AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

MOZAMBIQUE: AGRICULTURAL SECTOR RISK ASSESSMENT

RISK PRIORITIZATION

Kilara C. Suit and Vikas Choudhary

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The U.S. Government's Global Hunger & Food Security Initiative
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ACRONYMS AND ABBREVIATIONS

AES	Agriculture and Environment Services
AfDB	African Development Bank
ALES	Automated Land Evaluations System
ARMT	Agricultural Risk Management Team, World Bank
CBSD	Cassava Brown Streak Disease
CCGC	Coordinating Council for Disaster Risk Management
CIMMYT	International Centre for Maize and Wheat Improvement
CMD	Cassava Mosaic Disease
DANIDA	Ministry of Foreign Affairs of Denmark
EACC	Economics of Adaptation to Climate Change: Mozambique
FAO	Food and Agriculture Organization (of the UN)
FAOSTAT	Food and Agriculture Statistical Databases (UN)
FCMNB	Financial and Private Sector Development, Non-Bank Financing Institutions Unit
FEWSNET	Famine Early Warnings System Network
FRELIMO	Mozambique Liberation Front
G-8	Group of Eight
GCM	Global Climate Models
GDP	Gross Domestic Product
GFDL	Geophysical Fluid Dynamics Laboratory
GIEWS	Global Information and Early Warning System
ha	Hectare
ICT	Information and Communication Technology
IFPRI	International Food Policy and Research Institute
IIAM	Agricultural Research Institute of Mozambique
INAS	National Institute for Social Action
INGC	National Institute for Disaster Management
IPM	Integrated Pest Management
MASA	Ministry of Agriculture and Food Security
MIC	Mozambique Ministry of Industry and Commerce
MICOA	Ministry for Coordination of Environmental Affairs
MMAS	Ministry of Women and Social Action
MPF	Ministry of Planning and Finance
MT	Metric Ton
ND	Newcastle Disease
NGO	Nongovernmental Organization
OIE	World Organization for Animal Health
PEDSA	Strategic Plan for Agricultural Development
PES	Economic and Social Plan
PNISA	National Investment Plan for the Agrarian Sector in Mozambique
PPP	Public-Private Partnership
RENAMO	Mozambican National Resistance
SADC	Southern African Development Community
SETSAN	Technical Secretariat for Food Security and Nutrition
SIMA	Agricultural Market Information System
TIA	Mozambique Agricultural Census
UNDP	United Nations Development Programme
USAID	U.S. Agency for International Development
WFP	World Food Programme

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EXECUTIVE SUMMARY

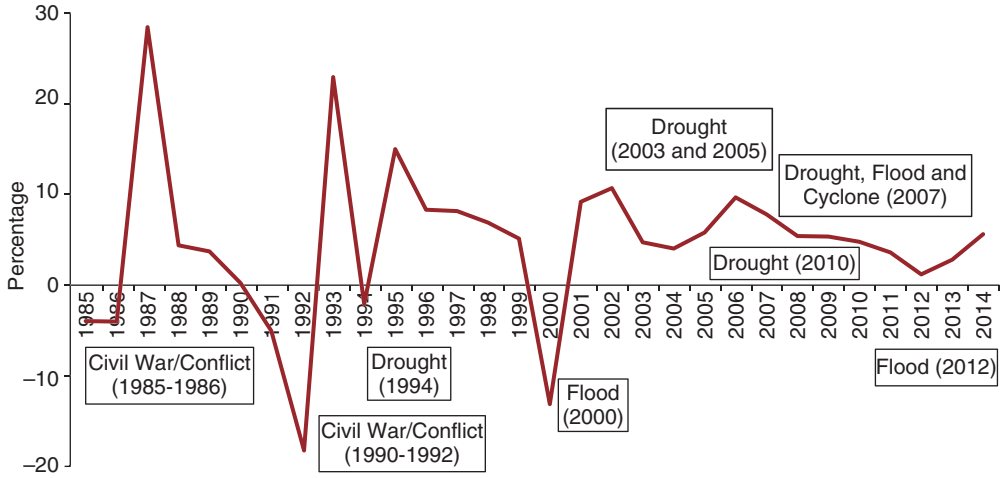
Agriculture plays a key role in the economy of Mozambique. It accounts for 31.8 percent of gross domestic product (GDP), providing a livelihood to almost 81 percent of the labor force. The majority of production undertaken by smallholder families is for consumption, and the main staple crops produced in the family agricultural sector are maize, sorghum, rice, millet, potatoes, sweet potatoes, cassava, and beans. Cash crops frequently grown by households include cotton, tobacco, copra, cashew nuts, sesame, sugar beans, sunflower, bananas, and sugarcane. Many family farms combine food crops with a single cash crop. The majority of Mozambican agriculture is rain fed and therefore very sensitive to climatic conditions. Climate change models indicate an increased likelihood of extreme weather events such as flood, drought, and cyclones leading to severe negative impacts on the agricultural sector in Mozambique.

Improved agricultural risk management is one of the core enabling actions of the Group of Eight's (G-8) New Alliance for Food Security and Nutrition. The Agricultural Risk Management Team (ARMT) of the Agriculture and Environment Services (AES) Department of the World Bank, at the request of the G-8, conducted an agricultural sector risk assessment in Mozambique with several goals: to provide a robust analytical underpinning to the Strategic Plan for the Development of the Agrarian Sector (PEDSA) and the National Investment Plan for the Agrarian Sector in Mozambique (PNISA), to incorporate agricultural risk perspective into decision making, and to build the capacity of local stakeholders in risk assessment and management.

Figure ES.1 shows the annual percentage growth in agriculture value added and the impacts of major shocks to the sector. The periods of intense civil war (1985–86 and 1990–92), drought (1994), and flood (2000) resulted in negative growth rates in the agricultural sector. Since 2000, the growth rate has not dipped into negative territory, but the occurrence of agricultural risk has had an adverse impact on agricultural growth.

The frequent occurrence of agricultural risks creates food affordability and availability problems for vulnerable rural populations and urban consumers, and results in sudden spikes in the food insecure population (figure ES.2).

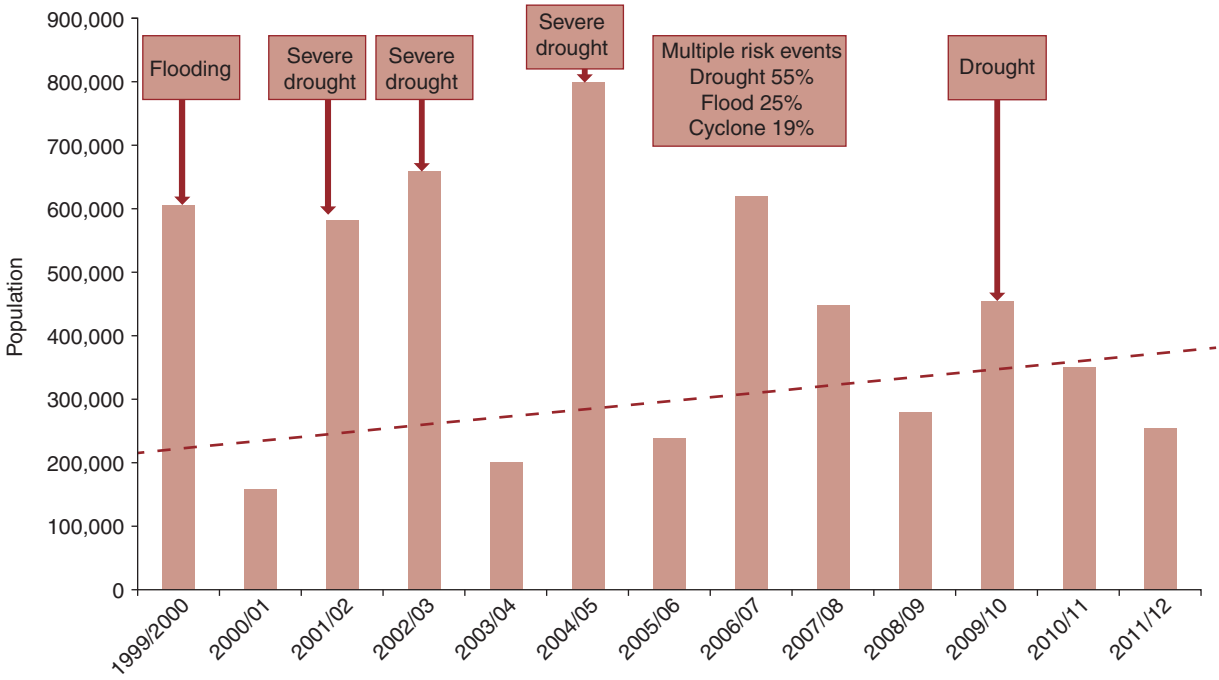
FIGURE ES.1. MAJOR SHOCKS TO CROP AND LIVESTOCK PRODUCTION: ANNUAL PERCENTAGE GROWTH IN AGRICULTURE VALUE ADDED



Source: World Development Indicators.

Update: Annual percentage growth in agriculture value added has dropped from 2011 at 5.8 percent to 2 percent in 2012 and 3.5 percent in 2013. A drop would be expected to be seen after the large flood of 2015.The figures that would reflect the effect of the flood in 2015 are currently not available.

FIGURE ES.2. ACUTE FOOD INSECURE POPULATION IN MOZAMBIQUE



Source: SETSAN reports.

Production risks: The main sources of production risk observed through analysis of data and interviews with a range of farmers and other stakeholders are drought, flood, cyclone, and pests and diseases. The absence of consistent, time-series data on disaggregated production output posed a challenge, and thus correlation between production risk and production declines could not be performed. The bulk of the analysis relied on data gleaned from multiple sources.

Drought was observed to be the most important agricultural risk, considered probable with catastrophic

consequences. An agricultural drought occurs when soil moisture is significantly deficient, resulting in reduced crop yields and output. This can be the result of low overall annual rainfall or variations in the timing and duration of seasonal rainfall, that is, late onset of rain, early cessation of rain, long rain-free periods, and so on. Weather analysis shows significant dry years in 1979 and 1992, with a lack of rain in specific regions indicated in 1983, 1988, 1994, 2005, 2008, and 2009. The analysis also depicts a declining trend of deficit rainfall events, highlighting that cumulative precipitation in Mozambique is increasing, on average.

Flooding is the second-most important risk in Mozambique, with a high probability of occurrence and critical consequences. Incidence of this risk generally occurs between December and February during the wet season and is often the result of heavy rainfall in a short period of time. This heavy rainfall not only causes flash flooding, but also causes rivers to burst their banks and, particularly for farmers around irrigation infrastructure, for dikes to burst and dams to fail. There is often little time to prepare and effects tend to be localized, compared with the often wide-reaching nature of drought. Weather analysis highlights significant events in 1981 in the south, 1989 in the north, and in 1999–2001 across the country (including devastating floods seen in 2000). The year 2013 witnessed catastrophic flooding, leading to severe losses across the country. The analysis also indicates a trend of rising excess rainfall events, suggesting that flooding might become more frequent in future.

Cyclones are frequent along the Mozambican coastline during the wet season, but are usually not considered particularly destructive if they are below Category 4. The main damage caused by cyclone events is inflicted on farm infrastructure: houses, storage, and so on, but in terms of agriculture, most damage is borne by tree crops: cashews, coconuts, and fruit trees.

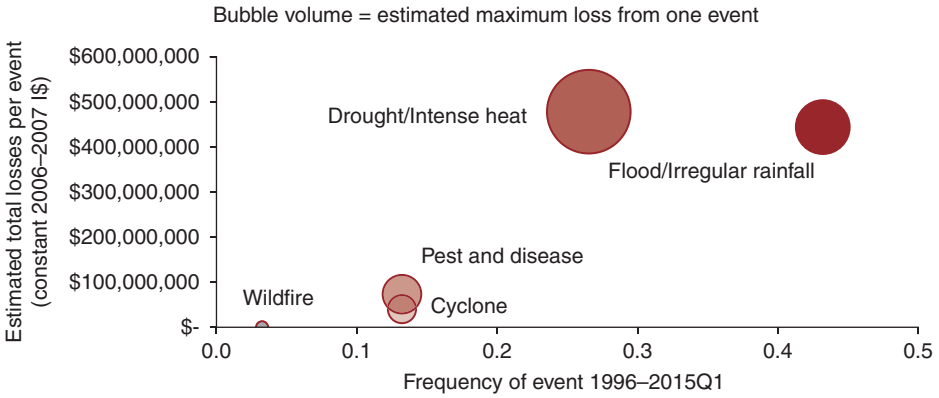
Market risks: Price volatility (domestic as well as international), exchange rate volatility, input volatility, and counterparty risk are some of the major market risks in Mozambique. They, however, are less significant than production risks, and in many instances, crop failure caused by production risks triggers price spikes in local markets.

Abrupt and steep price spikes and falls, often driven by underlying production deficits, market factors, or other exogenous factors, are a cause of serious concern with severe implications for consumers and producers alike. Although the northern region is more self-sufficient in food, local events and regional conditions (in Malawi, Tanzania, and so on) contribute to price volatility. The southern regions are more likely to experience food deficits and often rely on food imports from South Africa. These regions are more exposed to international price volatility, passed down to the domestic markets, as well as local production failures. Commodity price analysis demonstrated relatively fewer episodes of sudden spikes and a general trend of increasing prices, especially over the past five years. The price spike of white maize in 2006 was driven by local events (largely drought in 2005), whereas the 2008–09 jump was a pass-through effect of the global food price crisis. Because of heavy reliance on imports for rice, there is a resulting direct transmission of international price volatility to domestic markets. Among export commodities, tobacco and cashews do not demonstrate high volatility. Cotton, conversely, is exposed to severe price volatility.

Enabling environment risks: Enabling environment risk covers many different aspects of legal, institutional, fiscal, and policy volatility and/or uncertainty that affect stakeholders' ability to undertake their business within a sector. In Mozambique, the enabling environment is relatively weak, but stable, and thereby is not much of a risk for the agricultural sector. Conflict and insecurity, political instability, and regulatory risk can have an adverse impact on the agricultural sector.

Available data on actual losses resulting from adverse events in Mozambique are not particularly accurate or consistent within individual data sources. In an attempt to facilitate comparison and ranking of the costs and losses resulting from various events, different data sources were combined to generate a more or less consistent time series. Figure ES.3 uses 2000–2015Q1 data from the Technical Secretariat for Food Security and Nutrition (SETSAN) and other sources to quantify the frequency and severity of the impacts of major production risks.

FIGURE ES.3. ESTIMATED AGGREGATE TOTAL LOSSES BY RISK EVENT



Based on the assessment team's evaluation, which combined qualitative and quantitative analysis, drought and flood emerge as the two biggest agricultural risks in Mozambique. These are followed by pest and disease outbreaks, international price volatility, and domestic price volatility, which are often difficult to qualify.

To address the priority risks, the assessment deployed a holistic agricultural risk management framework, composed of mitigation (action taken to reduce the likelihood of events, exposure, and/or potential losses), transfer (risk transfer to a willing party, at a fee or premium), and coping solutions (activities geared toward helping cope with losses) to identify a list of potential interventions. Risk transfer solutions (insurance and hedging), owing to Mozambique's specific context, have limited applicability and will be quite challenging to implement. Microlevel options such as public-private partnership would require significant public investments in data and substantial growth in credit or input utilization. At the mesolevel, low levels of rural lending and lack of direct regulatory incentives for lenders to transfer portfolio-level agricultural risk means any form of unsubsidized mesolevel agricultural insurance program would have limited uptake and be unsustainable. Macrolevel sovereign agricultural risk financing and insurance would need to be looked at carefully through the lens of what the government thinks their contingent liability to the agricultural sector is. Coping solutions (social safety net programs) are required and quite important in Mozambique; however, they do not address fundamental risk issues in the agricultural sector and have limited applicability as a long-term solution. As ex post actions, coping solutions are generally expensive and do not transfer or mitigate the risk or help with making the overall sector and those within the sector more resilient in the long run. Risk mitigation is perhaps the most needed, and the most ignored, with the highest returns in addressing short- and long-term risk issues in Mozambique's agricultural sector. It is important to highlight that most of these potential interventions are complementary in nature, and most of them are required to effectively address agricultural risks. Nonetheless, considering the resource limitations, decision filters (see table ES.1) were used to help evaluate and prioritize interventions with the greatest potential to generate sizable risk management benefits.

Based on the prioritization of risk and intervention measures, the following three intervention categories might yield greatest risk management benefits:

1. **Water management:** Flood and drought are the two biggest risks for the agricultural sector in Mozambique and effective and efficient water management is a necessary precondition for managing both. This might entail (a) improved irrigation for drought management, (b) flood control infrastructure, and (c) improved water management practices.
   a. ***Irrigation:*** Irrigation has the potential to generate a sizable gain in household welfare, boost agricultural growth, improve food security, mitigate the impact of drought, and promote overall economic growth in Mozambique. However, the performance record of irrigation

TABLE ES.1. FILTERING OF RISK MANAGEMENT INTERVENTIONS AND POTENTIAL FOR MULTIPLE "WINS"

	Reduces the Risk	Reduces the Losses	Compensates after the Loss	Improves the Yield	Climate Change Mitigation	Climate Change Adaptation
Soil and water conservation measures (for example, conservation agriculture)	Y	Y	N	Y	Y	Y
Improved access to extension services	Y	Y	N	Y	Y	Y
Improved water management practices	Y	Y	N	Y	N	Y
Altered cropping patterns	Y	Y	N	N	Y	Y
Flood control infrastructure investment (dikes, drainage, and so on)	Y	Y	N	Y	N	Y
Small-scale irrigation	Y	Y	N	Y	N	Y
Large-scale Irrigation	Y	Y	N	Y	N	Y
Improved market information system	Y	Y	N	N	N	N
Building tolerant varieties system (flood, drought and disease-tolerant varieties)	Y	Y	N	N	N	Y
Timely and reliable availability of weather information to farmers and other stakeholders	N	Y	N	Y	N	Y
Regional coordination	Y	Y	N	N	N	Y
Promotion of integrated pest management (IPM)	Y	Y	N	Y	N	N
Subsidized crop insurance (for example, bundled with credit or input)	N	N	Y	Y	N	N
Commercial catastrophic weather insurance	N	N	Y	N	N	N
Sovereign risk financing	N	N	Y	N	N	N
Saving/credit	N	N	Y	N	N	N
On-farm storage	N	N	Y	N	N	N
Social safety net programs (for example, food/cash/ vouchers for work, food aid)	N	N	Y	N	N	Y
Facilitate temporary migration	N	N	N	N	N	N

schemes is very mixed, which at times could result in increasing exposure to risk (for example, regular flooding). To reverse the declining investment in irrigation, the government of Mozambique approved a National Irrigation Strategy for 2011–19. If designed appropriately, irrigation systems could help reduce drought risk and manage flood risk.

b. ***Flood control infrastructure:*** Thirteen big rivers flow across from southern Africa and through Mozambique, exposing the agricultural sector relying on these rivers to frequent flooding. Dams, dikes, and drainage systems are some of the flood control infrastructure that can effectively mitigate the impact of flood. Unfortunately, the existing condition of flood infrastructure in Mozambique is poor and in dire need of repair. Furthermore, the current flood control infrastructure must be significantly expanded to adequately address frequent flooding as well as extreme flood events.

c. ***Improved water management practices:*** Water deficit (drought) and water excess (flood) are likely to pose greater risks as a result of climate change; hence, effective water management has to be the cornerstone of any risk management strategy. This involves the planning, developing, distributing, and managing the optimal use of water resources. Activities such as improving data and reforming water governance—along with education and training on water management—would aid in water availability, particularly in drought-prone areas.

2. **On-farm practices for improved risk management:** Management of drought, flood, and pest and diseases requires effective on-farm practices on individual agricultural plot and community structures. This includes (a) soil and water conservation measures, (b) improved access to extension services, and (c) altered cropping patterns.

a. ***Soil and water conservation measures, including conservation agriculture:*** Soil and water conservation measures (such as sand dams, Ngare or Mhindu ridging, afforestation/reforestation, conservation agriculture practices) are effective and efficient mechanisms for mitigating the risk of droughts and/or floods. In addition, they yield significant productivity gains and help in mitigating the effects of climate change.

b. ***Improved access to extension services:*** Improved access to extension services would allow producers to be better informed, and to access advice, technology, and inputs to alter their agronomic practices in view of the current and emerging risk profile of agricultural sector. Although the coverage of extension services is increasing, it only reaches 12 percent of farming households in Mozambique. The bulk of the farming households do not have access to any extension services and further investment and expansion of extension services and development of new delivery channels will assist in improved management of agricultural risks.

c. ***Altered cropping patterns:*** Over the past few decades, Mozambique has witnessed changes in traditional cropping patterns. For instance, millet and sorghum (more drought tolerant) have replaced maize (a more sensitive crop), especially in low rainfall areas, resulting in increased risk exposure. Losses from drought could be significantly reduced by replacing maize with sorghum, millet, or root crops in areas where drought is particularly common. Root crops are generally more drought tolerant than are cereals. The trend of climate change will likely alter cropping calendars and seasonal agro-climatic conditions, which will necessitate changing cropping pattern and practices to better adapt to climate change.

3. **Farmer access to information (for example, weather, price, diseases, early warning):** Ready access to timely, accurate, and localized information about impending events that could have severe impacts on crops is a prerequisite for enabling any preemptive actions by farmers to reduce exposure or losses. This may mean relocating and minimizing losses before a

flood or postponing planting or early harvesting, as well as altering agronomic practices. Besides helping managing risks, this information could also help farmers manage inputs better and improve yields.

These three intervention categories align with PNISA and PEDSA, and many of them are being implemented and are having positive impacts, albeit at a smaller, localized level. Greater emphasis should be placed on scaling up these interventions to the national level to make a meaningful impact on the agricultural sector in Mozambique. This would require understanding the landscape of these interventions, assessing their relative efficacy, understanding principal challenges to success and scale, and identifying leverage points and necessary interventions to increase access to a wide majority of agricultural sector stakeholders. Assessing solutions to help prioritize specific interventions, scaling up priority programs, and putting in place a risk management implementation plan will be the next steps in the process of building resilience in Mozambique's agricultural sector.

CHAPTER ONE
INTRODUCTION AND CONTEXT

Agricultural risk management is a central issue that Mozambique faces in development, and multiple stakeholders have analyzed this challenge, sometimes with different terminology and focusing on varying aspects.[1] Risk is considered the probability of harmful consequences or expected losses resulting from interactions between natural or human-induced hazards and vulnerable conditions.[2] This is in comparison with trends that are longer term or "chronic" patterns (reversible or irreversible) that provide context for impact on agriculture or constraints that are existing conditions/bottlenecks that hamper the smooth functioning of the sector and lead to suboptimal performance. The government of Mozambique has adopted the Strategic Plan for Agricultural Development ([PEDSA][3] 2010–19) that focuses on (i) increasing the availability of food in order to reduce hunger through growth in small producer productivity and emergency response capacity; (ii) enlarging the land area under sustainable management and the number of reliable water management systems; (iii) increasing access to the market through improved infrastructures and interventions in marketing; and (iv) improving research and extension for increased adoption of appropriate technologies by producers and agro-processors.

To help implement PEDSA, in May 2013 the government adopted the PNISA, which has also been accepted by all the major stakeholders as the roadmap for national agricultural development. Components of the 2010–19 PEDSA seek to minimize and mitigate agricultural risks as well as to prepare the sector for dealing with climate change. There are also World Bank operations of note involved in making the sector more resilient and improving access to predictive information for farmers and early warning systems including the ongoing climate change development policy operation

[1] Related reports that address aspects of agricultural risks include, among others: (FAO/WFP, 2010); (SETSAN, 2010); (IFPRI, 2011); the World Bank's Agribusiness Indicators: Mozambique (2012); (System), 2012); (FEWSNET, 2006); and (INGC, 2009b).

[2] Definition as found on World Bank—Forum for Agricultural Risk Management for Development (FARMD) website.

[3] PEDSA is integrated into the instruments established by the National Planning System such as, the Green Revolution Strategy, the Priorities of the Agriculture Sector, the Research Strategy, the National Extension Programme, the Re-forestation Strategy, the National Forestry Plan, the Irrigation Strategy, the Food Production Action Plan, and the Strategic Plan for Livestock.

series that has so far supported thirteen cross-cutting and sector-level reforms.[4] However, the proposed actions are somewhat piecemeal and do not constitute a coherent approach to addressing the risks to the agricultural sector.

Improved agricultural risk management is one of the core enabling actions of the G-8's New Alliance for Food Security and Nutrition. Accordingly, the Agricultural Risk Management Team of the Agriculture and Environment Services Department of the World Bank, at the request of the G-8, conducted an agricultural sector risk assessment in Mozambique. This exercise aimed to provide a robust analytical underpinning to PEDSA and PNISA, incorporate agricultural risk perspective into decision making, and build capacity of local stakeholders in risk assessment and management.

This activity was carried out in collaboration with the Ministry of Agriculture and the financing was provided by the Feed the Future program in Mozambique, which is an initiative of the U.S. Agency for International Development (USAID). In addition, a multidonor trust fund supported by the Dutch Ministry of Foreign Affairs and the Swiss Secretariat of Economic Affairs (SECO) also made a financial contribution toward this work.

The ARMT of the Agriculture and Environmental Services Department and representatives from Financial and Private Sector Development, Non-Bank Financing Institutions Unit FCMNB (supported by the Agricultural Insurance Development Program) conducted this Mozambique Agriculture Sector Risk Assessment to:

1. Identify, analyze, quantify, and prioritize principal agricultural risks (production, market, and enabling environment risks) facing the agricultural sector;
2. Analyze the impact of agricultural risks on major agricultural sector stakeholders (farmers, vulnerable populations, commercial sector, and government);
3. Analyze existing and potential risk management strategies (mitigation, transfer, and coping);
4. Identify, analyze, and prioritize principal risk management interventions; and
5. Build capacity of local stakeholders in agricultural risk management.

The World Bank's Agriculture Sector Risk Assessment takes a holistic approach and relies on long time-series historical data to arrive at an empirical and objective assessment of agricultural risks and their impacts on Mozambique. A lengthy desk study of existing data and analyses was completed followed by an in-country field study to corroborate findings and present the risk assessment to stakeholders. A joint World Bank/USAID team undertook a technical mission to Mozambique April 2–19, 2013, for this purpose, including focus group discussions with farmer groups and a multitude of field interviews with various stakeholders (farmers, input suppliers, service providers, traders, processors, exporters, financial intermediaries, and government agencies). The team presented their preliminary findings to stakeholders in Maputo on April 18, 2013. This assessment will form the basis of the second step, solution assessment, whose final findings will inform PNISA. The solution assessment conducted in November 2014 looks into the three prioritized interventions that were discussed with the government after delivery of this report and include an extension risk landscape mapping for each intervention considering existing tools and interventions. More information can be found in the Mozambique Agricultural Sector Risk Solutions report, but they include mitigation interventions in relation to water management, conservation agriculture, and access to information systems and extension services.

This document considers the many aspects of assessing risk in the Mozambican agriculture sector. Chapter 2 introduces the major characteristics of the agricultural system leading into chapter 3, which presents a comprehensive picture of the risks that exist in the sector. Chapter 4, in quantifying the risks that have been observed, comments on the losses that have been incurred by the sector because of production risks, whereas chapter 5 provides a qualitative discussion of how risk has an effect on the different stakeholders present in the sector. Chapter 6 delves into the risk prioritization carried out

[4] These include introduction into MASA of a national action plan on climate resilient agriculture to support PEDSA implementation, ongoing WB support for the Transforming Hydro-Meteorological Services Project and development of digital elevation models to improve flood modeling in the Zambezi and Limpopo Valleys.

by the team and then comments on various management measures. The report concludes with chapter 6, in which recommendations are provided for improving risk management in Mozambique. There are several appendixes that include information on the methodology for calculating the production risk losses; a report produced as background for the report on available weather yield data; elements on vulnerability analysis; and a literature review to provide an impact assessment of climate change on agriculture.

CHAPTER TWO

MOZAMBIQUE'S AGRICULTURAL SYSTEM

Agriculture plays a key role in Mozambique's economy, making up 31.8 percent of GDP and providing a livelihood to almost 81 percent of the labor force (CIA 2013). The majority of Mozambican agriculture is rain fed and therefore very sensitive to climatic conditions.

The agricultural sector in Mozambique is dominated (99 percent) by smallholder farmers using family labor, most of whom cultivate small plots of land (0.5 to 1.5 hectares [ha]) with limited inputs and mechanization.[5] According to data from the Mozambique Agricultural Census (TIA) surveys, the total farmer population is estimated at 3.8 million. Producers were organized into small organizations and forums, although these only accounted for 7.2 percent of farmers in 2008 (Government of Mozambique 2008).

Following the Mozambique civil war, which ended in October 1992, increases in agricultural production have been credited for a reduction in poverty, as people were able to return to previously abandoned land. Despite the increased use of land for agricultural activity, low productivity is still considered a major constraint on development (Cungara and Garret 2011).

Mozambique is facing a natural resources boom, and agricultural exports have declined from 31.4 percent of total export revenue in 2002 to 14.4 percent in 2008 because of large-scale expansion of aluminum and electricity exports (World Bank 2012a). Even so, the agricultural sector remains largely responsible for job creation and the government and donors alike consider agricultural development as a driving force for poverty reduction.

AGRO-ECOLOGICAL CONDITIONS

The agro-ecological zones in Mozambique include three macro-agro-ecological zones: northern, central, and southern. These macro-agro-ecological zones are based on climate, vegetation, altitude, soils, and farming systems.

[5] A national survey in 2007 found that only 4 percent of farmers use fertilizer (FAO/WFP 2010).

TABLE 2.1. NUMBER OF AGRICULTURAL AND LIVESTOCK PRODUCTION UNITS IN MOZAMBIQUE

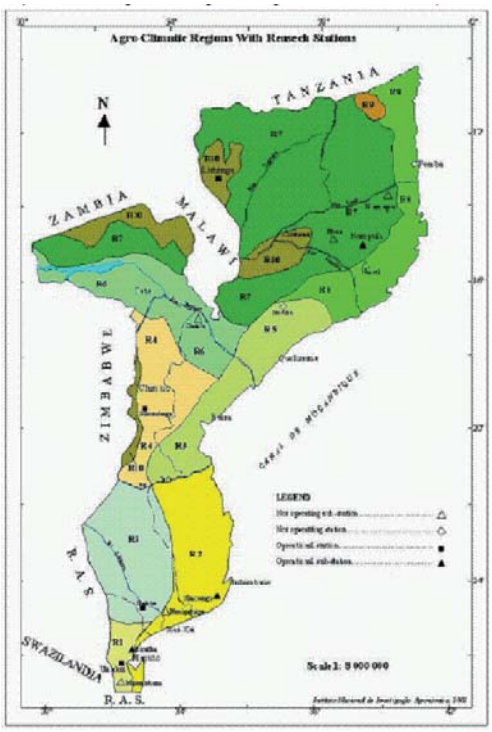
Type of Production Unit	Small	Medium	Large	Total
Countrywide	3,801,259	25,654	841	3,827,754
Percentage of distribution per type on total # of units	99.31%	0.67%	0.02%	
Cultivated area				
Countrywide	**5,428,571**	**130,651**	**73,565**	**5,632,787**
Percentage of cultivated land per type of units	96.37%	2.32%	1.31%	
Average land per type of unit (ha)	1.43	5.09	87.47	

Source: Agricultural and Livestock Census 2009/10.

In the north, between the Zambezi and Rovuma rivers, the major crops are maize, cotton, coconuts, cashews, cassava, sorghum, millet, and groundnuts. The central region between the Save and Zambezi rivers produces maize, cotton, cassava, bananas, citrus, sugarcane, vegetables, sorghum, cashews, and rice. In the southern region, south of the Save River, crops include maize, rice, groundnuts, cowpeas, cassava, citrus, sugarcane, vegetables, and cashews (Mucavele 2000).

These three macrozones, are composed of 10 diverse agro-ecological zones. They are pictured here in figure 2.1. Arid and semiarid zones dominate the south and southwest, whereas subhumid zones make up the majority of the center and north, and humid highlands are found primarily in the central provinces (United Nations Food and Agriculture Organization [FAO]/World Food Programme [WFP] 2010). Agriculture is practiced in all zones, with the exception of highly arid regions in the south and southwest part of Gaza province, which are only suitable for livestock. As noted in appendix B, this is due in particular to the increased incidence of extreme climatic events. The impact of climate change, if not addressed, may reverse progress made in agricultural development.

FIGURE 2.1. AGRO-ECOLOGICAL CONDITIONS—MOZAMBIQUE



LAND AND WATER RESOURCES

The country's climate and land are suitable for a wide variety of annual and perennial crops, along with livestock. The total cultivated area grew from 3,867,000 ha in 2002 to 5,632,787 ha in 2009/10 (Government of Mozambique 2009/2010), but according to the World Bank in 2011, permanent cropland made up only 0.3 percent of the land area (FAO/WFP 2010). Access to basic infrastructure in the rural areas is limited, as are support services including information and institutions. Irrigation potential is about 3.0 million ha, but the Ministry of Agriculture reports only 120,000 ha having irrigation infrastructure, and only 60,000 ha as operational under public irrigation schemes in 2010 (Chiloda et al. 2012). According to the joint Food and Agriculture Organization /World Food Programme Crop and Food Security Assessment Mission to Mozambique in 2010, only 55,000 ha of land are irrigated, of which 35,000

ha are under sugarcane with the remainder mostly under rice and vegetables (FAO/WFP 2010). As the center and south are characterized by irregular rainfall, irrigation infrastructure is concentrated in Gaza, Zambezia, Tete, and Manica (Government of Mozambique Ministry of Agriculture 2010). The World Bank in 2011 estimated that 73.9 percent of annual total freshwater withdrawals were for agriculture. Lack of irrigation is one of the main constraints to increasing production and mitigating the effects of droughts in many regions of Mozambique.

CROP PRODUCTION SYSTEMS

Main staple crops produced in the family agriculture sector are maize, sorghum, rice, millet, potatoes, sweet potatoes, cassava, and beans. Cash crops frequently grown by households include cotton, tobacco, copra, cashew nuts, sesame, sugar beans, sunflower, bananas, and sugarcane. Many family farms combine food crops with a single cash crop. The bulk of the agricultural sector is represented by the 11 commodities listed in table 2.2, which accounted for 67 percent of agricultural GDP in 2009 (Cungara and Garret 2011). These commodities and risks affecting their production are examined in chapters 3–6.

PRODUCTION TRENDS

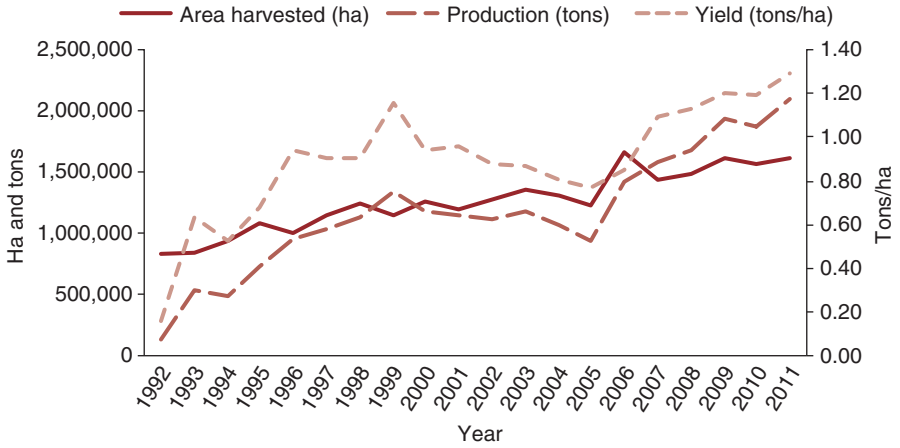
The growth of the agricultural sector between 2003 and 2009 averaged between 7.4 and 7.5 percent a year. Much of this growth is attributed to expansion of the cultivated area (particularly increased area for food crops such as maize, rice, and cassava, and concession agriculture such as sugarcane and bananas) (Cungara and Garret 2011). The large increase in area harvested since 1992 can be seen in figures 2.2 and 2.3. The lack of increase in area harvested for cassava is notable in figure 2.4, although this confirms its place as a crop primarily for self-consumption and food security, with little commercialization. Figures 2.2 and 2.3 further confirm that there has not been a huge improvement in yield for the major food crops over the same time period, apart from a slight improvement in maize.

