AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

94883

TANZANIA

AGRICULTURAL SECTOR RISK ASSESSMENT

Carlos E. Arce and Jorge Caballero

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CONTENTS

FIGURES

TABLES

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ABBREVIATIONS AND ACRONYMS

ASDP	Agricultural Sector Development Program
ASDS	Agricultural Sector Development Strategy
CEEST	Centre for Energy, Environment, Science and Technology
CFVSA	Comprehensive Food Security and Vulnerability Analysis
CGIAR	Consultative Group on International Agricultural Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCGE	Dynamic Computable General Equilibrium Model
FAO	Food and Agricultural Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Statistics Division
FEWS NET	Famine Early Warning System Network
GCM	Global Climate Model
GDP	Gross Domestic Product
GIEWS	Global Information and Early Warning System
GPCP	Global Precipitation Climate Project
IFPRI	International Food Policy Research Institute
INC	Initial National Communication
IPCC	International Panel for Climate Change
MAFC	Ministry of Agriculture, Food Security and Cooperatives
MIROC	Model for Interdisciplinary Research on Climate
NAPA	National Adaptation Program of Action
TACRI	Tanzania Coffee Research Institute
TTC	Tanzania Tobacco Council

EXECUTIVE SUMMARY

In spite of Tanzania's comparative advantage in the production of many crops (cashew nuts, coffee, cotton, tea, tobacco, maize, and rice, for example) and the relative abundance of natural resources, 38 percent of the rural population, or 13 million rural inhabitants, live below the poverty line. The agricultural gross domestic product (GDP) grew at an annual average rate of 4 percent between 2005 and 2012, which is significant but below the 6 percent considered necessary for reducing poverty. Most small-scale farmers in Tanzania still continue to use low, purchased-input technologies that result in poor yields and scanty economic returns while facing high production price volatility and limited incentives to invest.

In 2001, the government established the Agricultural Sector Development Strategy (ASDS). The ASDS highlights the key constraints to achieving agricultural growth targets, among them "un-managed risks with significant exposure to variability in weather patterns with periodic droughts." The Agricultural Sector Development Program (ASDP) Framework and Process Document (2005) provides the overall framework and processes for implementing the ASDS. Development activities at the national level are to be based on the strategic plans of the line ministries while activities at the district level are to be implemented by local government authorities. The ASDP components are to be financed through a basket fund. Currently, there is an attempt to link risk management interventions to the new ASDP.

This study was undertaken by the Agricultural Risk Management Team (ARMT) of the Agriculture and Environment Services Department of the World Bank under the leadership and coordination of the Directorate of Policy and Planning from the Ministry of Agriculture, Food Security and Cooperatives (MAFC). This volume comprises the first phase of the Agricultural Risk Assessment for Tanzania related to identification and prioritization of agricultural risks. The Second Phase will address risk management solutions and will be developed as a separate volume. The findings of this assessment aim at informing the Tanzania's Agricultural Sector Development Program, currently in preparation.

Tanzanian agriculture has not suffered natural or artificial events at a catastrophic level during the past 20 years, and that is reflected in the agricultural GDP growth

rate, which has never been negative during that period. In effect, it is fortunate that its abundance of natural endowments to date have not been impacted by catastrophic shocks. However, aggregated figures at the sector level tend to mask volatility at crop and regional levels, which in turn hide fundamental vulnerabilities. As was highlighted by the ASDS, such volatility represents an important constraint to growth and poverty reduction.

Unreliable rainfall in terms of intensity and distribution has been identified as one of the most likely and damaging production risks by most stakeholders. Drought is also recognized as a severe risk that occurs with lower frequency while retaining the potential to severely affect agriculture. Pests and diseases are also important production risks that cause yield volatility and, occasionally, when outbreaks occur, can result in severe and extensive damage to agriculture. However, their damage potential varies greatly among crops and is highly correlated to any risk management actions in place.

Price volatility is a key market risk in Tanzania and is particularly present in coffee and export crops, where interannual domestic price changes are very much in line with the high international price volatility of these commodities. Sudden fluctuations in prices are negatively affecting the segments of the supply chain with little capacity to manage volatility, being for the most part farmers. The enabling environment is another source of risk. For the purpose of this report, enabling environment risk refers to the set of conditions that facilitate the efficient performance of business along the supply chain, among which public policy and regulation are the most prominent. The most prevalent enabling environment risks identified are changes in regulation regarding the marketing system and the role of stakeholders in the supply chains; decision-making processes of primary societies in their intermediary roles; and logistic disruptions in the supply, access, and availability of inputs to agriculture. The relative importance with respect to each supply chain is discussed in the body of this document.

The value of the average annual production losses in the agricultural sector as a result of unmanaged production risks has been estimated at approximately US$203 million, or 3.5 percent of agricultural GDP. The calculation involves the following crops: tobacco, coffee, cotton, cashew nuts, sesame, maize, rice, beans, and cassava, which in aggregate make up more than 80 percent of agricultural GDP. Drought was the main cause of these shocks, sometimes in combination with other events. With regard to maize, more than 40 percent of losses over a 30-year period are concentrated in Mbeya, Manyara, Shinyanga, and Iringa. Kilimanjaro and Arusha have also been adversely affected by production volatility. Altogether, the six regions account for 61 percent of all losses.

How the losses are distributed among stakeholders within the supply chain is to a great extent a function of value chain governance and the actors' capabilities and opportunities for risk management. Some exporters, millers, and large trading companies are able to hedge price risks globally through the practice of standard futures risk management strategies. The great majority of farmers, traders, and cooperatives are highly exposed to price risk, largely through a lack of risk management practices and knowledge. Primary cooperative societies, ginners, and other procurement agents involved in export crops take significant risks when they make advance payments to farmers or keep the products in storage until delivery in the auction (coffee) or to the exporting companies (cotton). Small-scale farmers' capacity to protect themselves against price risk is extremely limited. Primary cooperative societies are also the weakest segment in the supply chain. Product price variations within the marketing year can expose primary cooperative societies to financial losses when practice multipayment systems.

All actors along the supply chains are exposed to the variability in primary farming production. However, smallholder farmers are particularly vulnerable to production and yield variability. Their family food security and monetary income are extensively dependent on the crop harvest. Thus, to mitigate weather and pest and diseases risks at the farm level, many producers adopt low-risk and low-yield crop and production patterns to ensure minimum volumes for food security purposes.

The identified risks were prioritized according to the frequency of realized risk events, their capacity to cause losses, and the ability shown by the different stakeholders to manage the risks. The prioritization exercise indicated

that the following were the major risks causing losses to the agricultural sector: drought events mainly for maize, rice, and cotton; widespread outbreaks of pest and diseases especially for cotton, maize, and coffee; price volatility for cotton and coffee; and regulatory risks, mostly within the trade policy framework, for various cash crops and for maize. Although these risks do not necessarily manifest themselves in the form of catastrophic shocks to agriculture as mentioned above, they are identified as the main drivers of agricultural GDP volatility that cause stakeholders income instability and recurrent food security problems.

Field interviews identified a number of potential solutions related to a combination of risk mitigation, risk transfer, and risk coping instruments.

The areas of focus for risk management solutions in the second phase have been identified as the following:

- » Strengthening seed supply chains for producing and delivering drought tolerant seeds, disease resistant seeds, and planting material, as well as inefficient seed markets that need to be addressed to reduce risks in agriculture.
- » Strengthening the agricultural technology innovation system to mitigate agricultural production losses. Agricultural risk mitigation practices can have very significant impacts on reducing risks derived from irregular or insufficient rainfall as well as from diseases and pests.
- » Current maize trade policy adds market volatility to the normal production (climatic and sanitary) risks because of the variability and unpredictability of the norms restricting trade and the way they are enforced.
- » Risk management strategies for high-priced, volatile export crops (principally coffee and cotton) are needed to reduce exposure to risk of the most vulnerable stakeholders in the respective supply chains.

These solutions will be addressed in a Risk Management Solutions mission (the second phase) and will be put within the framework of an action plan that addresses the most relevant risks with appropriate investments, programs, and policy measures.

CHAPTER ONE

INTRODUCTION AND CONTEXT

THE SCOPE OF THE STUDY

This study aims to achieve a better understanding of the agricultural risk and risk management situation in Tanzania with a view to identifying key solutions to reduce current gross domestic product (GDP) growth volatility.

For the purpose of this assessment, risk is defined as the probability that an uncertain event will occur that could potentially produce losses to participants along the supply chain. Persistence of unmanaged risks in agriculture is a cause of great economic losses for farmers and other actors along the supply chains (for example, traders, processors, exporters), affecting export earnings and food security.

THE RISK ASSESSMENT PROCESS

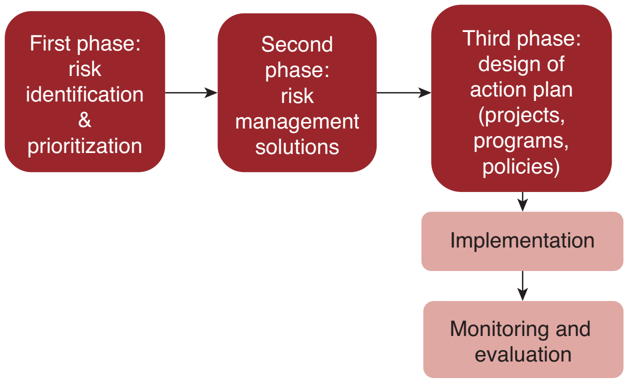
The Agricultural Risk Management Team of the Agriculture and Environment Services Department of the World Bank is conducting this Agricultural Sector Risk Assessment under the leadership and coordination of the Directorate of Policy and Planning from the Ministry of Agriculture, Food Security and Cooperatives (MAFC).

The Agricultural Sector Risk Assessment is a straightforward methodology based on a three-phase sequential process. Phase one begins by analyzing the chronological occurrence of inter-seasonal agricultural risks with a view to identify and prioritize the risks that are the drivers of agricultural GDP volatility. A short list of potential risk management solutions is also identified during this process. Those solutions are then assessed in a second phase that details the gaps that need attention to reduce risks. Finally, in the third phase, the solutions are placed within the framework of an action plan that addresses the most relevant risks with appropriate investments, programs, and policies that involve the participation of the concerned government and private sector stakeholders. Figure 1.1 shows the process.

This report contains the findings and recommendations of the first phase and includes the identification, analysis, and prioritization of major risks facing the agricultural sector in Tanzania, as well as recommendations regarding key solutions (see figure 1.2).

A combination of quantitative and qualitative techniques was used to generate the findings of this assessment, include an existing secondary analysis as well as comments and analyses from experts from MAFC at the central and regional levels.

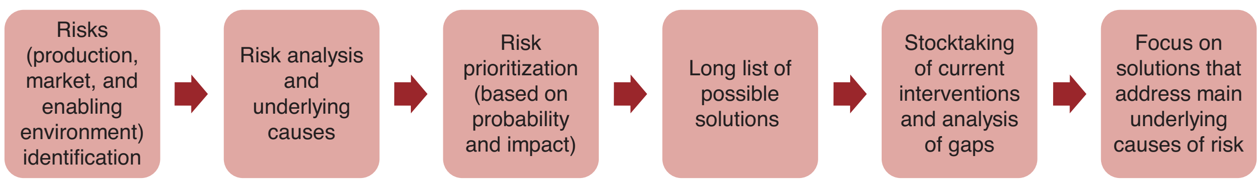
FIGURE 1.1. THE RISK ASSESSMENT PROCESS



CONTENTS OF THE REPORT

Chapter 2 of this report contains an overview of the agricultural sector and its performance, as well as a discussion of key agro-climatic, weather, and policy restrictions and opportunities. Chapter 3 includes an assessment of major risks (that is, production, market, and enabling environment risks) facing key export and food crops. Chapter 4 presents an estimate of historical losses due to realized production risks and a correlation of such losses with production volatility. Chapter 5 provides insights into the exposure to risks by different stakeholders and their actual capacities, vulnerabilities, and potential to manage agricultural risks. Finally, chapter 6 presents a risk prioritization by different supply chains and discusses the possible solutions, as well as specific recommendations for the Agricultural Sector Development Program (ASDP).

FIGURE 1.2. RISK IDENTIFICATION AND PRIORITIZATION



CHAPTER TWO

AGRICULTURAL SYSTEM

AGRICULTURAL SECTOR OVERVIEW AND PERFORMANCE

Tanzania is endowed with 44 million hectares suitable for agriculture, representing 46 percent of its territory. However, part of this arable land is currently only marginally suitable for agricultural production owing to, for example, soil leaching, drought proneness, and tsetse fly infestation. According to the Agricultural Sector Development Strategy (2001), only 10.1 million hectares (23 percent of arable land) are cultivated. This includes around 2.2 million to 3.0 million hectares of annual crops, fallow for up to five years, permanent crops, and pasture. It is also estimated that out of 50 million hectares suitable for livestock production, only half are currently being used, mainly owing to tsetse fly infestation.

Agriculture (which also encompasses livestock, forestry, hunting, and fishing) is an important pillar of the Tanzanian economy, accounting for 28 percent of GDP (2010) and 25 percent of export earnings (2011) and it provides a livelihood to more than 75 percent of the population (National Bureau of Statistics 2011). While the agricultural sector's contribution to national GDP declined significantly from 1990 (46 percent) as other sectors like industry and manufacturing began to grow across the country (see table 2.2), it is still an important sector that serves as one of the main activities and income sources for rural households (National Sample Census of Agriculture 2012).[1]

According to the Household Budget Survey (2007), 38 percent of the rural population lived below the poverty line (basic needs). Poverty is highest among those living in arid and semi-arid regions that depend entirely on livestock and food crop production for their livelihood. Although there is not one significantly worse- or better-off region in

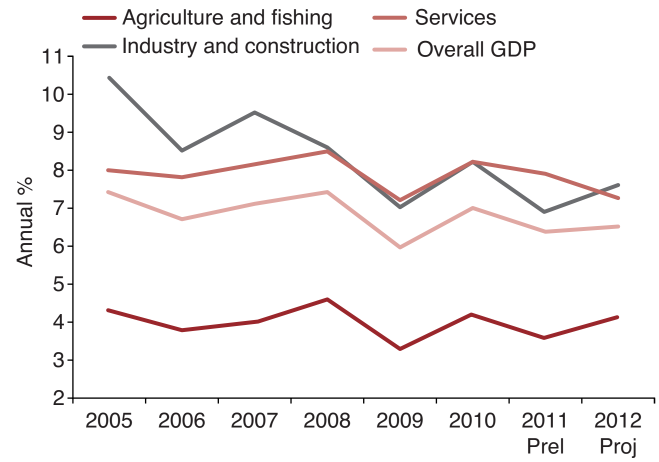
[1] Sale of food crops was the main cash income earning activity (61.6 percent in 2008 compared with 37.4 percent in 2003 of all the rural agricultural households), followed by sale of cash crops (9.9 percent compared with 17 percent in 2003) and other casual cash earnings (7.8 percent in 2008 compared with 15.1 percent in 2003.).

