Agriculture," by Kibiwott Koross, *The Star*, September 3, 2013.

FIGURE 1.2. AGRICULTURAL VALUE ADDED (annual % growth), 1980–2013



Source: WDI; 2013 growth estimate of 2.9 percent taken from 2014 Economic Review.

reallocated from development expenditure to meet emergency food needs.

In recent years, the GoK has had to channel increasingly more resources into emergency response measures amid mounting concerns over food security. In 2013, Kenya ranked 79 out of 107 countries, lagging behind countries like Ghana, Uganda, and Cote d'Ivoire, on the Global Food Security Index, which measures the affordability, availability, and quality of food (Alarcon, Joehnk, and Koch 2013). The country faces a structural deficit in some basic food staples, including maize, wheat, rice, and sugar. Stagnant productivity, the high cost of farm inputs, and poorly developed storage are often cited as common causes. Addressing these and other growth constraints has long been the focus of sector development programs. In addition, adverse shocks such as drought, disease outbreaks, and volatile market prices continue to disrupt and debilitate increasingly vulnerable crop and livestock production systems and the livelihoods they support. In response, public spending on emergency food aid has increased markedly in recent years. The number of Kenyans requiring food assistance rose from 650,000 in late 2007 to almost 3.8 million in late 2009 and early 2010. Recurrent food insecurity remains an ongoing challenge in Kenya.¹¹

¹¹ During 2007–11, Kenya received roughly \$933 million in emergency food aid. This compared to an estimated \$466.2 in emergency response assistance during the entire 16-year period 1990–2005.

The ASDS recognizes that farmers' high risk exposure impedes sector growth. In efforts to enhance the resilience of the agriculture sector, safeguard food security, and protect livelihoods, the GoK placed drought management and climate change mitigation and adaptation at the center of its agricultural and economic development strategy. Among key initiatives, it established the National Drought Management Authority (NDMA) in November 2011 to better coordinate drought mitigation, contingency planning, and response activities and resources at the national level. In March 2013, the GoK launched the National Climate Change Action Plan (NCCAP). NCCAP's primary objective is to implement Kenya's National Climate Change Response Strategy (NCCRS), which seeks to drive investments in, *inter alia*, water harvesting, early warning systems, food storage facilities, broader use of drought-tolerant crops such as millet and cassava, and promotion of conservation agriculture. To support the livestock sector, NCCRS recommends breeding animals better able to cope with drought stress, improving vaccination programs and disease surveillance, and establishing emergency fodder banks, among other initiatives.

Although responding to threats posed by climate change and natural disasters is important, the GoK also recognizes the need to better manage other risks that adversely impact agriculture. A better understanding of risk occurrences and their frequency and impacts is essential for developing appropriate strategies, interventions, and policies for improved agricultural risk management.

It is within this context that the World Bank, with support from the G-8 and the U.S. Agency for International Development (USAID) and in collaboration with Kenya's Ministry of Agriculture, Livestock and Fisheries (MoALF), commissioned the present study. It is one of a series of agriculture sector risk assessments that the World Bank agreed to conduct within the framework of the G-8's New Alliance for Food Security and Nutrition and in close partnership with partner countries. The objective of this assessment was to assist the GoK to (1) identify, analyze, quantify, and prioritize principal risks (i.e., production, market, and enabling environment risks) facing Kenya's agriculture sector; (2) analyze the impact of these risks; and (3) identify and prioritize appropriate risk management (i.e., mitigation, transfer, coping) interventions that might contribute to improved stability, reduced vulnerability, and increased resilience of agricultural production and marketing systems in Kenya. This report presents a summary of the assessment's key findings.

The study focuses on a select basket of priority crops and livestock products including maize, wheat, dry beans, tea, coffee, sugarcane, cut flowers, and meat and dairy. These together accounted for roughly four-fifths of the value of gross agricultural output in 2012 (FAOSTAT). The relative effectiveness of existing risk management measures was also assessed via (1) an appraisal of public interventions in the rural sector; (2) discussions with rural stakeholders directly involved in risk management; and (3) a technical consultation on the relative benefits of various risk mitigation interventions.

Chapter 2 provides an overview of Kenya's agriculture sector and a discussion of key growth constraints. Chapter 3 assesses the main agricultural risks (production, market, and enabling environment). Chapter 4 analyzes the frequency and severity of the major risks identified and assesses their impact. Chapter 5 presents some stakeholder perceptions of these risks and the potential to improve their management. Chapter 6 concludes with an assessment of priorities for risk management and a broad discussion of possible risk management measures that could help to strengthen the

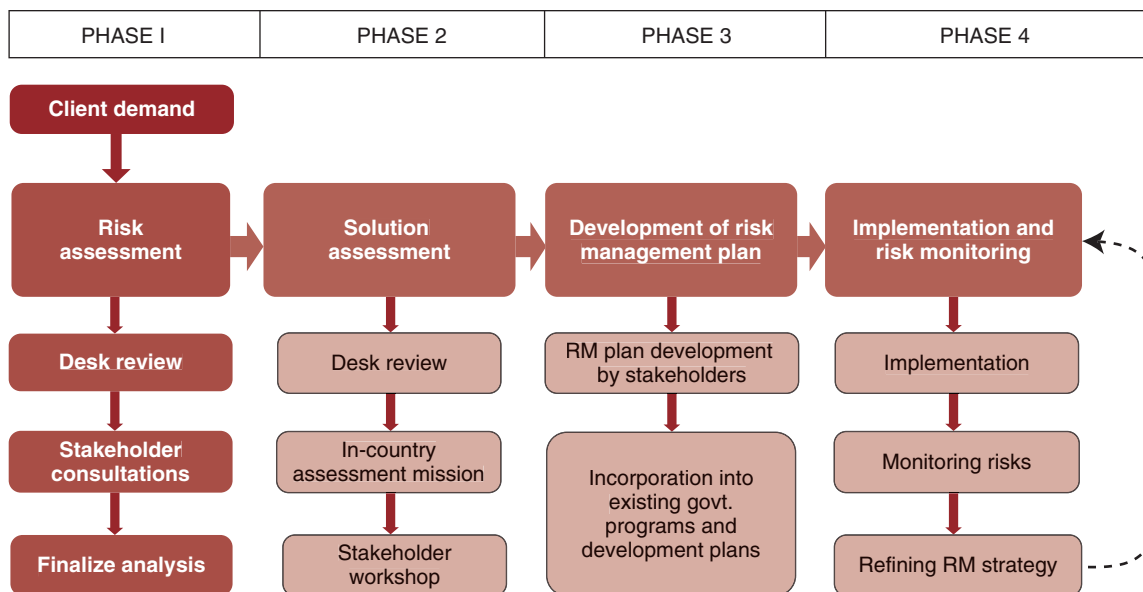
resiliency of agricultural supply chains and the livelihoods they support.

The analysis presented in this report is based on a methodology for assessing risks in agricultural supply chains designed by the Agricultural Risk Management Team of the World Bank's Agriculture and Environmental Services department. It offers a conceptual framework and set of detailed guidelines for conducting a more system-wide assessment of risk, risk management, and vulnerability within agricultural supply chains. The methodology contains logical steps within four consecutive phases (figure 1.3). Phase I, for which this study is the primary deliverable, focuses on identifying, quantifying, and prioritizing the major risks that cause adverse shocks to the sector. Key steps of the analysis include (1) identifying and characterizing risks across production systems and market systems and within the enabling environment; (2) prioritizing these risks based on a quantification of their indicative impacts over time; (3) assessing stakeholder vulnerability and the effectiveness of existing risk management strategies and instruments; and (4) identifying priority investments and needed policy and institutional changes that can strengthen agricultural systems' resilience.

Following in-depth analysis of baseline data, the study team conducted broad-based, in-country consultations with stakeholders in January–February 2014. These included individual farmers, farmer groups, input suppliers, market traders, food processors, and representatives of the government and research and academic institutes in and around Nairobi and in major production zones and markets across Kenya's eastern, northeastern, central, Rift Valley, and western regions. The mission team organized a wrap-up roundtable consultation at the Ministry of Agriculture, Livestock and Fisheries (MoALF) on February 7, 2014, to share preliminary results and solicit feedback. Participants were asked to prioritize possible future interventions by ranking a long list of risk management solutions.

The results of this assessment provide the conceptual basis for Phase II, which will focus on identifying the

FIGURE 1.3. AGRICULTURE SECTOR RISK MANAGEMENT PROCESS FLOW



Source: World Bank.

solution areas and related risk management interventions best suited to manage the priority risks identified. By the end of this activity, the World Bank, in close collaboration with the GoK and sector stakeholders, will develop and validate a matrix of priority interventions related to risk mitigation, transfer, and coping within a

comprehensive risk management framework. It is hoped that the outcome of this assessment will serve to inform ongoing and future GoK agricultural policy and planning, help ensure sustainability of agricultural investments, and enhance long-term agricultural resilience and growth.

CHAPTER TWO

AGRICULTURE SECTOR IN KENYA

To inform the analysis and discussion of agricultural risk in Kenya, this chapter presents an overview of the country's agriculture sector.¹² Sector characteristics most pertinent to risk are given particular attention. Analysis primarily covers the 33-year period from 1980 to 2012 to assess the frequency and severity of the most important risks.

Kenya is endowed with diverse physical features, including its low-lying arid and semi-arid lands (ASALs), an extensive coastal belt, plateaus, highlands, and the lake basin around Lake Victoria. Yet Kenya's agricultural resource base is best characterized by the limited availability of productive land. An estimated 17 percent of the country receives average annual rainfall of more than 800 mm, the minimum required for rainfed agriculture. The remaining land (83 percent) is arid or semiarid, generally unsuitable for rainfed farming or intensive livestock production. Cropland occupies approximately 31 percent, with grazing land (30 percent), forests (22 percent), and game parks, urban centers, markets, homesteads, and infrastructure accounting for the rest (GoK 2010b).

Three main land tenure systems exist in Kenya, each of which influences production systems in different ways: communal lands, government trust lands, and privately owned lands. The communal land ownership system is based on traditional customary rights, in which individuals have a right to use but not sell land. Privately owned lands are registered; the owner holds the title under a freehold or leasehold system. In pastoral areas, trust land is the dominant tenure arrangement.

Agriculture in Kenya covers small-, medium-, and large-scale farming, with small-holder farmers accounting for more than three-quarters of total production. Production is heavily reliant on rainfed systems. An estimated 7 percent is irrigated.

¹² Broadly, the sector comprises six subsectors: cash crops, food crops, horticulture, livestock, fisheries, and forestry. This study focuses on cash crops, food crops, horticulture, and livestock.

TABLE 2.1. AGRO-ECOLOGICAL ZONES AND RAINFALL CHARACTERISTICS IN KENYA

Agroclimatic Zone	Classification	Moisture Index (%)	Annual Rainfall (mm)	Land Area (%)	Land Area (km ²)
I. Agro-Alpine	Humid	>80	1,100–2,700		
II. High Potential	Subhumid	65–80	1,000–1,600	12	68,297
III. Medium Potential	Semihumid	50–65	800–1,400		
IV. Transitional	Semihumid to semiarid	40–50	600–1,100	5	28,457
V. Semiarid	Semiarid	25–40	450–900	15	85,371
VI. Arid	Arid	15–25	300–550	22	125,211
VII. Very arid	Very arid	<15	150–350	46	261,804

Source: Modified from Sombroek, Braun, and van der Pouw 1982.

Livestock production plays an important socioeconomic role in many areas across Kenya. The livestock subsector accounts for roughly 40 percent¹³ of agricultural gross domestic product (GDP) and as much as 13 percent of national GDP (GoK 2012a), and employs about 50 percent of the national agricultural workforce. In the country's ASALs, it accounts for as much as nine-tenths of employment and family income. The key livestock subsectors are beef and dairy cattle, sheep, goats, camels, pigs, and poultry.

AGROCLIMATIC CONDITIONS

Factors such as climate, hydrology, and terrain determine Kenya's agricultural productivity. Climatic conditions in Kenya vary from humid, tropical regions along the coast, to very humid highlands in the central and western regions, to arid inland areas in the north and east. Kenya has a total land area of 569,140 km² (excluding surface water). Of this, 83 percent is classified as ASAL, lying in agro-ecological zones V to VII (table 2.1; see also figure D.1 in Appendix D). Predominantly located in the northern and eastern portions of the country, the ASALs are generally unsuitable for rainfed agriculture due to low and erratic rainfall. Roughly 20–30 percent of Kenya's population and 50–70 percent of the country's

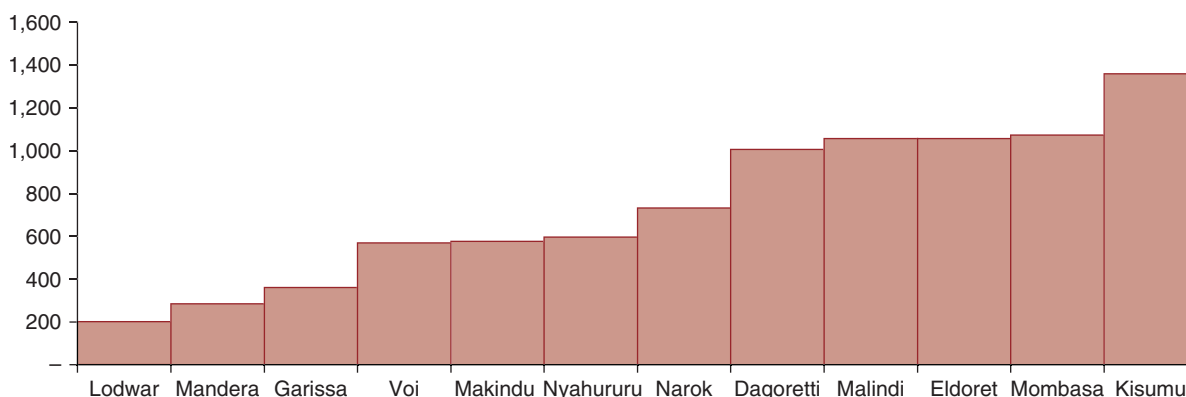
livestock are concentrated in the ASALs. These households depend mainly on extensive livestock production systems (ranching and pastoralism), often supplemented by low-input, low-output cropping. Kenya's high- to medium-potential areas, which receive more than 1,200 mm of rainfall annually, produce a large variety of crops such as tea, coffee, sugarcane, maize, wheat, potatoes, fruits, and vegetables. Figure C.2 in Appendix C provides a breakdown of Kenya's major farming systems and livelihood zones.

RAINFALL PATTERNS AND TRENDS

The country's climate is influenced by proximity to the equator, topography, the Indian Ocean, and the Inter-Tropical Convergence Zone (ITCZ). The ITCZ's influence is modified by the country's diverse topography, which contributes to high spatial variance in seasonal rainfall distribution due to the altitudinal differences. Annual rainfall in Kenya follows a strong bimodal seasonal pattern. Figure 2.1 and figure D.3 in Appendix D illustrate average cumulative rainfall amounts and seasonal patterns in 12 rainfall zones across Kenya during the period 1981–2011. Generally, the long rains occur from March to May, while the short rains occur from October to December. Mean annual rainfall ranges from approximately 200–300 mm in the north and northeast to nearly 1,400 mm in the central and southwestern highlands. The onset, duration, and intensity of rainfall vary considerably from one year to the next. However, analysis of rainfall

¹³ A joint Intergovernmental Authority on Development/Kenya National Bureau of Statistics study completed in 2011 demonstrated that livestock's contribution to Kenya's agricultural GDP was more than two-and-a-half times larger than the official estimate for 2009, or about \$4.54 billion versus \$5.25 billion for arable agriculture (ICPALD 2013).

FIGURE 2.1. AVERAGE CUMULATIVE RAINFALL (mm) BY RAINFALL ZONE, 1981–2011



Source: Kenya Meteorological Department.

data since 1960 does not show statistically significant trends (McSweeney, New, and Lizcano 2012).

CROP PRODUCTION SYSTEMS

Kenyan agriculture is predominantly carried out on a small scale and mainly in high-potential areas. Average farm sizes are 0.2–3 hectares (ha). Small-scale production represents roughly 75 percent of the total agricultural output and 70 percent of the marketed agricultural produce. Smallholders account for over 70 percent of maize, 65 percent of coffee, 50 percent of tea, 70 percent of beef, and 80 percent of milk production (GoK 2013a). Large-scale farming is practiced on farms averaging about 50 ha for crops and 30,000 ha for livestock ranches. The large-scale farming subsector, which accounts for 30 percent of marketed agricultural produce, mainly involves growing commercial crops such as tea, coffee, maize, sugarcane, and wheat.

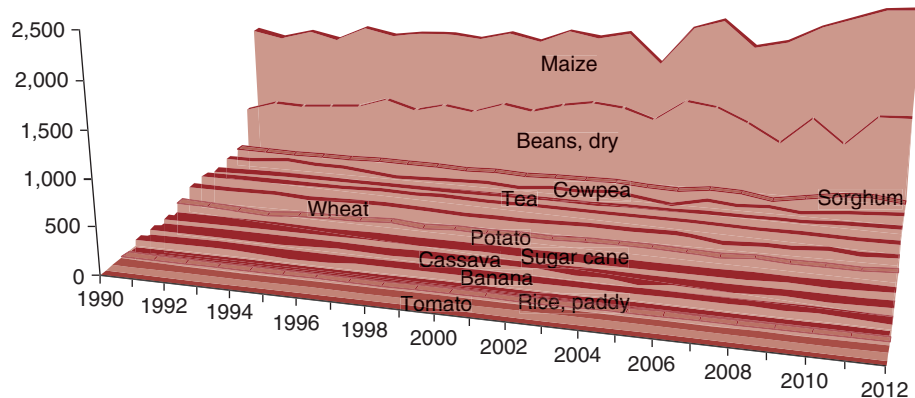
Agricultural production in Kenya is dominated by maize (38.2 percent) and dry beans (18.7 percent), which together cover well over half of total cropped area in 2012 (figure 2.2). The remainder comprises more than 150 other food and cereal crops, with sorghum (3.9 percent), cowpea (3.8 percent), tea (3.4 percent), coffee (2.8 percent), wheat, potatoes, pigeon peas, and millet among the most important (FAOSTAT). This crop composition has been fairly stable over time, with the exception of maize and dry beans, which in 1990 comprised 24.4 percent and 12.2 per-

cent, respectively, of total production. This growing consolidation of production toward maize and dry beans makes Kenya increasingly vulnerable to food insecurity.

In Kenya's heavily populated, high rainfall areas—mainly in the west—farmers grow a wide range of rainfed food and cash crops, including cereals, pulses, coffee, tea, fruits, and vegetables. In Kenya's transitional and semiarid areas, which cover roughly a fifth of the country and where rainfall is more variable, cropping diversity is less. In these areas, maize, pulses, roots, and tubers are important, with many farming households raising livestock, mostly small ruminants, in mixed crop/livestock systems. In the arid to very arid regions that cover roughly 68 percent of the country, the land is not suitable for rainfed agriculture. In these regions, extensive pastoralism is the main source of livelihoods, centered on cattle, small ruminants (mostly sheep and goats), and camels.

Reliable statistics on livestock populations are difficult to obtain. The last comprehensive livestock census was done in 1969. As in many other African countries, livestock populations in Kenya are estimated, and actual losses are difficult to calculate. The 2009 Kenya Population and Housing Census included questions on livestock ownership. Table 2.2 highlights considerable differences between FAO figures and the 2009 Census data, especially for species commonly kept in the more remote ASAL regions. Even for dairy cattle, it was estimated that Kenya's actual cattle population in 2003/04 could be as many as three times the government's estimated number (FAO 2011).

FIGURE 2.2. COMPOSITION OF CROP PRODUCTION
(area harvested, in thousand ha), 1990–2012



Source: FAOSTAT.

TABLE 2.2. LIVESTOCK POPULATION IN KENYA, 2009 AND 2012

Year	Cattle	Sheep	Goats	Camels	Pigs	Chickens	
						Indigenous	Commercial
2009 National Census data	17,467,774	17,129,606	27,740,153	2,971,111	334,689	25,756,487	6,071,042
2009 FAO data	17,467,800	9,903,300	13,872,300	947,200	334,689	31,827,000	
Percentage (%) difference	—	–42%	–50%	–68%	—	—	
2012 FAO data	19,129,800	18,171,000	29,409,100	3,065,400	354,600	32,865,000	

Source: FAOSTAT, 2009 Kenya Population and Housing Census.

Note: —, not available.

PRODUCTION TRENDS

Crop production overall has grown steadily (see figure 2.2), with an average annual increase in the crop production index of 6.2 percent from 1990 to 2012. This growth was largely driven by area expansion, with the total cultivated area increasing by 34.7 percent, or from 4.19 million ha in 1990 to 5.65 million ha in 2012 (FAOSTAT). Table 2.3 summarizes changes in area cropped, crop production, and yields for key food and cash crops. The area cultivated for food crops increased from as little as 10.7 percent (bananas) to as much as 274 percent (cowpea), with the exception of wheat, for which the area cultivated decreased slightly. In the case of industrial crops, tea cultivation expanded the most rapidly, eclipsing that of coffee, which remained virtually unchanged. Yields for some food crops increased, some considerably (cowpea, tomatoes), while that of five others declined, by more than 10 percent, with the exception of rice.

TABLE 2.3. TRENDS IN CROP PRODUCTION, 1990–2012^a

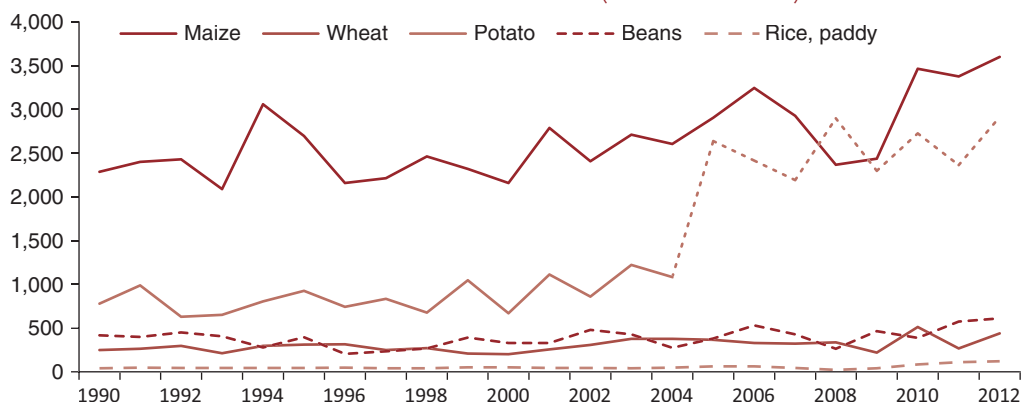
Food Crops	Area Change (%)	Production Change (%)	Yield Change (%)
Bananas	1.4	11.7	88.7
Beans, dry	55.6	22.2	–23.0
Coffee	2.8	–61.2	–62.3
Cowpea	273.8	236.8	123.2
Maize	39.6	17.3	–16.4
Potato ^b	39.3	23.6	–11.7
Rice, paddy	58.9	60.8	–3.6
Sorghum	51.5	9.6	–29.6
Sugarcane	49.4	23.6	–17.5
Tea	96.4	114.8	9.9
Tomatoes	110.3	399.5	142.6
Wheat	–6.4	44.6	51.6

Source: FAOSTAT.

^aFive-year average, 1986–90 versus 2008–12.

^bFor potato, Ministry of Agriculture, covering period 1990–2006, 5-year average, 1986–90 versus 2002–06.

FIGURE 2.3. FOOD CROP PRODUCTION (thousand MT), 1990–2012



Source: FAOSTAT.

FOOD CROPS

Kenya's principal food staples are maize, wheat, Irish potatoes, and dry beans. Rice is an increasingly important food staple, particularly among urban households. Production growth for these crops was notably modest in recent decades. In fact, according to available data,¹⁴ potato is the only food staple for which the production increase exceeded the increase in the population during the period 1990–2012. The area cropped to potato nearly doubled, and yields were more than four times higher in recent years than in the earlier period. During the same period, production of Kenya's other principal food crops increased 17.3 (maize), 44.6 (wheat), and 22.2 (dry beans) (figure 2.3). During the same period, the Kenyan population grew approximately 84 percent.

Maize: According to FAO, maize production accounts for approximately four-fifths (80.3 percent) by volume of Kenya's total grain output. It is also the fourth most important commodity (after milk, potato, and cattle meat) by value. Kenya produces between 37 and 40 million bags per year against a national requirement of approximately 42 million bags.¹⁵ Production is dominated by an estimated 3 million smallholder farmers who produce roughly

70 percent of total maize output in Kenya on an average of 2 hectares of land. They retain 60 percent of their output for home consumption and contribute roughly a third to total marketed surplus. Almost three in five (58 percent) smallholder maize producers are net buyers of maize (Kirimi et al. 2011). The remaining 30 percent of marketed maize is produced by a relatively small number of commercial farmers, who operate over 20 hectares on average and contribute 30 percent of total production.

Kenya boasts relatively high levels of adoption of hybrid seeds (up to 80 percent), but a much smaller percentage of farmers regularly use fertilizer (41 percent). Commercial farmers make good use of hybrid seeds as well as fertilizers and mechanization to attain high yields (Smale and Olwande 2014). Yields among smallholders, who generally forego investments in fertilizers and other improved production practices, are significantly lower (1.6 tons/ha in 2012).

Maize production in Kenya, as elsewhere, is mainly dependent on rainfall. As such, it is vulnerable to drought and to year-to-year yield fluctuations. Average maize yields increased about 10 percent from the early 1980s to the mid-1990s, but have been declining since. Increases in production since 1990 have been driven by a nearly 40 percent growth in land area under cultivation. Much of this expansion has been into marginal areas, where soils and rainfall are less favorable to maize production. La Rovere et al. (2014) estimate that nearly one-fifth (19.5 percent) of Kenya's maize production takes place in areas with high rainfall variability, rated with a probability of a failed season (PFS) of between 40 and 100 percent. Average yield in these areas is 1.08 tons/ha versus the

¹⁴The analysis highlights some notable discrepancies in both national and FAO data. According to data from the MoALE, potato yields and production in 2007 jumped by 215 percent and 255 percent, respectively, compared to the previous year, while area harvested increased by only 12 percent. According to official data, annual output has since remained well above historical averages. During the six-year period 2007–12, average output was 2.5 MT versus 0.96 MT during the period 2001–06. Due to these inconsistencies, the analysis considers only the period 1980–2006 for potato production.

¹⁵Maize is packed and marketed in 90-kg bags.

TABLE 2.4. VALUE OF HORTICULTURAL PRODUCTION^a

	Area (Thousand has)	Quantity (Thousand tons)	Value (K Sh Million)	Share by Value (%)
Vegetables	297	5109	95407	47
Fruits	168	3618	57582	28
Flowers	4	378	42086	21
Nuts	98	166	5524	2.7
Maps	9	57	1804	<1
Total	576	9328	202403	100

Source: Directorate of Crops.

^a Average 2010–12.

national average of 1.62 tons/ha. Another one-quarter (26.1 percent) of production is grown in areas rated with a PFS of 20–40 percent. These trends have contributed to higher levels of production variability, further amplifying Kenya's structural deficit in maize. Production is also constrained by underlying drawbacks such as soil acidification due to year-in, year-out usage of diammonium phosphate (DAP) fertilizer (USDA 2014) and a general decline in soil fertility. Much emphasis has been placed on the use of purchased inputs such as fertilizer and improved seeds, but adoption has not been sufficient to maintain the high yields achieved 30 years ago.

Wheat: After maize, wheat and rice are Kenya's most important cereal crops. Wheat is predominantly grown in areas above 1,500 meters in the south and upper Rift Valley (e.g., Narok, Nakuru, Uasin Gishu Counties) and in Meru County in Eastern Province. Traditionally, Kenyan wheat has been grown by large- and medium-scale commercial farms using capital-intensive technology such as tractors, tillage equipment, and combines. Wheat is the only crop for which area under cultivation has dropped in recent decades (table 2.3), and yield has become more variable. This trend may be partly due to an ongoing shift in the epicenter of production away from large farms in Upper Rift Valley to smaller-scale production in Narok County. Wheat stem rust, poor yields, the high cost of farm inputs, and the shift in the 1990s toward more liberalized markets are also likely to be among contributing factors (Chemonics 2010; FAO 2013a).

Rice: Irrigation schemes grow about 95 percent of all rice produced in Kenya while the rest is grown under

rainfed conditions, according to the National Irrigation Board (NIB). Rice production is expected to increase in response to ongoing GoK initiatives to rehabilitate and expand national irrigation schemes and growing adoption of New Rice for Africa (NERICA), a relatively new, high-yielding seed variety (USDA 2013). Despite anticipated productivity gains, however, Kenya will continue to rely heavily on imports given expected demand growth.

HORTICULTURE CROPS

Comprising a range of product categories including vegetables, fruits, flowers, nuts, and herbs/spices, Kenya's horticultural subsector continues to expand. Among these categories, vegetable production is the most important in terms of share of total agriculture output by value (38 percent in 2012), followed by fruits (22 percent) and cut flowers (18 percent). The subsector directly and indirectly employs an estimated 4 million people and makes a substantial contribution to household food needs. It also contributes substantially to Kenya's agricultural export earnings.

Vegetables account for nearly half (47 percent) of total production value (table 2.4). The leading vegetables by production volume and value are Irish potatoes, tomatoes, and cabbage, all of which are widely consumed by rural and urban households. The bulk of vegetables are produced by smallholder farmers (estimated at 1.8 million). Vegetables are grown in a wider range of areas across the country than any other horticultural subgroup (World Bank 2012).

Irish potato: In Kenya, Irish potato is the second most important food item after maize, with its importance growing along with urbanization. It is grown mainly by small-scale farmers as a cash and food crop, and is therefore important for rural income and food security. Potatoes are typically produced under rainfed conditions during two seasons. Farmers intercrop potatoes with maize and beans, and some plant potatoes after maize, wheat, or barley. In places like Meru, Kiambu, and Nyeri counties, where average farm sizes are smaller than 1 hectare, farmers grow potatoes on up to 40 percent of their cropland, without rotation, which favors the emergence of pests and diseases (World Bank 2012). According to MoALF statistics, potato production has grown by nearly 260 percent since 1990, while yields have more than doubled (115 percent). However, the expansion of crop area and yield is hampered by insufficient availability of high-quality planting seed.

Banana: Fruit production (28 percent value share in 2012) is second only to vegetable production in terms of the total value of horticultural production in Kenya. Within the fruit segment, banana is Kenya's most important product, representing 37.6 percent of the total value of domestic fruit production (MoA 2013). The crop is mainly grown by smallholder farmers under rainfed conditions. According to Africa Harvest, approximately 390,000 banana farmers operate in Kenya, of which approximately 84 percent are smallholder farmers (cultivating <0.2 hectares). Relatively affordable for the average rural and urban household, bananas are widely consumed across Kenya. The crop is important in terms of both food

security and rural incomes. Farming households consume about 24 percent of total output; the rest (76 percent) is sold to markets (World Bank 2012).

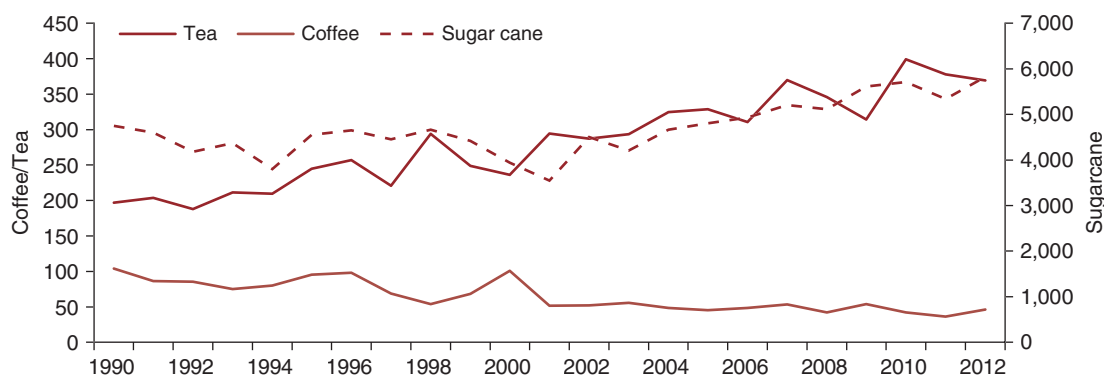
INDUSTRIAL CROPS

Tea, coffee, sugarcane, and cut flowers are among Kenya's principal cash crops. Among these, tea is by far the most important in terms of Kenya's agricultural export earnings.

Tea: At roughly 370,000 tons per year, Kenya stands as the world's third largest tea producer after China and India. The highland tea-growing regions on either side of the Great Rift Valley are endowed with the ideal climate for tea production. Production goes on year-round, with two main peak seasons between March and June and October and December, coinciding with the rainy seasons. Kenyan tea is grown without the use of insecticides or herbicides because at 1,500–2,700 meters above sea level, the growing conditions act as a natural deterrent to pests.

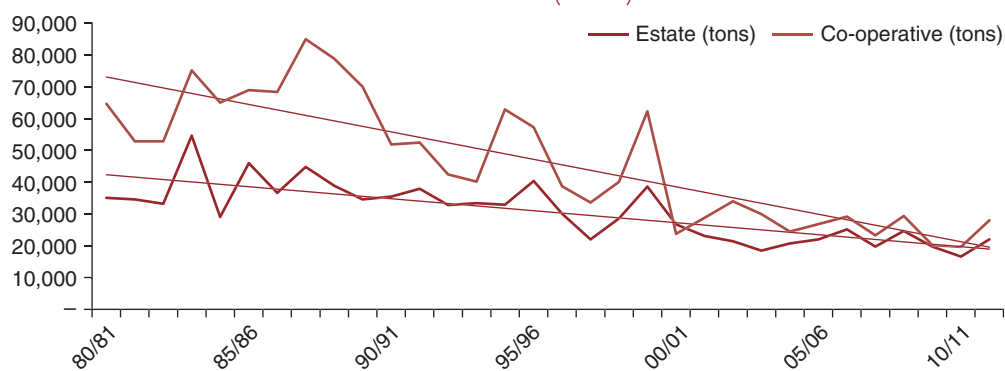
Tea production in Kenya has grown steadily over the most recent decade mainly because of expansion in land area under cultivation (table 2.3). Kenyan tea is produced under two distinct production systems: smallholder production and commercial production by vertically integrated multinationals. The latter benefit from higher yields but lower-quality output due to more extensive use of machinery for harvesting. According to the Tea Board of Kenya (TBK), the smallholder sector is growing in importance and today accounts for roughly three-fifths (59 percent in 2012) of national tea production. A state

FIGURE 2.4. INDUSTRIAL CROP PRODUCTION (thousand tons), 1990–2012



Source: FAOSTAT.

FIGURE 2.5. COFFEE PRODUCTION (tons), 1980–2012



Source: CBK.

corporation prior to 2000, the Kenya Tea Development Agency (KTDA) is now a farmer-owned limited liability company that procures, processes, and markets all smallholder production in the country. It manages 67 processing factories serving over 600,000 growers organized in Savings and Credit Cooperatives (SACCOs). The plantation subsector operates 39 tea factories and employs about 33,000 outgrowers.

Coffee: Coffee remains important to Kenya's agricultural economy, but its importance is waning (figure 2.4). Since production peaked in 1988 at nearly 128,000 tons, yields and output have dropped by nearly half. Among contributing factors are Kenya's aging tree stock (with high susceptibility to plant diseases) and declines in world coffee prices during 1986–1992 and 1998–2002. These trends have had a substantial impact, particularly on smallholders. Figure 2.5 shows the performance of estates and smallholders during 1980–2012. The latter suffered a drastic reduction in output, from around 70,000 tons during the mid-1980s (before the coffee price crisis) to less than 30,000 tons currently. Over 600,000 smallholder producers are organized into about 550 cooperatives and about 3,300 large-scale, vertically integrated coffee estates. Smallholders account for 75 percent of the land under coffee production but only slightly over half of production, according to the Coffee Board of Kenya (CBK). Average yields on the estates are nearly 1.5 times higher due to their more intensive use of fertilizers, pesticides, herbicides, and fungicides as well as irrigation.

Sugarcane: Kenya's sugar industry supports an estimated 2 million people and contributes an estimated

\$540 million to the country's GDP.¹⁶ It employs more than 250,000 smallholder farmers who supply over 92 percent of the sugarcane processed by nearly a dozen domestic sugar mills. The remainder is produced by factory-owned nucleus estates (KSB 2010; KSI 2009). Sugar production is concentrated in four major areas, primarily located in southern and southwestern Kenya. Increases in production during the most recent decade were largely the result of increases in total land planted while yields remained stagnant. Widespread use of poor-quality sugarcane varieties, poor agricultural and land management practices, and delayed harvesting of mature sugarcane (due to weather and/or transportation problems) contributed to poor yields over time.

Cut flowers: Kenya's floriculture industry was worth an estimated \$490 million in 2012. Cut flowers are predominantly cultivated under modern farming systems and are produced for export markets. Roughly 160 flower growers exist in Kenya. The majority of producers are medium- to large-scale agribusinesses. However, 20–25 of these growers are large to very large commercial enterprises that together account for roughly 75 percent of total flower exports. Such operations are highly capital intensive, best characterized by their managerial and marketing sophistication and sizable investments in advanced technology and cultivation techniques (Hortiwise 2012). The leading counties in horticultural production are Kiambu, Nakuru, Meru, Nyandarua, Murang'a, Bungoma, and Makueni, which together account for more than 57 percent of total

¹⁶ See "Kenya: Poaching sugarcane" by Katrina Manson, *Financial Times*, January 21, 2014.

output value, with the first three counties accounting for more than 30 percent (HCDA 2012).

LIVESTOCK PRODUCTION SYSTEMS

Several different livestock production systems are common across Kenya, most notably extensive pastoralism, mixed crop/livestock farming systems, and intensive poultry, pig, and dairy production. Each system faces different constraints and risks. Vulnerability to risks is considered greater within extensive systems than within intensive ones for myriad reasons—a lower level for capacity to mitigate risks among pastoralist communities, punctuated by declining mobility and unpredictable access to and availability of water, pastureland, and other factors of production. Thus, analysis of risks to extensive systems was prioritized in this study.

Approximately 50–70 percent of the country’s livestock is produced under extensive systems, mostly in the ASALs, where the subsector accounts for roughly nine-tenths of employment and animals provide the vast majority of household income. This system mostly comprises indigenous races of cattle, camels, sheep, and goats, which graze or browse natural forage. Land is usually communally owned, although private or group ranch systems also exist. Some feed supplementation occurs where there is mixed farming or irrigation using crop residues and weeds. Mixed farming, a system involving various food and cash crops integrated with a few cattle or sheep and goats, stretches from the southern parts of the ASALs into Kenya’s high-potential agricultural production areas. In highland areas, the animals are mostly dairy cattle and sometimes pigs. These systems are often accompanied by medium- or small-scale “backyard” poultry production.

Intensive livestock production systems mostly consist of commercial poultry and pig production and a more limited number of dairy farms. Commercial enterprises using intensive systems, especially for poultry, are normally established after undertaking their own risk assessments and are operated under high sanitary and biosecurity levels with in-built mechanisms to avert or avoid risk. As a result, such systems were not considered as part of this risk assessment.

Emerging from a significant downturn in the 1990s, Kenya’s milk production sector is growing again. Valued at \$800 million, it contributes 7 percent to national GDP and 19 percent of agricultural GDP (KNBS 2009 in Macharia 2013). Over 1 million households produce milk, with 80 percent of the 4 billion liters produced by small-scale farmers. The sector provides more than 850,000 jobs (FAO 2011). Government services were relatively effective in regulating production and trade until mid-1980s, but milk production started failing in the 1990s and collapsed in early 2000 due to corruption in the management of the cooperative sector. It was reinvigorated after being taken over by the new Kenya Cooperative Creameries (KCC) in 2004, and more than 30 registered processors are now in operation (Macharia 2013).

VARIABILITY IN CROP PRODUCTION

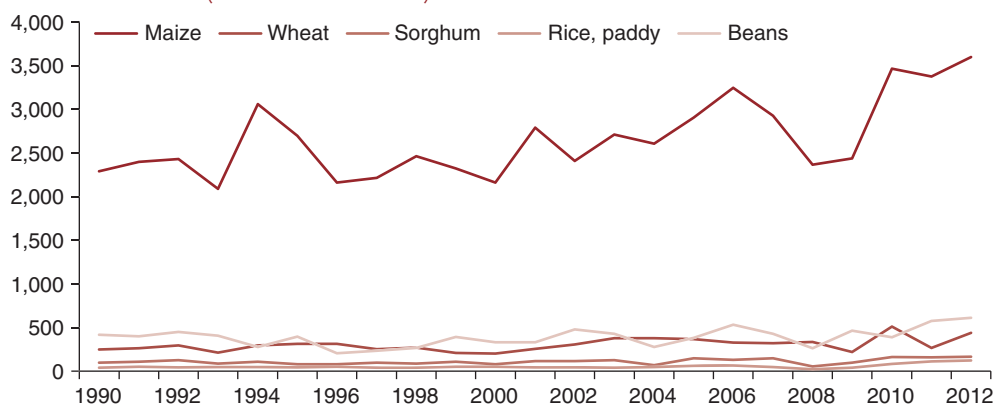
An analysis of production variability suggests that several of Kenya’s main crops exhibit moderate to high levels of interannual variation (see table 2.5). These crops include potatoes, rice paddy, coffee, bananas, sorghum, and cowpea. Fluctuations in yield rather than area planted across the time series largely explain notable production variability for potatoes and coffee, while fluctuations in both area planted and yield account for observed variability in dry bean and cowpea production.

TABLE 2.5. COEFFICIENTS OF VARIATION FOR CROP PRODUCTION, 1980–2012

	Production	Area	Yield
Bananas	0.30	0.14	0.24
Beans, dry	0.28	0.27	0.23
Coffee	0.35	0.10	0.41
Cowpea	0.37	0.25	0.26
Maize	0.19	0.17	0.13
Potatoes	0.77	0.30	0.55
Rice, paddy	0.38	0.32	0.20
Sorghum	0.32	0.27	0.24
Sugarcane	0.12	0.19	0.16
Tea	0.38	0.27	0.18
Wheat	0.26	0.13	0.22

Source: FAOSTAT; MoALE.

FIGURE 2.6. CEREAL PRODUCTION TRENDS
(thousand tons), 1990–2012



Source: FAOSTAT.

Figure 2.6. illustrates historical trends in production for five of Kenya's major staple crops. Figures F.1 through F.6 in Appendix F show individual production trends for six crops (i.e., maize, wheat, dry beans, tea, coffee, and sugarcane). Higher levels of variability in maize and wheat production over the last decade are apparent, as is a correlation in some years with extreme drops in production, suggesting covariance of shocks. In both cases, fluctuations in yields are the strongest determinant of output variability from one year to the next. Historical patterns for dry bean production suggest that both changes in yield and acreage planted have a strong influence on output. Among cash crops, variations in tea and coffee production are most directly affected by fluctuations in yields. For sugarcane production, changes in both yield and area planted appear to have a strong influence.