TABLE 2.2. AGRICULTURAL GDP SHARE IN MOZAMBIQUE, 2009

Commodity	Agricultural GDP Share (%)	Category
Maize	21.23	Cereals (food crop)
Cassava	18.34	Root crop (food crop)
Vegetable	8.21	Horticulture
Poultry	4.70	Livestock
Rice	4.41	Cereals
Groundnuts	3.06	Pulses, nuts, and oilseeds
Cashew nuts	2.51	Export-oriented crop
Cotton	0.75	Export-oriented crop
Tobacco	1.17	Export-oriented crop
Sugarcane	0.98	Export-oriented crop
Sorghum	2.56	Cereal food crop
Total	**67.92%**	

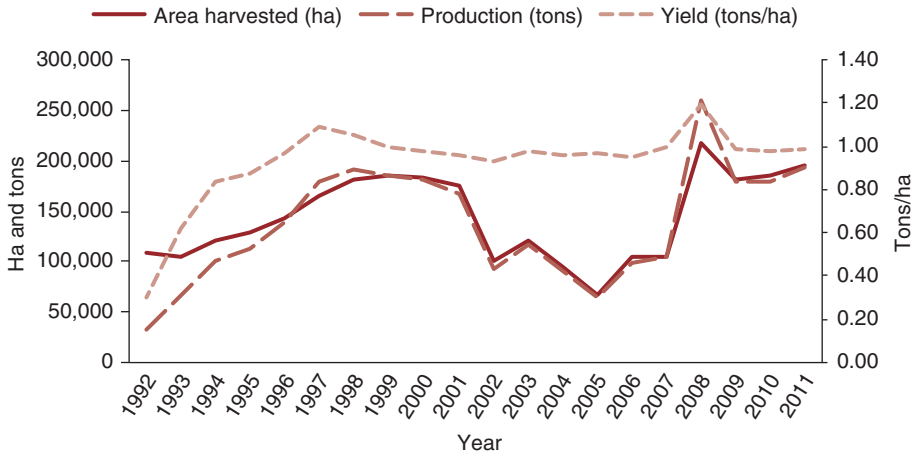
Source: Pauw et al. 2012.

FIGURE 2.2. MAIZE PRODUCTION, 1992–2011



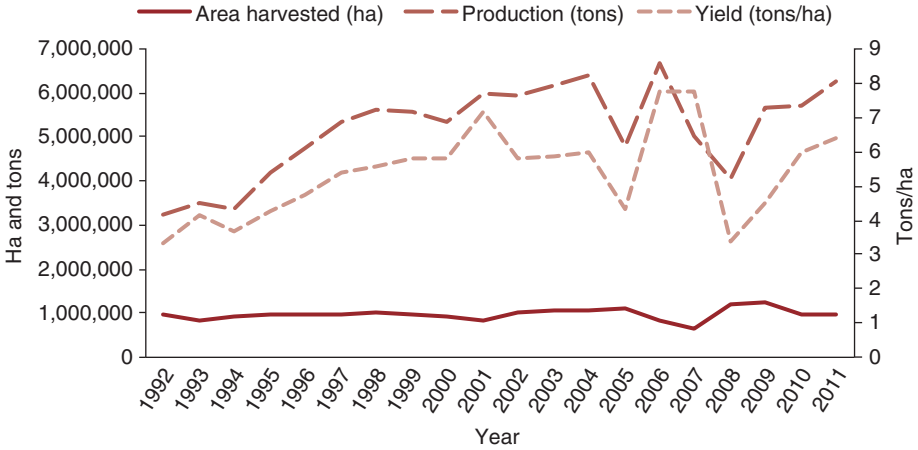
Source: FAOSTAT, Author's Calculations.

FIGURE 2.3. RICE PRODUCTION, 1992–2011



Source: FAOSTAT, Author's Calculations.

FIGURE 2.4. CASSAVA PRODUCTION, 1992–2011



Source: FAOSTAT, Author's Calculations.

In general, however, production growth and productivity are significantly below the averages for Southern Africa as a region. More than half of the rural population remains poor and food insecure. According to the Ministry of Agriculture and Food Security (MASA)/Mozambique Ministry of Industry and Commerce (MIC) Food Balance data, Mozambique faces a yearly food deficit of about 500,000 metric tons (MT) in cereals, even after commercial imports and food assistance.

FOOD CROPS

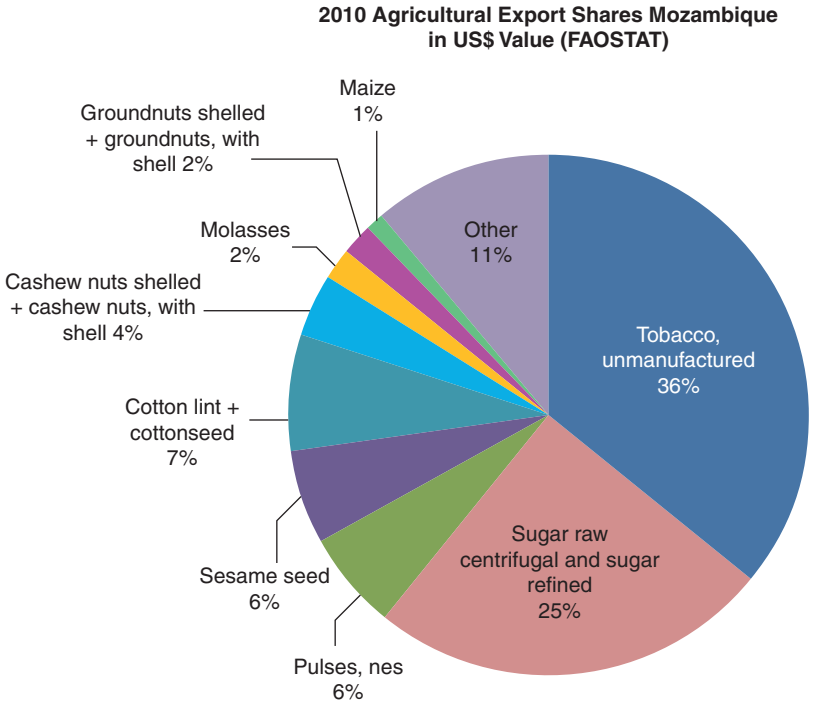
The majority of production undertaken by smallholder families is for consumption. This production has especially low yields and productivity. The main food crops in Mozambique include cassava and sweet potatoes, maize, rice, sorghum, millet, and pulses. Although characterized by "generally weak performance," staple food crop production has increased and Mozambique is self-sufficient in food crops such as maize, cassava, sweet potatoes, sorghum, and groundnuts (World Bank 2012).

Nationally, however, there is a large deficit in rice production and wheat is a major import for domestic consumption, with imports of cereals almost equivalent to all agricultural exports combined.

CASH CROPS

The major cash crops in Mozambique are cotton, tobacco, and sugarcane. Other cash crops include copra, cashews, sesame, sunflower, coconuts, bananas, and other horticulture. Cotton has seen a steady increase in production since the late 1990s. Tobacco and sugarcane have both seen huge spikes in production beginning in the early 2000s following the installation of processing facilities to capture value and reduce postharvest losses. Figure 2.5 shows

FIGURE 2.5. MOZAMBIQUE AGRICULTURAL EXPORT SHARES IN US$, 2010



Source: FAOSTAT.

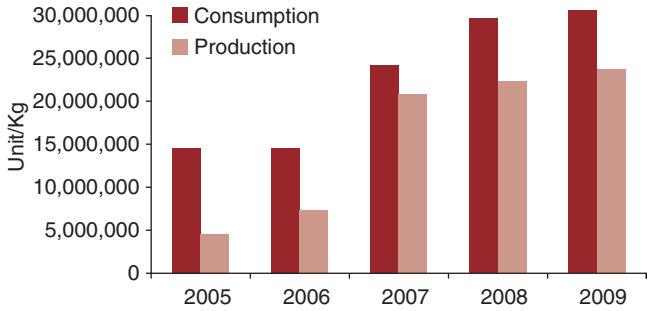
the quantity and value of exports in 2010 and the large percentage of exports that came from tobacco and raw sugar. Starting in 2011, cassava is becoming a cash crop as the result of SABMiller's cassava beer project in Nampula.

LIVESTOCK PRODUCTION SYSTEM

Livestock has an important place in the livelihoods of small and medium producers in Mozambique. In 2008, 58.8 percent of small and medium producers had chickens, 26.2 percent had goats, 12.1 percent had pigs, 11.4 percent had ducks, and 6.7 percent had cattle. However, only 10.9 percent used any sort of animal traction for production on their land (Government of Mozambique 2008). Livestock made up 10 percent of total agricultural production but contributed only 1.7 percent of GDP in 2008 (OIE 2008).

Mozambique relies heavily on imports for every commodity in the livestock sector and figure 2.6 clearly shows consumption outstripping production for poultry. It was estimated by the government that over 40 percent of beef consumed in Mozambique is imported from neighboring countries (Government of Mozambique, Ministry of Agriculture 2010). Almost all of the inputs (rations, concentrates, medicines, vaccines, veterinary instruments, and equipment) for the sector are also imported.

FIGURE 2.6. CONSUMPTION AND PRODUCTION OF POULTRY IN MOZAMBIQUE, 2005–09



Source: Associação Moçambicana de Avicultura.

There are some constraints that are specific to livestock production and have an impact on the productivity of the sector:

» The low genetic quality of the breeding animals, as well as unsuitable management practices.

- The weak network of veterinary assistance to smallholders.
- The lack of infrastructure for watering and managing cattle.
- The vast majority of slaughterhouses that are without running water, refrigeration, separation between clean and dirty areas, and pens in which the animals can be held before slaughter.

The poultry subsector has experienced significant improvements in production (figure 2.6) and productivity in recent years. The growth in poultry is traceable to a small but dynamic commercial subsector that has been successfully replacing imports in meeting the growing demand in the urban centers for poultry.

PRINCIPAL CONSTRAINTS

This document primarily analyzes agricultural risks, but it is also important to understand some underlying constraints, which can, in turn, aggravate the risk profile of a number of commodities and play a role in risk management. Whereas risks are defined by attributes of uncertainty, events, and losses, constraints are classified as conditions that lead to suboptimal performances by supply chain actors.

The principal constraints to the agricultural sector in Mozambique include:

- Limited input usage, availability, and market dynamics.
- Limited access to agricultural extension services: approximately 8.3 percent of farmers in 2008 had access to agricultural extension services despite efforts by the government and partnering nongovernmental organizations (NGOs) (Government of Mozambique, Ministry of Agriculture 2010).
- Limited access to credit: in Mozambique, less than 6 percent of total lending in 2010 was dedicated to agriculture, down from about 10.5 percent in 2004. A limited group of so-called traditional products (tea, sugar, cashews, sisal, coconuts, and cotton) are the main recipients of agriculture credit, account for 67.7 percent. Since 2004, only sugar and cashews show consistent growth in financing. In contrast, tea, coconuts, sisal, and, most recently, cotton have decreased.
- Lack of infrastructural facilities such as transportation, storage, and irrigation.
- Limited investment in the agricultural sector by the government and private sector.

CHAPTER THREE
AGRICULTURAL SECTOR RISKS

This chapter considers the types of risks that are observed in the agricultural sector and groups them into three main categories: production, market, and enabling environment. This chapter is a synthesis of analysis conducted by the assessment team as well as detailed review of secondary data. A detailed weather analysis (appendix B) was conducted to understand weather patterns (deficit and excessive rainfall) and their impact on crop yields. Appendix C reviews the existing literature on climate change and appendix D summarizes the vulnerability situation in Mozambique. Detailed commodity risk profiles highlight principal risks to nine major commodities in appendix E.

PRODUCTION RISKS

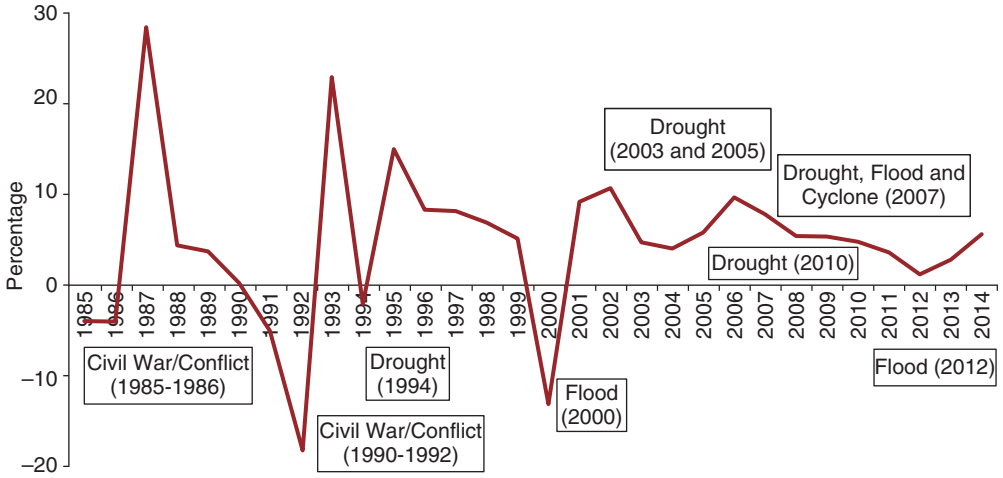
The main sources of production risk observed through analysis of data and interviews with numerous farmers are drought, flood, cyclone, and pests and diseases. Figure 3.1 shows the annual percentage of growth in agriculture value added and the declines that occur around major shocks to the sector. The periods of intense civil war (1985–96 and 1990–92), drought (1994), and flood (2000) resulted in negative growth rates in agriculture. Since 2000, the growth rate has not dipped into negative territory, although it has reflected the impact of several critical events (figure 3.1).

The weather analysis in appendix B provides further information on provincial trends in rainfall using data from 31 weather stations from January 1979 to December 2009. The climate is considered humid tropical in the north and on the coast, and dry tropical in the south and interior (Bay 1997). Soils with good agricultural potential exist in the north, central, and western parts of the country and those with limited potential occur in the southern part, in the low plateau (Bay 1997). The rainy season occurs in November/December and lasts until March/April. Annual rainfall is generally up to 400 mm in the south and central western areas and more than 1,200 mm in the north.

DROUGHT

Drought was observed to be the most important agricultural risk, considered probable and with catastrophic consequences. An agricultural drought occurs when soil moisture is significantly deficient, resulting in reduced crop yields and output. This can be the

FIGURE 3.1. MAJOR SHOCKS TO CROP AND LIVESTOCK PRODUCTION: ANNUAL PERCENTAGE GROWTH IN AGRICULTURE VALUE ADDED



Source: World Development Indicators.

Update: Annual percentage growth in Agriculture Value Added has dropped since 2011 at 5.8 percent to 2 percent in 2012 and 3.5 percent in 2013. A drop would be expected to be seen after the large flood of 2015. The figures that would reflect the effect of the flood in 2015 are not currently available.

result of low overall annual rainfall amounts or variations in the timing and duration of seasonal rainfall, that is, late onset of rain, early cessation of rain, and so on. Adverse timing and duration are particularly critical if they occur during the crop production cycle (seeding, flowering, and grain filling) with even a short absence of rain potentially having a detrimental effect on production. Long dry spells (consecutive days without rain); limited, sporadic rainfall; as well as excessive participation are collectively responsible for significant crop losses in Mozambique.

The weather analysis graph (figure 3.2) shows that the weather stations indicated a negative anomaly of precipitation, in other words, a possible drought. By counting all the stations that had a negative anomaly of precipitation (considered as a drought event), the following chart (figure 3.2) summarizes the number of total stations that had drought events per year with colors representing the different provinces (red = North, green = Central, blue = South). The weather station analysis shows significant dry years in 1979 and 1992 with a lack of rain in specific regions indicated in 1983, 1988, 1994, 2005, 2008, and 2009. Figure 3.2 also shows a declining trend of deficit rainfall events, highlighting that cumulative precipitation in Mozambique is increasing, on average. Table 3.1 provides further details on drought events, including the people reported to have been affected, deaths that occurred, and any indication found in regard to economic damages and hectares of planted crops or production lost because of negative abnormalities in precipitation.

HEAT AND EXCESSIVE TEMPERATURE

Heat and excessive temperature can be serious risks, especially for poultry and horticultural commodities. This was indicated by poultry farmers as a source of mortality for chickens and by horticultural producers as a source of losses. At times, heat waves and extreme temperatures are experienced alongside drought and are difficult to identify separately.

FLOOD

Flooding is also a significant risk in Mozambique, with a high probability of occurrence and critical consequences. Incidence of this risk generally occurs between December and February during the wet season and is often the result of heavy rainfall in a short period of time. This heavy rainfall not only causes flash flooding, but also leads rivers to burst their banks and, particularly for farmers around irrigation infrastructure, for dikes to burst and dams to fail. There is often little time to prepare and effects tend to be localized compared with the often wide-reaching

FIGURE 3.2. DEFICIT RAINFALL EVENTS BASED ON WEATHER STATION DATA ANALYSIS

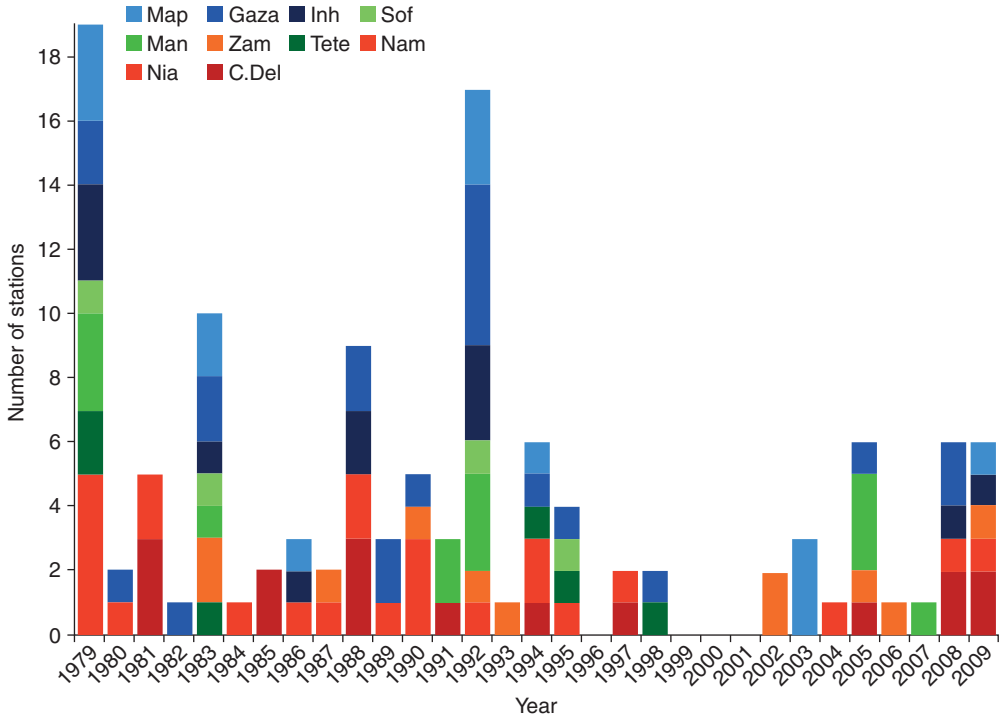


TABLE 3.1. SUMMARY OF DROUGHT EVENTS

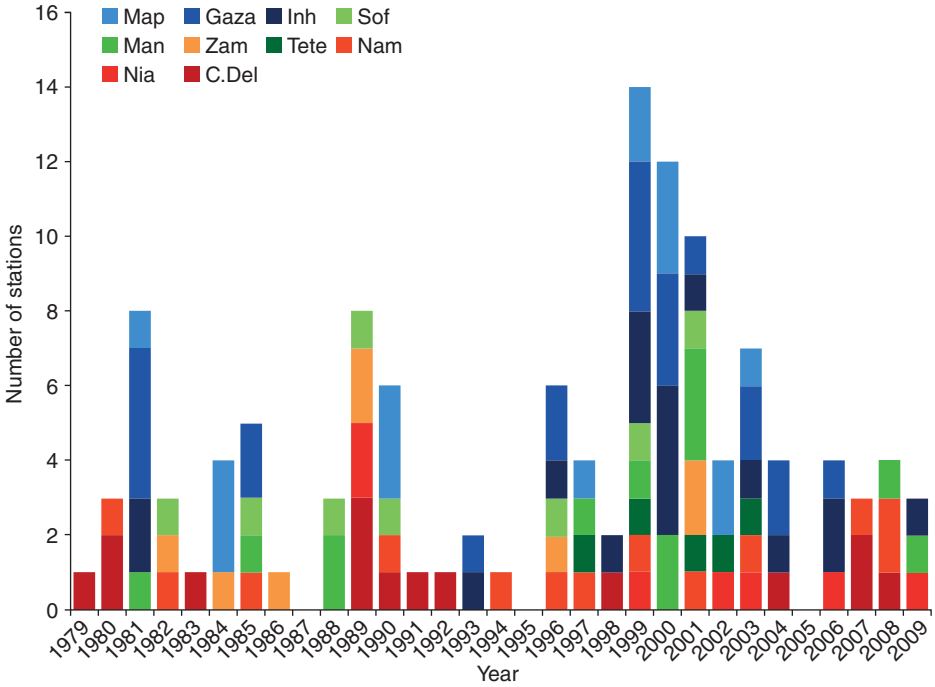
Year	Province	People Affected	Estimation of Total Economic Damages (US$)	Hectares/Production Lost
1983	Cabo Delgado, Nampula, Tete, Manica	4,750,000	419,200,000	Unknown
1991/92	Limpopo River Basin	3,300,000	50,000,000	Unknown
1999	Nampula	Unknown	Unknown	10,000 ha of maize, sorghum, peanuts, rice, beans, cotton, and horticulture
2002	Maputo, Gaza, Inhambane, Sofala, Tete, Zambezia, Manica	600,000	Unknown	160,629 ha
2003	Central and Southern	Unknown	Unknown	Almost total failure of maize crop
2005	Maputo, Gaza, Inhambane, Manica, Sofala, Nampula	1,400,000	Unknown	317,000 ha
2007/08	Inhambane	520,000	Unknown	Unknown
2010 (March)	Central and South	465,000	3,000,000	605,000 ha

Source: The annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), Famine Early Warnings System Network (FEWSNET)/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from the National Institute for Disaster Management (INGC)—Government of Mozambique data.

nature of drought. However, the number of physically displaced people is higher with floods and occurs immediately, which brings additional problems.

Figure 3.3 shows the weather station data analysis for excess rainfall events, indicating positive anomaly records for rainfall, with significant events in 1981 in the south, in 1989

FIGURE 3.3. EXCESS RAINFALL EVENTS BASED ON WEATHER STATION DATA ANALYSIS



in the north, and in 1999–2001 across the country (including devastating floods in 2000). Figure 3.3 helps to visualize that there were four dry years: 1979 stands out as a year in which almost all provinces experienced insufficient rainfall whereas 1992 follows closely as another dry year. Both 1983 and 1988 were also dry years with the lack of rain experience in some provinces only. The graph also indicates a trend of rising excess rainfall events, highlighting that flooding might become more frequent in future. As the number of events listed in table 3.2 indicates, for some provinces localized flooding is a regular occurrence, although farmers will remember 2000 and 2013 as being the most significant events during which they lost the most in recent years.

PESTS AND DISEASES

The main crop pests and diseases are as follows:

- Insects: Red and elegant locusts, lizards, wheat worm, large grain borer, stinkbugs, armyworms, bedbugs, fruit fly
- Diseases: Cassava fungus, peanut leaf curl, root rot, nematodes (tobacco, tomatoes, beans, fruit), brown streak disease, avian flu, Newcastle disease, *Trypanosoma*, powdery mildew, tomato virus
- Pests: Wild animals (boars, monkeys, elephants, birds), insects

There is a lack of detailed information on losses caused by pests and diseases, but table 3.3 gives an indication of the occurrences. Farmers stated that although pest damage is highly probable and causes considerable damage, pests are controllable if inputs are available. Subsequently, the government, along with commercial organizations and NGOs,[6] has undertaken aerial spraying for locusts and grain-eating birds, as well as insecticides, pesticides, fungicides, traps for fruit fly management, and so on.

WILDFIRES

As table 3.4 indicates, wildfires can lead to a large number of hectares being lost to agriculture. In Mozambique, wildfires can be caused by strong winds and high temperatures. Losses are also often recorded in various data sources that have been caused by fires started by arson/human error/poaching, which can also lead to significant local-

[6] ACDI/VOCA in coconuts, IRRI in rice, FAO for locust spraying, and FAO and World Bank for fruit fly pest management.

TABLE 3.2. SUMMARY OF FLOOD EVENTS

Year	Province	People Affected	Estimation of Total Economic Damages (US$)	Hectares/Production Lost
1985	Maputo	500,000	Unknown	Unknown
1988	Maputo	90,000	Unknown	Unknown
1990	Central	12,000	Unknown	Unknown
1996	Central and South	200,000	Unknown	170,000 ha of food crops including 45,000 ha of maize
1997	Tete, Sofala, Zambezia, Manica	43,000	Unknown	103,000 ha
1999	Inhambane	Unknown	12,400,000	63,000 ha
2000	South	4,500,000	100,000,000	12% of cultivated land, about 198,000 ha
2001	Zambezia, Northern Sofala, Tete, Manica	549,326	36,000,000	71,000 ha
2003	Nampula, Zambezia	100,000	Unknown	237,000 ha of crop fields of beans, cassava, and thousands of cashew trees
2006	Zambezia	Unknown	Unknown	6,754 ha
2007 (Jan)	Inhambane, Sofala, Tete, Manica, Zambezia	Unknown	100,000,000	288,000 ha in crops
2007 (Dec)	Sofala, Manica	Unknown	71,000,000	Failure of staple maize crop and reduced yields in others.
2008	Tete, Zambezia, Manica, Sofala	Tens of thousands	Unknown	More than 160,000 ha
2011	Zambezi, Lucheringo, Pungue rivers	180,000	Unknown	10,000 ha
2011	Maputo	123 families	Unknown	12,974
2012	Gaza	Unknown	Unknown	4,898 ha
2013	Gaza, Inhambane, Zambezia	240,000	Unknown	153,000 ha approximated
2015	Zambezia, Manica	157,172	0.5% drop in predicted economic growth rate	87,000 ha

Source: The annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data, and FAO.

ized losses. However, wildfires are not cited by farmers and stakeholders as a major risk and are classed as having a remote probability of occurring with negligible loss.

CYCLONES/TROPICAL STORMS

Cyclones occur often along Mozambique's coastline during the wet season, but are usually not considered particularly destructive if they are below Category 4. The main damage caused by cyclone events is inflicted on farm infrastructure: houses, storage, and so on. In terms of agriculture, most damage is done to tree crops (cashews, coconuts, and fruit trees) where trees are blown down and destroyed. Table 3.5 gives an indication of the Category 4 and above cyclones that have hit the Mozambican coastline since 1985 and the damages incurred.

TABLE 3.3. SUMMARY OF PEST AND DISEASE EVENTS

Year	Province	Type of Pest/ Disease	People Affected	Hectares Lost
1998/99	Cabo Delgado (four districts)	Red locust	Unknown	Rice and sorghum destroyed
1998/99	Nampula Coast and Cabo Delgado	Locusts and fungi	Unknown	Sorghum, millet, and rice crops severely affected
2000	Inhambane	Locusts	Unknown	160,000 ha of mainly cassava
2001/02	Unknown	Red-beaked sparrows	Unknown	30% of planted area of rice
2001/02	Cabo Delgado	Wild animals, others	Unknown	66,490 ha
2004	Nampula	Brown streak in cassava	14,500	Unknown
2004	South	Powdery mildew in cashews	Unknown	Unknown
2006	Gaza	Locusts, lizards, wild animal	Unknown	64,000 ha
2008	Zambezia	Lizards	Unknown	2,786 ha

Source: The annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data.

TABLE 3.4. SUMMARY OF WILDFIRE EVENTS

Year	Province	Origination	People Affected	Hectares Lost
2004	Maputo	Unknown	Unknown	6,860 ha
2008	Manica	Strong winds and high temperatures	89	3 million ha of farmland and forest

Source: The annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data.

TABLE 3.5. SUMMARY OF CYCLONE EVENTS

Year	Province	Type of Event/ Name	People Affected	Estimation of Total Economic Damages (US$)	Hectares Lost
1985	Maputo	Cyclone Domoina	Unknown	75,000,000	Serious damage to root crops
1994	Nampula, Ilha de Moçambique	Cyclone Nadya	2,502,000	700,000,000	600 tons of rice
2000	North/Coastal areas	Tropical Storm Delfina	1,000,000	Unknown	5,600 ha including 2,000 ha of beans
2003	Central	Cyclone Japhet	Unknown	Unknown	Unknown, included in flood losses
2006	Nampula	Tropical Storm	Unknown	Unknown	5,000 ha
2008	Nampula, Zambezia	Cyclone Jokwe	+200,000	20,000,000	1,500,000 cashew trees. 68,522 ha
2012	Mozambique Channel	Cyclone Funso/ Tropical Storm	5,000	Unknown	53,130 cashew trees, 157 mango trees, 252 coconut palms. 41,979 ha

Source: The annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data.

TABLE 3.6. PROJECTED CHANGES FOR 2046–65 IN AVERAGE TEMPERATURES DURING THE GROWING SEASON, CROP YIELDS UNDER RAIN-FED CONDITIONS, AND RAINFALL DURING THE CROP GROWING SEASON

Crop	Changes in Temperature			Changes in Yield			Changes in Rainfall		
	Median (past)	Change in Future		Median (past)	Change in Future		Median (past)	Change in Future	
	°C	°C	%	mm	mm	%	mm	mm	%
Cassava	23.8	2.0	8.5	0.397	−0.02	−4.2	633.7	−17.3	−2.7
Cotton	24.1	2.1	8.5	0.517	−0.02	−2.9	610.0	−20.0	−3.3
Groundnut	24.5	2.1	8.5	0.599	−0.03	−4.6	487.9	−5.1	−1.1
Maize	24.5	2.1	8.5	0.373	−0.04	−11.1	454.2	−5.8	−1.3
Sorghum	24.6	2.1	8.5	0.572	−0.02	−3.5	438.9	−3.9	−0.9
Soybeans	24.6	2.1	8.4	0.217	−0.03	−6.4	377.4	−4.5	−1.2

Source: Brito and Homan 2012.

CLIMATE CHANGE

Agriculture is highly vulnerable to climate change in Mozambique, and the effects are heterogeneous based on model assumptions and across regions, socioeconomic groups, and crops and livestock. There are direct impacts, such as changes in crop yields caused by precipitation changes, and indirect impacts, such as rising food prices caused by production changes and land tenure conflict stemming from shifting agro-climatic zones. If climate change is left unaddressed, then progress in agricultural development, food security, and poverty alleviation in general may be reversed.

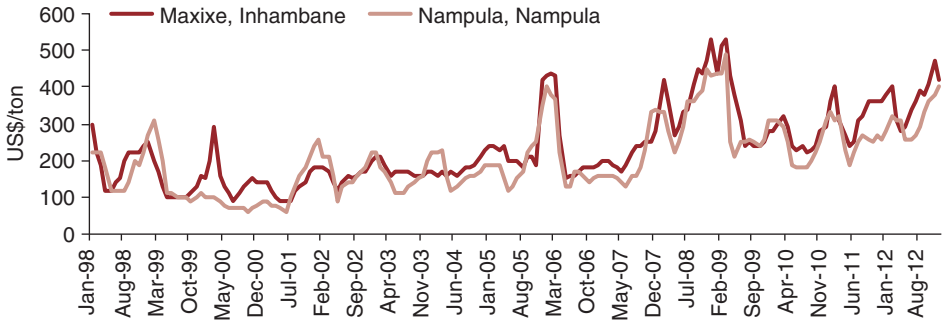
In the 2012 *Responding to Climate Change in Mozambique: Theme 6: Agriculture*, the INGC sought to quantify the effects of increased temperatures, changes in rain, and increased concentrations of carbon dioxide and ozone on six main crops (cotton, groundnuts, cassava, sorghum, maize, soy) (table 3.6). The report ran seven general circulation models to project temperature and rainfall data, and then used CliCrop to estimate yields based on soil humidity daily diary. Data came from 47 meteorological stations (Brito and Homan 2012).

The principal findings from research carried out for this report, further details of which can be found in appendix C, are the following:

- The increase in the likelihood of extreme events caused by climate change, as opposed to changes in average temperature or precipitation, may pose the greatest threat to agriculture in Mozambique. This includes flooding, drought, and tropical cyclones. Risk management therefore becomes increasingly important.
- Mozambique is highly vulnerable to climate change because of its geography, in particular, its long coastline.
- Temperature projections vary in various models and scenarios, but generally Mozambique expects to see a rise of 1°C–2.5°C by midcentury and an increase of 1.4°C–4.6°C by late century.[7]
- Projections on precipitation vary from both positive to negative changes, but increases in the proportion of rain that falls during the rainy period may occur.
- Crop yields and land suitability:
  - With some variations, generally there will be no significant change in areas suitable for crops (cassava, maize, soybeans, sorghum, groundnuts, and cotton).
  - Likewise, the average change in yields in crops is projected to change in small increments, but generally will decrease slightly (cassava, sorghum, soybeans, sweet potatoes and yams, maize, groundnuts, millet, potatoes).

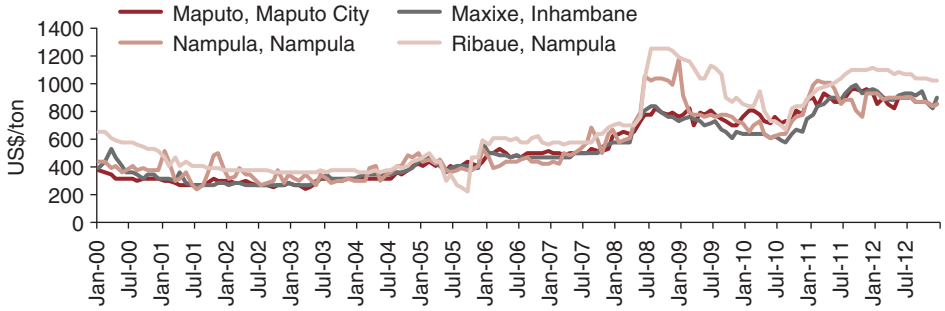
[7] IFPRI, UNDP.

FIGURE 3.4. MONTHLY RETAIL PRICES OF MAIZE (WHITE) IN KEY MARKETS IN US$/TON



Source: GIEWS Food Price Data and Analysis Tool.

FIGURE 3.5. MONTHLY RETAIL PRICES OF RICE IN KEY MARKETS IN US$/TON



Source: GIEWS Food Price Data and Analysis Tool.

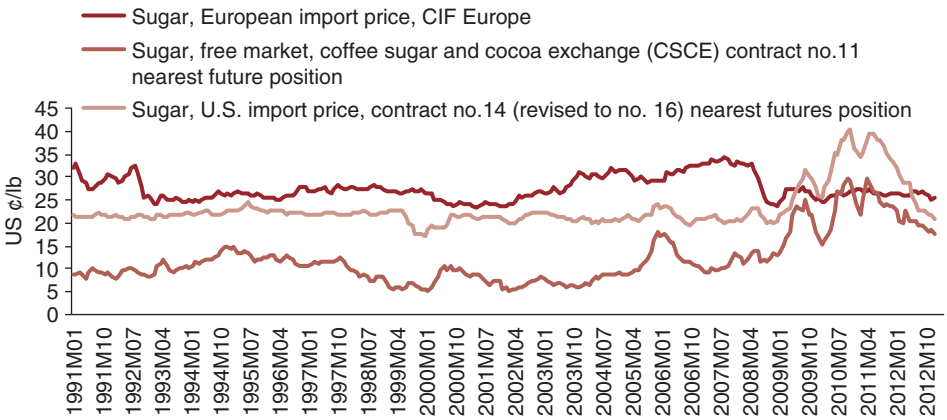
MARKET RISKS

Price volatility (domestic as well as international), exchange rate volatility, input volatility, and counterparty risk are some of the major market risks in Mozambique. They are, however, less significant than production risks, and in many instances, crop failure because of production risks triggers price spikes in local markets. The following section describes some of the major market risks.

DOMESTIC PRICE VOLATILITY

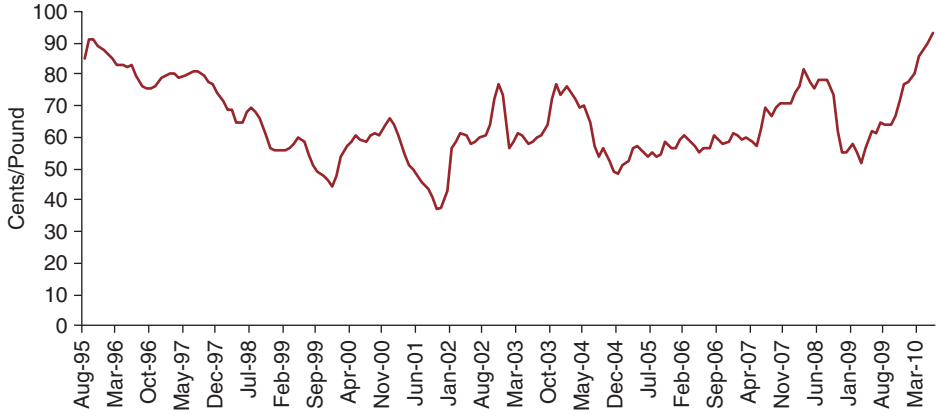
Seasonal price volatility is a feature of many agricultural commodities in Mozambique and is driven by seasonality of production, oversupply and deficit during particular months, and fluctuating demand for commodities. This, however, is often considered a "normal" cost of doing business in Mozambique, similar to many other countries. Abrupt and steep price spikes and falls, often driven by underlying production deficits, market factors, or other exogenous factors, are a cause of serious concern with severe implications for consumers and producers alike. The geography of Mozambique, coupled with limited transportation infrastructure, results in three regions of Mozambique (North, South, and Central) often behaving economically independently. Although the northern region is more self-sufficient in food, local events and regional conditions (in Malawi, Tanzania, and so on) contribute to price volatility. The southern regions are more likely to experience food deficits and often rely on food imports from South Africa. These regions are more exposed to international price volatility passed down to the domestic markets, as well as local production failures. Figures 3.4 and 3.5 show the volatility of maize and rice in the main markets of Mozambique. The graph in figure 3.4 depicts a few episodes of sudden spikes and a general trend of increasing prices, especially over the past five years. The price spike of white maize in 2006 was driven by local events (largely drought in 2005), whereas the 2008–09 price spike was a pass-through effect of the global food price crisis. Because of heavy reliance on imports for rice, this

FIGURE 3.6. INTERNATIONAL MONTHLY PRICES FOR SUGAR



Source: IMF Primary Commodity Prices.