TABLE 2.1. TANZANIA AT A GLANCE

Area (km^2)	948,087
Total population (millions) (2010)	44.8
Rural population (% of total population) (2010)	73.7
Rural population growth (annual %) (2010)	2.4
Economy and poverty	
GDP (US$ billions) (2010)	22.9
Agriculture GDP (% of total GDP) (2010)	28.1
Agriculture growth rate (2010)	4.1
GNI per capita (2010)	520
Poverty gap at national poverty line (%) (2007)	9.9
Poverty gap at rural poverty line (%) (2007)	11
Poverty head count ratio at rural poverty line (% of rural population) (2007)	37.4

Source: World Development Indicators 2013.

FIGURE 2.1. TANZANIA REAL GDP GROWTH BY SECTOR



Source: NBS, IMF, WB.

TABLE 2.2. GDP COMPOSITION BY SECTORS

GDP Composition	1990	2000	2009	2010
Agriculture (% of GDP)	46	33.5	28.8	28.1
Industry (% of GDP)	17.7	19.2	24.3	24.5
Manufacturing (% of GDP)	9.3	9.4	9.5	9.6
Services (% of GDP)	36.4	47.3	46.9	47.3

Source: World Bank 2010.

Tanzania, the most severe poverty can be found near the coast and in the southern highlands.

Agriculture performance. The agricultural GDP continuously increased during the past eight years at an annual average rate of 4 percent, which is acceptable but well below the almost 7 percent rate of the overall economy (see figure 2.1).

The agricultural GDP growth rate improved to 4.6 percent in 2008 from 4.0 percent in 2007 and 3.8 percent in 2006, largely reflecting favorable weather experienced in the 2007–08 agricultural season, improved irrigation and rural road infrastructure, and increased use of fertilizers. In 2009, the agricultural GDP growth rate registered the lowest value (3.3 percent) in the period as a consequence of a drought in 2008–09, especially in the northern part of the country. Growth continued at about the average 4 percent rate in the following years with the exception of 2011, when preliminary data show a slight dip to 3.6 percent.

AGRO-CLIMATIC CONDITIONS

Located in East Africa, Tanzania is composed of seven agro-ecological (land resource) zones (see figure 2.2) having different soils and topography, altitude, rainfall regimes, and growing seasons, with dry periods and extreme rainfall during the two rainy seasons that are prevalent in some zones (National Sample Census of Agriculture 2012, xv).

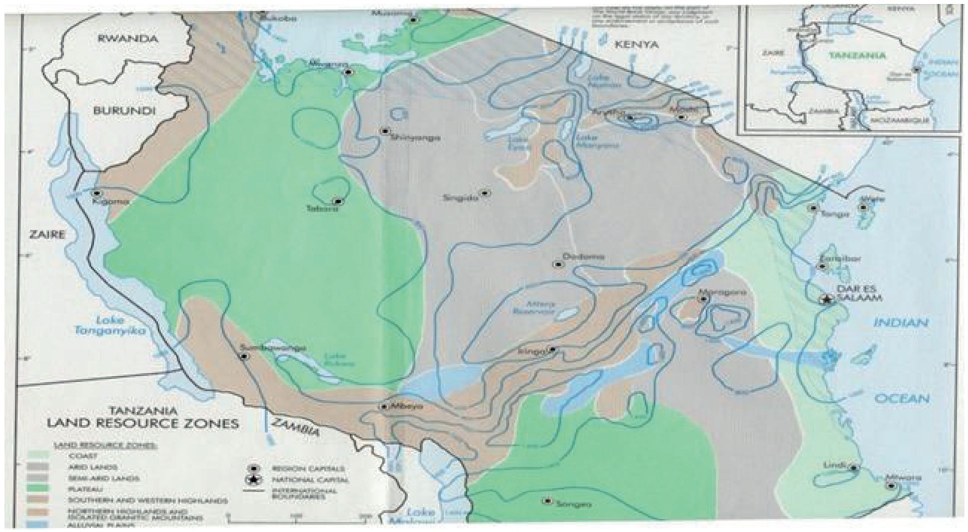
The combination of dry periods and heavy rainfalls, along with an inadequate land maintenance system, aggravates the land degradation process and makes the country's agricultural production highly vulnerable to weather-related shocks (Enfors and Gordon 2007).

RAINFALL TRENDS

Rainfall follows two different patterns in Tanzania. In the northeast and coastal areas there is a bimodal rainfall pattern with short rains (Vuli, in local parlance) from October to December and a long period of rains (Masika) from March to May. A different rainfall pattern is observed across the south and west. A unimodal pattern (Musumi) occurs with rainfall from December to April. Appendix A provides detailed information on the cumulative monthly rainfall in both zones.

Annual crop production takes place during the two rainfall patterns. The Vuli planting season is around

FIGURE 2.2. LAND RESOURCE ZONES



Source: World Bank 1994.

October–November, with harvesting in late January–February; the Masika, or main planting seasons, starts in late February–March, with harvesting in July–August. Most of the country's crop production occcurs in the Masika season with around 80 percent of total planted area, compared with 20 percent of the total planted area during the Vuli period (National Sample Census of Agriculture 2012, 30).

CROP PRODUCTION SYSTEM AND EXPORTS

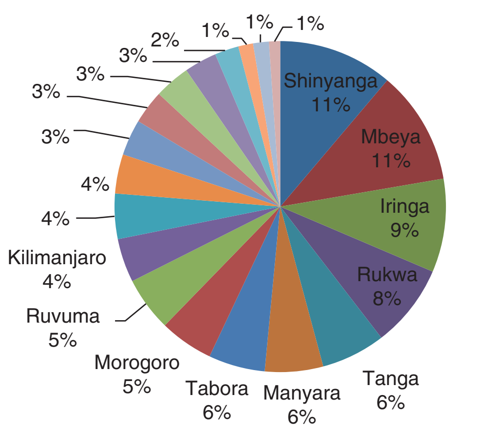
The crop subsectors account for the highest contribution to Tanzania's agricultural GDP, followed by livestock, forestry, and fishing (Ministry of Agriculture 2011). As such, crop production is the main rural smallholder household activity (National Sample Census of Agriculture 2012).[2] Food crops are grown for both family consumption and for sale. Pure cash crops (coffee, tobacco, cotton, rice, peas, and so on) are key commodities in the country. Crop smallholder farming is labor intensive and those farmers have very little access to modern farm technologies and inputs. Productivity and profits are low.

Over the decades, a Tanzanian farmer's choice of crop production has been influenced by environmental (soil quality, water accessibility, pest resistance), resource (fertilizers, quality seeds, machinery) and economic factors (such as marketability and seed prices) (Greig 2009). Farming preferences in the past have been largely focused on millet, cotton, sugarcane, and banana-based systems that have been shifted around greater maize, cassava, and rice production for the past few decades (Fermont 2009). Generally, mixed maize production is common in central semi-arid regions whereas the northern zones provide better conditions for coffee, maize, and tea. Coffee and tobacco production is predominant in the southern and western zones, and the Lake Victoria area is suitable for cotton (Ponte 2002, 38–39; Kimaro and others 2009, 115).

According to the latest crop census data, maize is produced across the country, with a relative concentration in some regions, and is the main crop for the majority of households (more than 5.1 million) (National Sample Census of Agriculture 2012, 30). Figure 2.3 shows the geographical distribution of producing regions. The largest producing regions (Shinyanga, Mbeya, Iringa, Rukwa, Tanga, Manyara) and Ruvuma are also surplus areas, with per capita production 20 percent above the national average.

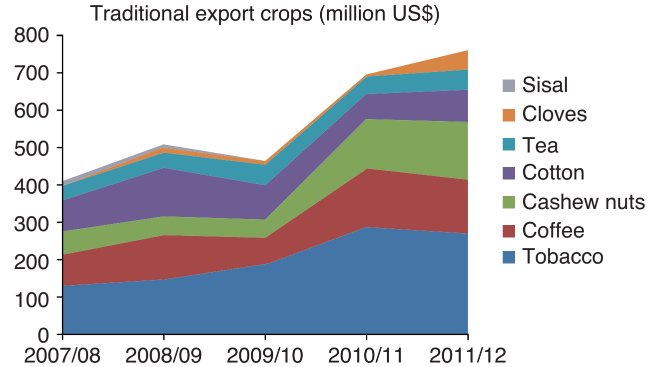
[2] At the national level, crop production was the dominant agricultural activity, which engaged 3,508,581 households (60.1 percent), followed by 2,268,255 (38.8 percent) households engaged in mixed crop and livestock, 57,770 (1 percent) households engaged in livestock only, and only 3,917 (0.1 percent) households engaged in pastoralism (chart 2.12). Of the total crop-growing households, 3,422,072 (98 percent) were on the mainland and 86,509 (2 percent) were in Zanzibar.

FIGURE 2.3. MAIZE PRODUCTION BY REGION



Source: MAFC.

FIGURE 2.4. TRADITIONAL EXPORT CROPS

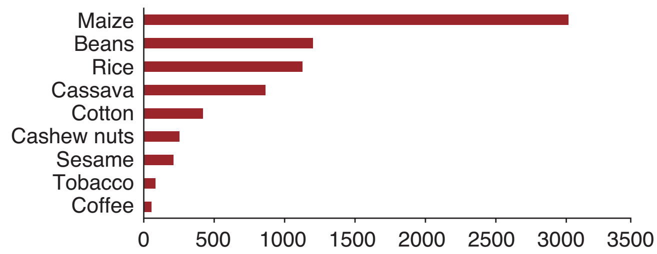


Source: Bank of Tanzania.

Agricultural exports. Tanzania's major exports include gold, tobacco, coffee, tea, cashews, cotton, gemstones, and some manufactured goods. Based on Bank of Tanzania data, the value of traditional commodity exports has increased during the past few years, and tobacco, coffee, and cashew nuts have been the leading commodity exports (see figure 2.4).

International Trade Centre (INTRACEN) data show that the agricultural sector (including livestock, forestry, hunting, and fishing) accounted for 25 percent of export earnings in 2011, down from 42 percent in 2007. The total value of agricultural exports increased between 2007 and 2011 from US$908 million to US$1.18 billion, but overall exports increased much more, from US$2.14 billion to US$4.73 billion. Tobacco export earnings grew steadily in

FIGURE 2.5. PLANTED AREA



Source: MAFC.

that period. The export volume of coffee remains low, but given the recovery of the international prices during the 2000s, export earnings are increasing.

YIELD, PRODUCTION, ACREAGE, AND MARKET TRENDS

Maize dominates according to the planted area, followed by beans, rice, cassava, and cotton (see figure 2.5).

Yields for maize are low and decreasing, averaging about 1.3 tons per hectare. This is a very low level compared with what has been achieved elsewhere. Rice productivity in irrigated areas is variable depending on location but, on average, is higher in irrigated than nonirrigated areas. The average yield in nonirrigated areas is less than 2 tons per hectares for paddy. The ASDP—Joint Implementation Review (2012) revealed that the yield per hectare for irrigated paddy can be as high as 8 tons per hectare in some places, such as KPL-Mngeta, where farmers receive some extension services as out-growers.[3] Table 2.3 shows the average area, yields, and production for the main food security and export crops.

PRINCIPAL CONSTRAINTS IN THE AGRICULTURAL SYSTEM AND POLICY REFORM

Tanzania's agricultural sector has a comparative advantage in the production of a diversified set of agricultural export crops (cashews, coffee, cotton, tea, and tobacco) as well as those for food consumption (rice and maize), and

[3] Information provided by Professor Gungu M. Mibavu.

TABLE 2.3. AVERAGE 2007/08–2009/10, EXCEPT FOR COFFEE AND CASHEW NUT, WHICH IS 2008/09–2009/10

	Area (000 ha)	Yields (tons/ha)	Production (000 tons)
Maize	3,328	1.30	4,313
Rice	943	1.90	1,795
Tobacco	65	0.96	63
Coffee	65	0.79	51
Cotton	505	0.62	313
Cashew nut	320	0.28	90

Source: Based on data from MAFC.

there is a relative abundance of natural resources (including arable land and range land) that can be used for productive purposes. Market opportunities are expanding in domestic markets for food, especially for livestock products and crops with high-income elasticity of demand. Moreover, Tanzania's membership in regional trade groups (East African Community and the Southern African Development Community) and signatory status to international trade protocols improves its market opportunities both within the region and globally.

Starting in the 1980s, the Tanzanian government implemented a series of agricultural reforms to support market liberalization, remove state monopolies, and encourage private sector development.[4] This policy process envisioned the transition of the agricultural sector from subsistence to export agriculture. The policy instruments included demand-driven and market-led technology development and encouraged private sector involvement. These reforms included the liberalization of marketing of nontraditional export crops in 1986, which was followed by liberalization of marketing of food crops in 1989 and finally liberalization of marketing of traditional export crops in the 1993/94 marketing season. The liberalization of agricultural marketing was expected to pave the way for the participation of cooperatives and private traders in crop marketing in a competitive environment that included competitive prices and free entry of marketing actors (producers, traders, processors, and exporters) at all levels of the marketing channel. See box 2.1 for brief details on commodity boards reform.

BOX 2.1. COMMODITY BOARDS REFORM DURING THE 1990s AND EARLY 2000s

The major cotton reform began with the Cotton Act of 1994, which allowed competition in both marketing and ginning of cotton. The Cotton Industry Act of 2001 specified that the Tanzania Cotton Board would officially regulate the cotton sector. Reform opponents argue that taxation remains excessive and the sector is still overly regulated. The quality of cotton also has been declining (Baffes 2004).

In the early 1990s, the Tanzanian government privatized previously nationalized coffee estates and abandoned controls on coffee prices. Today, the private sector has emerged in the coffee business and the overall processing capacity has increased. However, the export volume of coffee remains low and arguably the quality of coffee has decreased. Additionally, declining world coffee prices have cut real producer prices. During the 2000s, international prices recovered, giving producers an incentive to expand production. However, there are still high marketing costs that depress the ratio of farm gate price to auction price.

The marketing and pricing strategy for tobacco was overhauled with the Tobacco Industry Act of 2001. Reforms included assigning price according to tobacco demand worldwide and negotiations between tobacco farmers and buyers in U.S. dollars. Additionally, tobacco producers became free to take agricultural inputs on loans that helped productivity growth.

It should be noted, however, that these policy reforms have had implementation weaknesses that prevented maximization of available market opportunities domestically, regionally, and internationally. Most rural small-scale farmers in Tanzania continue to use low-purchased-input technologies that result in poor yields, weak economic returns, and high production volatility.