FOOD SUPPLY AND DEMAND

Kenya currently suffers from a structural deficit in the production of key staples, including maize, wheat, and rice (table 2.6). Over the last decade, annual imports for maize in particular fluctuated significantly, accounting for between 6.2 and 32 percent of consumption depending on the year, with a 10-year average of 14.5 percent, or 624,000 tons (FAOSTAT). Domestic production over the last decade accounted on average for roughly half (48.5 percent) and one-fifth (21 percent) of wheat and rice consumption, respectively.

Maize is the principal food staple in Kenya. It accounts for nearly one-third of the calories consumed by Ken-

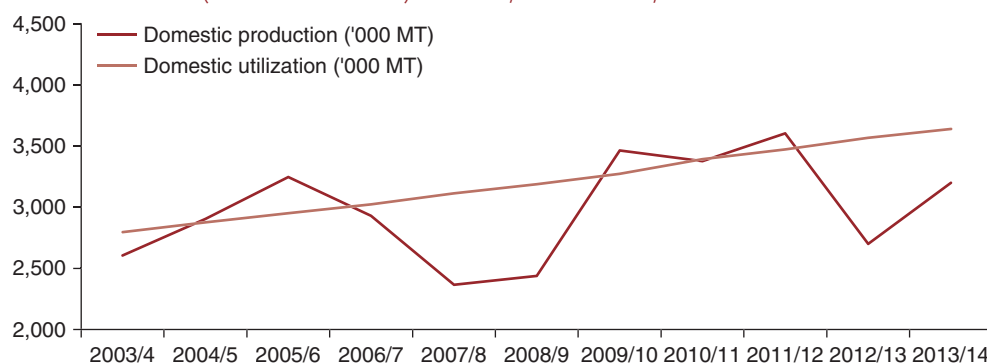
TABLE 2.6. CEREAL SUPPLY/DEMAND BALANCE (thousand tons), 2013/14

	Wheat	Rice	Maize	Total cereals
Cereal supply	(‘000 tons)			
Previous year production	442	122	3,922	4,486
Previous five years average production	356	83	3,300	3,739
Previous year imports	1,000	405	506	1,911
Domestic availability	405	85	3,616	4,106
2013 Production	390	190	3,489	3,994
Possible stock drawdown	15	10	127	152
Utilization	1,505	505	4,456	6,466
Food use	1,205	467	3,850	5,522
Nonfood use	300	25	606	931
Imports requirement	1,100	420	840	2,360

Source: FAO 2014.

yan households, with per capita consumption about 99 kg/year (FAOSTAT). It also accounts for roughly 40 to 50 percent of household food expenditures. While growing, maize production has not kept pace with population growth over the last 30 years. During the period 1980–2012, production increased roughly 60 percent while the population grew by 153 percent. To address the deficit,

FIGURE 2.7. MAIZE PRODUCTION VERSUS DEMAND
(thousand MT), 2003/04–2013/14



Source: FAOSTAT.

the country continues to depend heavily on imports. In 2012–13, for example, Kenya imported 425,000 tons of maize for commercial and relief purposes. Maize consumption will continue to grow despite efforts to diversify to other foods. Limited volumes of lower-grade maize go into the livestock feed industry. Deficits are offset by imports from within the East African Community (EAC), and imports from outside the EAC are subject to a steep external tariff (currently at 50 percent *ad valorem*).

Projections by FAO for current-year imports were 800,000 tons based on expected domestic output of 3.2 million tons and strong, continued growth in demand (figure 2.7). USDA (2014) forecasts were considerably lower at 2.8 million tons. The decline in production is attributed to poor yields due to below average rainfall. It is also due in part to delayed and inadequate supply of subsidized fertilizers¹⁷ and certified seeds, the spread of the MLND, widespread infestation by the parasitic weed *Striga*, and declining soil fertility. Shortages have also been aggravated by increased postharvest losses linked to poor drying and storage practices and early sales of green maize. The former contributes to high incidences of aflatoxin contamination.

Growing consumption of wheat and wheat-based products far outstrips domestic production. Kenya's wheat imports grew at an annual average rate of 13.25 percent between 2003/04 and 2012/13. In 2012/13, imports met roughly 44.2 percent of national wheat requirements.

Rising consumer demand for wheat is largely fueled by a growing preference among burgeoning urban consumers who view wheat products as a convenience food. Consequently, wheat imports are expected to remain above 1 million metric tons (MT) annually. The Russian Federation, Ukraine, Pakistan, Brazil, and Argentina remain the largest suppliers to the Kenyan wheat market.

Rice is the third most important cereal food crop after maize and wheat. Irrigation schemes grow about three-quarters (74 percent) of all rice produced in Kenya (FAO 2012); the rest grows under rainfed conditions. The NIB estimates per capita rice consumption will rise to 11 kg by 2015, up from 7 kg in 2013. The Ministry estimates annual consumption is increasing at a rate of 12 percent compared to 4 percent for wheat and 1 percent for maize. It is expected to more than double to 495,000 tons in 2014–15 (October 2014–September 2015) from about 237,000 tons consumed in MY 2004–05 (Gitonga and Snipes 2014).

This trend is attributed to a progressive change in eating habits, particularly among Kenya's urban households. Pakistan, Vietnam, Thailand, and India supply Kenya with most of the rice imports. Tanzania supplies a substantial amount through unrecorded cross-border trade. The *ad valorem* tariff for rice coming from outside the region currently stands at 35 percent but can be as high as 75 percent.

Consumption of maize and wheat is expected to increase because of population growth, increased urbanization, and growth in the food service sector. Imports to Kenya

¹⁷ Since 2007/08–2011/12, the GoK has allocated more than \$117 million for distribution of subsidized fertilizers to smallholders in the Rift Valley and western Kenya via the National Cereals and Producer Board (NCPB).

are subject to external tariffs that range from 10 percent for wheat, to 35 percent for rice, to 50 percent for maize. Minimal exports of these staple commodities occur through cross-border trade.

Although consumption is relatively diversified, production is much more so. Maize, wheat, sugar, milk, and palm oil together make up nearly two-thirds of daily per capita consumption. Maize accounts for the largest share of total daily staple food intake (65 percent) and total caloric intake (32 percent), with per capita consumption of about 99 kg/year. Wheat accounts for another 9 percent. Sugar, milk, and palm oil each contribute approximately 7–8 percent of calories and round out the top five contributors to calorie consumption.

In Kenya, domestic beef consumption has more than doubled over the past two decades, and Kenyans' rate of milk consumption, one of the highest in the world for developing countries (100 kg/capita/year), is still growing. Such local demand, and a growing export market for live animals and products, is leading to increased intensification of production. Intensification itself, particularly in a farming sector largely dominated by arid areas, can lead further to increased risk.

AGRICULTURAL MARKETS AND PRICE TRENDS

Agricultural markets in Kenya are highly integrated due to the country's relatively well-developed road and communications networks and sea ports and airports and its open trade regime. Kenya benefits from robust and growing trade with its regional neighbors, especially within the framework of the EAC, and steady international demand for some of its key exports. Tea and coffee have traditionally been Kenya's top two agricultural export commodities. In recent years, cut flowers have overtaken coffee to become Kenya's second most valuable export crop. During 2010–12, cut flowers accounted for 8.94 percent of total export value on average, after tea (20.27 percent) and coffee (4.46 percent). Vegetables, fruits, and related products accounted for an additional 4.5 percent (table 2.7). The country relies on a limited number of export products and trade partners, which makes Kenyan exports vulnerable to external pressures. For example, more than

60 percent of Kenya's tea exports go to only three consuming countries (Pakistan, Egypt, and the United Kingdom). Kenyan horticultural exports to the European market have dropped in recent years due to the economic crisis in the European Union (EU) and difficulties among Kenya's smallholder farmers in adhering to strict EU regulations over agrochemical residues.

FOOD CROPS

Due to Kenya's open trade regime and highly integrated markets, domestic prices in Kenya for agricultural commodities, including major staple foods, are relatively sensitive to both internal and exogenous pressures and shifts in supply and demand. The following analysis of price trends for key commodities (figure 2.8.) was based on time-series data of producer prices in local currency (K Sh) for the period 1992–2011

Overall, domestic cereal prices over the last two decades were characterized by moderate levels of volatility. However, prices became more volatile in recent years due to both external and internal dynamics. First, the surge in international food prices in 2006–07, and in 2009–11 (as measured by FAO's Food Price Index), had a notable impact on domestic prices for rice and sorghum in particular. Domestic unrest surrounding the 2007 elections likely contributed to increased levels of volatility. A ton of sorghum cost nearly 86 percent more in 2009 than just two years earlier. A ton of rice paddy was nearly 71 percent higher, and maize, 53 percent higher. Domestic prices for wheat followed similar patterns, with more pronounced variability in recent years. Wheat and rice are both routinely imported from world markets, and tariffs are generally effective in keeping domestic prices high for producers.

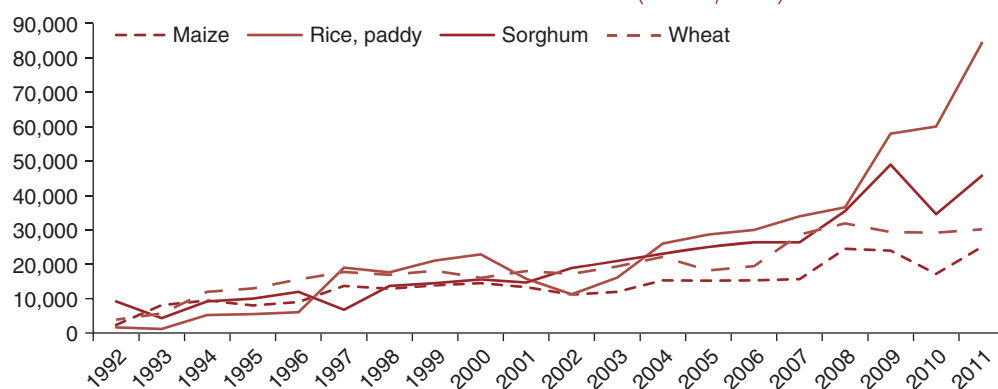
Maize and sorghum, on the other hand, are typically imported duty-free from countries within the EAC and COMESA (Common Market for Eastern and Southern Africa) regions and are only imported from world markets under exceptional circumstances. Consequently, tariffs are not always effective in keeping maize prices high for producers. Given the importance of maize to Kenya's food security, the GoK intervenes in markets to regulate prices and ensure sufficient surplus stock. In low production years, the government often suspends the 50 percent tariff

TABLE 2.7. VALUE OF AGRICULTURAL EXPORTS (US\$ thousands), 2010–12

	2010 (US\$000)	2011 (US\$000)	2012 (US\$000)	Average share 2010–12 (%)
Tea	1,163,630	1,176,308	942,101	20.27
Cut flowers and flower buds for bouquets	396,239	454,349	597,716	8.94
Coffee	207,473	223,509	291,937	4.46
Leguminous vegetables, shelled or unshelled	75,037	152,903	188,834	2.57
Vegetables, fresh or chilled	150,251	57,652	36,696	1.51
Fruit and vegetable juices, unfermented	26,997	27,876	15,588	0.44
Other	—	—	—	61.80
All products	5,169,112	5,853,310	5,169,142	100

Source: International Trade Centre.

Note: —, not applicable.

FIGURE 2.8. TRENDS IN CEREAL PRICES (K Sh/ton), 1991–2011

Source: FAOSTAT.

on grain imported from outside the EAC to hold prices down. During such periods, price volatility increases as imported maize competes with domestic maize. In addition, the National Cereals and Produce Board (NCPB) purchases maize at fixed prices from large-scale farmers and from some smallholders in a few major surplus zones, particularly in the Rift Valley. It also distributes subsidized fertilizer to smallholder farmers in parts of the Rift Valley and western Kenya.¹⁸

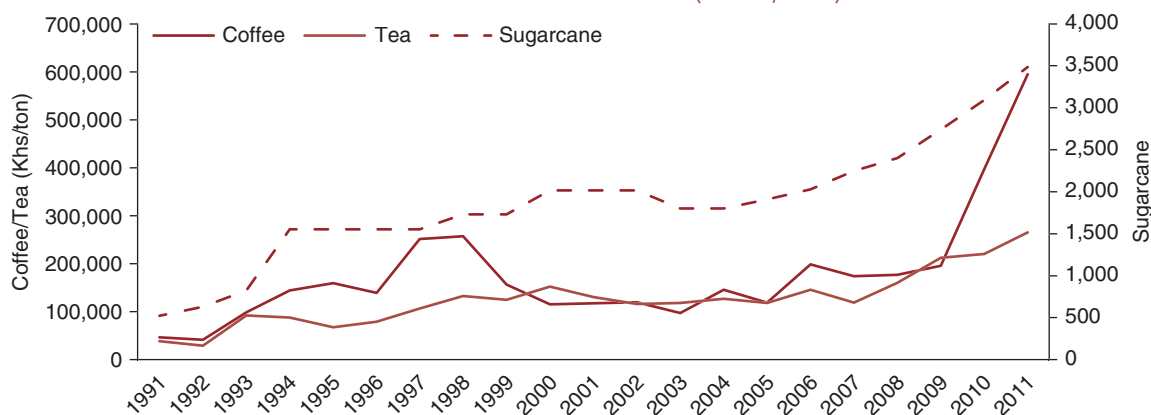
CASH CROPS

Domestic prices, supply chain governance, marketing, and other market dynamics for Kenya's key cash crops vary depending on whether the end product is destined for the

local or the export market. They are also influenced by the extent of government intervention and participation. The vast majority of tea and coffee produced is exported, while virtually 100 percent of the sugarcane produced in Kenya is refined and consumed domestically. Domestic tea and coffee prices are set via the major auctions in Mombasa and Nairobi, respectively. Prices in both auctions, in turn, are heavily influenced by prevailing prices in external markets. These include tea auction prices in Colombo and Calcutta and other major tea-producing countries, and the New York "C" contract market for coffee. Since market liberalization in the early 1990s, the GoK has assumed only a limited regulatory role in domestic tea and coffee industries through the TBK and the CBK. By comparison, Kenya's sugar industry remains highly regulated, with domestic prices directly influenced via import tariffs and quota protections.

¹⁸ Some evidence shows that overreliance on DAP has contributed to excessive soil acidity, and hence, low yields.

FIGURE 2.9. TRENDS IN CASH CROP PRICES (K Sh/ton), 1991–2011



Source: FAOSTAT.

Tea: The volume of Kenya's tea exports increased over the last decade, with some relatively modest fluctuations, while the average value per kilogram in Kenyan shillings (K Sh) has increased steadily since 2007 (figure 2.9). These trends led to rising export proceeds for the GoK over the most recent decade. In 2012, tea exports accounted for nearly one-fifth of Kenya's total agricultural exports, valued at \$942 million. Exports are highly dependent on three markets: Pakistan, Egypt, and the United Kingdom. Together, these account for more than 65 percent of national tea exports. Pakistan alone imports 24 percent of Kenya's total tea exports. The loss or significant reduction of demand from one or more of those markets is an ongoing risk to the industry, as happened during 2005–06 when tea exports to Pakistan fell drastically. Slowing demand in Egypt and Pakistan, and globally, and a glut in global production resulted in weaker prices for Kenyan teas in 2014.

Coffee: Despite the popularity of and strong appreciation for Kenyan coffee globally, Kenya's coffee industry is crumbling under the weight of mismanagement. The importance of Kenya's coffee crop as a major export has declined drastically since production and exports hit their peak during the mid-1980s. Today, it accounts for less than 5 percent by value of Kenya's agricultural exports.

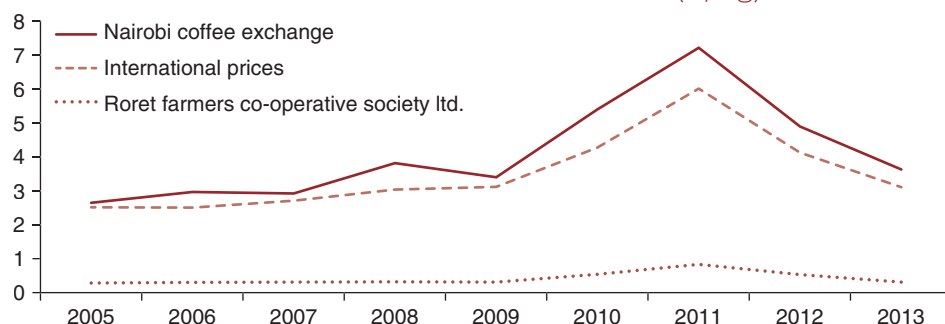
An important factor explaining the decline in coffee production and exports is the decline in world coffee prices between 1986 and 1992. Prices recovered partially between 1993 and 1997, but declined again between 1998 and 2002. After that, they increased consistently until 2014. The price decline only partly explains the

problem, as Kenyan coffee production has continued to slide amid a rebound in global prices. Kenya's aging trees are increasingly susceptible to coffee leaf rust (CLR) and coffee berry disease (CBD), serious biological threats that necessitate the use of costly fungicides. The rising value of land due in coffee-producing areas and competition with other crops further contribute to this decline.

The authority to regulate coffee sales and marketing in Kenya has been vested in the CBK. The Kenya Coffee Producers and Traders Association (KCPTA) manages the auction through which nearly all coffee marketed in Kenya is sold, with a small proportion sold through private contract arrangements.¹⁹ Estates and cooperative societies employ one of eight licensed marketing agents to represent them at the coffee auctions. Around 50 licensed coffee dealers purchase coffee from the auction for export. However, a handful of buyers account for the vast majority of transactions. In this situation, these buyers exercise strong market power in maintaining favorable auction prices, while agents and others are paid on a fixed fee basis. The result is consistently low farm-gate prices that discourage on-farm investments. Figure 2.10 compares Nairobi auction prices and internal prices with those received by the Roret Farmers Cooperative Society

¹⁹ The Coffee Act (2001) was amended through the Finance Act of 2005 to allow for direct marketing of green coffee beans by producers. The direct sales window, commonly referred to as the "second window," allows estate growers, cooperative societies, and cooperative unions to self-market their coffee and access foreign markets. However, since its inception in 2005, negligible volumes have been sold outside the auction due to stringent regulations and bank guarantee requirements.

FIGURE 2.10. COFFEE PRICE COMPARISON (\$/kg), 2005–13



Source: Nairobi Coffee Exchange; International Coffee Organization; Roret Farmers Cooperative Society.

from 2005 to 2013. Farmers were paid about one-tenth of the Nairobi auction prices on average.

These and the other dynamics outlined above have contributed to the decline of Kenya's coffee industry. The smallholder subsector, in particular, faces significant disease-related losses and limited incentives to invest in coffee production under Kenya's current marketing system.

Sugarcane: Kenya's sugar industry is closely linked to the government and is regulated via the Kenya Sugar Board (KSB). As a member of the COMESA Free Trade Area, Kenya is obligated to allow duty- and quota-free access for sugar and other products for member states. Since 2000, however, the country has maintained a market-access safeguard that was extended until March 2015. This has allowed a range of protective measures to help ease the sugar industry's transition to full market liberalization. Measures include tariffs and quotas²⁰ under the COMESA quota protection protocol that are applied to imports, effectively barring open competition between Kenyan and COMESA sugar producers. These protections have kept domestic prices artificially high, benefiting local producers but making raw sugar and sugar products more expensive for consumers.

The sector consists of more than 250,000 smallholder farmers, who supply over 90 percent of the sugarcane processed by sugar companies, while the remainder is supplied by factory-owned nucleus estates and 11 mills, six

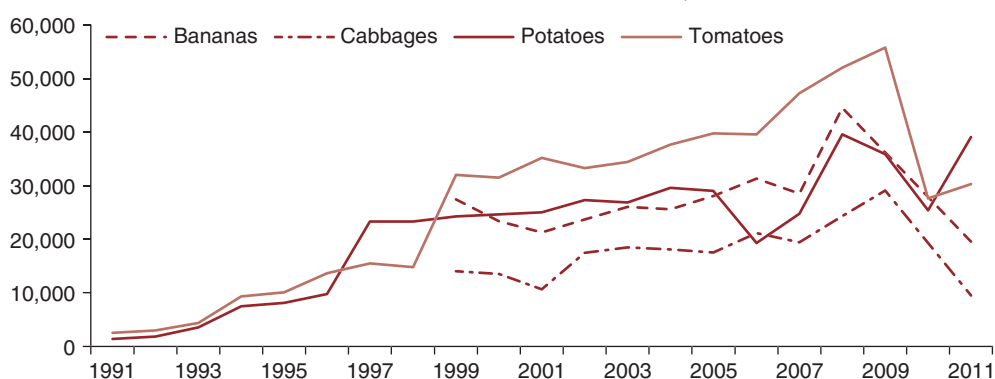
of which are privately owned. The largest mill, Mumias, is government owned. Outgrowers sell their product to sugar mills that process the sugarcane into raw sugar, which is then sold to the local food industry and households through wholesalers and retailers. Imported sugar is transported to major wholesale markets and retailers, where it competes directly with locally produced sugar.

Kenya's current sugar deficit is addressed through imports, both formal and illicit. Significant volumes of refined sugar from outside COMESA countries are reportedly regularly smuggled into Kenya and can at times cause significant distortions in the domestic market. Although imports are regulated through quotas and tariffs, insufficient administration and high local retail prices allow importer "syndicates" to obtain profit margins that can be more than double those of local producers (Millennium Cities Initiative [MCI] 2008). Poor administration of the quota system in years past resulted in heavy losses to processors unable to compete with significant volumes of cheaper imports, as happened in 2012.

Horticulture: Despite rapid growth in recent years, fruit and vegetable exports currently account for less than 5 percent of the total value of Kenya's agricultural exports. The EU is Kenya's biggest market for vegetables, importing about 90 percent of all vegetables destined for export. More than 90 percent of all fruit and vegetable production is consumed domestically, either on-farm or through domestic markets. Price trends across product segments were relatively stable until 2007, when the food crisis and other events led to increasing levels of volatility (figure 2.11.). In recent years, Kenya's small-scale farmers in particular have been hit by rising production costs and the

²⁰ Under the Safeguard Clause, Kenya was allowed to impose (1) a quota of 200,000 tons annually on sugar imported from COMESA countries and (2) a tariff of 120 percent for any amount that exceeds the quota amount.

**FIGURE 2.11. TRENDS IN PRODUCER PRICES (K Sh/ton)
FOR FRUITS AND VEGETABLES, 1991–2011**



Source: FAOSTAT.

EU's stringent food safety regulations concerning agro-chemical residues. EU demand has also slumped, partly as a result of the Euro-zone crisis. According to the Fresh Produce Exporters Association of Kenya (FPEAK), overall exports of vegetables declined by 2.6 percent between 2011 and 2012, from \$379 million to \$369 million. Bean sales dropped by 25 percent in January 2013 compared to January 2012, according to FPEAK.

LIVESTOCK PRODUCTION

As noted earlier, a comprehensive livestock census has not been done since 1969, so actual animal population figures are not known.²¹ According to FAO data, total cattle stocks were an estimated 19.1 million heads in 2012 (table 2.8).

²¹ The 2009 Kenya Population and Housing Census encompassed an accounting of livestock ownership and stock at household level.

Kenya produces approximately 410,000 tons of beef annually, worth approximately \$1.1 billion, amid strong growth in consumption, which doubled over the past two decades. Goats and sheep play a key role in the food security and incomes of pastoral households due to their short-generation intervals, high adaptability, and versatile feeding habits. The country is home to an estimated 29.4 million goats and 18.2 million sheep, which produce about 50,000 tons of chevon and mutton annually, worth an estimated \$128 million.

Milk production in Kenya is largely driven by the informal milk sector. An estimated 800,000 small-scale farmers and 350,000 small-scale milk vendors dominate the milk marketing chain. Following more than a decade of decline, the industry has rebounded in recent years since the GoK restructured it. New dairy regulations since 2004 enabled small-scale milk traders to gain licenses and to

TABLE 2.8. LIVESTOCK POPULATIONS IN KENYA

Livestock Group	Year				Annual Growth Rate (%)		
	1980	1990	2000	2010	1980–1990	1990–2000	2000–2010
('000s)							
Cattle	10,000	1,3793	11,444	17,862	3.79	–1.70	5.61
Sheep	5,000	9,050	7,939	17,562	8.10	–1.23	12.12
Goats	8,000	10,186	10,004	28,174	2.73	–0.18	18.16
Pigs	74	128	311	347	7.32	14.23	1.19
Camels	608	850	718	3,031	3.98	–1.56	32.24
Poultry	16,400	25,228	26,291	30,398	5.38	0.42	1.56

Source: FAOSTAT.

enroll for training in milk handling, processing, and marketing. In 2012, milk production was roughly 5.1 billion liters, with an estimated value of \$1.16 million. Although Kenya remains self-sufficient in milk, output has declined in recent years. Estimated annual per capita milk consumption ranges from 19 kg in rural areas to 125 kg in urban areas (FAO 2011).

Kenya has an estimated 31.8 million chickens, 80.2 percent of which are indigenous while 19.8 percent are commercial layers and broilers (GoK 2010a). Other poultry types (duck, turkey, pigeon, ostrich, guinea fowl, and quail) are becoming increasingly important. Annually, the country produces about 21,600 tons of poultry meat worth \$39.6 million and 1.3 billion eggs worth approximately \$110 million.

FOOD SECURITY

A series of poor cropping seasons in recent years has contributed to deterioration in Kenya's national food security status. The number of Kenyans requiring food assistance rose from 650,000 in late 2007 to almost 3.8 million in late 2009 and early 2010 (GoK 2011). In July 2011, an estimated 2.4 million Kenyans required food and nonfood aid assistance (KFSSG 2011). Aid agencies, the United Nations, and the GoK indicated that more than 3.5 million Kenyans faced starvation as the country struggled with what is believed to be its worst drought in 60 years. In response, GoK policies and interventions focused increasingly on stop-gap emergency measures such as safety net programs (e.g., food distribution, food for work), short-term export bans or import tariff reductions, and input subsidies.

Agricultural policies in recent years are best characterized by strong GoK presence and control of produce and input prices for producers and a sustained focus on stimulating productivity. Perhaps the most prominent example is the price stabilization and producer support prices for maize. The major policy objective for maize is ensuring

sufficient availability at stable, affordable prices for Kenyan consumers, especially in Nairobi, the major deficit market. NCPB is the primary implementing agency. The board procures and maintains a strategic grain reserve on the government's behalf to buffer against food shortages, and facilitates the procurement, storage, maintenance, and distribution of food aid to deficit areas under the National Famine Relief Program. The GoK has also provided input subsidies on a continuous basis, mainly for fertilizer, in the form of direct payment to farmers, free distribution, or voucher programs. The longer-term policy focuses on increasing production through upgrades to research and extension.

CONSTRAINTS TO AGRICULTURAL GROWTH

Agricultural production in Kenya is handicapped by a range of factors that limit producers' ability to invest in their farming enterprise and raise output. These constraints are well documented elsewhere and overcoming them has long been the focus of the GoK's sector development planning and investments. They include the decreasing size of landholdings, limited access to productivity-enhancing technology (including affordable and timely inputs and input credit), declining soil health, weak extension services and low technology adoption, and poor smallholder access to markets. These and other constraints are notable within the context of vulnerability to risks and agricultural risk management. While dampening income growth and agricultural supply chains' competitiveness, these constraints can also amplify the impacts of adverse shocks (e.g., drought, disease outbreak) by weakening farmers' and other stakeholders' ability to manage risk events and recover in their aftermath. It is worth noting here that many interventions that address risks can have positive spillovers in addressing growth constraints. For example, improved soil and water management used to mitigate drought risks can catalyze productivity and gains in farmers' income.

CHAPTER THREE

AGRICULTURE SECTOR RISKS

The main sources of agricultural risk in Kenya are reviewed in this chapter. These include production risks, market risks, and a general set of risks associated with the enabling environment for agriculture. The incidence and implications of multiple or successive shocks are also considered.

PRODUCTION RISKS

Based on analysis of available quantitative and qualitative data, the most common risks to agricultural production in Kenya are drought, flooding, and crop and livestock pest and disease outbreaks. The incidence of these and other adverse events is indicated in figure 3.1, based on reports of adverse events for the period 1980–2012. Drought emerges as by far the most common source of production shocks, followed by floods, which have a much lower impact on crop and livestock production. Related risk events (e.g., pest/disease outbreaks, bushfires) may occur in isolation but can also present as multiple, overlapping shocks, with far greater impacts and higher associated losses.

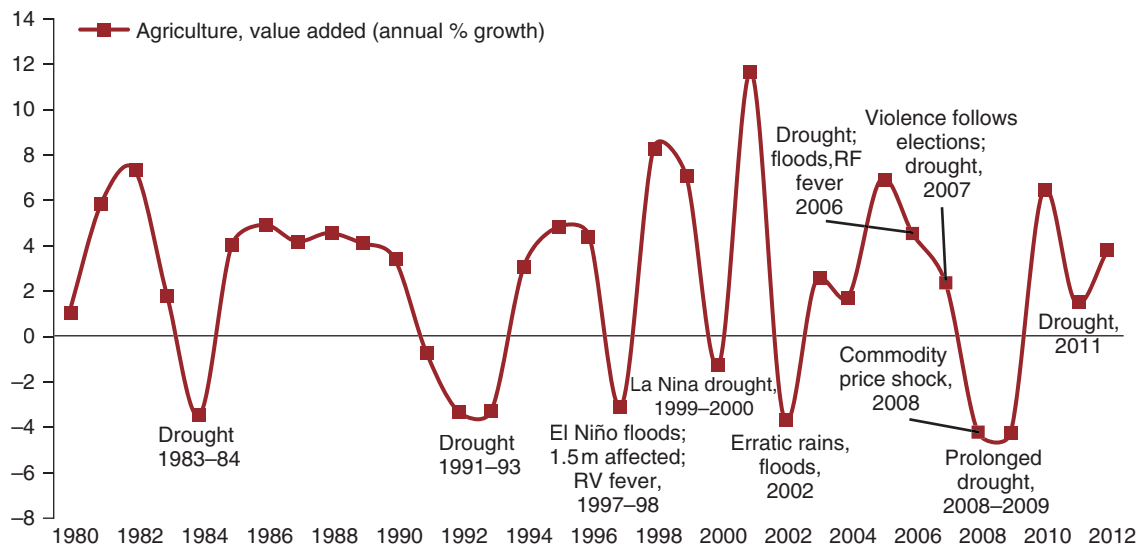
DROUGHT

An agricultural drought²² occurs when a deficit of soil moisture significantly reduces crop yields. It can occur in response to low overall annual rainfall or to abnormalities in the timing and distribution of annual rainfall.

Table 3.1 and table 3.2 are based on analysis of annual rainfall data collected from 12 weather stations for which consistent and reliable information was available for the period 1981–2011. It is worth noting that these weather stations are well distributed

²² Inadequate rainfall at key periods during the crop production cycle (seeding, flowering, and grain filling) affects crop yields, even when overall rainfall is comparable to long-term norms. During these periods, a soil moisture deficit during a period as short as 10 days can have a major impact on crop yields. Drought is typically defined relative to some long-term average balance between precipitation and evapotranspiration, which is considered “normal” for a particular location at a particular time of year. Drought is thus a relative concept in that suboptimal soil moisture levels and crop yields in one agroclimatic area may be acceptable in another.

FIGURE 3.1. HISTORICAL TIMELINE OF MAJOR AGRICULTURAL PRODUCTION SHOCKS, 1980–2012



Source: FAOSTAT; authors' notes.

across the country, and thus provide a reasonably indicative footprint of rainfall at the national level. An analysis of standardized cumulative rainfall provides insights into the frequency and severity of rainfall events during the 31-year period. For the purpose of this analysis, drought is defined as rainfall more than one standard deviation from the mean and extreme drought as rainfall more than two standard deviations from the mean.

Based on the analysis, the country experienced 13 years of widespread drought during the period under review; three of these were categorized as extreme droughts (1983, 1984, 2005). This equates to a drought event in one out of every three years on average. The frequency of more widespread and severe droughts has increased since 2000, while less severe drought events have occurred in other years, impacting one or more regions simultaneously. Table 3.2 lists the years during which Kenya experienced a drought event, with details on associated impacts referenced in media reports, GoK assessments, and the literature. It suggests that drought is a nearly constant dynamic that affects Kenya's agricultural landscape with varying levels of severity.

The impacts of drought depend on three factors: the frequency of droughts, the degree to which the country depends on rainfed agriculture, and the ability of the population to prepare for and adapt to drought conditions.

The combination of frequent severe droughts, high dependence on rainfed agriculture, and high poverty rates among smallholder farmers and pastoralists makes Kenya particularly vulnerable to the effects of droughts. A 2010 survey covering the country's humid, temperate, semiarid, and arid agro-ecological zones found that more than 80 percent of all households interviewed had experienced drought over the last five years, regardless of agro-ecological zone (Bryan et al. 2011). In addition to the immediate impacts, drought typically has long-term consequences. It generally takes more than one season for farmers to recuperate from seasonal droughts, as resources, including seeds, are not available for the following, nondrought season.

Large numbers of people, mainly in the ASALs, have personal knowledge of the impacts of drought, which have been widely documented (Aklilu and Wekesa 2002; Republic of Kenya 2012; Zwaagstra et al. 2010). In Kenya, drought has profound effects on the agriculture sector and is by far the biggest risk facing agricultural production, as its effects are typically felt over a wide area impacting both crop and livestock production systems. For instance, the drought of 2009 affected nearly one-quarter of the population. Drought conditions also favor the emergence of other risks such as pests or diseases, while weakening plant and animal resistance to such threats. Resulting losses from crop failure

TABLE 3.1. FREQUENCY OF MAJOR DROUGHT EVENTS IN KENYA, 1981–2011

Year	Lodwar	Mandera	Eldoret	Nyahururu	Garissa	Kisumu	Narok	Dagoretti	Makindu	Voi	Malindi	Mombasa	
1981	-1.03	1.14	-0.24	0.28	-0.33	-1.53	-1.16	0.67	0.40	0.92	-0.20	0.20	Drought
1982	3.31	0.50	0.86	1.48	0.42	0.57	0.18	0.65	1.69	0.69	2.52	1.81	Ext Excess
1983	-0.69	-0.87	1.63	-1.47	-1.34	-1.36	-0.50	-0.36	-1.49	-1.32	0.22	0.14	Ext Drought
1984	-1.08	-0.92	-2.18	0.40	0.17	-0.82	-1.50	-2.29	0.53	-0.22	0.67	0.20	Ext Drought
1985	0.01	-0.60	-0.60	-0.39	-1.02	-0.04	0.59	-0.80	-0.33	-0.62	-0.87	-0.63	Drought
1986	-0.32	-0.56	-1.43	0.10	-0.07	0.11	-1.30	-0.20	0.20	-0.08	0.13	0.05	Normal
1987	-0.15	-0.32	0.46	-1.26	-1.01	-0.41	0.69	-0.81	-1.26	-1.20	-0.10	-0.60	Drought
1988	1.40	-0.86	-0.28	0.50	0.16	0.41	0.49	1.28	0.63	0.22	-1.17	-0.24	Normal
1989	0.49	0.50	0.98	1.70	1.54	0.06	1.88	1.20	1.92	-0.45	-0.17	-0.11	Excess
1990	-0.89	0.68	-0.29	0.82	0.74	-1.13	-0.53	0.49	0.98	0.97	-0.80	-0.15	Normal
1991	-0.50	-0.11	-0.24	-0.51	-0.28	-0.52	-1.05	-0.39	-0.45	0.14	-0.32	0.17	Normal
1992	-0.97	-0.52	0.33	0.00	-0.21	-0.67	-1.48	-0.07	0.10	0.18	-1.16	-0.51	Drought
1993	-0.61	1.18	-1.84	-0.61	-0.14	-0.67	0.36	-0.42	-0.56	-0.17	-0.43	-0.81	Normal
1994	-0.51	-0.15	0.59	0.78	0.37	0.92	0.27	0.06	0.93	1.08	1.45	1.42	Excess
1995	-0.93	-0.08	-0.39	-0.99	0.27	0.71	-0.35	-0.19	-0.98	-0.73	-1.08	0.12	Normal
1996	-0.03	-0.92	0.17	-0.62	-1.26	1.15	0.45	-1.40	-0.57	-0.49	-0.71	-0.14	Drought
1997	1.26	4.08	0.79	0.91	3.23	1.60	1.45	1.02	1.07	0.79	2.41	3.51	Ext Excess
1998	-0.55	-0.54	2.42	1.72	1.69	-1.57	0.93	1.79	1.94	2.97	0.85	0.16	Ext Excess
1999	-0.73	-0.37	0.01	0.60	-0.33	0.97	-0.40	-0.11	0.74	-0.70	0.67	0.07	Normal
2000	-0.92	-0.39	-0.99	-0.37	-1.13	-1.07	-1.38	-1.58	-0.30	-0.33	-0.25	-0.28	Drought
2001	-0.75	-1.27	-0.18	0.40	-0.56	0.63	-0.02	1.80	0.53	-0.37	-0.68	-0.68	Drought
2002	0.95	0.18	-0.76	-0.38	0.95	1.72	1.85	0.37	-0.32	1.21	0.06	-0.07	Excess
2003	-0.03	-0.20	-0.56	-1.02	0.21	-0.42	0.37	-0.26	-1.01	-1.94	-0.42	-1.37	Drought
2004	-0.10	-0.20	0.06	-0.36	-0.88	0.41	-0.09	0.48	-0.29	1.10	-0.87	-0.90	Normal
2005	-0.18	-0.72	-0.49	-1.61	-1.25	-1.23	-1.26	-0.74	-1.65	-1.55	-0.99	-0.47	Ext Drought
2006	1.23	0.82	1.36	1.21	1.41	1.51	1.79	1.11	1.39	1.04	1.72	1.86	Ext Excess
2007	1.36	-0.15	0.44	-0.56	-0.29	-1.15	-0.15	-0.88	-0.51	-0.79	1.29	0.57	Normal
2008	-0.52	-0.80	-0.32	-0.90	-0.44	-0.82	-0.63	-0.96	-0.88	-0.73	-0.28	-0.70	Drought
2009	-0.30	-0.11	-1.03	-1.20	-0.43	0.42	-0.80	-0.97	-1.20	0.10	-0.59	-1.24	Drought
2010	0.43	0.61	1.44	-0.75	0.25	0.85	0.22	1.39	-0.71	-0.41	-0.47	-0.35	Normal
2011	1.37	0.95	0.28	2.08	-0.44	1.37	1.11	0.12	-0.58	0.67	-0.44	-1.02	Excess

Source: Kenya Meteorological Department; authors' calculations.

and animal mortality can be substantial, especially in extreme drought years.

As an example, the GoK estimated that total damages and losses resulting from the 2008–11 drought were \$12.1 billion, equivalent to a drag on economic growth of 2.8 percent per year on average (GoK 2012a). An estimated 85 percent of damages and losses were to agriculture (13 percent) and livestock (72 percent). GoK estimates of resources required for recovery and reconstruction were an additional \$1.77 billion. During 1999–2002, an estimated 23 million people were affected by severe drought in west-

ern and central Kenya, the country's agricultural heartland, severely impacting tea and coffee production. Tea output dropped by an estimated 15 percent during the three-year period (Rice 2006). This prolonged drought is estimated to have cost the Kenyan economy around \$2.5 billion (CERF 2008), accounting for approximately 20 percent of the country's GDP at the time (IMF 2008). In 2005–06, another severe drought affected 3.5 million people, mostly nomadic pastoralists in northeast Kenya. An estimated 70 percent of the livestock in affected areas died (CERF 2009). The same drought reportedly caused heavy losses to the tea industry. The TBK reported that black tea produc-

TABLE 3.2. DATES AND IMPACTS OF DROUGHT EVENTS IN KENYA, 1980–2011

Year	Regions Affected	Impacts
1980–81	Lodwar, Kisumu, Narok	400,000 people affected
1983–84	Nyahururu, Garissa, Kisumu, Makindu, Voi, Lodwar, Eldoret, Narok, Dagoretti,	50–75 percent cattle mortality in the northern rangelands; severe food shortages in Eastern
1987	Nyahururu, Garissa, Makindu, Voi	province
1991	Lodwar, Nyahururu, Kisumu, Narok, Lodwar, Mandera, Narok, Malindi, Mombasa	1991–92: 1.5–2.7 million people affected; pastoralists forced to move out of ancestral lands. Substantial numbers of livestock lost
1995–96	Lodwar, Nyahururu, Makindu, Voi, Malindi, Mandera, Garissa, Dagoretti,	1995–96: Est. \$2.8 billion in damages from the loss of crops and livestock, etc.
1999–2000	Lodwar, Voi, Garissa, Kisumu, Narok, Dagoetti	23 million people affected; est. \$80 million from animal losses; 3.3 million affected households; maize harvest drops by one-third; maize/bean prices 30–50 percent above five-year average
2003–04	Eldoret, Nyahururu, Makindu, Voi, Garissa, Malindi, Mombasa	Long rains began late and were poor in many areas; est. 3 million households need food assistance
2005	Nyahururu, Garissa, Kisumu, Narok, Makindu, Voi	3.5 million people and 37 of 78 districts affected; est. \$450 million in losses; \$197 million in GoK and international humanitarian aid
2008–09	Mandera, Nyahururu, Kisumu, Dagoretti, Makindu, Voi, Malindi, Mombasa, Eldoret	3.8 million people affected; \$423 million in GoK and international humanitarian aid; cattle and sheep mortality rates in six ASAL districts ranged from 57 to 65 percent.
2011	Mombasa	4.3 million people affected; food prices 130% higher than normal; from 2008 to 2011, est. \$630 million in animal losses, other losses valued at \$7.22 billion

Source: EMDAT (Emergency Events Database); UN International Strategy for Disaster Reduction ; media and GoK reports; authors' notes.

Note: ASAL, arid and semiarid land; GoK, government of Kenya.

tion fell by 20 percent in the first half of 2006 compared to the same period in 2005. Extended dry periods mostly affect crops in marginal tea production areas, and some losses can occur when the dry period coincides with frost.

According to the literature and anecdotal evidence collected for this study, the main risk for northern pastoralists remains drought (see Chapter 5). Livestock herders used to anticipate major droughts once every 10 years. This cycle allowed farmers to recover and rebuild their livestock and crops before the next drought. In recent years, however, the frequency of drought has increased to once in every three to four years, leaving less time for recovery and for rebuilding stocks of food and livestock. The impact of weather variability is likely much greater in recent times due to rapid population growth and demographic change, contributing to an increasing loss of mobility and access to grazing areas, and a break-

down of traditional coping mechanisms. In recent years, these trends have contributed to an increasing reliance on emergency aid in the ASALs. Drought can also exacerbate market risks related to price volatility and the affordability of concentrate feeds and fodder.