FIGURE 3.7. INTERNATIONAL MONTHLY PRICES FOR COTTON "A" INDEX



Source: National Cotton Council of America.

commodity leads to direct transmission of international price volatility to domestic markets.

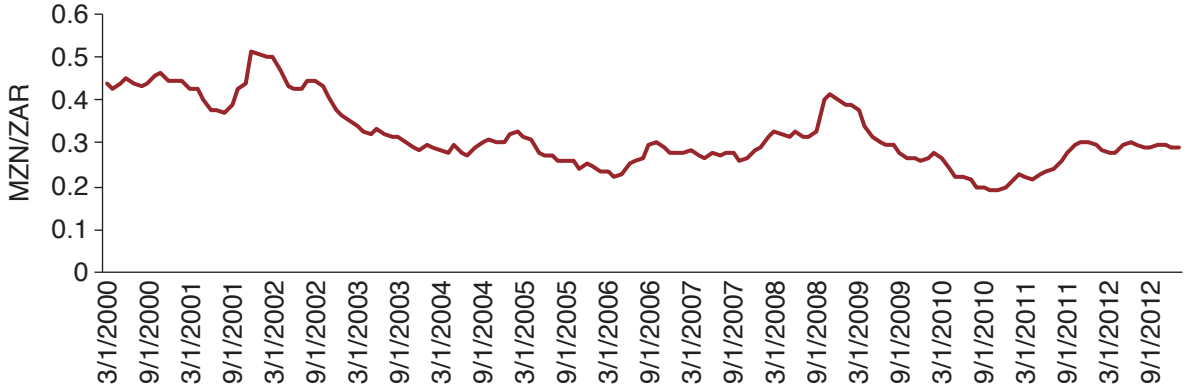
INTERNATIONAL PRICE VOLATILITY

International markets can also be volatile and will often have a knock-on effect for domestic prices, as figures 3.6 and 3.7 demonstrate. Mozambique relies on imports to supplement much of its domestic consumption needs each year, meaning the country inherits some international market volatility. This was in evidence in 2008 when international food price crises caused spikes in international prices that were also seen in the domestic market, leading to political unrest in Mozambique. Transmission of this volatility to domestic producers is significant; this can be seen by the mirroring of peaks in domestic versus international prices and is also reflected in export prices. Apart from sugar, the impact that this price volatility has on food crops means that the risks extend far beyond those that just have an effect on farmers and producers.

EXCHANGE RATE RISK

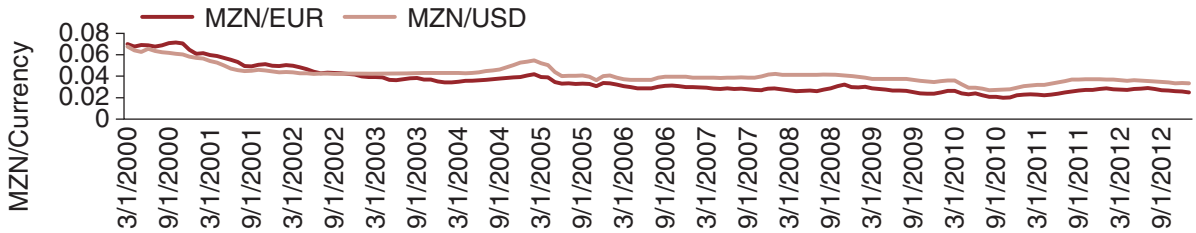
Given Mozambique's geographic location close to Sub-Saharan Africa's biggest market (South Africa), along with its heavy reliance on trade with this neighbor, movement in the rand/metical exchange rate can be a potential source of risk. Figure 3.8 shows the historical trends of the metical against the rand, indicating significant troughs and peaks. As figure 3.9 indicates, although the metical has been steadily appreciating against the rand, there has not been marked movement in the past 10 years between the metical and the euro/U.S. dollar. These peaks and troughs, driven by macroeconomic factors, monetary policies, and currency market events, can have a marked effect on the prices that producers receive

FIGURE 3.8. EXCHANGE RATE RISKS—METICAL/RAND



Source: Oanda.

FIGURE 3.9. EXCHANGE RATE RISKS—METICAL/EURO AND METICAL/US$



Source: Oanda.

if they are engaged in regional trade (South Africa is the biggest regional market partner for Mozambique) and the prices that consumers have to pay at market for imported commodities. The peaks and troughs shown in figure 3.8 will have a similar effect to those against the rand because Europe is a substantial export market for Mozambique and various commodities are imported in U.S. dollars. Going forward, Dutch disease, driven by natural gas and the energy economy (and the corresponding threat of underinvestment in agriculture and significant overvaluation of the metical), could have disastrous impacts on the agricultural sector.

INPUT PRICE RISK

In 2008, only 10 percent of maize farmers and 4 percent of rice farmers used improved seeds (Government of Mozambique 2008), and most of these were engaged in commercial production. The cases of fertilizer and diesel are similar to that for seeds, and input application is currently the domain of commercial farmers. Although the input prices are not enormously volatile, they are consistently high, which reduces their widespread adoption. Considering that a very small percentage of the Mozambique agricultural sector is reliant on input markets (seed, fertilizer, diesel, and so on), the volatility in input prices does not have significant impact on the broader agricultural sector.

COUNTERPARTY RISK

Counterparty risk/default risk is particularly important for stakeholders further up the agricultural value chain involved, for instance, in off-taker agreements or with out-grower arrangements, particularly in the cotton, sugarcane, and tobacco supply chains. Various contractual arrangements exist, including provision of inputs in the form of fertilizer or seed to be paid back based on an agreed price for a commodity or signed contract based on quantity and a fixed price. Although Mozambique has relatively sound legislation for the enforcement of contracts, various economic and sociocultural issues sharply limit the use of formal, written contracts in the agriculture sector. Although this is a perennial problem in some commodities, the impact on the broader agricultural sector is not particularly significant.

ENABLING ENVIRONMENT RISK

Enabling environment risk covers many different aspects of legal, institutional, fiscal, and policy issues that influence the ability of stakeholders to undertake their business within a sector. Domestically, this includes factors such as competitiveness (exit/entry conditions, incentives/subsides for production units by size, tax considerations); regulation and enforcement (for example, tax code, property rights, resource management); and trade policy barriers. On an international level, several factors should be taken into consideration in assessing risks to the Mozambican agricultural sector: international trade regulations and treaties; other international protocols, policies, regulations of nationals, and trading blocs; and the extent to which international trade agreements and conventions affect commodity performance (Jaffee, Siegel, and Andrews 2008).

CONFLICTS AND INSECURITY

Rising pressure on land because of insecure land tenure rights,[8] land grabs, and other issues are not yet major sources of risk in Mozambique. As all land is state owned this can create a certain amount of protection for communities, although frequent disputes between communities, government, and investors have occurred.

POLITICAL INSTABILITY AND REGULATORY ISSUES

After the peace accords were signed in October 1992 to end civil war between The Front for the Liberation of Mozambique (FRELIMO) and Mozambican National Resistance (RENAMO), conflict has not been a serious threat to the country (the recent disturbances in Sofala District notwithstanding). FRELIMO has remained in power since 1992, with elections held in 1994, 1999, 2004, and 2009. Although the elections have been more contested in recent years, they did not generally lead to frequent changes in the policy or institutional environment as FRELIMO remained in control of the government. Policies and regulations have also been relatively stable in Mozambique, for better or worse, and have not been registered by stakeholders as a major risk.

LINKAGES BETWEEN RISKS

Although individual risks and their occurrence as described above are significant, it is important to understand the dynamics of the linkages among and between these risks. This is particularly pertinent in Mozambique because of the differing agro-climatic zones[9] and the concurrent emergence of several different types of risk.[10]

INDEPENDENT RISKS OCCURRING SIMULTANEOUSLY

Although not presented in detailed timeline form in this chapter, it is clear that Mozambique appears to suffer from some type of risk every year and sometimes several in the same year, leading at times to significant losses. Flood and drought are often considered to be risks independent of each other however there have been years where both risks were experienced in the country, such as 1999, 2007, and 2010.

DEPENDENT RISKS

Drought, one of the most significant risks in Mozambique, is a clear example of one risk that can trigger others. These could include price volatility caused by supply deficits and import or export restrictions, which can in turn also bring about domestic price volatility and other risks such as exchange rate risk, and so on. Similarly, pest and disease outbreaks, such as incidents of fruit flies in 2008 and 2010,[11] could lead to export restrictions in regional and international markets. Flood risk is often accompanied by alluvion,[12] in which sediment is deposited when rivers break their banks, and also the tempo-

[8] Only about 10 percent of communities have their rights registered according to the IS Academy on Land Governance—(LANDac 2012).

[9] Mozambique lies between 10°S and 27°S. Chapter 2 gives further information on the agricultural system of Mozambique.

[10] In 2007, for example, Mozambique suffered from drought, flood, and cyclone, resulting in an estimated loss of 563,885 ha combined.

[11] Fruit imports from Mozambique to South Africa and Zimbabwe were banned in September 2008 and February 2010, respectively.

[12] In 1999, Inhambane registered losses of 22,018 ha directly linked to alluvion according to the INGC.

rary movement and relocation of communities when flooding is especially bad. A specific example of risk dependence occurred in 2008 during the international food price crises, with international price volatility, insecurity, and changes in government policy seen in Mozambique. Riots took place in urban centers as food price increases coincided with a reduction in fuel and food subsidies. These interdependencies, as with the independent risks that occur simultaneously, demand special attention when addressing the combined issue rather than the separate symptoms.

REGIONAL SHOCKS

It is important to consider regional systemic shocks, particularly as Mozambique shares borders with six countries. The Zambezi River System, for example, crosses all the way from Angola through Zambia, Malawi, Tanzania, and Zimbabwe before ending in Mozambique and empting into the Indian Ocean. Regional events can affect the ability of people to cope with risks as they occur. Refugees coming across the borders have been known to induce the risks associated with conflicts and insecurity and present a risk that is hard to mitigate or cope with.

DIFFERENTIAL IMPACT OF RISK

Location and timing of risks can also have an important impact on the sector. For instance, where flooding or drought or wildfires take place, the type of land that is affected will determine the extent of the effects. The 2008 wildfire that hit Manica, and is reported to have led to losses of 3 million hectares, is generally agreed to have affected mainly uncultivated forest land. More precise distinctions would help to identify who was affected as well as the appropriate measures based on these stakeholders for management of the risk.

PROVINCIAL RISK PROFILE

The impact of agricultural risk varies greatly by region depending on agro-climatic conditions, agricultural system and composition, and regional institutional arrangement. In the northern and central regions, the climate can be classified as tropical and subtropical; in contrast, steppe and dry arid desert conditions exist in the south. There is also a strong coastal-to-inland orographic, or elevation gradient, effect on weather patterns in Mozambique. Weather patterns change as they move west from the southeastern, low-elevation, coastal belt into the central and north-central plateau regions of the country. Some areas of Mozambique such as coastal zones do not conform to the "administrative division of Mozambique" but characterize specific geographic areas vulnerable to droughts, floods, and storm surges directly and indirectly related to sea level rise. Other parts of different provinces are influenced by basins of major rivers flowing to the Indian Ocean. Table 3.7 highlights the major crop production systems in the country and principal hazards they face.

However, despite this type of classification, a picture of the vulnerability of the 10 different provinces can be inferred from the number of occurrences registered in the last two decades as highlighted in table 3.8. Provinces such as Gaza and Sofala are equally exposed to drought and flood risks. Flood is a more serious concern in Zambezia, whereas drought is a bigger issue in Inhambane.

COMMODITY RISK PROFILES

The adverse impact of risk varies greatly by agricultural commodity, as well as by province/region. Risk profiles of cash crops, food crops, and the livestock sector can be quite different. Table 3.9 summarizes principal risks for major commodities analyzed in Mozambique, highlighting the risk of droughts, floods, pest and disease outbreaks as well as price volatility. Detailed commodity risk profiles, providing more information about individual commodities, their risks, and impacts can be found in appendix E.

CLIMATE CHANGE

Considering its importance in inducing structural shifts and altering the risk profile of the agricultural sector, it is important to examine climate change separately, even though it is a trend, and not a risk per se. Agriculture in Mozambique is highly exposed and vulnerable to climate change, and the effects are heterogeneous based on model assumptions and across regions, socioeconomic groups, and crops/livestock. There is, however, consensus across

TABLE 3.7. MAJOR CROP SYSTEMS AND THEIR PRINCIPAL HAZARDS IN MOZAMBIQUE

Location	Principal Hazards
Coastal urban areas (most important, Maputo and Beira)	This zone is marked by highly differential vulnerability across income groups, with large peri-urban areas vulnerable to flooding from both rivers and the ocean.
Nonurban coastal strip	This zone is marked by high vulnerability to coastal flooding and storm surges from tropical cyclones as well as threats of erosion. It is relatively food secure, with low rates of poverty; it encompasses the coastal provinces of Maputo, Gaza, Inhambane, Sofala, Zambezia, Nampula, and Cabo Delgado but the Central and Northern Provinces are more affected.
Limpopo river valley districts upstream of Xai-Xai	This zone is unique in being highly exposed to two very different threats: river flooding and drought. It has relatively high population density, and thus high numbers of poor people. Gaza and Southern Inhambane are under its influence.
Other flood-prone river valleys	These zones, in particular in the Buzi and Zambezi river valleys, are highly susceptible to floods (especially those caused by tropical cyclones), but less so to droughts. Sofala and Low Zambezia are within this zone.
Drought-prone inland areas (especially in the South Inhambane)	These areas are highly susceptible to drought: adequate rainfall to support agriculture is an exception rather than the rule. Inhabitants of this region are often dependent on remittances for survival. Population densities are low.
Inland areas of higher agricultural productivity (including the highly productive and populated areas in Zambezia)	These areas are perhaps the least vulnerable in Mozambique, facing adequate rainfall most years, and no extreme risks from flooding or tropical cyclones. They are somewhat heterogeneous in terms of poverty rates and food security. The highly productive regions stand out for their high population density and relatively low vulnerability.

Source: EACC publications; World Bank Group.

TABLE 3.8. PROVINCES AND PRINCIPAL HAZARDS

Events	Maputo	Gaza	Inhambane	Sofala	Manica	Tete	Zambezia	Nampula	C. Delgado	Niassa
Drought	XX	XXX	XXX	XXX	XX	XXX	X	XX	X	X
Floods	X	XXX	XX	XXX	XX	XX	XXX	XX	X	X
Storms		XXX					XXX	XXX	XXX	
Flash floods	X	XX	XX	XX	X	XXX	XXX	X	XX	X
Cyclones	X			X			XX	XXX	X	
Rains		XXX	XXX				XXX	XXX		
Alluvions	XXX		XX					X	X	X
Conflict			XX			XXX			XX	X
Epidemics	X		X	X	XXX	XX	XX	XX	X	X
Fire							XX	XXX	XX	XX

Source: Compiled based on data from Desinventar-Disaster Information System—UNISDR.
Note: Level of impact: XXX = severe, XX = considerable, X = moderate.

different models that the increase in the likelihood of extreme events (flooding, drought, and tropical cyclone) caused by climate change, as opposed to changes in average temperature or precipitation, may pose the greatest threat to agriculture in Mozambique. With some variations, models generally indicate there will be no significant change in areas suitable for crops (cassava, maize, soybeans, sorghum, groundnuts, and cotton). Likewise, the average change in yields in crops is projected to change in small increments, but generally will decrease slightly

TABLE 3.9. PRINCIPAL RISKS BY COMMODITY

Commodity	Principal Risk 1	Principal Risk 2	Principal Risk 3
Maize	Drought	Domestic price volatility	Pests and diseases
Rice	Drought	Flood	International price volatility
Cotton	Drought	International price volatility	Pest and disease outbreak
Groundnuts	Drought	Pests and diseases	Price volatility
Sugarcane	Flood	Drought	Pests and diseases
Poultry	Pests and diseases	Input price volatility	Poultry price volatility
Sorghum	Pests and diseases	Drought	Domestic price volatility
Cassava	Pests and diseases	Flood	Price volatility
Cashews	Pests and diseases	Cyclone	Drought
Vegetables	Pests and diseases	Flood	Price volatility
Tobacco	Drought	Flood	Pests and diseases

(cassava, sorghum, soybeans, sweet potatoes and yams, maize, groundnuts, millet, potatoes). Projections on precipitation vary from both positive to negative changes, but increases in the proportion of rain that falls during the rainy period may occur. These models, showing increased variability, would indicate that it will be ever more difficult for farmers to predict appropriate times for planting and harvesting. Appendix C provides an exhaustive literature review of potential climate change impacts on the agriculture sector in Mozambique. In Mozambique, negative impacts on agriculture from climate change will primarily be from the increased likelihood of extreme events such as flooding and droughts. However, outside of the expected increase in extreme events, agriculture in Mozambique will see little change in land suitability and yield. Thus risk management becomes increasingly important as uncertainty, frequency, and severity of risk events will increase as a result of climate change.

CHAPTER FOUR
QUANTIFICATION OF LOSSES AND IMPACT OF AGRICULTURAL RISKS

This chapter outlines the conceptual and methodological basis used for analysis and seeks to quantify the impacts of production risk events. The various sources of risk are then prioritized on the basis of indicative losses and consideration given as to how to manage these risks in chapter 5.

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 but for which some probability of occurrence can be estimated on the basis of historical experience. Accordingly, risk implies exposure to substantial losses, over and above the normal costs of doing business. In agriculture, farmers incur small losses each year caused by moderately adverse climatic conditions and fluctuations in output or input prices. Risks discussed here refer to more severe and unpredictable events.

INDICATIVE QUANTIFICATION OF LOSSES

Available data on actual losses caused by adverse events in Mozambique are not particularly accurate or consistent within individual data sources. In an attempt to facilitate comparison and ranking of the costs and losses caused by various events, different data sources were combined to generate a more or less consistent time series. Appendix A describes the methodology for quantifying risk. The figures used (refer to tables 3.1–3.6)

are from actual data sources[13] and attempts have been made to prevent double-counting.[14]

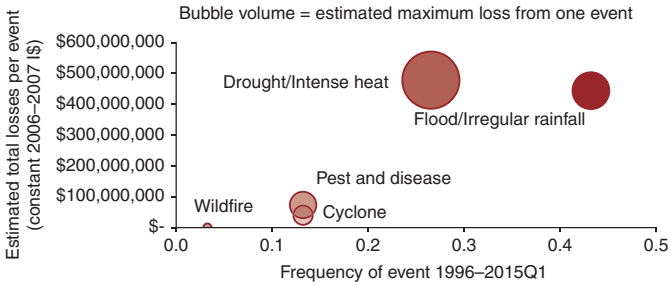
EXPECTED LOSSES AND RISK PRIORITIES FOR PRODUCTION

Figure 4.1 shows estimated aggregate total losses by risk event for 1996–2015Q1 clearly indicating that drought generates the most total losses but occurs slightly less than floods. It is also indicated that it was a drought that is estimated to have led to the single largest loss from one event (US$182 million—drought 2009/10).

Table 4.1 presents the estimated losses in numbers per event over the time period 1996–2015Q1 that total US$900 million from 3 million hectares lost. According to our calculations, 2000, 2007, and 2010 (see table 4.2) all had losses of over US$85 million in constant 2004–06 U.S. dollars. Table 4.1 also clearly indicates that in regard to frequency, floods and droughts happen regularly whereas catastrophic pests and disease outbreaks and cyclones (that incur severe damage) happen far less frequently. The incidence of wildfire was extremely low. However, the frequency of pest and disease outbreaks, in general, is much higher but their aggregate impacts are either localized or much smaller, thus not leading to severe losses at the national level.

Table 4.2 presents the same data broken down by year rather than risk event and shows that between 1996 and 2015Q1 there was an event that led to recorded losses every year except 2014, with some years experiencing as many as three events (2000 and 2007) and several with

FIGURE 4.1. ESTIMATED AGGREGATE TOTAL LOSSES BY RISK EVENT



Source: FAOSTAT (April 2015), the annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data, and Author's calculations.

two events (1999, 2002, 2003, 2006, 2009, 2010, and 2012). In 2000, widely accepted as the most memorable year as far as losses are concerned among farmers, it is estimated that 363,600 hectares were lost at an estimated cost of US$85.9 million. Of this, calculations suggest that 198,000 hectares or US$46.8 million was caused by flood, 160,000 hectares or US$37.8 million caused by locusts, and 5,600 hectares or US$1.3 million caused by cyclone. The extensive losses estimated in 2007 of 563,885 hectares demonstrate the impact of having flood and drought events in the same year. It was estimated that 203,263 hectares or US$50.5 million was lost caused by drought, 288,000 hectares or US$71.5 million because of flood and 72,622 hectares or US$18 million because of cyclone. The same is seen in 2010 with a total of 607,950 hectares or US$183.3 million (605,000 hectares of US$182.4 million caused by drought and 2,950 hectares or US$0.9 million caused by cyclone).

Unfortunately, sufficient data did not exist to be able to undertake sensible quantification on livestock losses, particularly for poultry. Given the importance of livestock in Mozambique's GDP,[15] as well as to food security more generally, it would have been useful to attempt to quantify the losses. Responses from farmer groups as well as a desk-based study strongly suggested that livestock diseases are a source of significant losses. Vaccines exist and producers

[13] Data sources used for the calculations include: FAOSTAT, the annual *Plano Economico e Social* (Economic and Social Plan), the annual *Balanço de Plano Economico e Social* (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data.

[14] Estimated losses were calculated as follows: the share of production from crops/agriculture was assumed to the 60 percent of net production value in constant 2004–06 US$, which was taken from FAOSTAT. This was divided by the amount of land in hectares planted for arable and permanent crops, also from FAOSTAT, to formulate an estimated cost per hectare. This estimated cost per hectare was then applied to the number of hectares lost per event per year that was derived from the various sources previously mentioned. Additional details on methodology are found in appendix A.

[15] According to IFPRI 2007 calculations, poultry was a 4.7 percent share of agricultural GDP.

TABLE 4.1. ESTIMATED AGGREGATE TOTAL LOSSES BY RISK EVENT, 1996–2015

Risk Event	Hectares Lost	Estimated Costs of Losses (constant 2004–06 US$)	Number of Events, 1996–2015Q1	Estimated Maximum Loss per Event (constant 2004–06 US$)
Drought/ intense heat	2 million	475.5 million	8	182 million
Flood	900,000	300 million	13	72 million
Pest and disease	300,000	70 million	4	38 million
Cyclone	100,000	39 million	4	18 million
Wildfire	7,000	2 million	1	2 million
TOTAL	**3 million**	**900 million**	**30**	

Source: FAOSTAT, the annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data, and Authors' calculations.

TABLE 4.2. ESTIMATED AGGREGATE TOTAL LOSSES BY YEAR, 1996–2015

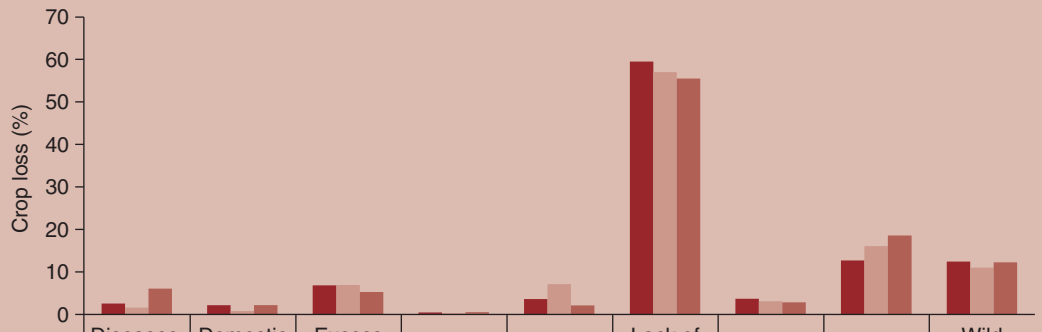
Year	Hectares Lost	Estimated Cost of Losses (constant 2004–06 US$)	Number of Events
1996	170,000	$39.3 million	1
1997	103,000	$24.5 million	1
1998	60,600	$15.0 million	1
1999	73,000	$18.4 million	2
2000	363,600	$85.9 million	3
2001	116,208	$28.8 million	1
2002	227,119	$53.6 million	2
2003	258,760	$63.4 million	2
2004	6,860	$1.7 million	1
2005	317,200	$70.1 million	1
2006	70,754	$17.3 million	2
2007	563,885	$140.0 million	3
2008	2,786	$0.8 million	1
2009	185,000	$47.7 million	2
2010	607,950	$183.3 million	2
2011	13,974	$4.5 million	1
2012	46,877	$15.2 million	2
2013	153,000	$50.0 million	1
2014	–	–	–
2015Q1	87,000	$28.2 million	1
TOTAL	**3,427,573**	**$789.8 million**	**30**

Source: FAOSTAT, the annual Plano Economico e Social (Economic and Social Plan), the annual Balanço de Plano Economico e Social (Balance of the Economic and Social Plan), FEWSNET/USAID monthly bulletins, SETSAN (Food Security) Reports for the Government of Mozambique and the Disaster Information System, UISDR from INGC—Government of Mozambique data, and Authors' calculations.

BOX 4.1. CROP LOSSES ACCORDING TO THE AGRICULTURAL CENSUS

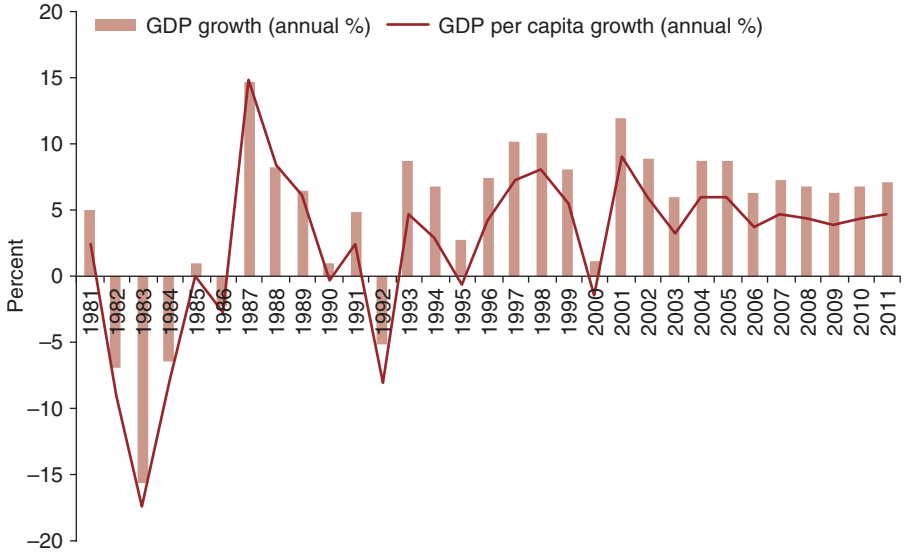
The Mozambique Agricultural Census 2002–07 asked small and medium producers (95 percent of all production in Mozambique) about the principal cause of crop losses. Figure B4.1.1 takes data from the 2002, 2003, 2005, 2006, and 2007 surveys. It can be clearly observed that lack of rain was the largest cause of loss: over 50 percent for maize, rice, and others. Losses attributable to pests and wild animals were lower, although still significant at over 10 percent, whereas floods, excess rain, and disease/rot (in other crops) came in at about 5 percent.

FIGURE B4.1.1. PRINCIPAL CAUSE OF CROP LOSSES



	Diseases, rot	Domestic animals	Excess rain	Fires	Floods	Lack of rain	Others	Pests	Wild animals
Maize	2.6	2.2	6.8	0.3	3.6	59.5	3.7	12.7	12.4
Rice	1.6	0.8	6.9	0.2	7.1	57.0	3.1	16.1	11.0
Others	6.1	2.2	5.3	0.4	2.1	55.5	2.8	18.6	12.2

FIGURE 4.2. ANNUAL GDP GROWTH AND GDP PER CAPITA



Source: World Development Indicators Database 2012.

are generally aware of their benefits, but they are not widely used because of their costs and limited availability.

Box 4.1 illustrates the percentage of crop losses that can be attributed to different types of risk according to the Mozambique Agricultural Censuses. Although exact figures do not exist, this information gives a good indication of the major risks as far as they are assessed in the minds of small and medium producers (95 percent of those involved in agricultural production in Mozambique).

IMPACT OF AGRICULTURAL RISKS ON NATIONAL GDP

In addition to having an effect on agricultural production, agricultural risks affect foreign exchange earnings, the GDP growth rate, per capita income, and government revenues. Responding to these impacts requires substantial resources. Figure 4.2 indicates the volatility of GDP growth and GDP per capita growth. The results suggest a close relationship between drops in GDP growth rates and risk events. Prior to 1992, the volatility is probably primarily the result of the civil war and political unrest, but these have not been important factors in the past two decades.

CHAPTER FIVE
STAKEHOLDER RISK ASSESSMENTS

How different stakeholder groups perceive and manage production risks varies significantly depending on the commodity as well as on the priorities and capacities of individual stakeholders. The importance and character of market risks for individual stakeholder groups is very much a function of the nature and extent of interaction with markets. A minority of producers use the market as a source of inputs and an outlet for their production to any significant extent. Almost the entire population depends on markets to some degree as a source of food. Enabling environment risks also affects everyone, but again by varying degrees at different points in time.

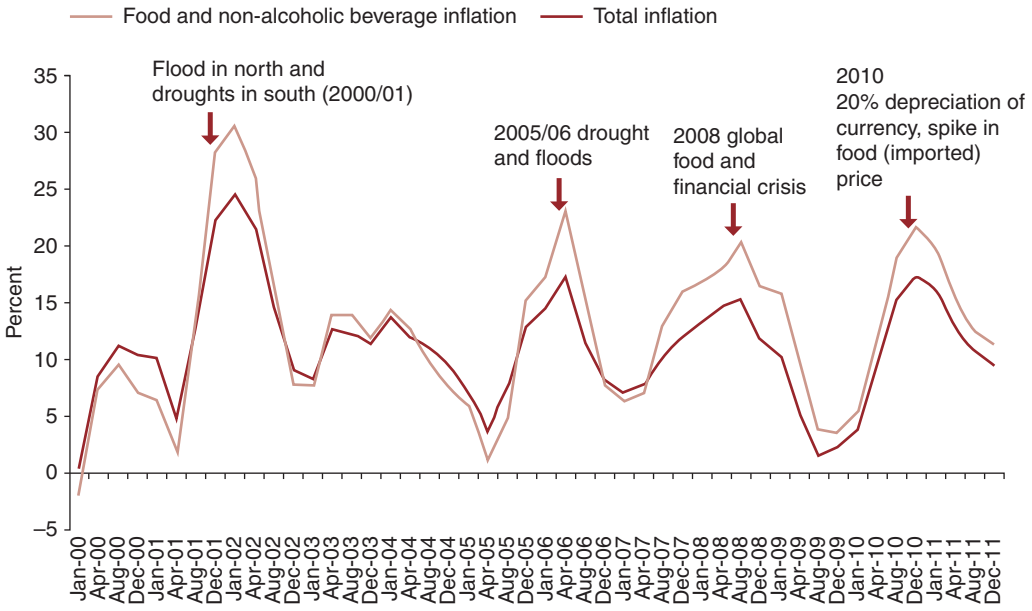
This chapter discusses the impacts of the range of risks described in chapter 3 on the major stakeholder groups, namely, government, producers, consumers, and the most vulnerable. Producers are a heterogeneous group that can be differentiated in several ways, including size of operations and relationships to markets. The vulnerable can be considered as components of producer and consumer groups, but are treated separately here in recognition of the severity of the impacts of risk-related events on this segment of the population.

This discussion disaggregates the impacts of the risks presented in chapters 3 and 4 by stakeholder group indicating which types of risks are most significant to each group as well as how the group is affected. Although there are insufficient data for formal quantification, the results provide additional guidance for the prioritization of risks and their management, which is the focus of chapter 6. In addition to severity and frequency of risk-related events, their differential impacts on stakeholder groups are considered in the prioritization and management response planning processes.

GOVERNMENT

The impact of agricultural risks is far reaching for governments, particularly when the economy and livelihoods are agriculturally dependent, and the government of Mozambique is no exception. Not only does it have to provide financing for immediate relief and coping, it also incurs loss of revenue from the agricultural sector, reduced GDP, and financial losses across the economy. The government has to confront the devastating effects on people's

FIGURE 5.1. ADVERSE IMPACT OF AGRICULTURAL RISKS ON INFLATION



livelihoods, in particular income loss (crop failure) and asset loss (livestock and infrastructure damages, for example, during flooding). Because producers can lose a substantial part of their crop production and much of the livestock in the areas where the disaster is most severe, the government must cope with the consequences, launching programs to relieve instances of food insecurity and malnutrition.

In the cases of floods and cyclones, the government has to bear the costs of resettling families in less flood-prone areas. There are also social consequences of moving populations a considerable distance from their farms, as naturally some are reluctant to leave their traditional zones of living and can be traumatized by the need, in certain cases, to forge new livelihoods.

One of the immediate effects of crop failure or price volatility is the drastic fall in volume and/or value of commodities trading, which reduces the government's capacity to collect taxes. It also reduces foreign exchange earnings because of the fall in production or value of export crops such as cotton, cashews, tobacco, tea, sugar, and other traditionally exported products.

The government annually provides US$3.5 million–US$5 million to INGC for disaster risk management and response, which may increase depending on the magnitude of the disaster. The contingency plan is also funded by international donors. Emergency financing put in place because of drought, flood, and cyclone leads to diversion of funding previously allocated for development activities. The ad hoc crisis response mode, rather than risk management, diverts attention from development priorities of the country, with significant opportunity costs. The frequent occurrence of agricultural risks leads to sudden spikes in inflation (figure 5.1), contributing to macroeconomic instability with adverse consequences for consumers.

PRODUCERS

Producers are directly and immediately affected by occurrence of market, production, and enabling environment risks. However, their exposure to risk and their capacity to manage are dependent on their production systems, size of operations, commodity spread, and so on, which eventually determine their losses.

SMALLHOLDERS

The agricultural economy is still heavily subsistence oriented; less than 10 percent of households sell their surpluses of maize, cassava, and so on. By being largely subsistence oriented, the majority of smallholders reduce their exposure to market-induced risks (World Bank 2006). Smaller farms commonly have diversified sets of farm and nonfarm enterprises, partially in an effort to

ensure they have some production and income for their survival when drought or other risks strike and result in crop or income loss. Nationally, 42.3 percent of family sector farmers experienced shortages of food at some time during the year (CAP 2009/10, INE). According to CAP 2009/10, irregularity of rainfall (51.3 percent) affecting 822.713 small farm units is the major reason for food deficit during the season 2009/10.

Although the small farms have diversified their crop composition and livelihood profile, they have only limited access to resources (information, technology, finance, infrastructure, and so on) and low capacity to manage. Their lack of use of inputs will also exacerbate losses experienced from pests and disease. Crop failures force small farms to become even more dependent on the market for their basic needs at times when prices are likely to be high and availability low.

COMMERCIAL FARMERS

Commercial farmers are those who regularly produce a surplus of one or more commodities that they sell locally in markets or to companies under contract. They are not necessarily self-sufficient in basic staple foods, but rather may opt to produce cash crops and buy at least a portion of their staple food needs from the market. They have a plot of five or more hectares with limited access to credit and can employ people for planting, weeding, and harvesting.

These farmers do not differ very much from the vast majority of smallholders whose land on average is 1.5 ha. As such, their vulnerability to the major natural hazards is similar to the vast majority of small farms. In many cases, these natural hazards may have more dramatic consequences on the welfare of the family because they have considerable costs of production (mechanized land preparation, significant lab costs, planting and harvesting, and so on) and potentially have loans that must be repaid. Their size is reported to be less than 1 percent of the total farmers involved in agriculture.

MEDIUM-SIZE FARMS

Medium-size farms follow more or less the same production pattern as do small farms. They cultivate larger plots, with their chosen crops based on cash crops and include some food crops such as beans, maize, rice, and cassava. In the lowlands of Sofala, Zambezia, and Gaza, huge losses have been reported in rice production relating to floods.