The Agricultural Sector Development Strategy and Program. In 2001, the government established the Agricultural Sector Development Strategy (ASDS). The ASDS was created

[4] This section was extracted from Ministry of Industry, Trade and Marketing, Agricultural Marketing Policy, December 2008.

as an integral component of macroeconomic adjustment and structural reforms that were supported by Tanzania's development partners. Its primary objective was to create an enabling and conducive environment for improving profitability in the sector as the basis for increasing farm incomes and reducing rural poverty in the medium and long term. The Agricultural Sector Development Program (ASDP) Framework and Process Document (2005) (United Republic of Tanzania 2006), developed jointly by the lead ministries for the agricultural sector, provides the overall framework and processes for implementing the ASDS. Development activities at the national level are to be based on the strategic plans of the line ministries, whereas activities at the district level are to be implemented by local government authorities, based on District Agricultural Development Plans (DADPs).[5] The ASDP national and local components are to be financed through an ASDP Basket Fund.

The ASDP highlights the key constraints to achieving agricultural growth targets:

i. High transaction costs due to the poor state or lack of infrastructure and the overall policy and regulatory environment governing market transactions (including tax regimes and licensing requirements and costs).
ii. Underinvestment in productivity-enhancing technologies. Although recent progress has been made in increasing land productivity, progress has been hampered by the relative under-investment in research.
iii. Limited access to technology demand and delivery channels—with 60 to 75 percent of households estimated to have no contact with research and extension services.
iv. Limited access to financing for the uptake of technologies.
v. Unmanaged risks with significant exposure to variability in weather patterns with periodic droughts. The impact of these events is amplified by the dependency on rain-fed agriculture and the limited capacity to manage land and water resources.
vi. Weak coordination and capacity in policy, and the formulation and implementation of public intervention among the various actors in the sector (including the multiplicity of ministries dealing with agriculture). (United Republic of Tanzania 2006, 7)

This risk assessment aims at complementing current agricultural risk management analysis and practices within ASDP.

[5] Tanzania mainland is divided into 25 administrative regions: Dodoma, Arusha, Kilimanjaro, Tanga, Morogoro, Pwani, Dar es Salaam, Lindi, Mtwara, Ruvuma, Iringa, Mbeya, Singida, Tabora, Rukwa, Kigoma, Shinyanga, Kagera, Mwanza, Mara, and Manyara. Furthermore, the regions are divided into urban and rural districts, totaling up to 119 administrative districts (National Sample Census of Agriculture 2012).

CHAPTER THREE
AGRICULTURAL SECTOR RISKS

Tanzania has not suffered catastrophic natural or artificial events during the past 20 years, good fortune that is reflected in a positive agricultural gross domestic product (GDP) growth rate throughout those two decades. In effect, Tanzania's natural endowments reduce its exposure to systemic agricultural risks. However, aggregated figures at the sector level tend to mask volatility at crop and regional levels, which in turn hide fundamental vulnerabilities (see box 3.1 on regional vulnerabilities).

The analysis focused on critical food security crops: tobacco, coffee, cotton, and cashew nuts (representing 88 percent of the total value of the agricultural exports in 2011/12) as well as rice and maize, the main food staple (Bank of Tanzania). Risks are highly concentrated in these supply chains, which also show great, largely unmanaged volatility. It is recognized, however, that there are other crops, such as roots and tubers (for example, cassava) and legumes (for example, beans), that are food security coping crops in specific regions or grown under intercropping systems, with risk profiles not radically different from the crops that are actually being studied.

Tanzania's dependency on rain-fed agriculture makes it acutely vulnerable to weather changes. Most stakeholders have cited unreliable rainfall—in terms of intensity and distribution—as one of the most likely and damaging production risks. Drought is also recognized as a severe risk that occurs with lower frequency but with great potential to severely affect agriculture. Climate change may be exacerbating the typical inter-seasonal weather risks facing the agricultural sector. A couple of climate change assessments (see appendix B) predict impact variations across geographical areas and among agricultural subsectors. There might even be gains in some regions while losses might occur in others. This study focused specifically on short-term interannual risks rather than long-term changes in climate. However, the recommendations provided in this report will need to be linked to the findings contributed by climate change studies regarding mitigation and adaptation to climate change.

Pests and diseases are also important production risks that cause yield volatility and, occasionally when outbreaks occur, can result in severe and extensive damage to

BOX 3.1. REGIONAL VULNERABILITY

The World Food Program's 2010 Comprehensive Food Security and Vulnerability Analysis reports the top three most frequent shocks to household food security as drought (58 percent of surveyed households), high food prices (53 percent), and plant disease/animal pests (35 percent). Drought was most frequently reported in the northern regions (Arusha, Tanga, Manyara, Kilimanjaro, and Mara), central regions (Dodoma and Morogoro), and southeastern regions (Mtwara and Lindi). The "increasingly bimodal" tendencies and rainfall patterns in the north correspond with this finding. High food prices were cited across Tanzania, but particularly so in Kilimanjaro, Mara, Dodoma, Singida, Lindi, and Mtwara; western regions reported this shock less frequently. Shocks related to plant disease and animal pests were more prevalent in regions close to the water, specifically, Lindi, Kigoma, Mara, Mtwara, and Mwanza. The Shinyanga, Ruvuma, and Arusha regions were least affected.

agriculture. However, their damage potential varies very much among crops and is highly correlated to the actual risk management actions in place. Other risks identified include fake and expired chemicals and strong winds (strong winds were recorded in 2009 and 2010, affecting banana and coffee trees). The greatest impact occurred when strong winds coincided with drought and therefore exacerbated the damage to already weakened trees.

Price volatility is a key market risk in Tanzania and is particularly present in export crops, for which interannual domestic price changes are very much in line with the international and regional market variations. Sudden fluctuations in prices negatively affect the segments of the supply chain with little capacity to manage volatility.

Enabling environment, another source of risk, for the purpose of this report refers to the set of conditions that facilitate the efficient performance of business along the supply chain, among which public policy and regulation are the most prominent. The prevalent enabling environment risks identified are changing regulation regarding the marketing system and the role of stakeholders in the supply chains; decision-making processes of primary societies in their intermediary roles; and, logistical disruptions in the supply, access, and availability of inputs to agriculture.

Finally, there are long-term threats that if not properly addressed may become actual risks. These are challenges over the medium to longer term because of structural tendencies that signal sustainability issues for the supply chain. Three different types of long-term threats were identified: environmental, financial, and price related.

This section presents findings regarding the production, market, and enabling environment risks in the most relevant supply chains as well as discussions on the impact of the adverse events on the different stakeholders.

TOBACCO

Tobacco is Tanzania's largest agricultural export crop (US$272 million in 2011/12) and a major cash crop for many smallholders. It is an important source of foreign exchange, tax revenue, and income for stakeholders along its supply chain. The National Sample Census of Agriculture (2012) estimated that about 64,572 hectares at the end of the 2007/08 agricultural year were under tobacco cultivation on the mainland.[6] The Tabora region accounted for the largest tobacco production, equivalent to 51.1 percent of total harvested quantity (36,056 tons; National Sample Census of Agriculture 2012). More than 85 percent of people in Tabora depend on tobacco for their livelihood.[7]

The tobacco supply chain is regulated by the Tanzania Tobacco Board (TTB). Tobacco growers organize themselves in primary cooperative societies. These primary societies form a cooperative union at the regional level (such as the Western Zone Tobacco Growers Cooperative Union, or WETCU) and these cooperative unions give rise to a tertiary cooperative organization, the Tanzania Tobacco Co-operative Apex, which represents farmers at the Tanzania Tobacco Council (TTC).[8] TTC is a body that comprises all stakeholders of the tobacco industry and is the institutional forum in which important issues related to the industry are discussed. Lastly, there is the Association of Tanzanian Tobacco Traders (ATTT),

[6] There was no tobacco production in Zanzibar.

[7] Personal communication Mr. Yobu Kiungo, Regional Forestry Officer, Tabora, January 14, 2013.

[8] The Tanzania Tobacco Co-operative Apex unites approximately 300 tobacco primary cooperative societies, representing more than 100,000 small holder tobacco growers. Source: IPP Media 2012.

owned by the two largest tobacco processors in Tanzania, and practically acting as a service provider to farmers on behalf of the two largest exporters.

Production risks. In tobacco production, weather risks tend to come in the form of droughts or heavy rainfall with strong winds and hail storms that can either hurt the quality of tobacco or completely destroy the crop. Wet soil after heavy rain causes the tobacco plant to become stunted. Such weather occurrences are common at least once a year, but they are localized.

Risks posed by pests and diseases are negligible, according to the ATTT, as crops are kept as clean as possible. The Tobacco Research Institute of Tanzania also claimed that diseases do not affect tobacco very much, as nematodes are left in the tobacco field after harvesting. Standard tobacco farming practice to avoid contamination prescribes moving plants after harvesting and planting another crop such as maize rotating with tobacco.

Market risks. Production of tobacco is price driven, and lags a season behind. Although farmers base their planting decisions on the previous year's price, exposing themselves to the risk of fluctuation of both agricultural inputs and tobacco purchase price, the product price is reported to be more or less steady, with the exception of some years such as 2011, which witnessed the entrance of a new tobacco purchaser—a development that drove prices higher.[9]

Long-term threat (environmental risk). Tobacco farmers tend to engage in a farming practice whereby after harvesting one plot, they leave it fallow, move to the next plot, and thus advance into forestland. In addition, flue-cured tobacco farming requires the use of woodland. It is estimated that approximately one hectare of woodland is required to flue-cure one hectare of planted tobacco. In the absence of reforestation programs, this represents a great environmental constraint and may exacerbate production risks in the future.

[9] Agricultural input decisions are taken at the primary society level in January, a few months before the purchase price for tobacco is negotiated at the Tanzania Tobacco Council in May–June. In June–July, seeds are issued to farmers who prepare the seedlings to be planted between October and December.

COFFEE

Today, coffee is Tanzania's second-largest export crop after tobacco. It accounted for 20 percent of agricultural export proceeds[10] and 3.6 percent of all export proceeds in 2012. More than 400,000 households with an average area of 0.5 to 1 hectare are responsible for most coffee production. Participants in the supply chain are farmers, cooperatives, farmer groups, traders, exporters, and dry mills.

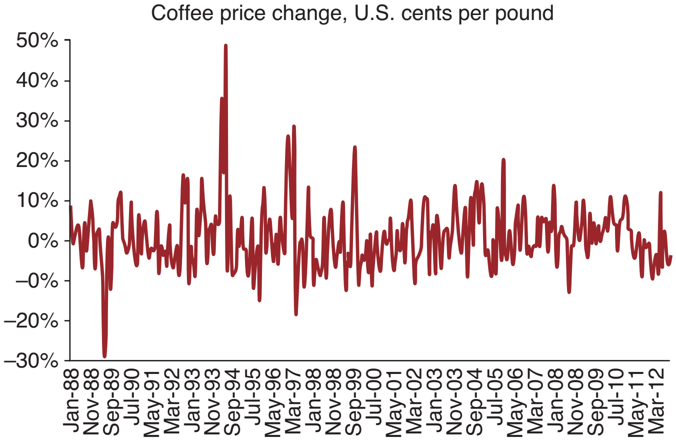
Small-scale farmers trade their produce through traders and primary cooperative societies. Traders and primary cooperatives collect roughly 75 to 80 percent of the market, and estates account for the rest. Coffee harvested by cooperative member farmers is processed in the cooperative centers using the wet method (arabica coffee) to obtain parchment coffee. Cooperative unions buy from the associated primary cooperative societies, arranging for hulling and grading in private mills, and then sell beans at auction or export them directly (if authorized). The auction is an efficient pricing mechanism, in the sense that realized prices move in accordance with the New York Board of Trade futures prices but, it is argued, the mandatory nature of the auction increases marketing costs.[11] The second grade associations (cooperative unions) provide bank-financed credit resources to primary cooperative societies to enable them to afford the processing costs and to prefinance farmers. Some exporters also have production promotion support programs to assist farmers to expand and improve production.

Production risks. Coffee is exposed to erratic rains in all agro-ecological zones where it is produced, although rain irregularities are more pronounced in the north. It has been reported by the local stakeholders in Arusha that short rains (November–December) seem to have been diminishing during the past few years. For instance, the Meru Rural Cooperative Society Ltd. (Singesi-Arusha) identified 4 years of drought during the past 10 years, and in 2010/11 coffee processed by cooperatives dropped to 12,000 kg against an expected 24,000 kg. The Tanzania Coffee Research Institute (TACRI) is working on the

[10] Source: Bank of Tanzania.

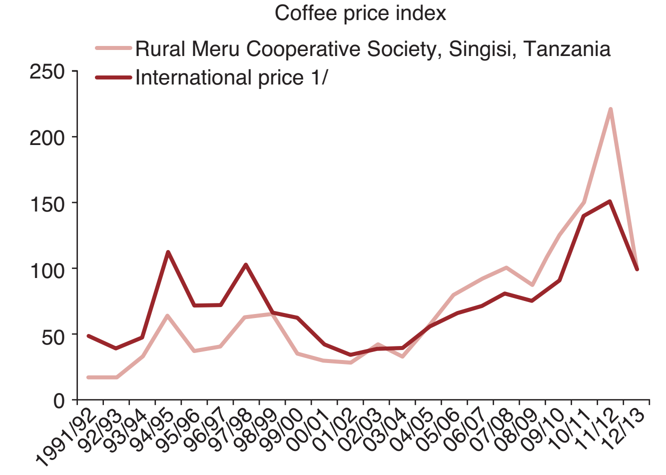
[11] See John Baffes, "Tanzania's Coffee Sector: Constraints and Challenges."

FIGURE 3.1. INTERNATIONAL COFFEE PRICE CHANGE



Source: International Coffee Organization: Coffee, Other Mild Arabicas, New York cash price, ex-dock New York.

FIGURE 3.2. COFFEE INTERNATIONAL-DOMESTIC PRICE COMPARISON



Source: International Coffee Organization—Coffee, Other Mild Arabicas, New York cash price, ex-dock New York, U.S. cents per pound.

development of drought-resistant varieties. The program is now at the initial stage.

Coffee growers interviewed in focus groups also identified diseases as a considerable risk for coffee plants, whereas pests are considered less important (thrips in 2011 and 2012, with 20 percent local losses in 2012). The Tanzania Coffee Research Institute (TACRI) undertakes extensive research in coffee plant diseases and pests, including coffee bean diseases, coffee wilt disease, and coffee leaf rust. Disease research has been successful, mainly in leaf rust, and the results are being transferred to farmers. TACRI is promoting the replacement of old varieties with the new disease resistant varieties, the introduction of improved management practices, and the use of pesticides suitable for each agro-ecological zone. Regarding pest research, TACRI is still at the experimental stage to develop resistant varieties and is for the moment recommending appropriate practices. The adoption rate is low, however, and much effort is needed at different levels to ensure the acceptance of the new practices and varieties.