The impacts of past drought years on the livestock sector are summarized below²³:

- » 1983/84: 50–75 percent of cattle reported to have died in the northern rangelands
- » 1999/01: Death of animals led to direct losses of K Sh 6 billion (\$80 million) (Aklilu and Wekesa 2002)
- » 2005/06: Drought caused losses of \$450 million
- » 2008–11: Drought caused death of animals valued at K Sh 56.1 billion (\$630 million)

²³ More details on mortality rates are available in Aklilu and Wekesa (2001, 2002); Zwaagstra et al. (2012); and Fitzgibbon (2012).

In addition to a perceived increase in the frequency of dry years, pastoralists believe that the rains themselves are getting shorter; the long rains used to last three months, but now last only two to three months. Droughts result in reduced pasture and reduced recharge of wells, and thus to water shortages and reduced feed for animals. Drought obliges pastoralists to use boreholes instead of shallow wells; the boreholes are not only quickly overloaded but the surrounding grazing land is rapidly depleted and eroded. As animals weaken and lose value, the price of staple food items has a tendency to increase. In the 2008–11 drought, terms of trade (TOT) for pastoralists dropped to 50–60 percent of the five-year average (GoK 2012a). An analysis of market risks (see section, “Market Risks”) finds similar adverse movements in TOT.

Beyond the problem of drought, erratic rainfall (including late rain onset, rains ending early, and extended dry periods during the rainy season) has become a significant problem for Kenyan farmers. Historically, farmers could count on rains arriving the last 10 days in October (short rains) and the last 10 days of March (long rains). In recent years this has been less certain, and farmers find they do not know when they will have enough moisture for the planted seed to survive. Planting late results in poor yields or outright crop failure, while planting too early results in the need to replant, perhaps several times, and higher costs. Farmers also report a higher incidence of years when rains end early or a dry spell occurs during the rainy season and compromises yield. Maize farmers reported significant losses due to this phenomenon in 2011 in particular. In some areas, such as the Eastern Province, farmers indicated that they could only get a good maize harvest once every six to eight seasons. Yet many continue to plant maize every season.

Significant amounts of rainfall in the dry season (January–February) can cause losses in coffee quality because of anticipated flourishing. Likewise, extended rainfall after the long rains (March–May) can encourage higher incidences of coffee-related pests and diseases, necessitating treatment, lowering yields, and upping the costs of production. As stated by farmers during the mission field visits, erratic rainfall can cause yield losses in coffee of up to 20–40 percent.

Although certain global climate models predict increasing rainfall trends for the region as a whole, the risks of future droughts should not be underestimated given anticipated increases in climate variability linked to climate change. A 2011 rainfall analysis by the International Food Policy Research Institute (IFPRI) highlighted a noteworthy increase in the frequency and persistence of dry events in recent years (IFPRI 2013). The same study also found through crop water production modeling that water stress caused by insufficient rainfall plays a significant role in rainfed maize production, a finding that has substantial implications for Kenya’s food security situation.

FLOODS

Extreme rainfall causing localized flooding of cropland and/or pastureland is a common weather phenomenon in Kenya. Perennial floods affect low-lying regions of the country such as river valleys, swampy areas, lakeshores, and the coastal strips that are unevenly distributed in the country’s five drainage basins. Geographically, the western, northern, eastern, central, and southeastern parts of the country are quite susceptible to seasonal floods during the two rainy seasons. The Lake Victoria Basin in western Kenya is the most flood-prone region, while the country’s ASALs are also prone to floods, despite their low average rainfall of only 300–500 mm.

Table 3.3 shows years during which Kenya was affected by excessive rainfall during the period 1981–2011. Based on the analysis, the country experienced eight years during which the amount of rainfall was significantly higher than the norm; four of these were categorized as extreme rainfall events (1982, 1987, 1988, 2006). This suggests that floods occur roughly once every four years on average.

Despite the relatively frequent occurrence of flooding in many regions, resultant losses to crops or livestock are rarely extensive at an aggregate level as impacts tend to be isolated locally. An exception to this was the 1978/98 El Niño event, which resulted in severe floods after major rivers in the country attained record peaks. Flooding caused loss of lives and significant damage to infrastructure and other assets, with one estimate placing losses at 11 percent of national GDP. Widespread floods in 2006 affected large swaths in Coast Province and parts of North Eastern Province, in which the most affected dis-

TABLE 3.3. FREQUENCY OF SURPLUS RAINFALL EVENTS, 1963–2012

Year	Lodwar	Mandera	Eldoret	Nyahururu	Garissa	Kisumu	Narok	Dagoretti	Makindu	Voi	Malindi	Mombasa	
1981	-1.03	1.14	-0.24	0.28	-0.33	-1.53	-1.16	0.67	0.40	0.92	-0.20	0.20	Drought
1982	3.31	0.50	0.86	1.48	0.42	0.57	0.18	0.65	1.69	0.69	2.52	1.81	Ext Excess
1983	-0.69	-0.87	1.63	-1.47	-1.34	-1.36	-0.50	-0.36	-1.49	-1.32	0.22	0.14	Ext Dry
1984	-1.08	-0.92	-2.18	0.40	0.17	-0.82	-1.50	-2.29	0.53	-0.22	0.67	0.20	Ext Dry
1985	0.01	-0.60	-0.60	-0.39	-1.02	-0.04	0.59	-0.80	-0.33	-0.62	-0.87	-0.63	Normal
1986	-0.32	-0.56	-1.43	0.10	-0.07	0.11	-1.30	-0.20	0.20	-0.08	0.13	0.05	Normal
1987	-0.15	-0.32	0.46	-1.26	-1.01	-0.41	0.69	-0.81	-1.26	-1.20	-0.10	-0.60	Drought
1988	1.40	-0.86	-0.28	0.50	0.16	0.41	0.49	1.28	0.63	0.22	-1.17	-0.24	Normal
1989	0.49	0.50	0.98	1.70	1.54	0.06	1.88	1.20	1.92	-0.45	-0.17	-0.11	Excess
1990	-0.89	0.68	-0.29	0.82	0.74	-1.13	-0.53	0.49	0.98	0.97	-0.80	-0.15	Normal
1991	-0.50	-0.11	-0.24	-0.51	-0.28	-0.52	-1.05	-0.39	-0.45	0.14	-0.32	0.17	Normal
1992	-0.97	-0.52	0.33	0.00	-0.21	-0.67	-1.48	-0.07	0.10	0.18	-1.16	-0.51	Normal
1993	-0.61	1.18	-1.84	-0.61	-0.14	-0.67	0.36	-0.42	-0.56	-0.17	-0.43	-0.81	Normal
1994	-0.51	-0.15	0.59	0.78	0.37	0.92	0.27	0.06	0.93	1.08	1.45	1.42	Excess
1995	-0.93	-0.08	-0.39	-0.99	0.27	0.71	-0.35	-0.19	-0.98	-0.73	-1.08	0.12	Normal
1996	-0.03	-0.92	0.17	-0.62	-1.26	1.15	0.45	-1.40	-0.57	-0.49	-0.71	-0.14	Normal
1997	1.26	4.08	0.79	0.91	3.23	1.60	1.45	1.02	1.07	0.79	2.41	3.51	Ext Excess
1998	-0.55	-0.54	2.42	1.72	1.69	-1.57	0.93	1.79	1.94	2.97	0.85	0.16	Ext Excess
1999	-0.73	-0.37	0.01	0.60	-0.33	0.97	-0.40	-0.11	0.74	-0.70	0.67	0.07	Normal
2000	-0.92	-0.39	-0.99	-0.37	-1.13	-1.07	-1.38	-1.58	-0.30	-0.33	-0.25	-0.28	Drought
2001	-0.75	-1.27	-0.18	0.40	-0.56	0.63	-0.02	1.80	0.53	-0.37	-0.68	-0.68	Normal
2002	0.95	0.18	-0.76	-0.38	0.95	1.72	1.85	0.37	-0.32	1.21	0.06	-0.07	Excess
2003	-0.03	-0.20	-0.56	-1.02	0.21	-0.42	0.37	-0.26	-1.01	-1.94	-0.42	-1.37	Drought
2004	-0.10	-0.20	0.06	-0.36	-0.88	0.41	-0.09	0.48	-0.29	1.10	-0.87	-0.90	Normal
2005	-0.18	-0.72	-0.49	-1.61	-1.25	-1.23	-1.26	-0.74	-1.65	-1.55	-0.99	-0.47	Ext Dry
2006	1.23	0.82	1.36	1.21	1.41	1.51	1.79	1.11	1.39	1.04	1.72	1.86	Ext Excess
2007	1.36	-0.15	0.44	-0.56	-0.29	-1.15	-0.15	-0.88	-0.51	-0.79	1.29	0.57	Normal
2008	-0.52	-0.80	-0.32	-0.90	-0.44	-0.82	-0.63	-0.96	-0.88	-0.73	-0.28	-0.70	Normal
2009	-0.30	-0.11	-1.03	-1.20	-0.43	0.42	-0.80	-0.97	-1.20	0.10	-0.59	-1.24	Drought
2010	0.43	0.61	1.44	-0.75	0.25	0.85	0.22	1.39	-0.71	-0.41	-0.47	-0.35	Normal
2011	1.37	0.95	0.28	2.08	-0.44	1.37	1.11	0.12	-0.58	0.67	-0.44	-1.02	Excess

Source: Kenya Meteorological Department; authors' calculations.

tracts were Mombasa, Kwale, Kilifi, Isiolo, Turkana, and Moyale. Even though potatoes are highly susceptible to flooding and water logging, these risks are not commonly faced by growers because the crop is predominantly cultivated in the highland areas of Rift Valley, Central, and Eastern Provinces, which are not prone to these risk factors. Tomatoes and some other vegetables are susceptible, but farmers generally do not consider flooding to be a major risk.

Based on observable records, an estimated nine major flood events affected various regions between 1980 and

2012. Floods affecting only a single region were recorded in another two years. Floods typically do not impact as much area or as many farmers as a drought, although the impact on those directly affected may be quite severe. Adverse impacts from floods were not evaluated for this study as the agricultural damages associated with them are not as significant as those compared to drought. In the ASALs, other climatic events such as cold or out-of-season heavy rain and flash floods can cause severe losses to herds, especially those weakened by disease or lack of feed. These events and their impacts are often localized, however.

FROST

Frost mostly impacts crop production at higher altitudes. Tea is most susceptible to frost. Tea farmers near Kericho who provided input for this study reported that frost events have become more frequent in recent years. Frost exposure does not typically result in plant death but can reduce productivity for several months while affected plants recover. Although damages from frost exposure at the aggregate level have been negligible historically, in January 2012 the industry reportedly lost an estimated 20 million kg of green leaf, valued at US\$11.4 million, from frost in what the KTDA reported as the worst case of frost to ever hit the country.

OTHER WEATHER-RELATED RISKS

In addition to droughts, floods, and frost, Kenyan agriculture is affected by weather events such as hailstorms and windstorms (often accompanying heavy rain or hail). However, such weather-related risks tend to affect smaller areas with only negligible impacts on aggregate production.

CLIMATE CHANGE

Kenya is ranked as one of the countries (#13 of 169) most vulnerable to physical climate impacts from extreme weather, according to the Center for Global Development. In all of Africa, only Somalia (#7), Sudan (#9), Malawi (#11), and Ethiopia (#12) are ranked higher. Across Kenya's economic landscape, the agriculture sector is by far the most vulnerable to impacts from climate change.

The climate predictions of IFPRI (2013) and others for Kenya highlight a number of risks and impacts for the agriculture sector.²⁴ These include more frequent extreme events such as prolonged drought and flooding, leading to a decrease in reliable cropping days and higher incidences of crop failure. Increased frequency of drought will likely contribute to more frequent water shortages for domestic use and crop and livestock agriculture. Unpredictable precipitation during both the short and long rains, together with extreme events, particularly increased frequency of drought, may cause a decline in agricultural productivity. In addition, changes in the timing of long and short

rains will make it increasingly difficult to plan sowing and harvest times, causing lower maize yields in some major production zones, and greater food insecurity. Also, incremental changes in temperature and rainfall patterns are expected to contribute to biodiversity loss and emergence of new pests and diseases.

Some crops are expected to experience more favorable growing conditions as a result of climate change, whereas others will find future climatic conditions intolerable. Equally, some regions (the mixed rainfed temperate and tropical highlands) are projected to experience an increase in crop yield, whereas others (the ASALs) are projected to witness a significant decline in crop yield and livestock numbers as water resources become increasingly scarce.

PESTS AND DISEASES

As in other countries, pests and diseases are a permanent fixture of both crop and livestock production systems in Kenya. The majority of pest and disease threats are manageable, but farmers and livestock herders do not always practice prevailing control measures or avail themselves of available technologies, due to lack of information, access to needed inputs, or financial resources. This subsection presents a discussion of some of the most notable pest and disease risks in Kenyan agriculture. The main biological threats and the crops they affect are summarized in table 3.4.

CROP PESTS AND DISEASES

Outbreaks of African armyworm (*Spodoptera exempta*) are commonplace across Kenya. The armyworm attacks all graminaceous crops and is a significant and perennial concern for farmers and livestock herders. Uncontrolled outbreaks can cause total crop loss, with millions of hectares of farmland and pastureland affected in bad years. Normal rainfall following drought often precipitates large-scale infestation. According to CABI Africa, outbreaks of armyworm in mid-2008 were reported in 24 districts in Kenya, damaging 10,324 ha of crops and 41,435 ha of pasture. Existing control measures are generally effective. These are managed via a national forecasting unit that monitors previous outbreaks and meteorological data to predict broadly where outbreaks might occur in the near-term and an early warning system network of more than

²⁴ See Appendix A for a synopsis of recent climate change impact analyses.

TABLE 3.4. PRINCIPAL PEST AND DISEASE RISKS IN KENYAN AGRICULTURE

Pest/Disease	Crops/Animals Affected
Crops	
Maize Streak Virus (MSV) Disease	Maize
Maize Lethal Necrosis Disease (MLND)	Maize
Large Grain Borer	Maize
Maize Weevil	Maize
Stem/Stalk Borer	Maize, wheat, sugarcane
Ratoon Stunting Disease	Sugarcane
Sugarcane smut	
Termites	Maize, sugarcane
Armyworm, bullworm	Cereals, root crops, sugarcane, vegetables, pasture grasses
Thrips, Aphids, Mealybugs, Nematodes	Maize, coffee, tea, sugarcane, vegetables, fruits
Coffee Leaf Rust (bacterial blight)	Coffee
Coffee Wilt Disease	
Coffee Berry Disease	
Cassava Mosaic Disease (CMD)	Cassava
Cassava Brown Streak Disease (CBSD)	
Banana <i>Xanthomonas</i> Wilt (BXW)	Bananas
Black Sigatoka Leaf Spot (BSLS)	
Panama Disease	
Yellow Sigatoka	
Bacterial Wilt	Potato, tomato
Late/Early Blight	Potato, tomato
Potato Leaf Roll	Potato
Weevils, beetles	Sweet potato
Red Spider Mite	Tomato
Striga	Cereals
Livestock	
East Coast Fever	Cattle
Rift Valley Fever	
Anthrax	Cattle
Foot and Mouth Disease	Cattle, pigs
Contagious Bovine Pleuropneumonia (CBPP)	
<i>Pestes des Petits Ruminants</i> (PPR)	Goats, sheep
Newcastle Disease	Poultry

Source: Authors' notes.

400 pheromone traps operated by extension agents and the Plant Protection Services.

Maize: Maize is particularly vulnerable to a wide range of pests and diseases. Practically speaking, weeds are a constant threat to maize production. Effective control requires the use of significant labor or expensive herbicides. Striga is a parasitic weed reported to infest 210,000 hectares in western Kenya alone (AATF 2006). According to the African Agricultural Technology Foundation, Striga costs African farmers across the continent about \$1 billion per year.

Myriad insects are also a constant threat to maize production (e.g., stemborer) and storage (e.g., larger grain borer, weevils), while others pose a more sporadic threat. Common insect pests are categorized into three general groups: (1) moths, which include cutworms, earworms, stemborer, and grain moths; (2) beetles, including rootworms, wireworms, grubs, grain borers, and weevils; and (3) disease vectors, most notably leaf hoppers, thrips, and aphids. Many pests and diseases can be controlled with good crop husbandry and chemical treatments, but these are often costly, and farmers hesitate to pay the cost of treating for pests or diseases not expected to be a serious problem. Some farmers' reluctance to respond to low-level threats also contributes to periodic outbreaks of known pests and diseases.

Maize is susceptible to a long list of fungal (e.g., rust, spot, blight, smut) and viral diseases (e.g., maize streak virus). Pests and diseases will typically lower yields but not cause substantial losses, as most farmers are aware of and know how to manage them. The real problem is the emergence of a new threat. A recent example is the appearance of the maize lethal necrosis disease (MLND), first reported in June 2011 in Bomet, Naivasha, and Narok Counties in the Southern Rift Valley (Wangai et al. 2012). Since then, additional outbreaks of MLND have been reported in parts of the North Rift Valley as well as in the south. According to KEPHIS (Kenya Plant Health Inspectorate Services), the disease is now widespread in Chepalungu, Sotik, Transmara, Bureti, Nakuru, Konoin, South Narok, Mathira East, Imenti South Districts, and Nyeri. Incidence in the field ranges from 40 to 100 percent of the crop, and over 80 percent crop loss has been reported in some cases.

MLND has been the greatest pest/disease threat in recent years in Kenya because there is no cure and resistant varieties have yet to definitively emerge from research. The main transmission route is insect vector (thrips and beetles), but transmission via seeds also seems likely. Chemical treatment to limit disease vectors is believed to help control its spread, but many farmers in parts of the Southern Rift Valley have reportedly switched to other crops after suffering severe crop losses. The GoK has ramped up research and distributed sorghum, finger millet, cassava, and sweet potato seeds to farmers from areas previously affected with MLND to grow as alternatives to maize (Kamau 2013). Kenya Agricultural Research Institute (KARI), KEPHIS, and the International Institute for Tropical Agriculture (IITA) are leading the search for effective ways to combat the disease, but the process of breeding resistant varieties will likely take three to six years.

Potato: The biggest threat to potato production in Kenya is bacterial wilt (caused by *Ralstonia solanacearum*). The disease is prevalent in all potato-growing areas in Kenya, affecting over 70 percent of potato farms and causing yield losses of between 50 and 100 percent (World Bank 2012). Late blight is another common threat affecting an estimated two-thirds of all potato crop farms.

Coffee: Unlike tea, which is relatively resistant to pests and diseases, Kenya's coffee industry is threatened by two major diseases: CBD (*Colletotrichum kahawae*) and CLR (*Hemileia vastatrix*). Both are major diseases of Arabica coffee that, left untreated, can cause significant losses. Severe rust incidence may lead to loss of foliage (up to 50 percent) and berries (up to 70 percent) (Alwora and Gichuru 2014). CBD infects all stages of the crop, from flowers to ripe fruits, and can cause up to 50–80 percent yield loss if conditions are favorable and no control measures are adopted (Gichimu and Phiti 2012). Both CBD and CLR are manageable via adoption of good cultural practices, such as planting resistant varieties and applying contact and systemic fungicides. Chemical control of these diseases is expensive (up to 30 percent of total production costs), however. Control measures also focus on the development and dissemination of coffee varieties resistant to CBD and CLR, but farmer access and the replanting of improved varieties remains limited.

Sugarcane: Sugarcane smut, caused by the fungus *Ustilago scitaminea*, is considered the most important disease impacting sugarcane production in Kenya. It is endemic across Kenya's sugarcane production zones. Yield losses of 21–38 percent were documented recently through field research by the Kenya Sugar Research Foundation (KESREF). These and other findings suggest that varieties previously rated as resistant or immune are becoming increasingly susceptible and that new strains of the fungus may have evolved (KESREF 2011). Ratoon Stunting disease is another common threat, but yield losses are thought to be much lower. Among pests, stock borer and termites are common threats.

LIVESTOCK PESTS AND DISEASES

East Coast fever (ECF) is considered the most serious livestock disease and is present on several of Kenya's borders. Tick-borne, ECF can kill large numbers of calves in pastoralist herds. Spraying the ticks can be an effective method of control if maintained, but this is expensive. With ECF present in neighboring countries, controlling ECF is difficult given Kenya's open borders; emergency fodder provision and climate change have also expanded the areas affected by ECF as the tick species responsible has spread.

Rift Valley fever is similarly hard to control in Kenya. It could be considered a constraint rather than a risk as its strong, positive correlation with heavy rainfall and flooding makes it relatively predictable. The risk is that very few animals are vaccinated, because vaccination frequently leads to abortion in pregnant animals; even if mortality is relatively low, the losses are high when outbreaks occur and vaccination takes place.

Foot and mouth disease (FMD) is endemic in Kenya and can cause high mortality rates, especially in improved breeds. Vaccination is effective and provides short-term immunity, but since cost recovery was introduced in the late 1980s, coverage has fallen to around 10 percent. FMD is especially damaging when it coincides with drought and animals are weak and stressed. Over a 93-day quarantine and observation period due to FMD in 2001, a study on a large Kenyan dairy farm recorded costs and losses that included milk losses (42.0 percent), purchase of additional feeds (13.6 percent), culling of milk cows that devel-

TABLE 3.5. FREQUENCY AND IMPACT OF LIVESTOCK DISEASE OUTBREAKS IN KENYA, 1980–2013

Year	Description
Early 1980s	Animals worth K Sh 230 million lost to FMD
1996	1.47 million, 2.48 million, and 1.15 million animals vaccinated after FMD, Rinderpest, and CBPP outbreaks, respectively
1997	105 and 106 reported outbreaks of FMD and Rift Valley fever
1999	139 reported outbreaks of FMD; 0.65 million animals vaccinated
2000	95 cases of FMD; 0.46 million animals vaccinated; 16 cases of CPB and 1.1 million animals vaccinated
2001	54 FMD outbreaks, 0.76 million animals vaccinated; 1.96 million animals vaccinated against CPB (18 outbreaks); 11 cases of Newcastle disease
2002	48 FMD reported cases; 19 cases of CBPP; 21 cases of lumpy skin disease; 10 cases of Newcastle disease
2003	87 reported FMD outbreaks; 21 reported CPB outbreaks; 16 reported cases of Infectious bursal disease (Gumboro disease)
2004	95 FMD outbreaks; 46 cases of fowl typhoid; 24 cases of infectious bursal disease
2007	First outbreak of PPR, causing 1,500 animal deaths in Rift Valley; 37 cases of Rift Valley fever across 29 of 69 administrative districts in six of eight provinces
2011	4 reported severe outbreaks of African Swine fever in 16 districts

Source: OIE database; HANDISTATUS II; media reports; GoK reports.

Note: FMD, foot and mouth disease; contagious bovine pleuropneumonia (CBPP).

oped chronic mastitis (12.5 percent), extra labor inputs (8.9 percent), veterinary fees (3.3 percent), transport (3.0 percent), deaths (3.0 percent), drugs (2.9 percent), abortions (1.4 percent), and chemicals (0.5 percent). Quarantine and lack of sales of other livestock (pigs) and commodities (hay) on the farm led to overall short-term, farm-level direct and indirect losses of approximately \$16,026.²⁵ An earlier FMD outbreak in the 1980s was estimated to have caused K Sh 230 million in losses (GoK 2009a).

Other animal diseases that are potentially most serious during a drought include small ruminant pest (PPR), contagious bovine pleuropneumonia (CBPP), and catarrhal fever. Anthrax is a serious, yet localized threat, and a new respiratory disease in camels is a source of concern. Animal disease is especially dangerous when drought and disease are covariant, as is often the case, as even common day-to-day levels of infection by normally mild diseases (e.g., orf, pox) or internal or external parasites can become fatal.

Table 3.5 provides some details on reported pest and disease outbreaks affecting Kenya's livestock populations

during the period 1980–2013. Incidences of unreported outbreaks are undoubtedly considerably higher. The lack of information on losses associated with these outbreaks makes it difficult to quantify their impacts.

MARKET RISKS

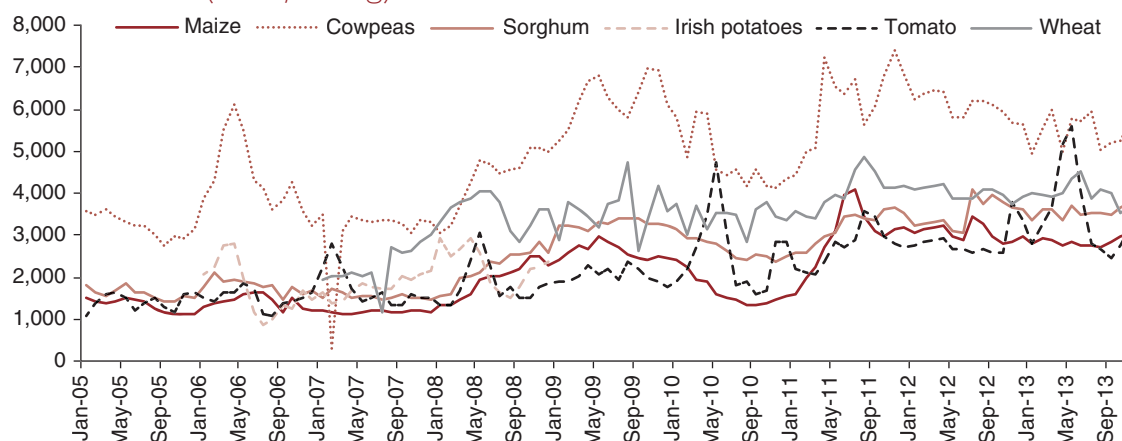
Among the most common market risks presented in this section are price variability for crops and inputs, exchange rate and interest rate volatility, counterparty risks, and livestock theft.

CROP PRICE RISK

Price fluctuations are inherent in agricultural markets, and some level of variability is to be expected. This is partly due to supply and demand dynamics and the unpredictability of weather patterns and harvest yields. However, extreme price volatility deters producers from making productivity-enhancing investments and can weaken food access among poorer households. It can also lead to lost income. The analysis of producer price variability is based on interannual price variability for the period 1991–2011, measured by CVs. Nominal prices in \$/ton are used for the analysis of domestic producer prices. Annual producer price data are drawn from FAOSTAT.

²⁵ The Kenya Veterinarian (2001); see <http://www.ajol.info/index.php/kenvet/article/view/39523> and <http://www.flockandherd.net.au/other/reader/fmd%20kenya.html>

FIGURE 3.2. AVERAGE MONTHLY WHOLESALE MARKET PRICES
(K Sh/90 kg), 2005–13



Source: MoALE.

Note: Potato price is based on 110 kg unit; tomato price is based on 64 kg unit.

TABLE 3.6. INTERANNUAL CROP PRICE VARIABILITY (CV), 1991–2011

<i>Coefficient of Variation</i>					
Cereal Crops		Other		Cash Crops	
Maize	0.33	Cowpea	0.42 ^a	Tea	0.29
Wheat	0.33	Dry beans	0.32 ^a	Coffee	0.53
Sorghum	0.49	Potato	0.28	Sugarcane	0.23
Rice (Paddy)	0.75			Banana	0.28

Source: FAOSTAT.

^aPrices for cowpea and dry beans cover 1999–2011.

Based on CV analysis, producer prices in Kenya for key crops are subject to moderate to high levels of inter-annual price variability (table 3.6). Among crops, rice paddy, coffee, sorghum, and to a lesser extent, cowpea, exhibit the highest levels of year-on-year price volatility. In the case of rice and coffee, this suggests that domestic prices are highly influenced by imports and changes in international market prices. It also suggests that rice and coffee producers in Kenya are highly exposed to significant swings in farm-gate prices from one year to the next.

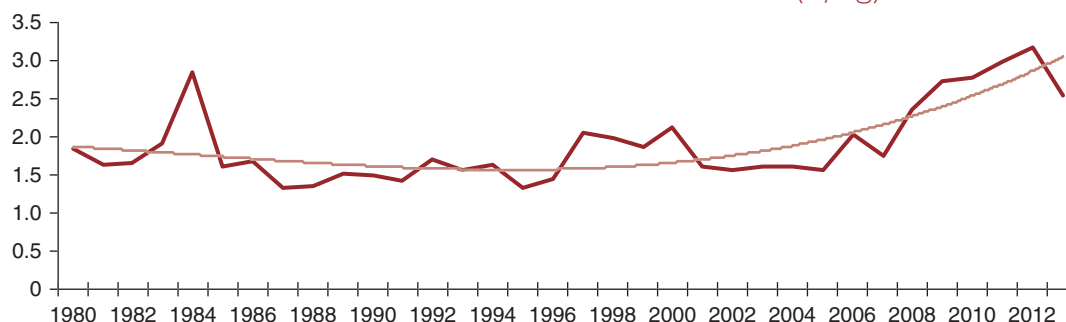
Figure 3.2 shows monthly fluctuations in wholesale prices for six key crops during the period 2005–13. Tomato, maize, and Irish potato exhibit the highest levels of variability, with CVs of 35–38 percent, while wheat prices

remain relatively stable (19 percent). Maize price volatility, in particular, is a critical issue for the GoK, given the importance of maize to household consumption and to food security. In Kenya, maize prices increased sharply in 2008–2009, fell in 2010, and rose again in 2011 and 2012. During the first half of 2011, maize prices jumped by 145 percent. This followed a sharp increase (39 percent) in the commodity food price index and a near doubling of U.S. maize prices during the period June 2010–February 2011.²⁶ In general, domestic maize prices tend to be more volatile than international maize prices, as domestic prices are highly sensitive to constant speculation in projected and real annual output.

Government procurement programs regularly exert pressure on normal market price developments and contribute to higher intra-annual price volatility for maize and other major staples. For farmers, maize prices invariably collapse at the peak of the harvest season. The GoK intervenes by announcing a pan-territorial price for all maize bought by the NCPB for replenishment of the strategic grain reserve. The intervention invariably pushes up prices in the short term. In 2013–14, the pan-territorial price for maize was K Sh 33,000 (\$385) against an average market price of K Sh 30,000 (\$347) per ton. When significant shortages occur, the Kenyan government can also waive the 50 percent duty on extra-COMESA maize

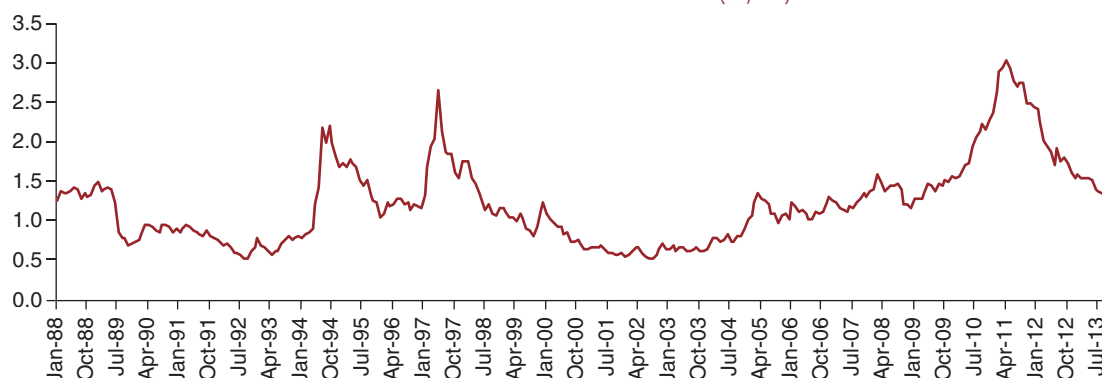
²⁶ According to Index Mundi at indexmundi.com. Data accessed May 2014.

FIGURE 3.3. PRICE OF TEA AT MOMBASA AUCTION (\$/kg), 1980–2012



Source: TBK.

FIGURE 3.4. INTERNATIONAL COFFEE PRICES (\$/lb),* 1988–2013



Source: International Coffee Organization.

Note: *New York cash price, ex-dock New York; (\$/lb).

imports, as happened in 2008. When implemented, this measure exerts considerable and rapid downward pressures on prices.

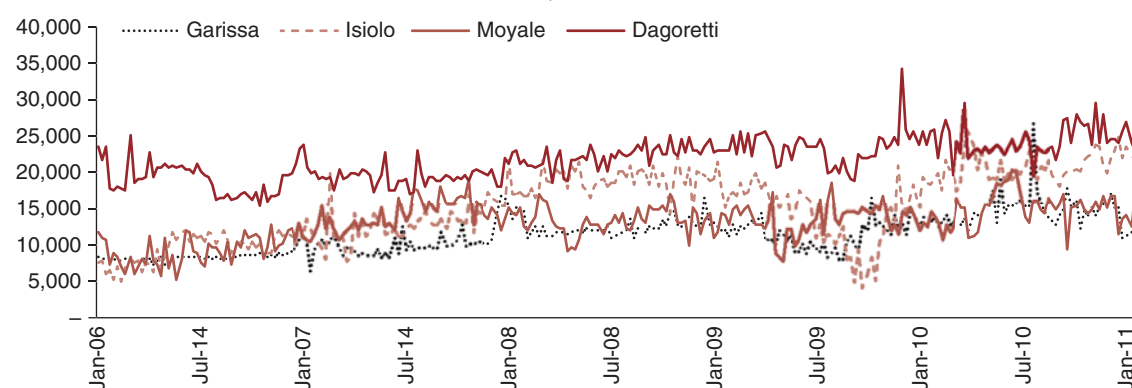
No universal reference market exists for tea prices as for other major commodities. Instead, domestic prices are influenced by prevailing auction prices in other major tea-producing countries, such as those in Colombo and Calcutta. The Mombasa Auction average yearly prices have increased since 2002, with notable inflexions during 2007–09 and 2011–12 (figure 3.3). The interannual variations are not very pronounced. In effect, the CV of the average annual auction price is 27 percent (1980–2013), relatively modest compared to the average annual international price of coffee (41 percent CV in the period 1988–2013) based on the New York market.

Smallholder suppliers to KTDA factories are paid a fixed price during the whole year per green leaf kilogram (K Sh 14/kg in 2013–14). In addition, farmers receive a supplemental year-end bonus, determined on the basis

of the average tea selling price at the auction (excluding marketing, processing, and transport costs). Total farmer payments are typically above 70 percent of the auction price, which is considered to be a relatively good incentive to maintain good crop husbandry and carry out farm investments. Multinational companies operating in Kenya make just one payment to their outgrowers. During certain seasons, their buying practices promote side-selling among KTDA farmers who prefer immediate payment in full. Whatever the extent of volatility, price risk is primarily borne by individual tea farmers and cooperative societies, and KTDA's dual payment system has come under increasing pressure in recent years as farmers demand better price transparency.

Coffee prices in the international market have historically been highly volatile. During the period 1988–2013, interannual fluctuations in coffee prices were subject to a CV of 0.43 (figure 3.4). The level of variability has decreased markedly as prices have slid from their record peak in April 2011. Price risk faced by buyers of Kenya coffee is

**FIGURE 3.5. WEEKLY BEEF CATTLE PRICES (K Sh/kg)
IN VARIOUS MARKETS, 2006–11**



Source: MoALF.

largely managed via hedging on futures. Agents and other downstream actors in the supply chain mostly work on commission and fixed fee-based rates, so face little to no price risk. For the country's farmers, their major concern is consistently low prices at farm-gate rather than intra- or interannual variability of prices. During periods where coffee prices are low, these households are often highly vulnerable to food insecurity due to limited resources employed for food production.

LIVESTOCK PRICE RISK

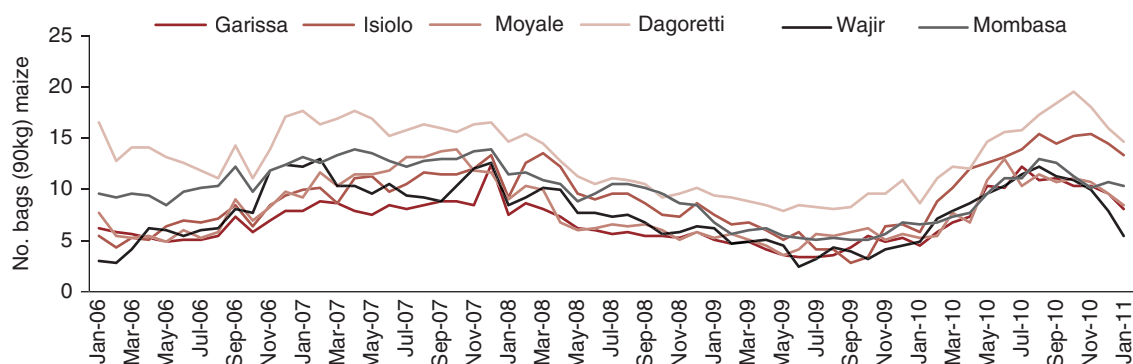
Seventy percent of Kenya's cattle are located in the ASALs, and the income they generate is essential to residents' livelihoods. Livestock marketing has been liberalized, and no livestock trade policies or regulations directly affect domestic prices (FAO 2013b). However, this analysis showed that cattle producers receive substantially less than equivalent world market prices. The first reason for this is the nature of the markets themselves.

Livestock prices are variable across both seasons and years; cattle prices are the most variable (see figure 3.5). Drought triggers adverse trends in prices both of animals and of the commodities that pastoralists consume, especially food items, such as maize and beans, that they do not produce themselves. At early signs of low rainfall, pastoralists start to sell animals and market prices fall because few buyers exist. At the same time, farmers and traders begin storing food in the expectation of future price rises, pushing up the price of food staples. Combined with the falling price of animals, pastoralists are caught in a classic price scissors situation.

Figure 3.6 and figure 3.7 compare real prices and TOT between maize and beef cattle in six major market centers, including Nairobi and Mombasa, for the period January 2006 to January 2011. The TOT are calculated as the number of 90-kg bags that can be purchased by selling one cow. Variations in average monthly prices and TOT ranged between 40 and 77 percent within years. The sample years include the drought years of 2008–11. A depression in prices and especially in TOT is clearly seen as drought occurs. However, the highest variation in TOT occurred in nondrought years rather than drought years, when cattle prices often bottom out. Market dynamics in Nairobi, the major cattle market sink, show more stability than those in pastoral areas, especially in Isiolo Market (figure 3.7) where price drops are most visible. In other centers such as Garissa and Moyale, the variation may be less, as these are border towns with greater flows of cattle from neighboring countries. The data clearly show how vulnerable livestock owners are to price and market dynamics.

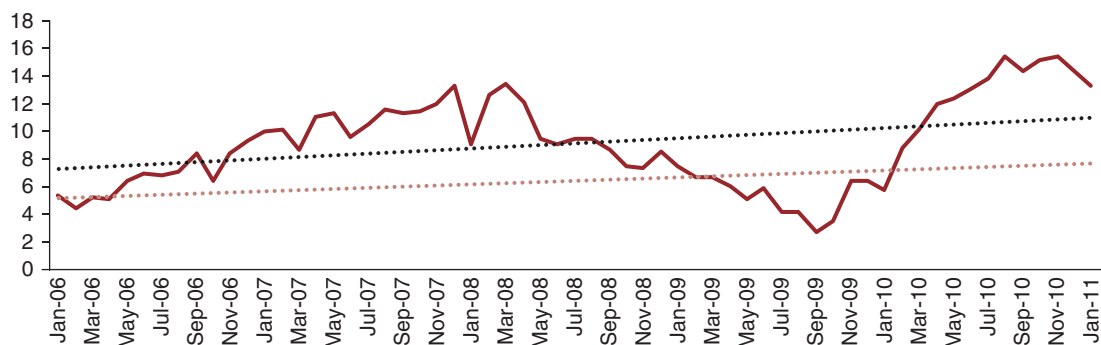
Livestock marketing is poorly regulated and quite disorganized. Sellers are often exploited by traders and middlemen, and significant inefficiencies exist. Producers face substantial market price disincentives despite Kenya's status as a net exporter of cattle (Makooha et al. 2013). These arise from market structure (traders' high profit margins and heavy government fees and taxes imposed on cattle trekkers). The distortions are in part due to information asymmetry. Additional graphs showing the variation in TOT for each of the individual markets are provided in Appendix E (figures E.2–E.7).

FIGURE 3.6. BEEF CATTLE VERSUS MAIZE TOT IN SIX MAJOR MARKETS, 2006–11



Source: MoALF.

FIGURE 3.7. CATTLE VERSUS MAIZE TOT IN ISIOLO MARKET, 2006–11



Source: MoALF.

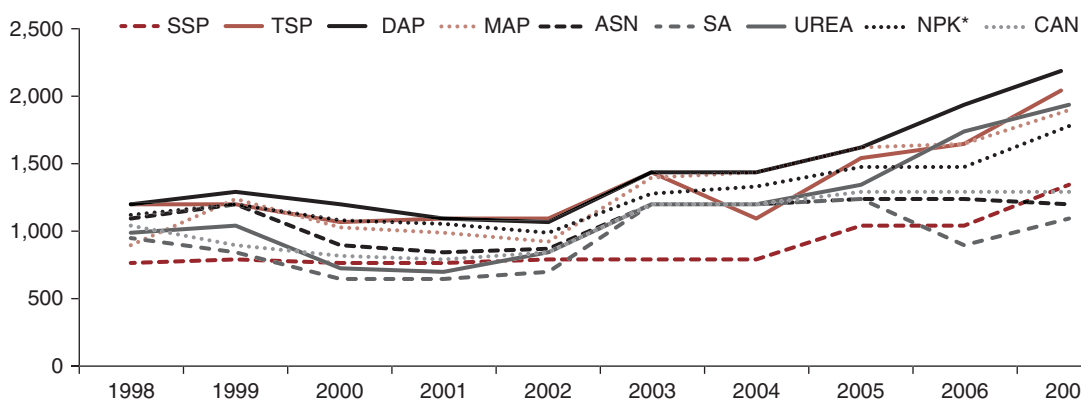
INPUT PRICE VOLATILITY

As elsewhere, high prices inhibit broad farmer utilization of fertilizers in Kenya. Since 2008, the GoK has imported roughly 60,000 MT of planting and top-dressing fertilizers annually through NCPB to stimulate production and enhance food security. Yet fluctuating prices can impose added risk on farmers, making it difficult for them to plan ahead. An analysis of average annual prices across key agricultural fertilizers during the period 1998–2007 suggests that while prices increased, producers faced only moderate levels of year-on-year price volatility. Among nine fertilizers for which historical price information was available, only one (Urea, with a CV of 34 percent) exhibited higher than normal levels of price variability over the 10-year period (figure 3.8). A further analysis of interannual prices for six fertilizers during 2008 showed limited variability, with CVs ranging from 15 to 24 percent. The analysis suggests that farmers face limited risks from input price risk volatility.