Despite the difficulties in overcoming the effects of the major hazards such as floods and droughts, their access to production means and financing can be substantially easier than the smaller farms. The difference is that they can "bet" a little more on pure cash crops and have the means to conduct their business more professionally, using the right technology with access to funds, and so on. This also increases their potential losses because their investment is higher than that of the smallholder farmers.

LARGE FARMS

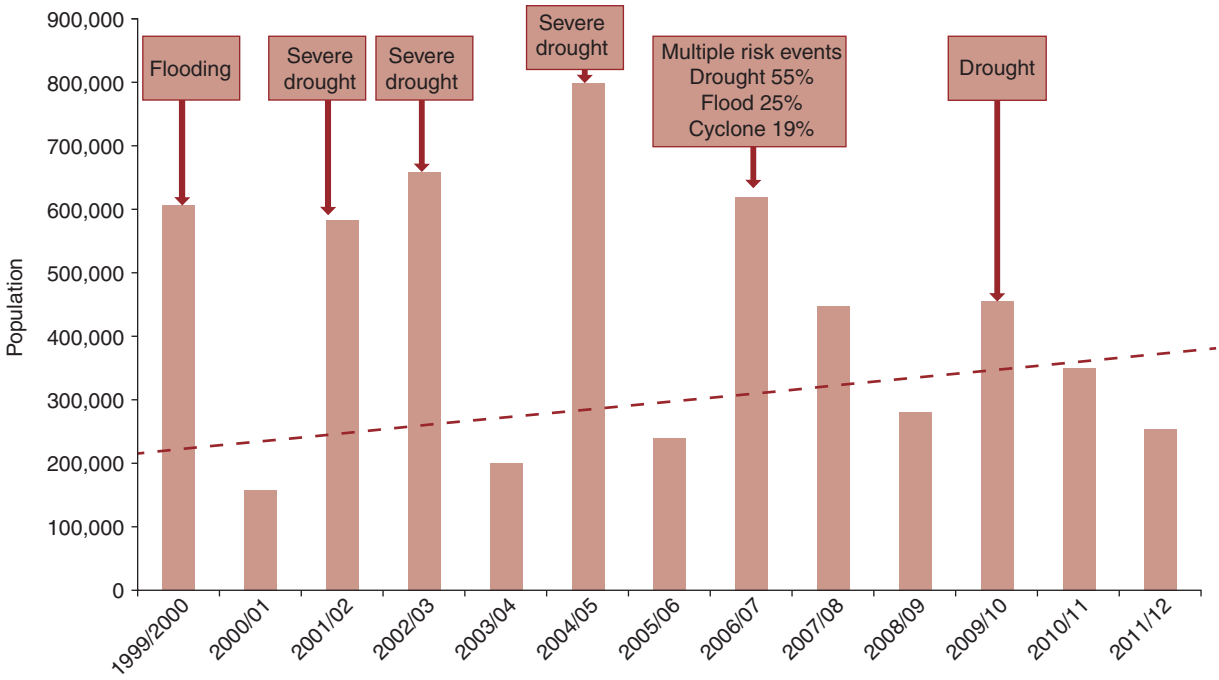
Large farmers tend to specialize, which gives them greater exposure to risks that may be specific to a particular commodity. They are exposed to drought, flood, and pest and disease outbreaks as well as international price volatility, given many are involved in production of export commodities. Some are also engaged in contract farming operation with small and medium farms, increasing their exposure to counterparty risk. Considering large farms have significant infrastructure (irrigation, machinery, and so on), they are exposed to severe and long-term asset loss, especially from flooding.

Although exposure is high, large farms have relatively better capacity to manage because of their access to information (weather, prices, and so on), finance, infrastructure, and technology, which help them in better decision making to reduce losses. Although the local availability of information, technology, and other instruments for managing risks is relatively limited, some of the larger firms are able to access these from South Africa.

VULNERABLE GROUPS

Agricultural risk is one of the biggest poverty traps, other than health risk, in Mozambique, leading to adverse impact on two of the biggest vulnerable groups: the rural poor and the urban poor. The bulk of the vulnerable population in rural areas is composed of small-scale farmers and female-headed households, with both groups significantly affected by occurrence of agricultural risks. Frequent crop failures and price spikes create food availability

FIGURE 5.2. ACUTE FOOD INSECURITY IN MOZAMBIQUE



Source: SETSAN reports.

and affordability problems for poor rural producers and poor urban consumers. A social safety net assessment of Mozambique produced by the World Bank (2012b) showed that, in the previous five years, households were exposed to a series of covariate and idiosyncratic shocks such as increases in food prices (reported by 36.5 percent of households) followed by drought (19.8 percent), the death of a household member (10.8 percent), or an illness in the household (8.1 percent).

Severe drought in 2004/05 resulted in a fourfold increase in acute food insecurity, with the population at risk growing from 200,000 to 800,000. Figure 5.2 highlights that every major occurrence of agricultural risk has resulted in a sudden increase in food insecurity in Mozambique. Not only does agricultural risk aggravate the situation for acute food insecure populations, it also is the principal cause of transient food insecurity.

The capacity to manage risk is weakest among the vulnerable population in Mozambiaque and this increases their vulnerability to a range of agricultural risks. Appendix D provides a detailed vulnerability analysis in Mozambique, with desciptions of vulnerable groups, recent trends in vulnerability, underlying factors to food security, and major shocks to food security in Mozambique.

CHAPTER SIX
RISK PRIORITIZATION AND MANAGEMENT

Risks for the agricultural sector differ significantly from one another not only in their character, but also in the severity, frequency, and distribution of their impacts on different areas, commodities, and sections of the Mozambican population. Chapter 3 describes the major risks affecting the agricultural sector. Production-related risks, notably drought and flood, are prominent, but there are also a range of risks associated with markets and the enabling environment. Chapters 4 and 5 attempt to quantify the losses associated with these major risks and assess their impacts on government and consumers as well as different categories of agricultural producers and service providers. Special attention has been given to the impacts on the most vulnerable groups in this process.

The information and analysis in the preceding chapters enable a prioritization of risks according to the magnitude, frequency, and distribution of the impacts of risk-related events. However, those results must be matched with measures to more effectively manage risks to be of use to those affected: individuals, communities, private enterprises, and public agencies. There is already an array of programs and activities that government, businesses, and individual farmers use to manage risks. Consumers manage higher prices and limited availability for some commodities by substituting with others. How effective are these activities and how adequate is their coverage? What are the options for better managing these risks and which are most feasible to implement in Mozambique?

This chapter summarizes the approaches and results of the risk prioritization (see "Risk Prioritization") and risk management (see "Risk Management") that are the focus of this initial phase of the agricultural sector risk assessment study. These findings in turn provide the background information for an examination of ways in which Mozambique can more effectively manage risks. It is important to note that difficulties in accessing good data and information to assess risks were encountered, which may have affected the prioritization undertaken. Interventions to better manage the risks prioritized, including access to information, are the focus of a proposed second phase for this exercise that took place in November 2014.

TABLE 6.1. RISK PRIORITIZATION

Probability of Event	Degree of Impact				
	Negligible	Moderate	Considerable	Critical	Catastrophic
Highly probable			Pests and diseases (for example, locusts, wild animals, cassava mosaic virus) Irregular rainfall	Flood	
Probable	Alluvian/soil erosion Input price volatility (for example, fertilizer, diesel) Counterparty risk Infrastructure disruption Heat/excessive temperature	Domestic price volatility Exchange rate risk Execution risk Cyclone/storm	International price volatility		Drought (late onset of rain, early cessation of rain, low cumulative rainfall)
Occasional					
Remote	Wildfires Violent conflict				

RISK PRIORITIZATION

The identification and prioritization of risks are critical initial steps in designing a more comprehensive and effective set of measures to manage those risks. To better utilize scarce resources, it is important to understand which risks, or subset of risks, are causing maximum losses, and at what frequency. Figure 4.1 in chapter 4 highlights the priority production risks, using quantitative measures, for the crop subsector. Because of the paucity of data, some of the risks could not be quantified. The ranking of risks combines qualitative and quantitative measures, based on the assessment team's evaluation. The relative significance of these risks for different segments of the population varies, as discussed in chapter 5.

A more in-depth discussion of agricultural risks is undertaken in chapter 3, whereas the analysis in this section highlights principal risks according to frequency and severity (see table 6.1). These include (1) weather-related risks (drought, flood, cyclones, high temperatures); (2) pests and diseases (locusts, other insect pests, wild animals, plant and animal diseases); (3) price volatility (domestic and international markets for products and inputs); (4) infrastructure disruption; (5) political instability; (6) soil erosion; (7) counterparty risks; (8) wildfires; and (9) execution risks.

RISK MANAGEMENT

Some risks are much more readily managed than are others, though there is no silver bullet to manage any given risk. Effective risk management typically requires a combination of measures; some are designed to remove underlying constraints and others to directly address the risk. One cannot control the weather, and significant resources are required to effectively offset the effects of drought and floods (for example, irrigation and flood control measures). Resource availability will often determine what is possible, and integrated risk management programs are often more effective than stand-alone programs.

CATEGORIES OF RISK MANAGEMENT MEASURES

Risk management measures can be classified into the following categories:

- **Risk mitigation (ex ante).** Actions designed to reduce the likelihood of risk or to reduce the severity of losses (for example, soil and water conservation measures, changes in cropping patterns, adoption of improved practices that improve performance and reduce risks such as conservation farming, using short duration and tolerant varieties; irrigation and flood control infrastructure).
- **Risk transfer (ex ante).** Actions that will transfer the risk to a willing third party. These mechanisms usually will trigger compensation in the case of a risk-generated loss (for example, purchasing insurance, reinsurance, financial hedging tools).
- **Risk coping (ex post).** Actions that will help the affected population and the government cope with the loss. They usually take the form of compensation (cash or in-kind), social protection programs, and livelihood recovery programs (for example, government assistance to farmers, debt restructuring, contingent risk financing).

Table 6.2 uses these classifications to highlight some of the indicative interventions that could be undertaken to manage selected risks in Mozambique, grouped by management strategy. This is followed by a brief description of 11 risk management interventions. Although agricultural risk management measures are discussed individually and/or sequentially, many of these interventions, if implemented jointly, can have positive and complementary impacts while addressing multiple risks and contribute to improved risk management in the short, medium, and long term.

Interventions are described in more detail below, where appropriate flood, drought, and pest and disease outbreaks have been grouped together if the intervention relates to various risks.

Soil and water conservation measures: Soil and water conservation measures (such as sand dams, Ngare or Mhindu ridging, afforestation/reforestation, conservation agriculture practices) are effective and efficient mechanisms for mitigating the risk of droughts and/or floods. In addition, they yield significant productivity gains and help in mitigating the effects of climate change adaptation. The bulk of these measures are undertaken on individual farmland or at the community level, whereas those involving a broader watershed or landscape approach require coordinated measures across a number of communities. Under the umbrella of conservation agriculture, a number of soil and water conservation practices are being promoted in Mozambique by projects funded by International Fund for Agricultural Development (IFAD), Millennium Challenge Corporation (MCC), USAID, and the African Development Bank (AfDB) and implemented by the Ministry of Agriculture and NGOs. Many of the practices of conservation agriculture contribute to soil and water conservation and help in mitigating drought and flood risk. Recent years have witnessed growth of projects, with successful results at the local level. However, on a broader level, the interventions are not yet on a scale to make any sizable impact on mitigating effects of drought or flood at a regional or national level. More coordinated landscape and/or watershed approaches and further scaling up of investments, at national and regional levels, with appropriate soil and water conservations measures will yield multiple dividends and should be the cornerstone of a stronger risk management plan in Mozambique.

Tolerant seed varieties: Widespread availability of tolerant seed varieties and short-maturing varieties will help in ensuring crop production during drought and flood years in addition to reducing losses from pest and disease outbreaks. In essence, short-maturing varieties escape the effects of drought at either end of the growing season when the frequency of rains tends to be most unpredictable. Tolerant varieties, conversely, are better able to survive periods of moisture stress or excess water and build resistance against specific pests and diseases. This needs to be coupled with early warning about impending weather and disease outbreaks to help inform farmer decisions on using appropriate varieties and thus mitigate the risk of total crop failure. The national system is currently unable to ensure sustainable delivery of tolerant seed, at affordable or subsidized prices, to all the farmers who need them. As a result, in spite of all the work being done by the government, its partners, and the private sector, only 10 percent of maize farmers and 4 percent of rice farmers (Governement of Mozambique 2008) (mostly large- and

TABLE 6.2. POTENTIAL INTERVENTIONS FOR RISK MANAGEMENT

	Mitigation	Transfer	Coping
Drought	• Soil and water conservation • Drought-tolerant varieties • Changing crop pattern • Irrigation (small and large scale) • Improved extension services • Improved weather information and early warning • Improved water management	• Crop insurance (farmer level) • Macro (government) level crop insurance	• Social safety net programs • On-farm storage • Savings/credit • Sovereign risk financing
Flood	• Soil and water conservation • Flood control infrastructure investments (for example, dikes, drainage) • Regional coordination • Flood-tolerant varieties • Altering crop pattern • Improved extension services • Improved weather information and early warning • Improved water management		• Social safety net programs • On-farm storage • Savings/credit • Sovereign risk financing
Pest and disease outbreak	• Promotion of integrated pest management • Pest- and disease-tolerant varieties • Improved extension services • Improved information and early warning		• Facilitate temporary migration
International price volatility	• Improved market information systems (production, stocks, prices, and so on) • Long-term forward contracts • Reducing postharvest losses • Improving storage	• Price hedging	• Social safety net programs • On-farm storage • Savings/credit • Sovereign risk financing
Domestic price volatility	• Improved market information systems (stocks, production, prices and so on) • Reducing postharvest losses • Improving storage • Investment in transportation and storage infrastructure • Facilitate regional trade	• Price hedging	• Social safety net programs • On-farm storage • Savings/credit • Sovereign risk financing

medium-scale commercial farmers) have access to these improved seeds that are largely aimed for yield improvement and not tolerance. A number of interventions are currently being undertaken by the Instituto de Investigação Agrária de Moçambique (IIAM), in collaboration with the International Centre for Maize and Wheat Improvement (CIMMYT) and other institutions, to develop and expand a number of tolerant varieties (HAR05 for resistance to downy mildew in maize, testing a flood-tolerant rice variety from East Asia, and developing drought-tolerant varieties of maize, and so on), which is a positive step. Addressing this issue will require a national- or regional-level approach to develop a seed system that ensures the sustainable delivery of tolerant varieties. This might entail

further support and expansion of seed multiplication by seed producers and cooperatives, expansion of seed multiplication by producers' organizations and private commercial firms, further support to agricultural input shops, and continuation of social protection activities whereby NGOs provide improved seeds to poor smallholder households. Furthermore, the possibility of research and development into newer varieties that are tolerant as well as high yielding (during normal years) could be explored.

Risk Transfer solutions: Agricultural insurance and commodity price hedging (using forward contracts and futures) could be useful risk management instruments. Successful functioning of farmer-level agricultural insurance requires the presence of a number of necessary preconditions: affordability (ability and willingness to pay premiums); relatively low frequency of events; robust crop and weather data infrastructure; farmers' access to financial products and services, and so on. Most of the necessary preconditions for farm-level agricultural insurance, unfortunately, do not exist currently in Mozambique, which places serious limitations on rolling out a large-scale agricultural insurance program in Mozambique. Appendix F provides further details of potential risk transfer and risk financing products in Mozambique. Price hedging using futures and forward contracts to manage price volatility in cotton and sugarcane is currently being undertaken by some of the larger exporters in Mozambique. Such instruments could potentially be used in other commodities and by small exporters, traders, and farmers' groups. However, they too require a large number of prerequisites: homogenization/standardization of commodities, transparency in commodity markets, limited interventions by the government, the presence of infrastructure (storage and warehousing), and so on. In Mozambique, many of these preconditions do not exist, which limits the potential use of hedging as a tool for managing price risk at a broader level.

Altered cropping patterns: Over the past few decades, Mozambique has witnessed changes in traditional cropping patterns. For instance, millet and sorghum (more drought tolerant crops) have replaced maize (a more sensitive crop), especially in low rainfall areas, resulting in increased risk exposure. Losses from drought could be significantly reduced by replacing maize with sorghum, millet, or root crops in areas where drought is particularly common. Root crops are generally more drought tolerant than are cereals. The trend of climate change will likely alter cropping calendars and seasonal agro-climatic conditions, which will necessitate altering cropping patterns and practices. This is a complicated endeavor as altering farmers' behavioral patterns, which are rooted in psycho-socioeconomic belief systems, can be very challenging. Nonetheless, cropping patterns that respond to appropriate weather and crop risk profiles are fundamental to managing agricultural risks while building resilience to climate change.

Irrigation: Irrigation has the potential to generate sizable gains in household welfare, boost agricultural growth, improve food security, mitigate the impact of drought, and promote overall economic growth in Mozambique. However, the performance record of irrigation schemes is very mixed, at times potentially increasing risk exposure (regular flooding and so on). Nonetheless, there is a strong case for investment in irrigation. Although it might not be able to address severe systemic droughts, it could help ensure food availability in food-deficit areas in the case of localized drought or poor rainfall distribution. Irrigation infrastructure in Mozambique is less developed than in the average Sub-Saharan African country. As of 2007, 2.7 percent of the country's cultivated area was equipped for irrigation, below the Sub-Saharan average of 3.5 percent. The equipped irrigation area contributes just 4.8 percent to the total agricultural output. In order to reverse this trend, the government of Mozambique approved a National Irrigation Strategy for 2011–19. The strategy is estimated to cost US$645 million and aims to double total irrigated land in the provinces of Sofala, Manica, and Zambezia from 66,000 hectares to 113,000 hectares by 2019. There is an increased push for small-scale irrigation, owing to its low cost and higher sustainability. For large-scale infrastructure projects, there is an emphasis on rehabilitating existing irrigation infrastructure and improving management. If designed appropriately, irrigation systems could help reduce drought risk and manage flood risk.

Weather, pests and disease, and early warning information systems for farmers: Ready access to timely, accurate, and localized information about impending events that could have a severe impact on crops is a prerequisite to enable preemptive actions by farmers to reduce exposure or losses. This may mean relocating and minimizing losses before a flood or postponing planting or early harvesting, as well as altering agronomic practices. Besides helping

managing risks, this information could also help farmers to better manage inputs and improve yields. The needs for such information will further increase because of weather uncertainties induced by climate change. Despite a number of small initiatives and rapid growth of information and communication technology (ICT), the majority of the farmers still do not have access to such information. Although there is an effective early warning system in Mozambique for flood, cyclone, and food security, its emphasis is on disaster response and saving human lives. Using information systems to guide and influence decision making by farmers and communities to reduce hazard, exposure, and losses at the farm level is still not high on the development agenda, despite the multiple benefits such systems could generate.

Flood control infrastructure investments: Thirteen big rivers flow across from southern Africa through Mozambique, exposing the agricultural sector relying on these rivers to frequent flooding. Dams, dikes, and drainage systems are some of the flood control infrastructure that can effectively mitigate the impacts of such events. The rehabilitated Massingir dam on the Limpopo River prevented floods in 2008 that could have affected the cities of Chókwe and Xai-Xai and protected the largest irrigation scheme in the country in Chókwe. Protection dikes have also been popular measures to protect settlements from floods: during 2007 and 2008, for example, dikes along the Zambezi were seen to have protected the towns of Luabo and Marromeu from inundation. Unfortunately, the existing condition of flood infrastructure is poor and in dire need of repair. Furthermore, the current flood control infrastructure must be significantly expanded to adequately address frequent flooding, as well as extreme flood events. Although the principal objective of such infrastructure has to be saving human settlements and infrastructure, preventing crop losses, and diverting and storing excess water for irrigation could be a useful secondary aim. Although national- and regional-level planning and coordination are necessary, the nature of the problem requires regional coordination among neighboring countries. There are already regional bodies, such as the Zambezi River Basin Initiative, that address issues related to shared water resources. Regional coordination also would allow countries to come together and provide critical mass to address issues before and as they arise.

Improved water management practices: Water deficit (drought) and water excess (flood) are two of the principal risks for Mozambique's agricultural sector that will be further aggravated attributable to climate change, hence effective water management has to be the cornerstone of any risk management strategy. This involves planning, developing, distributing, and managing the optimal use of water resources. Activities such as improving data and reforming water governance along with education and training on water management would aid in water availability, particularly in drought-prone areas. Improved water management both at the public sector level by government and private sector level (individual farming household and community) will be required for tackling the issue. The Ministry of Foreign Affairs of Denmark (DANIDA) supports activities to encourage those in arid and semiarid zones with water management.

Improved access to extension services: Improved access to extension services would allow producers to be better informed and to access advice, technology, and inputs to alter their agronomic practices in view of the current and emerging risk profile of the agricultural sector. The public extension service in Mozambique has been characterized by great variability in terms of availability of extension staff. Efforts of public extension are being complemented by NGOs and the private sector. In 2009, it was reported that 378,043 households were covered by public extension services; 203,683 households by NGOs; and 375,351 households by private sector extension services (SADC 2010). Though the coverage of extension services is increasing, it reaches only 12 percent of farmer households in Mozambique. The bulk of farming households do not have access to any extension services and further investment and expansion of extension services and development of new delivery channels will assist in improved management of agricultural risks.

Social safety net programs: Despite the vulnerability of the population to agricultural risk, other perils, and acute poverty, the social safety net programs are relatively weak in Mozambique. The World Bank's recent safety net assessment for Mozambique identified about 40 different social protection-related programs, but most of them were fragmented, had low coverage, and were not well targeted. There are limited mechanisms to help affected populations cope with high-frequency and high-impact covariate shocks. Although emergency food aid and disaster relief from donors and government partially help the

affected population to survive, aid alone is not sufficient to help the population recover from income and asset losses. There is an urgent need to consolidate, scale up, refocus, and improve targeting of social safety net programs. A recently approved US$50 million social protection project by the World Bank aims to provide temporary income support to extremely poor households and to put in place the building blocks of a social safety net system.

Improved market information system: Accurate, timely, and transparent availability of information about the production and stocks, trade flows, and prices in different markets can help manage price volatility in domestic markets. Although Mozambique's Agricultural Market Information System (SIMA) collects and provides price information concerning major agricultural commodities, there is limited reliable information about stocks and production, which hampers SIMA's efficacy. Strengthening agricultural statistics and collection and compilation of production data, along with collecting reliable information on stocks and trade flows, will improve transparency in agricultural markets and help in price risk management.

DECISION FILTERS

In a resource-constrained environment such as Mozambique, decision makers are compelled to find the quickest, cheapest, and most effective measures among myriad possibilities. A detailed and objective cost-benefit analysis can help in selecting the most appropriate intervention options. But conducting a cost-benefit analysis of many different options in itself can be costly and time consuming. Further, there is a range of not easily quantifiable considerations/criteria that are not easily factored into such types of analysis. Using decision filters to evaluate and prioritize among a list of potential interventions could help in making rational resource allocation decisions in lieu of a detailed cost-benefit analysis.

The following criteria were used by the World Bank team. There are a number of complex analytic screening tools to assess all of these decision filters and this study does not claim methodological rigor while assessing these filters. Instead, the study team applied these filters as a sort of rapid assessment to obtain first order of approximation, based on their assessment of the situation on the ground:

- ***Outreach.*** Although some interventions, because of prerequisites, might be able to benefit a small group of stakeholders, other interventions have an opportunity to reach many more stakeholders.
- ***Replicability.*** Some interventions with the potential to reach larger numbers of stakeholders can be more easily replicated than others.
- ***Cost.*** Without detailed assessments, it is difficult to estimate the cost of some interventions. However, based on the experience of the assessment team, the relative cost of interventions can be assessed. The cost involved in a large-scale irrigation project, for example, is generally much higher than the cost involved in setting up a system for seed distribution.
- ***Difficulty of implementation.*** The technical complexity of interventions and the capacity of local stakeholders to implement them are filters that could be used to prioritize decisions. Simpler interventions might find greater acceptability and will be easier to implement.
- ***Return time.*** Some interventions have a long gestation period, whereas others could yield quick results. Although risk management will require short-, medium-, and long-term perspectives, quick wins are often a high priority for decision makers.
- ***Sustainability of benefits/interventions.*** Given the scarcity of public resources, it is critical to ensure that money spent on these interventions will have a lasting impact.
- ***Environmental impact.*** Some of the risk management interventions, especially large-scale spraying of chemicals for locust destruction, could have long-term catastrophic consequences for the environment. Hence, it is important to scrutinize the potential adverse environmental impacts of a given intervention.
- ***Potential impact on poverty alleviation.*** Whereas some interventions would directly contribute to improved income and poverty alleviation, others might indirectly contribute to the goal. Using this filter helps to identify risk management interventions that might yield large poverty alleviation dividends.

The results after application of the decision filters (table 6.3) are indicative and imperfect; nonetheless, they present a first step toward the development of a more comprehensive

TABLE 6.3. DECISION FILTERS FOR PRIORITIZING INTERVENTIONS

	Outreach (low, medium, high)	Replicability (low, medium, high)	Cost (low, medium, high)	Difficulty of Implementation (low, medium, high)	Return Time for Impact (low, medium, high)	Sustainability of Benefits/ Interventions (low, medium, high)	Environmental Impact (positive, neutral, negative)	Potential Impact on Poverty Alleviation (high, medium, low)
Building tolerant systems (flood-, drought-, and disease-tolerant varieties)	H	H	L	M	S	M	Neutral	H
Small-scale irrigation	M	H	L	M	M	H	Neutral	H
Soil and water conservation measures (for example, conservation agriculture)	M	H	M	M	M	H	Positive	H
Improved market information system	H	M	M	M	L	H	Neutral	L
Altered cropping patterns	M	M	L	H	S	H	Neutral	M
Improved access to extension services	M	M	H	M	S	H	Positive	H
Saving/credit	L	H	M	M	S	H	Neutral	H/M
On-farm storage	M	H	M	M	S	H	Neutral	H
Social safety net programs (for example, food/ cash/vouchers for work, food aid)	M	H	H	M	S	M	Neutral	H

Improving water management practices	H	H	L	M	S	H/M	Positive	M
Large-scale irrigation	L	L	H	H	H	M	Positive or Negative	L
Flood control infrastructure investment (dikes, drainage, and so on)	M	M	H	H	M/L	H	Negative or positive	M
Timely and reliable availability of weather information to farmers and other stakeholders	H	H	H	H	S	H	Neutral	M
Regional coordination	H		L	H	M	H	Neutral	M
Promotion of integrated pest management	H	H	M	M	S	M	Positive	M
Subsidized crop insurance (for example, bundled with credit or input)	L	L	H	L	M	M	Neutral	M
Commercial catastrophic weather insurance	L	L	H	L	M	L	Neutral	L

Note: H = high, M = medium, L = low.

TABLE 6.4. MULTIPLE "WINS"

	Reduces the Risk	Reduces the Losses	Compensates after the Loss	Improves the Yield	Climate Change Mitigation	Climate Change Adaptation
Soil and water conservation measures (for example, conservation agriculture)	Y	Y	N	Y	Y	Y
Improved access to extension services	Y	Y	N	Y	Y	Y
Improved water management practices	Y	Y	N	Y	N	Y
Altered cropping patterns	Y	Y	N	N	Y	Y
Flood control infrastructure investment (dikes, drainage, and so on)	Y	Y	N	Y	N	Y
Small-scale irrigation	Y	Y	N	Y	N	Y
Large-scale Irrigation	Y	Y	N	Y	N	Y
Improved market information system	Y	Y	N	N	N	N
Building tolerant systems (flood-, drought-, and disease-tolerant varieties)	Y	Y	N	N	N	Y
Timely and reliable availability of weather information to farmers and other stakeholders	N	Y	N	Y	N	Y
Regional coordination	Y	Y	N	N	N	Y
Promotion of integrated pest management	Y	Y	N	Y	N	N
Subsidized crop insurance (for example, bundled with credit or input)	N	N	Y	Y	N	N
Commercial catastrophic weather insurance	N	N	Y	N	N	N
Sovereign risk financing	N	N	Y	N	N	N
Saving/credit	N	N	Y	N	N	N
On-farm storage	N	N	Y	N	N	N
Social safety net programs (for example, food/cash/vouchers for work, food aid)	N	N	Y	N	N	Y
Facilitate temporary migration	N	N	N	N	N	N

strategy for managing risks to the agricultural sector. Table 6.4 goes a step further and considers the various outcomes and whether multiple "wins" can be incurred. In both tables, potential outcomes are grouped by highest prioritization (table 6.3) and most "wins" (table 6.4).

The process put forth here and carried out by the team allowed for an initial consideration of all options. Following this, further discussions took place with the government and ultimately this informed the decision of MASA to continue with the three areas detailed in the ASRSA report.

TABLE 6.5. RISK MANAGEMENT INTERVENTION INTEGRATION WITH PNISA

Intervention	PNISA Components	PNISA Components
Soil and water conservation measures (for example, conservation agriculture)	Component 1: Production and Productivity	Program 6: Agrarian Extension
Improved access to extension services	Program 6: Agrarian Extension	
Improving water management practices	Component 1: Production and Productivity	Program 6: Agrarian Extension
Access to information (weather, price, diseases, early warning, and so on) to farmers	Program 6: Agrarian Extension	Program 19: Cartography and Remote sensing
Altered cropping patterns	Program 6: Agrarian Extension	
Flood control infrastructure investment (dikes, drainage, and so on)	Program 5: Agrarian Investigation	Program 7: Irrigation
Small-scale irrigation	Program 7: Irrigation	
Large-scale irrigation	Program 7: Irrigation	

The multiple "wins" achieved by the different interventions illustrated in table 6.4 include reducing the risk, reducing the losses incurred because of the risk, whether they lead to a compensation for those affected after the loss, whether they improve the yield of the crop affected, and whether there is any aspect of climate change mitigation of adaptation.

Based on prioritization of risk and intervention measures, the following seven intervention categories might yield the greatest risk management benefits:

1. Soil and water conservation (including conservation agriculture)
2. Improved access to extension services
3. Improved water management practices
4. Access to information (weather, price, diseases, early warning, and so on) to farmers
5. Changes in cropping practices, including cropping patterns and use of improved varieties
6. Flood control infrastructure
7. Irrigation (small and large scale)

All seven priority interventions align with PNISA (see table 6.5) and many of these interventions are already in place with successful positive outcomes. Many of these interventions are being implemented on a much smaller scale and are having positive impacts but at a localized level. Greater emphasis should be placed on scaling up these interventions to the national level to make a meaningful impact on the agricultural sector of Mozambique.

Expansion of the scale of these interventions would require understanding the landscape of interventions, assessing their relative efficacy, understanding principal barriers/challenges to success and scale, and identifying leverage points and necessary interventions to increase their access to a wide majority of agricultural sector stakeholders. Assessing solutions to help prioritize specific interventions to scale up priority programs and putting in place a risk management implementation plan will be the next steps in the process of building resilience in Mozambique's agricultural sector.

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APPENDIX A

METHODOLOGY/APPROACH TO PRODUCTION RISK LOSSES CALCULATION

- Gross production value [A] is taken from FAOSTAT.
- Share of production from crops/agriculture [b] was assumed to be about 60 percent of gross production value.
  - $b = 0.6 \times A$
- The amount of land planted in hectares for arable and permanent crops [C] per year was taken from FAOSTAT.
- The estimated value per hectare of land planted with arable and permanent crops [d] was derived by dividing the figure for the share of production from crops/agriculture using constant 2004–06 U.S. dollars by the estimated amount of land planted for arable and permanent crops.
  - $b/C = d$
- The hectare risk event number of hectares lost (e) was taken from analysis of annual reports from SETSAN (food security situation reports), the PES (The Annual Balance of Economic and Social Plan and Annual Economic and Social Plans), FEWSNET reports, Global Information and Early Warning System (GIEWS)/FAO reports and data downloaded from the Early Warning System.
- The estimated loss (f) was calculated by multiplying the estimated value per hectare by the hectares lost in a given year because of risk events.
  - $d \times e = f$

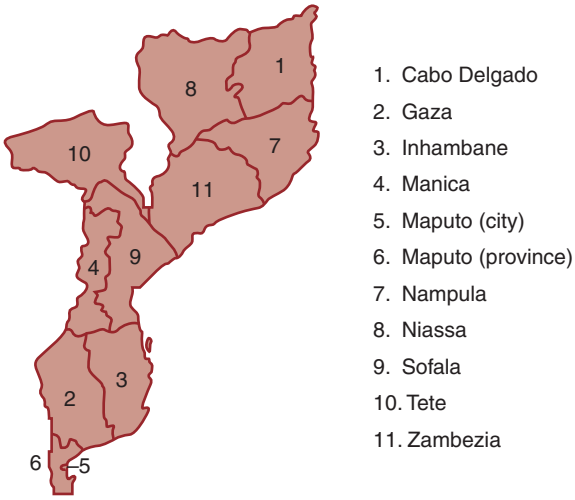
APPENDIX B
WEATHER YIELD REPORT

BACKGROUND

The World Bank is conducting a study of the relationship that several climatic events have on different crop yields for Mozambique. The purpose of the study is to determine whether yield is affected by climatic events and by how much these events affect it.

Figure B.1 shows the political division of Mozambique, which comprises 11 provinces, sorted here alphabetically.

FIGURE B.1. PROVINCES OF MOZAMBIQUE



Source: https://en.wikipedia.org/wiki/Provinces_of_Mozambique.

Agricultural information is provided on a regional basis but only for 10 provinces because the city of Maputo has no available data. The database comprises two variables: sowed area in thousand hectares, and production in thousand tons. Yield is not provided, but can be estimated as follows:

$$Yield = \frac{Production}{Area}$$

RAINFALL PATTERNS IN MOZAMBIQUE

A weather database was provided that consists of 31 weather stations spread across the country with data on a daily basis from January 1, 1979, to December 31, 2009. The available variables are precipitation, maximum temperature, and minimum temperature. Figure B.2 shows the geographic distribution of the weather stations.

On a general basis, rainfall follows a clear pattern throughout the whole country. From November to April rain is plentiful but is scarce from May to October it. Figure B.3 shows the mean cumulative rainfall per month for all the stations in each region.

DROUGHT AND EXCESS RAINFALL ANALYSIS

Because of the rainfall pattern described above, the year is not considered to be the calendar year, but rather the period from October of the previous year to September of the next year, in order to consider that rain falls mainly in the November–March period. Instead of showing the cumulative rainfall in each year, standardization was applied according to the following formula:

$$StdRain_i = \frac{\left(\Sigma_{i=nov}^{sep} Prec_i - \mu_i\right)}{\sigma_i}$$

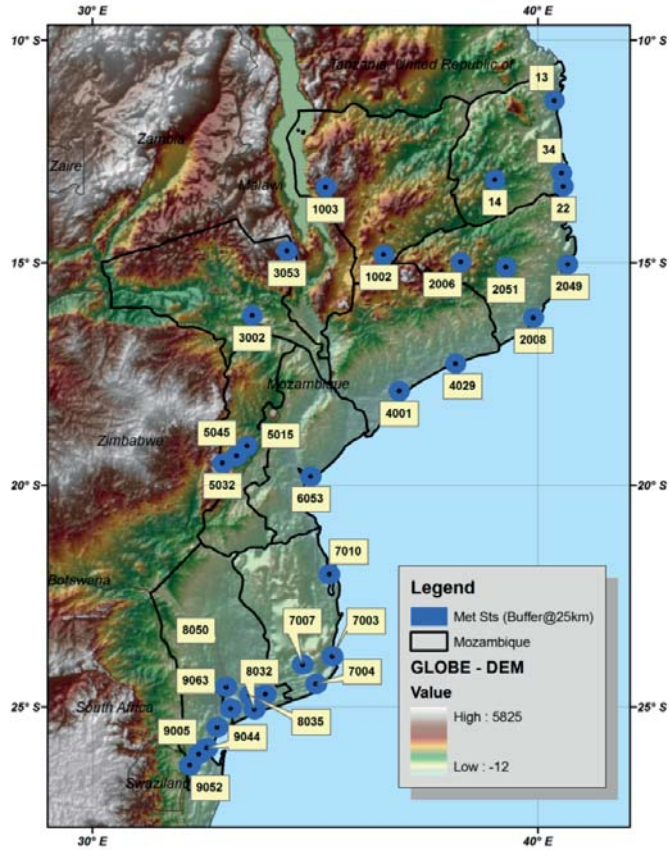
Where
StdRain, standardized cumulative rainfall
Prec, daily rainfall
μ, mean yearly rainfall
Σ, standard deviation of yearly rainfall
i, year

This way, it is easier to highlight drought and excess rainfall events.

SUMMARY

By counting all the stations that had a negative anomaly of precipitation (considered as a drought event), the following chart (figure B.4) summarizes the number of total stations that had drought events per year with colors representing the different provinces (red = North, green = Central, blue = South).

FIGURE B.2. LOCATION OF METEOROLOGICAL STATIONS



Source: Uribe.
Note: Labels indicate station ID.