Market risks (price volatility). Coffee prices in the international markets are subject to great variability. Monthly New York price changes between January 1988 and December 2012 are shown in figure 3.1. The series standard deviation is more than 8 percent.

Transmission of the interannual international price changes to domestic producer prices is high, making all actors in the value chain vulnerable to the volatility in the international markets. Figure 3.2 illustrates the quasi-perfect price transmission effect on the prices received by the Rural Meru Cooperative Society from Singisi, Arusha, as compared with the New York cash price over the past 20 years.

Value chain actors relying on the multipayment system for settling payments to farmers experience different degrees of impact resulting from price volatility. Farmers receive an initial payment before the auction from the primary cooperative societies and a second payment afterward. The multipayment system allows farmers to benefit from any price increase between the two payment moments but it introduces considerable price risk for the cooperatives given the long period between the delivery to the primary society and the auction. If the first payment made to the coffee growers was higher than the auction realization plus other costs, the cooperatives would operate at a loss. Because CRDB Bank Plc. has been involved in financing the coffee subsector through the cooperatives, it has been sharing the risk with farmers and farmers' organizations. Meanwhile, exporters operate in the local market protected by futures operations in the international markets and therefore are less exposed to price volatility.

Long-term threats (price related). Coffee farmers perceive the price drop risk very strongly after the international price crisis strongly hit their economies. Coffee area expanded

significantly during the 1970s and 1980s when prices were favourable and declined thereafter during the world coffee price crisis—from 1980/81 to 1998/99 coffee sales declined from 61,000 tons to 41,500 tons. Production in 2010/11 increased again to 60,500 tons but small farmers are extremely cautious about investing in improving and expanding coffee cultivation.

COTTON

Cotton is a key cash crop in Tanzania not only in terms of foreign exchange earnings (US$88 million in 2011/12) but also in terms of provision of direct employment in primary production and in marketing (transport) and processing. It provides livelihoods to more than 1 million people. Farm production of cotton is predominantly undertaken by smallholder farmers within an average area ranging from 0.5 to 1 hectare per household.

The Cotton Development Trust Fund procures inputs and distributes through private ginners on a credit basis, with payments deducted from the cotton seed price paid by the ginners to the farmers. Farmers are organized in local primary cooperative societies and they have formed a regional body known as the Nyanza Cooperative Union. The Cotton Board plays a key role regulating the subsector and advising the MAFC on cotton-related policies. This organ is vested with the responsibility of engaging key stakeholders in establishing indicative prices through a farm gate price-setting forum. The price determined in this forum becomes a floor price that will be applicable in a specific cotton-buying season.

Production risks. Cotton farm production relies on rainfall and, as a result, it succumbs to sporadic adverse weather conditions. The Tanzania Cotton Board (2011) annual report of 2010/11 reports a 39 percent decline in production with respect to the previous year, which is attributed to localized drought, more than average rainfall in some areas, and failure of the voucher inputs system.The lower cotton production in the 2010/2011 marketing season resulted in a failure for most local ginners to fulfill their contractual obligation of supplying bales to external buyers and a poor supply of lint to the local textile industry. Nonfulfillment of the contracts eventually led to the blacklisting of some local cotton companies by the International Cotton Association in Liverpool.

FIGURE 3.3. INTERNATIONAL COTTON PRICE CHANGE

Source: Cotlook via IMF, Cotton, Cotlook 'A Index,' Middling 1–3/32 inch staple, CFR Far Eastern ports, U.S. cents per Pound.

Farmers reported that insect pest and diseases together represent another production risk, which is captured in the annual reports by the Cotton Board. Farmers are fairly vulnerable to production shocks partly because of the low margins of profitability that constrain them from adopting more effective agricultural practices. They suffer most from low volumes of production, followed by other actors along the value chain such the ginners; textile industries may suffer, but only marginally. Promotion of newly released agricultural technologies is not effectively undertaken owing to institutional problems related to lack of functioning linkages between extension services within the local government authorities and the agricultural research centers. In addition, the existence of fake seeds or agrochemicals in the market is an additional risk for farmers.

Market risks. The price announced by the cotton forum is supposed to be indicative but, in reality, it tends to become the actual buying price for all practical purposes. Given that world cotton prices play a significant role in setting the indicative price, significant volatility is transmitted to domestic prices. In effect, cotton international prices are very volatile, as can be observed in figure 3.3 (standard deviation is 6 percent).

Unexpected losses can occur when the world price falls below the corresponding indicative seed cotton price. The capacity of ginners and traders to manage such price risks varies markedly depending on their expertise, size, and

scale. Price risk is currently borne by ginners, particularly small operations (totaling around 34) that basically sell to textile industries. Considerable side-selling is present given that farmers sell to different primary societies when there is an opportunity for better margins or less uncertainty about payment for the seed cotton they deliver (counterparty risk). Some primary societies may also be at risk if they are not able to recover enough seed cotton to cover the amounts of credit they provide to farmers in terms of inputs.

Enabling environment risks. Major risks in this perspective include port delays due to inefficiencies caused by multiple factors, including poor technology. The most affected stakeholders are the cotton exporters who end up in disputes with their customers aboard.

CASHEW NUTS

Cashew nuts are grown along the coastal lowlands, with the more productive areas in the south, close to the border with Mozambique. Nationally, a total of some 400,000 households produce cashew nuts. The majority of farms are small but there are also some relatively large farms, exceeding 100 hectares. There are a number of small factories, as well as one large and one medium-scale facility. About 70 percent of national exports are made in raw form, with the cashew kernel still within the shell of the nut. Virtually all raw nut exports are destined for India, where they are processed and sold in the domestic market or reexported.

The sector is supervised and regulated by the Cashew Board of Tanzania and supported by a Cashew Industry Development Trust Fund, established in April 2011, which is financed partly through the export levy and partly by government financial contributions. There is currently a single-channel marketing system referred to as the warehouse receipt system, under which farmers must deliver their entire crop to their local cooperative society for acceptance without grading. There is thought to be a significant unrecorded amount of side-selling outside this system. The society transports accumulated deliveries to the store of its parent cooperative union, where they are held separately from deliveries from other societies. At intervals during the buying season, the union prepares a sales catalogue listing as separate lots the stocks that it holds from each society. Licensed buyers submit sealed tenders for these lots, which are opened at an auction attended by union staff and staff of the societies whose nuts are being sold.

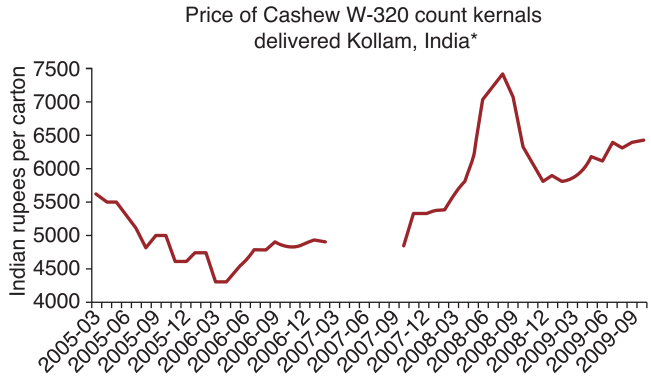
Production risks. The main risk that cashew farmers face is too much rain at the wrong time, leading to outbreaks of fungal diseases on the leaves, flowers, premature nuts, and apples. Fungal diseases can be controlled relatively easily through the application of sulfur. If these diseases are not treated, virtually the entire crop can be lost. The principal problem stems from the possibility that farmers may be unable to acquire the necessary chemicals, either because they are physically unavailable at the right time or because they cannot afford to purchase them. The Naliendele Agricultural Research Institute, which has national responsibility for cashew nut research, has developed recommendations as to the appropriate timing and quantity of sprays that extension staff can pass on to farmers. Currently, this advice has yet to be transmitted to all farmers, so some individual farmers risk losing a part of their crop through poor spraying practices.

Market risks (price volatility). International prices for cashew nut kernels change markedly from day to day, month to month, and from year to year. This volatility is reflected in the international prices negotiated for raw cashew nuts. There are no long-term time series of international cashew prices.[12] The only available long-term price series for valuing Tanzanian cashew production is the Food and Agriculture Organization Statistics Division (FAO-STAT) data on the national unit value of raw nut exports (see figure 3.4). Because Tanzania exports virtually all its cashew output, price volatility in the international market is reflected in export prices and in the prices received by growers.

Enabling environment risks. The changing regulatory framework has been a major cause of dysfunction in the cashew supply chain over the past 40 years and the origin of great production volatility (see box 3.2). Similarly, the sesame supply chain has been subject to changing regulations that affected the marketing system and the roles of primary

[12] There are no readily available time series indicative of the international prices of raw cashew nuts given that worldwide there are no formal markets in which prices are formed. (A futures market for 320-count cashew nut kernels operated at the Kolam exchange in India from 2005 to 2009.)

FIGURE 3.4. CASHEW NUT EXPORT PRICE



*Price for the nearest expiration futures contract at the National Commodity and Derivatives Exchange Ltd., India. (There are no data for March to September 2007.)

societies. Further examples of disruption in the supply chain are the risk of the government withholding loan guarantees to tobacco primary societies, and the unreliable supply of agricultural inputs by ginneries to farmers in cotton production.

Long-term threat (financial). A sustainable single-channel marketing system, as for most export crops, must either lead to payment of a total price to farmers that reflects the net farm-gate value of their output or it must provide a mechanism for systematically subsidizing farmers when world prices fall. In the absence of this, a single-channel system will simply stagger from crisis to crisis, creating continued uncertainty within the industry.

MAIZE AND RICE

Maize and rice are the main staple food crops in Tanzania. Maize is the traditional food in both rural and urban areas and rice is increasingly becoming more important in towns as family income tends to rise. Maize is also the most widespread crop among smallholders, and production surpluses are traded to the extent that in good years it may become a relevant cash crop. Agro-ecological conditions for growing maize are good in Tanzania, and normal conditions are better than in neighboring countries. In spite of this, in general productivity is low.

Large traders that have developed broad buying networks dominate maize trade and their purchases from local farmers, middlemen, and farmer associations are rules based (quality, and so on). Rice trade involves few large trading intermediaries and is less rules based. Wholesale traders and millers in main urban centers similarly tend to specialize in trading either maize or rice. Regarding international trade, protection barriers for rice are high and constant and for maize are lower but variable. Exports are regulated with periodic bans depending on the season's domestic supply.

These policies are focused on the short term, mostly directed to guarantee national and regional (subnational) food security, but deny market opportunities that may be available in neighboring countries.

Production risks. Rainfall shortages and drought pose critical risks for maize and upland rice. During the past 30 years, yield has oscillated at an average of 1.4 tons per hectare, with many years above the average in the 1980s and 1990s, but with worsening yield in recent years. During 2000–07, maize production increased at a slower rate (2 percent) than the overall population growth rate (3 percent). Such poor performance has been attributed to erratic rainfall and low application of fertilizers and improved seeds. Currently, the country has introduced a farm input subsidy (voucher system) program covering fertilizers and improved seeds to address the low adoption rates (MAFC 2011a).

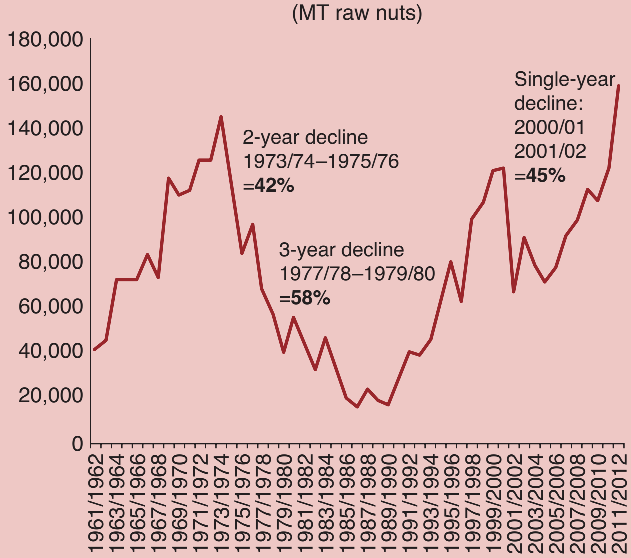
Farmers have already developed practical mitigation strategies. The most common drought mitigation strategy is to mix farming and intercropping in small plots (for instance, maize-beans, maize-peas, beans-sunflower, coffee-bananas-beans). In addition, the government has assisted farmer households by guaranteeing food security and rehabilitating agriculture when severe droughts occurred in the past as a way to cope with the losses.

Pests and diseases. Armyworms and rodents are relatively moderate risks provided that they are controlled in a timely manner with chemicals. Rice yellow mottle virus is also a moderate risk (disease) if controlled adequately. Birds feeding on rice can be devastating if not prevented from doing so; sometimes entire farmer families have been forced to spend all day in the fields chasing birds. Armyworm damage has also been very severe when outbreaks spread.

BOX 3.2. EXAMPLES OF CHANGING MARKET ENVIRONMENT

Cashew nuts. The cashew nut sector performed strongly after independence, with production growing strongly. Marketing was through a single-channel system using cooperative societies and unions. Production fell abruptly in 1973/74 and again, by an even greater percentage, in 1974/75. After a short recovery, the decline continued with further massive falls between 1976/77 and 1979/80. Production continued to fall by large percentages during the next decade but from a much smaller base, as illustrated in the accompanying figure.

National cashew nut production (1961/62/2011/12)
(MT raw nuts)



Source: MAFC.

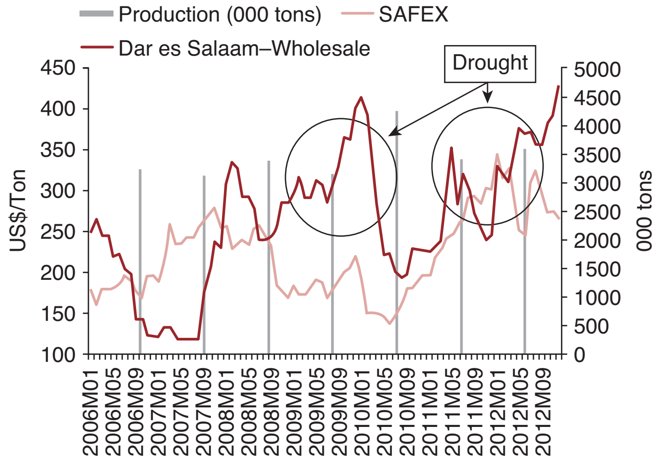
What was the cause of these production falls and why did they extend over such a long period? If we look back, we see that the successful marketing system was disrupted, first, in 1974 with the creation of a crop-specific marketing board that took away much of the power and influence of the cooperatives. Second, in 1976, primary societies were abandoned and replaced by village agents. Many farmers were also relocated under "villagezation" policies away from their trees. This institutional disruption was the main cause of these output declines. After more than a decade of recovery, production plummeted by 45 percent in 2001/02, representing the biggest fall yet recorded. It would appear that, this time, it was the result of a tightening of marketing regulations that complicated trading, as well as the impact of the 1999 Local Government Act. This law added local authorities as collectors of revenues and led to an increase in the tax burden of farmers. Production has since grown strongly with the reintroduction of single-channel marketing using the cooperative societies and unions, and the sale of raw nuts to exporters by tender.