EXCHANGE RATE VOLATILITY

Kenya's heavy reliance on cereal and other agricultural imports means that movements in exchange rates between the Kenyan shilling and major trading currencies represent a potential source of market risk. Any volatility also affects exporters of agricultural products such as cut flowers, tea, coffee, and horticultural crops. Available data from 1995 to 2013 show that significant monthly nominal exchange rate fluctuations occurred between May 2007 and April 2009, and then again from January 2011 to March 2012 (figure 3.9). The exchange rate actually rose from a low of K Sh 61.96 per U.S. dollar in May 2008 to a high of K Sh 101.16 per U.S. dollar in October 2011. This drastic currency depreciation was due in part to Kenya's growing trade imbalance and its sizable current account deficit, which was above 10 percent of GDP in 2011, one of the highest in the world. The gradual depreciation has dampened Kenya's capacity to import essential food and energy commodities, while making its exports more competitive.

FIGURE 3.8. DOMESTIC FERTILIZER PRICES, 1998–2007



Source: Agri-Business Directorate.

FIGURE 3.9. EXCHANGE RATES (\$/K Sh), 1995–2013



Source: OANDA.

FIGURE 3.10. COMMERCIAL BANKS' INTEREST RATES* (%), 1992–2013



Source: Central Bank of Kenya.

* Weighted monthly average lending rate.

INTEREST RATE VOLATILITY

Analysis of monthly interest rates on commercial bank lending for the period 1992–2013 shows that rates have declined markedly since their peak in 1994 (figure 3.10).

During the same period, volatility was relatively high, with a CV of 30 percent. Variability declined markedly over the last decade (2004–13), with the exception of a sudden spike beginning in late 2011 when inflationary

pressures, tighter monetary policy, and unexpected volatility in exchange rates drove up lending rates by nearly one-third (31.7 percent) over a two-month period. This analysis suggests that volatility in the cost of credit could pose a risk. Considering Kenya's narrow agricultural credit markets, which accounted for a mere 3.6 percent of total lending in Kenya in 2013 (CBOK 2014), any ex post impacts are considered negligible at the aggregate level.

COUNTERPARTY AND DEFAULT RISKS

Counterparty risk refers to the risk that one or more parties participating in a transaction will not live up to, or will otherwise default, on their obligations. Most stakeholders across Kenya's agricultural supply chains (including producers, wholesale traders, processors, and banks) have only limited means to effectively manage such risks. With few alternatives, many actors prefer to minimize their exposure by operating on a limited volume, cash-and-carry basis. For rural banks, microcredit institutions, and other credit lenders, repayment failure is a constant problem and a significant disincentive to lend to farmers, especially smallholders, who represent a substantial and hard-to-manage default risk. In fact, the inability to manage such risks is a principal factor limiting farmers' access to credit and driving up the cost of agricultural credit.

Side-selling is another form of nonpayment risk that is particularly common among sugarcane and, to a lesser extent, tea producers in Kenya. Come harvest time, small-scale sugarcane farmers often sell their crops to impromptu roadside buyers rather than honor contracts with millers who regularly provide inputs in exchange for the crops they help finance. The practice is known locally as "cane poaching." Mumias Sugar Company, Kenya's largest miller, reportedly made pre-tax losses of \$26 million in 2013 as a result of the combined impact of illegal imports and cane poaching. In the same way, smallholder farmers who are members of KTDA often sell to estate companies, attracted by their spot payment arrangements and, depending on the market, attractive prices. This has been a problem for some KTDA factories, which have operated well below their potential due to an insufficient supply of green leaf tea.

ENABLING ENVIRONMENT RISKS

Other sector risks arise from both internal and external changes in the broader political and economic environment in which agriculture operates. Agriculture sector policy and regulation are a source of risk when public involvement in sector activities has unexpected, adverse consequences. Other risks include general insecurity as a result of domestic social unrest or transboundary conflict that disrupts agricultural production systems and livelihoods.

POLICYMAKING

Ongoing implementation of Kenya's 2010 Constitution will continue to have major consequences for agriculture sector policies and programs. It requires a drastic reduction by at least half in the number of ministries and a substantial consolidation and reorganization of ministerial functions. It also calls for consolidation of more than 100 overlapping pieces of legislation into four new laws: the "Agriculture, Fisheries and Food Authority Act," the "Livestock and Fisheries Act," the "Crops Act," and the "Kenya Agricultural and Livestock Research Act." The first three were passed in January 2013 and are now undergoing implementation. The new constitution also mandates devolution of sector service delivery to Kenya's 47 counties.

Such drastic changes raise the spectre of uncertainty over planning and support to the sector in the near to medium term. In many cases, experienced District Agricultural Officers are being replaced by new graduates from the local area, a process that will potentially reduce the quality of the civil service officers available and the extension services they provide. Anecdotal evidence suggests that counties have a growing tendency to raise taxes collected on local agricultural production and to collect taxes again on any products in transit across their territory. This may significantly increase the cost of transporting grain and other staples from surplus to deficit areas, especially if they must cross several counties to get there.

Another source of risk within the sector's enabling environment stems from the government's active role in regulating domestic food markets. These risks are most notable in the maize and sugar subsectors. In the case

of maize, uncertainty over the scope and timing of GoK interventions in grain markets poses a considerable risk to maize producers, traders, and other stakeholders across the maize supply chain. The common wisdom is that a lack of storage prevails at the farm level and in rural communities. An alternative view is that strong disincentives exist to storing grain. This is because government policy can cause unexpected adverse price shocks, such as temporary suspension of the 50 percent tariff on non-EAC maize imports or the release of grain from the Strategic Grain Reserve. In part because farmers and first buyers have no interest in storing grain that will enter commercial channels, little consideration is given to moisture content and quality. Rather, value chain participants each try to sell the grain before it deteriorates, leaving the responsibility for drying and quality to the next buyer in the chain. Thus, much of the grain entering commercial channels is unfit for storage and subject to significant losses and quality deterioration (including aflatoxin contamination).

Moving forward, it is unclear how Kenya will be able to overcome recurrent maize production shortages, which can jeopardize food security. Amid increasing import volumes, uncertainty exists over whether imports will be able to fill the gap in light of Kenya's 50 percent *ad valorem* tariff for non-COMESA sourced maize, its import ban on genetically modified (GM) maize, and inadequate supplies of non-GM-exportable maize in the COMESA region. This is especially true in light of episodic export bans for maize in Tanzania, Malawi, and Zambia. Supply markets have also been thinned in recent years by the growing attractiveness of the South Sudan market for Ugandan maize exporters and of DRC markets for Tanzanian maize exporters.

Another major risk is government intervention in input markets, such as for fertilizer. Kenya's fertilizer market was liberalized during the early 1990s when price and marketing controls, licensing arrangements, import permits, and quotas were eliminated. The bulk of fertilizers are imported and distributed by the private sector. Since 2008, however, the government through the fertilizer subsidy program has procured about 494,000 MT of fertilizer in support of the agriculture sector. In 2015, the government is projected to import and distribute 143,000 MT of fertilizers through NCPB. This government involvement

in the fertilizer market has created a number of challenges including (1) uncertainty over the timing of delivery and year-on-year support; (2) poor targeting of subsidies; (3) late planting and high farmer dependency; and (4) lack of a clear exit or sustainability strategy.

In Kenya's sugar industry, the unpredictability of current policy²⁷ with regard to import regulations and exceptions to the COMESA rules poses considerable risk to mills, cane producers, and other stakeholders. It also impedes investments. Sizable unrecorded imports of refined sugar from outside the region pose yet another risk to the industry. Imported sugar slated for industrial use has been known to find its way into domestic markets for household consumption. In any case, prices can fall precipitously when the market becomes saturated and mills are unable to compete. For example, in 2002, the industry suffered considerable losses due to import surges and the failure among sugar millers to make payments to cane farmers and other suppliers. As a result, the entire sugar sector accumulated heavy debts. The high level of indebtedness of state-owned mills, reportedly five times more than their current assets combined, has helped stall needed reforms.²⁸

Overregulation, lack of transparency, and asymmetric governance in Kenya's coffee supply chain threaten the coffee industry's long-term viability. International buyers and marketing agents wield excessive market power while farmers are forced to absorb an oversized share of market as well as production risks. As a consequence, farm-gate prices are consistently low, leaving farmers with scant incentives to maintain proper crop husbandry within the context of aging trees, widespread disease, and declining productivity.

Kenya's livestock subsector has long been underfunded and faces a range of challenges ahead. Since most of Kenya's livestock herds are found in the ASALs, which are both more exposed to impacts from natural disasters (e.g., droughts, conflict) and more vulnerable than other

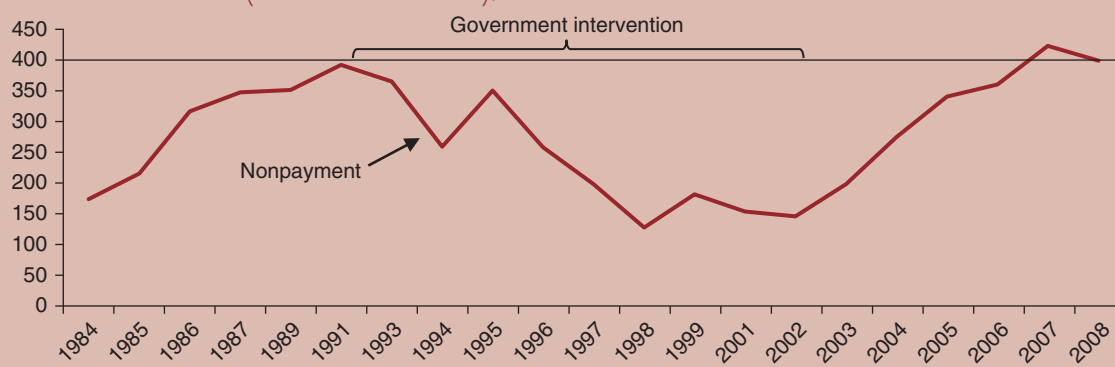
²⁷ In February 2014, COMESA approved the extension for a further year of Kenya's special safeguard arrangement for sugar, thus allowing Kenya to maintain a 350,000-ton ceiling on duty-free sugar imports from COMESA.

²⁸ See "COMESA approves 1-year extension of Kenyan sugar safeguards," *Agri-trade*, May 11, 2014.

BOX 3.1. KENYA'S DAIRY SECTOR—A CASE STUDY OF MARKET AND ENABLING ENVIRONMENT RISK

Kenya's dairy sector has only recently fully recovered from a 15-year crisis caused in part by mismanagement. Government services to the sector were reliable until the mid-1980s, but started failing in the 1990s and collapsed in early 2000 due to corruption and mismanagement in the cooperative sector. This caused a decline in milk handling of 266 million liters (estimated value \$43 million). A failure to pay producers for milk in 1994 alone caused a loss in excess of \$16 million. Amid failing public services, privatization of the sector and service delivery began in 1993, including artificial insemination. With privatization and recession in the sector, concentrate feed production also dropped during 1993–94. Counterparty risk in the milk sector due to manipulation of Kenya Cooperative Creameries (KCC) board members led to delays and failures in payment. In 2008, livestock concentrate and fodder (hay) prices increased by 40 percent and 100 percent, respectively, due to postelection violence and impacts from the global financial crisis, and in 2010, a substantial surplus in milk production caused market glut and farmer distress.

FIGURE B3.1.1. MILK PRODUCTION IN THE FORMAL SECTOR
(millions of liters), 1984–2008



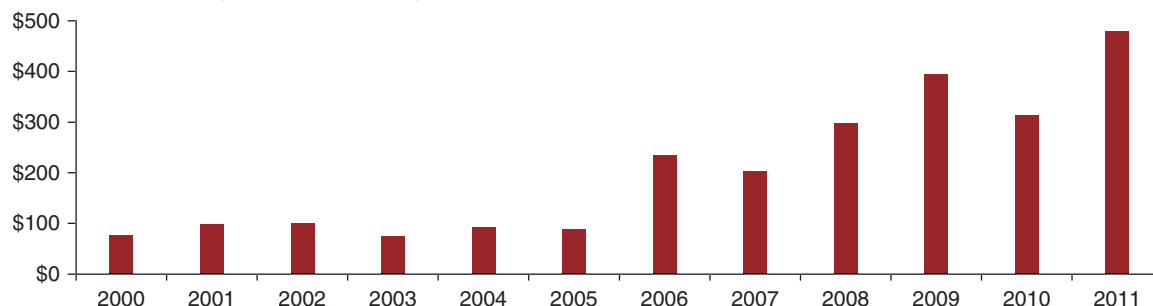
Source: FAO 2011.

livelihood zones, public support to the sector often comes in response to emergencies rather than to modernizing and restructuring the livestock sector. Thus, Kenya's northern rangelands continue to suffer from insufficient infrastructure, low education levels, and poor delivery of health care and other services. And some policies in place remain outdated. Health quarantine laws, for example, hinder livestock trade as many of the facilities originally in place to

test and graze quarantined animals no longer exist or have become dysfunctional. A review of such policies and the broader legal and regulatory framework is required.

Another enabling environment risk to Kenya's agriculture sector is linked to the country's growing dependence on food aid (figure 3.11). During 2006–11, Kenya received \$1.92 billion in emergency response aid, up from \$150

FIGURE 3.11. HUMANITARIAN ASSISTANCE TO KENYA
(US\$, millions), 2000–11



Source: Central Bank of Kenya.

Note: Weighted monthly average lending rate.

million during the prior five-year period (2000–04). As evidenced elsewhere, frequent crises coupled with overreliance on food aid can lead to a breakdown of household resilience. This happens as household capital (i.e., savings, assets) is depleted to finance emergency coping mechanisms. When affected communities have insufficient time to rebound and replenish their resources, subsequent shocks further weaken their capacity to cope and withstand future shocks. Although emergency food aid can help address immediate food needs, it does little to help rebuild household resilience and may induce higher rates of dependency and chronic malnutrition. In this way, it can also increase the cost of managing future crises, and is thus not a sustainable way to manage food crises. For example, the cost of humanitarian aid needed to respond to the famine in Niger in 2010 was twice that needed in 2005 (Michiels, Blein, and Egg 2011).

INSTABILITY

Internal and cross-border conflict is a significant source of risk for Kenyan agriculture. The violence and civil unrest surrounding the December 2007 presidential elections resulted in large-scale displacement and crop losses as farming communities abandoned their fields. It also delayed land preparation and planting in the next season. Partly as a result, losses in maize production alone were an estimated \$101 million, or more than 1.0 percent of the value of agriculture GDP in 2008. According to a study by the Centre for the Study of African Economies (CSAE) at Oxford University, impacts from the postelection violence in 2007–08 on the Kenyan flower industry reduced flower exports across the country by an estimated 24–38 percent. Political instability and conflict in neighboring Somalia can adversely impact agricultural markets, particularly livestock production and trade across Kenya's northeast region. Since Kenya's military intervention in Somalia in 2011, Kenya has seen a rising incidence of attacks by the Somalia-based Al-Shabaab group, which claimed more than 14 bombings or armed attacks in 2012 alone. Kenya also witnessed a resurgence of interethnic violence between August and December 2012.

Customary land tenure systems are another source of conflict, particularly in the ASALs, either when disagreement arises within the system between different rights-holders or when members of a different ethnic group

contest the rights of the first group to exclude strangers. Disputes of this sort have arisen and continue between Somali and Boran pastoralists in northern Kenya, and can give rise to extended conflict. Such conflict is most likely to arise in a drought or other period of stress on people and animals, when access to water and pasture is essential, and herds have to leave their normal grazing areas to find them.

CONFLICT AND INSECURITY IN ASALS

Kenya's low-density, sparsely populated northern counties and long borders provide both opportunities and risks. Conflicts over natural resources, normally contained by customary rules, become much more difficult to settle when government staff, members of the armed forces, and wealthy businessmen become involved. The presence of jihadist fighters on the border with Somalia and nearby across the Gulf of Aden in Yemen adds a complicating factor.

In a regional drought, cattle prices are low but variable, providing traders with an opportunity to provide a useful arbitrage service. Such arbitrage occurs for animals from Somalia, Djibouti, Ethiopia, and northeastern Kenya. The main problem for such traders is insecurity. Traders who buy animals cheaply in Somalia need an escort to get them to Kenya. This escort needs to be a local person from each place—locality or larger area—who is well known and can persuade local people in each area to guarantee safe passage, provide protection, and provide contacts for the sale of the animals, all of which adds substantially to the cost.

Interethnic conflict has occurred at a large scale during elections since the early 1990s and up to those of 2007–08. Clashes also occur regularly over water, grazing, and land control in various counties, particularly in the ASALs but also in parts of the more fertile Rift Valley. Clan and tribal conflicts are frequent along borders (e.g., Pokot and Turkana districts, and Moyale in 2013).

The insecurity triggered by jihadist movements in Somalia has created a serious risk for all members of society in Kenya. The direct risk to life and livelihoods from jihadists is as likely to affect city dwellers in Nairobi and Mombasa as it is livestock owners in northern Kenya. In border

areas, animal health services can be disrupted due to threats to Kenyan government staff, carjacking, and so on, and some traders, suppliers, and transporters may avoid traveling to border areas. Livestock owners and traders are affected by the impact of antiterror operations and tensions along the Somali border due to the Al-Shabab, as transaction costs, restrictions, and harassment by security personnel are likely to increase.

CROP THEFT AND CATTLE RUSTLING

Farmers and traders face the risk of both crop and cattle theft. The increase in market prices in recent years has encouraged growing incidences of crop theft, particularly in maize-growing areas across Kenya. The risk is greatest around harvest time when harvested maize is left in the fields for drying, but many farmers have reported losing their crops to thieves even before harvest. Partly to save harvesting, drying, and storage costs, but also to protect themselves from theft risk, some farmers sell green maize. As happened in 2012, this practice can result in significant drops in farm-gate prices for both fresh and dried maize. It also contributes to maize shortages by reducing the volume of maize reserves.

Cattle rustling has long existed among pastoralists in the region. Losses can be large or small, and local mechanisms for recovering stolen livestock and the resulting fines are well developed within pastoralist communities. The risk of cattle rustling has grown as it has become more commercialized and protected by politically connected elites, rendering traditional resolution mechanisms obsolete and ineffective. Well-organized, “commercial” cattle rustling has emerged since the early 2000s and was a notable problem especially during the election periods in the Rift Valley.

MULTIPLICITY OF RISKS

An important feature of agricultural risk is the high degree of covariance of the main risk components. For example, drought and animal disease commonly occur together when animals weakened by lack of feed and water subsequently travel long distances and become more susceptible to infection. In so doing, they end up spreading infections over long distances. This happened, for example, in 2008–10, when rinderpest returned to Kenya from South Sudan and Somalia, where internal conflict had halted disease control. Similarly, drought and price volatility and market and enabling policy risks are often highly interrelated.

CHAPTER FOUR

ADVERSE IMPACTS OF AGRICULTURAL RISKS

The frequency, severity, and costs of adverse events are analyzed in this chapter as the basis for prioritizing the various sources of risk. The conceptual and methodological basis described below is applied to production, market, and enabling environment risks. The various sources of risk are then reviewed to discern the most critical ones.

CONCEPTUAL AND METHODOLOGICAL BASIS FOR ANALYSIS

For the purposes of this study, risk is defined as an exposure to a significant financial loss or other adverse outcome whose occurrence and severity is unpredictable. Risk thus implies exposure to substantive losses over and above the normal costs of doing business. In agriculture, farmers incur moderate losses each year due to unexpected events such as suboptimal climatic conditions at different times in the production cycle and/or modest departures from expected output or input prices. Risk within the context of the current analysis refers to the more severe and unpredictable events that occur beyond these smaller events and that result in substantial losses to assets and livelihoods at the aggregate, sector level.

This concept differs from the common perception of “risk” by farmers and traders based on year-to-year variability of production and prices. It should also be distinguished from constraints, which are predictable and constant limitations to productivity and growth faced by farmers and other agricultural stakeholders. In Kenya, these constraints include poor access to farm inputs, limited access to markets, limited credit, poor infrastructure, and the decreasing size of landholdings.

LOSS THRESHOLDS

As agricultural production is inherently variable, the immediate step for analysis is to define *loss thresholds* that distinguish adverse events from smaller, interannual variations in output. This is achieved by first estimating a time trend of “expected” production in any given year, based on actual production, and treating the downside difference

TABLE 4.1. COST OF ADVERSE EVENTS FOR CROP PRODUCTION, 1980–2012

Year	Description	Indicative loss value	
		US\$, millions	Percentage (%) GDP
1980	Regional droughts; 400,000 people affected; 728 MT maize loss	–304.9	–3.2
1984	Drought in Lodwar, Eldoret, Narok, Dagoretti regions; 274 MT maize loss	–258.3	–2.7
1993	Regional droughts in Eldoret; low rainfall in Lodwar, Nyahururu, Kisumu, Mombasa	–243.2	–2.6
1996	Widespread drought in ASALs; 1.4 million people food insecure; 323K MT maize lost	–291.9	–3.1
1997	El Nino floods; Rift Valley fever outbreaks; 1.5 million people affected (1997–98); 157,000 MT maize loss	–383.2	–4.0
1998	El Nino floods; Rift Valley fever outbreaks; 1.5 million affected (1997–98)	–266.6	–2–.8
2000	La Nina drought hits Garissa, Kisumu, Narok, Dagoretti; maize harvest drops by one-third	–359.3	–3.8
2001	Drought in Mandera; poor rainfall in Lodwar, Malindi, Mombasa	–223.2	–2.4
2002	Erratic rainfall; floods	–242.6	–2.6
2004	Regional droughts in Gariss, Malindi, Mombasa; estimated 3 million households require food aid	–255.9	–2.7
2009	Widespread drought across Eldoret, Nyahururu, Makindu, Mombasa; 592,000 MT maize loss	–395.3	–4.2
2011	Regional drought in region of Mombasa	–231.5	–2.4
2012		–284.0	–3.0

Source: FAOSTAT; authors' calculations.

Note: Cowpea losses were included from 1989 to 2012 due to data availability. Potato losses were calculated from 1980 to 2004 due to inconsistencies in data thereafter. ASAL, arid and semiarid land; MT, metric ton.

between actual and expected production as a measure of loss. A loss threshold of 0.33 standard deviations from trend is then set to distinguish between losses due to adverse events and those that reflect the normal costs of doing business. Those below threshold deviations from trend allow estimation of the frequency, severity, and cost of loss for a given time period (see Appendix H for illustrations of indicative crop loss estimates). The frequency and severity of losses derived in this manner were also verified against historical records to ensure consistency with actual adverse events.

THE INDICATIVE VALUE OF LOSSES

Available data on actual losses due to adverse events are not always accurate or consistent enough to facilitate the comparison and ranking of losses. The analysis was thus based on estimates of the “indicative” value of losses, which provide a more effective basis for comparison. Indicative loss values are also compared to the value of agricultural GDP in the relevant year to provide a relative measure of the magnitude of loss. These estimates draw on actual data as much as possible, but it is emphasized that they represent indicative, not actual, losses.

DATA SOURCES

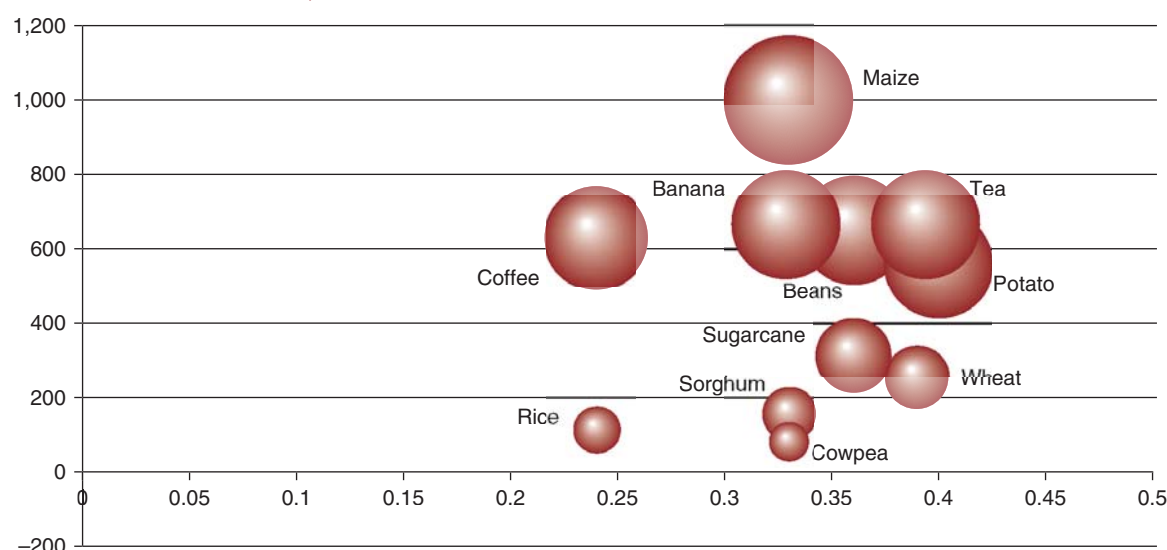
Analysis of this nature requires a consistent set of data on both production and prices for an extended time period. Of the various sources of data available, FAOSTAT's data series on the value of gross agricultural production (1980–2012) and crop production (1980–2012) were considered the most suitable. These data allow the analysis of risk over a 33-year period.

CROP PRODUCTION RISKS

Measured in terms of gross agricultural value,²⁹ crop production in Kenya was significantly reduced by adverse events 13 times during the period 1980–2012, for an overall frequency rate of 39 percent (table 4.1). All of these crop loss events on aggregate resulted in a drop in agricultural GDP of 2 percent or more. Losses ranging from 3 to 4.2 percent occurred in six years. Indicative losses were substantial for these events, as would be expected, whether measured in value of lost production or as a percentage of agricultural GDP. They amounted to nearly

²⁹ Gross aggregate value is the total value of volume of production for each crop multiplied by the producer price.

FIGURE 4.1. INDICATIVE PRODUCTION LOSSES AND FREQUENCY FOR KEY CROPS, 1980–2012



Source: FAOSTAT; authors' calculations.

Note: Cowpea calculations were made using data from 1989 to 2012 due to data availability. Losses for tea and potatoes were calculated for the periods 1998–2012 and 1980–2004, respectively, due to inconsistencies in available data.

TABLE 4.2. COST OF ADVERSE EVENTS BY CROP, 1980–2012

Crop	Frequency Rate	Total Losses (tons)	Total Losses (US\$, Millions)
Maize	0.33	–3,752,514	1012.4
Rice, paddy	0.24	–140,325	115.1
Wheat	0.39	–691,113	250.9
Sorghum	0.33	–293,452	155.3
Beans, dry	0.36	–986,993	651.1
Cowpea ^a	0.33	–129,216 ^a	83.9 ^a
Potato ⁺	0.40	–1,360,331	556.5
Tea	0.39	–233,408	663.7
Coffee, green	0.24	–132,596	630.4
Banana	0.33	–1,923,262	668.1
Sugarcane	0.36	–8,195,675	310.9
Total		–17,435,580	5,098.3

Source: FAOSTAT; authors' calculations.

^aCowpea calculations were made using data from 1989 to 2012 due to data availability. Losses for tea and potatoes were calculated for the periods 1998–2012 and 1980–2004, respectively, due to inconsistencies in available data.

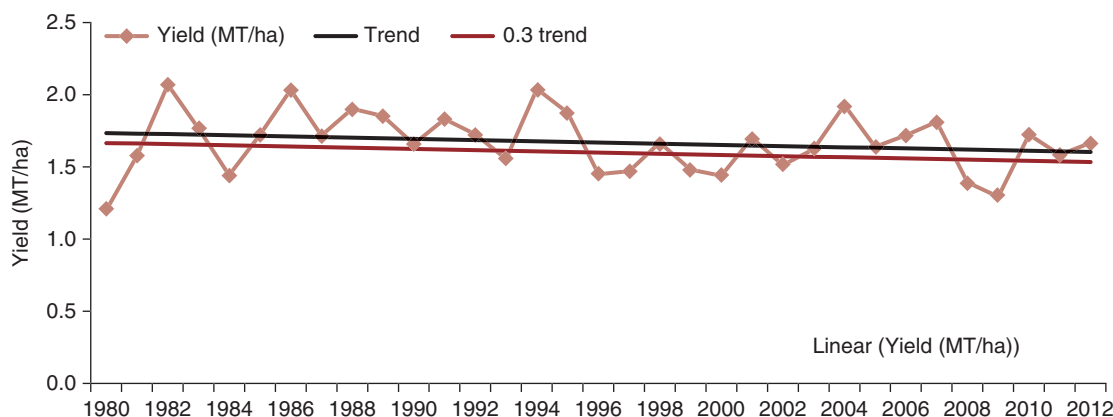
\$5.10 billion, or roughly \$154.5 million on an average annual basis, during the 33-year period.

Table 4.2 and figure 4.1 show the indicative costs of adverse events by crop for the period 1980–2012 and

their frequency. Maize accrued by far the biggest losses by value over the period, accounting for roughly one-fifth (19.8 percent) of total indicative losses. Coffee and tea also incurred substantial losses due to their high market values. Sugarcane and maize recorded the highest losses by volume, followed by banana and Irish potato. In terms of frequency, wheat production was adversely impacted on average every two to three years but in only two of these years (1993, 2009) did associated losses amount to the equivalent of a 3 percent loss to agricultural GDP. Other crops such as maize, sorghum, and cowpea were affected by adverse events on average every third year, with the exception of rice paddy, potato, and coffee, which experienced notable shocks every four years on average.

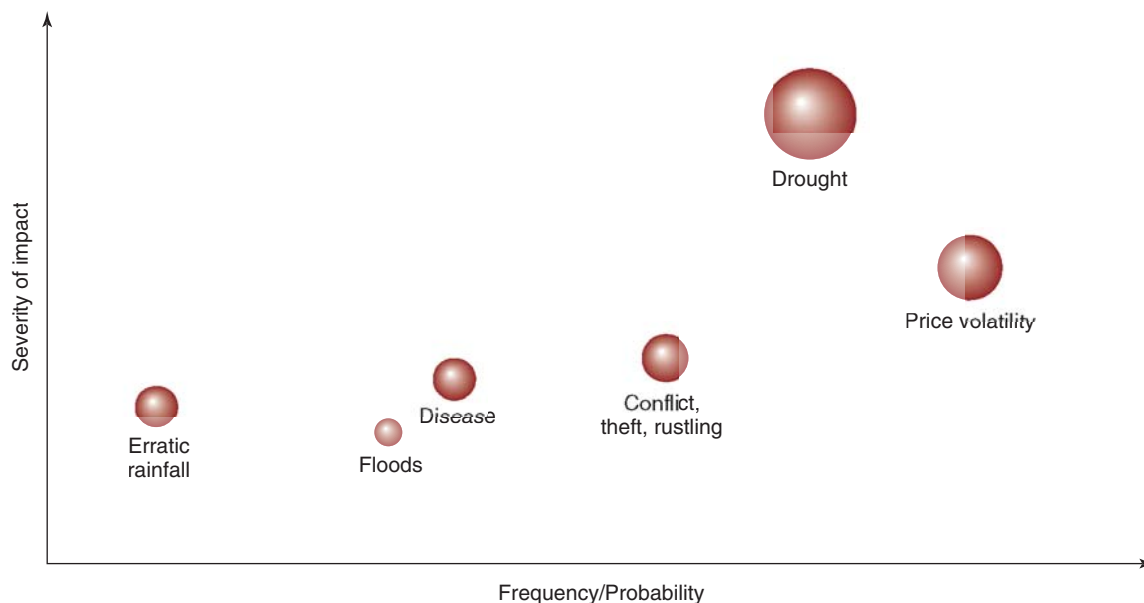
Given the importance of maize production and the diverse agroclimatic conditions in which Kenyan maize is grown, it is not surprising that maize is so vulnerable to production shocks, or that aggregate losses are substantial. However, of the 11 risk events observed, three catastrophic event years (1980, 2008, 2009) accounted for nearly half (47 percent) of the total aggregate losses for maize over the 33-year period (figure 4.2). Estimated indicative losses in 1980 (723,133 tons) and 2009 (605,926 tons) were likely caused in large part by the severe droughts that affected major maize production areas across Kenya in those years, while the postelection violence in 2008 is undoubtedly a

FIGURE 4.2. INDICATIVE CROP LOSSES FOR MAIZE, 1980–2012



Source: FAOSTAT; authors' calculations.

FIGURE 4.3. PRIORITIZATION OF RISKS TO KENYA'S LIVESTOCK SECTOR



Source: Authors' calculations.

major factor behind the 386,792-ton observed loss in that year.

LIVESTOCK RISKS

The key risks in terms of probability and impact to Kenya's livestock sector were identified as severe drought, price volatility, and cattle rustling. Animal diseases (such as FMD, Rift Valley fever, and anthrax) and floods were important but considered a lesser priority. Some of these risks are more relevant to ASAL production systems than to Kenya as a whole. Drought-induced price shocks, disease and resultant quarantine restriction movements, theft, and counterparty risk are more likely to threaten highland and mixed farming systems.

Figure 4.3 provides a risk profile based broadly on the assessment team's estimation of how frequently such various risks events have occurred over the period 1983–2011, and the severity of their impacts. Severity is measured on a hypothetical scale of 1–5 (where 5 is very high impact) and estimated based on how widespread the impact might be in terms of geographic spread or losses, bearing in mind that cattle rustling and theft might be highly localized, while price volatility may occur frequently but can have both positive and negative impacts among different stakeholder groups. The dearth of information on the impact of diseases, floods, off-season or erratic rains, and cattle rustling unfortunately limits a more precise prioritization of risks based on actual financial losses.

CHAPTER FIVE

STAKEHOLDER VULNERABILITY ASSESSMENT

Agricultural shocks are one important factor driving chronic poverty and food insecurity in Kenya. Shocks impact household well-being by limiting food availability, weakening food access, and negatively affecting monetary well-being through the depletion of productive assets. Chronically vulnerable groups with high exposure to hazards experience a disproportionately large impact from adverse events and lack coping mechanisms available to other groups. In this context, vulnerability is a useful lens through which to examine agricultural shocks because it allows policy makers to determine which groups are most affected and to target risk management solutions accordingly.

GENERAL TRENDS IN VULNERABILITY

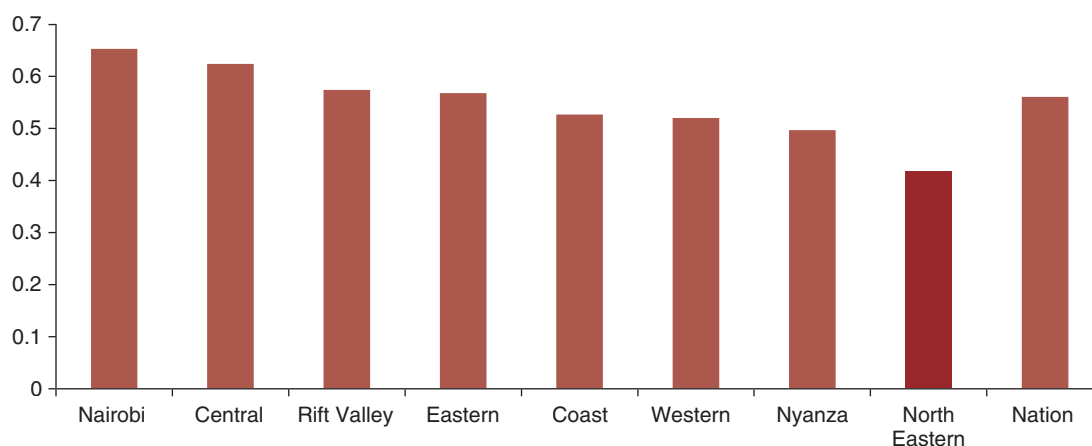
Some general considerations and trends concerning human development and vulnerability in Kenya are as follows:

- » Levels of human development, poverty, and food insecurity vary widely between regions.
- » Exposure to extreme weather events is highly correlated with being poor and being food insecure.
- » About 70 percent of Kenya's poor live in the central and western regions, in areas that have medium to high potential for agriculture (IFAD 2013).
- » Poverty and food insecurity are acute in the country's ASALs, which have been severely affected by recurrent droughts.

LIVELIHOODS AND AGROCLIMATIC CONDITIONS

Especially in rural areas, patterns of livelihood activities are strongly influenced by the prevailing agroclimatic conditions, which determine planting calendars, soil quality, and crop suitability. Approximately 80 percent of Kenya's land area lies in the

FIGURE 5.1. HUMAN DEVELOPMENT INDEX SCORES, BY PROVINCE



Source: UNDP 2009.

ASALs, home to more than 30 percent of the population and 75 percent of the country's livestock (GoK 2011). ASAL districts have the highest incidence of poverty in the country, contain 18 of Kenya's 20 poorest constituencies, and are predominantly inhabited by pastoralists and agro-pastoralists (GoK 2009c). Pastoralist districts consistently rank below the national average in terms of the Human Development Index (HDI), as well as on other indicators of well-being (figure 5.1). These communities are among the most chronically food insecure in the country and typically experience the highest rates of severe malnutrition. Several underlying factors increase pastoral communities' vulnerability, including land fragmentation, population growth, low literacy and education provision, poor infrastructure, and weak market integration. These chronic weaknesses undermine pastoralist groups' capacity to respond to shocks like drought and livestock disease outbreaks, which occur frequently in the ASALs. In turn, the increasing frequency and simultaneous occurrence of multiple shocks erode the effectiveness of traditional coping mechanisms, creating a vicious cycle of crisis and underdevelopment.

POVERTY AND VULNERABILITY

In 2005–06, approximately 17 million Kenyans, or 47 percent of the population, were too poor to buy enough food to meet the recommended daily nutritional requirements

and minimal nonfood items. Of these 17 million people, more than 85 percent live in rural areas. Spatial disparities in both the incidence and depth of poverty are pronounced: Poverty incidence at the district level ranges from 94 to 12 percent, and the poverty gap ranges from 70 to 2 percent. According to an econometric analysis of district-level poverty data, stark spatial variations in the incidence and depth of poverty arise from differences in agroclimatic conditions and income-earning opportunities, as well as unobserved factors (World Bank 2008). In other words, household location is an excellent predictor of livelihood activity, poverty status, and household consumption level (figure 5.2).

Districts with high levels of poverty and food insecurity are also characterized by a high frequency of extreme weather events. Households in the bottom expenditure quintile are the most likely to experience a weather-related shock. By virtue of their location, poorer households experience a variety of natural hazards more frequently compared to better-off and richer households, and are less able to mobilize productive resources to respond to shocks.

Figure 5.3 shows the percentage of severely food insecure households as of May 2013 in areas where the World Food Programme (WFP) operates. The graph reflects the food security status of nonbeneficiary households, as opposed to WFP-beneficiary households.

FIGURE 5.2. MAP OF KENYA'S LIVELIHOOD ZONES

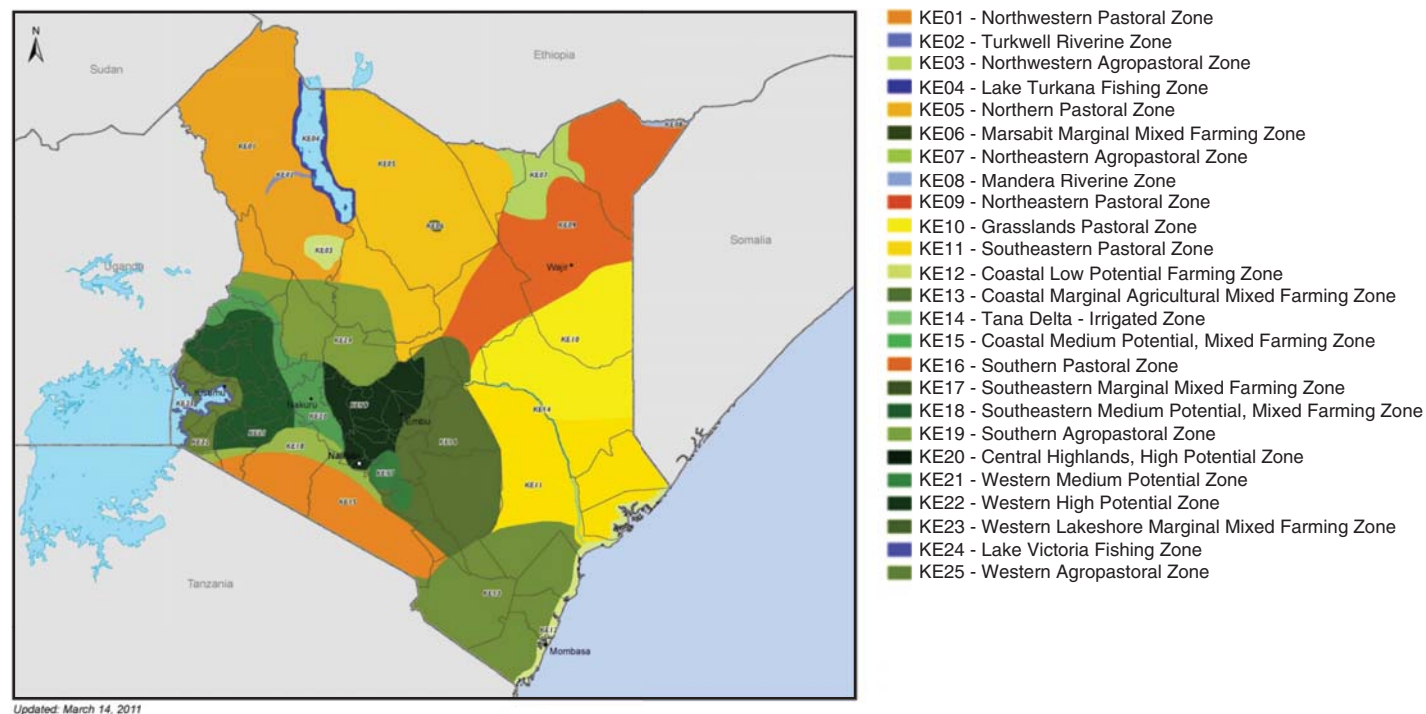
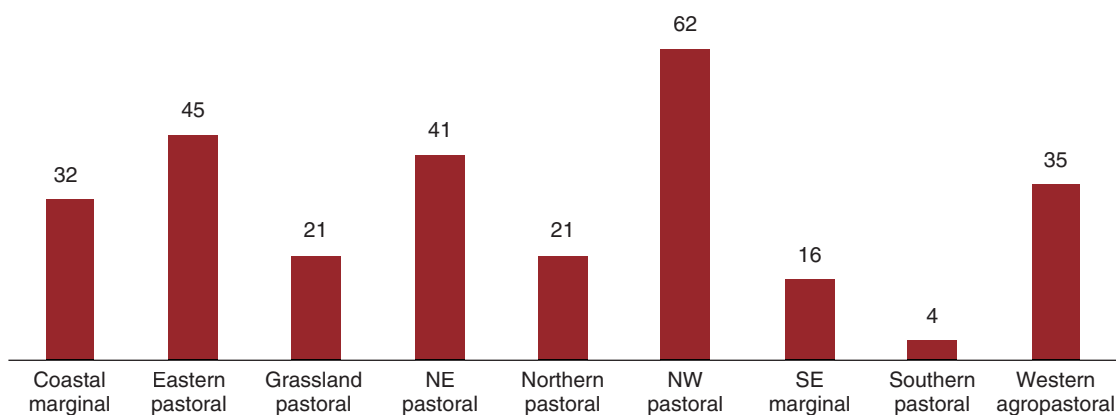


FIGURE 5.3. PERCENT OF SEVERELY FOOD INSECURE, NON-WFP BENEFICIARY HOUSEHOLDS BY LIVELIHOOD ZONE



Source: WFP 2013.