Figure B.4 helps to visualize that there were four dry years: 1979 stands out as a year in which almost all provinces experienced insufficient rainfall, whereas 1992 follows closely as another dry year. Both 1983 and 1988 were also dry years with the lack of rain experienced only in some provinces.

At the other end of the rain spectrum, figure B.5 shows that there were three consecutive years in which rain was abundant in Mozambique. From 1999 to 2001, stations in many provinces experienced plentiful precipitation, particularly in the southern provinces of Inhambane, Gaza, and Maputo. Additionally, 1981 was humid, mainly in the south, whereas 1989 was humid, but mainly in the north.

FIGURE B.3. MEAN CUMULATIVE RAINFALL PER MONTH

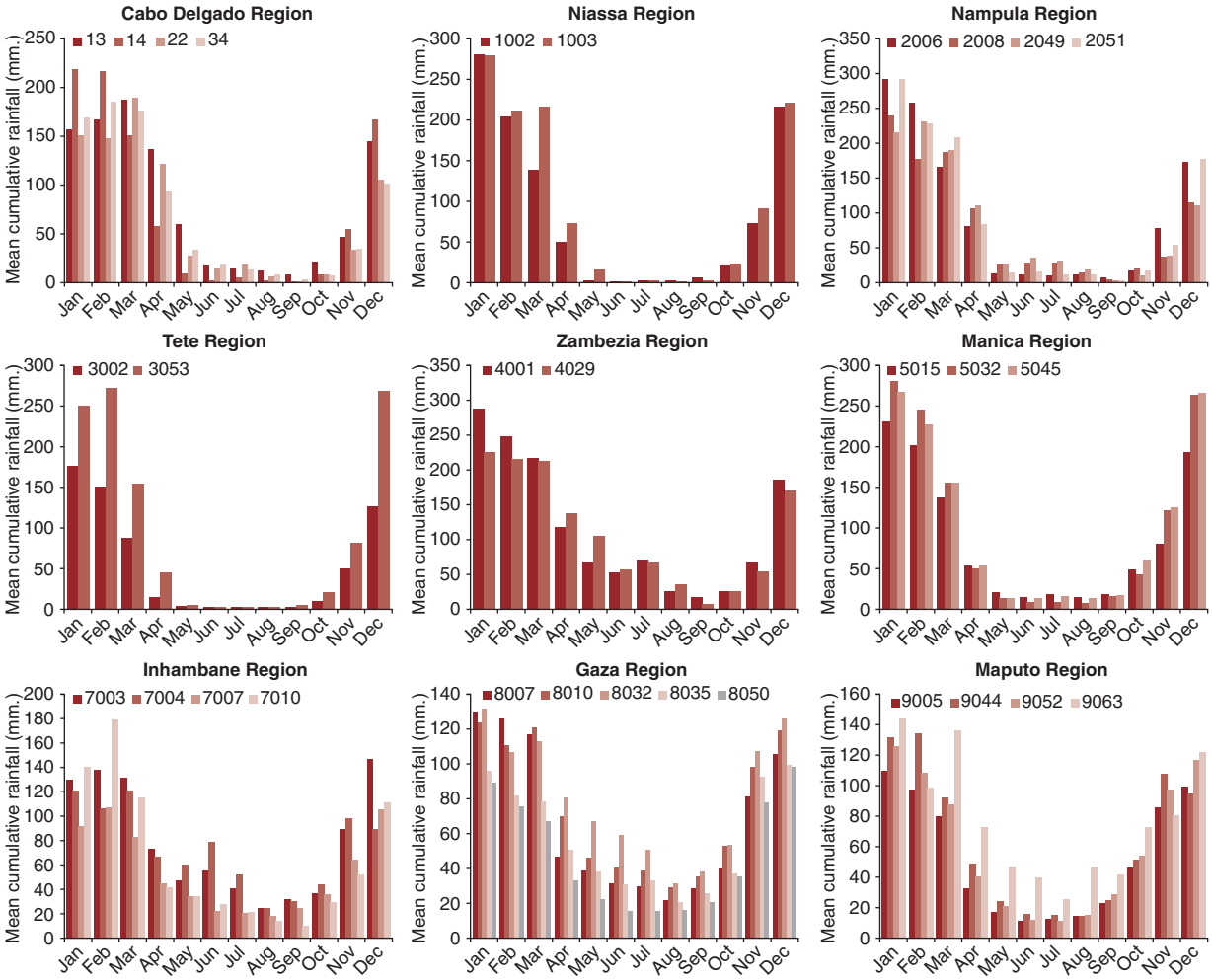


FIGURE B.4. DROUGHT EVENTS, 1979–2009

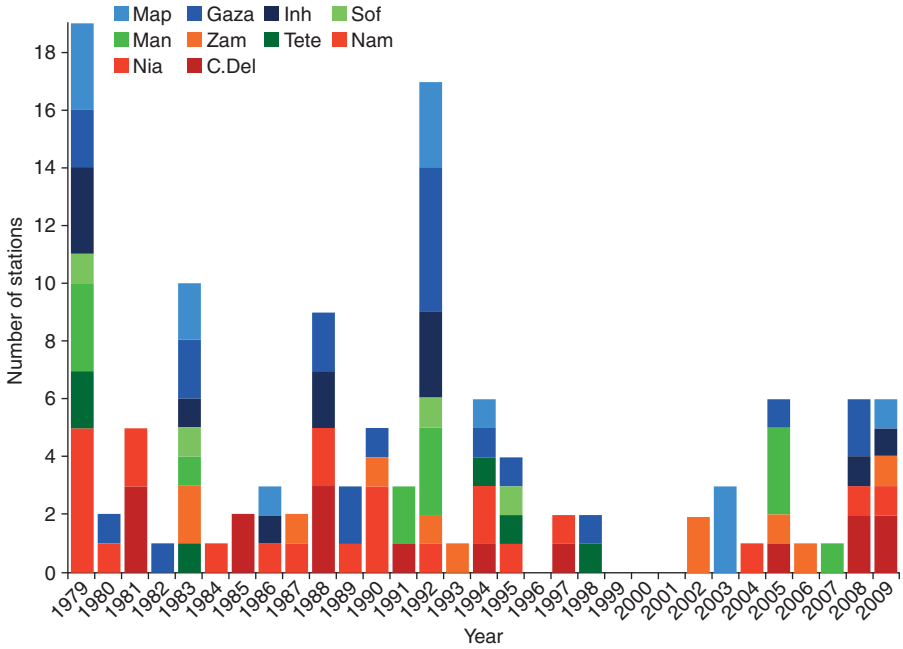
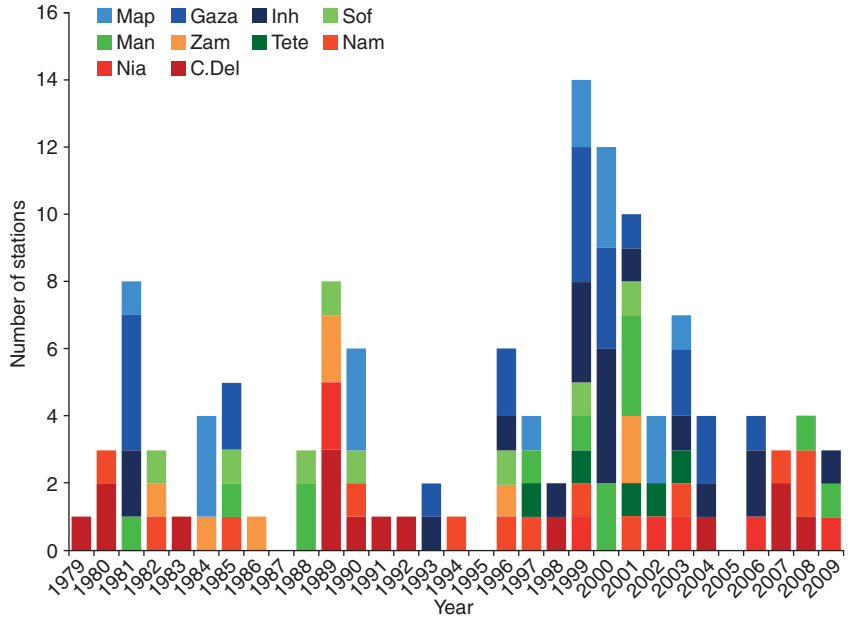


FIGURE B.5. EXCESS RAINFALL EVENTS, 1979–2009



RAINFALL—YIELD REGRESSIONS

It is significant that geographic resolution of data is not the same. Rainfall data are available on point estimates; at the same time, yield data are available regionwide, making up the whole political division as described above. Therefore, it is needed to make equivalent the geographic resolution of both data sets. As there is no information regarding the sowing zones within each region; all available stations within the region were considered to match the yield information of each region. Thus, the average of the available stations within a region was used as a proxy of each region's rainfall.

Linear regression models use each crop's growing phase cumulative rainfall as the explanatory variable for yield.

$$Yield = \beta_0 + \beta_1 CumRain_1$$
$$Yield = \beta_0 + \beta_2 CumRain_2$$
$$Yield = \beta_0 + \beta_3 CumRain_3$$

Where
$CumRain_1$ is the cumulative rainfall of the sowing season
$CumRain_2$ is the cumulative rainfall of the midseason
$CumRain_3$ is the cumulative rainfall of the harvest season

The main objective of the regression analysis is to calculate the determination coefficient (R^2) for each season. The determination coefficient is a measure of the proportion of the variability in yield that is being explained by cumulative rainfall. Therefore, whenever it is high (<40 percent), it is a good indication that rain and yield are related.

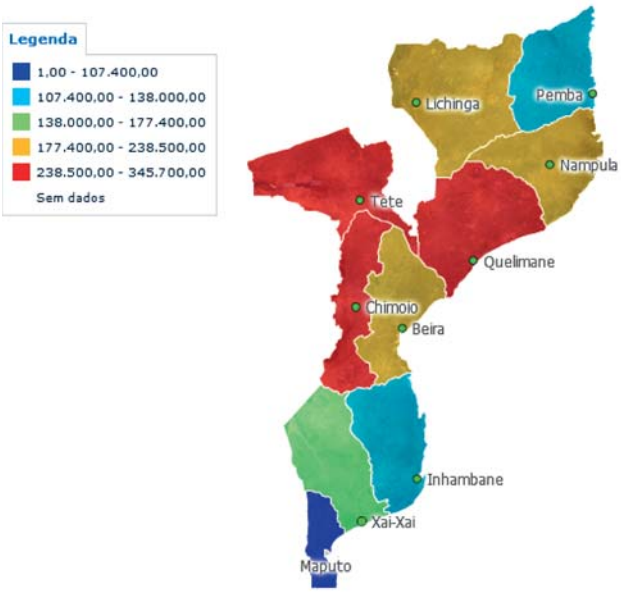
MAIZE (MILHO)

Maize is grown in most of Mozambique with an average of approximately 1.2 million hectares sown countrywide. But the area has been steadily increasing each year, with 1.6 million hectares sown in 2011. Production, conversely, has been increasing at a higher rate, with more than 2 million tons produced during 2011.

Thus, yield on a national level follows a similar pattern, with a steady increase, particularly since 2006, up to 1,300 kg/ha, whereas the average yield is 894 kg/ha. From 1992 to 1995, yield was low, but it has been steady since then (except in 2005, when yield was 769 kg/ha, lower than average).

The distribution of surface sown differs by region; in the central regions of Zambezia, Tete, and Manica, the most surface is sown, whereas Cabo Delgado, Inhambane, and Maputo are the regions where the least surface is sown. Figure B.6 shows the distribution of surface by region during 2008.

FIGURE B.6. MIDSEASON REGRESSION MODELS FOR NIASSA, INHAMBANE, AND MAPUTO PROVINCES



Estatisticas Regionais ... 2008

	Área	Valor
1	Zambezia	326.700,00
2	Tete	303.500,00
3	Manica	266.100,00
4	Nampula	209.100,00
5	Sofala	205.700,00
6	Niassa	196.100,00
7	Gaza	150.700,00
8	Cabo Delgado	135.100,00
9	Inhambane	118.300,00
10	Maputo	51.400,00

All studies of charts show a positive slope, indicating that the more rain, the more yield; as such, this signals a drought risk for the midseason. It is worth noting that in in the Niassa province, the two lowest yield years (2005 and 2007), in which yield was approximately 600 kg per hectare, were also the years with the lowest rainfall (227 mm in both instances).

In the province of Inhambane, there are also two observations with low rainfall as well as low yield. During 2002 and 2005, less than 60 mm fell and yield was low (less than 180 kg per hectare), but the lowest yield year (2003, with 156 kg/ha) had 143 mm of rainfall.

In Maputo, yield shows more volatility with a minimum of 194 kg/ha, matching a dry year (2003 with 110 mm), and a maximum of 1,028 kg/ha, matching a rainy year (2006, with 273 mm), so the drought signal is clear for this stage.

RICE (ARROZ)

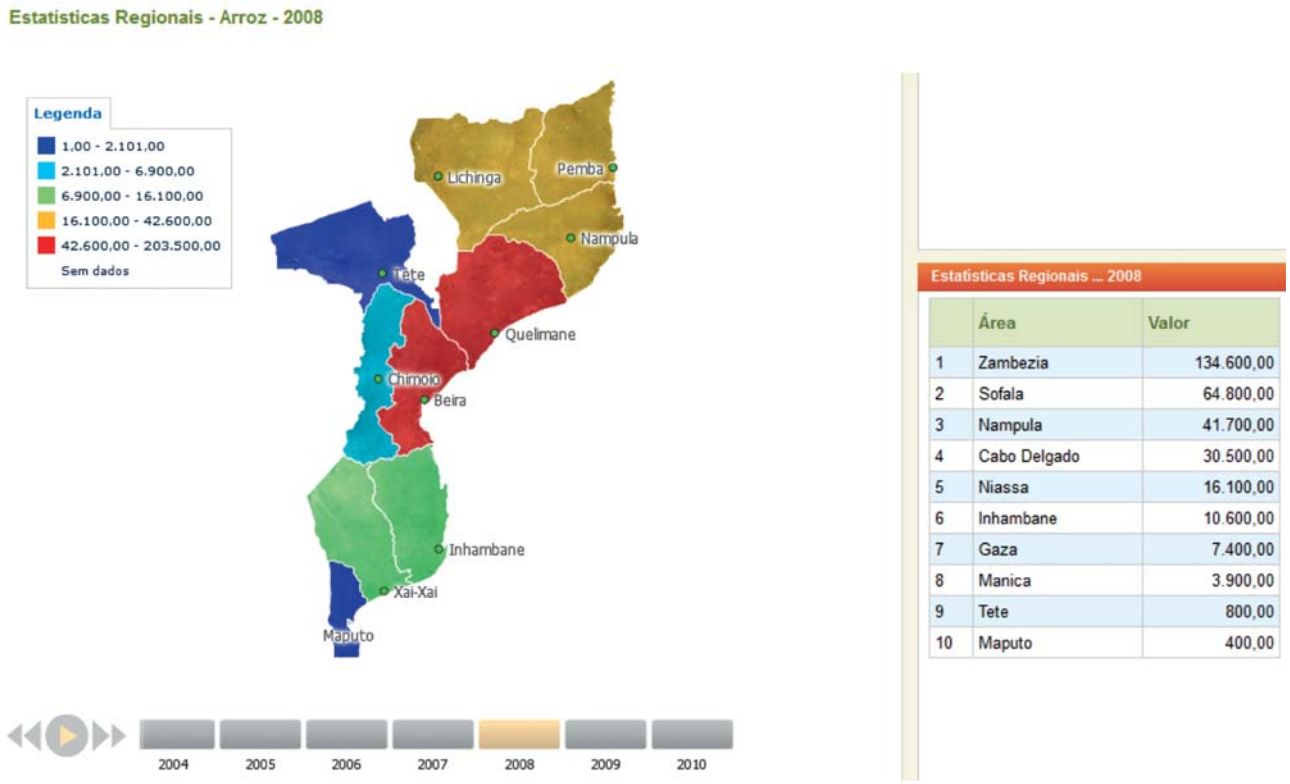
Rice is sown mainly in the coastal central region of Mozambique, but the surface dedicated to its production has varied significantly during the past 20 years. In the late 1990s, almost 200,000 ha of rice were sown, but then at the turn of the century it was halved to a minimum of 67,000 ha in 2005. Subsequently, the area sown grew to reach approximately 200,000 ha again.

Production follows the same pattern as surface, almost emulating the behavior of the surface sown. Yield, conversely, has been quite steady. Since 1994, yield has oscillated between 800 and 1,200 kg/ha, with little variation other than a peak in 2008 of 1.19 tons per hectare. The average yield is 930 kg/ha. Zambezia province provides almost half of the national surface, whereas Sofala and the northern provinces of Nampula, Cabo Delgado, and Niassa provide the other half. Figure B.7 illustrates the distribution of surface sown by region.

As with maize, regional data are only available from 2002 to 2008 (with the exception of 2004). Regional mean yield is 315 kg/ha, which is significantly lower than the national mean yield (930 kg/ha). The standard deviation is 204 kg/ha, which is an indication of low volatility in yield.

Given the absence of a specific sowing calendar for each crop, the same general sowing calendar used for maize was used for rice. Cumulative rainfall was calculated for each weather station for each stage in the calendar in order to determine the relationship between rainfall and yield. Simple linear regressions were run per region in order to determine the relationship of yield and rainfall. Table B.1 shows the determination coefficient (R^2) of the linear regression models applied by region.

FIGURE B.7. 2008 RICE SURFACE SOWN BY REGION (HECTARES)



	Área	Valor
1	Zambezia	134.600,00
2	Sofala	64.800,00
3	Nampula	41.700,00
4	Cabo Delgado	30.500,00
5	Niassa	16.100,00
6	Inhambane	10.600,00
7	Gaza	7.400,00
8	Manica	3.900,00
9	Tete	800,00
10	Maputo	400,00

Source: Instituto Nacional de Estatística.

TABLE B.1. DETERMINATION COEFFICIENT (LINEAR REGRESSION MODEL, RAINFALL, AND RICE YIELD)

	Determination Coefficient		
Province	**Sowing (%)**	**Midseason (%)**	**Harvest (%)**
Cabo Delgado	40	5	10
Niassa	0	95	14
Nampula	0	16	0
Tete	34	20	1
Zambezia	39	11	1
Manica	10	27	36
Sofala	6	1	37
Inhambane	0	2	20
Gaza	8	9	27
Maputo	31	60	26

For Zambezia, the most important region in terms of surface, and Cabo Delgado, cumulative rainfall during the sowing season shows a relatively important correlation with yield. In these regions, rain explains roughly 40 percent of the variability in yield.

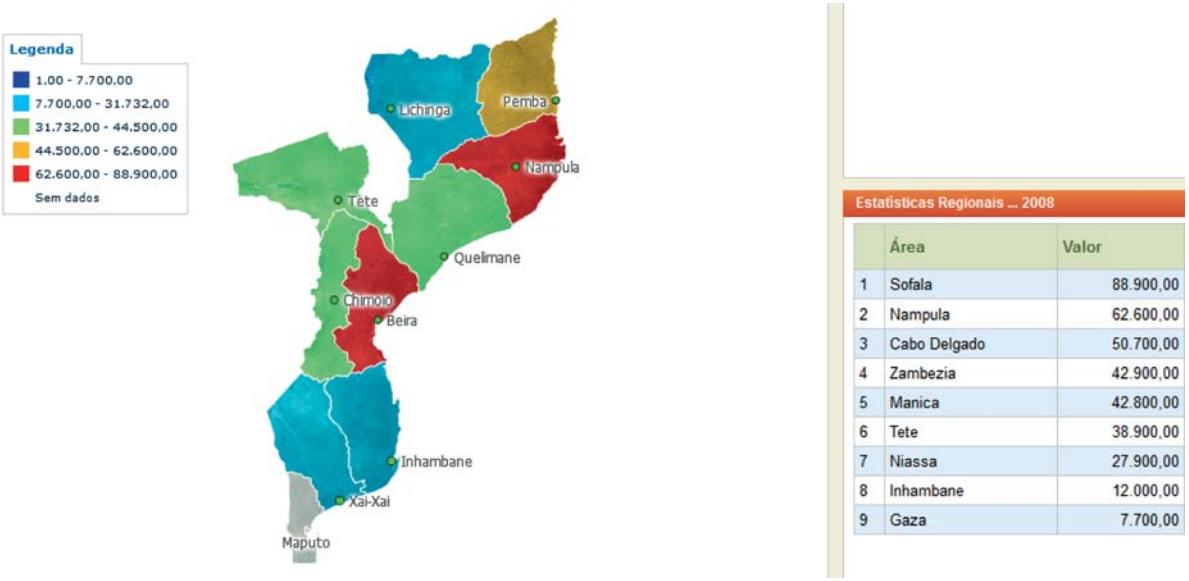
For Manica province, the outcome is negative, indicating that the more rain, the lower the yield. This is particularly evident because during 2007, yield was high (714 kg/ha) with only 73 mm of rain during the harvest season. Conversely, during 2002, yield was quite low (61 kg/ha) but 276 mm of rain fell, indicating an excess rainfall event affected yield during that season.

However, for Sofala the outcome is positive given that during very humid years (2003 and 2006) when approximately 800 mm of rain fell during the harvest season; the higher rainfall matched higher yields (300 kg/ha). It is worth noting that in Sofala province there is only one meteorological station, so it is possible that it is not located near the areas where rice is sown.

SORGHUM (MAPIRA)

The surface dedicated to sorghum production is spread more widely throughout the country. During the 1990s, an average of 400,000 ha were sown with sorghum, falling to less than 300,000 ha in the new century. In recent years, this has doubled with approximately 600,000 ha sown nationwide.

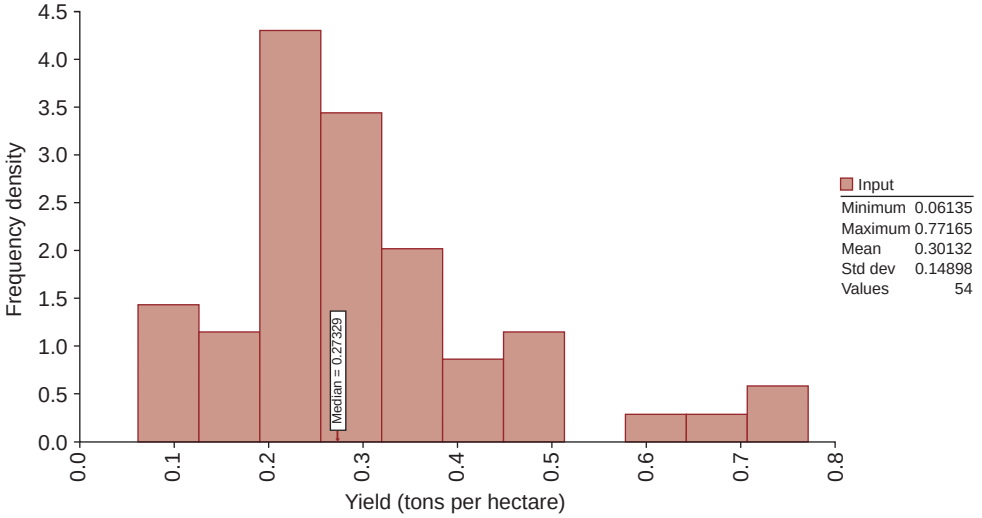
FIGURE B.8. 2008 SORGHUM SURFACE SOWN BY REGION (HECTARES)



	Área	Valor
1	Sofala	88.900,00
2	Nampula	62.600,00
3	Cabo Delgado	50.700,00
4	Zambezia	42.900,00
5	Manica	42.800,00
6	Tete	38.900,00
7	Niassa	27.900,00
8	Inhambane	12.000,00
9	Gaza	7.700,00

Source: Instituto Nacional de Estatística.

FIGURE B.9. SORGHUM YIELD HISTOGRAM FOR ALL REGIONS



Production follows the same pattern as surface, almost emulating the behavior of the surface sown, but always with less production than surface sown. Yield has been quite steady. From 1995 onward, yield has had little variation above or below the average of 550 kg/ha. There seems to have been an increase recently, as 2011 recorded a maximum of 787 kg/ha.

Sofala is the main province where sorghum is grown, with almost 90,000 ha sown during 2008. Nampula, Cabo Delgado, Zambezia, and Manica follow with approximately 50,000 ha in each province. Figure B.8 illustrates the distribution of surface sown by province.

As with the other crops, regional data are only available from 2002 to 2008 (again, with the exception of 2004). Regional mean yield is 301 kg/ha, which is significantly lower than the national mean yield (556 kg/ha). The standard deviation is 148 kg/ha, which is an indication of low volatility in yield. Figure B.9 shows the distribution of yield in all regions.

Because specific sowing calendars do not exist for each crop, the same general sowing calendar used for maize was used for sorghum. Cumulative rainfall was calculated for each weather station for each stage in the calendar in order to determine the relationship between rainfall and

TABLE B.2. DETERMINATION COEFFICIENT (LINEAR REGRESSION MODEL, RAINFALL, AND SORGHUM YIELD)

	Determination Coefficient		
Province	**Sowing (%)**	**Midseason (%)**	**Harvest (%)**
Cabo Delgado	44	10	21
Niassa	5	20	19
Nampula	5	3	8
Tete	58	16	77
Zambezia	59	6	2
Manica	1	8	4
Sofala	6	2	48
Inhambane	4	0	0
Gaza	0	4	3

yield. Simple linear regressions were run per region in order to determine the relationship of yield and rainfall. Table B.2 shows the determination coefficient (R^2) of the linear regression models applied by region.

There are three provinces for which rain during the sowing season is significant to explain variation in yield: Cabo Delgado, Tete, and Zambezia.

GROUNDNUTS (AMENDOIM)

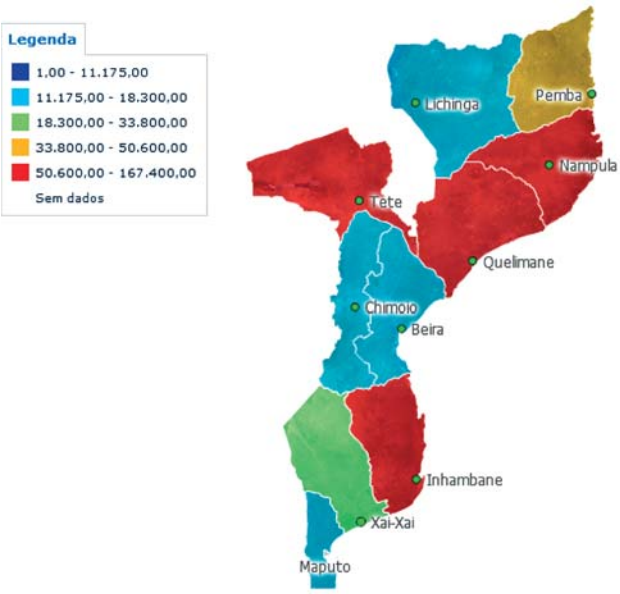
The surface dedicated to groundnut production has been steady during the past 20 years. Approximately 300,000 ha have been sown annually, with a maximum of 357,000 ha sown during 2009.

Production has also been steady at about 100,000 tons per year, but recently it has decreased to a level of 70,000 tons per year. Thus, yield shows a peak and a valley. In the late 1990s, yield reached a peak of more than 500 kg/ha, but recently, yield has been below the 20-year average of 353 kg/ha, with a minimum of 190 kg/ha during 2009.

Nampula is the most important province in terms of surface, with more than 160,000 ha sown during 2008. Zambezia, Tete, and Inhambane follow, with approximately 60,000 ha in each province. Figure B.10 illustrates the distribution of surface sown by province.

Once again, regional data are available only from 2002 to 2008 with the exception of 2004. Regional mean yield is 211 kg/ha, which is slightly lower than the national mean yield (353 kg/ha). The standard deviation is 117 kg/ha, which is an indication of low volatility in yield. The histogram in figure B.11 shows the distribution of yield in all regions.

FIGURE B.10. 2008 GROUNDNUTS SURFACE SOWN BY REGION (HECTARES)



Estatisticas Regionais ... 2008

	Área	Valor
1	Nampula	167.400,00
2	Zambezia	69.000,00
3	Tete	57.600,00
4	Inhambane	54.600,00
5	Cabo Delgado	34.900,00
6	Gaza	22.100,00
7	Niassa	14.400,00
8	Manica	13.000,00
9	Maputo	12.700,00
10	Sofala	12.500,00

Source: Instituto Nacional de Estatística.

FIGURE B.11. GROUNDNUT YIELD FOR ALL REGIONS

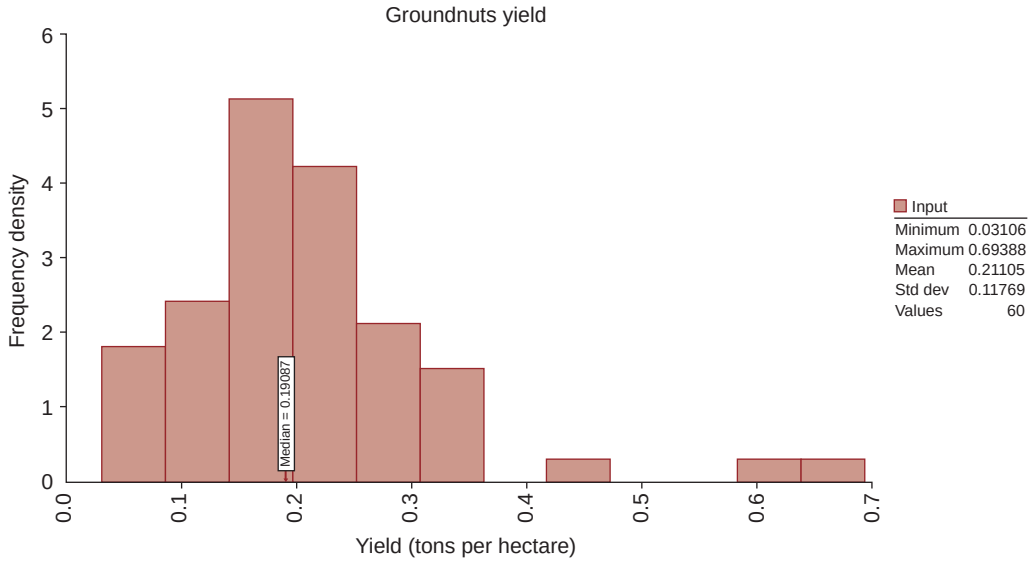


TABLE B.3. DETERMINATION COEFFICIENT (LINEAR REGRESSION MODEL, RAINFALL, AND GROUNDNUT YIELD)

	Determination Coefficient		
Province	**Sowing (%)**	**Midseason (%)**	**Harvest (%)**
Cabo Delgado	39	0	10
Niassa	40	29	49
Nampula	12	6	19
Tete	15	43	17
Zambezia	9	13	6
Manica	50	35	1
Sofala	6	6	7
Inhambane	45	70	26
Gaza	34	2	14
Maputo	2	25	66

In the absence of a specific sowing calendar for each crop, the same general sowing calendar used for maize was used for groundnuts. Cumulative rainfall was calculated for each weather station for each stage in the calendar in order to determine the relationship between rainfall and yield. Simple linear regressions were run per region in order to determine the relationship of yield and rainfall. Table B.3 shows the determination coefficient (R^2) of the linear regression models applied by region.

As table B.3 indicates, there are four provinces for which rain during the sowing season is significant to explain variation in yield: Cabo Delgado, Niassa, Manica, and Inhambane all have a significant correlation.

APPENDIX C

CLIMATE CHANGE IMPACT ASSESSMENT ON AGRICULTURE IN MOZAMBIQUE: LITERATURE REVIEW

INTRODUCTION

Agriculture is highly vulnerable to climate change in Mozambique, and the effects are heterogeneous based on model assumptions and across regions, socioeconomic groups, and crops and livestock. There are direct impacts, such as changes in crop yields attributable to precipitation changes, and indirect impacts, such as rising food prices because of production changes and land tenure conflict stemming from shifting agro-climatic zones. If climate change is left unaddressed, then progress in agricultural development, food security, and poverty alleviation in general may be reversed.

In the *Mapping the Impacts of Climate Change* index under "Agricultural Productivity Loss," the Center for Global Development ranks Mozambique 85th out of 233 countries globally for "direct risks" attributable to "physical climate impacts" and 28 out of 233 for "overall vulnerability" attributable to "physical impacts adjusted for coping ability" (Wheeler 2011). As agriculture accounts for 31.8 percent of the GDP and 81 percent of the labor force are involved in agriculture, there is great potential for widespread impact (CIA 2013).

Varying impacts, in combination with numerous approaches to impact studies, make it difficult to generalize the potential effects of climate change on agriculture in Mozambique. This appendix discusses possible outcomes in the context of agricultural productivity and yield.

PRINCIPAL FINDINGS

» The increase in the likelihood of extreme events caused by climate change, as opposed to changes in average temperature or precipitation, may pose the greatest threat to agriculture in Mozambique. This includes flooding, drought, and tropical cyclones. Risk management therefore becomes increasingly important.

- Mozambique is highly vulnerable to climate change because of its geography, in particular, its long coastline.
- Temperature projections vary in various models and scenarios, but generally Mozambique expects to see a rise of 1°C–2.5°C by midcentury and an increase of 1.4°C–4.6°C by late century.[16]
- Projections on precipitation vary from both positive to negative changes, but increases in the proportion of rain that falls during the rainy period may occur.
- Crop yields and land suitability:
  - With some variations, generally there will be no significant change in areas suitable for crops (cassava, maize, soybeans, sorghum, groundnuts, and cotton).
  - Likewise, the average change in yields in crops is projected to change in small increments, but generally will decrease slightly (cassava, sorghum, soybeans, sweet potatoes and yams, maize, groundnuts, millet, and potatoes).

BRIEF HISTORY OF CLIMATE CHANGE IMPACT ASSESSMENTS

The government of Mozambique has been very involved in climate change adaptation initiatives and disaster risk reduction strategies, including the 2007 National Adaptation Programme of Action (written following the United Nations Framework Convention on Climate Change) and the Mozambican Institute for Disaster Management's Climate Change program.

DANIDA and the United Nations Development Program (UNDP) funded the 2009 INGC Climate Change Report, which was coordinated by the Mozambican Institute for Disaster Management and focused on cropland "suitability." In October 2012, the INGC published another study (Phase II) on climate change digging further into impacts on agriculture by looking specifically at production and yields.

In 2010, the World Bank published a report, *Economics of Adaptation to Climate Change: Mozambique (EACC)*. Currently, the World Bank has two main activities in Mozambique related to climate change—the Climate Resilience Pilot Programme and the Global Facility for Disaster Risk Reduction.

METHODOLOGIES AND TEMPERATURE/ PRECIPITATION PROJECTIONS

In 2007, the Mozambican Initial Communication to the United Nations Framework Convention on Climate Change (UNFCCC) found that with a doubling of CO_2 the mean air temperature would increase 1.8°C–3.2°C, rainfall would be reduced by 2–9 percent, solar radiation would increase by 2–3 percent, and evapotranspiration would increase by 9–13 percent (MICOA 2003).