Sesame. Single-channel marketing systems for sesame under which all seed was to be channeled through cooperative unions were introduced by regional councils in 2008, including in the Lindi and Mtwara regions. Different systems were established by the regional councils in Lindi and Mtwara. These single-channel systems were poorly organized and inadequately managed, controlled, and monitored. In the key Lindi producing region, farmers were paid an administratively determined price by their primary cooperative society that was well above the export parity producer price, meaning that one or more of the institutions involved in the value chain would necessarily end up losing money. In Mtwara region, a more rational two-payment system was introduced with a relatively low first payment. However, a part of the revenue from sales to exporters was diverted by at least one cooperative union to fund investments not specifically devoted to sesame marketing, including the construction of a new warehouse and the acquisition of trucks. The large 2011/12 cashew harvest, coupled with problems encountered by cooperatives in selling their stocks of raw cashew nuts, resulted in union warehouses being full at the time of the local 2012 sesame harvest. Consequently, the government directed that sesame buying should be opened up to private traders resulting in the reestablishment of a free market. Farmers now sell directly to small-scale private traders operating on their own account or to agents of the main exporting companies, OLAM, Export Trading, and Mohammed Enterprises.

Market and enabling environment risks. Assessing the role of price volatility in food crops is more complex than it is for export crops, in particular maize. Maize's domestic price for the most part reflects crop availability in the domestic market and is less correlated to the short-term oscillations of the price in international markets (see figure 3.5, with monthly prices). The revision of the past six years shows that the higher peaks in the domestic price (wholesale) are reached after a drop in domestic production. However, in "normal years" (or when there are no droughts) the domestic price tends to align to the longer-term trend of the international price.

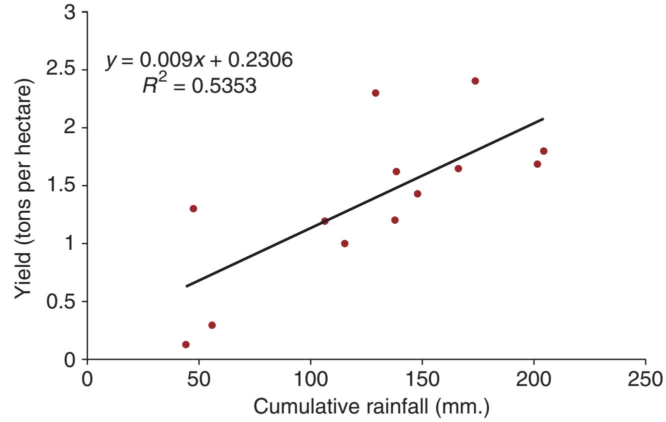
In effect, maize trade is somehow dominated by a policy that establishes export bans and import permits when the government deems it necessary to stabilize prices and guarantee food security. These interventions have not been successful in stabilizing prices, and because there is much

FIGURE 3.5. MAIZE PRICE



Source: FAO—Global Information and Early Warning System (GIEWS) and South African Futures Exchange (SAFEX).

FIGURE 3.6. REGRESSION CHART FOR ARUSHA



Source: Global Precipitation Climate Project (GPCP), author's analysis.

uncertainty about when and for how long the restrictions will operate (generating a separate and distinct risk), they tend to create confusion and obscure the functioning of the market. This policy also results in additional transaction costs that are transferred to farmers through lower costs.

Moreover, in the long run this policy tends to curb the trade opportunities offered by markets in neighboring countries (mostly but not exclusively Kenya), thus reducing the investment incentives to increase production and reduce volatility, with the side effect of encouraging informal cross border trade.[13] Price volatility impacts are greatest for the most vulnerable segment of the supply chain (small-scale farmers and traders) that cannot profit from high prices determined either by the international market or domestic scarcity.

For rice, domestic price oscillations tend to be less dramatic than they are for maize. This can be explained by the fact that part of the crop is cultivated under irrigation and because rice is a less sensitive commodity in terms of food security in Tanzania and is more likely to be a cash crop for farmers.

[13] Tanzania's recorded trade in maize is modest; during the period 2005–07, imports averaged about 3 percent of apparent consumption and exports represented just 2 percent of maize production.

EMPIRICAL EVIDENCE

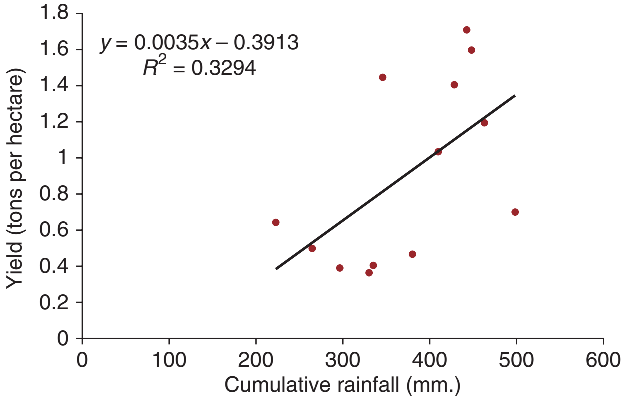
Maize yield—cumulative rainfall relationship. An attempt was made to correlate yields and cumulative rainfall to find statistical evidence of yield variations by crops and regions.[14] Some results for maize are shown in this section for illustrative purposes; the entire study is included in appendix A.

The best results were found for the Manyara region, where both the sowing and the mid-season periods explain a significant amount of the variability in yield (72 percent and 75 percent). For the sowing season alone, cumulative rainfall is significant for three regions: Arusha, Manyara, and Tanga. Figure 3.6 offers an example of a regression analysis for Arusha alone.

For Arusha, the relationship is quite clear, with a determination coefficient (R^2) of 54 percent, meaning that 54 percent of the variability in yield can be explained by the cumulative rainfall of the sowing season alone. The slope is positive, which means that more rain results in a higher yield, signaling that drought is the main threat here. It is also clear that the worst years in terms of rainfall (1997

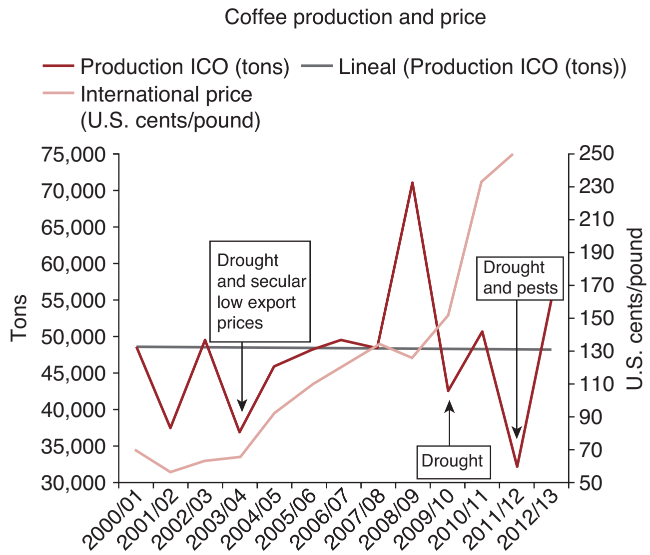
[14] Linear regression models were built for each region to establish the relationship between maize yield, expressed in tons per hectare, and the cumulative rainfall of each of the crop seasons (sowing, mid-season, harvest). The model is expressed as: $Yield = {}_0 + {}_1 Rain_i$ The determination coefficient (R^2) was calculated for each model. The R^2 is a measure of the proportion of the variance in yield that can be explained by the cumulative rainfall in each season.

FIGURE 3.7. REGRESSION CHART FOR DODOMA



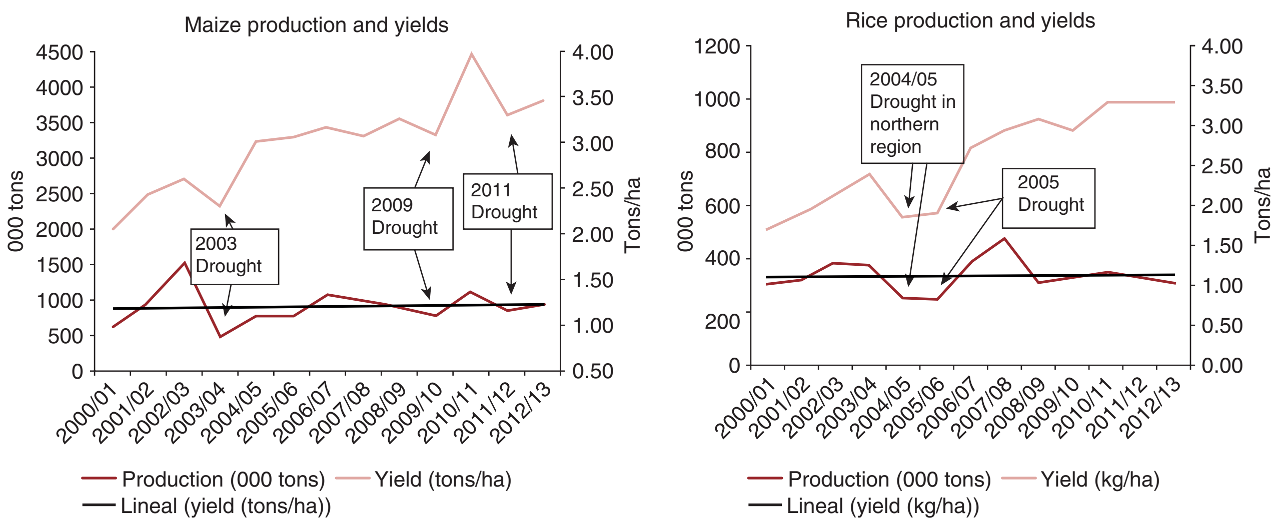
Source: GPCP, author's analysis.

FIGURE 3.8. COFFEE: OCCURRENCE OF RISK EVENTS



Source: TCB and ICO.

CHART 3.9. MAIZE AND RICE: OCCURRENCE OF RISK EVENTS



Source: USDA.

and 2000, when only 44 mm and 55 mm fell through each season, respectively) were also the worst years in terms of yield (with 129 kg and 300 kg per hectare, respectively). Therefore, it is clear that drought in the sowing season has an important effect on maize yield in the Arusha region.

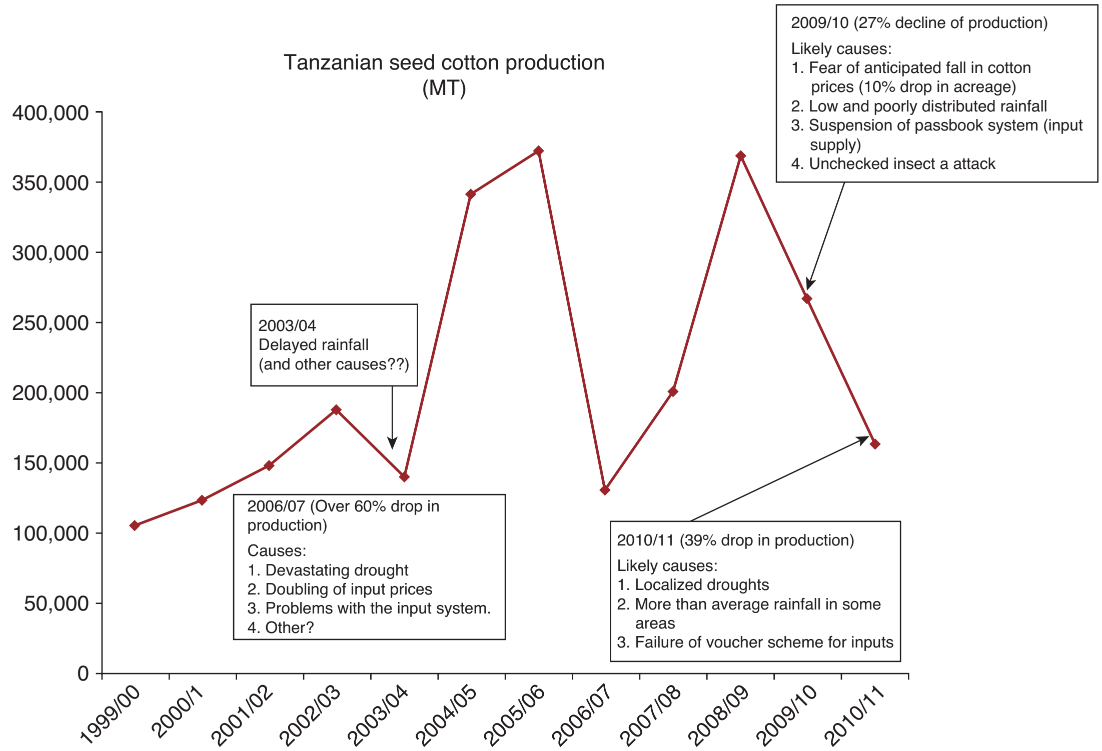
As for mid-season, rainfall explains the variability of yield for the following regions: Dodoma, Manyara, Mbeya, and Ruvuma. Figure 3.7 illustrates the relationships in Dodoma.

Even though the determination coefficient for Dodoma is not very high (33 percent), it is clear that there are two different groups of points: those with low rainfall and low yield, and the opposite. Rainfall wasn't significant for any region in the harvest season.

Risk event occurrence. Many of the production declines can be easily explained by natural hazards, mostly weather events, as is reported in different technical reports and other publications. Figure 3.8 shows the evolution of coffee production at the national level, since coffee prices began to recover in the international market around 2002.

Coffee output steadily increased between 2003/04 and 2008/09 followed by two pronounced drops in 2009/10

FIGURE 3.10. COTTON: OCCURRENCE OF RISK EVENT



Source: Tanzania Cotton Board (TCB) annual reports.

and 2011/12. These declines are attributed to a combination of production (yield) problems: drought and/or pest attacks.

Previous drops in production are most likely associated with the extended depressed market period, characterized by low and unstable prices. In 2003/04, however, the fall in production was also driven by drought problems. Figure 3.9 illustrates production performances for maize and rice during the last decade.

There have been three years for maize and two years for rice when production has dropped, coinciding with drops in yields below the trend line. Droughts were reported during those years.

Another example is cotton. Figure 3.10 shows a sequence of events that caused production to drop in recent years, and identifies a combination of causes related to weather, pests, and regulatory risks.