VULNERABILITY AMONG LIVELIHOOD GROUPS

Certain population groups and certain types of households are more vulnerable to agricultural shocks than others, depending on their level of exposure to risks, susceptibility, and capacity to respond and/or recover from adverse events. In many cases, patterns of vulnerability reflect underlying inequalities and social marginalization

that preclude access to resources for individuals, households, or livelihood groups. The groups identified below are especially vulnerable to agricultural shocks:

PASTORALISTS

- » Pastoralist households are more likely to be poor and more likely to be food insecure than nonpastoralist households.

- » Up to a fifth (15–20 percent) of households in the Northern Pastoral Zone engage in begging, a rate much higher than in any other livelihood zone.
- » The highest rates of global acute malnutrition are in the Northeastern and Northwestern Pastoral Zones (WFP 2013).

FEMALE-HEADED HOUSEHOLDS (FHHs)

- » FHHs are 13 percent less likely to be food secure than male-headed households (MHHs).
- » FHHs, on average, have smaller farm sizes and lower education levels compared to their male counterparts.
- » Roughly 49 percent of the total cultivated land owned by MHHs is good to medium fertile land compared to 39 percent of land owned by FHHs (Kassie et al. 2012).

UNSKILLED/CASUAL WAGE LABORERS

- » Casual wage laborers are considered particularly vulnerable to food price, production, and labor shocks since they purchase almost all of their food from the market.
- » During the 2008 food crisis, labor demand and wage rates stagnated as food prices rose by up to 50 percent (KFSSG 2008).

VULNERABILITY AND RISK MANAGEMENT

The distribution of losses among stakeholders within a supply chain is to a great extent a function of supply chain governance and stakeholders' capacities and opportunities for risk management. The way stakeholders are affected depends greatly on their level of vulnerability, as defined by their socioeconomic situation, gender, and location, among other factors. All actors along a supply chain are exposed to the variability in primary farming production. However, smallholder farmers and their families are particularly and very strongly affected by production risks. They are the weakest segment in the supply chain, and the prevalence of risks contributes to the tightening of the vicious cycle of poverty.

RISK MANAGEMENT CAPACITY

The capacity to manage risks among different stakeholders varies widely, based on myriad factors. These include prevailing production systems, household income levels, and diverse income sources. Assessing levels of vulnerability among specific groups thus requires an understanding of their level of exposure and their risk management capacity. This includes their capacity to cope with and recover from resulting losses.

About 84 percent of Kenyan farmers own less than 3 ha of land, and 45 percent own less than 1 ha (World Bank 2012). This statistic is supported by findings in panel surveys by the Tegemeo Institute, which found that 69 percent of smallholder farmers cultivate 1.5 or less (Tegemeo 2010). It is difficult to grow enough food crops on these small farms to feed a family for an entire year and/or produce enough income to meet the household's basic needs. Most families on these small farms do not achieve subsistence, but must sell their labor or find other sources of income. Many end up selling a portion of their food crops to obtain income for critical needs (sickness, school fees, debts, and other social obligations). Many maintain livestock as an additional source of revenue. If they have access to a reliable market, many grow some horticultural crops, which can be sold at prices that tend to be higher than those for cereals.

With regard to subsistence, most smallholder farmers in Kenya are net buyers of maize (Buy only + Net buyer in table 5.1). Since maize is the most important food crop, this strongly supports the contention that the majority of smallholder households do not achieve subsistence. A very high proportion of Kenyan farmers (possibly as high as 80 percent) are resource-poor, low-input, low-output crop and livestock producers. Thus a majority of smallholder farmers are net buyers of food staples and are highly dependent on the market for the purchase of food items.

VULNERABILITY IN ASALS

Pastoralist communities in arid lands long ago developed their own drought-coping and adaptation strategies, but those are no longer effective. One reason is

TABLE 5.1. HOUSEHOLD CHARACTERISTICS ACCORDING TO POSITION IN THE MAIZE MARKET, 1997, 2000, AND 2004 (nationwide sample of small-scale households in Kenya)

Characteristic	Household market position (% of households)						Total (n = 3972)
	Sell Only (n = 781)	Buy Only (n = 2052)	Net Seller (n = 467)	Net Buyer (n = 242)	Net Equal (n = 18)	Neither Buys nor Sells (n = 412)	
% of total sample	19.7	51.7	11.8	6.1	0.5	10.4	100
Land Cultivated (Ha)	3.0	1.1	1.9	1.2	1.0	1.5	1.6

Source: Kiriimi et al. 2011.

that drought intensity and frequency have increased, while political marginalization and chronic underdevelopment of pastoralist communities, characterized by lack of basic education, infrastructure, and health, have greatly reduced their capacity to adapt and their resilience to shocks.

Pastoralists' and other livestock keepers' ranking of their main risks is largely shared by administrators. A rapid informal survey by the National Drought Management Authority (NDMA) in four pastoral counties (Turkana, Kitui, Kajiado, and Laikipia) in 2013 showed that some variant of the four most important threats—drought, animal disease, market disruption, and conflict—was cited in all ASAL counties, although their priorities differed (GoK 2013b). A simple weighting procedure shows how these risks are assessed against each other (table 5.2).

TABLE 5.2. HOUSEHOLDS' PRIORITIZATION OF RISKS IN ASAL COUNTIES

Threat	Importance (weighted score)
Drought	21
Animal disease	11
Market disruption	17
Conflict	8
Predation	3
Wild fire	2
Floods	2
Policies and institutions	2

Source: NDMA; authors' calculations.

Note: Impacts weighted as follows: catastrophic, 5; critical, 4; considerable, 3; moderate, 2; negligible, 1. Maximum possible score is 40.

CHAPTER SIX

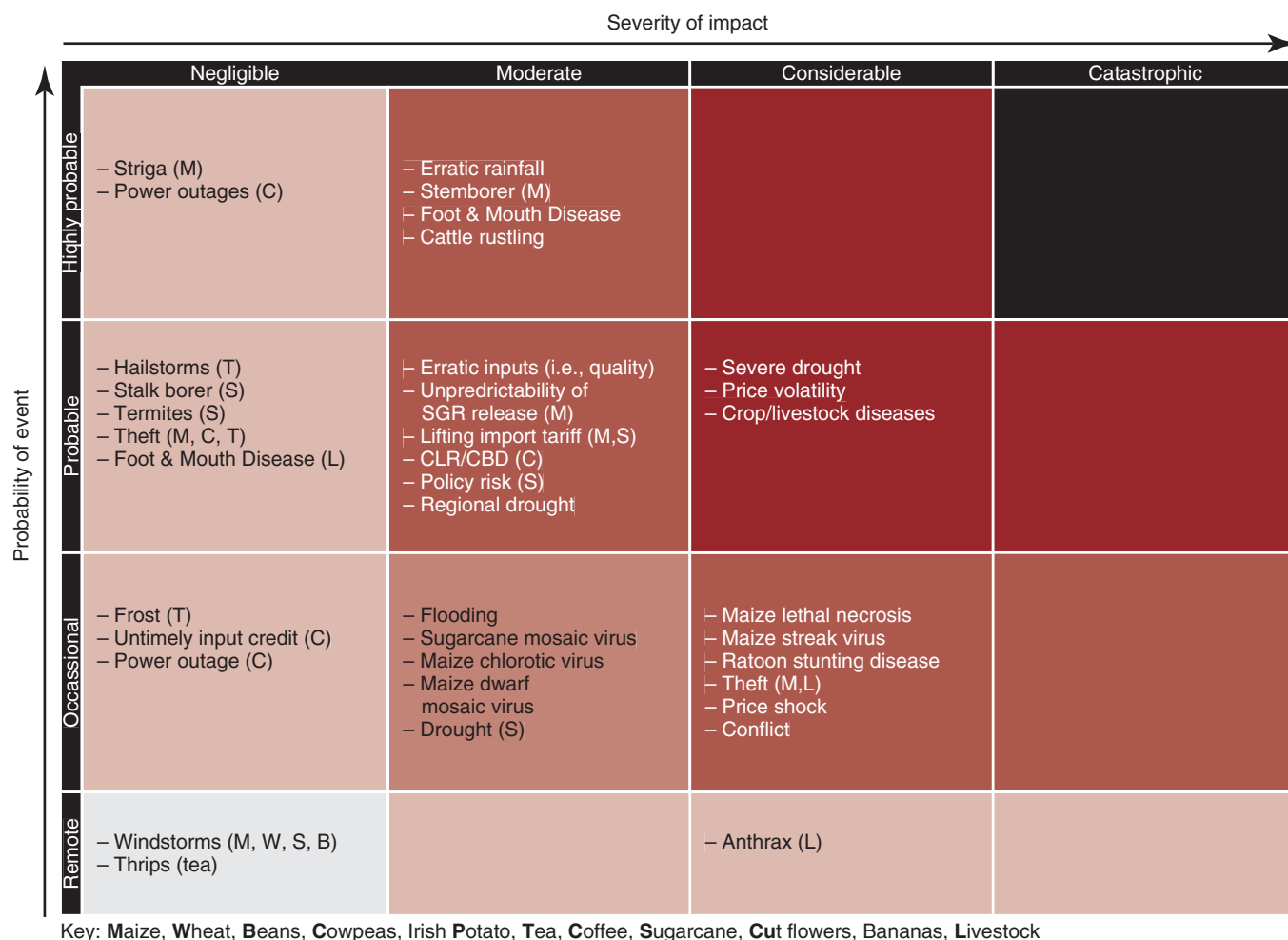
RISK PRIORITIZATION AND MANAGEMENT

RISK PRIORITIZATION

This assessment has highlighted the Kenyan agriculture sector's key inherent risks, which are both numerous and complex. They manifest with varying levels of frequency and severity and can result in substantial losses to crops and livestock, which can have profound short- and long-term impacts on income and livelihoods. Putting in place effective risk management measures can help to reduce agricultural stakeholders' vulnerability and the impacts of related shocks to production and marketing systems. In resource-constrained environments, however, it is virtually impossible to address all risks at once. Thus, a prioritization of interventions is needed to address the risks that occur most frequently and that cause the greatest financial losses.

Chapters 3 and 4 identified priority risks using quantitative measures and anecdotal evidence collected directly from crop and livestock subsectors stakeholders. Due to the paucity of data, some risks could not be quantified so the assessment team relied more on qualitative measures. Based on the team's combined quantitative and qualitative assessment, figure 6.1 prioritizes the most important risks for focus crop and livestock subsectors. These were validated at a roundtable at MoALF in Nairobi on February 7, 2014. The figure shows a summary of the agricultural risks sorted on the basis of the probability of each event and its anticipated financial losses. The grayer the area, the more significant is the risk. Overall, this prioritization identified the most important risks facing Kenya's agriculture sector to be (1) severe drought, affecting both crop and livestock production; (2) price volatility; and (3) crop and livestock diseases. Erratic rainfall, floods, cattle rustling, and conflict were also deemed important, but to a lesser extent.

FIGURE 6.1. PRIORITIZATION OF KEY AGRICULTURAL RISKS IN KENYA



Source: World Bank.

RISK MANAGEMENT MEASURES

No single measure can manage all risks. Effective risk management requires a combination of coordinated measures. Some are designed to remove underlying constraints. Others are designed to directly address a risk or a subset of risks. Available resources are often a limiting factor, but integrated risk management strategies are often more effective than one-off or stand-alone programs. Risk management measures can be classified into the following three categories:

1. **Risk mitigation (ex ante):** Actions designed to reduce the likelihood of risk or to reduce the severity of losses (e.g., water harvesting and irrigation infrastructure, crop diversification, extension).
2. **Risk transfer (ex ante):** Actions that will transfer the risk to a willing third party. These mechanisms

typically trigger compensation in the case of a risk-generated loss (e.g., purchasing insurance, reinsurance, financial hedging tools).

3. **Risk coping (ex post):** Actions that will help affected populations overcome crises and build their resilience to future shocks. Such interventions usually take the form of compensation (cash or in-kind), social protection programs, and livelihood recovery programs (e.g., government assistance to farmers, debt restructuring, contingent risk financing).

Table 6.1 highlights potential interventions that could help address the key risks identified by this assessment, classified by the three types of risk management measures described above. The list is by no means exhaustive, but it is meant to illustrate the type of interventions that, based on the analysis, have good potential to improve

TABLE 6.1. INDICATIVE RISK MANAGEMENT MEASURES

	Mitigation	Transfer	Coping
Drought (crops)	Promote diversification toward more drought-tolerant crops (e.g., cassava)	Macro-level crop insurance	Facilitate temporary migration or permanent relocation
	Establish community-level food banks	Farm-level crop insurance	Develop cash-for-work and food-for-work programs to support soil and water conservation
	Promote adoption of soil and water conservation/natural resource management techniques		Expand social safety net programs (e.g., food-for-work)
	Improve availability of existing drought-resistant seed varieties		Use weather index for triggering early warning and response
	Strengthen input delivery systems and ensure quality inputs		Use a decentralized disaster contingent fund for rapid response to local emergencies
	Improve farming techniques (e.g., conservation agriculture, intercropping)		Promote household/community savings and informal credit
	Promote water harvesting and irrigation		
	Strengthen early warning systems and response		
	Develop effective and environmentally appropriate systems of water harvesting, management, and irrigation	Sovereign agriculture risk financing	Buy fodder, crop residues; supplementary feed, emergency stores
	Link early warning system to rapid reaction and relevant response (e.g., tracking strategy and LEGS ¹ programming)	Index-based livestock insurance	Ensure emergency water supply; use fuel subsidies and repair boreholes
Drought (livestock)	Improve access to emergency grazing		Build water pans (via safety net programs)
	Invest in climate proof livestock sector infrastructure		Support exceptional livestock movements
	Promote haymaking and storage, reserve grazing/standing pastures; irrigated fodder (and food) production incorporating stakeholder and pastoralist ownership and interests		Support conditional parks grazing/wildlife/livestock coexistence
	Enforce tougher screening at international borders		Develop multiyear food and cash mechanisms based on early warning and food security data
	Develop plan for long-term subsector support and new livelihood growth program		Support livestock destocking—commercial and GoK purchases for a fixed price, with animals slaughtered and meat distributed among most needy households/communities
	Support conditional parks grazing/wildlife livestock coexistence		Reconstruct destroyed assets with improved, climate-resilient standards
			Promote herd diversification

(continued)

TABLE 6.1. INDICATIVE RISK MANAGEMENT MEASURES (*continued*)

	Mitigation	Transfer	Coping
Pests and diseases (crops and livestock)	Where relevant, adapt policy to arid lands and ensure appropriate, affordable service delivery	Warehouse receipts systems	Conduct strategic livestock vaccination in response to outbreaks
	Establish private, quality, comprehensive animal health care facilities		Strengthen quarantine measures/mechanisms
	Intensify and strength disease surveillance		Implement proven and approved veterinary response interventions (LEGS, OIE)
	Improve animal health through increased uptake of vaccination campaigns		Promote farmer group-operated storage centers
	Train (farmers and local officers) on IPM, fumigation, and pre- and postharvest management		
	Apply/enforce moisture and grain quality standards		
	Promote use of hermetically sealed storage sacks and silos		
Price volatility (crops and livestock)	Improve producers' access to market information	Commodity hedging	Improve efficiency of emergency grain reserve
	Raise the levels of strategic food reserves to stabilize maize prices	Warehouse receipt systems	Promote market subsidies and commercial destocking
	Develop and expand livestock markets		Use transport subsidies
	Improve market infrastructure		Destock livestock
	Develop policy on livestock marketing to fit global standards and local conditions (farm to fork)		
	Train and build capacity of producers and officers towards market orientation and opportunity		
	Conduct international and regional planning		
	Exploit value chain niche markets and develop cross-sector linkages		
	Link different sectors of the value chain		
	Promote good governance and implement existing laws		Restock livestock
Cattle rustling	Address conflict: reinforce customary mechanisms and create joint customary/formal mechanisms		Support social safety nets
	Support community peacekeeping programs		

Source: Authors' notes.

¹ The Livestock Emergency Guidelines and Standards (LEGS) provide a set of international guidelines and standards for the design, implementation, and assessment of livestock interventions to assist people affected by humanitarian crises. Established in 2005, the LEGS Project is overseen by a Steering Group of individuals from the EU, FAO, the International Committee of the Red Cross, the Feinstein International Center at Tufts University, the World Society for the Protection of Animals, and Vetworld UK.

agricultural risk management in Kenya. Unlike drought or livestock diseases, which have a generally negative impact on almost everyone, price risk may affect certain stakeholder groups differently. For example, the release of maize stocks by NCPB can be considered both a risk to traders with large inventories and a windfall for rural and urban households. It is also worth noting that many of these interventions, if implemented concurrently, can help address multiple risks at once, with positive spillover effects across the sector.

ILLUSTRATIVE RISK MANAGEMENT MEASURES

The following section provides a brief description of broad areas of intervention (encompassing some of the measures highlighted above) with scope to address the most important risks impacting Kenya's agriculture sector.

STRENGTHENING RESPONSE AND RESILIENCE TO DROUGHT

Drought sets off a vicious cycle of adverse socioeconomic impacts. It begins with crop-yield failure, unemployment, income disruptions, depletion of assets, worsening of living conditions, and poor nutrition. It often ends in decreased coping capacity among affected communities, and thus, increased vulnerability to subsequent shocks. Early warning and early response coupled with effective coordination and coherence in both short- and long-term efforts to safeguard livelihoods and promote future resilience are critical to effective drought risk management.

Many drought mitigation activities have been tried over the years in northern Kenya, beginning in the colonial era when government-sponsored destocking of vulnerable stock took place on a large scale through the activities of the Livestock Marketing Division (LMD). More recently, this approach was superseded by more limited, *ad hoc* responses designed to mitigate the impact of drought via the provision of ex post emergency assistance to affected communities. Such measures are often poorly coordinated at the local or national level. Until recently, few measures have been taken to improve pastoral communities' self-sufficiency or to assist development of community-managed drought mitigation activities.

In 2009, Kenya pioneered a drought management contingency planning system, managed by the newly established NDMA, which consists of (1) an early warning system; (2) a rapid reaction capability, including contingency funding for urgent mitigation activities such as destocking and emergency food aid; and (3) a recovery program to assist those most affected to get back on their feet and strengthen their resilience to future droughts. The NDMA provides a platform for long-term planning and action, as well as a mechanism for coordination across GoK agencies and with other stakeholders. For financing early mitigation efforts to reduce the time between warning of drought stress and responses at district and national levels, the GoK and its donor partners established a multidonor basket fund, the National Drought and Disaster Contingency Fund (NDDCF).

The economic case for early reaction to impending drought in the ASALs is strong. In a modeling exercise, various mitigation activities were costed against the benefits that would accrue (Venton et al. 2012). The results were encouraging. For example, the benefit-cost ratio for destocking was 390:1; that is, every U.S. dollar spent on commercial destocking generated \$390 in benefits (measured in food aid and animal losses avoided). The ratio for building resilience—via ensuring that pastoralists have access to functioning livestock markets, veterinary care, and adequate feed and water—was also positive, although to a much lesser extent (2.9:1). According to the study, a full package of livestock interventions that build resilience would result in \$5.5 of benefits for every \$1 spent. Additional benefits such as improved functioning of livestock markets and more effective animal health would likely accrue in nondrought times as well.

Scope now exists to review Kenya's recent experience in responding to drought emergencies under the NDMA regime. The objective of such a review would be to identify existing operational, institutional, and financial barriers that impede more rapid and effective response measures. It could also identify potential synergies with other programs and avenues for more effective data monitoring, information sharing, and coordination of interventions in the future and innovative ex ante approaches to building resilience. Efforts to strengthen existing drought management systems might include development and adoption of

a common approach to using triggers to better ensure that decision makers know exactly what they ought to be doing as the situation deteriorates and the consequences if they fail to act. Ideally these triggers should be developed with input from all stakeholders, be context specific to account for different livelihood zones, and avoid facilitating interventions that undermine communities' existing and future capacity to cope.

Future initiatives might also expand on existing Food-for-Assets (FFA) and Cash-for-Assets (CFA) projects, currently led by the WFP, designed to promote food security and reduce levels of vulnerability. These activities range from rainwater harvesting for human and livestock use and soil and water conservation, to rehabilitation of degraded agricultural land and production of drought-tolerant crops. Through new or rehabilitated assets and development of relevant skills, communities can improve their resilience to weather-related shocks and invest in a more sustainable future.

IMPROVING LIVESTOCK MOBILITY

Drought's effects are exacerbated by a number of features associated with the local livelihood system and national policy. Land tenure is among the most important of these. Policy on land ownership and tenure, and user rights, must take note of the likely continued need for mobility in ASAL livestock systems. The erosion, and in places destruction, of traditional grazing systems creates new risks where there were fewer before. In the Maasai areas of southern Kenya, subdivision of previously communally held land, and in many places sale of land, has had a powerful influence on the way livestock are grazed. Some Maasai have been able to preserve seasonal pastures which they use in rotation, including dry season reserves. In areas where fencing of subdivisions of former Maasai grazing land has gone quite far, a new risk has been created: because of the fences, herders are unable to move their animals away at the first sign of pasture or water shortage. Movement away from a risk is a key response in drought; pastoralists move to their own reserve pastures, to the land of kin and allies, and to government land. The places pastoralists move to in times of crisis need to be better protected and managed. Stronger recognition of the importance of mobility is a key part of any pastoral drought management and development policy.

In northern Kenya, customary systems of land use persist. These can be quite simple, with a minimum of rules to be followed, but all customary grazing systems have rules about who may graze what area of land in what season, and under what conditions. The most sophisticated of these sets of rules is probably that of the Boran pastoralists in northcentral Kenya; it includes detailed rules for pasture use in different seasons, the preservation of emergency drought pastures, and access to wells and water use, as well as rules for dealing with strangers and passers-by. The Boran have been able to preserve the key features of this system of natural resource management, but the system is under constant pressure from the rest of Kenya, where customary resource management systems of that complexity are rare and not well understood, and where land privatization is extensive. Similarly, large water and oil resources have recently been found in pastoral areas; it is vital that exploitation of these resources takes into account local needs and that stakeholder participation is included in future planning.

Finally, as cross-border movement and trade are significant and vital to Kenya's livestock sector, regional approaches and mechanisms for policy implementation must more effectively ensure that livestock owners have ready access to cross-border markets and services. The proposed Regional Pastoral Livelihoods Resilience Project (RPLRP) is a step in the right direction. In Kenya, the project is being implemented in 14 ASAL counties (Lamu, Isiolo, Laikipia, Mandera, Marsabit, West Pokot, Turkana, Tana River, Garissa, Baringo, Samburu, Narok, Samburu, and Wajir), all of which have transboundary stock routes linking pastoral communities on either side of the border with Somalia, Ethiopia, and the Sudan. Meetings of officials from both sides and technical people, together with pastoralist leaders, can help stakeholders avoid problems and conflicts.

STRENGTHENING PASTORALISTS' LIVELIHOODS

Livelihood development initiatives in the ASALs should be based on proven, evidence-based research carried out over a reasonable time frame (three to five years) to ensure sustainability and economic viability. Too often, academic or modern innovations for temperate or tropical animal production are imposed on extensive mobile

systems, and most tend to fail as they are not suitable. Governments, organizations, and farmers have all suffered losses due to failure to test new approaches in the pastoral sector context. To ensure successful policy making and wide uptake at the grassroots level, it is recommended that customary law be considered in policy mechanisms. Full stakeholder participation and ownership are encouraged in the formulation and implementation of policies and strategies.

IMPROVING ANIMAL HEALTH AND VETERINARY SERVICES

Private sector provision of affordable, quality veterinary services is economically infeasible, especially in extensive production systems in remote arid regions, due to a number of well-documented constraints. Efforts must be made, supported by reforms where necessary, to ensure nascent private sector initiatives are allowed to prosper. To succeed, any approach will have to include the decentralized Community-Based Animal Health Worker system. Efforts should be explored to support and strengthen the system with the use of vouchers or via partnerships with the private sector in emergency relief. The veterinary department must be assured of adequate resources and qualified personnel so that quality and timely services are available when needed. In remote areas, it is often difficult for a young graduate veterinarian or livestock professional to operate at the level at which he or she has been trained, as local resources and basic services are limited. This is a source of demotivation and leads to lack of field presence, access to farmers, and service provision. As needs are great and government services are likely to remain overstretched and underfunded in many remote counties, the GoK should establish an enabling environment to incorporate proven and recognized animal health service providers (e.g., SIDAI franchisees) to provide services at scale even during emergencies.

IMPROVING LIVESTOCK MARKET INFRASTRUCTURE

Markets are increasingly important for livestock enterprises. An efficient pastoral livestock marketing system needs to be developed, where stock can be finished on feedlots or ranches and dividends paid to producers to encourage a more commercial market orientation that

produces quality products for value-added market opportunities. Innovative ways to protect the TOT of livestock and staple foods and services in the pastoralist system must be investigated. Price variations regularly reach 100 percent even in normal years due to seasonality and market supply and demand. TOT can drop by 300 percent or more in shock years, which regularly occur every three to four years, and preventative measures are needed to avoid price collapse and food insecurity. Market information systems (MISs) for enhanced price transparency could be developed. Effective actions include collective cereal or commodity storage, credit systems, insurance, and early marketing. Years of underinvestment and neglect mean that much more needs to be done to establish or improve the infrastructure essential to markets, especially road, transport, and communication systems. This includes ensuring adequate resources and qualified personnel are available to the livestock marketing and animal production departments of MoALF and innovative but proven quality services are provided.

IMPROVING SECURITY IN ASALS

Laws and legal frameworks already exist for dealing with theft and cattle rustling. Due to corruption and inefficiency, however, a sense of impunity and a breakdown of law and order prevail in Kenya. Reported incidences in which members of the security services and armed forces have been involved in livestock theft and reports of political protection facilitating large-scale or “commercial” cattle raiding during past elections do little to convince livestock owners that a solution or response to theft is imminent. The solution lies in good governance and ensuring that police and security forces are adequately equipped and motivated to fulfill their duties and provide services as intended. As the majority of government services are city or town based, it is recommended that community involvement in ensuring security and peace-building is incorporated and expanded in more remote or rural areas where feasible. Kenya’s northern borders with other ASAL countries are far too long to be effectively policed by the army or the police force. They can be watched, however, by pastoralists living in border areas and legitimately occupying territory that they know better than anyone else. In the process of rehabilitating pastoral livelihoods, it would be easy to design this role, for which pastoralists could be compensated.

STRENGTHENING EXTENSION SERVICES

Reliable farmer access to extension services is an integral part of any agricultural risk management strategy. It can also produce positive spillovers. Adoption of improved practices (e.g., conservation agriculture, IPM), drought- and disease-resistant seeds, and other innovations can at once help farmers lower their risk exposure and their costs while enhancing their productivity. Figures vary on the proportion of Kenyan farmers accessing public extension services. The World Bank estimates that 50 percent of farmers now have access, but anecdotal evidence collected during this study suggests that in some districts, at least, access is much lower. The government currently allocates roughly 25 percent of its agriculture budget to extension services—a relatively high amount compared to other African countries. Yet service delivery is still recognized as inadequate. The increased reliance on private extension providers means that extension services are often skewed toward well-endowed regions, bypassing poorer farmers, and can lack sufficient state funding to ensure their effectiveness in meeting farmers' needs. Paying for services is beyond the reach of most poor farmers. Moving to “demand-driven” services requires further state investment in building farmer's organizations' capacity, because the poorest farmers are not currently organized and are poorly positioned to demand and/or pay for services.

Strong scope exists within the framework of Kenya's National Agricultural Sector Extension Policy (NASEP) to explore broader use of new information and communication technologies (ICTs) to disseminate targeted information and knowledge more cost-effectively and provide needed training to more farmers. The ICTs can amplify the efforts of extension and advisory services providers in disseminating agricultural information to remote locations and diverse populations. They can greatly facilitate the delivery of near real-time information on weather, market prices, disease and pest outbreaks, and the availability of services, allowing farmers to make more informed decisions on what to grow and how best to grow it. In doing so, they can also help build farmers' capacity to manage production and other risks.

IMPROVED WATER AND SOIL MANAGEMENT

In Kenya, where access to irrigation remains limited, farmers are at the mercy of rainfall. Perception of high

production risks drives their *ex ante* decisions and discourages them from investing in fertilizers, improved seeds, and better crop husbandry practices. Irrigation infrastructure build-out is costly and not suitable for many areas where long-term access to ground-water is uncertain. Alternatively, water harvesting and improved soil management offer a sustainable and cost-effective way to favor investments in nutrients and other yield-enhancing practices. Water harvesting alone—via water pans, roof and rock catchment systems, subsurface dams, and other means—has been reported to provide between a 1.5- to 3-fold increase in yields in Kenya, as elsewhere in Burkina Faso and Tanzania (Hatibu et al. 2006; Kayombo, Hatibu, and Mahoo 2004; Ngigi et al. 2005; Rockstrom, Barron, and Fox 2002).

The Kenya Rainwater Association (KRA) has been working to promote rainwater harvesting and complementary technologies since the mid-1990s. These and other initiatives such as MoALF's Water Harvesting for Food Security Programme (WHFSP) should be supported and expanded to assist more farmers in mitigating risks associated with erratic rainfall and drought. Low-head drip irrigation offers farmers a flexible system that is relatively easy and affordable to install, operate, and maintain. This and other systems can be scaled up in size to accommodate larger dimensions and enable farmers to gradually increase their crop production over time. Through the Kenya Horticulture Competitiveness Project, KRA with its partners has trained 2,200 growers in eastern Kenya in water-harvesting techniques and has established 60 water ponds that are proving reliable water sources for more than 4,750 farmers in the region. Likewise, better soil management through increased use of organic matter, composting, demi-lunes, zero tilling, and other conservation agriculture techniques can help to increase water retention capacity while restoring soil nutrients and soil health. These and similar initiatives should be promoted more widely via public and private extension to benefit more farmers.

STRENGTHEN SEED DISTRIBUTION SYSTEMS

Farmer adoption of improved drought- and other stress-tolerant maize varieties can go a long way toward reducing weather-induced production risks, but farmers should

also be encouraged to invest in other yield-enhancing inputs and practices. More broadly, these practices could help improve Kenya's food security situation by lowering the country's year-on-year maize production variability. Broad farmer adoption depends on access, however. Maize seed research in Kenya as elsewhere in the region is ongoing, and new drought-resistant varieties are finding their way into the market. The Drought Tolerant Maize for Africa (DTMA) Project, funded by the Bill and Melinda Gates Foundation, promotes the development and dissemination of drought-tolerant, high-yielding, locally adapted maize varieties in Kenya and a dozen other countries in Africa. During 2007–12, participants marketed or otherwise made available 60 drought-tolerant hybrids and 57 open pollinated varieties to small-holder farmers. Such efforts should be further supported and scaled up.

The International Wheat and Maize Improvement Center reports that the drought-tolerant maize germ-plasm developed for Africa in collaboration with IITA allows a yield increase of 40 percent over commercial varieties, under severe stress, and an equal yield level under optimal cropping conditions (Cenacchi and Koo 2011). In addition to drought tolerance, the new varieties and hybrids also possess desirable traits such as resistance to major diseases (e.g., maize streak virus, Turicum leaf blight, and gray leaf spot) and superior milling or cooking quality. Despite these advances, adoption rates among Kenya's maize farmers remain low due to limited availability and farmer awareness. To have an impact, seeds must be available at the right time, at the right place, and at the right price. Ways to incentivize new investments in seed duplication, marketing, and training services, coupled with initiatives to stimulate farmer demand, are needed to strengthen seed supply networks and improve farmers' access.

LIVESTOCK INDEX INSURANCE

Today, few Kenyan farmers have access to risk transfer instruments to help them mitigate their exposure to price, weather, and other risks. Kenya's rural credit and agricultural insurance markets are as yet underdeveloped. Aside from the adverse effects of weather shocks on farmers' livelihoods, farmers' high risk exposure limits their access to credit as banks and other formal lending institutions

consider them too risky. This study notes how agricultural insurance, when combined with other, more traditional risk mitigation and coping measures, can greatly reduce the immediate losses and long-term development setbacks farmers absorb from agricultural risks. Insurance can also help to lower borrowing costs, thereby enhancing farmers' access to needed credit.

The GoK is committed to expanding farmers' access to agricultural insurance. Recognizing the importance of Kenya's livestock sector, MTPII (2013–17) calls specifically for establishment of a National Livestock Insurance Scheme. This initiative will build on the experience of two innovative insurance programs already underway in Kenya. Kilimo Salama is an insurance scheme that protects farmers' investments in seeds, fertilizers, and other inputs via payouts when experts monitoring local weather conditions and rainfall determine that crops have become unviable. In northern Kenya, the ILRI-led Index Based Livestock Insurance (IBLI) uses satellite images of vegetation to determine when scarce pasture is likely to lead to animal mortality, triggering automatic payments to insured livestock keepers.

The GoK has already expressed interest in setting up a public-private partnership (PPP) platform to scale up programs for livestock insurance that will enhance the resilience and reduce the vulnerability of small-scale pastoral farmers. With support from the World Bank's Agriculture Insurance Development Program (AIDP), IRLI, and others, the State Department of Livestock (SDL) is exploring scope for the development of a macro-level livestock Normalized Difference Vegetation Index (NDVI) insurance program in the ASALs. Under the proposed scheme, targeted beneficiaries would receive fully supported insurance, purchased on their behalf by the GoK, while wealthier households would be able to purchase the product on a voluntary basis. It is envisaged that the macro livestock insurance product will aim at offering asset protection (i.e., covering the impact of pasture degradation on risk reduction expenditures such as relocation, destocking, or purchase of fodder) versus asset replacement (i.e., covering livestock mortality). Payouts would be made at the onset of severe drought, thus reducing livestock mortality and asset depletion. Appendix E provides more details on the proposed initiative.

REVIEW OF COFFEE SECTOR

Kenya's coffee sector is in decline, in large part due to aging trees, falling productivity, a weak cooperative sector, and competition from other economic activities offering higher returns. The decline is also due to inefficient regulation and a marketing structure that handicaps smallholder farmers' and cooperatives' ability to cope within the context of low returns and high risks. Under Kenya's marketing system, price risk and marketing costs are transferred back upstream to farmers in the form of consistently low farm-gate prices. The result is growing divestment in coffee production among Kenya's farmers, who have scant capacity or resources to combat plant diseases, price shocks, and other risks. A review of the coffee sector's structure could aid identification of opportunities for streamlining how coffee is bought and sold and for opening up Kenya's coffee markets to more competition and increased efficiencies. A more open marketing system holds scope to rebalance the way in which value and costs are shared across the coffee supply chain. It could also create a more enabling environment that incentivizes farmers—via higher farm-gate prices and better access to information and needed technologies—to invest in risk reduction and productivity-enhancing measures. This includes replanting old trees with new varieties resistant to CBD and CLR via improvements in extension and seed and input distribution services (see above). Any initiatives to address these challenges would undoubtedly require strong political will on the part of the Kenyan government and would greatly benefit from broad engagement with the cooperative and private sectors.

PRIORITIZATION OF RISK MANAGEMENT MEASURES

Most of the measures outlined above are complementary in nature and have strong potential to contribute to improved risk management in the short, medium, and long term. However, decision makers are compelled to find the quickest, cheapest, and most effective measures among myriad policy options. Ideally, a detailed, objective, and exhaustive cost-benefit analysis would help in selecting the most appropriate intervention options, but such an analysis is often costly and time consuming.

Decision filters can be used as an alternative approach to evaluate and prioritize among a lengthy list of potential interventions. This can aid decision makers in making rational resource allocation decisions in lieu of a detailed cost-benefit analysis. The following decision filters were developed and used by the World Bank team. The study team applied these filters to facilitate a rapid assessment to obtain a first order of approximation, based on its assessment of the situation on the ground. The team presented preliminary results and the filtering approach to MoALF officials at a roundtable in Nairobi in early February 2014. During the exchange, the team solicited feedback that it subsequently incorporated into the final results. Appendix 8 presents the results of the filtering process for proposed mitigation, transfer, and coping strategies. Whatever the filtering process and criteria adopted to evaluate decision options, it is important to ensure their clarity and consistency.

Table 6.2 describes the filtering criteria the assessment team used to rate each intervention.

TABLE 6.2. FILTERING CRITERIA FOR RISK MANAGEMENT SOLUTIONS IN KENYA

Criteria	Description
Applicability to current agricultural policy/programming or business objectives	Public sector: Is the proposed solution in line with current/existing agricultural policy/programs/priorities, and so on? Private sector: Is the proposed solution in line with current/existing business objectives, and so on?
Feasibility of implementation	Is the proposed solution “easy” to implement in the short to medium term?
Affordability of implementation	Is the proposed solution affordable to put into action/implement?
Scalability of implementation	Is the proposed solution easy to scale up/make available to an increased number of beneficiaries?
Long-term sustainability	Is the proposed solution sustainable in the long term?

Source: World Bank.

Note: The team answered the question posed in each criteria's description using a scale of 1–5 (1, No; 2, Marginally; 3, Somewhat; 4, Yes; 5, Absolutely).

Management of agricultural risks is nothing new to Kenya, and the GoK has a long track record of investment in risk mitigation, transfer, and coping mechanisms. Moving forward, Kenya's *Vision 2030* recognizes the need to strengthen existing risk management systems, and the GoK has launched a range of new initiatives to confront the most severe threats facing the country. In 2011, it established the Drought Risk Management Authority to better coordinate preparedness and speed up response measures. It also launched the Disaster Risk Reduction Program, the National Climate Change Action Plan, and the Hunger Safety Net Program.³⁰ These and other initiatives by the GoK and its development partners are already helping to safeguard livelihoods, promote adaptation, and strengthen resilience against impacts from natural disasters and a changing climate. And yet as highlighted by this report, agricultural supply chains in Kenya remain highly vulnerable to myriad risks that disrupt the country's economic growth, cripple poverty reduction efforts, and undermine food security. The current study highlights the need for a more targeted and systematic approach to agricultural risk management in Kenya.

Based on an analysis of key agricultural risks, an evaluation of levels of vulnerability among various stakeholders, and the filtering of potential risk management measures, this assessment makes the following recommendations for the GoK's consideration. The proposed focus areas of intervention encompass a broad range of interrelated, mutually supportive investments, that together—aligned with *Livelihoods Enhancement* goals within Kenya's *Vision 2030*—hold strong scope to strengthen the resilience of vulnerable farming and pastoralist communities and the agricultural systems on which their livelihoods and the country's food security depend:

- » To better **optimize rainfall** and **soil moisture** in marginalized production areas, promoting **community-driven investments** in **improved soil** and **water management** measures such as terracing, water harvesting pans, roof and rock catchment systems, subsurface dams, and micro-irrigation systems

- » To **curb soil erosion**, **increase soil fertility** and **water retention**, and **enhance the productivity**³¹ and **biodiversity** of smallholder systems across Kenya, promoting **broadier awareness and adoption** (via farmer field schools and other participatory extension approaches) of **conservation agriculture** practices such as zero tillage, mulching, composting and use of organic fertilizers, crop diversification and rotation, intercropping, and IPM
- » To **strengthen certified seed** production and distribution **systems**, build their credibility, and stimulate demand for improved seeds and fertilizers by smallholders, investing in capacity building and training to **strengthen monitoring and enforcement** of quality standards and **reduce incidences** of **counterfeiting**, adulteration, and other abuses that dampen farmer demand and productivity
- » To **reverse degradation** of **water, soil, and vegetation cover**, **safeguard** the long-term **viability** of Kenya's arid and semiarid **rangeland ecosystems**, and **ensure access** to **sufficient** grazing land, promoting (1) use of contour erosion and fire barriers, cisterns for storing rainfall and runoff water, controlled/rotational grazing, grazing banks, homestead enclosures, residue/forage conservation, and other **sustainable land management** practices; and (2) innovative **rangeland comanagement** (state and local community) approaches that leverage customary forms of collective action and economic instruments to reward sound pasture management
- » To **strengthen drought resilience** among vulnerable **pastoral communities** in target ASAL counties and better safeguard the viability of animal herds during shortages, supporting the **development of feed/fodder production** and **storage systems, animal health, market and weather information**, and other critical services

³⁰ The Hunger Safety Net Program is one of five cash transfer programs under the National Safety Nets Programme (NSNP). HSNP is implemented by NDMA and targets the poorest and most vulnerable households in four ASAL counties (i.e., Turkana, Mandera, Wajir, and Marsabit).

³¹ Conservation agriculture allows yields comparable with modern intensive agriculture but in a sustainable way and with lower production costs (time, labor, inputs). Yields tend to increase over the years with yield variations decreasing.

- » To mitigate growing pressures on rangelands in the ASALs and increasing vulnerability of smaller livestock (<50 animals) owners in particular, putting in place supportive policies and **livelihood development programs** (targeted credit schemes, skills training, public sector investments in labor intensive infrastructure projects, cash for work) to facilitate their engagement **in alternative livelihood and income-generating activities**
- » To **strengthen fiscal management** and **reduce** the GoK's **budget volatility** (and diversion of development resources caused by ex post crisis response), better **safeguard rural livelihoods**, and **increase resilience**, deepening investments in agricultural insurance mechanisms and markets (in partnership with the private sector), with an initial focus on **asset protection** (via early warning triggers and expedited payouts) among **vulnerable pastoralist communities** and area yield index insurance for smallholder maize farmers
- » To facilitate **improved, evidence-based decision making** among farmers, pastoralists, and policy makers and to mitigate price volatility, investing in integrated **data and information systems build-out** for more **robust, cost-effective**, and **reliable collection, management**, and **dissemination** (via surveying, GIS, ICT, SMS) of crop production, agro-weather, market price (input/output) information, and agricultural research and advice
- » To further objectives of the devolution process, promoting institutional and organizational **capacity building** and **technical training** at county and national levels to promote **standardized collection and management of agricultural data** (in line with recently developed national guidelines)

CONCLUSION

This Phase I assessment analyzes agricultural risks and impacts incurred in Kenya over the period 1980–2012. By documenting and analyzing how Kenya's agriculture sector has been affected in the past by risk events, the study generates insight into which sources of risk are most likely to impact agricultural production systems and livelihoods in the future. It prioritizes the most important agricultural risks for the country based on objective criteria. It offers a framework for development of a more comprehensive, integrated risk management strategy to strengthen existing risk mitigation, transfer, and coping measures in Kenya. Finally, it provides a filtering mechanism to select an appropriate set of best possible interventions for agricultural risk management.