The UNDP Climate Change Country Profile for Mozambique from 2008 notes projected increases in temperature of 1.0°C to 2.8°C by the 2060s, and 1.4°C to 4.6°C by the 2090s (McSweeny, New, and Lizcano 2008). Two notable characteristics will be warming occurring more rapidly in the interior and high numbers of "hot" days and nights.[17]

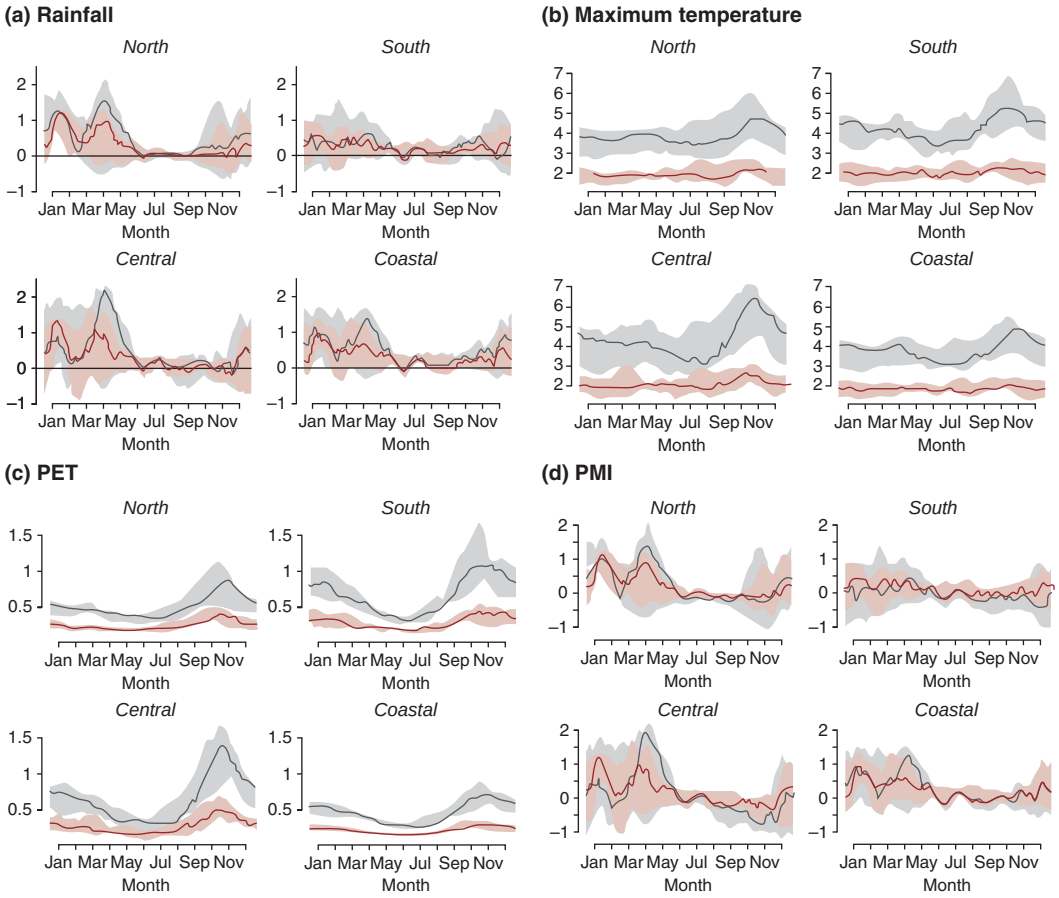
Using data from the National Institute of Meteorology of Mozambique (INAM), the 2009 INGC Climate Change Report ran seven general circulation models[18] forced with the SRES A2 emissions scenario, focusing on 2046–65 (midcentury) and 2080–2100 (late century) to project downscaled future climate scenarios. The seven Global Climate Models (GCMs) were also used in the IPCC 4th Assessment in 2007. The models incorporated the Geospatial Stream Flow Model (GeoSFM) to determine water resource conditions, and a dynamic and automated land evaluations system (ALES) to determine land utilization. ALES allows for the simulation of crop yields/performance under different management levels, and for the purposes of Mozambique associated yields with "prevailing smallholder traditional low-input farming systems and potential yields corresponding to limitation free highly managed commercial crop production systems." To look specifically at land suitability for six major crops, the report used three GCMs (Geophysical Fluid Dynamics Laboratory [GFDL] as the dry scenario, Pierre Simon Laplace Global Institute of Science of the Environment [IPSL] as

[16] IFPRI, UNDP.

[17] "Hot" days projected to increase by 17–35 percent by the 2060s and 20–53 percent by the 2090s.

[18] The seven different GCMs: CGCM3.1 (T63), CNRM-CM3, CSIRO-Mk3.0, ECHAM5/MPI-OM, GFDLCM2.1, GISS-ER, and IPSL-CM4

FIGURE C.1. ANNUAL CYCLE OF RAINFALL, MAXIMUM TEMPERATURE, POTENTIAL EVAPOTRANSPIRATION, AND POTENTIAL MOISTURE INDEX



Source: INGC, 2009b.

Figure 5: Changes in the annual cycle of a) Rainfall (mm day-1); b) Maximum temperature (°C); c) potential evapotranspiration (PET) (mm day-1) and d) Potential Moisture Index (PMI) (Rainfall – 0.5*PET) (mm day-1) simulated by seven GCMs for the North, Central, Southern and Coastal zones. Green shading indicated the range (olive line the median) for the 2046–2065 period, blue shading the range (blue line the median) change for the 2080–2100 period (Todross 2009).

wet, and ECHAM as intermediate) (vanLogchem and Britos 2009). FAO's CropWat model was used.

By midcentury, the models project increases in rainfall during two periods: (1) December, January, and February; and (2) March, April, and May. Higher increases in rainfall and seasonal variability are expected along the coast and in the south. Evotranspiration increases are greater than rainfall increases during two periods as well: (1) June, July, and August; and (2) September, October, and November. Averaged across the country, a 10–25 percent increase in rainfall is expected (van Logchem and Britos 2009).

Also by midcentury, higher temperatures are projected, particularly in the inland areas during the September, October, November period. The median estimates of increase in maximum temperatures are 2.5°C–3°C. Other observations from the INGC include that during the September, October, and November period, similar minimum temperature increases are projected for the Limpopo and Zambezi valleys and seasonal variability decreases for the maximum temperature in the north. During the March, April, and May period and the June, July, and August period, seasonal variability in maximum and minimum temperature increases in the north.

As the latter part of the 21st century approaches, the projections predict increases in temperature in the center of Mozambique of up to 5°C–6°C during the September, October, and November period (van Logchem and Britos 2009). The annual cycles are represented graphically in figure C.1.

TABLE C.1. PROJECTED CHANGES FOR 2046–65 IN AVERAGE TEMPERATURES DURING THE GROWING SEASON, CROP YIELDS UNDER RAIN-FED CONDITIONS, AND RAINFALL DURING THE CROP GROWING SEASON

	Changes in Temperature			Changes in Yield			Changes in Rainfall		
	Median (past)	Change in Future		Median (past)	Change in Future		Median (past)	Change in Future	
Crop	°C	DC	%	mm	mm	%	mm	mm	%
Cassava	23.8	2.0	8.5	0.397	−0.02	−4.2	633.7	−17.3	−2.7
Cotton	24.1	2.1	8.5	0.517	−0.02	−2.9	610.0	−20.0	−3.3
Groundnut	24.5	2.1	8.5	0.599	−0.03	−4.6	487.9	−5.1	−1.1
Maize	24.5	2.1	8.5	0.373	−0.04	−11.1	454.2	−5.8	−1.3
Sorghum	24.6	2.1	8.5	0.572	−0.02	−3.5	438.9	−3.9	−0.9
Soybeans	24.6	2.1	8.4	0.217	−0.03	−6.4	377.4	−4.5	−1.2

Source: Brito and Homan 2012.

Finally, the INGC Climate Change Report (INGC 2009b) suggests that there may be an increase in frequency and intensity of cyclones. Under the INGC report, there are two general scenarios for sea level by 2100: (1) low sea level rise of 30 cm, and (2) high sea level rise of 500 cm. Under the low scenario, tropical cyclones are the principal threat, along with coastal erosion and setback (approximately 30 m). In the high scenario, the coast and low-lying areas may be permanently flooded, with setback at about 500 m (devastating impact) (van Logchem and Britos 2009).

The World Bank Mozambique EACC derived climate outcomes from four general circulation models: global wet, global dry, Mozambique wet, and Mozambique dry. These scenarios were used to estimate changes in yield for rain-fed and irrigated crops, alongside demand for irrigation in six cash and eight food crops. This study was meant to supplement the INGC, and all four scenarios were also used by the INGC (World Bank 2010). The World Bank used CliCrop, a generic crop model,[19] to calculate the impact of changes in precipitation and increased CO_2 on crop yields and irrigation demand.

In the 2012 *Responding to Climate Change in Mozambique: Theme 6: Agriculture*, the INGC sought to quantify the effects of increased temperatures, changes in rain, and increased concentrations of carbon dioxide and ozone on six main crops (cotton, groundnuts, cassava, sorghum, maize, soy) (see table C.1). The report ran seven general circulation models to project temperature and rainfall data, and then used CliCrop to estimate yields based on soil humidity using a daily diary. Data came from 47 meteorological stations (Brito and Homan 2012).

International Food Policy and Research Institute's (IFPRI) study is based on the four downscaled global climate models from the IPCC AR4 (CNRM, ECHAM, CSIRO, and MIROC). 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. The CSIRO model projects little change in precipitation (although a slight decrease in the eastern part of Inhambane province, and an increase in part of Tete province), and projects the smallest increase in temperature, 1°C–1.5°C generally, but almost 2°C increases in parts of the south. The MIROC model projected little change in precipitation in the southern regions and most of the coast, but away from the coast in the north and northwestern regions. it projected increases in rainfall (occasionally exceeding 200 mm). MIROC projected warmer temperatures than CSIRO, with increases of 2°C–2.5°C (particularly in the northeast) (IFPRI 2012).

[19] CliCrop was developed jointly by the World Bank and the INGC to improve yield predictions and fix problems with monthly water estimations in previous models.

GENERAL FINDINGS

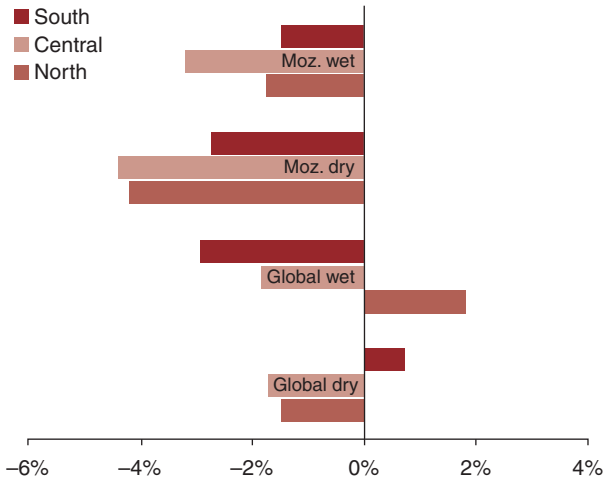
According to the 2009 INGC Climate Change Report, Mozambique is considered particularly vulnerable to climate change because of geographic factors. These geographic factors include a 2,700 km coastline, the convergence of multiple international rivers destined for the Indian Ocean, and large tracts of land below sea level. Other factors that increase Mozambique's vulnerability to climate change include already high temperatures, aridity, infertile soil, endemic disease, lack of a communications infrastructure, high illiteracy levels, high population growth rate, high absolute poverty rates, and dependence on natural resources requiring "predictable rain" (INGC n.d.).

The central zone will be hit hardest, with increased drought risk during the October, November, and December period, resulting in the highest likelihood of crop failure across the country according to the INGC assessment, particularly low-lying regions, such as the Zambezi valley, that already have high temperatures (van Logchem and Britos 2009). Generally, the increased risk of drought centers on Cahora Bassa in Mozambique, but also covers most of Zimbabwe and Zambia. It is important to consider neighboring countries as well, because increased drought risk in Zimbabwe during January, February, and March will have significant implications for trans-boundary water usage and agricultural trade (van Logchem and Britos 2009).

In the southern zone, increased temperature leads to a 10 percent increase in evapotranspiration and higher crop water requirements. But five of the seven models show that the risk of drought, damage to crops, and crop failure in southern Mozambique will be unchanged. In the north, all seven models project no change in drought risk or crop failure during the January, February, and March period. In the October, November, and December period, projections suggest low risk for drought, but possible increased or decreased crop failures (although along the coast it is more certain that there may be mild reductions in the frequency of crop failure) (van Logchem and Britos 2009). The projections make it difficult to generalize about changes in flooding, but generally, increased flood peaks will occur in small watersheds wherever storms make landfall.

With some variations, generally there will be no significant change in areas suitable for crops (cassava, maize, soybeans, sorghum, groundnuts, and cotton). Area may increase in the center and the north, and decreases will occur primarily where there are already issues of irregular and extreme climatic events (including the mixed arid-semiarid systems in the Gaza, semiarid systems in northern Inhambane and south of Tete, coastal zones in the south, southern central zones, and drier areas of major river systems such as the Save, Limpopo, and Zambeze) (van Logchem and Britos 2009).

FIGURE C.2. CLIMATE CHANGE EFFECTS ON YIELD FOR ALL MAJOR CROPS



Source: World Bank 2010.
Note: The crops modeled are cassava, sorghum, soybeans, sweet potatoes and yams, wheat, groundnuts, maize, millet, and potatoes.

River flow is not projected to decrease significantly in the north, and there is irrigation potential. The INGC projects that "increases in yields attainable with the intensification of agriculture and technological development are higher than the expected decreases in yields caused by climate change" (van Logchem and Britos 2009).

The World Bank EACC Mozambique projected a 2–4 percent decrease in major crops by 2050, particularly in the central region. This loss will be exacerbated by increased frequency of flooding (particularly along rural roads) and agricultural practices such as "slash and burn." The EACC predicts a 4.5–9.8 percent loss of agricultural GDP (World Bank 2010a).

In the 2012 INGC report, yields are examined across the six main crops (see table C.1). According to their models,

TABLE C.2. CLIMATE CHANGE EFFECTS (RAIN, TEMPERATURE, CO_2, AND O_2 CHANGES) ON CROP YIELDING IN THE 2046–65 PERIOD

Crop	Rain and Temperature	Temperatura	Co_2	O_3	Total
Cotton	−2.9%	−11.0%	+27.0%	−37.0%	−23.9%
Groundnut	−4.6%	−11.0%	+10.0%	−14.0%	−19.6%
Cassava	−4.2%	+6.0%	+10.0%	−14.0%	−2.2%
Sorghum	−3.5%	−11.0%	+7.0%	−9.0%	−16.5%
Maize	−11.1%	−11.0%	+7.0%	−9.0%	−24.1%
Soy	−6.4%	−11.0%	+20.0%	−28.0%	−25.4%
Average	−5.5%	−8.2%	+13.5%	−18.5%	−18.6%

Source: Brito and Homan 2012.

the most affected crop appears to be maize (with an overall 24.1 percent decrease in yield in the 2046–65 period), and the least affected crop as cassava (with an overall decrease of 2.2 percent) (Brito and Homan 2012).

The 2012 INGC report went a step further and used a layered approach to assess the effect of a rise in temperature, background ozone, and atmospheric carbon dioxide. Even using a layered approach, ground level ozone and atmospheric carbon dioxide have an interaction (see table C.3). The model used by INGC shows that a projected 15 parts per billion (ppb) increase in background ozone by midcentury virtually cancels out the increase in yield seen from a 178 parts per million (ppm) atmospheric carbon dioxide.

MAIZE

The IFPRI impact assessment results varied regionally, but CSIRO and MIROC generally showed 5–25 percent yield gain for rain-fed maize in the north, and differed in the south by 2050. The CSIRO model predicted both yield gains and losses of over 25 percent. MIROC, conversely, showed significant yield increases, most in excess of 25 percent. Both the CSIRO and MIROC show substantial yield gain across southern Gaza, along the confluence of the Limpoto and Olifants rivers (see figure C.3).

The INGC assessment, conversely, found a relatively constant, "no significant change" in suitable land for maize in 70 percent of the center zone, 69 percent in the south, and 76 percent of the coastal area. Figure C.4 is taken from the 2009 INGC Climate Change Report, as are similar charts in subsequent sections (van Logchem and Britos 2009).

The EACC Mozambique showed regional variability in change to maize yields, but when averaged across scenarios and regions saw a very small projected change of −0.66 percent. There is a stark contrast in suitability between the north and the south.

CASSAVA

The EACC Mozambique projects an ambiguous, but primarily a decrease, change in yields for cassava when averaged across scenarios and regions (−3.65 percent). Yields performed similarly under the 2012 INGC, showing decreases in a band across the center in Tete, and Sofala.

The 2009 INGC assessment found "no significant change" in land suitability for cassava. This is primarily because of cassava's relative drought and poor soil fertility tolerance. Interestingly, the greatest area of change away from land suitability is in the north. There is also an increase across parts of the center, principally Sofala.

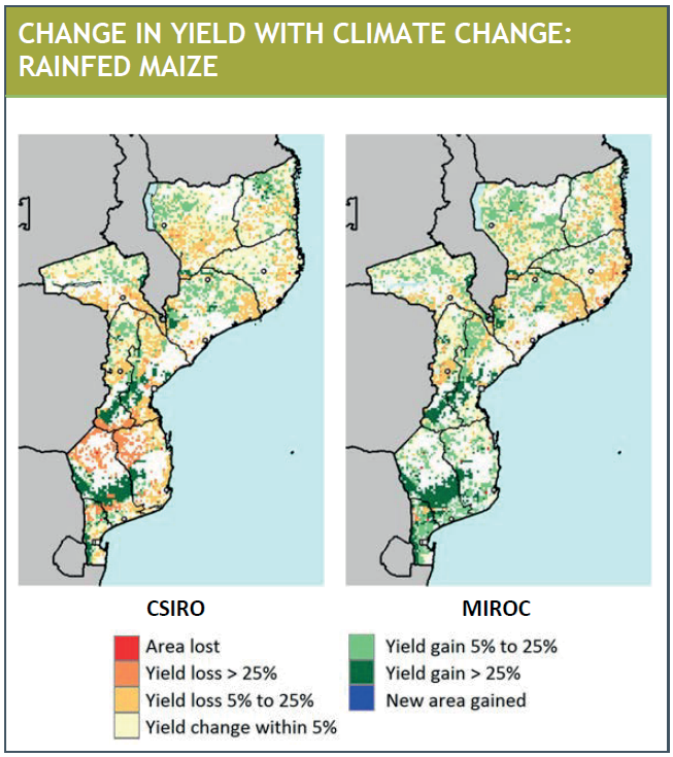
SOY

The EACC Mozambique showed little change in soybean yields, −1.28 percent, when averaged across scenarios and regions. According to the INGC assessment, the primary finding was "no significant change" for soy land suitability except in the south (inland) (van Logchem and Britos 2009). Yields similarly remained stable in the 2012 INGC

TABLE C.3. IMPACT OF MIDCENTURY CLIMATE CHANGE ON CROP YIELD IN MOZAMBIQUE: EFFECT OF RISE IN TEMPERATURE, BACKGROUND OZONE, AND ATMOSPHERIC CO_2, A LAYERED APPROACH

		Back Ground Ozone +15 a 30 ppb			Atmospheric CO_2 +178 ppm (550 ppm)			Surface Air Temperature +1.8 a 2.4 °C			Sum		
Crop	**Sensitivity Factor for Ozone**	**+15 ppb O_3**	**+23 ppb O_3**	**+30 ppb O_3**	**+15 ppb O_3**	**+23 ppb O_3**	**+30 ppb O_3**	**+1.8 °C**	**+2.1 °C**	**+2.4 °C**	**Min Total**	**Med Total**	**Max Total**
Cotton	1.6	−24%	−37%	−48%	+21%	+27%	+33	−9%	−11%	−13%	−12%	−21%	−28%
Soybeans	1.2	−18%	−28%	−36%	+16%	+20%	+25	−9%	−11%	−13%	−11%	−19%	−24%
Groundnuts	0.6	−9%	−14%	−18%	+8%	+10%	+12	−9%	−10%	−12%	−10%	−14%	−18%
Cassava	0.6	−9%	−14%	−18%	+8%	+10%	+12	+5%	+6%	+7%	+4%	+2%	+1%
Maize	0.4	−6%	−9%	−12%	+5%	+7%	+8	+10%	−13%	−15%	−11%	−15%	−19%
Sorghum	0.4	−6%	−9%	−12%	+5%	+7%	+8%	−8%	−10%	−11%	−9%	−12%	−15%

FIGURE C.3. CHANGE IN YIELD WITH CLIMATE CHANGE: RAIN-FED MAIZE



assessment, with the exception of decreases across the center, particularly in Tete.

Land suitability appears to increase slightly in the south with areas of "significant increase risk" in Zambezia (INGC 2009).

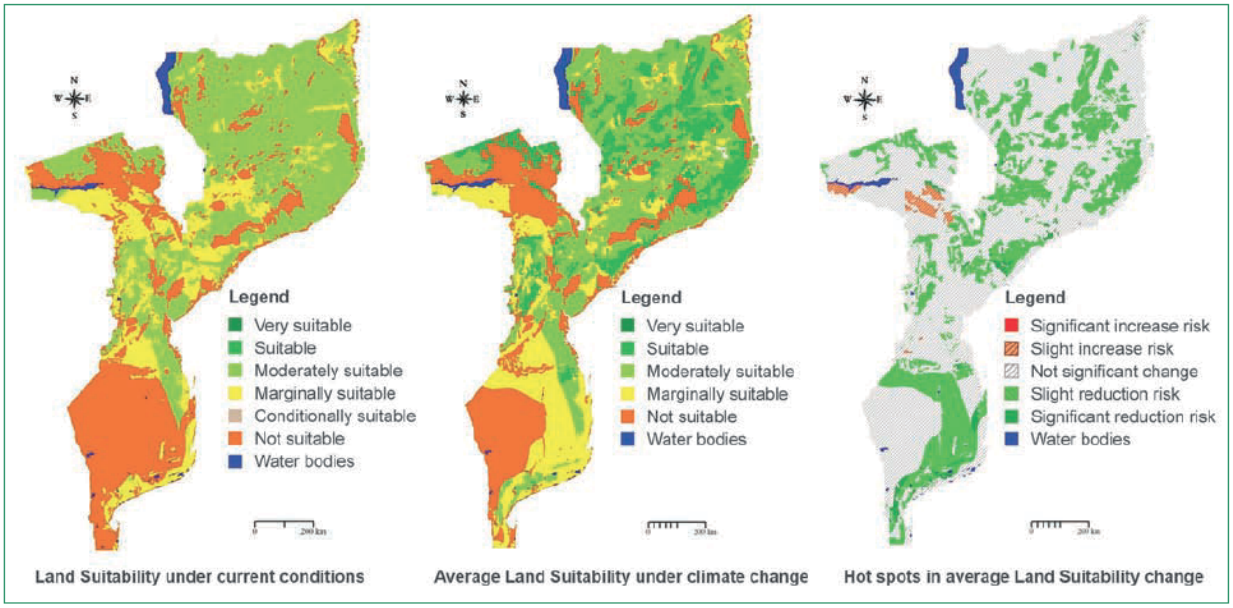
SORGHUM

The 2009 INGC assessment also found little change in land suitability for sorghum, although in a small section in the northern inland near Lake Nyasa, a sharp increase in risk is expected. Similarly, the EACC Mozambique found little change in yield across scenarios and regions. Averaged across scenarios and regions, the EACC Mozambique predicted a 0.51 percent decrease in yield. Very small changes in yield were noted by the 2012 INGC, concentrated in Tete. These changes in yields are among the lowest predicted for various crops.

OTHER CROPS

The EEAC Mozambique also projected changes in yield for sweet potatoes and yams, wheat, groundnuts, millet,

FIGURE C.4. MAPS OF LAND SUITABILITY AND HOTSPOTS RESULTING FROM CLIMATE CHANGE, FOR MAIZE



Source: IIAM 2008.

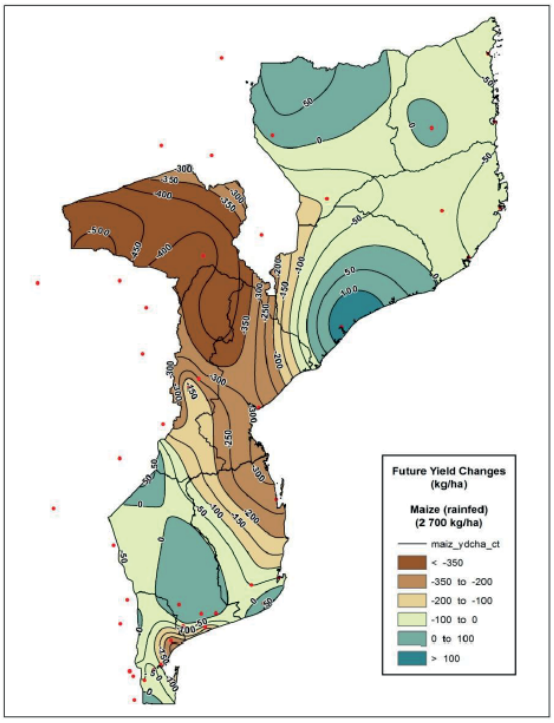
and potatoes. The results are displayed in table C.4 from the report.

CONCLUSION

In Mozambique, negative impacts on agriculture from climate change will primarily be caused by the increased likelihood of extreme events such as cyclones and flooding. However, outside of the expected increase in extreme events, agriculture in Mozambique will see little change in land suitability and yield (see figures C.5 through C.13).

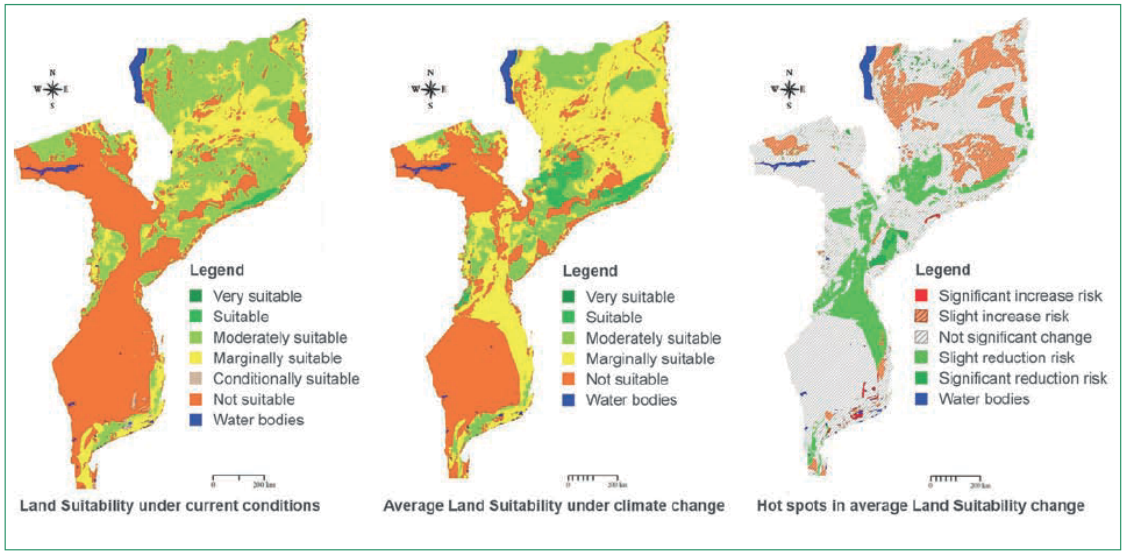
Risk management then becomes increasingly important as risk incidents increase across the country in a variety of manifestations. Among other tools, information systems (such as early warning systems, the disaster risk database) are paramount to mitigating these risks. Other risk management instruments noted throughout this agriculture risk assessment will also be crucial to protect producers and consumers alike as the uncertainty of climate change unfolds.

FIGURE C.5. EXPECTED CHANGES IN THE FUTURE (2046–65) FOR MAIZE (EXPRESSED IN KG/HA) UNDER RAIN-FED AGRICULTURE BASED ON THE MEDIAN OF ALL SEVEN GCMS



Source: Brito and Homan, 2012.

FIGURE C.6. CHANGE IN LAND SUITABILITY PER CROP RESULTING FROM CLIMATE CHANGE



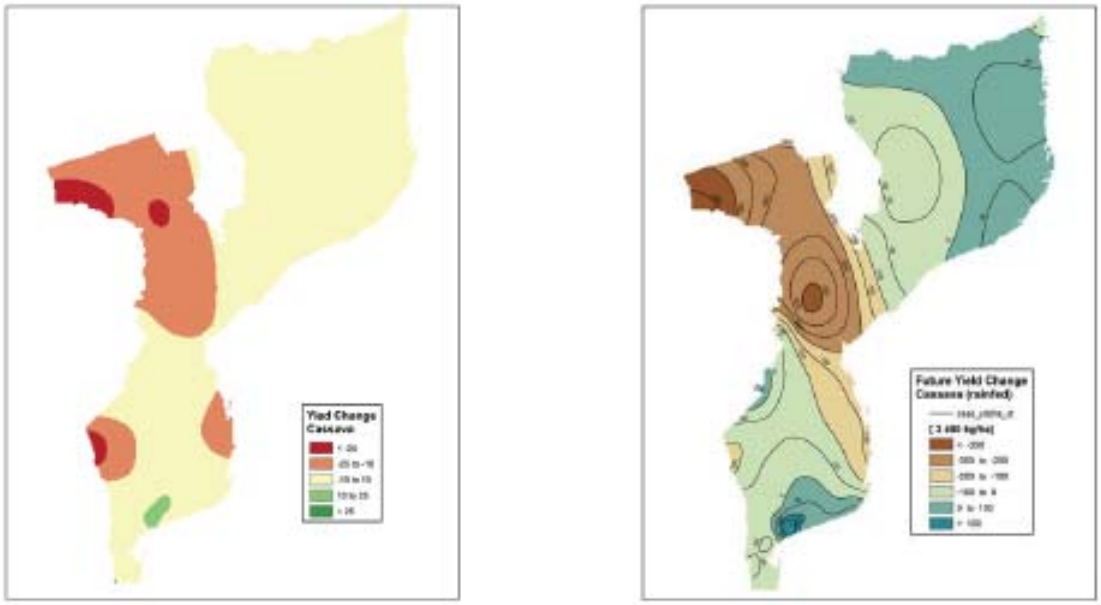
Maps of land suitability and hotspots resulting from climate change, for Cassava. The left map shows current suitability for the crop, the middle map the average suitability in the future (2030/40-2060), and the right map the difference between the two (whereby red is a significant reduction in suitability; pink a slight reduction in suitability; white shows no change; light and dark green show slight and significant increase in suitability, respectively). *Source: IIAM, 2008.*

TABLE C.4. AVERAGE OF THE PERCENTAGE CHANGE IN YIELD FOR MOZAMBIQUE

Crop	North				Central				South				
	csiro30_ a2 Global Dry	*ncarc_ a2 Global Wet*	*ukmo1_ a1b Moz. Dry*	*Ipsl_ a2 Moz. Wet*	*csiro30_ a2 Global Dry*	*ncarc_ a2 Global Wet*	*ukmo1_ a1b Moz. Dry*	*Ipsl_ a2 Moz. Wet*	*csiro30_ a2 Global Dry*	*ncarc_ a2 Global Wet*	*ukmo1_ a1b Moz. Dry*	*Ipsl_ a2 Moz. Wet*	*Average*
Cassava	−3.44%	2.01%	−6.51%	−0.09%	−6.24%	−4.75%	−6.21%	−3.10%	−3.27%	−9.36%	−3.20%	0.36%	−3,65%
Sorghum	−0.99%	0.66%	−6.08%	−1.59%	0.25%	−0.74%	−0.66%	−1.97%	0.55%	−1.57%	1.33%	− 0.68%	−0.51%
Soybeans	−0.40%	0.06%	−2.58%	−1.00%	−0.52%	−3.63%	−5.81%	−1.46%	−1.32%	−6.06%	5.91%	1.47%	−1,28%
Sweet Potatoes and Yams	0.29%	0.58%	−5.70%	−1.39%	−1.45%	−4.05%	−6.70%	−5.70%	−0.32%	−3.69%	−4.45%	−0.63%	−2.77%
Wheat	−2.18%	−2.31%	−5.11%	−3.20%	−0.93%	−4.33%	−3.03%	−2.93%	−1.64%	5.11%	2.48%	0.20%	−2.10%
Groundnuts	0.71%	1.65%	−3.23%	−1.84%	1.17%	−0.08%	−4.73%	−3.66%	−1.66%	−2.90%	−3.72%	0.58%	−1.48%
Maize	−1.32%	1.27%	−1.87%	−2.92%	0.64%	0.34%	−2.59%	−3.04%	6.37%	3.49%	−3.95%	−4.36%	−0.66%
Millet	−6.82%	10.03%	−17.38%	−8.40%	−1.35%	−3.45%	−1.78%	−6.29%	−2.78%	−10.07%	7.85%	0.29%	−3,34%
Potatoes	−0.36%	4.15%	−5.87%	−1.10%	−3.20%	−1.15%	−8.05%	−1.46%	−4.09%	−6.78%	−3.10%	1.29%	−2.69%
Average	−1.61%	2.01%	−5.44%	−2.07%	−1.29%	−2.43%	−4.40%	−3.29%	−0.91%	−4.67%	−0.09%	−0.45%	−2,05%

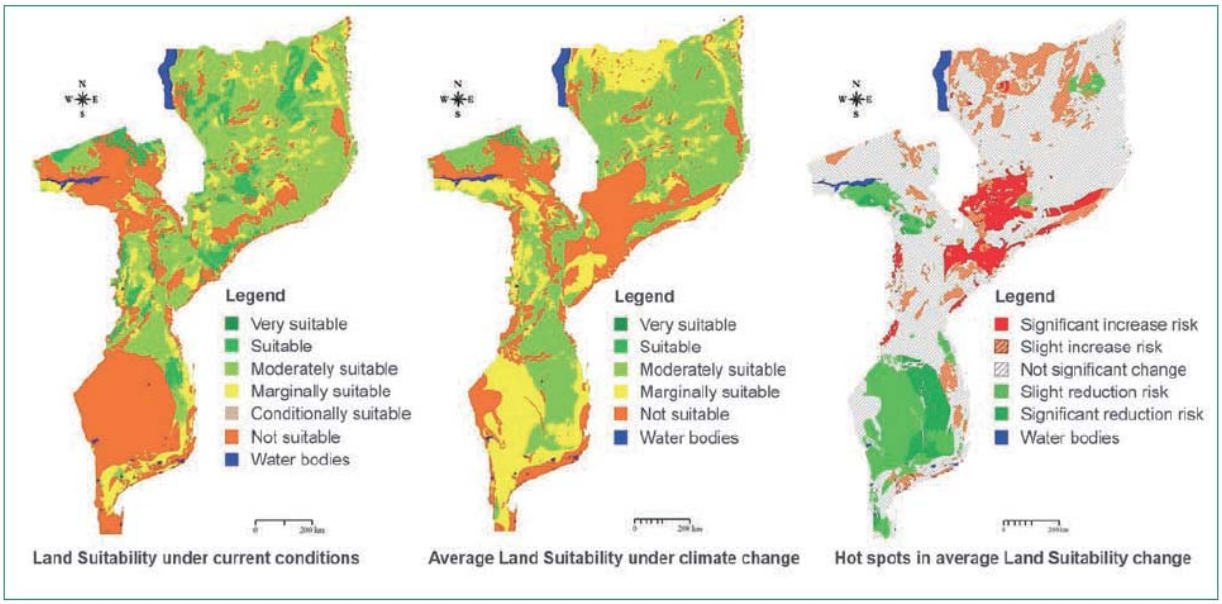
Source: World Bank 2010.

FIGURE C.7. A. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR CASSAVA IN PERCENTAGE OF PRESENT YIELDS. B. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR CASSAVA IN KG/HA



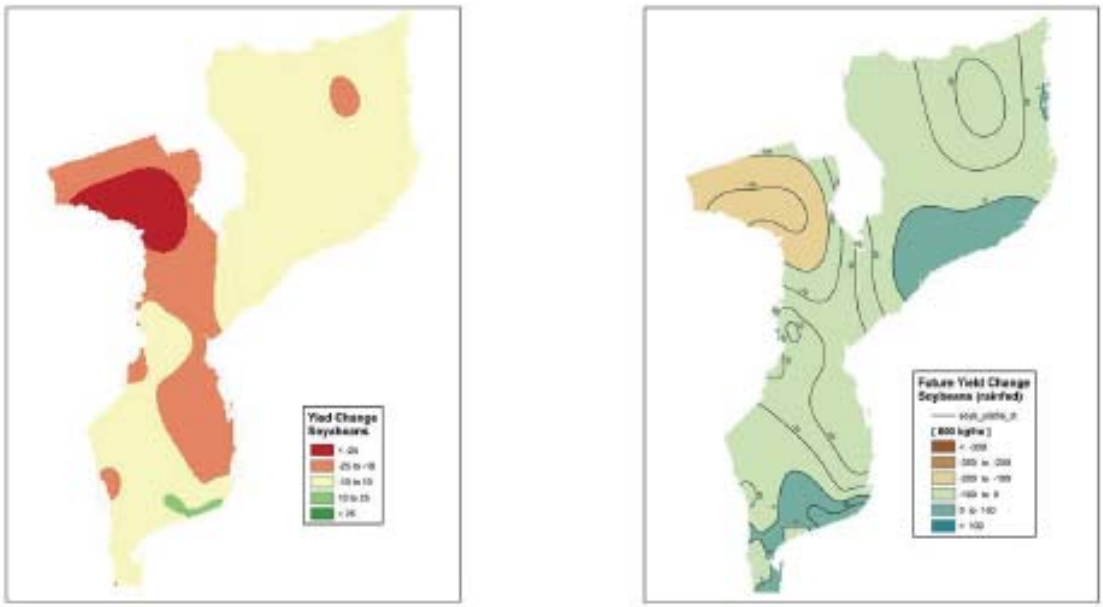
Source: Brito and Homan, 2012.