CHAPTER FOUR
ADVERSE IMPACT OF AGRICULTURAL RISK

QUANTIFICATION OF LOSSES

The quantification of losses presented in this report refers largely to production risks, such as drought and pest attacks. In this section, the indicative value of agricultural output lost for a particular year is calculated as the deviation of the actual annual yield from a historic yield trend value multiplied by the actual area that year, valued at 2008–10 average producer prices and converted into U.S. dollars at the 2010 exchange rate. Indicative loss values are also compared with agricultural gross domestic product (GDP) in the relevant year to provide a relative measure of the loss.

Approximately US$203 million or 3.5 percent of the agricultural GDP was estimated as the value of the average production loss annually in the agricultural sector as a result of unmanaged production risks. The calculation involves the following crops: tobacco, coffee, cotton, cashew nuts, sesame, maize, rice, beans, and cassava, which together are responsible for more than 80 percent of agricultural GDP and as such as representative of sector risks. Drought was the main cause of these shocks, sometimes in combination with other events. See table 4.1 for detailed information by crop.

In terms of the regional distribution of the losses with regard to maize, more than 40 percent of the 30-year losses are concentrated in Mbeya, Manyara, Shinyanga, and Iringa. Kilimanjaro and Arusha have also been badly affected by production volatility. Altogether, the six regions account for 61 percent of all losses.

PRODUCTION VOLATILITY

We should expect that an agricultural system (for example, a country or a particular region) that is intrinsically exposed to high production volatility would be more prone to suffer greater economic losses from natural hazards (a drought, for instance) than one that is more stable. Higher volatility means that the production system (yields)

TABLE 4.1. VALUE OF THE AVERAGE ANNUAL LOSSES (AT 2010 PRICES)

Crop	Period	Average Annual Losses (tons)	Average Annual Losses (US$)	Losses as % of Agricultural GDP
Export				
Tobacco	1982–2007	2,697	10,511,265	0.18%
Cotton	1981–2010	14,676	21,506,786	0.37%
Coffee	1981–2011	1,539	5,148,697	0.09%
Sesame	2001–2012	9,210	2,267,709	0.04%
Cashew nuts	2003–2010	733	348,738	0.01%
Food security				
Maize	1981–2010	246,823	55,767,795	0.96%
Rice	1981–2010	58,044	39,246,307	0.68%
Cassava	1981–2010	177,139	28,805,572	0.50%
Beans	2003–2010	59,982	39,924,138	0.69%
TOTAL			203,527,008	3.50%

Source: Author's calculations.

can change significantly from cycle to cycle in either direction; and lower volatility means that production (or yields) do not fluctuate dramatically, but change at a steady pace over time. In this context, agricultural volatility is closely linked to the natural resources base, the predominant technology and skill, and the market development and regulations.

A study was performed to measure the relative volatility of the different regions and at a national level using the coefficient of variation of yields.[15] For illustrative purposes, maize was the focus of this analysis, given that there is available a relatively extensive database for all regions from the Ministry of Agriculture, Food Security and Cooperatives (MAFC) and because maize is in practice the only crop cultivated throughout Tanzania and traded extensively within the country.

Maize production volatility is very different among the regions as measured by the coefficient of variation of yields, with a maximum of 56.3 percent in Coast and a minimum of 14.2 percent in Ruvuma (see table 4.2). The highly productive regions of Mbeya, Iringa, and Rukwa exhibit moderate volatility (23 to 25 percent). The national coefficient is relatively low (20 percent) as this aggregate value masks variability within regions. Table 4.2 shows the coefficient of variation of yields and the annual average production loss that results from unmanaged production risks, by region.

The different levels of production volatility among agro-ecological regions reflect the great diversity in terms of weather patterns and natural resource endowments. Further analysis would be required to examine the importance of developing technology and market strategies for smoothing those differences and reducing overall agricultural volatility throughout the country. This is an issue for the risk solution stage of this study.

The regions with larger maize production are certainly those suffering greater losses when adverse natural events occur, simply due to the volume of production, as shown in table 4.2. That is true, for instance, for Mbeya, Shinyanga, and Iringa. Questions arise, however, about whether lower volatility would necessarily result in fewer losses, and whether risk-related losses and production volatility are linked. A strong correlation would support the

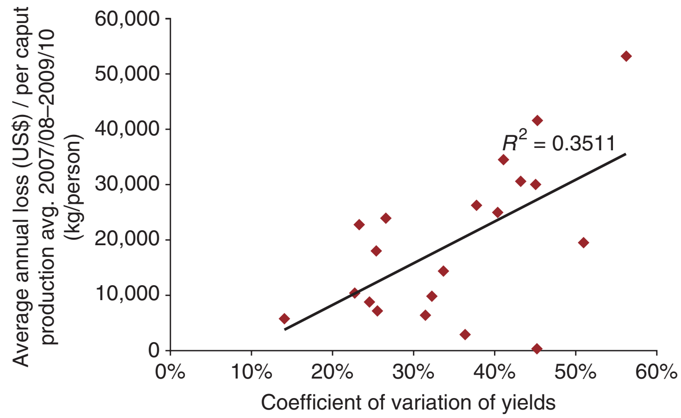
[15] Calculated as the standard deviation divided by the series arithmetic media. It shows the extent of variability in relation to mean of the population: the higher the number is, the worse the situation is.

TABLE 4.2. MAIZE PRODUCTION VARIABILITY BY REGION

Regions	Maize Production by Region—Avg. 2007/08 and 2009/10 (000 tons)	Average Annual Loss (US$)	Coefficient of Variation of Yields (%)
Mbeya	503	4,844,386	23.3
Manyara	253	4,799,232	26.7
Shinyanga	508	4,623,777	43.3
Iringa	407	4,490,286	25.5
Kilimanjaro	199	3,972,870	45.1
Arusha	152	3,972,284	45.3
Dodoma	158	2,858,077	41.1
Singida	110	2,254,946	40.4
Rukwa	367	1,903,361	25.6
Tabora	251	1,711,112	33.8
Kagera	151	1,642,120	37.9
Tanga	283	1,374,540	24.7
Morogoro	240	1,169,570	32.3
Ruvuma	234	1,051,896	14.2
Coast	66	835,494	56.3
Mtwara	50	788,085	51.0
Kigoma	149	705,524	22.9
Mwanza	194	351,611	31.6
Lindi	64	219,752	36.4
Mara	173	44,386	45.3
Total National			20.0

Source: Based on data from MAFC.

FIGURE 4.1. MAIZE PRODUCTION VOLATILITY



Source: Author's calculations.

understanding that it is meaningful to put in place specific policies to reduce volatility.

Such correlation is attempted below through a regression of the monetary losses weighted by per capita (2007/08–2009/10) average production (as a way to isolate the regions' size effect) with the coefficient of variation of yields in a cross section regression among regions. Figure 4.1 illustrates this relation.

Although the correlation coefficient is not high (35 percent), the points are well aligned, corresponding to what would be expected if volatility and average annual losses were connected positively.[16]

[16] In this cross-section analysis, the number of observations is limited by the number of regions.

CHAPTER FIVE
STAKEHOLDERS' ASSESSMENT

IMPACT OF RISKS AT INDIVIDUAL STAKEHOLDER LEVEL

How the losses are distributed among stakeholders within the supply chain is to a great extent a function of value chain governance and the actors' capabilities and opportunities for risk management.

Price risk. Exporters, millers, and large trading companies are capable of managing price risks globally through the practice of standard futures risk management strategies. CRDB Bank, the main agricultural financing bank, has unsuccessfully tested innovative ways to manage price risk for coffee and cotton, such as gaining access to international markets for price hedging. Normally, banks manage lending risk through regular banking risk management procedures, such as collateral management, due diligence, and the maintenance of loan loss provisions (as their loan recovery prospect is particularly related to short-term commodity price variation). Traders, middlemen, and small storage and processing companies can manage price risk via keeping/releasing physical stocks, at the same time assuming the additional risk of accumulating higher losses if prices decline. However, those involved in export crops take important risks when they make advance payments to farmers or are required to keep the products in storage until delivery in the auction or to the exporting companies.

Small-scale farmer capacity to manage price risk is extremely limited. Primary cooperative societies and, to some extent, second-level farmers' associations are also the weakest segment in the supply chain. Product price variations within the marketing year can expose farmers to financial losses when they practice multipayment systems. Primary cooperative societies tend to have fragile financial structures and rely on bank credits to support farmers in marketing their products and paying for marketing and processing costs.

Price risk management strategies are needed at the farm level (farmers and cooperatives) to reduce the exposure to price risks without having to resort to financial price hedging instruments, because only a small group of stakeholders can benefit from

these market-based instruments. In any case, primary cooperative societies could be the target for such policies, and appropriate training should be a central component. Timing is of the essence in price risk management, and there is plenty of room to reduce price volatility exposure for the various participants along coffee and cotton supply chains.

Production risks. All actors along supply chains are exposed to the variability in primary farming production. However, smallholder farmers are particularly exposed to production and yield variability. Their family food security and monetary income are dependent on the crop harvest. Thus, to mitigate weather and pest and disease risks at the farm level, many producers adopt low-risk and low-yield crop and production patterns to ensure that they end up with at least a minimum quantity of food available. These production patterns come at the expense of high-risk, high-return production that could create income growth and the buildup of capital. More cost-effective technologies and agricultural practices can provide better protection against production risks but that would imply that improved research and extension services are available for smallholder farmers. In export crops, such as coffee or cotton, exporters and processors tend to provide marketing and productive service assistance to farmers to increase and stabilize supplies.

The government role. Most of the specific risk mitigation actions implemented by the government are directed at coping with the impact of natural hazards (food aid, seed distribution, and so on). The government aims at maintaining social, economic, and political stability as well as assuring food security. Government expenses to cope with agricultural risks are usually met through budget resources when they are not required in response to catastrophic events.

Summary. Table 5.1 summarizes the stakeholders risk profile, which is defined by the following variables: the sources of risks that are most common for each stakeholder; the significance of the perceived damage expected from the realized risk events; and, finally, the stakeholders' current capacities to manage those risks. Smallholder farmers and their families are the weakest segment in the supply chain and the prevalence of risks contribute to the vicious cycle of poverty.

VULNERABLE HOTSPOTS

During an average year, Tanzania has enough food for its population. Data available from Food and Agriculture Organization-Global Information and Early Warning System (FAO-GIEWS) show that total domestic cereals availability has surpassed requirements for domestic utilization since at least 2002/03.[17] The same holds true for maize (see figure 5.1).

However, the Ministry of Agriculture, Food Security and Cooperatives (MAFC 2010) reports that for 2010/11 "pockets of vulnerable areas" or "vulnerable hotspots" had been identified in 45 districts in 11 regions, namely, Arusha, Tanga, Shinyanga, Mwanza, Kilimanjaro, Coast, Tabora, Mara, Manyara, Kagera, and Mtwara. Of these, four are definitely food deficit regions, five are self-sufficient, and two are surplus regions. With the exception of Tanga and Manyara, all the other regions have high production volatility (coefficient of variation higher than 30 percent).

Moreover, the 2009/10 Comprehensive Food Security and Vulnerability Analysis reported that, at the time of the survey, 4.1 percent of households in rural mainland Tanzania had poor food consumption, and 18.9 percent had borderline consumption.[18,19] In terms of undernutrition, 5.7 percent of children under five years of age were wasted, 36.6 percent were stunted, and 14.3 percent were underweight. Regions of Mtwara, Manyara, Arusha, Singinda, and Lindi had the highest prevalence of food-poor consumption households, whereas Dodoma, Morogoro, and Manyara reported the highest prevalence of households with borderline consumption. Child wasting rates were highest in Arusha, Manyara, and Mtwara. The latter two also had the highest prevalence of underweight rates. Stunting prevalence, by contrast, was highest in regions such as Iringa, Rukwa, and Kigoma, which did not report poor or borderline food consumption

[17] Further details regarding vulnerability analysis are contained in appendix C.

[18] Poor food consumption households have a diet based mainly on cereals with almost no animal protein and very little of any other food item (three days per week vegetables, and two days per week pulses).

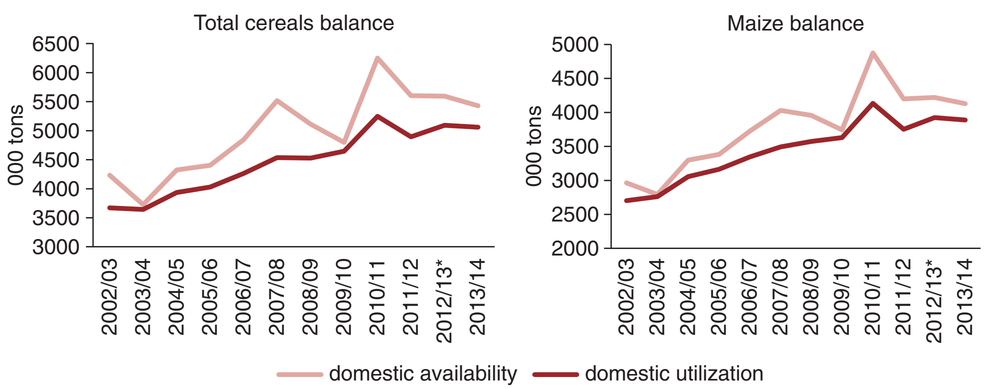
[19] Borderline food consumption households have a marginally better diet than poor food consumption households as they consume approximately one day more per week pulses, vegetables, and fruits.

TABLE 5.1. SUMMARY OF STAKEHOLDER RISK PROFILES

Stakeholders	Most Common Sources of Risk	Perceived Risk	Current Risk Management Capability
Smallholder farmers	Natural hazards (climate and pest and diseases). Price drop and exchange rate variation.	Significant production losses, reduced family income, and food insecurity. Minor to medium income losses.	No drought risk mitigation. Inefficient diseases and pest risk mitigation. No price and exchange rate risk transfer. Indebtedness. Sell assets.
Primary cooperative societies/union cooperatives	Climate and pest and diseases. Product and input short-term price variation.	Reduced procurement and higher unit costs. Potential important financial losses.	Delay payments to farmers. Fall into arrears with creditors. Increase indebtedness.
Traders/processors	Climate and pests and diseases. Short-term price variations.	Reduced procurement and higher unit costs. Revenue variation and possibility of breakdown when price drop is pronounced.	Diversification. Price bargaining. Stockpiling. Increase indebtedness.
Exporters	Short-term price variations.	Revenue variation.	Hedging.
Banks	Financial losses accrued by clients owing to production and market risks.	Credits in arrears and economic losses.	Collateral management, due diligence, maintenance of loan loss provisions.
Government	Natural hazards. Internationally soaring food prices.	Social instability. Budget implications.	Budget resources for risk coping programs (food aid, seed distribution, cash transfers, and so on).