Many of the proposed intervention areas are covered to varying degrees under the GoK's *Vision 2030* and ASDS development frameworks. Some may currently be in the process of implementation by either government agencies or their development partners. Moving forward, stronger emphasis should be placed on scaling up these interventions to reach a larger number of beneficiaries. A greater emphasis should also be placed on ensuring a more coordinated, integrated approach to risk management in Kenya to ensure more effective and meaningful risk reduction and resilience building across the sector.

It is hoped that this assessment's findings and conclusions will contribute to the existing knowledge base regarding Kenya's agricultural risk landscape. To be certain, Kenya's agriculture sector faces myriad risks. By prioritizing them, the study can help the GoK focus attention and resources on a smaller set of key risks that have the most adverse impacts on production yields, incomes, and livelihoods. It is also hoped that the study will inform a dialogue between the GoK, the World Bank, and the GoK's other development partners that will lead to concrete interventions toward improved agricultural risk management and livelihood resilience in Kenya.

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APPENDIX A

CLIMATE CHANGE IMPACTS ON AGRICULTURE IN KENYA

INTRODUCTION

Like those of many of the countries in Sub-Saharan Africa, Kenya's agriculture sector is highly vulnerable to the effects of climate change. The country's climate is already characterized by high temperatures and low but highly variable annual precipitation, factors that negatively affect the productivity of heat-sensitive crops. Climate change is a long-term trend that will exacerbate natural resource constraints on agricultural production in Kenya by making weather patterns more variable and by increasing the frequency and intensity of severe weather events. As a result, climate change will directly affect the incidence of some agricultural risk events and indirectly affect the incidence of others. Understanding how climate change trends affect farm productivity is essential to formulating an agricultural risk management plan that maximizes the use of scarce resources. Regardless of the future extent of global warming, identifying and implementing risk management strategies that address agricultural risks, including those exacerbated by climate change, can reduce volatility and improve sustainability in the sector.

Due to the importance of the agriculture sector in Kenya's national economy, climate change impacts on crop yields and land suitability will have far-reaching effects. Agriculture accounts for 24 percent of national GDP and 65 percent of all export earnings (GoK 2012a). Agriculture also plays a key role in poverty reduction and food security through its contribution to livelihood security. The sector employs more than 75 percent of the workforce and generates most of the country's food requirements. Within the sector, smallholder farms account for 85 percent of employment and 75 percent of total agricultural output (GoK 2012a). In the *Mapping the Impacts of Climate Change* index under "Agricultural Productivity Loss," the Center for Global Development ranks Kenya 13 out of 233 countries globally for "direct risks" due to "extreme weather" and 71 out of 233 countries for "overall vulnerability" to climate change when adjusted for coping ability.

Climate change impacts agriculture through temperature increases, changes in precipitation, and increases in the frequency and severity of extreme weather events. There are direct impacts, such as changes in land suitability for crops due to temperature changes, and indirect impacts, such as changes in food prices that ultimately affect food demand and well-being. Models predicting the effects of climate change on agriculture vary across regions and crop/livestock sectors, and depend heavily on the underlying assumptions. The projected effects of changes in precipitation are particularly difficult to reconcile, given the vast regional variation in annual rainfall and limited district-level data. Rising temperatures are also expected to increase evapotranspiration, offsetting productivity gains. Although a large degree of uncertainty exists about the magnitude of the impacts, this brief synthesizes existing crop forecasts, highlights areas of consensus between different studies, and identifies areas of disagreement.

PRINCIPAL FINDINGS

Several structural vulnerabilities in the sector are likely to exacerbate the impact of rising temperatures and changes in precipitation on crop and livestock production, including dependence on rainfed agriculture; overcultivation and land degradation; lack of technologies to improve production; and high levels of poverty among smallholder farmers.

The studies cited in this report conclude that temperature increases will have a significant impact on water availability and soil quality, and thus will likely exacerbate drought conditions. Precipitation is projected to increase between 0.2 and 0.4 percent per year in Kenya, but the direction and magnitude of change vary considerably across regions, and warming-induced increases in evaporation rates are likely to offset the benefits of precipitation increases in some regions. In addition, an increase in the *intensity* of high rainfall events is expected in Kenya and is already underway: the number of extremely wet seasons is increasing to roughly 1 in 5, compared to 1 in 20 in the late twentieth century (Christensen et al. 2007; Herrero/IFPRI 2010). In the arid and semiarid lands (ASALs) of Kenya, fragile soils are particularly vulnerable to flash-flooding and erosion during high rainfall events.

Temperature and precipitation changes suggest that the length of the growing period (LGP), a key deter-

minant of land suitability for production, will decrease in many places. Some regions (the mixed rainfed temperate and tropical highlands) are projected to experience an increase in crop yield. Other regions, especially the ASALs, are projected to experience a significant decline in crop yields and livestock productivity as water resources become increasingly scarce. These patterns are largely driven by regional variability in future precipitation and geographic exposure to extreme events, particularly drought frequency.

Key uncertainties surrounding the impact of climate change on agriculture include

- » Extent of crop yield increases due to CO₂ fertilization
- » Effect of ozone damage on crop yields (Ainsworth and McGrath 2010; Iglesias et al. 2009)
- » Extent of crop damage caused by the evolution of pests and diseases

CLIMATE CHANGE AND SEVERE WEATHER EVENTS

The frequency of severe weather events has already increased, and the intensity of weather events like drought, extreme heat, and floods is likely to increase as temperatures rise (IPCC 2011). In Kenya, recurrent drought in particular has profound effects on the agriculture sector. Intense droughts occurred in 1991–92, 1995–96, 1998–2000, 2004–05, and 2008–11, resulting in severe crop losses, livestock deaths, spikes in food insecurity, and population displacement. For instance, the government of Kenya (GoK) imported 2.6 million bags of maize worth K Sh 6.7 billion between 2008 and 2009. In the future, any increase in the frequency and/or severity of drought conditions will have profound far-reaching effects on national food security and the viability of livelihood activities, especially for people living in the ASALs.

METHODOLOGIES

Data analyses from the literature reviewed in this brief draw from downscaled general circulation models (GCMs). The studies use multiple GCMs, simulate between one and four greenhouse gas emissions scenarios, and incorporate crop prediction models. As a result,

conclusions vary depending on the underlying model assumptions:

- » Based on these models, the IFPRI study uses the Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling software projections for crop yields, comparing yield projections for 2050 against real 2000 yields.
- » Thornton et al. (2006) combine projected climate change scenarios with vulnerability data to identify high-risk regions and population groups. The analysis uses LGP as a proxy for agricultural impacts. Predictions on changes in LGP vary considerably across Kenya depending on the underlying assumptions. Across a range of future climate scenarios, however, many parts of Kenya are predicted to experience a decrease in LGP, and some a severe decrease. This suggests a need to focus on the development and dissemination of short-season cultivars, as well as water management strategies.
- » Thornton et al. (2009) examines the spatial variation of climate change impacts on crop yields, using GCMs, crop models CERES-Maize and BEANGRO, and soil and crop management data.
- » A study undertaken by the Adaptation to Climate Change and Insurance (ACCI) Programme evaluates the current and future suitability of the Lake Victoria region (Busia and Homa Bay counties) for major agricultural crops using a range of GCMs, soil data, and crop models.
- » The Information Center for Tropical Agriculture (CIAT) analyzes future climatic suitability for tea-growing areas in Kenya. The study combines current climate data with future climate change predictions from 19 GCMs for 2030 and 2050 (emissions scenario SRES-A2). These data are then used in MAXENT, a crop prediction model.

CROP PREDICTIONS

Maize: Maize is the principal food crop in Kenya. Grown in every region, maize accounts for 37.5 percent of the total harvested area, and contributes 17.9 percent to the total value of production of agricultural

commodities. Crop yield projections for maize vary widely, depending on the region and the specified climate scenario. Although the magnitude of the change in yields varies under each scenario, most models predict declining yields in large parts of the ASALs and in the lowlands, and yield increases in the temperate central and western highlands.

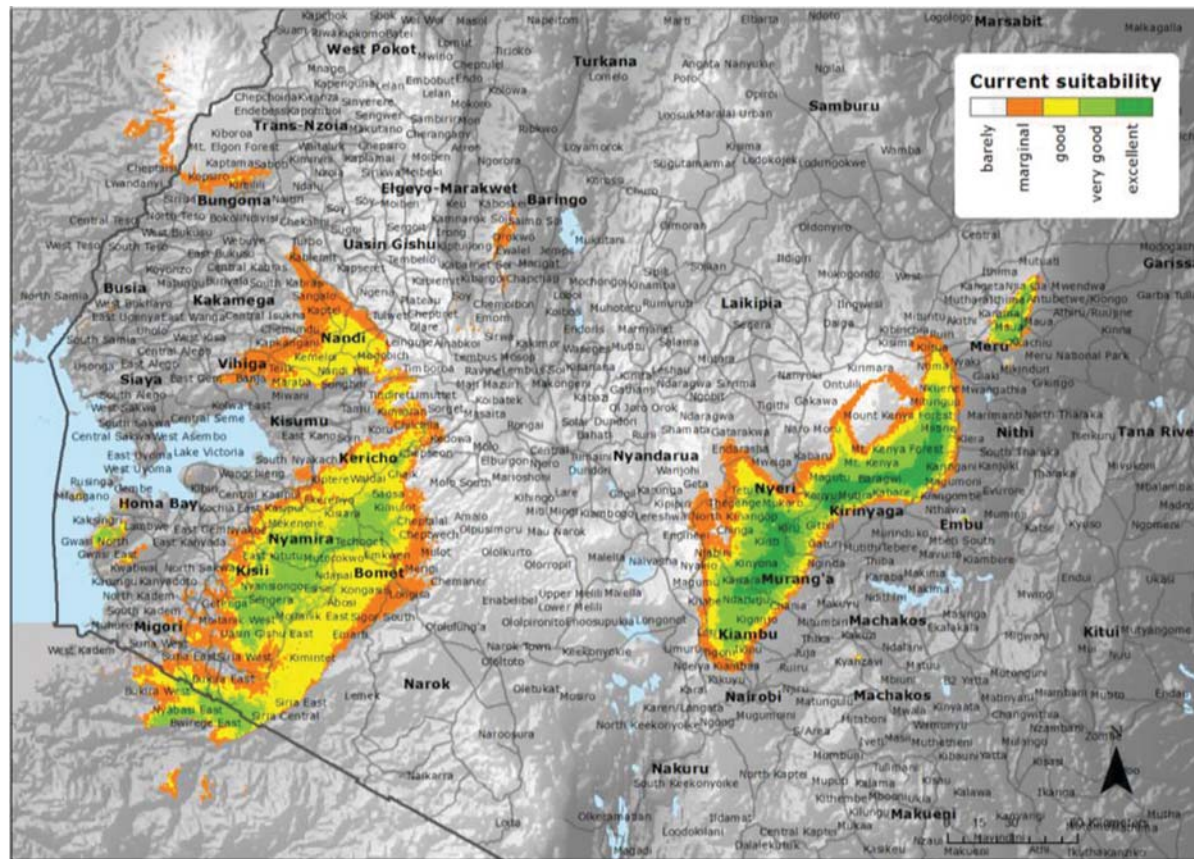
According to the IFPRI analysis, four out of six climate scenarios predict an overall decrease in rainfed maize yields. Kenyan maize yields drop by 51–55 percent under the NCAR 369, CSIRO 369, and CSIRO 532 A2 scenarios, compared to 2050 yields with historic climate levels. In contrast, yields increase by 25 percent under the Hadley 369 A2a scenario.

Thornton et al. (2009) predict a maize production decline of 8.4 percent and 9.8 percent in the semiarid areas and humid/subhumid areas, respectively. The same study predicts a 46.5 percent increase in maize production in the mixed rainfed systems in the temperate areas. Under this scenario, however, total production would still decline given the relatively small contribution of the temperate areas to total production.

Beans: Beans are an important food security crop in Kenya, accounting for 17.9 percent of the total harvested area. Beans are grown in every region in the country, with about 75 percent of total production concentrated in three regions: Rift Valley, Nyanza, and Eastern Province (Katungi et al. 2009). Like maize, crop yield projections for beans vary depending on the region and the specified climate scenario. Although the magnitude of the change in yields varies under each scenario, most models project yield declines.

Thornton et al. (2011) use an ensemble mean of three emissions scenarios and 14 GCMs to run crop simulations for conditions in a 4°C warmer world by 2090. For East Africa, a mean yield loss of 47 percent is projected for beans. However, the disaggregated analysis predicts substantial yield increases for beans at higher elevations in Kenya's western highlands, up to average temperatures of about 20–22°C, after which yields decline (DFID 2012).

FIGURE A.1. CURRENT SUITABILITY OF TEA PRODUCTION AREAS



Lobell et al. (2008) use 20 GCMs to run crop simulations in East Africa. At least 75 percent of the projections are associated with *Phaseolus* bean yield losses.

Tea: Tea is the most important agricultural export crop in Kenya, accounting for 33 percent of total agricultural exports and 3.5 percent of GDP³². Although few rigorous estimates of future changes in yield exist for the tea sector, several authors have analyzed the impact of climate change on future land suitability for tea production. Most studies find declines in suitability for land currently under tea production and increases in suitability for new areas at higher altitudes. As a result of higher temperatures, all of the models predict major shifts in the geographic distribution of tea production.

According to maps provided by UNEP-GRID, a 2°C increase in temperature would render much of the current tea-growing area in Kenya unsuitable for produc-

tion. Recent declines in tea production have already been directly linked to erratic rainfall patterns and drought (Herrero et al. 2010).

According to a suitability analysis conducted by the CIAT, some areas will become unsuitable for tea (Nandi, Kericho, and Gucha), while some will remain suitable for tea (Bomet, Kisii, Nyamira) *if* farmers adapt agricultural management practices to new climate conditions. Suitability for tea increases in some current growing areas (Meru, Embu, Kirinyaga, Nyeri, Murang'a, Kiambu), and new areas will become suitable for tea (especially higher altitudes around Mount Kenya). However, many of the potential new areas for tea are located in protected areas and forested lands (figures A.1 to A.3).

Preliminary results from an FAO study indicate that climate change is expected to increase suitability of tea-growing areas by 8 percent by 2025, and then negatively impact suitability as mean air temperatures rise above the 23.5°C threshold, dropping by 22.5 percent by 2075 (FAO 2013).

³² Data available at <http://faostat.org>.

FIGURE A.2. FUTURE SUITABILITY OF TEA PRODUCTION AREAS

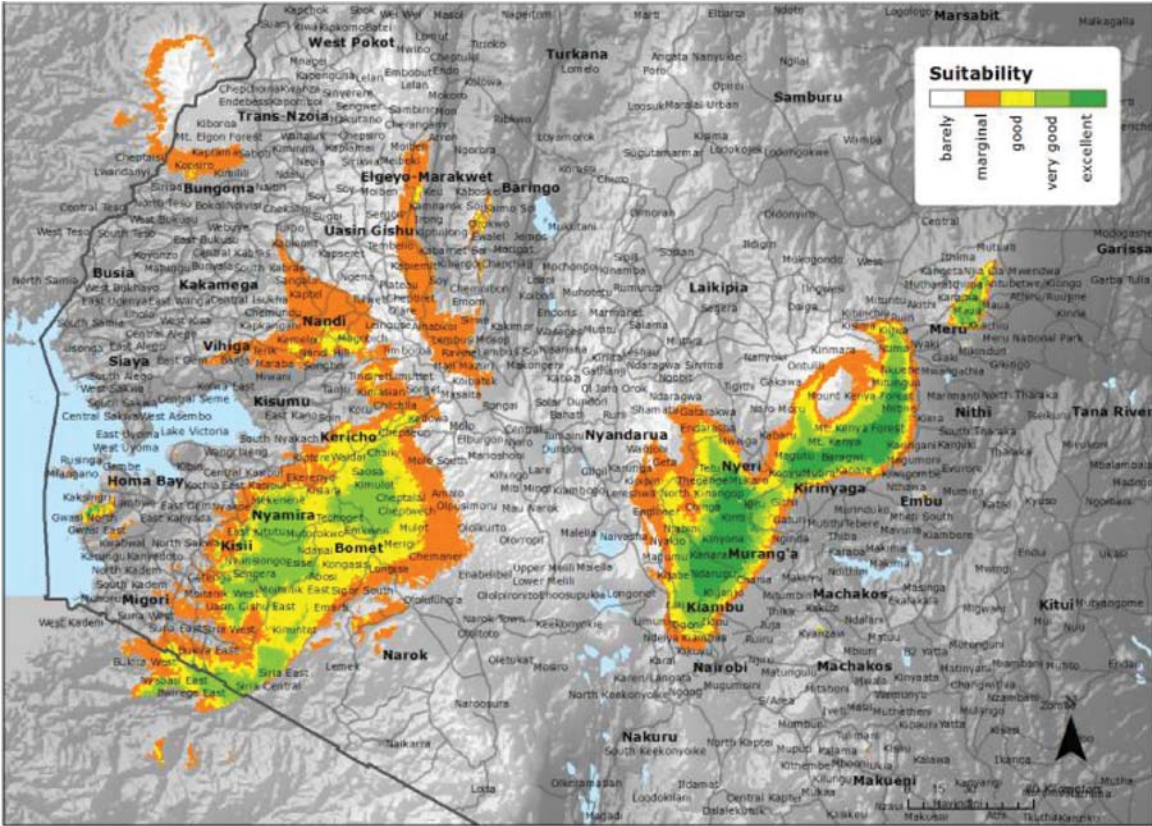
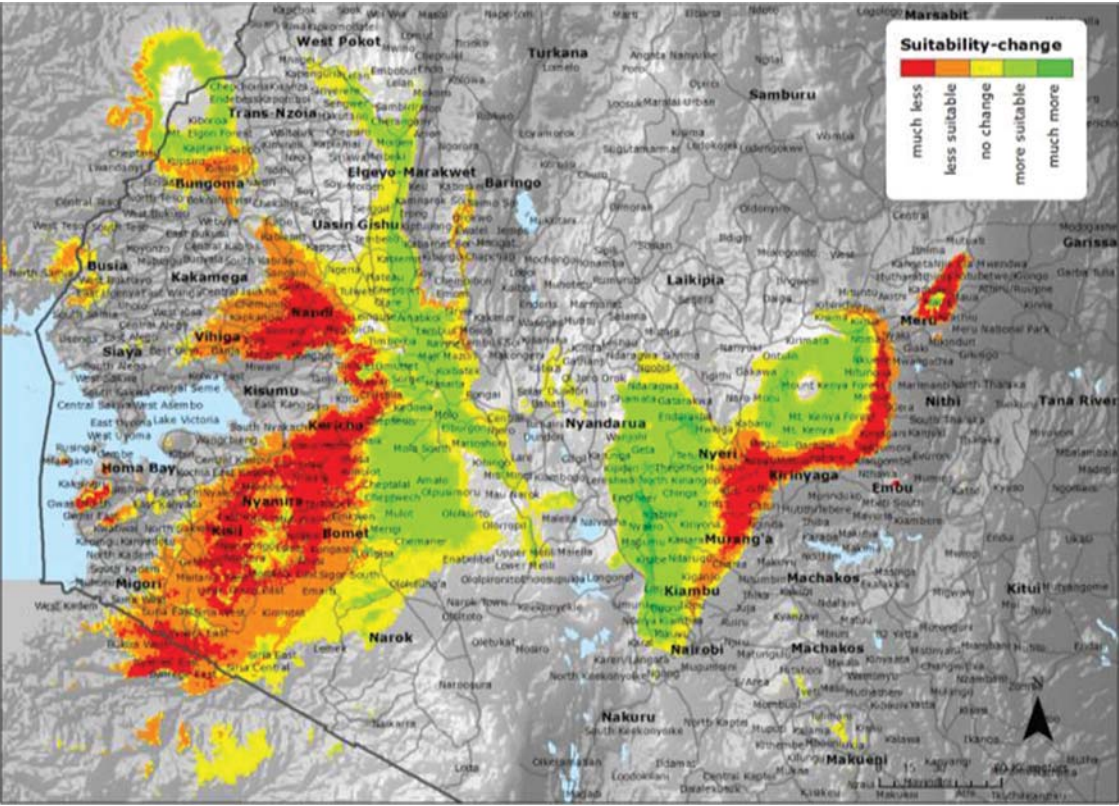


FIGURE A.3. SUITABILITY CHANGE FOR TEA PRODUCTION IN 2050



Source: CIAT 2011.

CROPS RESISTANT TO CLIMATE CHANGE

A regional study undertaken by the ACCI Programme (Luedeling 2011) analyzes the future suitability of the Lake Victoria region for major agricultural crops. It should be noted that the results of the study are limited to Busia and Homa Bay counties. Using a range of GCMs, soil data, and crop prediction models, the study found that sorghum, groundnuts, and fava beans were moderately resistant to the effects of climate change. The ACCI study also identified cassava, sweet potato, mango, banana, and pineapple as crops with the potential to thrive under warmer temperatures.

CONCLUSIONS

As discussed previously, the projected impacts of climate change on agriculture vary considerably depending on the climatic model specified, and national-level estimates

hide vast regional differences in crop performance under climate change. Many of the existing studies on crop yield and land suitability under future climate scenarios lack detailed, regional impact assessments. Regional and district-level crop analyses could provide a better understanding of the aggregate impact of climate change on agricultural systems and food security in Kenya.

The studies all agree that rising temperatures are likely to exacerbate drought conditions in some regions, especially the ASALs, due to highly variable rainfall patterns, changes in seasonal water availability, and poor soil quality. Even with increases in annual precipitation, extreme heat and drought conditions will negatively affect yields in parts of the current production area for crops like maize and tea. Thus, as climate variability and uncertainty increase, there is an urgent need to identify and implement risk management solutions to mitigate agricultural losses and increase stakeholders' coping capacity.

APPENDIX B

STAKEHOLDER RISK PROFILES

CASE STUDY 1: PHILIP MUTUA MBAI— SMALLHOLDER MAIZE FARMER, MACHAKOS COUNTY

INTRODUCTION

Philip Mbai is a 68-year-old small-scale farmer in Machakos County. He bought his 23-acre farm in 1978 while still working as an administrative clerk with Gailey and Roberts, Ltd, an engineering firm, and settled down to full-time farming in 2000. He practices mixed farming and grows maize and beans on 8 and 4 acres, respectively, and commits another 2 acres each to green grams and cowpea and approximately another 2 acres to fruits (mangoes, bananas, and oranges) and vegetables (kales, onions, tomatoes, and cabbages). The remainder of his farm is used for growing pasture to feed his four exotic cattle (Guernsey) and another six indigenous cattle. A small portion is also dedicated to bee farming, with an apiary of about 50 beehives featuring traditional log hives, Kenya top bar hives, and modern Langstroth bee hives.

OVERVIEW OF KEY FARM ACTIVITIES

Except for the production of vegetables, Mr. Mbai's crop production is purely rainfed, with low attainable yields of below 0.5 ton/acre (about 10 90-kg bags per acre) largely attributed to low and unreliable rainfall. Located about 1,600 meters above sea level, his farm receives less than 800 mm of rainfall annually on average, although in the last 10 years, average annual rainfall has been below 600 mm and is falling. The farm serves as a meteorological monitoring site for rainfall data and has a fitted rain gauge that Mr. Mbai monitors on a daily basis. In a good year, Mr. Mbai makes about K Sh 500/bag, which translates to K Sh 40,000 a year. On average, Mr. Mbai derives 30 percent of his income from maize farming and the rest from the other farm activities.

IMPACT OF RISK EVENTS

Mr. Mbai encounters the following major agricultural risks, in decreasing order of importance: drought, pests and diseases, postharvest losses, and volatile market prices that are exacerbated by lack of markets. “Overall, dependence on rainfed agriculture is the most important risk in this area” (Philip Mbai). The drought problem in Machakos has been worsened by changes in the onset and cessation of rains. Ten years ago the onset of rains was predictable, today rains typically begin late and cease early, which has shortened the length of the growing season. The frequency and severity of droughts in the recent past has also increased. “While 30 years ago we experienced a drought once every 5 years, today we experience

a drought once every two years. For instance in the last 10 years we had droughts in 2001, 2003, 2005, 2008, 2011 and now in 2014” (Philip Mbai). The severity of these droughts has also increased, with yield losses estimated to have increased from about 20–50 percent to 100 percent in the recent past.

RISK PRIORITIZATION

In decreasing order of importance, the key risks encountered in Machakos include

- » Drought
- » Pests and diseases
- » Postharvest losses
- » Price volatility

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Crop	Frequency	Impact
1.	Drought	Maize	Once every two years	Yield losses of 30–50%
2.	Pests and diseases	Maize	Occasionally	Yield losses of up to 10%
3.	Postharvest losses	Maize	Each season	Yield losses of up to 30%
4.	Price volatility	Maize	Occasionally	Income losses of up to 20%

RISK MITIGATION STRATEGIES

To mitigate against drought, Mr. Mbai undertakes a number of agronomic practices. These include growing drought-resistant maize varieties, planting early, and using soil and water conservation practices (terracing, road water harvest-

ing, planting Napier grass along terraces, enterprise diversification, and supplementary irrigation when possible). Even though relief food supplies are the most widely used drought-coping strategy in the area, Mr. Mbai does not rely on relief food, but instead sells livestock in times of severe drought.

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Drought	Early planting Drought-tolerant varieties Soil and water conservation Enterprise diversification Supplementary irrigation	None	Sale of livestock	Not effective
Pests and diseases	Use of chemicals	None	Use of indigenous knowledge in disease and pest control	Somewhat effective
Postharvest losses	Adoption of improved storage technologies	None	Use of indigenous knowledge	Somewhat effective
Price volatility	Storage	None	Sourcing alternative markets	Somewhat effective

CASE STUDY 2: MRS. MARABA—AGRO-INPUT DEALER, ELDORET UASIN GISHU COUNTY

INTRODUCTION

Mrs. Maraba operates an agro-input shop in Eldoret Town of Uasin Gishu County that is located in Kenya's main maize-growing zone. The agro-input shop doubles both as a wholesale and a retail outlet selling to other agro-input dealers and farmers. She has been in this business for the last 15 years and stocks farm inputs such as seeds, fertilizers, chemicals, livestock feed, and veterinary vaccines. Her major customers are small-scale farmers who are unable to access subsidized fertilizers from the state-run National Cereals and Produce Board (NCPB) that in the last three years has been stocking subsidized fertilizers. Mrs. Maraba sources her inputs from seed companies such as Kenya Seed Co. Ltd, FreshCo Kenya Ltd, East Africa Seed Co. Ltd, and Western Seed Company Ltd. Unlike those of other seed companies, prices for seeds from Kenya Seed Company, which accounts for more than 80 percent of the market share, are regulated, with the company controlling prices at both the wholesale and retail levels. Fertilizer supplies are sourced from the seven major fertilizer importers in Kenya: Yala, MEA East Africa Ltd, Export Trading Company, Africa Ventures, Devji Megji Brothers, Sharkaji (SKL), and Eldoret Packers.

OVERVIEW OF KEY ACTIVITIES

Mrs. Maraba employs about five permanent staff and another five casual workers on a daily basis. The major activity in the outlet revolves around stock management even though her staff also provide extension advice to farmers seeking to purchase inputs. Agro-input dealers in Kenya are regulated by both the Kenya Plant Health Inspectorate Service (KEPHIS) and the Kenya Bureau of Standards (KEBS), whose regulatory services revolve

around seed and fertilizer, respectively. In addition, agro-inputs are regulated by the Poisons and Pharmacy Board along with the Kenya Veterinary Board. Operations in the agro-input outlet typically peak around January to April when farmers in the region are planting maize and again in June when they are top dressing. In the other months, animal feed and day-old chicks are the main inputs sold.

IMPACT OF RISK EVENTS

Agro-input dealers face the following main risks, in declining order of importance: government policy (NCPB subsidies), erratic seed quality, adulteration of fertilizers, foreign exchange, theft, and health risks. Government policy in the recent past has negatively affected input dealers since the subsidized inputs present an unfair competition to other industry players. This makes it difficult for input dealers to plan their stocking rates because they fear the price undercutting associated with subsidized fertilizers. When an input dealer stocks fertilizers before the government's pronouncement of subsidized fertilizer prices, he or she is saddled with stocks that cannot be sold after the arrival of government-subsidized fertilizers. Besides subsidized fertilizers, another key risk is associated with stocking of poor-quality seeds, especially from Kenya Seed Co. In the last two years, farmers have complained about the poor germination rate of maize seed from Kenya Seed Co. Given that agro-input dealers source substantial amounts of seed from there, this issue presents a real business constraint.

RISK PRIORITIZATION

In decreasing order of importance, the key risks faced by agro-input dealers include

- » Unpredictable government policy
- » Erratic seed quality
- » Adulterated fertilizers
- » Insecurity
- » Foreign exchange fluctuations
- » Health risks

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Crop	Frequency	Impact
1.	Unpredictable government policy	Maize	Occasionally	20–30% reduction in profits
2.	Erratic seed quality	Maize	Occasionally	10% loss in market share
3.	Adulterated fertilizers	Maize	Occasionally	5% loss in market share
4.	Insecurity	Maize	Occasionally	Scares away workers
5.	Foreign exchange	Maize	Occasionally	
6.	Health risks	Maize	Occasionally	Scares away workers

RISK MITIGATION STRATEGIES

This agro-input dealer's key risk mitigation strategy is the procurement of insurance against theft, fire, and burglary.

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Unpredictable government policy	Stocking operations	None		Not effective
Erratic seed quality	Forward contracts with suppliers	None		
Adulterated fertilizers	Forward contracts with suppliers	None		
Insecurity	Adherence to safety standards	Insurance	Safety at the workplace	Somewhat effective
Foreign exchange	Hedging		Forward contracts	
Health risks	Medical insurance	Insurance	Observance of work safety	

CASE STUDY 3: LESHAMON OLEKOONYO—WHEAT FARMER, NAROK

INTRODUCTION

Mr. Olekoonyo is a wheat farmer in lower Narok, where he grows wheat on 400 acres. He also chairs the Narok Wheat Farmers' Association, a farmers' organization formed to lobby wheat millers to provide better prices to wheat farmers. Through the farmers' association and in collaboration with the Cereal Growers Association (CGA), wheat farmers in Kenya were able to sign an agreement in 2008 that ensures that wheat millers purchase all wheat produced in Kenya before resorting to imports. On average, Mr. Olekoonyo attains a yield of 15 bags/acre, equivalent to 1.35 MT/acre. At the current price of K Sh 3,100/bag and given a production cost of

K Sh 2,500/bag, Mr. Olekoonyo earned K Sh 3.6 million from his wheat enterprise last year.

OVERVIEW OF KEY FARM ACTIVITIES

The key farm activities on Mr. Olekoonyo's farm revolve around wheat production. The period February to April is used in land preparation, where the main challenge is the high cost of tractor hire, largely driven by the high cost of diesel. After planting, the farm engages in top dressing, chemical control of pests and diseases, and later on harvesting, which occurs between June and July. The area has two rainy seasons and therefore produces two wheat crops each year. The major challenge in harvesting is achieving a moisture content of 13 percent, because most of the wheat is harvested at high moisture content, and the cost of drying at the National Cereals and Produce Board (NCPB) is K Sh 26 per percentage drop in moisture.

IMPACT OF RISK EVENTS

Risks are inherent in wheat production right from planting through harvesting. Wheat farmers in Narok face the following major risks, in decreasing order of importance: drought, pests and diseases, erratic input quality, volatile prices, hailstorms, and high wind speed, which leads to logging. Droughts in particular have become a major challenge in lower Narok, with their frequency estimated at once every two years. In upper Narok however, the major risk to wheat production is hailstorms, which hit once every three to four years, although their incidence has increased in the recent past. On average, drought reduces wheat yield from 15 bags/acre to 10 bags/acre, a loss of 30 percent; at times drought leads to a total loss. Given the current prices of maize and wheat and the ongoing threat of drought and hailstorm, some farmers are shifting to maize production. “The only reason why I continue to produce wheat is because it is fully mechanized unlike maize” (Mr. Olekoonyo).

The quality of both seed and fertilizer inputs has become extremely erratic. In the recent past, wheat seed quality has deteriorated to the extent that large-scale wheat farmers have begun to import seed from as far as South Africa. Moreover, wheat marketing has become a challenge because millers, which are local producers’ only buyers, have not signed a new agreement since 2008; that agreement is outdated and does not reflect the current cost of production. Given this state of affairs, wheat millers dictate the prices paid to farmers, and prices have been changing from one year to the next. Farmers would prefer to negotiate prices each year.

RISK PRIORITIZATION

In decreasing order of importance, the key risks faced by wheat farmers in Narok include the following.

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Crop	Frequency	Impact
1.	Drought	Wheat	Once every two years	Yield losses of up to 30%
2.	Pests and diseases	Wheat	Occasionally	Yield losses of up to 10%
3.	Erratic input quality	Wheat	Each season	Yield losses of up to 30%
4.	Price volatility	Wheat	Occasionally	Income losses of up to 20%
5.	Hailstorms	Wheat	Occasionally	
6.	High wind speed	Wheat	Occasionally	

RISK MITIGATION STRATEGIES

A few large-scale farmers in Narok have begun to purchase crop insurance from Cooperative Insurance Company (CIC). Typically CIC insures the cost of wheat production, estimated at K Sh 24,000/acre or an equivalent yield of 8 bags/acre. Insurance premiums are currently set at about 6 percent, or an equivalent of K Sh 1,450/acre. A

vast majority of the indigenous Maasai wheat farmers in Narok have not adopted any drought mitigation strategies. Mr. Olekoonyo says he would rather let God be his insurance. Mr. Olekoonyo’s failure to insure his crop is due to the experiences of some wheat farmers who had to go to court to claim compensation from the insurance companies.

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Drought	Drought-tolerant varieties Soil and water conservation	Insurance		Not effective
Pests and diseases	Use of chemicals	Insurance	Use of indigenous knowledge in disease and pest control	Somewhat effective
Erratic input quality	Imports	None	Use of own seed	Somewhat effective
Price volatility	Storage	None	Sourcing alternative markets	Somewhat effective
Hailstorms		Insurance	Planting edge trees	
Wind		Insurance	Planting wind breaks	

CASE STUDY 4: MARCEL WAMBUA—HEAD OF FINANCE, LESIOLO GRAIN HANDLERS LIMITED

INTRODUCTION

Marcel Wambua is the Head of Finance at Lesiolo Grain Handlers Limited (LGHL), a medium-sized grain handler located in Lanet of Nakuru County. Established in 2003 through funding from the International Finance Cooperation (IFC) and the East Africa Development Bank (EADB), LGHL's existence stems from the belief that agriculture in Kenya demands both modern and efficient grain handling services. LGHL's management believes that these demands are best served by private sector entities like itself. LGHL provides a comprehensive solution for grain storage and related services. The core services offered include grain drying, cleaning, fumigation, storage, and seed dressing, among a host of other services aimed at allowing customers the opportunity to realize the highest prices for their grain. LGHL currently handles maize, wheat, and barley. Its main customers are large-scale wheat farmers, primarily located in Nakuru, Narok, Moiben, Timau, and Naivasha. The company was contracted by East Africa Breweries Limited (EABL) to handle barley grown in the region under contract.

OVERVIEW OF KEY ACTIVITIES

LGHL has an installed storage capacity of over 30,000 MT in a configuration of 16 silos and 8 wet bins. The equipment includes two Cimbria 54-ton dryers, two Cimbria Delta 120 cleaners, a belt conveyor system, and a 12-ton mini-dryer to cater to smaller customers. The company has the capability to handle bulk or bagged grain and has a bagging unit to accommodate customers with specific needs. LGHL also has 2 mobile dryers with a 12-ton holding capacity that are used to dry farmers' grains at farm gate. These mobile dryers can be operated by tractor or using 3-phase electricity. In addition, the company runs a laboratory where it is able to determine

grain moisture content, protein, bushel weight, levels of aflatoxin, and all grain parameters in grain grading.

The company's average annual grain handling turnover is 110,000 MT. Its drying charges are K Sh 28 per percentage moisture drop per bag. In collaboration with the Eastern Africa Grain Council (EAGC) and other partners, LGHL participates in EAGC's regulated Warehouse Receipting System. This allows clients to deposit at least 10 tons of maize or wheat into certified silos during the harvest season when prices are low. The client is given a warehouse receipt that can be used in participating banks for financing. The banks provide financing up to 60–80 percent of the crop value, allowing clients to hold their crop until the prices are better. For example, farmers who deposited grain in January 2012 when the price was K Sh 2,200 per 90-kg bag sold their maize in May 2012 at K Sh 3,400. They paid a total of 120 per bag for the five months of storage, earning a K Sh 1,080/bag margin. In addition, LGHL buys wheat, maize, sorghum, beans, and soybeans from farmers and sells them to local processing companies (e.g., flour millers, feed manufacturing plants, breakfast cereal manufacturing firms, and humanitarian relief organizations). The company also buys grain on behalf of millers, which reduces their logistical costs and frees their finances for production until they actually require the crop. LGHL offers competitive rates to farmers for their crops to enable them to have access to markets.

IMPACT OF RISK EVENTS

The major risks faced by the company emanate from government policy, especially the operations of the National Cereals and Produce Board (NCPB). The board's buying operations negatively impact LGHL's buying operations since the board's prices are always fixed at rates higher than the market. The other risks faced emanate from farm operations and include high moisture content in grains, pests and diseases, and drought.

RISK PRIORITIZATION

In decreasing order of importance, LGHL faces the following key risks:

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Crop	Frequency	Impact
1.	Government interference	Wheat, maize	All the time	Profit losses of about 10%
2.	High moisture content	Wheat	Occasionally	Reduces farmer incomes
3.	Pests and diseases	Wheat	Each season	Reduces farmer yields
4.	Price volatility	Wheat	Occasionally	Income losses of up to 10%
5.	Operational hazards (fire, injury, etc.)	Wheat	Occasionally	Reduces staff productivity

RISK MITIGATION STRATEGIES

LGHL is fully insured against fire, theft, and burglary and maintains work insurance for all of its staff. In addition, it employs the following tools and mechanisms:

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Government policy	Forward contracts		Stock management	Not effective
High moisture content				
Pest and diseases	Fumigation	Insurance	Fumigation	Somewhat effective
Price volatility	Storage	None	Stock management	Somewhat effective
Operational hazards	Maintenance of work safety standards	Insurance		

CASE STUDY 5: MICHAEL WAIGWA—AGRICULTURAL UNDERWRITER, COOPERATIVE INSURANCE COMPANY

INTRODUCTION

Michael Waigwa is an agricultural underwriter at the Cooperative Insurance Company (CIC), a general insurance company that provides crop insurance to wheat farmers in Kenya. Mr. Waigwa has been in the crop insurance business for the last four years. On average, the farms covered are in the range of 10–7,000 acres. In collaboration with Swiss Reinsurance, an international reinsurance company, CIC offers crop insurance to wheat, barley, maize, and barley farmers. For the last four years,

the company has offered a Multi-peril Crop Insurance (MPCI) that covers risks associated with drought, excess rain, flooding, hail, and frost; over the period 2011–2012, it paid out claims amounting to K Sh 130 million to wheat farmers in Narok alone. CIC's loss ratio (claims divided by premiums) in 2011 was 170 percent, indicating that the company incurred a loss from its MCPI business.

OVERVIEW OF KEY ACTIVITIES

The MCPI is reinsured by Swiss Reinsurance, which covers 80 percent of the risks while CIC covers the rest. Premiums are shared in the same ratio as claims. Insurance coverage is provided subject to crop inspections conducted periodically by CIC. Three inspections are undertaken during the crop life: at germination, mid-season, and shortly preharvest. CIC provides farmers with a 65 percent yield guarantee based on their long-term average yield; for example, assuming a long-term average yield

of 12 bags/acre, the company would insure the equivalent of roughly 8 bags/acre. The figure of 8 bags/acre is estimated to be the cost of production for wheat. CIC compensation enables farmers to recoup production costs in case of a shock. For instance, if a farmer has bought insurance and his yield falls to 6 bags/acre, CIC compensates the farmer for the difference of 2 bags/acre. The premiums charged are 6 percent of the sum insured, or an equivalent of K Sh 1,450/acre assuming a production cost of K Sh 24,000/acre for wheat.

IMPACT OF RISK EVENTS

Crop insurance in Kenya is a new phenomenon that many farmers have not yet taken advantage of, but Mr. Waigwa feels adequate capacity exists to undertake cereals insurance in Kenya from CIC and other insurance companies, such as Union and Provisional (UAP). Crop insurance in Kenya is a risky business, as evidenced by CIC's loss ratio in 2011. One key impediment to successful crop insurance in Kenya is the lack of legislation that makes crop insurance mandatory, as it is for motor vehicle insurance. In addition, farmers have difficulties understanding the sum

insured; the majority want to be compensated for production revenues rather than for the cost of production, even though their insurance covers the latter. For example, CIC currently faces a court case in which a farmer is claiming K Sh 600,000 even though his yields were above the 65 percent trigger threshold. Other challenges faced by insurance companies include diversion of product, fraud, and diversion of inputs in cases of contract farming, such as for barley.

RISK PRIORITIZATION

CIC insures the following major risks:

- » Drought
- » Excessive rain/flooding and logging
- » Hailstorms

These risks reduce the insurance company's profits by an estimated 30 percent. On the other hand, CIC faces the following key risks:

- » Fraud
- » Crop/input diversion
- » Excessive litigation by clients

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Crop	Frequency	Impact
1.	Fraud	Wheat	Occasionally	Profit losses of about 10%
2.	Crop/input diversion	Wheat/barley	Occasionally	Reduces profits
3.	Excessive litigation	Wheat	Occasionally	Reduces profits

RISK MITIGATION STRATEGIES

CIC's key risk mitigation strategy is reinsurance with Swiss Reinsurance. There is a new initiative to include

Kenya Reinsurance in this scheme and to share the premiums and claims across CIC, Kenya Reinsurance, Africa Reinsurance, and Swiss Reinsurance.