FIGURE C.8. MAPS OF LAND SUITABILITY AND HOTSPOTS RESULTING FROM CLIMATE CHANGE, FOR SOY



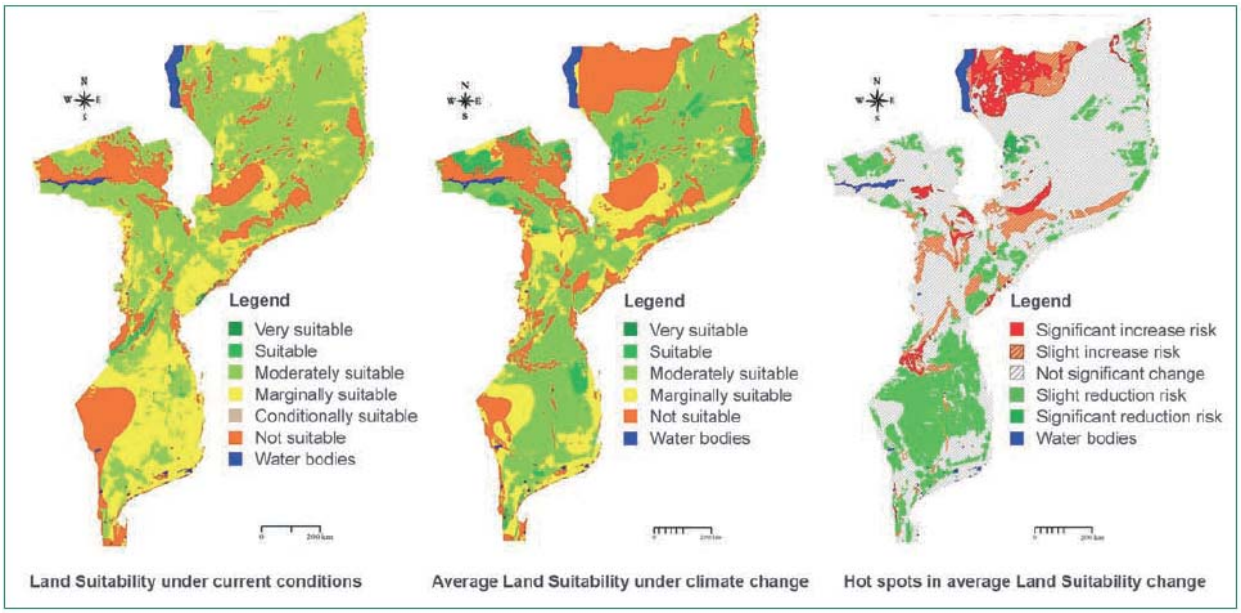
Source: IIAM 2008.

FIGURE C.9. A. PROJECTED CHANGES IN THE FUTURE (2046–65) OF SOYBEAN YIELDS IN PERCENTAGE OF PRESENT YIELDS. B. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR SOYBEANS IN KG/HA



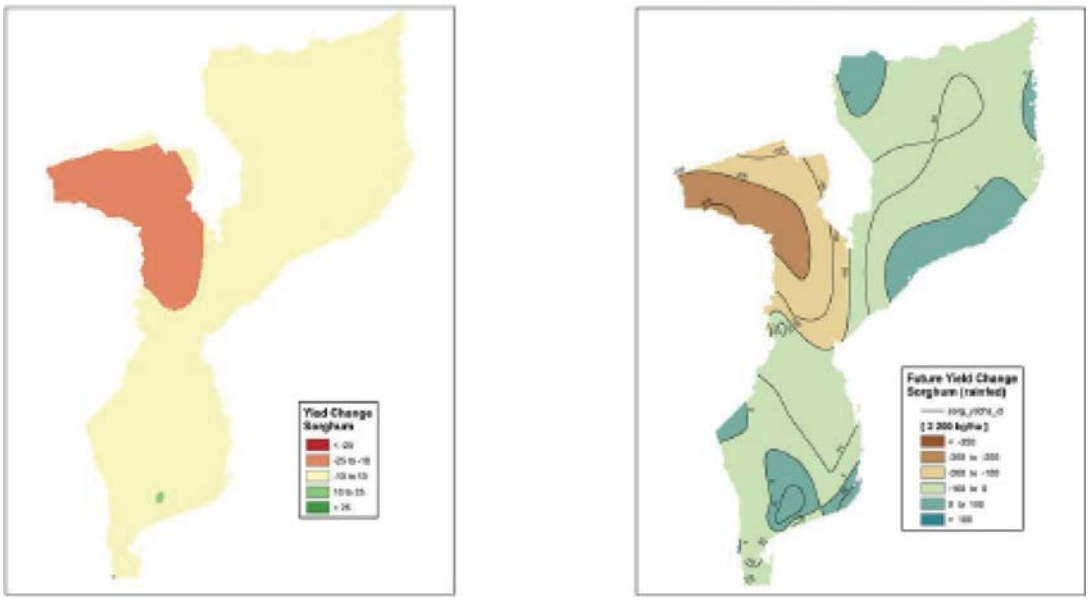
Source: Brito and Homan, 2012.

FIGURE C.10. MAPS OF LAND SUITABILITY AND HOTSPOTS RESULTING FROM CLIMATE CHANGE, FOR SORGHUM



Source: IIAM 2008.

FIGURE C.11. A. PROJECTED CHANGES IN FUTURE (2046–65) FOR SORGHUM (MEDIAN OF ALL SEVEN GCMS), EXPRESSED IN PERCENTAGE OF PRESENT YIELDS. B. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR SORGHUM (MEDIAN OF ALL SEVEN GCMS), EXPRESSED IN KG/HA



Source: Brito and Homan, 2012.

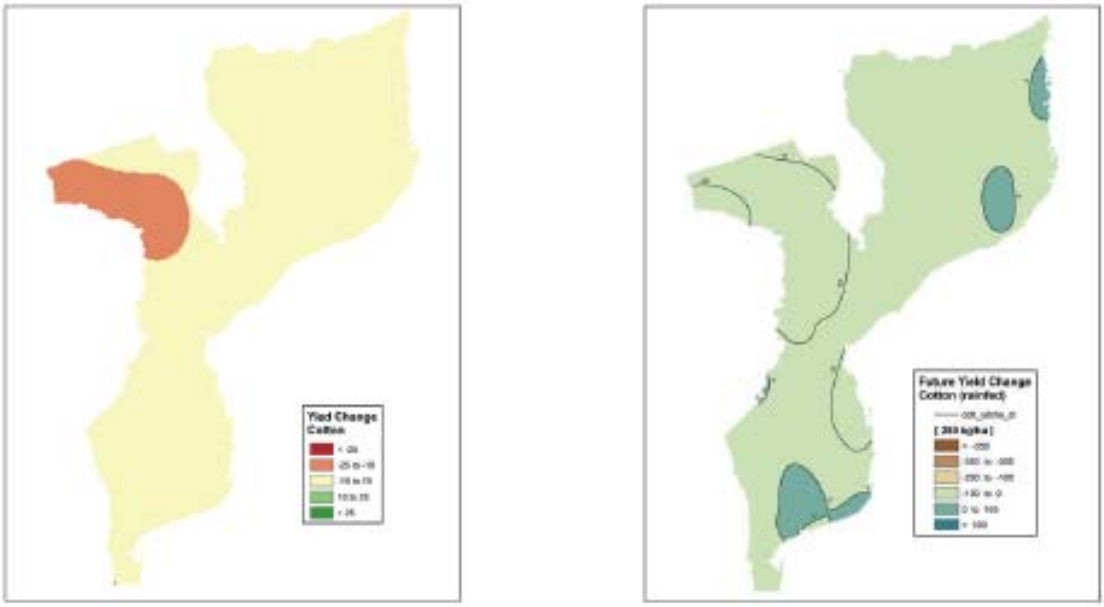
LIMITATIONS

The glaring limitation of a climate change impact assessment in Mozambique is the uncertainty of extreme events (such as drought, flood, and cyclones) and their depth of impact on the agricultural sector.

Additionally, climate change impact on livestock is one avenue for further research. There are several studies that have suggested increased foliage growth, potentially a positive impact on livestock, and there are also implications in heat fluctuations for male livestock fertility.

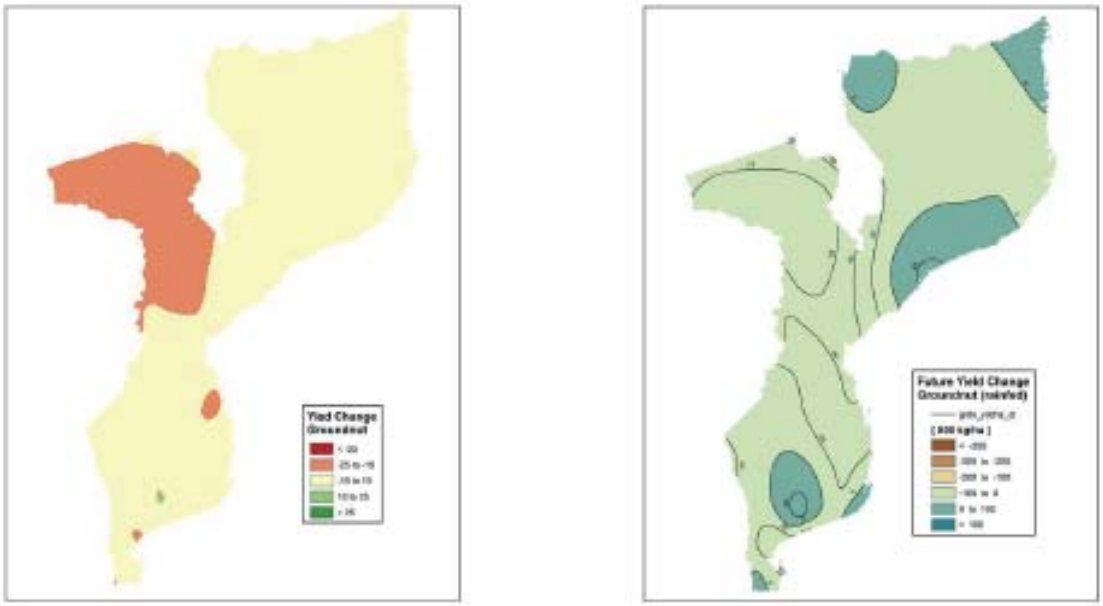
Other gaps include information on the impact of climate change for some of the primary cash crops such as cotton and sugar cane. The 2009 INGC assessment briefly mentions cotton in the methodology section, but does not elaborate on its findings.

FIGURE C.12. A. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR COTTON (MEDIAN OF ALL SEVEN GCMS), EXPRESSED IN PERCENTAGE OF PRESENT YIELDS. B. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR COTTON (MEDIAN OF ALL SEVEN GCMS), EXPRESSED IN KG/HA



Source: Brito and Homan 2012.

FIGURE C.13. A. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR GROUNDNUTS IN PERCENTAGE OF PRESENT YIELDS. B. PROJECTED CHANGES IN THE FUTURE (2046–65) FOR GROUNDNUTS, EXPRESSED IN KG/HA



Source: Brito and Homan 2012.

APPENDIX D
VULNERABILITY ANALYSIS

The World Bank defines *vulnerability* as exposure to uninsured risk, leading to a socially unacceptable level of well-being. An individual or household is vulnerable if it lacks the capacity and/or resources to deal with a realized risk. It is generally accepted that in low-income countries, rural populations are both poor and vulnerable, and that primary risks to these populations may include climate and market shocks (Sarris and Karfakis 2006). Vulnerability is a useful lens through which to view shocks, because it allows for determination of impacts on populations and who will be most affected. Vulnerability is discussed here particularly in the context of food security.

SETSAN performs identification of "vulnerability to external shocks," measured through food security (see tables D.1 and D.2). As of 2009, other leading government bodies mandated with addressing the needs of vulnerable groups were the Ministry of Women and Social Action (MMAS) and a subordinate institution, the National institute for Social Action (INAS) (Waterhouse 2009).

DEFINITIONS

SETSAN views vulnerability as "associated with exposure to risks and [it] determines the susceptibility of people, places, or infrastructures to a particular natural disaster." The Ministry of Planning and Finance (MPF) defined vulnerability as, a "lack of defense against adversity (including) . . . exposure to external shocks, tension and risks, and lack of internal defense, of means to compete without suffering serious losses" (MPF 2000; Waterhouse 2009).

RECENT GENERAL TRENDS IN VULNERABILITY

- Sustained high levels of food insecurity
- "Deepening" of the HIV/AIDS crisis
- More frequent and severe climate-related events such as drought, floods, and cyclones
- "Increasing feminization of chronic rural poverty" (Waterhouse 2009)

FIGURE D.1. VULNERABLE GROUPS WITHIN MOZAMBIQUE

Marginal households (very poor)	• Households perpetually live on the edge • Low access to all resources • Concentrations: Cabo Delgado, Nampula, Inhambane
Low income laborers (poor households)	• Concentrations in northern provinces: Nampula, Zambezia, Tete, and Inhambane
Households with low levels of "well-being"	• Lower levels concentrated in Tete, Cabo Delgado, Niassa, and Nampula • (Using a composite index of well-being based in the analysis of the five capitals by FEWSNET)
Households with lower dietary diversity ("very inadequate diet")	• Concentrations in: Tete, Manica, Inhambane

Source: FEWSNET.

FIGURE D.2. VULNERABILITY CHARACTERISTICS

Vulnerability Characteristics	Provinces where the Vulnerability Characteristic Is More Frequent	
Highest % female-headed households	Gaza (47%) Inhambane (37%)	Cabo Delgado (36%)
Highest % elderly-headed households	Cabo Delgado (31%)	Maputo (30%)
Highest % of never enrolled children	Girls in Niassa (18%)	Boys and girls in Nampula (15%)
Lowest enrolment level for orphans	Boys in Niassa (61%) Boys in Nampula (63%)	Boys in Maputo (65%)
Highest level of never enrolled orphans	Boys in Niassa (23%)	Nampula (23%)
Highest & of HHs with Chronically ill members	Sofala (12%)	
Highest % of HHs with disabled	Inhambane (29%)	
Highest % of HHs hosting orphans	Gaza (26%)	Zambezia (22%)
Highest % of HHs with recent death of family member	Cabo Delgado (11%)	Sofala (11%)

Note: Niassa and *Nampula* seem to have the major shortcomings in terms on education as they particularly low enrolment levels for both children and orphans. In terms of demographic characteristics of the households, Cabo Delgado shows serious results on the percentage of female and elderly headed households and households with a recent death.

VULNERABLE GROUPS AND CHARACTERISTICS

Certain types of households, livelihood activities, and populations are more vulnerable to shocks than others. Figure D.1 identifies four types of vulnerable groups and lists regions in Mozambique with particularly high concentrations of vulnerable households.

At the household level, certain characteristics, apart from income and well-being, are associated with high levels of vulnerability. For instance, female-headed households and households hosting orphans are considered particularly vulnerable to shocks. Figure D.2 details provinces with high levels of vulnerable populations as assessed by the SETSAN Vulnerability Assessment Group (SETSAN 2010).

Figure D.3 highlights provinces with poor infrastructure, characteristics that will in effect influence levels of vulnerability. Sanitation, particularly access to water, is an issue, deepening vulnerability in crises (SETSAN 2010). This issue is particularly salient for food crop farmers and fishermen, who are less likely than other types of workers to have access to safe water and sanitation.

TABLE D.1. UNDERLYING FACTORS OF FOOD SECURITY IN MOZAMBIQUE

	Description	Vulnerable Groups	Vulnerable Period	Vulnerable Areas
Climate	Recurrent droughts (increasing frequency), major devastation. Results in almost complete failure of nontolerant crops (maize). Increased frequency and magnitude of cyclones. Floods result in temporary deficient food access.	Drought: Rain-fed agriculture dependent households		Drought: Southern region, semiarid central regions. Cyclones: Coastal districts of Inhambane, Nampula, Sofala, and Zambezia. Floods: Central and southern rivers.
Poverty and fragile livelihoods	Poverty weakens the ability of households to mitigate recurrent shocks.	50% of households engage in food production as their main economic activity. Vulnerable to production shocks, depending on diversification of other economic activities.		Rural and peri-urban residents.
Food reserves	Normal year → households produce enough food for 2–5 months postharvest to be self-sufficient, and then begin purchasing. Food deficit years → intensive, unsustainable coping strategies.	Households with no other sources of food/income	Years with low agricultural production and the hungry period: October–January.	The southern regions.
Markets	Poor functioning markets, lack basic products. Major constraint for markets is the "lack of effective demand (poverty)."	Populations in remote areas with a lack of income options.		

(continued)

TABLE D.1. UNDERLYING FACTORS OF FOOD SECURITY IN MOZAMBIQUE *(continued)*

	Description	Vulnerable Groups	Vulnerable Period	Vulnerable Areas
Limited options	Remote markets have high food prices because of transportation costs, limiting access.	Poor households with limited income options, reliance on purchased food for consumption.		South and central food-deficit areas.
Chronic malnutrition	Stunting rates are high.			Nampula and Tete have the highest proportions of stunted children (63 and 51 percent). Gaza and Inhambane have the lowest (31 and 32 percent).
Limited public service delivery (health, water, and sanitation)	Low access to basic services. Health problems may compound food insecurity conditions even in high-surplus areas.			Northern provinces.
Increase in the effective dependence ratio	Many households have lost an economically active member.	HIV/AIDS–affected groups.		
Government policies	A decrease in government investment in the agricultural sector.	Households dependent on the agricultural sector.		

Source: Mozambique, FEWSNET.

FIGURE D.3. PROVINCES WHERE VULNERABILITY CHARACTERISTIC IS MORE COMMON

Vulnerability Characteristics	Provinces where the Vulnerability Characteristic Is More Common
Highest % HHs with poor quality housing	Sofala (51%) Inhambane (44%) Gaza (31%)
Highest % of HHs with water from unimproved sources	Niassa (95%) Nampula (94%) Cabo Delgado (93%)
Lowest % of HHs treating water before drinking	Niassa (6%) Tete (6%)
Highest % of HHs with unsafe sanitation	Nampula, in particular rural Nampula (100%)
Highest % of asset poor households	Tete (37%) Niassa (31%) Zambezia (32%)

Source: SETSAN.

TABLE D.2. MAJOR SHOCKS TO FOOD SECURITY IN MOZAMBIQUE

Hazard/Shock	Description/Impact	Vulnerable Time Period	Vulnerable Areas
Drought	High frequency, major devastation. Recurrent and severe droughts recently.		Southern and central regions.
Floods	Impact is difficult to assess—potentially destructive, positive externalities for flood-recession agriculture.		More than 50% of Mozambican land is classified as part of international river basins.
Cyclones	Households may lose houses, food reserves, crops, and fruit trees, and often face acute food shortages. (Despite the damage, may bring needed rainfall.)	November–April (Coincides with the main agricultural season).	The majority of the coastal area, the most at risk between Pemba and Angoche, and near Beira.
Cassava brown streak	Plant disease, affects cassava (food crop)		The northern regions.
Lumpy skin disease	Bovine disease, limits the movement and sale of animals, which reduces income and assets.		The southern provinces.
Human diseases	Cholera, other diarrheal diseases, malaria, HIV/AIDs. Because of HIV/AIDS, child-headed households, elderly-headed households, and orphans are increasing. Two impacts on food security: (1) loss of an economically active adult and additional children to be fed without a caretaker and (2) the malnourishment trap (sick → less work → less money/food → sickness continues).	Illnesses such as malaria increase during rainy seasons.	
Earthquake	Relatively new potential shock.		The central and northern provinces, with close proximity to the southern end of the East Africa Rift System.

Source: Mozambique, FEWSNET.

APPENDIX E
COMMODITY RISK PROFILES

POULTRY

The poultry sector in Mozambique represents an estimated 4.7 percent of agricultural GDP[20] and is the primary source of meat and the most common form of livestock for rural households. In 2008, 58.8 percent of small and medium producers surveyed had chickens, but only 4.4 percent of them were vaccinated.[21]

PRODUCTION RISKS

DROUGHT

Drought not only affects poultry directly but also indirectly through the availability of grain feed. In particular, the lack of rainfall limits harvests and redirects potential feed to addressable markets and not poultry. Whereas drought per se does not lead to fatalities in poultry, high temperature does. Interviews with farmer groups also confirmed that high temperatures have at times led to a total loss of chickens. A secondary effect of drought is selling to neighboring provinces, which not only affects prices in the province from which they are being sold, but also increases the likelihood of the transmission of diseases and pests.

FLOODING

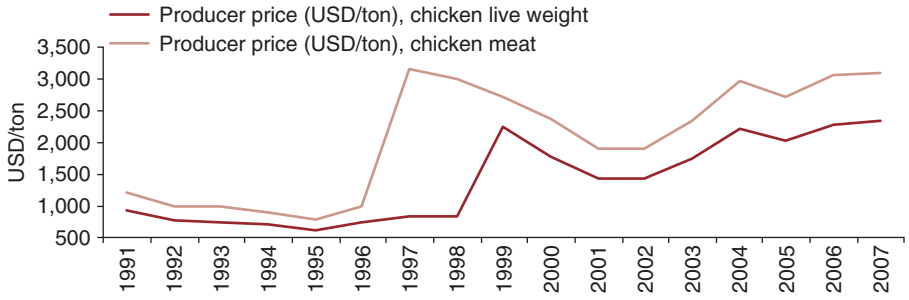
Although an indirect effect, the type of storage of chickens in rural areas means that when flooding is high enough, infrastructure, along with the chickens themselves, will be washed away. This occurred, as related during farmer interviews, in Chokwe, Manica province, during the recent floods of 2013.

PESTS AND DISEASES

Infectious bursal disease, avian salmonellosis and pasteurelosis, parasitosis, and Newcastle disease (ND) all jeopardize poultry health. Newcastle disease ranks first as the most devastating disease for village poultry, often killing from 50 to 100 percent of chickens in a flock.[22] Major losses were recorded in 2005/06 as a result of Newcastle disease (ND),[23] which is transmitted and cultivated by chickens ingesting contaminated feed, water, and feces. Although poultry may be vaccinated against ND, the presence of any of the above diseases or predatory threats—birds, reptiles, mammals—results in the total loss of the animals and any future income. According to the 2008 TIA, of 17,220,796 chickens that small and medium producers surveyed said they had, 12,257,403 were lost to disease—71.2 percent.

As avian flu affected the global sector, it was also devastatingly felt in Mozambique. Farmer interviews confirmed that along with the birds that contracted the disease and died, many potentially healthy birds had to be culled, under advisement from the National Department of Veterinary Services of the Ministry of Agriculture (MASA/DNSV) to prevent further transmission. In 2004, there was a nationally recorded outbreak of avian flu.[24]

FIGURE E.1. DOMESTIC PRICE VOLATILITY, POULTRY



Source: FAO PriceSTAT.

[20] IFPRI document.

[21] TIA 2008.

[22] Control of ND on Dropbox.

[23] Report on Current Vulnerability in Mozambique, 2006.

[24] Direccao Nacional de Pecuaria—Relatorio Annual 2004.

MARKET RISKS

INPUT VOLATILITY

Traditionally, the raising of chickens is undertaken either with free-range scavenging or on a commercial scale. Although the more common free-range scavenging requires minimal inputs, commercial production requires access to shelter, feed, and medication, whether antibiotics or vaccinations. Virtually all inputs (rations, concentrates, medicines, vaccines, veterinary instruments, and equipment) are imported to Mozambique and the traders are generally located only in the capital city, with links to the provincial capitals.

INTERNATIONAL PRICE VOLATILITY

The global poultry market forecast and price index is affected by three primary factors: wheat-feed prices, alternative meat prices (that is, beef), and disease outbreaks. Each of these makes for volatility in the marketplace (figure E.1).

SORGHUM

Sorghum, a major cereal grain, accounts for 2.56 percent of national agricultural GDP (Pauw et al. 2012) with over 2.7 million hectares planted, and is generally used for household food security compared with maize and rice. Because of a lack of seed and poor distribution of improved varieties, farmers continue to use local varieties, which have low productivity (0.2–0.6 ton/ha[25]).

PRODUCTION RISKS

DROUGHT

Sorghum thrives in arid and semiarid conditions and is considered relatively drought resistant.[26] It is commonly grown on upland fields and is more drought tolerant than is maize. During the planting season and before the rainy season at about November, it is often intercropped with maize and is thus a way for farmers to ensure they procure some production from a field in the event that weather and fertility conditions are inadequate for successful maize production.

PESTS AND DISEASES

The major diseases affecting sorghum are stalk borer complex, *Busseola fusca*, *Sesamia calamistis*, anthracnose, charcoal rot, downy mildew, ergot, and leaf blight. Insect pests including borers, shoot fly, chafer grubs, armyworms, grasshoppers, and locusts also constrain production. The most important threat however comes from weeds. In particular *Striga*, a parasitic weed that attaches itself to the sorghum roots from which moisture and nutrient requirements are drawn and inhibits plant growth, reduces yields and, in severe cases, causes plant death.

In terms of actual observed losses, in 1998/99 locusts attacked sorghum, among other crops, in the coastal regions of Nampula and Cabo Delgado.[27]

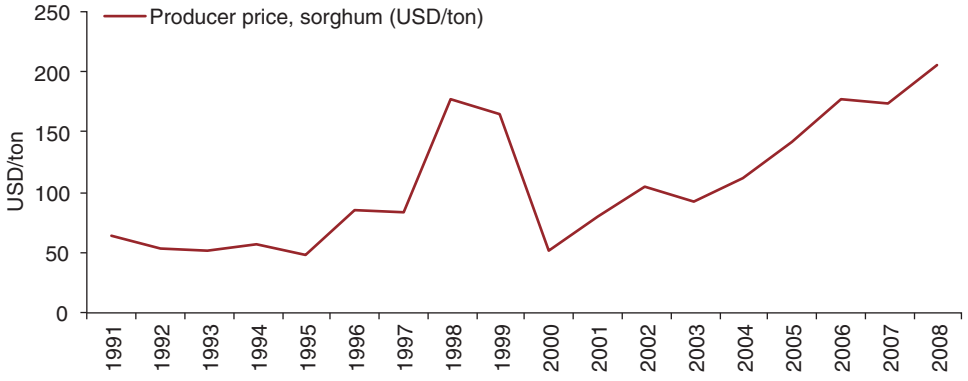
MARKET RISKS

DOMESTIC PRICE VOLATILITY

Nearly all sorghum is produced by small farmers, mainly for subsistence. Few farmers sell any significant quantities of sorghum to market on a regular basis. Seasonal price variations and price collapses in good years pose important risks to farmers as they typically sell all their harvest at the same period, driving down prices (see figure E.2).

It should be noted that with the presence of growing ethanol demand, sorghum is slowly becoming an important substitute for feed and human consumption and this will likely have an impact on prices, both domestic and international.

FIGURE E.2. DOMESTIC PRICE VOLATILITY, SORGHUM



[25] http://intsormil.org/smimpacts/IIAM.pdf.

[26] http://africaharvest.org/sorghum.php.

[27] Annual Report on the Agricultural Campaign 1998/99 and Evaluation of a Technical Mission Team Report.

TOBACCO

Tobacco is the most exported agricultural commodity but it is produced by only 10.24 percent of farming households in Mozambique (over 73,725 hectares[28]) and it represented just 1.17 percent of national agricultural GDP (Pauw et al. 2012). The provinces of Niassa and Tete account for 90 percent of this cultivated area.

Mozambique was the 16th largest exporter globally in 2010.[29] Tobacco exports were valued at US$204 million in 2011, accounting for 6.2 percent of total exports.[30] There are several large commercial operations with downstream integration with farmers along the value chain through contract farming. This leads to about 52 percent of the total area planted by small farms.[31]

PRODUCTION RISKS

DROUGHT, DELAY IN RAINS

Tobacco is typically a transplanted crop, whose seedlings are cultivated for 60 days and then moved into fields. It is during this phase in particular that the plant is vulnerable to the effects of drought. Typically, the crop requires average rainfall of 625–1,000 mm. For example, a delay in rains in 2008/09 during the seeding phase led to a significant drop in reported yield.

FLOODS

Conversely, in waterlogged soil, diffusion of gases is strongly inhibited and this adversely affects growing roots of the plant while also retaining the broken-down gases such as carbon dioxide that it produces. This can result in loose or dead roots, rot, and stunting.[32] Yield is reduced by 23 percent, 43 percent, 76 percent, and 82 percent because of 24, 48, 72, and 96 hours of waterlogging, respectively.[33]

PESTS AND DISEASES

Tobacco pests include beetles, crickets, aphids, weevils, cutworms, and suckfly. One particular disease often observed in Mozambique in tobacco is rattle virus, which causes necrosis and leaf molting that stunts the cultivated parts of the plant.

MARKET RISKS

DOMESTIC PRICE VOLATILITY

Tobacco is a crop with established off-takers and whose prices are published well before the start of trading. Private companies are promoting contract growers' schemes with smallholder (0.5 to 1 ha) producers. These producers receive credit for inputs (seeds, fertilizers, and pesticides) that are then deducted at the end of the campaign (for marketing). Producers are organized into small groups (6–15 members per group). Approximately 20–30 groups are then assisted by extension agents who work for private companies.

INTERNATIONAL PRICE VOLATILITY

Given that tobacco is a primary cash crop for export, domestic farmers are heavily influenced by international market movements. Real prices of tobacco have fallen in most countries, but much less rapidly than prices of other agricultural crops and basic commodities.[34] In the absence of volume sales growth, the tobacco industry relies on pricing strength and product mix improvements via innovation to keep profits rising. However, pricing strength is threatened by issues such as illicit trade and tobacco control measures such as plain packaging, which is causing the commodification of cigarettes and eviscerating profit growth.[35] From 1975 to 1998, world tobacco production has increased by nearly 60 percent. This increase, however, is not evenly distributed across production countries; nearly all growth in production comes from developing countries.

[28] http://www.drumcommodities.com/assets/33/Tobacco_Project_Executive_Summary_April_2012.pdf.

[29] http://www.drumcommodities.com/assets/33/Tobacco_Project_Executive_Summary_April_2012.pdf.

[30] Ibid.

[31] Dropbox under Benfica name.

[32] http://www.plantstress.com/articles/waterlogging_i/waterlog_i.htm.

[33] http://link.springer.com/article/10.1007%2Fs40502-013-0008-0.

[34] http://www.fao.org/docrep/006/y4997e/y4997e0l.htm#bm21.1.

[35] http://www.researchandmarkets.com/research/393vsz/pricing_in_the.

ENABLING ENVIRONMENT

All tobacco produced is exported to Europe and Asia after processing (separation of the ribs of the leaf blade). In Mozambique, there are single concession areas where private companies operate for a period of 10 years. Annually, the promoter company must submit a business plan to the Provincial Directorate of Agriculture of the province.

In 2008/09, the sector also experienced what can best be described as execution risk—there was a delay because of rains and a systemic delay in the distribution of inputs, particularly fertilizer, because a commitment by a company in Nampula was not upheld.[36]

[36] Balanco de PES 2009.

VEGETABLES

Vegetables are often included as a component of horticultural commodities that also comprise fruits and ornamental plants. The focus in Mozambique is on the more common, highly perishable vegetables, including tomatoes, squash, peas, green beans, garlic, onions, cabbage, lettuce, Irish potatoes, and peppers. Most cultivation occurs in Manica and Sofala provinces by smallholder farmers—accounting for 99 percent of output—and is likely to remain primarily for domestic consumption as it makes up less than 0.1 percent of export value.[37] Of the 36 percent of farming households that produce vegetables, only 8 percent is sold and taken to market.[38] As calculated by IFPRI, in 2009, vegetables accounted for 8.21 percent of national agricultural GDP share and from 5 percent to 33 percent in inter-regional agricultural GDP share.

It is important to note that given the perishability of the produce, price volatility, and the high cost of necessary inputs given current scale, the poorest 60 percent of sellers account for only 7 percent of the total value of sales.[39]

PRODUCTION RISKS

DROUGHT

Most vegetable production takes place under irrigation during the drier winter season, when growing conditions are more favorable for these commodities. Normally, 8–10 gallons of water per minute per acre are required for horticultural crops.[40] Fifty-two percent of horticulture producers state that they use manual or mechanical irrigation systems. This has led to a control of the damage incurred because of drought. Hot, humid conditions, though, do stress most vegetables and irrigation cannot totally offset this.

EXCESSIVE RAIN AND TROPICAL STORMS

As with other commodities, excessive rain and tropical storms are always a risk in certain areas of Mozambique. In January 2012, 0.8 percent of the planted area of maize, beans, and horticulture in Cabo Delgado, Zambezia, Sofala, Inhambane, Gaza, and Maputo were lost because of excessive rain and the tropical storms Dando and Funso.

PESTS AND DISEASES

Pests and diseases are the major risk to vegetable production and can lead to rapid, systemic, and catastrophic damage that can occur to the harvest. There are several pest species that affect vegetables including fruit flies, mites, bollworms, ants, aphids, cutworms, worms, leaf miners, and grasshoppers.[41]

These pests and diseases cause significant damage by affecting the growth process, leading to stunted growth in addition to breaching plant skin and rot. Given the sensitivity of fresh vegetable produce, pests and diseases need to be addressed immediately in order not to lose the entire production or to prevent the risk of spread of the contamination.

In the 2001/02 agricultural year, both nematodes and birds affected tomato growing in the south, so much so that it was noted in reports that year.[42] A significant drop in production also occurred in 2009/10 linked to adverse climatic conditions, but particularly tomato virus.[43]

Farmer interviews suggested that the risks present in regard to the tomato virus could be easily overcome with the correct application of pesticides and the like once they were identified.

MARKET RISKS

INPUT PRICE VOLATILITY

The high cost of fertilizer and pesticides is a barrier for many farmers and is a risk that hedges how much cultivation is actually undertaken. The use of fertilizer inputs

[37] Smallholders Involvement in Commercial Agriculture.

[38] IIAM.

[39] Ibid.

[40] http://aggie-horticulture.tamu.edu/archives/parsons/drought/cropmgmt.html.

[41] http://www.nri.org/projects/adappt/docs/Nyirenda.pdf.

[42] RA DINA 2002.

[43] Balanco de PES 2010.

can increase yields upward of 67 percent if prices stabilize at low levels.

Risks associated with the enabling environment exist but are generally less significant and mainly apply to a minority of producers who specialize in production for market.

DOMESTIC PRICE VOLATILITY

High price variability in domestic markets is the result of the local production and market dynamics of the crops. Surplus production tends to enter the market at specific times every year, accentuating the volatility of domestic prices.

GROUNDNUTS

In Mozambique, groundnuts are cultivated solely by small farming households for several uses but are most commonly used as edible oil seed in local dishes or for confectionary exports. Current groundnut production is on the order of 130,000 MT a year, of which 78 percent are grown in Nampula, Inhambane, Zambezia, and Cabo Delgado along the coast.[44] Although there is limited productivity—on average 200–300 kg/ha in the south and somewhat larger yields in the north (450–600 kg/ha)—for a household, it is heavily constrained by agronomic practices that rely on saving seed for planting the following season.

PRODUCTION RISKS

DROUGHT

Drought exacerbates issues with groundnut production in Mozambique, which also suffers from conditions of low soil fertility and moisture content. This water stress affects the crop at different growth stages during the season. Drought stress during the flowering and the pod filling stages is critical for yield and other agronomic characteristics. This results in a drastic reduction in crop yield with the magnitude of degree of reduction depending on the varieties. It is accepted that there must be adequate water during the flowering period, the peg formation (about 6–8 weeks after planting), and the pod formation and filling.[45]

Not only the yield but also the quality of groundnuts decreases under drought conditions.[46] A water deficit delays the start of the period of rapid pod growth by about 15 days and hence extends the time required to reach maturity.[47] Harvesting should be performed when most (more than 80 percent) of the pods show signs of maturity, that is, by the darkening of the inside of the pods.[48]

PESTS AND DISEASES

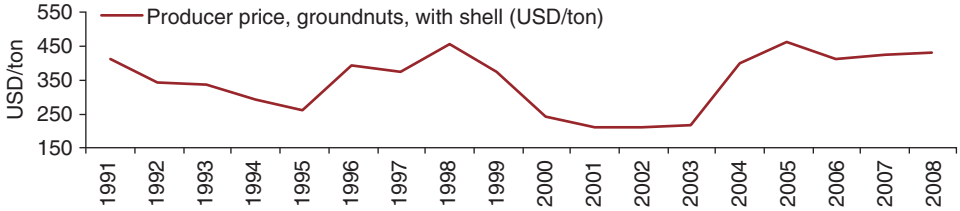
The major pests and diseases include pests such as aphids, termites, grasshoppers, leaf beetles, larvae, weevils, and diseases like leaf spot, rosette virus, mosaic, aflatoxin, and thuku. In particular, Mozambique groundnuts are shown to have higher levels of aflatoxin than export quality standards allow—especially for product destined for South Africa.[49] Many factors can contribute to the levels of aflatoxin in groundnuts and, in terms of risk, end-of-season drought is a particular issue. Contamination is exacerbated by slow evacuation and processing of the crop postharvest, which is an issue that needs to be taken into consideration as far as dealing with constraints is concerned.[50]

MARKET RISKS

DOMESTIC PRICE VOLATILITY

Producer prices vary between provinces, reflecting transportation cost differentials.[51] In the southern part of the country, most of the harvest is used for home consumption and only a small portion (usually not more than 30 percent) is sold at market. In the north, it has

FIGURE E.3. DOMESTIC PRICE VOLATILITY, GROUNDNUTS



Source: FAOSTAT.

[44] External Market Taskforce document on Dropbox.

[45] Ibid.

[46] http://www.ajebs.com/vol-4/39.pdf.

[47] http://www.sciencedirect.com/science/article/pii/037842909390032I.

[48] External Market Taskforce.

[49] Ibid.

[50] Technical report—aflatoxin on Dropbox.