Source: Authors.

FIGURE 5.1. FOOD BALANCES



Source: FAO, GIEWS.

Notes: Domestic availability is the sum of opening stocks and production; domestic utilization is the sum of food use, feed use, and other uses.

* = 2012/13 is current forecast

households.[20] Food consumption was lowest among the poorest households, whereas households with the poorest food consumption tended to have access to less livestock, cultivate less diverse crops, cultivate less than one ha of land, and be less likely to use chemical fertilizers.

[20] The regional distribution of child malnutrition simply confirmed that food availability and consumption do not translate necessarily into adequate nutrition.

The coincidence of certain regions as hosts of both "pockets of vulnerable areas" and poor and borderline food consumption households, as well as areas specially exposed to agricultural risks (such as Arusha, Manyara, and Mtwara) is especially worrisome. These regions should be specially targeted with interventions aimed at guaranteeing food security under the Agricultural Sector Development Program (ASDP).

CHAPTER SIX
RISK PRIORITIZATION AND MANAGEMENT

To better utilize scarce resources, it is important to understand which risks are causing major shocks to the sector in terms of losses and observe at what frequency they occur. The sections below summarize the risks facing the agricultural sector and possible solutions. The latter were identified by the World Bank mission team and then validated and prioritized with stakeholders at different levels and at a workshop on January 28, 2013, in Dar es Salaam. This workshop was organized by the Ministry of Agriculture, Food Security and Cooperatives (MAFC) to present the findings of the mission and to reach consensus on the identified risks and key risk solution areas.

RISK PRIORITIZATION

The following tables, arrived at through a consensus process with stakeholders, provide a summary of agricultural risks aggregated on the basis of the probability that risk events occur and the expected impact (losses) for food and for cash crops. The identified risks located in the darkest shaded area (upper right corner) represent the most significant risks owing to their potential to cause the greatest losses and the frequency of their occurrence. The second level of importance is represented by the lighter shaded boxes, whereas the unshaded boxes (on the left side of table 6.1) represent identified risks that either have low potential to cause damages or their frequency of occurrence is also low.

In summary, the exercise of risk prioritization (based on the frequency of realized risk events, their capacity to cause losses, and the ability to manage the risks shown by the different stakeholders) identified the most significant risks, listed below:

» Drought events, especially for maize, rice, and cotton
» Widespread outbreaks of pests and diseases, especially for cotton, maize, and coffee
» Price volatility for cotton and coffee
» Regulatory risks, mostly linked to the trade policy framework, for various cash crops and maize

Although these risks do not necessarily manifest themselves in the form of catastrophic shocks to agriculture (as shown in table 6.1), they are identified as the main drivers

TABLE 6.1. RISK PRIORITIZATION—FOOD CROPS

Probability of event	Negligible	Moderate	Considerable	Critical	Catastrophic
Highly probable		• Diseases (rice yellow mottle virus) (R)		• Drought (M)	
Probable	• Aflatoxins (M) • Pests (wild animals) (Ca) • Diseases (for example, maize streak diseases) (M)	• Pests (rodents, armyworms, quealea birds) (R) • Erratic rainfall (R) • Cassava mosaic disease) (CMV) (Ca) • Diseases (B) • Pests (for example, rodents, armyworms, stock borer) (M) • Cassava brown stick diseases (CBSD) (C) • Excess water (Ca) • Insects and pests (for example, beetle, armyworm) (B) • Food deficits/surplus in neighboring countries (M)	• Price volatility (R) • Unpredictable trade policy (M)	• Droughts (R)	
Occasional					
Remote		• Flood (R)			

Source: Authors. *Key:* R=Rice, M=Maize, B=Beans, Ca=Cassava, Cot=Cotton, Tob=Tobacco, Co=Coffee, C=Cashew Nuts, S=Sesame.

of agricultural volatility that cause stakeholders income instability and recurrent food security problems. Whereas implementation of the solutions will certainly entail regional specificities, an appropriate national institutional and policy framework must first be identified. The assessment of regional risk dimensions will be part of the detailed solutions definition and the program and project design that will follow. This will be part of the second assessment mission.

PRIORITY RISK MANAGEMENT MEASURES

RISK SOLUTIONS: THE LONG LIST

Below is the long list of risk solutions discussed during the risk assessment mission with various stakeholders (table 6.3). These potential solutions were identified during field interviews and were previously suggested in various government and nongovernmental documents. Usually, risk strategies are a combination of risk mitigation, risk transfer, and risk coping instruments. Risk mitigation refers to actions taken to eliminate or reduce events from occurring, or reduce the severity of losses (for example, water-draining infrastructure, crop diversification, extension, and so on); risk transfers are mechanisms to shift the risk to a willing third party, at a cost (for example, insurance, reinsurance, financial hedging tools, and so on); and risk coping makes up actions that will help cope with the losses caused by a risk event (for example, government assistance to farmers, debt restructuring, and so on).

FILTERING RISK MANAGEMENT MEASURES

Many of the actions included in the Agricultural Sector Development Program (ASDP) and other specific projects and programs for the agricultural sector are already tackling some of the risk solutions identified in the long list in table 6.3.

TABLE 6.2. RISK PRIORITIZATION—EXPORT CROPS

Probability of event		Negligible	Moderate	Considerable	Critical	Catastrophic
	Highly probable	• Counterparty risk (farmers)/ Side-selling (Cot and Tob)	• Sesame flea beetle infestation (insects) (S) • Fungal diseases (for example, powdery mildew) (C)	• Diseases (for example, CBD, CWD, CLR) (CO) • Insects/pests (cotton bull worm and so on) (Cot) • Drought (Cot)	• Cotton price volatility (Cot)	
	Probable	• Pests and diseases (Tob) • Incidence of diseases (for example, leaf spot, bacterial blight, stem rot) (S)	• Pests (for example, thrips) (Co) • Price volatility (CO) • Counter party (Ginners)/ International buyers (Cot) • Excess rainfall (Tob)	• Erratic rainfall (CO) • Price volatility (unstable world prices) (C)	• Regulatory risk	
	Occasional		• Occurrence of severe drought (S)			
	Remote					

Source: Authors. *Key:* R=Rice, M=Maize, B=Beans, Ca=Cassava, Cot=Cotton, Tob=Tobacco, Co=Coffee, C=Cashew Nuts, S=Sesame.

Moreover, the government of Tanzania is now working on a new agriculture policy that is expected to be finalized and approved soon and may include changes to the ASDP.

Table 6.4 contains a number of these projects and programs, as identified by the mission, indicating their connection with the risk assessment results and the potential gaps to be covered with specific risk management actions additional to existing measures.

RISK SOLUTIONS: THE SHORT LIST

The long list of general solutions in table 6.3 and the gap analysis presented in table 6.4 were used to start narrowing down to specific areas of solutions that tackle the key risk issues. The final result will be a package of interventions that could effectively lower volatility and increase resilience in agriculture. The identified interventions to reduce agricultural risks will also have the added benefit of contributing to higher productivity and a direct positive impact on the reduction of poverty.

The shortlist areas for deepening the risk solutions are, in brief, the following:

Highly drought- and pest-tolerant seeds. There are weaknesses in the supply chains for delivering drought tolerant seeds, disease resistant seeds, and planting material, and inefficiencies in seed markets that should be addressed. In principle, this encompasses food crops such as maize and rice, and export crops such as cotton and coffee. This would imply the need to effectively intervene in the short to medium term to make the seed supply chains work more effectively along the range of stakeholders involved (from breeders to seed producers to farmers) as well as to clearly define the roles of public and private sectors in developing this market.

Good agricultural practices to address drought, pests, and diseases. Widespread, improved agricultural risk mitigation practices can have significant impacts in reducing risks derived from irregular or insufficient rainfall, as well as from diseases and pests. This implies a

TABLE 6.3. RISK SOLUTIONS: THE LONG LIST

Risk	Mitigation	Transfer	Coping
Drought	• Drought tolerant seed varieties • Water harvesting and irrigation • Improving early warning systems • Reforestation/afforestation • Contour farming/Soil and water conservation programs/ Assisted natural regeneration/Land and water management • Agronomic practices for on-farm drought management • Crop diversification	• Insurance	• Food reserves • Food imports • Social safety net programs • Risk financing
Price volatility	• Improved understanding of price risk management • Managing food stocks • Trade policies • Increased domestic processing • Improved quality to access stable niche markets • Improved market information systems and transparency • Contract farming • Improved storage • Infrastructure development • Foster competition in markets	• Hedging	• Imports • Trade policies • Social safety net programs
Diseases	• Scale-up disease tolerant varieties • On-farm agronomic practices • Early warning systems • Integrated pest management • Quarantines measures • Improved phytosanitary laboratory systems • Improved extension services		• Quarantine measures • On-farm agronomic practices • Integrated pest management
Pests	• On-farm agronomic practices • Early warning systems • Integrated pest management • Quarantines measures • Improved phytosanitary laboratory systems • Improved extension services		• Quarantine measures • On-farm agronomic practices • Integrated pest management
Regulatory risks	• Improved efficacy of commodity councils • Promote proactive rather than reactive policies • Develop clear, long-term, efficient, and transparent policies for commodities and sector development • Improved transparency in policy decision making		

Source: Authors.

need to strengthen the existing disconnected technology systems through effective coordination among research, extension, and training, including the effectiveness of information and communication outreach to farmers.

Balanced maize trade policy. The export and import policy has to be predictable and stable and at the same time allow for a transparent market. Policy predictability, market transparency, and fewer nontrade barriers would result in greater incentives for farmers to invest in technology that increases productivity and reduces production volatility in a sustainable way. This would create a better balance between the short-term food security goal and the long-term productivity growth aim.

TABLE 6.4. GAP ANALYSIS

Risk and Rating	Solution	Current Projects or Programs	Statement on Risk Solving Perspective	Gap	Short List Solution Proposal
Drought—critical or considerable and probable or highly probable risk	**Irrigation systems, land and water management.**	ASDP: A total of 353 irrigation schemes were upgraded, rehabilitated, or newly developed. TAFSIP: Irrigation development, sustainable water, and land use management. Feed the Future Program: Increase area under irrigation by 15.5% through the development of seven smallholder irrigation schemes in Morogoro and Zanzibar.	Prospective sector risk reduction impact is small because of nonmassive type of investment.	Expansion of coverage to build up from current projects' experiences.	None
	More extensive use of drought resistant seeds.	There are available drought tolerant seeds in Tanzania (for example, maize) and there is research under way (for example, coffee) but there is low adoption.	Reduction of yield variability and crop losses but learning required for optimal balance between risk reduction and high productivity.	Planting materials and research results are available; information and promotion are missing.	Specific program to be included in set of specific proposals.
Pests and diseases—critical or considerable and probable or highly probable risk	**Good agricultural practices to address drought and pest and diseases.**	ASDP: Strengthening agricultural research and training. Feed the Future Program: Agricultural support services and capacity building including research and development and financial services.	Existing research results need to be disseminated to farmers. Specific knowledge is required to address pest and disease prevention and control.	To build up from the ASDP subprograms.	Redesign current programs and expand geographically to cover the entire country and/or new more specific technology transfer program.
	Introduce disease resistant seeds and planting material.	No comprehensive program in place. There are available disease resistant seeds (coffee and so on).	Reduction of yield variability and crop losses, depending on the crop.	Progress in coffee, for instance, but no program covering most crops.	Specific program to be included in set of specific proposals.

(Continued)

TABLE 6.4. GAP ANALYSIS (*Continued*)

Risk and Rating	Solution	Current Projects or Programs	Statement on Risk Solving Perspective	Gap	Short List Solution Proposal
Price volatility—moderate to critical and probable and highly probable, mostly cotton, cashew nuts, and coffee	**Improved understanding of price risk management, market information, and hedging.** **Trade policies.** **Contract farming.** **Improved storage.** **Infrastructure development.** **Improved efficacy of commodity councils.**	Agricultural Marketing Systems Development Program: (a) agricultural marketing policy development; (b) small producers' empowerment by building their entrepreneurial and organizational capacity and improving their links to markets; (c) introducing a warehouse receipt system, allowing the small farmers using the warehouses to obtain loans for the period between harvest and sale; and (d) the development of rural marketing infrastructure, including storage facilities, market places, and roads. ASDP: Marketing and Private Sector Development Improving overall sector policy, regulatory and legal framework.	Project-related interventions can have good results in terms of targeted stakeholders but massive and sustainable achievements require nationwide policies and institutional buildup.	No practical strategies in place to reduce price risk exposure to vulnerable stakeholders.	Reforms needed to deal with price volatility. To deepen into institutional arrangements and current roles of public and private sector.
Maize short–term policy variability—considerable and probable risk	**Develop clear, long-term, efficient, and transparent commodities and sector development policies.**	Several programs to support maize production at farming level.	Difficult to have impact from single projects if policy framework is weak.	Policy framework still suffering of great variability and discretionarily (because of food security goal) and therefore provides poor incentives to invest in production.	Find an adequate equilibrium between the short-term food security goal and the long-term productivity growth aim.

Source: Authors.

Risk management strategies for key export crops with high price volatility (in principle, coffee, and cotton). The way these supply chains are organized depend on which stakeholder is exposed to price risk. A set of options on how to reduce exposure to risk can be explored by analyzing the physical and financial flows on current transaction arrangements for exports. This would imply a need to deepen institutional arrangements and clarify current roles of the public and private sectors.

Whereas there are already interventions of various temporal and spatial natures in Tanzania on these shortlist solutions, the key issue is to identify the gaps among cur-

rent interventions and design a package of solutions that addresses the main underlying causes of risk. A Risk Management Solutions Assessment will be planned as a follow-up to current risk identification. The coming assessment will have the task of linking the risk management interventions to the ASDP by developing concrete proposals (policy solutions, investment solutions, and technical assistance solutions) for better managing the risks identified in the short list. In particular, the mission will:

- (i) Identify the risk management gaps in existing interventions; and,
- (ii) Propose a set of interventions for incorporating them into the medium-term ASDP, which could be financed by the public sector and/or donors.