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Fraud		Reinsurance		
Crop diversion		Reinsurance		
Excessive litigation			Hire lawyers	

CASE STUDY 6: WILSON MURUNYA—LIVESTOCK HERDER, KAJIADO COUNTY

INTRODUCTION

Wilson Murunya is a 30-year-old herder from Kajiado County with a primary-level education. Like many other young Maasai men, Mr. Murunya dropped out of school to start herding. He started keeping livestock at the age of 20 after inheriting 10 cows from his father. Mr. Murunya comes from a polygamous family; his father owns approximately 200 acres of land that are shared among the extended family. He concentrates purely on herding, whereby he keeps indigenous zebu and a few crosses with the dual-purpose sahiwal. He states that the dual-purpose sahiwal is good for milk production and faster growth. However, the crosses are less resistant to diseases and succumb more quickly to drought than the zebus. Nevertheless, Mr. Murunya asserts that the sahiwal is more in demand despite these limitations. He managed to raise his herd to 120 heads of cattle, but currently has only 50 heads, all of which are indigenous zebu, having lost almost 70 animals to drought. He also keeps a few goats, which are mainly raised by women and children. His herd includes 12 mature females, which when milked produce up to 1 liter per cow per day. According to the Maasai tradition, milk belongs to women and is either consumed at home or sold in the market.

RISK EVENT MATRIX

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Livestock	Frequency	Impact
1.	Drought	Cattle, sheep, goats	Every 10 years for a major drought, and every 5 years for a minor drought	Loss of pasture Lack of water Low prices of livestock (50% drop) Livestock deaths. Mr. Murunya lost 70 out of 120 heads of cattle in 2007
2.	Animal diseases	Cattle, sheep, goats	Most of the diseases are endemic and occur every time there is a trigger. Most common are FMD, mastitis, lumpy skin disease, anthrax. Occurrence of FMD and anthrax was very probable, while the other were rare.	Livestock deaths High costs of drugs
3.	Unsustainable milk supply	Milk market prices	When there is drought, the supply of milk is unstable; hence, most traders exit the market.	Lack of stable markets Low prices of milk

Mr. Murunya's main source of income is sale of live animals. On average, a mature zebu steer raises K Sh 30,000 during the normal season sales. Mr. Murunya acknowledges that in a year he can sell up to 20 steers depending on financial need. The money acquired is used to buy food for his family, drugs for the livestock, supplementary feed, and sometimes children's school fees.

RISK EVENTS

According to Mr. Murunya, drought is the main risk affecting herders in the region. During such times, herders are forced to migrate and look for pasture in other areas, sometimes trekking hundreds of kilometers. "In 2007, there was an extensive drought and we had to move our livestock in search of pasture. I moved up to Magadi where I lost over 70 cows while looking for pasture. Since then, I have not been able to restock again and my current herd size is 50. During the same year, we went to herd our animals in the Tsavo National parks where some of our colleagues were killed by the lions. Drought not only brings us livestock deaths but also loss of human life, and our families back home also suffers" (Mr. Murunya).

RISK PRIORITIZATION

- » Drought
- » Animal diseases
- » Unsustainable milk supply

RISK MANAGEMENT STRATEGIES

Mr. Murunya relies on the following risk management strategies:

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Drought	Reserve grazing areas during the dry season Increase the number and sizes of water pans Standing hay	None	Buying hay Outmigration	Not effective since hay has to be gotten from very far and is expensive Migration leads to more disease spread and animal deaths
Animal diseases	Vaccination campaigns Cattle dips	None	Regular vaccination	Effective during the rainy season, but during the dry spells, animals are too weak to be sprayed
Unsustainable milk supply	Upgrading zebus with sahiwal to increase milk supply to the market	None	Sourcing milk from other villages to sustain the market demand	Not effective

CASE STUDY 7: YUSUF KHALIF ABDI—LIVESTOCK HERDER, GARISSA COUNTY

INTRODUCTION

Yusuf Khalif is a 65-year-old full-time herder from Modogashe in Garissa County. Although Mr. Khalif did not enumerate the number of animals he currently owns, he said he keeps cattle, goats, and sometimes camels. His sole source of income is sale of live animals. He occasionally selects livestock from his herd and brings them to Garissa market for sale.

RISK PRIORITIZATION

According to Mr. Khalif, the major types of risks are

1. Recurrent drought
2. Animal diseases

3. Low financial stability
4. Insecurity and theft
5. Clan conflicts over pasture
6. Social pressure
7. Price risks
8. Floods along the rivers

Mr. Khalif notes that “In 2010–2011, a major drought occurred, I moved with my 700 goats from Modogashe to Fafi, but I only returned back with 14 goats, all the others died on the road due to lack of pasture.” Before outmigrating, Mr. Khalif wanted to sell his animals in a move to destock, but the community did not allow this; community members believe that if an animal is meant to die, it will, so herders are pressured not to sell. A major drought occurred in 1987, and another in 2000. These droughts resulted in extensive livestock deaths; the community was afraid to speak about them in case “It heard and came back.”

RISK EVENT MATRIX

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Livestock	Frequency	Impact
1.	Recurrent drought	Cattle, goats, sheep, camel	Every 10 years for a major drought, and every 2–3 years for a minor drought	Varied. In 2010–2011, Mr. Khalif lost 700 goats, or over 90% of his stock
2.	Animal diseases	Cattle, goats, sheep, camel	Occasionally	In 2007, farmers lost over 50% of their stock from Rift Valley fever
3.	Low financial stability	Herders lack financial capacity due to lack of <i>Sharia</i> -compliant credit institutions	Often	Herders' inability to destock their animals when there is an early warning
4.	Insecurity	Cattle, goats, sheep, camel	Occasionally	
5.	Clan conflicts over pasture	Grazing pastures	Occasionally during drought	Sometimes loss of lives as clans fight for grazing pasture
	Social pressure	Affects efforts to destock	Often	Farmers end up losing their animals as the community puts pressure not to destock
	Price risks	Market prices for cattle, goats, sheep, camel	Often	The price of animals drops up to 50% during a drought

RISK MANAGEMENT STRATEGIES

Mr. Khalif employs the following tools and mechanisms to manage risks:

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Recurrent drought	Establish irrigation schemes for pasture. A case in comparison is the Ewaso Nyiro irrigation scheme	None	Livestock migration Supplementary feeds like hay	Not effective: Leads to livestock deaths and disease spread
Animal diseases	Regular vaccination and vaccination campaigns	None	Vaccination	Effective
Low financial stability	Provision of <i>Sharia</i> -compliant credit schemes	None	Herders sell their animals and keep the money in the house	Sometimes the herders lose the money due to lack of secure measures
Insecurity	Community surveillance	None	Community surveillance	Relatively effective but the problems are always recurrent
Clan conflicts over pasture	Community peacekeeping programs	None	Clan elders solve major conflicts with the clan	Relatively effective but the problems are always recurrent
Social pressure	Community peacekeeping programs	None	Herder currently succumbs to social pressure. For example, when Mr. Khalif was denied selling his goats due to drought, he decided to migrate and look for pasture, and in the process, some goats died	
Price risks	Proper structures for livestock trade	None	Herders are price takers, and have low bargaining power	

CASE STUDY 8: FRESHA DAIRY—MILK PROCESSORS, GITHUNGURI COUNTY

INTRODUCTION

Fresha Dairy, opened in 2004 with a capacity of 50,000 liters per day, now has a capacity of 200,000 liters per day. The dairy cooperative owns the whole value chain, including production, processing, and distribution. The dairy processing plant is owned by the Githunguri Dairy Society, which started in 1961 with a membership of 34 and has grown to the current 23,120 members, of which 19,000 are active dairy farmers. It has 75 milk collection centers, at which 200,000–218,000 liters of milk are collected from members daily. Fresha has 65 stores where members can access animal feed and other inputs on

credit and artificial insemination services at a subsidized rate. The Fresha processing plant has a good risk management strategy; while it supports its farmers to produce more milk, the factory ensures that all milk is purchased from the farmers. The cooperative also ensures a steady and rising price per liter paid to its members. Fresha management stated their farmers are not adversely impacted by risk because

- » When there is less fodder, the cooperative buys hay in bulk on behalf of its farmers, which they can pay for with the milk they supply.
- » Fresha supplies other feed on credit, ensuring a steady supply of milk from farmers.
- » In addition to processing milk, the cooperative has embarked on value addition and making long-life milk, which allow staggering of sales and hence more steady prices.

RISK EVENT MATRIX

RISK FREQUENCY AND SEVERITY

Rank	Risk Type	Affected Livestock	Frequency	Impact
1.	Low-quality milk/spoilage		Occasionally	Low volume of milk processed
2.	Drop in milk supply		Occasional	Low operational capacity
3.	Oversupply of milk during the rainy season			Milk spoilage

RISK MANAGEMENT STRATEGIES

Fresha Dairy employs the following risk management strategies:

CURRENT RISK MANAGEMENT PRACTICES

Risk Type	Risk Mitigation	Risk Transfer	Coping Strategy	Effectiveness
Low-quality milk/spoilage	Milk quality checks at the farm level Training farmers on clean milk production Quality checks at the laboratory	None	Training farmers on clean milk production	Effective
Drop in milk supply	Support to farmers to maintain regular supply of milk; for example, buying hay and concentrates for farmers, which the farmers pay for after delivering the milk	None		
Oversupply of milk during the rainy season	Milk value addition—process yoghurt and other dairy products Establishment of a long-life milk processing plant to handle excess milk	None		

APPENDIX C

STAKEHOLDER VULNERABILITY ANALYSIS

Agricultural shocks are one important factor driving chronic poverty and food insecurity in Kenya. Shocks impact household well-being in a variety of ways, by limiting food availability, weakening food access, and negatively affecting monetary well-being through the depletion of productive assets. Chronically vulnerable groups with high exposure to hazards experience a disproportionately large impact from adverse events and lack coping mechanisms available to other groups. In this context, vulnerability is a useful lens through which to examine agricultural shocks because it allows policy makers to determine which groups are most affected and to target risk management solutions accordingly.

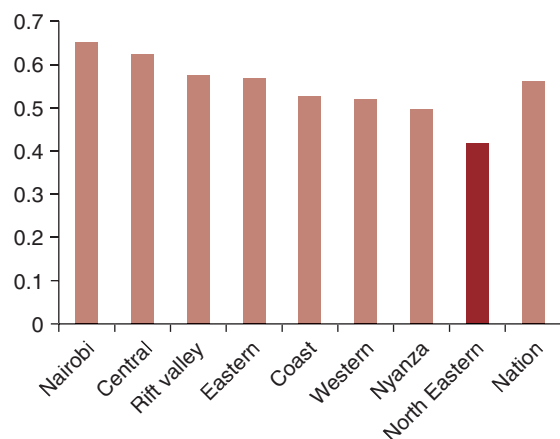
GENERAL TRENDS IN VULNERABILITY

- » Levels of human development, poverty, and food insecurity vary widely between regions.
- » Exposure to extreme weather events is highly correlated with being poor and being food insecure.
- » About 70 percent of Kenya's poor live in the central and western regions, in areas that have medium to high potential for agriculture (IFAD 2013).
- » Poverty and food insecurity are acute in Kenya's arid and semiarid lands (ASALs), which have been severely affected by recurrent droughts.

VULNERABILITY, LIVELIHOODS, AND AGROCLIMATIC CONDITIONS

Especially in rural areas, patterns of livelihood activities are strongly influenced by prevailing agroclimatic conditions, which determine planting calendars, soil quality, and crop suitability. Approximately 80 percent of Kenya's land area lies in the ASALs, home to more than 30 percent of the population and 75 percent of the country's livestock (GoK 2011). ASAL districts have the highest incidence of poverty in the country, contain 18 of Kenya's 20 poorest constituencies, and are predominantly inhabited by pastoralists and agro-pastoralists (GoK 2009). Pastoralist districts consistently rank below the national average in terms of Human Development Index (HDI) scores

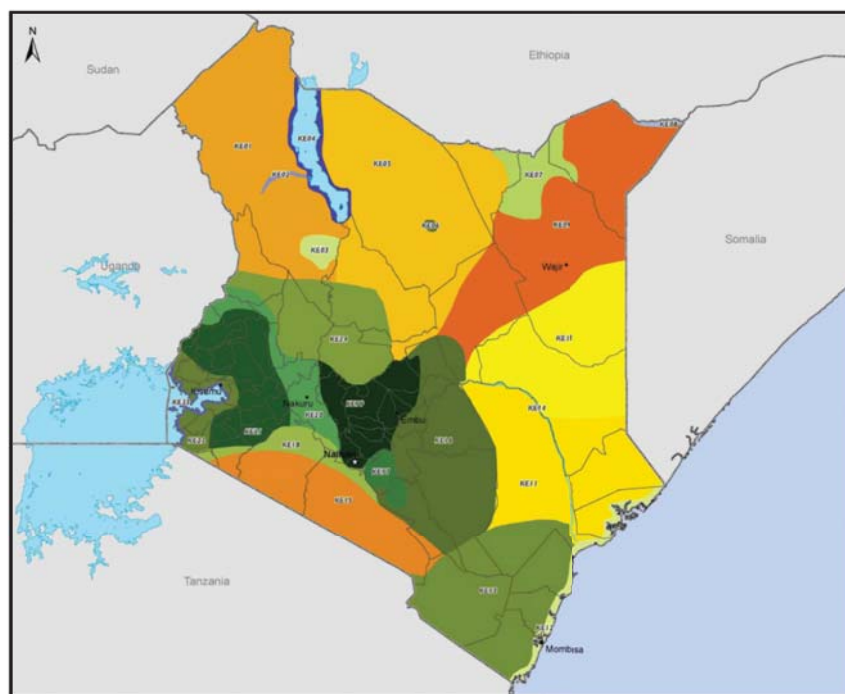
FIGURE C.1. HUMAN DEVELOPMENT INDEX SCORES, BY PROVINCE



Source: Kenya National Human Development Report 2009.

(figure C.1), as well as on other indicators of well-being. These communities are among the most chronically food insecure in the country and typically experience the highest rates of severe malnutrition. Several underlying factors increase pastoral communities' vulnerability, including land fragmentation, population growth, low literacy and education provision, poor infrastructure, and weak market integration. These chronic weaknesses undermine pastoralist groups' capacity to respond to shocks, like drought and livestock disease outbreaks, which occur frequently in the ASALs. In turn, the increasing frequency and simultaneous occurrence of multiple shocks erode the effectiveness of traditional coping mechanisms, creating a vicious cycle of crisis and underdevelopment.

FIGURE C.2. MAP OF KENYA'S LIVELIHOOD ZONES



- KE01 - Northwestern Pastoral Zone
- KE02 - Turkwell Riverine Zone
- KE03 - Northwestern Agropastoral Zone
- KE04 - Lake Turkana Fishing Zone
- KE05 - Northern Pastoral Zone
- KE06 - Marsabit Marginal Mixed Farming Zone
- KE07 - Northeastern Agropastoral Zone
- KE08 - Mendera Riverine Zone
- KE09 - Northeastern Pastoral Zone
- KE10 - Grasslands Pastoral Zone
- KE11 - Southeastern Pastoral Zone
- KE12 - Coastal Low Potential Farming Zone
- KE13 - Coastal Marginal Agricultural Mixed Farming Zone
- KE14 - Tana Delta - Irrigated Zone
- KE15 - Southern Pastoral Zone
- KE16 - Southeastern Marginal Mixed Farming Zone
- KE17 - Southeastern Medium Potential, Mixed Farming Zone
- KE18 - Southern Agropastoral Zone
- KE19 - Central Highlands, High Potential Zone
- KE20 - Western Medium Potential Zone
- KE21 - Western High Potential Zone
- KE22 - Western Lakeshore Marginal Mixed Farming Zone
- KE23 - Lake Victoria Fishing Zone
- KE24 - Western Agropastoral Zone

Updated: March 14, 2011

Source: FEWSNET 2011.

POVERTY STATUS AND VULNERABILITY

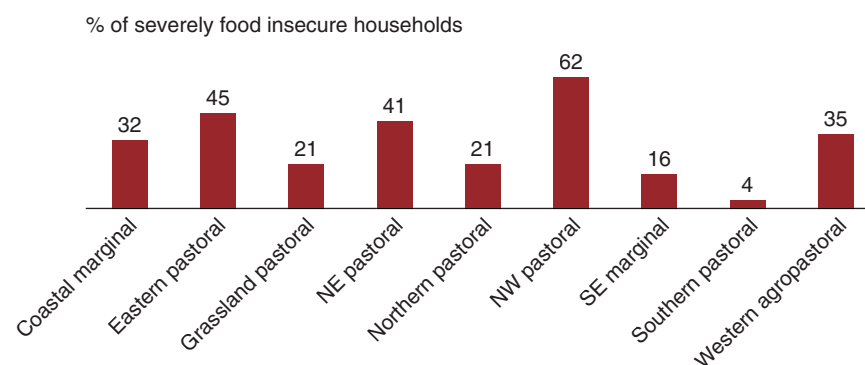
In 2005–06, approximately 17 million Kenyans, or 47 percent of the population, were too poor to afford the cost of buying enough food to meet the recommended daily nutritional requirements and minimal nonfood items. Of these 17 million people, more than 85 percent live in rural areas. Spatial disparities in both the incidence and depth of poverty are pronounced: poverty

incidence at the district level ranges from 94 percent to 12 percent, and the poverty gap ranges from 218–230K. According to an econometric analysis of district-level poverty data, stark spatial variations in the incidence and depth of poverty arise from differences in agroclimatic conditions and income-earning opportunities, as well as unobserved factors (World Bank 2008). In other words, household location is an excellent predictor of livelihood activity, poverty status, and household consumption level (figure C.2).

TABLE C.1. POVERTY TRANSITIONS BY LIVELIHOOD GROUP

Livelihood Group	Remained Poor	Escaped Poverty	Became Poor	Remained Non-Poor	Percent Poor at the Beginning	Percent Poor at the End	Percentage Point Change in Poverty
Mix farm, high	31	0	11	48	41	42	1
Farm/fish, low	24	7	14	55	31	38	7
Farm/ livestock, low	43	11	13	33	54	56	2
Pastoral	38	3	22	36	42	61	19
Urban	42	14	15	29	56	57	1
Average	35	9	14	42	44	50	5

Source: Mango, et al (2007).

FIGURE C.3. HOUSEHOLD FOOD SECURITY BY LIVELIHOOD ZONE

Source: World Bank 2008.

Districts with high levels of poverty and food insecurity are also characterized by a high frequency of extreme weather events. Households in the bottom expenditure quintile are the most likely to experience a weather-related shock. By virtue of their location, poorer households experience a variety of natural hazards more frequently compared to better-off and richer households, and are less able to mobilize productive resources to respond to shocks. Table C.1 shows how the poverty status of different types of households changed between 1997 and 2005–06.³³ At the end of the study period, the poverty rate was highest among pastoralists (61 percent), and a higher percentage of pastoralists had slid into poverty than any other livelihood group (22 percent), indicating a substantial drop in well-being.

³³ “Mix farm, high” is a mixed crop area with high potential. “Farm/fish, low” is a mixed crop and fishing area with low or marginal potential, and “Farm/livestock, low” is an agro-pastoral area with low or marginal potential.

Figure C.3 shows the percentage of severely food insecure households, as of May 2013, in areas where the World Food Programme (WFP) operates. The graph reflects the food security status of nonbeneficiary households, as opposed to WFP-beneficiary households.

VULNERABLE GROUPS

Certain population groups and certain types of households are more vulnerable to agricultural shocks than others, depending on their level of exposure to risks, susceptibility, and capacity to respond and/or recover from adverse events. In many cases, patterns of vulnerability reflect underlying inequalities and social marginalization that preclude access to resources for individuals, households, or livelihood groups. The groups identified below are especially vulnerable to agricultural shocks:

PASTORALISTS

- » Pastoralist households are more likely to be poor and more likely to be food insecure than nonpastoralist households.
- » Up to a fifth (15–20 percent) of households in the Northern Pastoral Zone engage in begging, a rate that is much higher than in any other livelihood zone.
- » The highest rates of global acute malnutrition are in the Northeastern and Northwestern Pastoral Zones (WFP 2013).

FEMALE-HEADED HOUSEHOLDS (FHHS)

- » FHHs are 13 percent less likely to be food secure than male-headed households (MHHs).

- » On average, FHHs have smaller farm sizes and lower education levels compared to their male counterparts.
- » Roughly 49 percent of the total cultivated land owned by MHHs is good to medium fertile land compared to 39 percent of land owned by FHHs (Kassie et. al. 2012).

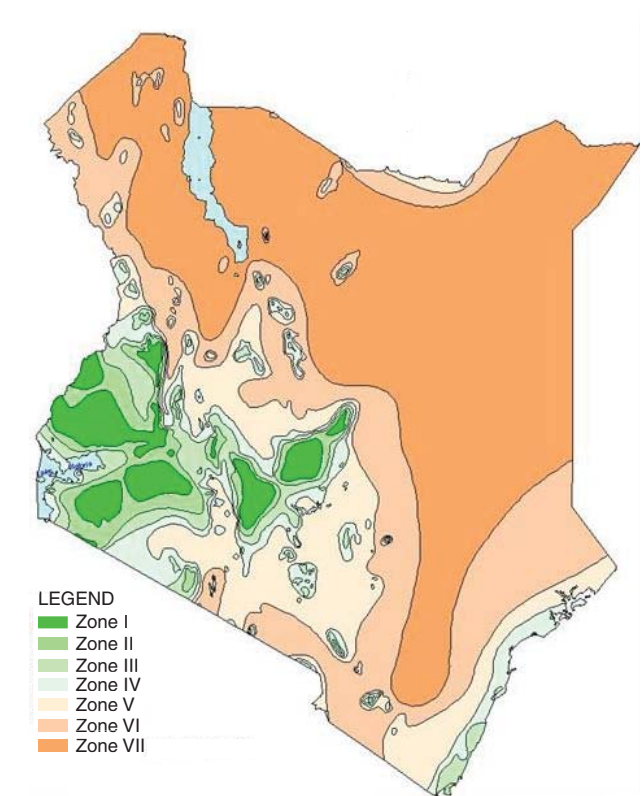
UNSKILLED/CASUAL WAGE LABORERS

- » Casual wage laborers are considered particularly vulnerable to food price, production, and labor shocks since they purchase almost all of their food from the market.
- » During the 2008 food crisis, labor demand and wage rates stagnated as food prices rose by up to 50 percent (KFSSG 2008).

APPENDIX D

RAINFALL ANALYSIS

FIGURE D.1. AGRO-ECOLOGICAL ZONES



Source: Adapted from Kenya Soil Survey 2009.

FIGURE D.2. MEAN ANNUAL RAINFALL (mm)

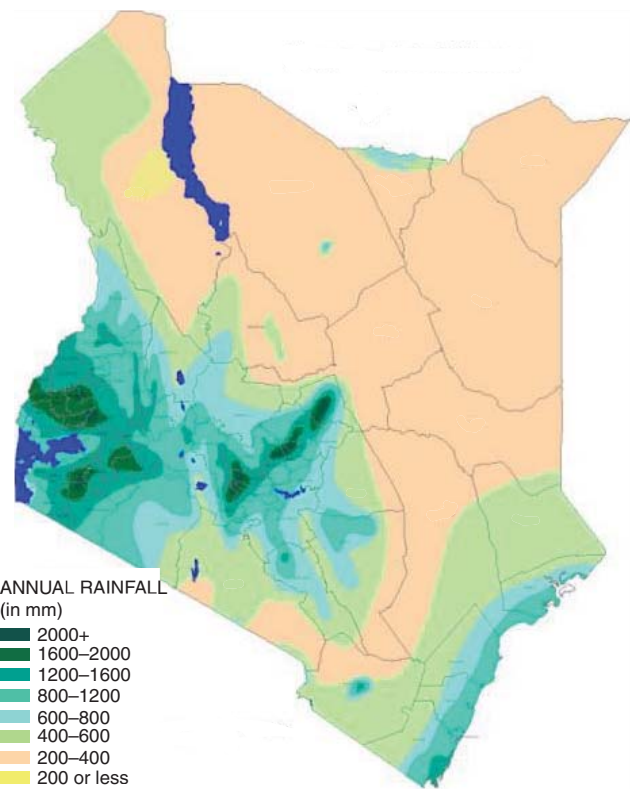
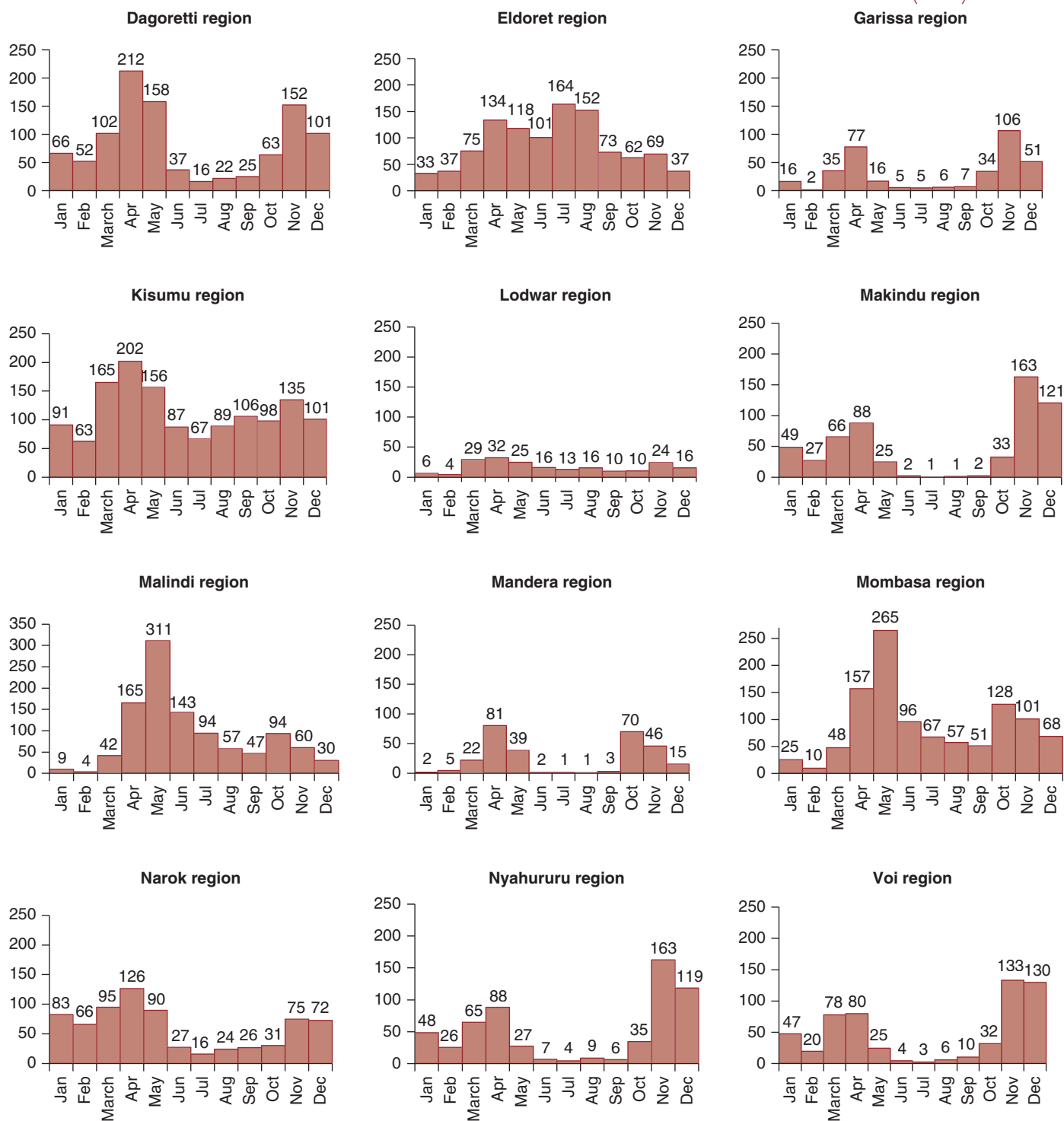


FIGURE D.3. MONTHLY CUMULATIVE RAINFALL PATTERNS BY RAINFALL ZONE (mm), 1981–2011



Source: Kenya Meteorological Department.

FIGURE D.4. LOCATION OF
REGIONAL WEATHER
STATIONS IN KENYA



Source: GFDRR 2012.

APPENDIX E

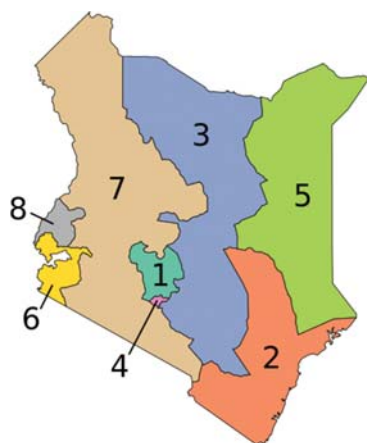
WEATHER AND YIELD IMPACT ANALYSIS

BACKGROUND

The World Bank is conducting a study on the effect of several climatic events on different crops' yield in Kenya. The purpose of the study is to determine whether and by how much yield is affected by climatic events.

Figure E.1 shows the political division of Kenya prior to implementation of the 2010 Constitution; at that time, Kenya had eight provinces.

**FIGURE E.1. PROVINCES IN KENYA
BEFORE 2010**



Provinces: 1 = Central, 2 = Coast, 3 = Eastern, 4 = Nairobi, 5 = North Eastern, 6 = Nyanza, 7 = Rift Valley, 8 = Western.

SUMMARY AND KEY FINDINGS

Rainfall distribution in Kenya is highly variable. In very dry years, like 1984, 2000, and 2009, little precipitation fell throughout most of the country. But 1968, 1997, and 2006 were very humid years. This high variability in rainfall distribution affects the yield of Kenya's main food crops.

Rainfall occurs mostly between March and May; April is the most humid month of the year. But a second rainy period also exists: November receives a lot of precipitation in some regions of the country. Main crops like maize and beans are sown in March to take advantage of the first rainy season. The dry season during July–September, when crops are in the middle of their growing stage, can affect their yield, however.

In Kenya's Central and Coast Provinces, statistical evidence shows that drought during the growing stage greatly affects maize production. For example, maize production was low in the Central Province during dry years like 2001, 2004, and 2008, and in the Coast Province in 2011 and 2012.

Bean production is affected by too many rainy days during the harvesting season in the Coast Province; for example, in 1997, a very wet year, bean production was low.

Similarly, in the Rift Valley Province, many rainy events during 1998 explain low production there.

Wheat production in the Eastern Province is affected by rainy events during the growing season. For example, in 2004, higher than expected rainy events catastrophically affected wheat production.

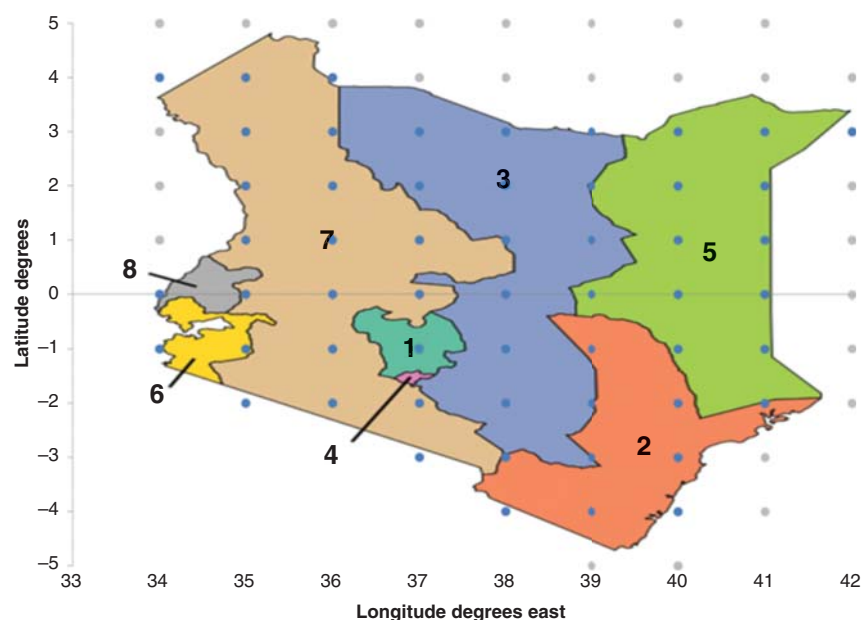
It is worth noting that the geographical resolution of the crop production information is very low, because it is only available at a provincial level; this might mask some relationships that could be found with a finer geographical resolution.

WEATHER INFORMATION

Two data sources were used to analyze Kenya's rainfall patterns. The Kenya Meteorological Department provided a database with annual cumulative rainfall at 18 different weather stations from 1963 to 2012. This information is only available at an annual level.

A gridded database from the Global Precipitation Climate Project (GPCP, see <http://precip.gsfc.nasa.gov/>) was also used. The resolution of the grid is 1 degree, so there are many pixel points with data from January 1, 1997, to December 31, 2013, for the whole country. Figure E.2 provides a scope of the grid superimposed on a map of Kenya. Pixels in blue were considered for the analysis.

FIGURE E.2. RAINFALL PIXELS SUPERIMPOSED ON A MAP OF KENYA

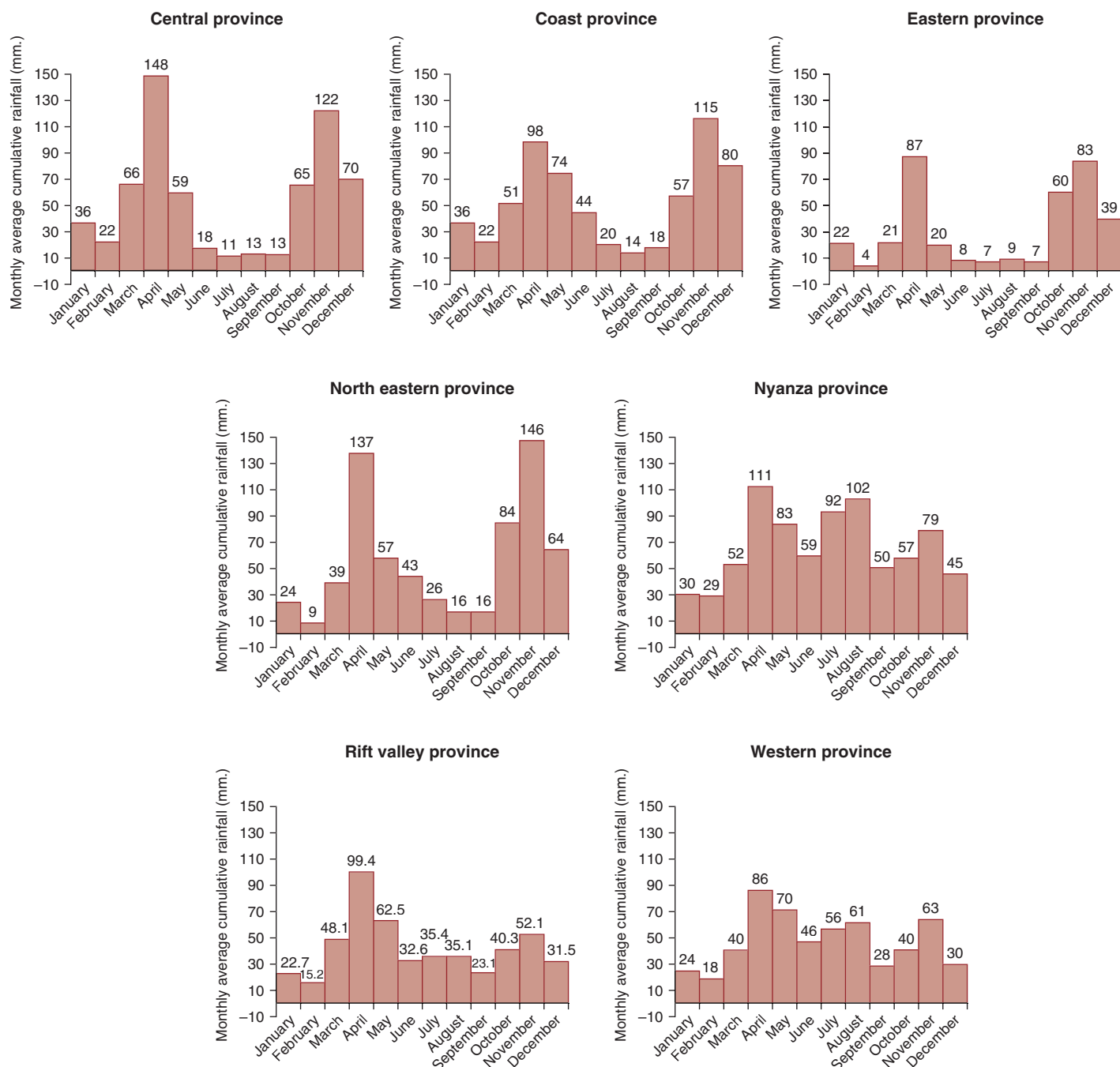


ANNUAL RAINFALL DISTRIBUTION IN KENYA

Rain in Kenya follows two seasonal patterns throughout the year: the “long rains” season, which occurs from March/April to May/June; and the “short rains” season, which occurs from October to the end of the year. Figure E.3 shows the average monthly distribution of rain for a pixel within all regions.

The bimodal pattern (long rains, short rains) is clear in most provinces, although rain falls more uniformly in Western and Nyanza Provinces, the provinces farthest from the coast. April is the wettest month in all provinces, with average cumulative rainfall fluctuating between 86 and 148 mm, while August seems to be the driest month, with only 10 mm on average, except in the westernmost provinces, where cumulative rainfall ranges between 35 and 102 mm.

FIGURE E.3. MONTHLY RAINFALL PATTERN BY REGION



Source: Kenya Meteorological Department.

DROUGHT AND EXCESS RAINFALL ANALYSIS

The Kenya Meteorological Department database was used to analyze the differences among years, since its time series is longer (50 years) than that of the gridded database, and it only includes annual cumulative rainfall. To determine whether a year was dry or wet, the standardized cumulative rainfall was calculated for each region according to the following formula:

$$StdRain_i = \frac{(Prec_i - \mu_i)}{\sigma_i}$$

where

StdRain, Standardized cumulative rainfall

Prec, yearly rainfall

μ , mean yearly rainfall

σ , standard deviation of yearly rainfall

i, year

Using the standardized cumulative rainfall makes it easier to identify drought and excess rainfall years. Table E.1 shows the standardized cumulative rainfall by year and weather station, color coded as follows: red means an extreme drought event ($StdRain < -2$); orange means a drought event ($StdRain < -1$); light blue mean a light excess rainfall event ($StdRain > 1$); and navy blue means an excess rainfall event ($StdRain > 2$).

Several conclusions can be drawn from table E.1. First, there were 33 normal years, 7 drought years, and 8 excess rainfall years. Extreme drought and extreme excess rainfall years each occurred once. Second, extreme events seem to have occurred less frequently in recent times, a conclusion that might be at odds with the general concept of climate change.

Drought years were 1965, 1975, 1976, 1980, 1984, 1987, 1993, and 2000. During these eight years, rain was more than one standard deviation below average for at least five stations. The year 1984 was particularly extreme, with 11 stations showing drought, of which five had an extreme drought shock. For several stations, cumulative rainfall was less than 500 mm for the whole year. The most recent generally dry year was 2000, when six stations showed

drought events, although 2009 was also generally dry. The Narok station (about 150 km west of Nairobi) had consecutive extreme drought events in 2002 and 2003, with 0 mm and 50 mm of cumulative rain, respectively, but it is odd that no other station experienced a similar event.

Excess rainfall years were 1963, 1967, 1968, 1977, 1978, 1988, 1998, 2006, and 2012. During these nine years, rainfall was more than one standard deviation above average for at least five stations, meaning that rainfall was generally plenty during these years. The year 1968 was the most humid, with 10 stations showing a positive anomaly in rainfall, and seven showing an extreme event. Nanyuki station seems to be an outlier or to have a measurement error, because its observation for 1968 is 9,895 mm, a figure completely out of line. Still, more than 2,000 mm fell at several stations. The year 2012 was also wet, with seven stations showing excess rainfall, particularly the Kisii and Kericho stations (both close to Nyanza Province), which saw more than 2,000 mm of cumulative rainfall.

RAINFALL—YIELD REGRESSIONS

The NASA database was used to determine the relationship between rain and yield for the various crops since it has daily data, allowing for a deeper analysis of dates and events. The only caveat is that these data do not cover the whole 50 years for which crop data exist.

It is worth noting that the geographical resolution of the two data sets is not the same. Rainfall data are available on point estimates for pixels on a 1×1 degree grid, while yield data are available by province. It is therefore necessary to make equivalent the geographical resolution of both data sets. Because no information exists regarding the sowing zones within each province, all available pixels within the province were considered to match the yield information of each province. Thus, the average of the available pixels within a province was used as a proxy for each province's rainfall.

Figure E.4 depicts the calendar used to determine the sowing, growing, and harvesting seasons for the main crops in Kenya.