[51] Ibid.

become an important cash crop where local aggregators, large companies, and NGOs work to collect, process, and market groundnuts.[52] However, the graph in figure E.3 indicates the volatility in this market; for example, the spike in 1998 matches the insufficient rainfall in the southern coastal belt.

National prices have historically been flat because of limited refining capacity, but they have decreased over the past year. They are increasingly influenced by traders and processors aiming to export to South Africa and Europe.[53] With this comes the influence of price seasonality with established commercial relationships.

[52] Ibid.

[53] Ibid.

CASHEW NUTS

Cashew nuts are the primary cash crop for over 1.3 million smallholder farmers with average household production of 100 kg generating about US$50 per season.[54] Although these smallholder farmers account for 98 percent of national output, production is centered in Nampula (48 percent of sales) with intensive planting in Inhambane, Cabo Delgado, Gaza, and Zambezia. Once a large exporter in international markets, contributing 40 percent to global trade in the 1970s, Mozambique now makes up just 2 percent of the US$2.4 billion global industry.[55] Furthermore, only 18 percent of the value added within the value chain is contributed within Mozambique itself.[56]

PRODUCTION RISKS

DROUGHT

Irregular rainfall during flowering and at the beginning of fruit formation is detrimental to cashew tree health. This can result in stunted tree growth and longer maturation periods.[57] Droughts occur in all cashew-producing areas but with a higher incidence in the central and southern regions. In particular, drought has affected the production in the provinces of Sofala, Inhambane, and Gaza, which account for one-third of total national production.[58] In 2009, for example, "cashew rains" needed during flowering and fruiting did not occur after the last rainfall in March 2009, affecting production.[59]

CYCLONES AND TROPICAL STORMS

Nampula province in the north, which has the largest concentration of cashew trees, has suffered from regular cyclones and/or high winds, which regularly cause cashew tree losses. In 2000, thousands of cashew trees were knocked down by tropical storm Delfina,[60] and in 2003 cyclone Japhet downed 12,325 trees.[61] Another cyclone in 2008, Jokwe, hit Nampula and destroyed 1.47 million of the 10 million trees in the province,[62] and cyclone Funso downed 53,130 trees in 2012.[63]

WILDFIRES

Wildfires damage 30–50 percent of trees because of the lack of proper crop management and an absence of weeding and burning areas to clean them.[64]

PESTS AND DISEASES[65]

The fungus *Colletotrichum gloecosporioides* is one of the most common pathogens found in cashews. Initial symptoms show the development of reddish-brown, shiny, water-soaked lesions, followed by resin oozing from the affected parts. The affected nuts and apples decay and shrivel, and the flowers turn black and fall off. There may be associated pitting of the surface of the nut. This serious disease requires the affected branches to be pruned and sprayed with fungicides.

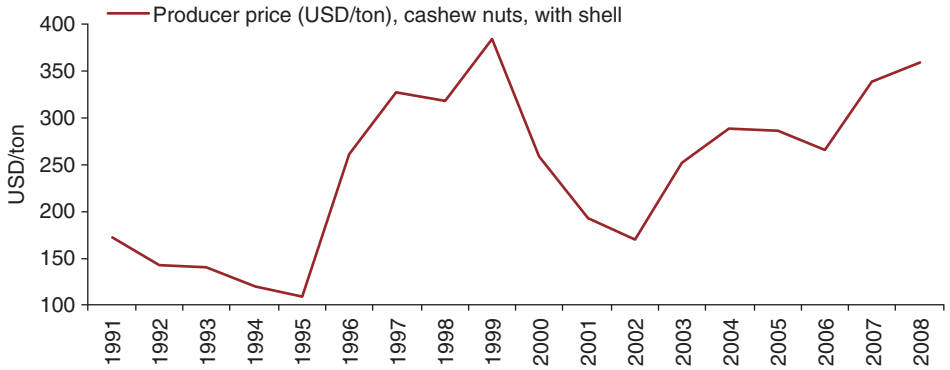
MARKET RISKS

Given that Mozambique is primarily an exporter of raw cashew kernels as opposed to processed nuts, producers are vulnerable to domestic value chain inefficiencies and international market fluctuations.

In 2009/10, the government started a program to distribute cashew seedlings to schools under its Let's Plant More Cashew Trees initiative. Although the price effect of this

[54] Dropbox Doc.
[55] PREM document on Dropbox.
[56] Africa Cashew Initiative on Dropbox.
[57] http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1677-04202007000400012.
[58] Africa Cashew Initiative on Dropbox.
[59] Balanco de PES 2009.
[60] IRIN.
[61] ReliefWeb.
[62] ReliefWeb.
[63] AllAfrica.com.
[64] Africa Cashew Initiative.
[65] http://www.fao.org/inpho_archive/content/documents/vlibrary/ac306e/ac306e03.htm.

FIGURE E.4. DOMESTIC PRICE VOLATILITY, CASHEW NUTS (WITH SHELL)



Source: FAOSTAT.

project will not be evident until the trees are at maturity by 2013/2014, the 66,252 trees planted may cause localized effects.[66] There was a significant increase in price in 2010/11 were prices went from 26 to 42 cents/kg to over 50 cents/kg, causing producers to flood the market (see figure E.4).[67]

INTERNATIONAL PRICE VOLATILITY

Foreign processor demand, changing produce quality standards, and consumer demand drive fluctuations in international market prices. Given the global value chain, these international factors are often controlled by traders and roasters in Asia before proceeding to developed markets. Consequently, ultimately local nut cultivators receive only 10 percent of what final consumers pay abroad.[68]

ENABLING ENVIRONMENT RISKS

As a primary export commodity, the history of the cashew sector is a prime example of the potential negative impact of government policies. Mozambique's liberalization and privatization of the cashew sector in the early 1990s—eliminating export controls and processor protections—increased capital intensity in production and output but resulted in negative shocks to farm gate prices and urban employment. These risks are now somewhat mitigated through strong government support of the private sector and market liberalization policies that directly affect the demand of raw cashew nuts. The parastatal body of the National Cashew Institute (INCAJU) has the responsibility for collecting this tax and other permit revenues to provide extension services and establish nurseries.[69]

[66] Balanco de PES 2009.

[67] Balanco de PES 2011.

[68] Africa Cashew Initiative.

[69] World Bank Cashew Reforms Revisited on Dropbox.

COTTON

The cotton sector currently accounts for 20 percent of Mozambique's agricultural GDP and benefits over 300,000 households, or 1.5 million inhabitants.[70] In 2008, cotton was the third most valuable export crop, behind tobacco and sugar. Production is primarily concentrated in the regions of Cabo Delgado and Nampula and is variable annually (figure E.5), largely because of risks that reinforce low productivity, prices, and returns.[71]

PRODUCTION RISKS

DROUGHT AND FLOODS

Cotton copes relatively well with weather variability compared with other crops (for example, maize and sesame). However, various stakeholders in the cotton supply chain largely attribute yield variability to weather factors, particularly severe drought. The country was affected by regional droughts in 1994, 1996, and 2001; these droughts negatively affected crop production in some provinces. Drought is more of a relevant risk in the southern region than in the cotton-growing central and northern provinces.

Stakeholder interviews in provinces near river areas estimate flood-related losses suffered by cotton production run at about 10–12 percent nearly every year. In some of the border regions (such as the border with Malawi), the low altitudes in cotton-growing areas increase its vulnerability to flooding because of rains coming in from neighboring countries. The causes of yield variations shown in figure E.5 are difficult to pinpoint without long-term historical weather and yield data for various regions, though it appears at first glance that some droughts and floods can partly explain the behavior of yield volatility.

PESTS, WEEDS, AND DISEASES

Insect infestations are an important risk in cotton production yields in Mozambique: aphids, jassids, and American bollworms are considered the most critical. If not controlled in time, an outbreak of red or American bollworm can cause serious damage, as much as 30–50 percent or more of production losses in the affected areas. A farm-based, multiyear study has shown that timely application of pesticides by farmers improves productivity by more than 100 percent.[72]

Controlling pests—particularly American bollworm—is among the most important activities to improve yields. First sprays each season are particularly important in order to effectively kill sucking pests. Second and third pesticide applications kill pests at hatching, before they invade the cotton squares, flowers, and bolls. Furthermore, studies show that many farmers spend up to 50 percent of their cotton labor time weeding around the crop to prevent stunted plant growth.

MARKET RISKS

DOMESTIC PRICE VOLATILITY

Mozambique has a national minimum pricing system for cotton that applies to all ginners who are awarded geographic concessions. In this indicative system, ginners and farmers agree on a bale price as far as 7 to 8 months before procurement of cotton begins. The aim of this indicative price is to assist farmers in deciding on their cotton production plans and as an incentive to minimize crop substitution. Agreeing on a price with farmers, in advance of their procuring seed cotton from farmers, places the greatest risk of price volatility on the cotton ginners. Therefore, credit default risks in the cotton industry are moderate because farmers who do not deliver cotton seed to the ginneries leave the ginneries unable to procure repayment for the inputs they provided to farmers in the sowing season. Although this system protects farmers from intra-seasonal price volatility, they remain exposed to price volatility.

In 2009, prices paid to producers decreased by 35.6 percent, causing them to cease production. This development was largely attributed to a lack of understanding in regard to application of phytosanitary treatments.[73]

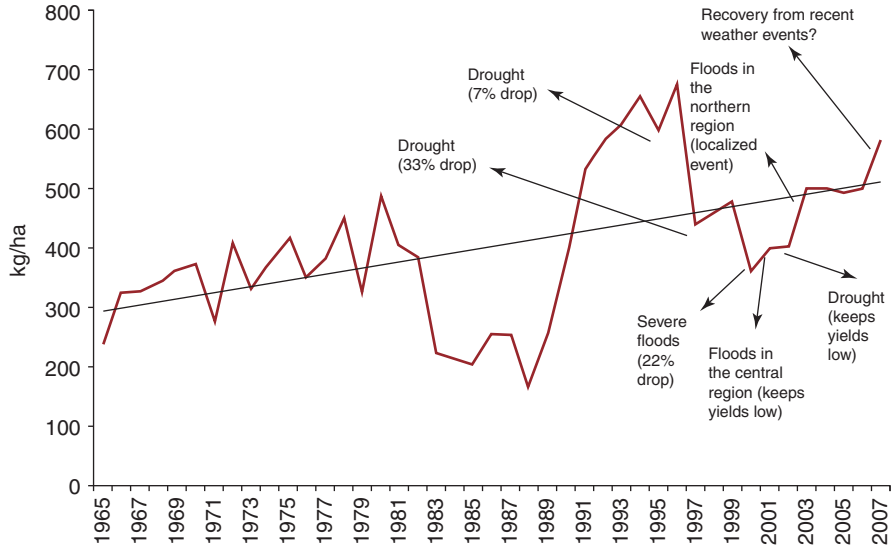
[70] http://www.icac.org/tis/regional_networks/documents/africa_10/business_meeting/5_mozambique.pdf.

[71] Ibid.

[72] ARMT Risk Assessment.

[73] Balanco de PES 2010.

FIGURE E.5. COTTON YIELDS, 1965–2007 (KG/HA)



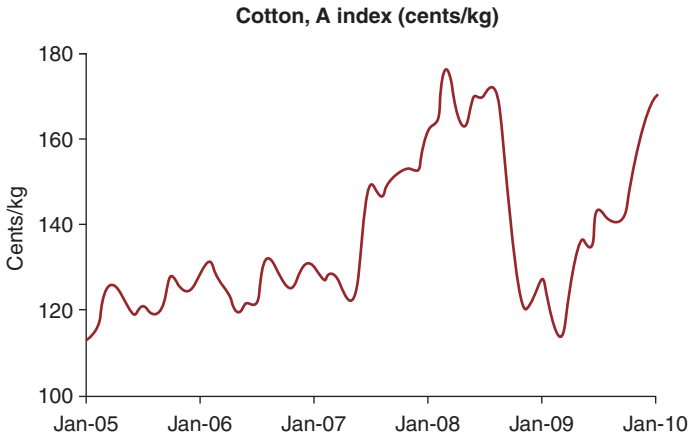
Source: World Bank 2010b.

Another 30 percent drop occurred in 2011/12 compared with 2010/11 despite increases in international prices.[74]

INTERNATIONAL PRICE VOLATILITY

The minimum price systems for cotton buffer farmers from intra-seasonal price volatility; however, it places the greatest risk of price volatility on to the cotton ginners and traders. The system of minimum prices and fixed prices places the ginners and traders at risk of falling world cotton prices, as prices are set up to 8 months prior to purchasing and processing the physical cotton. Although world cotton prices play a significant role in setting the minimum price, there is significant volatility that is currently borne by ginners. Unexpected losses can occur when the world price (which is part of the minimum price formula) falls below the agreed minimum price for seed cotton. The capacity of ginners and traders to manage such price risk varies markedly depending on their expertise, size, and scale (see figure E.6).

FIGURE E.6. INTERNATIONAL COTTON PRICES, 2005–10



Source: World Bank 2010b.

Crop substitution: Given the concentration of activities around ginneries, the major risk facing the industry today is related to guaranteeing the supply of seed cotton from farmers as the central operators of the cotton supply chain. Securing input supply of seed cotton from farmers is by far the highest risk facing the cotton industry today, which is becoming increasingly erratic as a result of crop substitution by farmers. Several other crops (for example, sesame, pigeon peas/cow peas, soybeans) have become more remunerative and are competing with cotton for acreage. Depending on comparative price of these different crops, farmers are making their decision, creating huge uncertainty of seed cotton supply for the ginners.

[74] Balanco de PES 2011.

SUGARCANE

Sugarcane contributes 25 percent to total agricultural exports, the second largest export commodity after tobacco.[75] Unlike tobacco or cotton, sugarcane is grown as a plantation crop by large industry stakeholders and through their out-grower schemes.[76] It is forecast that sugarcane production will increase to almost 4 million tons in 2012/13 based on an increase in hectares planted. This growth trend originated with the sugar industry witnessing average production increases of 30 percent annually between 2000 and 2006.[77] The planted area of sugarcane is expected to increase to about 50,000 hectares, with new investments and increases in the processing efficiencies of Mozambique's four commercial sugar mills.[78]

PRODUCTION RISKS

DROUGHT

Plants are constituted of about 85 to 95 percent water, and any losses in water content produce changes in physiological reactions. Plants suffering from a water deficit change their metabolism in order to protect themselves against this stress. This results in stunted inter-nodes, drying of bottom leaves, and inward rolling of top leaves. Drought can reduce elongation by about 30 percent and yield loss can be even more. Early stages of growth, particularly the active tilling period, are critical in drought situations. [79]

Although the majority of sugarcane is irrigated, which minimizes the problems caused by irregularities in rainfall, there was an 8.3 percent reduction in production in 2005/06 because of a deficiency in the irrigation system, which failed to smooth out the lack of required rainfall.

FLOODS

Generally, sugarcane is not considered a flood-tolerant crop and there is a reported mean yield reduction of 8.3 to 25 percent under a 15 cm water table.[80] At the same time, previous research by USDA-Agriculture Research Service (USDA-ARS) indicates that sugarcane can tolerate repeated floods of 7–14 days without yield loss, if this short-duration flooding occurs just before or during harvest. However, the biomass of recently planted sugarcane is increasingly reduced by flood durations of zero to 6 weeks and flood onsets after 2 or 4 weeks at a 12-inch water-table depth are similarly detrimental.[81]

PESTS AND DISEASES

African armyworms, stem borers, sugarcane scale, mealy bugs, termites, and rats are common pests for sugarcane crops. These pests attack the stems and leaves of the plant and result in yield losses of between 18 percent from termites and 30 percent from sugarcane scale.[82] Sugarcane diseases such as the mosaic potyvirus, rust, red rot, Ratoon stunting disease, and scald are equally devastating, often requiring the complete destruction of harvests and repeated application of pesticides.[83]

MARKET RISKS

DOMESTIC PRICE VOLATILITY

Domestic price volatility has closely mirrored general food inflation in Mozambique, resulting in higher prices and decreased general consumption by 11 percent (figure E.7).[84]

ENABLING ENVIRONMENT RISK

Raw and processed sugars are subject to import surtaxes, in addition to the basic duty of 7.5 percent. The two

[75] GAIN report on dropbox or http://www.thebioenergysite.com/reports/?id=585.

[76] http://www.africanwaterfacility.org/fileadmin/uploads/awf/publications-reports/COFAMOSAREPORTNOV07_0.PDF.

[77] Smallholder Sugarcane Production on Dropbox.

[78] Xinavane and Maragra in Maputo province and Sena and Mafambisse in Sofala province.

[79] http://cdn.intechopen.com/pdfs/26982/InTech-Sugarcane_responses_at_water_deficit_conditions.pdf.

[80] http://www.wsrjournals.org/download.php?id=477277168993247722.pdf&type=application/pdf&op=1.

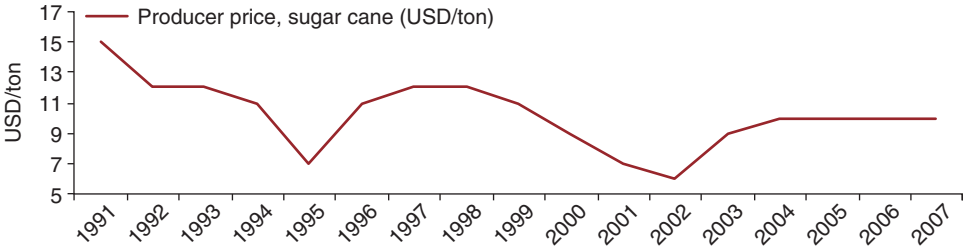
[81] https://www.certifiedcropadviser.org/story/2012/may/mon/study-examines-effects-of-flooding-on-young-sugar-cane.

[82] http://www.infonet-biovision.org/default/ct/134/crops.

[83] Ibid.

[84] GAIN report on dropbox or http://www.thebioenergysite.com/reports/?id=585.

FIGURE E.7. DOMESTIC PRICE VOLATILITY, SUGARCANE



Source: FAO PriceSTAT.
Note: 2003–07 are FAO forecasts.

variable surtaxes are set on a monthly basis and depend on the difference between the Mozambican minimum prices (US$385/ton for raw sugar and US$450/ton for processed sugar) and world market reference prices.[85] The sugar surtaxes have been in place since 1999,[86] implemented through a variable import tax system to absorb world market price fluctuations. The authorities claimed that, given distorted international sugar prices, such a system provided greater certainty to the investors that rehabilitated the estates devastated in the civil war.[87]

[85] Ministerial Diploma No. 56/2001 of 30 March 2001 sets out the mechanism. For February 2008, Order of Service No. 002/DGA/2008 of January 28, 2008, sets the applicable reference prices (per ton) for raw (US$347.18) and processed sugar (US$388.09), and the associated surtaxes on raw sugar (10 percent) and processed sugar (15 percent).

[86] Decree No. 74/99 of 12 October 1999.

[87] WTO Trade Policy Review Mozambique 2009, https://www.wto.org/english/tratop_e/tpr_e/tp309_e.htm.

CASSAVA

Cassava is a subsistence commodity produced across 2.5 million farms and is a staple crop with 70 percent of national harvests utilized as household food.[88] Production is concentrated along the northern and southern coasts, with the provinces of Zambezia, Nampula, Cabo Delgado, and Niassa accounting for 85 percent of production. The crop is versatile with high levels of drought tolerance and efficient growth without the intensive application of fertilizers or pesticides. However, it is exposed to various risks because of inadequate agronomic practices, geographic vulnerabilities, and limited market linkages and support.

PRODUCTION RISK

DROUGHT

Although mature cassava is drought resistant, the crop is especially vulnerable during the planting period. The use of stem cuttings allows planting any time of year yet typically farmer's plant near the end of the dry season in September to take advantage of the oncoming rains.[89] As sprouting happens as early as one week after planting there is particular vulnerability in the first month. Drought and irregular rainfall disrupt planting timing, reduce soil moisture, and increase the likelihood of cuttings not developing.[90] From 1992 to 2012, the northern and southern coastal regions have been victims of eight major drought events.

FLOODING

During the rainy season, there are continued threats from flooding. In particular, there is a high probability of flash flooding, which severely threatens cassava harvesting. Research shows that although mature cassava can remain in the ground upward of two years, this does not necessarily protect the plant from adverse flood effects, reducing root yields by 24 percent, reducing nutritional value by 30 percent of starch content, increasing flesh cyanide concentration, and causing root rot. Although the latter is particularly likely given periodic flooding over a harvest season, negative effects can begin to be seen within three days of there being standing surface water.[91]

In terms of actual recorded losses, in 2000, tropical storm Delfina destroyed 2,000 ha of beans and cassava[92] and the 2001/02 season saw losses in the cassava sector as a result of irregular and insufficient rain.[93] Furthermore, in 2003 flooding led to losses of 3,000 ha in Nampula and Zambezia.[94]

PESTS AND DISEASES

There are several types of pest and disease threats to cassava including cassava brown streak disease (CBSD), cassava mosaic disease (CMD), cassava bacterial blight, green spider mites, mealy bugs, white flies, fungal diseases, and locusts.

Although it is often difficult to differentiate between them, these diseases result in increased root rot and decreased leaf size and stem size.[95] Although not resulting in total crop failure in many cases if caught early and treated, contamination and nontreatment with pesticides can result in future crop issues because cuttings taken continue to be diseased. Furthermore, varieties bred to be resistant to cassava mosaic disease are being observed as susceptible to new strains of CBSD.[96] In 2002, a CBSD outbreak led to decreases in output prices and thus to price spikes of up to 45 percent in Nampula (McSeen et al. 2006). Cassava is particularly important in Mozambique regarding food security, thanks to the "natural storage" offered because it needs to be harvested for up to two years before it can be used. However, CBSD can render roots unusable when left in the ground for

[88] Sub-Sector Strategic Study on Cassava 2007).

[89] Ibid.

[90] FAO http://www.fao.org/docrep/x5032e/x5032E01.htm.

[91] "Cassava Breeding Report: Proceedings of the Fourth Regional Workshop," November 2–6, 1993.

[92] IRIN.

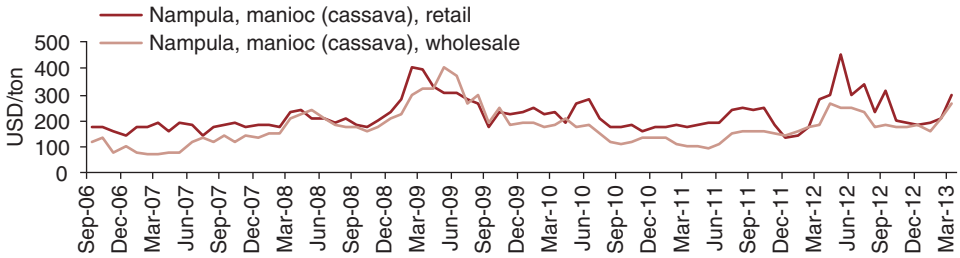
[93] RA DINA 2002.

[94] ReliefWeb.

[95] http://www.apsnet.org/publications/apsnetfeatures/Pages/cassava.aspx.

[96] This has been observed in Uganda, inland areas of Tanzania, and Western Kenya. "Cassava Brown Streak Diesease," ASRECA—National Crops Resources Research Institute (NaCRRI) Namulonge Paper, 1.

FIGURE E.8. INTERNATIONAL PRICE VOLATILITY, CASSAVA



over 9 months[97] or cause root yield loss of 100 percent in the worst, untreated cases. The threat continues with upward of 40 percent of crops exhibiting incubated signs of the disease (McSween et al. 2006). In terms of actual recorded losses, in 2000 it was recorded that locusts destroyed about 160,000 hectares of cassava,[98] whereas in 2001/02 root rot[99] was recorded as negatively affecting production and in 2001/02[100] and 2004[101] a brown streak disease epidemic was recorded.

MARKET RISK

With this domestic market orientation of cassava consumption and sales, its exposure to market risk is based on price volatility along with common constraints such as value chain inefficiencies, crop loss, and spoilage caused by postharvest deterioration. Additionally, the characteristics of cassava are such that degradation begins within 48 hours and so losses are magnified because of an inability to get the product to market in time.[102] Figure E.8 provides an indication of the price volatility since 2006 of producer prices, both retail and wholesale.

The lack of support for cassava-based product (that is, cassava flour, cassava chips) producers not only inhibits cassava's market potential but also makes production victim to low prices and volatility, and it removes the incentives for farmers to invest in better agronomic techniques. Cassava in particular is very responsive to fertilizer application, yet its low utilization by households means there is little short-term volatility in input prices.

[97] Cassava Brown Streak Diesease, ASRECA—National Crops Resources Research Institute (NaCRRI) Namulonge paper, 1.

[98] IRIN.

[99] RA DINA 2002.

[100] Ibid.

[101] Ibid.

[102] The Cassava+ project, 110921 case description for Agri-ProFocus knowledge agenda on BDS, DADTCO.

MAIZE

Maize is Mozambique's most cultivated agricultural commodity, produced by 78 percent of all rural households, and the staple dietary crop, with only 18 percent sold into the market (Donovan and Tostao 2010). Maize is intensively farmed in the northern provinces, which account for about 50 percent of national production and 70 percent of sales (Tschirley, Abdula, and Weber 2006). Whereas output has increased over the past 60 years, this has predominately been caused by expansion of cultivated areas. The lack of productivity increases can be partly explained via several risks and inefficiencies in the value chain resulting in average actual maize yields of 1.4 tons/ha compared with 5 tons/ha potential (Zavale, Mabaya, and Christy, 2006).

PRODUCTION RISKS

DROUGHT

Maize is produced under rain-fed conditions. This makes for an especially vulnerable crop because it thrives on high fertility and in soils with good moisture-retention capabilities.[103] Water or heat stress at the time of a maize plant's flowering can directly reduce yields by disrupting pollination and the formation of maize grain; at 8 inches in height, the numbers of kernel rows on the ear have already been determined.[104] Yield reductions by as much as 7 percent per day of plants under stress have been observed, making this development stage the most sensitive to drought and increased temperatures.[105] Furthermore, the 14-day periods before and after silking—or the emergence of the ear shoots—are crucial to final yield.[106] Recorded losses indicate that in the 2010/11 season, a lack of rain in January and February led to production declines of 22 percent in Tete and 39 percent in Inhambane and Gaza.[107]

[103] USAID Maize Value Chain.

[104] http://dirp3.pids.gov.ph/ACIAR/relatedresources/Impact%20of%20drought%20on%20corn%20productivity.pdf.

[105] USAID and USGS.

[106] http://dirp3.pids.gov.ph/ACIAR/relatedresources/Impact%20of%20drought%20on%20corn%20productivity.pdf.

[107] Report on Monitoring of Food Security and Nutrition in Mozambique 2011.

FLOODS

Maize is also very sensitive to flooding, particularly in the early vegetative stages, and can survive for only two to four days underwater.[108] Waterlogged soil reduces the diffusion of oxygen, gradually suffocating plant roots and leading to an accumulation of toxic nutrients. Studies have shown that maize is more susceptible during early seedling and the ensuing tasseling stages, resulting in visible leaf rolling, wilting, and root decay.[109]

In terms of actual recorded losses, about 45,000 hectares were destroyed in 1996,[110] whereas the devastating floods of 2000 saw about 140,000 hectares lost in total; maize and rice[111] made up most of the losses. In 2009, a national loss of 13 percent was recorded,[112] whereas the most recent floods in 2013 led to estimated losses of up to 154,000 hectares total, including a large proportion of maize.[113] Excessive rain and the storms Dando and Funso have been recorded as leading to losses of planted areas in Cabo Delgado, Zambezia, Sofala, Inhambane, Gaza, and Maputo.[114]

PESTS AND DISEASES

Given maize's high prevalence throughout the country, it is regularly exposed to various pests and diseases. The major maize diseases can be grouped into four categories: leaf blights, stalk rots, ear rots, and viral diseases. The main pests include cutworms, ground weevils, maize chafer, beetles, and aphid disease.[115] Because maize is usually intercropped and cultivated from earlier harvest generations, there are many vectors for disease transmission. Given the importance of the early vegetative stage of the plant, the application of herbicides and other pesticides completed within the first two months of corn development will have a significant impact on output.[116]

[108] http://www.ag.ndsu.edu/procrop/env/fldwhb07.htm.

[109] Ibid.

[110] FAO.

[111] World Bank.

[112] IRIN.

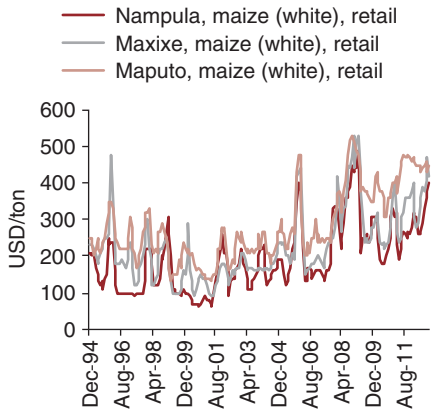
[113] FAO.

[114] Balanco de PES 2012.

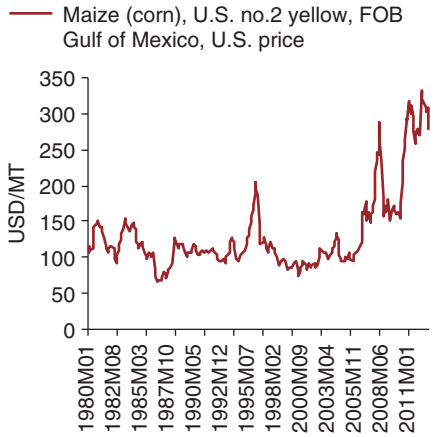
[115] http://www.biodiversityexplorer.org/plants/poaceae/zea_mays_pests.htm.

[116] http://dirp3.pids.gov.ph/ACIAR/relatedresources/Impact%20of%20drought%20on%20corn%20productivity.pdf.

FIGURE E.9. DOMESTIC AND INTERNATIONAL PRICE VOLATILITY, MAIZE



Source: FAO GIEWS Food Price Data and Analysis Tool.



Source: IMF Primary Commodity Prices.

In 1998/99, it was observed that locusts, birds, and wheat-worm negatively affected maize production,[117] and locusts and lizards brought about the destruction of the second season crop in Gaza in 2006.[118]

MARKET RISKS

DOMESTIC PRICE VOLATILITY

The limited volatility in Mozambique's maize prices can be largely attributed to the government's trade policies. Administrative procedures imposed to ensure food security, product safety, and the addressing of environmental issues has distorted the trade of goods, conditions for retail, and factors of production. This environment has fostered an uncertain investment climate, often creating a disincentive for private sector actors to make significant investments. The trading environment is characterized by a lack of harmonization in cross-border trade with deficits and surpluses moderated by informal and illegal trading with neighboring states.

Maize prices show distinct seasonal fluctuations, as production is based on rain-fed irrigation systems and there is a single, main wet season. A particular example of domestic volatility was the price spike of 2005. A combination of a bad production year and of the crop forecasting system not capturing the losses resulted in limited supply and unexpectedly high prices. Traders, lacking information, were unable to import quantities to fill the resulting demand gaps.

INTERNATIONAL PRICE VOLATILITY

Another notable aspect is that the high prices in Mozambique seen in the recent period have not declined as world market prices declined (figure E.9).[119] Commodity prices, set by maize futures contracts, are intimately tied to energy prices and weather predictions. The alternative use of maize as a source of fuel ethanol affects prices directly and indirectly. Maize prices peaked at US$310.24 per ton (US$7.88/bushel) in June 2008 with the after effects of floods in the United States, then fell in late 2008 and early 2009 as commodity prices, led by oil prices, declined during the 2008 financial crisis. Analysis from the International Food Policy Research Institute estimates that rising demand for ethanol caused 40 percent of the rise in maize prices from 2000 to 2007. The United States, the world's major exporter, had a federal mandate to devote approximately 27 percent of the 2011 maize crop to ethanol production.[120]

[117] Annual Report Agricultural Campaign 1998/99.

[118] RNDD 2000.

[119] Donovan et al (2010) Staple food prices in Mozambique, Prepared for the Comesa policy seminar, Comesa-MSU-IFPRI African Agricultural Marketing Project (AAMP).

[120] http://www.unctad.info/en/Infocomm/AACP-Products/Commodity-Profile---Corn/.

APPENDIX F
RISK TRANSFER AND FINANCING OPTIONS IN MOZAMBIQUE

MICROLEVEL OPTIONS

THE PUBLIC-PRIVATE PARTNERSHIP (PPP) IN AGRICULTURAL INSURANCE FOR FARMERS

Developing a viable PPP in agricultural insurance would require significant public investments in data and would probably need to be accompanied by substantial growth in credit or input utilization. Developing a PPP in agricultural insurance is a long-term objective that requires appropriately sustained engagement and high levels of investment from both the public and private sectors. In addition, to achieve sustainability and meaningful uptake, it relies on several key pillars, one of which is an effective distribution channel to rural farmers through which insurance can be sold. These distribution channels can take many forms, such as rural lending institutions, input suppliers, or social welfare payment systems. The main distribution channels in Mozambique currently are rural credit and input suppliers, but only 2.3 percent of the rural population has access to finance (World Bank 2012b); 3.7 percent has access to credit (World Bank 2012b); and only 10 percent of maize farmers and 4 percent of rice farmers use improved seeds (Government of Mozambique 2008). These low levels of outreach in effect mean that currently there is not an effective distribution channel to provide insurance to the vast majority of rural farmers. Experience from other countries also suggests that significant investments in weather, yield and satellite data collection, and auditing would be required if agricultural insurance products were to offer reliable protection to farmers at low cost. Currently, a very limited amount of yield data are collected in Mozambique and the weather station network is limited. Moreover, the audit procedures for these types of data are not in line with international reinsurance standards.

Given the significant fiscal burden of developing a PPP in agricultural insurance, other risk management options may be more cost effective at this time. The investments in data mentioned above, as well as the institutional and market investments required to develop distribution channels to a level that would achieve critical mass, would be high relative to other investment options in agricultural risk management currently available to Mozambique. In the future, any investments in agricultural insurance would be coupled with other initiatives; for example, should the government of Mozambique want to develop rural productivity, it could look to develop the rural credit market to increase rural lending to farmers. Agriculture insurance is an excellent partner for such a venture; if effectively developed, it can protect vulnerable farmers against shocks as well as rural lending institutions against covariate risks that can lead to bankruptcy, increasing their resilience.

MESOLEVEL OPTIONS

MESOLEVEL AGRICULTURE RISK FINANCING

Given the low levels of rural lending in Mozambique and the lack of any direct regulatory incentive for lenders to transfer their portfolio-level agricultural risk, implementing any form of unsubsidized mesolevel agricultural insurance program would have limited uptake and thus be unsustainable. Insurance companies require high levels of premium volume from the products they sell to be sustainable in the long run.[121] This becomes a key challenge when, for example, insurance companies look to sell microinsurance; because the premiums are so much lower, they must sell a large number of policies to be sustainable. Given the low levels of rural credit in Mozambique, any insurance program targeting rural lending is unlikely to achieve sufficient uptake (and thus generate sufficient premium volume) to be sustainable. Again, in the medium term, should the government look to develop the rural credit market, this option could be considered.

CATASTROPHE WEATHER INDEX-BASED INSURANCE

Catastrophe weather index-based insurance (WII) products could be considered for large-scale commercial farmers. However, the development impact of any such products may be low.

MACROLEVEL OPTIONS

SOVEREIGN AGRICULTURE RISK FINANCING AND INSURANCE

It is unclear as to what the government considers its contingent liability to the agricultural sector, and what it considers to be the responsibility of donors or farmers. However, if the government considers its contingent liability to be relatively low, then developing a sovereign agriculture risk financing strategy may have lower impact than other agricultural risk management investments. In recent years, the government has taken steps to increase the protection it offers to vulnerable farmers against agricultural shocks. It has established a platform for disaster risk management in Mozambique, the Coordinating Council for Disaster Risk Management (CCGC) under the Council of Ministers, comprising representation across sectors. It also established The INGC, the executive arm of the CCGC, which is responsible for the coordination of disaster risk management activities, including disaster response and reduction. Disaster risk management, including disaster risk reduction, is also integrated into strategic planning documents including; the National Action Plan for Poverty Reduction, and the 2010–14 5-Year Plan. It also has several initiatives in place to assist vulnerable farmers in the aftermath of agricultural shocks, such as

[121] This is to cover overheads, such as fixed costs, variable costs, cost of capital, and so on.

distribution of free seeds. That said, given the fact that the government is reliant on donor funding for both its budget[122] as well as disaster response,[123] it has a limited contingent liability to the agricultural sector. Were the government to plan to increase its fiscal expenditure in the aftermath of disasters, then a sovereign agricultural risk financing strategy may become a more attractive option.

INDEX-BASED SOCIAL SAFETY MECHANISMS

Although the government is looking to increase the outreach of the social welfare scheme, currently there do not appear to be immediate plans or interest in developing a scheme that would automatically expand social welfare payments in the aftermath of an agricultural shock based on a predefined set of rules.

[122] Foreign aid accounted for 46 percent of the state budget in 2010, according to the AfDB in 2011.

[123] The government funds between 20 percent and 30 percent of the total estimated annual expenditure of expected disaster scenarios, with the remaining funds provided by donors.

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