TABLE E.1. RAINFALL ANOMALIES FOR THE 18 WEATHER STATIONS

Year	Eldoret	Embu	Garissa	Kajiado	Kakamega	Kericho	Kiambu	Kisii	Kisumu	Kitalo	Machakos	Meru	Mombasa	Nakuru	Nanyuki	Narok	Nyahururu	Nyeri	Ext Dro	Drought	Normal	Excess	Ext Excess	Comment
1963	1.72	1.14	0.60	-1.42	0.30	0.71	2.33	-0.40	-0.16	-0.98	2.45	-0.03	0.46	0.22	0.15		2.12	0.93	0	1	11	5	3	Excess
1964	0.79	-0.69	-0.12	1.19	-0.02	0.40	-0.35	-0.40	0.65	-0.20	-0.22	0.79	-0.55	-0.17	0.08		0.82	0.59	0	0	16	1	0	Normal
1965	-0.88	-0.99	-0.26	-0.41	-0.42	-0.86	-0.77	-0.26	-0.89	-1.64	-0.44	-1.91	0.20	-2.00	-0.25		-1.69	-1.04	0	5	12	0	0	Drought
1966	0.80	0.11	-0.58	0.55	-0.98	-0.60	0.92	1.78	1.66	0.39	0.38	0.85	0.37	0.28	0.01		-0.53	-0.54	0	0	15	2	0	Normal
1967	1.38	1.56	0.88	-0.12	-0.53	-0.27	1.42	-0.51	-0.66	-3.33	0.89	2.22	1.09	-0.51	0.04		0.00	0.15	1	1	11	5	1	Excess
1968	-0.04	2.22	3.49	-0.10	0.22	0.79	2.17	-0.48	2.03	-0.40	2.38	2.65	1.39	0.44	6.85		1.60	1.39	0	0	7	10	7	Ext Excess
1969	-0.61	-0.24	-0.47	0.00	-0.73	-2.39	-1.44	0.22	-0.91	-0.56	0.22	1.08	-0.28	-0.95	0.03		-0.76	-0.94	1	2	14	1	0	Normal
1970	1.60	-0.65	-0.71	1.66	0.84	0.57	-0.17	1.25	-0.61	0.23	-0.17	1.16	-0.64	0.76	-0.12		0.30	0.18	0	0	13	4	0	Normal
1971	0.01	0.49	0.01	0.33	-0.47	-1.56	0.52	4.12	0.28	-0.10	0.25	0.03	-0.99	-0.39	-0.01		0.51	-1.08	0	2	14	1	1	Normal
1972	0.16	1.60	-1.04	-0.59	0.48	-1.41	-0.43	0.66	0.60	1.69	-0.05	2.59	0.79	-0.47	-0.12		-0.47	-0.11	0	2	12	3	1	Normal
1973	-0.91	-1.14	-0.55	0.29	1.50	-0.83	-1.28	-0.53	-1.75	-0.84	-0.14	0.11	-0.04	-0.85	-0.16		-0.85	-0.43	0	3	13	1	0	Normal
1974	-1.11	-0.11	-0.69	0.20	-0.98	-1.19	-0.46	-0.47	-0.93	-0.81	0.38	1.12	-0.83	-0.03	-0.03		0.22	-0.62	0	2	14	1	0	Normal
1975	1.18	-1.18	-0.20	0.33	0.07	0.81	-1.12	-0.03	-0.60	-0.31	-0.35	-1.03	-0.50	1.02	-0.09		0.58	-1.06	0	4	11	2	0	Drought
1976	-0.43	-0.47	-0.98	-1.45	-0.51	-1.21	-0.60	0.24	-0.52	-1.13	-0.56	-1.00	-0.43	-0.51	0.04		-0.78	-0.58	0	4	13	0	0	Drought
1977	2.49	0.63	0.37	1.85	1.33	-0.51	1.38	1.56	1.32	2.01	0.63	0.76	0.19	0.86	0.04		1.90	-0.15	0	0	9	8	2	Excess
1978	-0.12	0.85	2.32	0.59	0.09	1.64	1.40	0.52	2.06	1.36	1.28	1.64	0.38	0.97	0.01		1.53	0.35	0	0	9	8	2	Excess
1979	0.24	0.37	1.13	-0.07	-0.47	-0.58	-0.47	-1.52	0.40	0.45	2.21	0.59	0.97	-0.12	-0.13		0.30	1.41	0	1	13	3	1	Normal
1980	-0.90	-0.94	-1.51	-0.59	0.07	-1.21	-0.21	-1.07	-1.48	-1.10	0.90	-1.01	-0.48	-0.61	-0.40		-0.78	-1.18	0	7	10	0	0	Drought
1981	0.53	0.74	-0.28	-0.41	1.04	-0.83	0.32	-0.97	-1.81	0.80	0.70	0.38	0.05	-0.21	-0.04		0.37	-1.06	0	2	14	1	0	Normal
1982	-0.15	0.37	0.52	0.03	1.52	-0.27	-0.12	-1.52	0.40	1.80	-0.56	0.70	1.31	0.30	-0.16		0.69	0.89	0	1	13	3	0	Normal
1983	0.00	-0.42	-1.40	-0.61	-0.29	1.04	-0.80	-0.39	-1.37	-0.11	-1.44	-0.87	0.07	-0.25	-0.29		-0.33	0.26	0	3	13	1	0	Normal
1984	-2.95	-1.10	0.92	-1.27	-2.08	-2.54	-2.65	-1.14	-0.77	-1.49	-0.87	-0.21	-0.82	-1.61	-0.29		-2.67	-1.24	5	11	6	0	0	Ext Dro
1985	-0.67	0.76	-0.78	-0.94	3.01	1.40	-0.42	0.00	-0.12	0.35	0.03	-0.13	-0.94	-0.06	-0.26	0.45	-0.17	0.00	0	0	16	2	1	Normal
1986	-1.08	-0.54	0.03	-0.65	-0.76	-0.80	-0.53	-0.75	-0.35	-1.64	-0.44	-0.59	-1.97	-0.22	-0.21	-0.83	-0.09	0.84	0	3	15	0	0	Normal
1987	0.22	-0.87	-1.78	-2.30	-0.19	0.51	-0.25	1.27	-0.39	-0.30	-1.97	-1.49	-2.04	-1.12	-0.30	0.37	-2.28	-1.21	3	8	9	1	0	Drought
1988	-0.39	2.08	0.26		1.67	1.48	1.18	0.53	0.20	0.06	0.00	-0.70	-1.48	0.97	-0.25	0.35	0.59	1.18	0	1	11	5	1	Excess
1989	-0.70	-0.44	-0.19		-0.10	0.60	1.62	-1.12	-0.31	0.04	-0.19	-0.55	-1.53	3.94	-0.06	2.13	-0.85	-0.62	0	2	12	3	2	Normal
1990	-0.31	1.20	1.03		2.80	0.11	0.76	0.43	-0.85	-0.28	0.69	0.06	0.36	-0.05	-0.16	0.06	0.19	0.62	0	0	14	3	1	Normal
1991	-0.39	-1.05	-0.07	1.40	0.26	0.42	-0.40	-1.42	-0.69	0.06	-0.72	-0.18	0.38	2.39		-0.50	-1.02	0.38	0	3	12	2	1	Normal
1992	0.02	-1.96	-0.21	-0.15	-0.80	-0.03	0.04	-1.17	-0.65	0.08	-0.77	-0.79	-0.32	-0.34	-0.40	-0.89	-0.80	-0.67	0	2	16	0	0	Normal
1993	-1.76	-1.19	-0.55	1.08	-1.54	-0.64	-0.69	-1.05	-1.12	0.28	-0.48	-0.65	-0.47	-1.11	-0.44	0.30	-0.33	-0.18	0	6	11	1	0	Drought
1994	0.51	-0.39	0.50	1.59	-0.22	0.38	-0.15	0.44	0.66	0.13	0.28	-0.39	2.53		-0.21		-0.32	1.26	0	0	13	3	1	Normal
1995	-0.50	0.51	0.37		-0.07	-0.55	1.15	0.23	0.42	0.61	-0.70	-0.59	-0.01	-0.29	-0.32	-0.12	-0.05	0.38	0	0	16	1	0	Normal
1996	0.00	-1.03			0.19	0.51	-1.53	0.56	0.86	-0.32		-0.91	-0.28	-0.23	-0.20	0.38	-0.49	-0.99	0	2	13	0	0	Normal

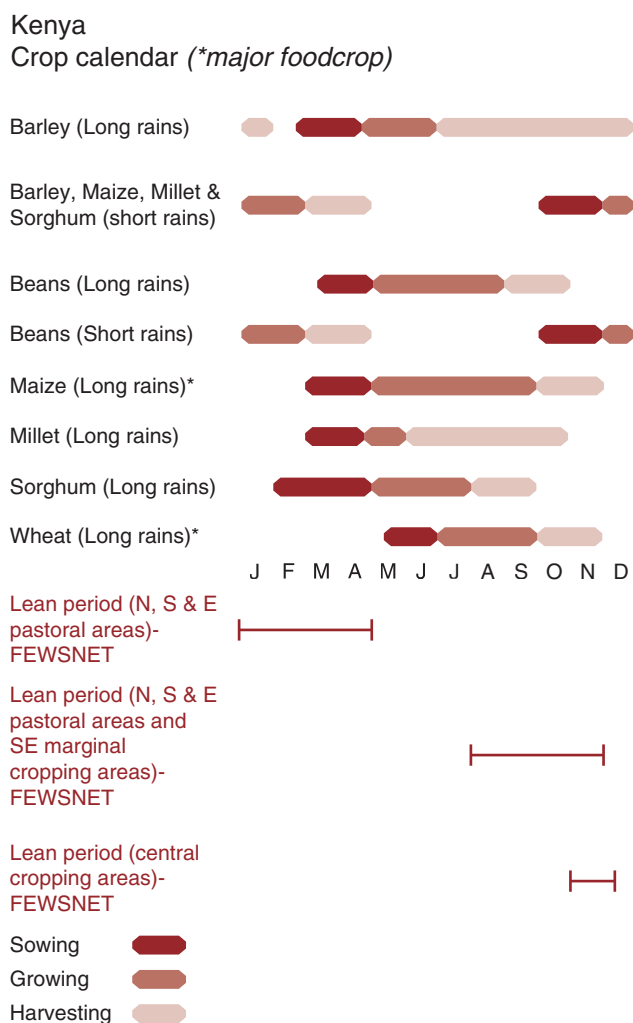
(continued)

TABLE E.1. RAINFALL ANOMALIES FOR THE 18 WEATHER STATIONS (continued)

Year	Eldoret	Embu	Garissa	Kajiado	Kakamega	Kericho	Kiambu	Kisii	Kisumu	Kitale	Machakos	Meru	Mombasa	Nakuru	Nanyuki	Narok	Nyahururu	Nyeri	Ext Dro	Drought	Normal	Excess	Ext Excess	Comment
1997	0.55				-1.19	-0.26	0.34	-0.21	1.27	-0.01	0.06		2.84	0.18	0.11	0.97	0.48	3.06	0	1	10	3	2	Normal
1998	1.93				-0.33	1.01	0.91	-0.69	-1.03	0.83	0.36		2.34	-0.01	0.07	0.53	1.14	1.24	0	1	8	5	1	Excess
1999	-0.06				-0.79	-0.13	0.08	0.27	0.70	-0.27	-0.55		0.52	-1.10	-0.28	-0.22	-0.75	-1.58	0	2	12	0	0	Normal
2000	-1.02				-1.79	-0.31	-0.58	0.07	-0.87	-0.89	-1.16		0.88	-1.47	-0.39	-0.92	-1.12	-1.50	0	6	8	0	0	Drought
2001	0.32				0.06	2.11	0.50	0.42	0.60	0.85	-0.78		-0.26	0.53	-0.06	0.08	0.90	0.37	0	0	13	1	1	Normal
2002	-1.00				0.11	0.71	0.26	0.62	1.62	-0.19	-0.75		0.03	0.35	-0.15	-2.57	-0.09	0.42	1	1	12	1	0	Normal
2003	-0.49				0.66	0.19	-1.23	0.73	-0.62	0.50	-0.77		0.04	0.53	-0.04	-2.39	-0.17	0.68	1	2	12	0	0	Normal
2004	-0.15				-1.31	-0.32	0.55	0.07	0.15	-0.51	-0.67		-0.51	-0.31	-0.10	-0.27	-0.26	-0.44	0	1	13	0	0	Normal
2005	-0.65				0.14	-0.25	-0.38	-1.16	0.72	-0.94	-0.97		-0.30	-0.41	-0.13	0.24		-1.16	0	2	11	0	0	Normal
2006	1.45	1.73	1.66		0.93	1.42	1.33	0.42	1.15	0.94	1.46	1.19	0.89	-0.06	-0.16	1.26	0.36	1.78	0	0	7	10	0	Excess
2007	0.25	-0.08	-0.24		-0.02	0.60	0.24	-0.85	-1.07	1.30	-0.94	0.03	0.32	0.86	-0.10	-0.05	1.46	0.15	0	1	14	2	0	Normal
2008	-0.42	-0.62	-0.41		-0.18	-0.06	-0.93	-0.22	-0.79	-0.14	-1.35	-0.91	-0.39	-0.74	-0.26	-0.38	-0.17	-0.79	0	1	16	0	0	Normal
2009	-1.05	-0.48	-0.40		-0.74	-0.66	-0.92	0.01	0.25	0.02	-1.31	0.11	-0.75	-1.05	-0.33	-0.49	-1.14	-0.98	0	4	13	0	0	Normalw
2010	1.13	-0.32	0.36		0.15	0.96	0.49	0.83	0.60	1.05	-0.21	0.15	-0.17	1.46	-0.07	0.20	1.27	0.07	0	0	13	4	0	Normal
2011	0.11	-0.04	-0.41		-0.05	0.63	-0.70	0.26	1.03	1.10	-0.86	0.47	-0.61	0.41	0.04	0.80	0.30	-0.15	0	0	15	2	0	Normal
2012	1.33	0.56	-0.60		0.16	1.27	-0.33	0.87	1.71	1.54	-0.39	0.46	-0.80	0.79	0.03	1.02	1.34	1.69	0	0	10	7	0	Excess
Extreme Drought	1	0	0	1	1	2	1	0	0	1	0	0	1	0	0	2	2	0						
Drought	6	7	4	4	5	7	6	9	7	6	4	6	4	7	0	2	6	10	Ext Dro					1
Normal	35	27	31	19	38	35	35	36	34	36	31	36	40	38	49	21	35	32	Drought					7
Excess	9	7	5	6	7	8	9	5	9	8	5	8	6	4	1	3	8	8	Normal					33
Extreme Excess	1	2	2	0	2	1	2	1	2	1	3	3	3	2	1	1	1	1	Excess					8
Prob Ex Drought	2%	0%	0%	3%	2%	4%	2%	0%	0%	2%	0%	0%	2%	0%	0%	8%	4%	0%	Ext Excess					1
Prob Drought	12%	17%	10%	14%	10%	14%	12%	18%	14%	12%	10%	12%	8%	14%	0%	8%	12%	20%						
Prob Normal	70%	66%	78%	66%	76%	70%	70%	72%	68%	72%	78%	72%	80%	78%	98%	81%	71%	64%						
Prob Excess	18%	17%	13%	21%	14%	16%	18%	10%	18%	16%	13%	16%	12%	8%	2%	12%	16%	16%						
Prob Ext Excess	2%	5%	5%	0%	4%	2%	4%	2%	4%	2%	8%	6%	6%	4%	2%	4%	2%	2%						

Source: Kenya Meteorological Department.

FIGURE E.4. CALENDAR FOR MAIN CROPS IN KENYA



The following rainfall parameters were estimated for each crop season (sowing, growing, and harvesting):

- » Cumulative rainfall (cumrain)—The sum of daily precipitation in millimeters for each season described above.
- » Number of rainy events (events)—The number of days in the season in which rain is greater than 5 mm.

Figure E.5 illustrates the average cumulative rainfall during 1997–2012, which covers the NASA rainfall database for the March–November timeframe.

Figure E.5 shows that Western and Nyanza Provinces are the most humid, getting more than 1,000 mm of rainfall on average. North and Coast Provinces follow with more than 800 mm of rainfall on average. But most of the center of the country is very arid, with less than 400 mm of rainfall on average for this period of the year.

To determine the relationship between yield and rain, linear regression models were run using both rain parameters during each stage of the crop cycle as the explanatory variable for yield.

$$\begin{aligned} \text{Yield} &= \beta_0 + \beta_1 \text{cumrainsow} \\ \text{Yield} &= \beta_0 + \beta_2 \text{cumraingrow} \\ \text{Yield} &= \beta_0 + \beta_3 \text{cumrainharvest} \\ \text{Yield} &= \beta_0 + \beta_4 \text{eventsow} \\ \text{Yield} &= \beta_0 + \beta_5 \text{eventgrow} \\ \text{Yield} &= \beta_0 + \beta_6 \text{eventharvest} \end{aligned}$$

FIGURE E.5. MAP OF AVERAGE CUMULATIVE RAINFALL, BY PIXEL

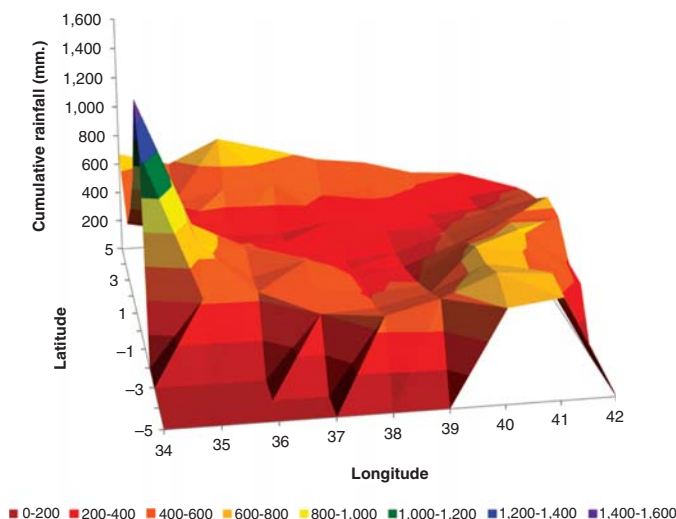


TABLE E.2. SIMPLE LINEAR REGRESSION RESULTS FOR MAIZE

ProvNo	Province	CumRain1	Cumrain2	CumRain3	Events1	Events2	Events3
1	Central	2.0%	60.0%	0.0%	4.3%	59.6%	0.0%
2	Coast	8.0%	44.3%	0.4%	5.3%	20.7%	0.0%
3	Eastern	0.3%	6.6%	0.2%	1.8%	4.1%	0.6%
6	Nyanza	2.8%	0.1%	0.0%	2.3%	0.0%	1.3%
7	Rift Valley	1.1%	0.8%	3.3%	5.0%	0.0%	3.5%
8	Western	9.4%	13.1%	12.8%	5.4%	5.0%	4.2%

TABLE E.3. MULTIPLE LINEAR REGRESSION RESULTS FOR WHEAT

ProvNo	Province	CumRain1-CumRain3	Events1-Events3
1	Central	10.1%	31.1%
3	Eastern	18.7%	36.3%
7	Rift Valley	28.5%	28.4%

TABLE E.4. SIMPLE LINEAR REGRESSION RESULTS FOR WHEAT

ProvNo	Province	CumRain1	CumRain2	CumRain3	Events1	Events2	Events3
1	Central	7.3%	0.0%	0.7%	4.4%	3.4%	0.8%
3	Eastern	3.7%	17.0%	1.2%	1.0%	32.6%	1.1%
7	Rift Valley	4.4%	22.1%	1.7%	12.1%	20.3%	2.3%

The main objective of the regression analysis is to calculate the determination coefficient (R^2) for each variable. The determination coefficient is a measure of the proportion of the variability in yield explained by each rainfall variable. Therefore, the higher the R^2 , the more likely the particular rain parameter and yield are related. Regression analyses for each crop and province follow.

Maize: Table E.2 summarizes the regression determination coefficient for each rain parameter by province.

Table E.2 shows that cumulative rainfall seems to better explain maize yield than the number of rainy events. Cumulative rainfall during the growing season explains a significant amount of the variability in maize yield for the Central and Coast Provinces. The number of rainy events during the growing season also explains a significant proportion of variability in maize yield in these provinces, but slightly less than cumulative rainfall. Rain during the harvest season is not significant in explaining maize yield.

Wheat: Wheat production data were only available for three provinces. Table E.3 summarizes the regression determination coefficient for a multiple linear regression analysis using the three seasons of the cumulative rainfall and the three seasons of the rainy event variables by province.

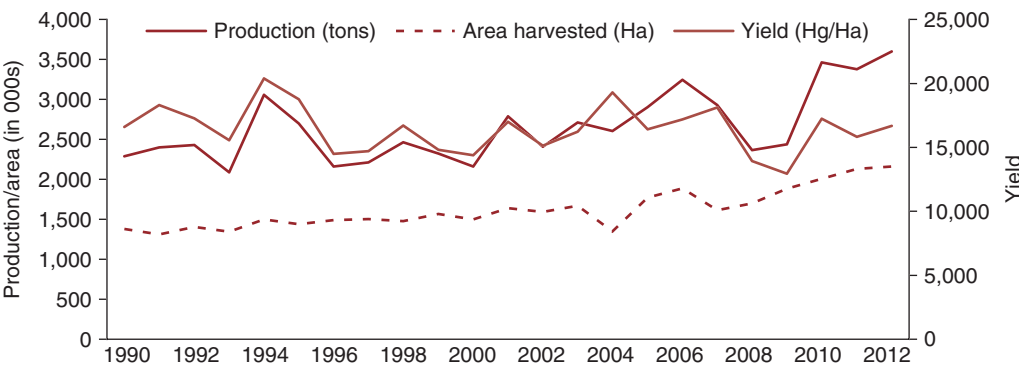
As table E.3 shows, generally speaking, the number of rainy events in the three seasons (sowing, growing, and harvesting) explains more variability in wheat yield than cumulative rainfall does. Table E.4 summarizes the simple linear regression analysis performed using each variable as a regressor.

Once each season is analyzed separately, it can be seen that as with maize, the growing season explains more variability in wheat yield than the other seasons. But the number of rainy events during the growing season is the most significant variable, explaining between 19 and 33 percent of the variability in yield.

APPENDIX F

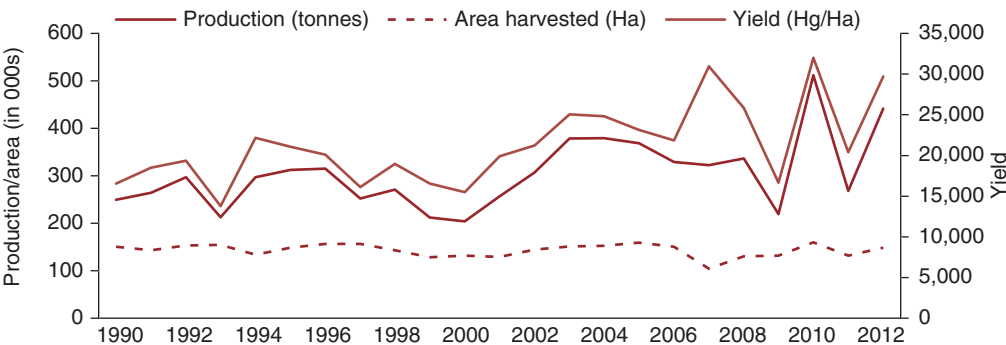
CROP PRODUCTION TRENDS

FIGURE F.1. MAIZE PRODUCTION, 1990–2012



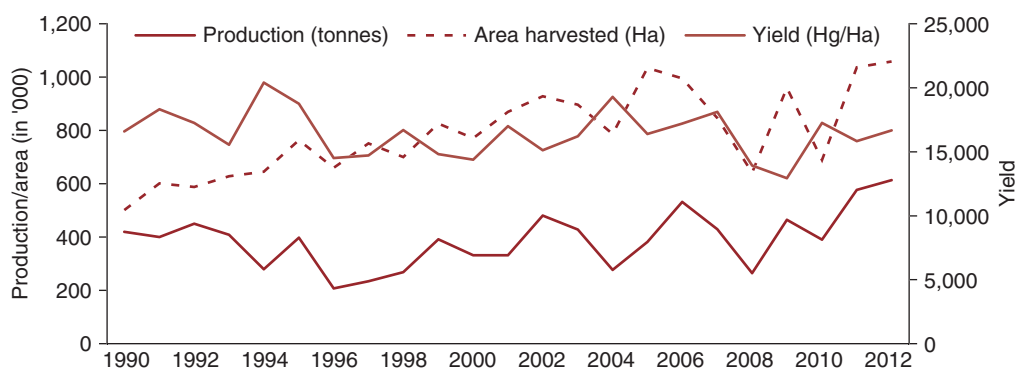
Source: FAOSTAT.

FIGURE F.2. WHEAT PRODUCTION, 1990–2012



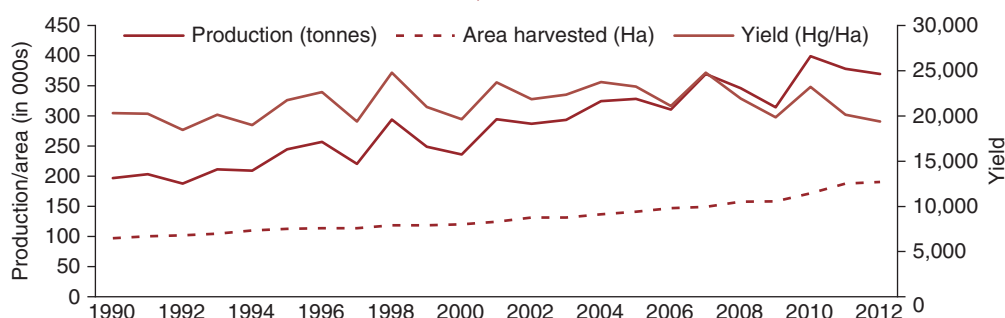
Source: FAOSTAT.

FIGURE F.3. DRY BEAN PRODUCTION, 1990–2012



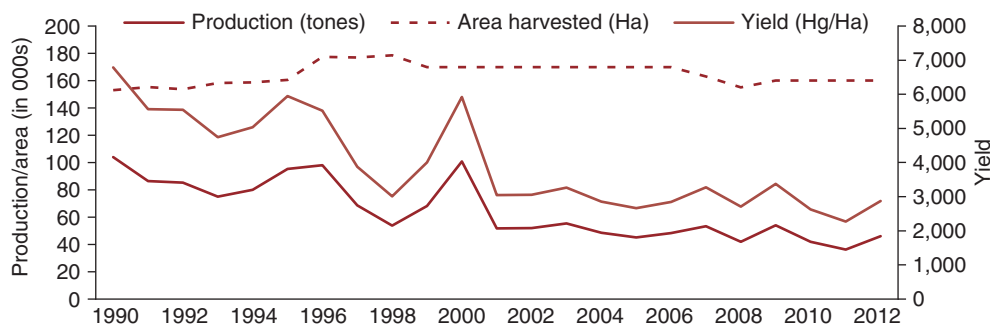
Source: FAOSTAT.

FIGURE F.4. TEA PRODUCTION, 1990–2012



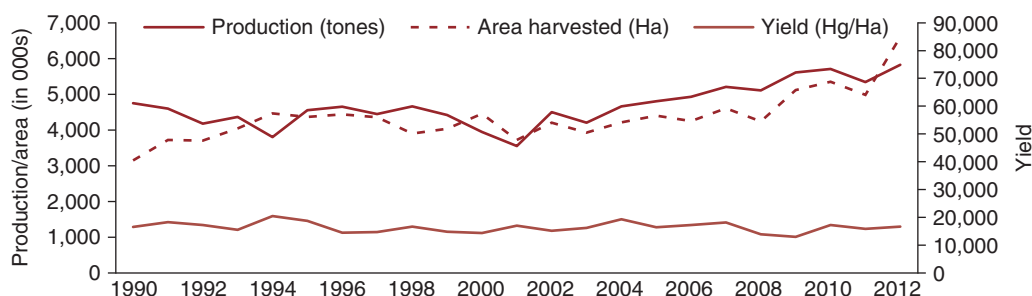
Source: FAOSTAT.

FIGURE F.5. COFFEE PRODUCTION, 1990–2012



Source: FAOSTAT.

FIGURE F.6. SUGARCANE PRODUCTION, 1990–2012



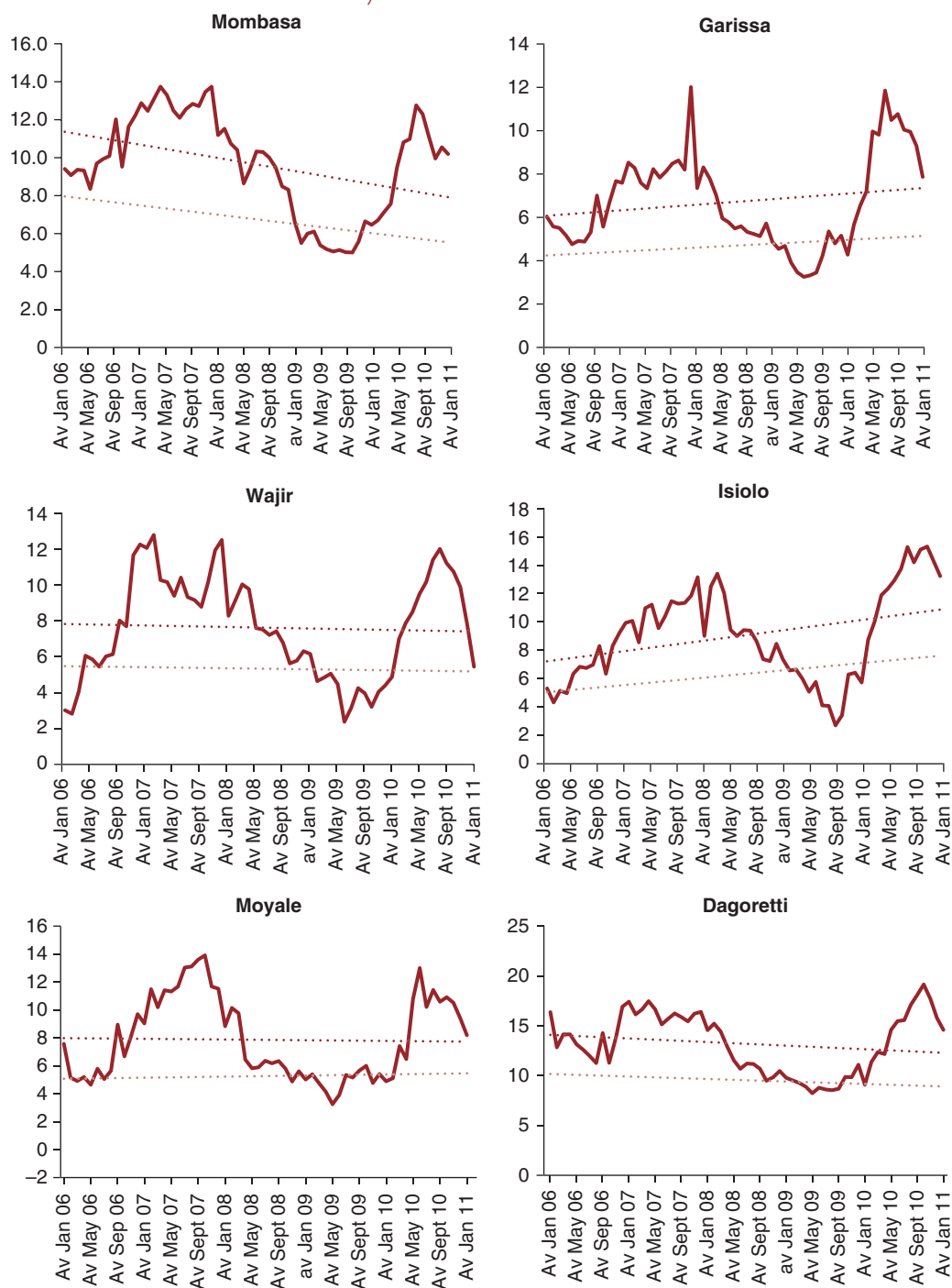
Source: FAOSTAT.

APPENDIX G

LIVESTOCK TERMS OF TRADE ANALYSIS



FIGURE G.1. TOT OF INDIVIDUAL MARKETS IN NORTHERN KENYA, 2006–11 (number of 90-kg bags of maize exchanged for 1 beef cow)



Source: MoALF 2014.

APPENDIX H

OPTIONS FOR SCALING UP LIVESTOCK INSURANCE IN KENYA

In the recent past, livestock insurance has gained a lot of interest in Kenya as a viable solution to addressing covariate risks like those associated with drought. International Livestock Research Institute (ILRI) has piloted index based livestock insurance (IBLI) in arid and semiarid land (ASAL) regions of Kenya. The pilot started in Marsabit County in 2010 is now in three counties (Marsabit, Wajir, and Isiolo), and ILRI has plans to expand to all 14 counties³⁴ in ASAL regions. Through IBLI, farmers are able to cushion themselves against the impact of droughts, which have increased in frequency and severity, a phenomenon associated with climate change. In Kenya, 28 severe droughts have been recorded in the last 100 years, including four droughts in the last 10 years. In the major drought of 2000, major animal losses occurred. Analysis undertaken by ILRI on IBLI has shown that providing access to insurance creates an effective safety net for vulnerable-but-non-poor pastoralists.

The importance of agricultural insurance in addressing food security seems to have been embraced by Kenya's current crop of politicians. In the 2013 presidential election, provision of agricultural insurance was one of the key pledges of candidates. The coalition that won the election included livestock insurance as part of its party manifesto. Kenya's agricultural/livestock insurance policy is clearly spelled out in Executive Order No. 2, which outlines what the current government intends to achieve. Medium Term Plan II (MTP-II), which covers 2013–2017, recognizes the importance of livestock insurance and talks of establishing a National Livestock Insurance Scheme.

To keep its political promise and to implement the projects spelled out in MTP-II, the government of Kenya (GoK) through the Ministry of Agriculture, Livestock and Fisheries (MoALF) sought support from the World Bank Agriculture Insurance Development Program (AIDP) to assist in formulating a large-scale national agricultural insurance program as a public-private partnership (PPP). Starting in January 2014,

³⁴ Lamu, Isiolo, Laikipia, Mandera, Marsabit, West Pokot, Turkana, Tana River, Garissa, Baringo, Samburu, Narok, Samburu, and Wajir Counties.

the AIDP team worked closely with State Department of Livestock (SDL) to think through an appropriate livestock insurance PPP for the government. In partnership with the World Bank's Financial Sector Development unit and ILRI, AIDP will assist the MoALF in implementing a macro-level livestock Normalized Difference Vegetation Index (NDVI) insurance program to address the SDL's objective of enhancing resilience and reducing vulnerability of small-scale pastoral farmers.

Under the SDL-driven livestock insurance initiative, a graduated approach is envisaged, with government purchasing an insurance product at a macro level for targeted vulnerable households, while wealthier households will be able to purchase the product on an individual, voluntary basis. It is envisaged that the macro livestock insurance product will offer asset protection, having early payouts with the onset of drought to empower pastoralists to protect their herds. The voluntary component is expected to initially be an asset replacement-type product, paying out at the end of the drought season; however, in the medium term, the SDL with the support of AIDP will develop an asset protection-type product to be offered to this group as well. The asset protection cover would use the ILRI NDVI database and methodology to make timely payouts to targeted vulnerable pastoralists (beneficiaries) at the onset of severe drought, thus reducing livestock mortality and asset depletion. This product assumes that investments will strengthen availability of animal feed, destocking, and other critical market services.

The macro-level NDVI index insurance cover would be purchased by SDL-GoK as part of their national drought risk reduction and risk financing strategy for pastoralists in ASAL regions; SDL would be the insured party, responsible for payment of the premium for the macro-level coverage. SDL has also requested that AIDP design: (1) voluntary top-up coverage for targeted beneficiaries; and (2) a micro-level individual livestock producer policy. AIDP has proposed to SDL linkage of the macro-level livestock index insurance product with the Hunger Safety Net Program (HSNP) program in Mandera, Marsabit,

Turkana, and Wajir Counties and use of HSNP's livestock census and classification system for targeting. Beneficiaries of the SDL-paid macro coverage will be "vulnerable pastoralists" immediately above HSNP target beneficiaries (the 100,000 poorest households) in these counties. AIDP has agreed to target households above those already receiving a nonconditional cash transfer from HSNP and to provide insurance coverage for five Tropical Livestock Units (TLUs) for selected households.

HSNP counties were selected to introduce the macro-level insurance product because household censuses have already been done in them, their poverty levels have been determined, and the infrastructure to pay herders (in the event of a payout) has been established. HSNP's infrastructure will be used to register and make payouts³⁵ to the SDL beneficiaries. ILRI-supported IBLI will also be available and accessible to those who want to top-up (e.g., those covered by the government-paid insurance) or those who want to voluntarily purchase it (e.g., those who are not under macro-level coverage). The voluntarily purchased coverage will be available in more counties than those covered under HSNP (because it will not require HSNP infrastructure to operate and there would be no need to target).

Strong synergies would be gained from working closely with the World Bank-supported Regional Pastoral Livelihood Resilient Project (RPLRP) to promote livestock insurance in the targeted counties. RPLRP's objective is to enhance the resilience of pastoral and agro-pastoral communities in drought-prone areas through regional approaches. The project will be implemented in 14 counties, and one of its key components is pastoral risk management, which corresponds well with the objective of promoting livestock insurance.

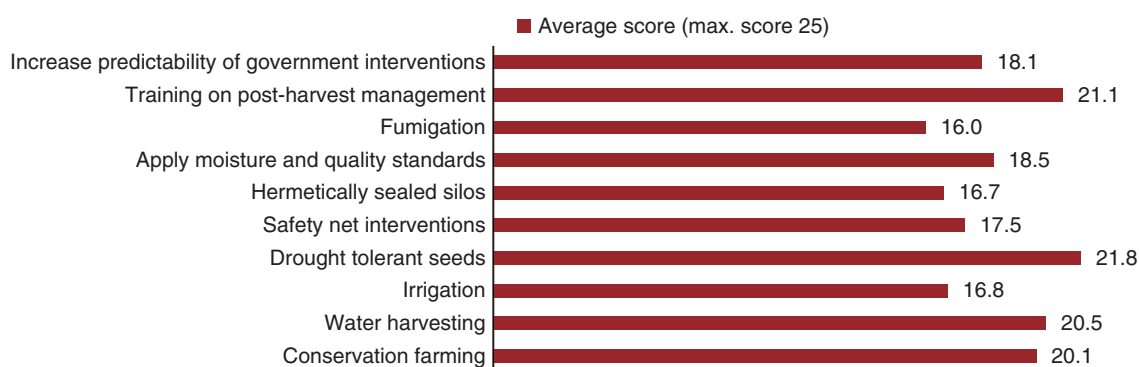
³⁵ HSDL is working with Equity Bank to ensure that every beneficiary household of the cash transfer program has a bank account. It is hoped that a similar agreement can be reached with Equity Bank for the separate AIDP-SDL macro-level livestock index insurance program.

APPENDIX I

RESULTS OF SOLUTIONS FILTERING PROCESS

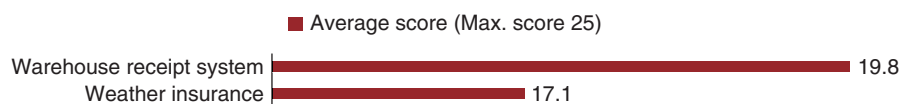
FOOD CROPS

FIGURE I.1. PRIORITIZATION OF RISK MITIGATION SOLUTIONS FOR FOOD CROPS



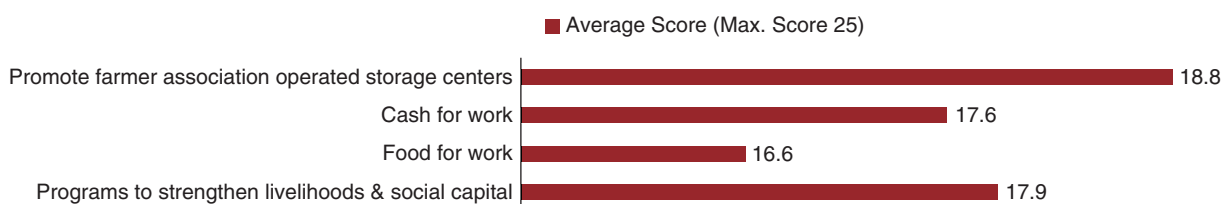
Source: Authors' notes.

FIGURE I.2. PRIORITIZATION OF RISK TRANSFER SOLUTIONS FOR FOOD CROPS



Source: Authors' notes.

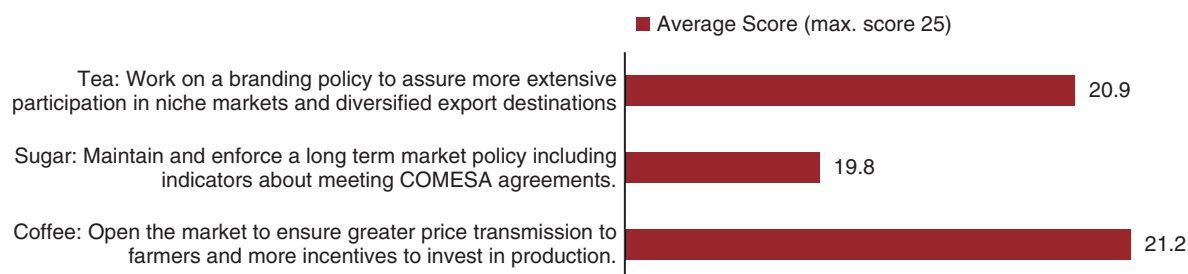
FIGURE I.3. PRIORITIZATION OF RISK COPING SOLUTIONS FOR FOOD CROPS



Source: Authors' notes.

CASH CROPS

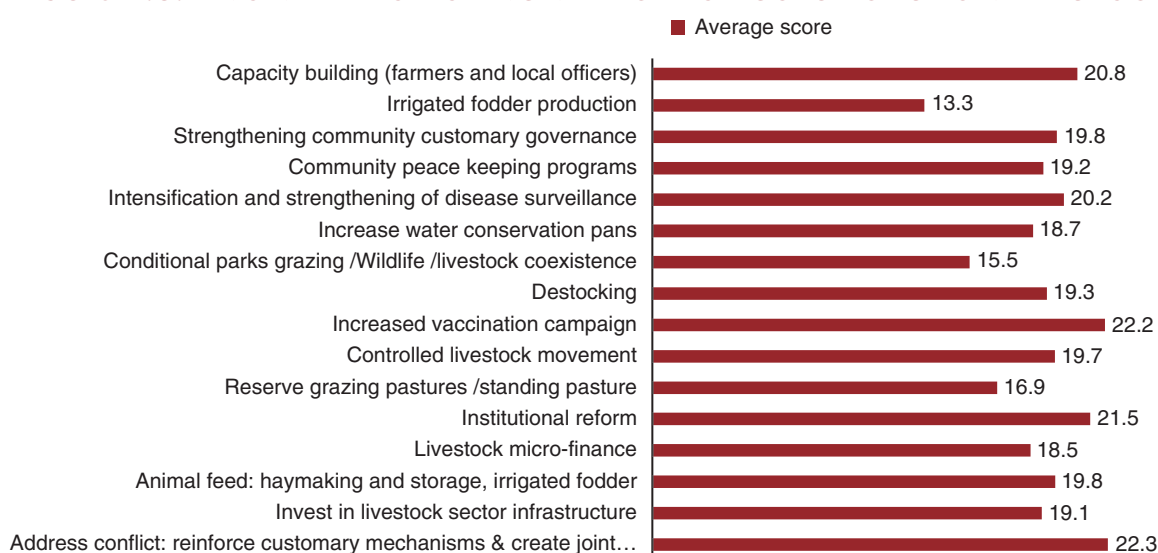
FIGURE I.4. PRIORITIZATION OF RISK MITIGATION SOLUTIONS FOR CASH CROPS



Source: Authors' notes.

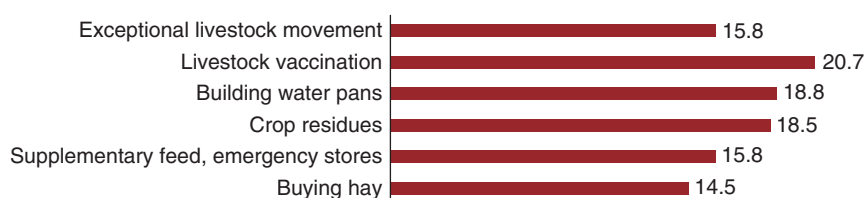
LIVESTOCK

FIGURE I.5. PRIORITIZATION OF RISK MITIGATION SOLUTIONS FOR LIVESTOCK



Source: Authors' notes.

FIGURE I.6. PRIORITIZATION OF RISK COPING SOLUTIONS FOR LIVESTOCK



Source: Authors' notes.

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