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APPENDIX A

WEATHER ANALYSIS

Tanzania comprises 26 regions and each crop is sown is some regions so some of them may not have available data for all crops. Agricultural information is provided on a regional basis, made up of two variables: sowed area in thousand hectares and production in thousand tons. Yield is not provided, but can be estimated as follows:

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

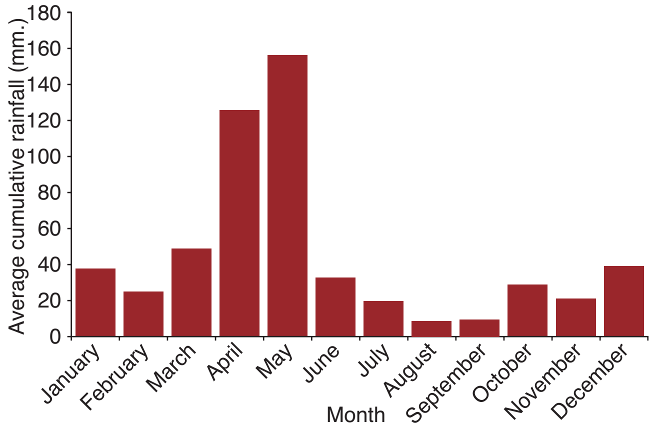
RAINFALL PATTERNS IN TANZANIA

Rainfall data were available through a gridded database from the Global Precipitation Climate Project (GPCP, http://precip.gsfc.nasa.gov/). The resolution of the grid is 1 degree so there is a pixel point with data from January 1, 1997, to August 31, 2009, for the whole country. Rainfall follows two different patterns in the country. In the northeast and coastal regions, a bimodal rainfall regime with short (*vuli*) rains from October–December and a long (*masika*) period of rains from March–May. The following chart has the mean cumulative rainfall per month for pixel #84 on the east coast.

In the rest of the country (south and west), a different rainfall pattern is observed. A unimodal (*musumi*) regime occurs with rainfall from December to April. Figure A.2 illustrates this pattern.

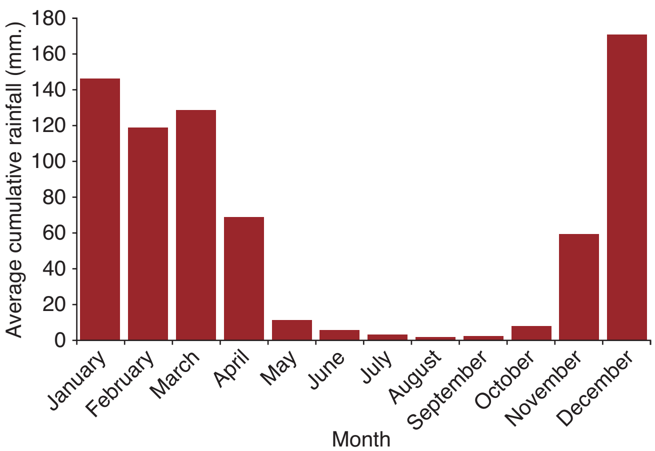
It is worth noting that geographical resolution of data is not the same. Rainfall data are available on point estimates whereas yield data are available regionwide, making up the whole political region as described above. Therefore, the geographical resolution of both data sets must be made equivalent. Because there is no information regarding the sowing zones within each region, the centroid of each region was considered as the coordinates to relate to the rainfall grid. Figure A.3 shows the centroid for each region.

FIGURE A.1. MONTHLY RAINFALL PATTERN FOR PIXEL #84



Source: GPCP.

FIGURE A.2. MONTHLY RAINFALL PATTERN FOR PIXEL #77



Source: GPCP.

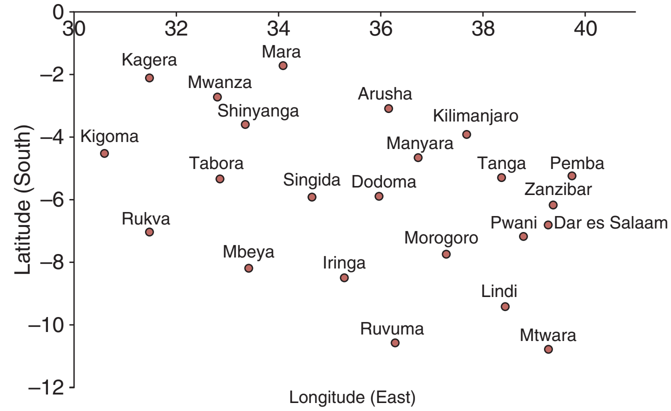
To assign rainfall pixels to political regions the distance between each pair of centroid (*i*) and pixel (*j*) was calculated using the Euclidean Distance Formula, as follows:

$$Dist = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

where:
Dist = Euclidean Distance
x_i = longitude from region's *i* centroid
x_j = longitude from pixel *j*
y_i = latitude from region's *i* centroid
y_j = latitude from pixel *j*

By using this formula and comparing each region's centroid to all pixels, we can get the five nearest pixels to each region's centroid (table A.1).

FIGURE A.3. TANZANIA REGION CENTROIDS



Source: GPCP.

Thus, the average of the five nearest pixels can be used as a proxy of region's rainfall.

MAIZE

Maize is grown in most of Tanzania with an average of approximately 2 million hectares sown countrywide. But the area grown was previously less than 2 million hectares prior to the 2000–01 cycle, when the surface was increased up to a maximum of 5.8 million hectares in the 2002–03 cycle. It then decreased to a steady amount of about 3 million hectares a year after that cycle. Figure A.4 shows the total area and production for each cycle.

National production follows a similar pattern, with an increase in the new century, and an average production of 3.8 million tons after year 2000. Figure A.5 shows the time series of yield on a national basis.

Yield has oscillated around an average of 1.368 tons per hectare, with many years above the average in the 1980s and 1990s, but declining yield recently. Year 2002/03 stands out as the worst when yield reached its lowest point of 0.593 tons per hectare, representing 43 percent of the mean yield.

Figure A.6 shows the distribution of surface by region color coded to identify nearby regions.

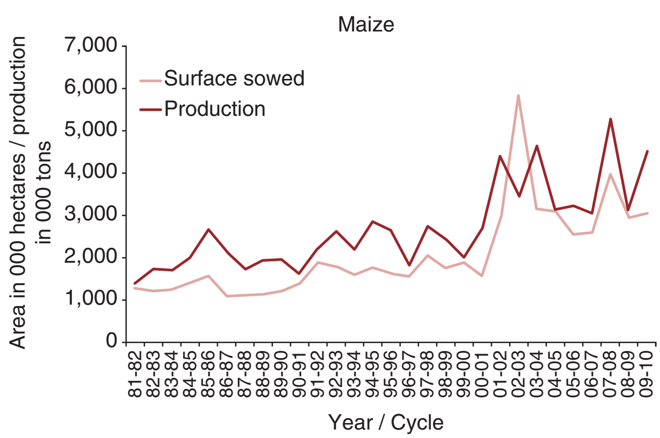
The regions in which the most maize is sown are Mbeya, Shinyanga, and Iringa, representing 13.6 percent, 12.7 percent, and 11 percent of the national surface, respectively.

TABLE A.1. THE FIVE NEAREST PIXELS TO EACH REGION'S CENTROID

Region	Number	Pixel 1	Pixel 2	Pixel 3	Pixel 4	Pixel 5
Arusha	1	135	136	121	149	134
Dar es Salaam	2	82	83	96	97	68
Dodoma	3	93	107	92	94	79
Iringa	4	64	50	65	51	63
Kagera	5	144	145	130	131	143
Kigoma	6	102	116	101	115	103
Kilimanjaro	7	123	122	137	136	109
Lindi	8	53	54	39	40	67
Manyara	9	108	122	107	121	109
Mara	10	147	148	146	133	134
Mbeya	11	62	63	48	49	76
Morogoro	12	66	67	80	81	52
Mtwara	13	26	27	40	41	12
Mwanza	14	132	146	131	145	133
Pemba	15	111	110	97	96	125
Pwani	16	82	81	68	67	96
Rukwa	17	74	75	60	61	88
Ruvuma	18	23	37	24	38	22
Shinyanga	19	118	132	119	133	117
Singida	20	92	91	106	105	78
Tabora	21	104	90	103	89	105
Tanga	22	109	110	95	96	123
Zanzibar	23	96	97	82	83	110

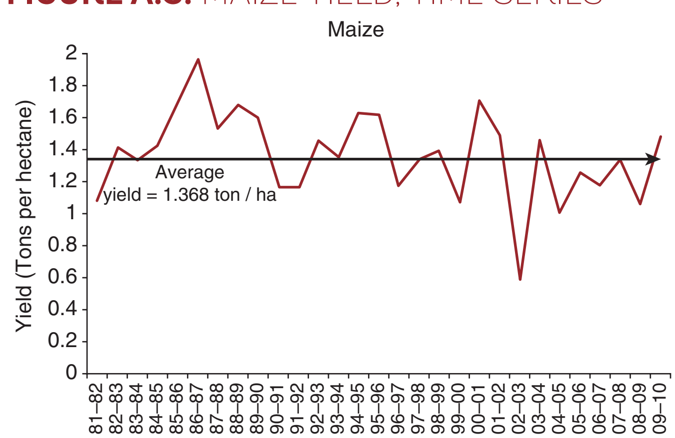
Source: Author.

FIGURE A.4. MAIZE SURFACE SOWED AND PRODUCTION VOLUME, TIME SERIES



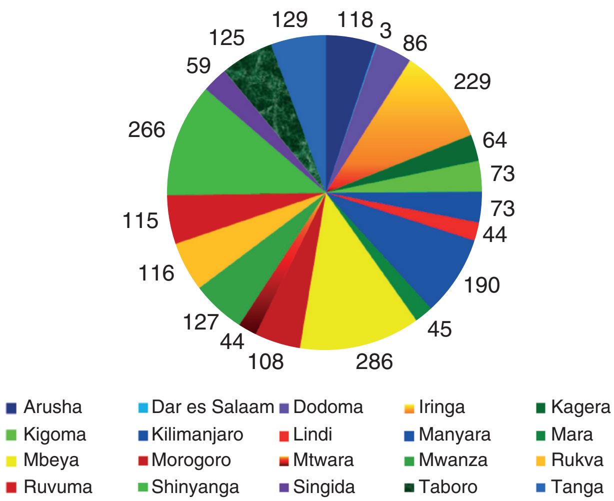
Source: MAFC.

FIGURE A.5. MAIZE YIELD, TIME SERIES



Source: MAFC, author's calculations.

FIGURE A.6. AVERAGE MAIZE SURFACE BY REGION IN THOUSAND HECTARES



Source: MAFC.

The histogram in figure A.7 shows the distribution of yield in all regions.

The regional mean is very similar to the national mean at 1.341 tons per hectare, but the histogram shows that the fifth percentile is 0.49 tons per hectare, meaning that in 5 percent of the regional cases yield has been even lower than half a ton per hectare.

Following the rainfall pattern and seasonality. the sowing calendar in the northeast and coastal regions has three stages: a sowing stage from February–March; a mid-season stage from April–June; and the harvest stage from July–August. In the south, the calendar follows this pattern: a sowing stage from December–January; a mid-season stage from February–April; and the harvest stage from June–July.

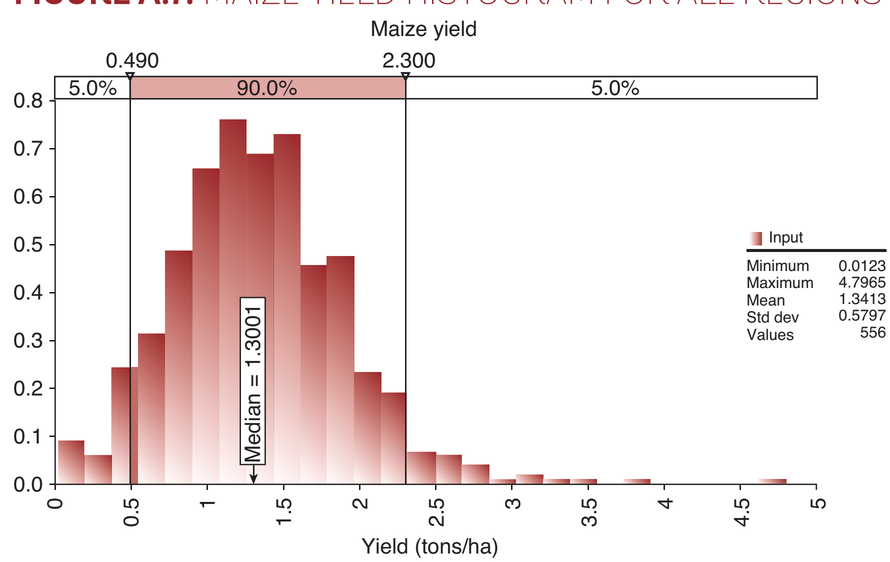
Cumulative rainfall was calculated for each pixel for each stage to determine the relationship between rainfall and yield. Although it is known that the first calendar applies only to the north-coast regions, it is not clear precisely which regions follow it, so regressions were run with both rainfall patterns against all regions to determine which regions follow which pattern (table A.2).

As table A.2 shows, Arusha and Manyara in the northeast were the regions in which the first rainfall calendar related more closely. Figure A.8 shows the time series of cumulative rainfall for the first stage (February–March) and yield for the Arusha and Manyara regions.

Figure A.8 shows that poor harvest years such as 1997, 2000, 2003, and 2009 also have low cumulative rainfall for the sowing stage, meaning that February–March rainfall is a good indicator of the yield that can be obtained in the cycle. The charts in figure A.9 show the linear regression models for each region.

The charts in figure A.9 confirm that stage 1 (February–March) cumulative rainfall explains yield in both regions.

FIGURE A.7. MAIZE YIELD HISTOGRAM FOR ALL REGIONS



Source: MAFC.

TABLE A.2. DETERMINATION COEFFICIENT (R^2) OF THE LINEAR REGRESSION MODELS APPLIED TO THE FIRST RAINFALL PATTERN ON ALL REGIONS

		Determination Coefficient (R^2)		
Number	**Region**	**Sowing (%)**	**Mid-Season (%)**	**Harvest (%)**
1	Arusha	53	1	1
2	Dar es Salaam	7	1	30
3	Dodoma	6	1	1
4	Iringa	4	3	0
5	Kagera	7	15	6
6	Kigoma	7	0	3
7	Kilimanjaro	2	1	1
8	Lindi	6	25	2
9	Manyara	65	76	17
10	Mara	7	1	2
11	Mbeya	2	3	0
12	Morogoro	5	3	19
13	Mtwara	5	5	1
14	Mwanza	7	0	3
17	Rukwa	0	5	1
18	Ruvuma	0	25	6
19	Shinyanga	1	3	4
20	Singida	10	1	1
21	Tabora	4	3	0
22	Tanga	0	1	14

Source: Author's calculations.

The determination coefficient (R^2) is significant, meaning that approximately 60 percent of the variation in yield is being explained by stage 1 cumulative rainfall. For both cases, it is clear that drought is the main threat to maize yield. Years with low cumulative rainfall, such as 1997 and 2000 when 48 mm and 56 mm on average fell over the Arusha region, showed the lowest yield records (129 kg and 300 kg per hectare, respectively).

The charts in figure A.10 show the relationship between stage 2 cumulative rainfall (April–June) and yield for both regions.

It can be seen that stage 2 cumulative rainfall is not significant for the Arusha region as the determination coefficient is very low; for the Manyara region it is significant, though lower than for stage 1.

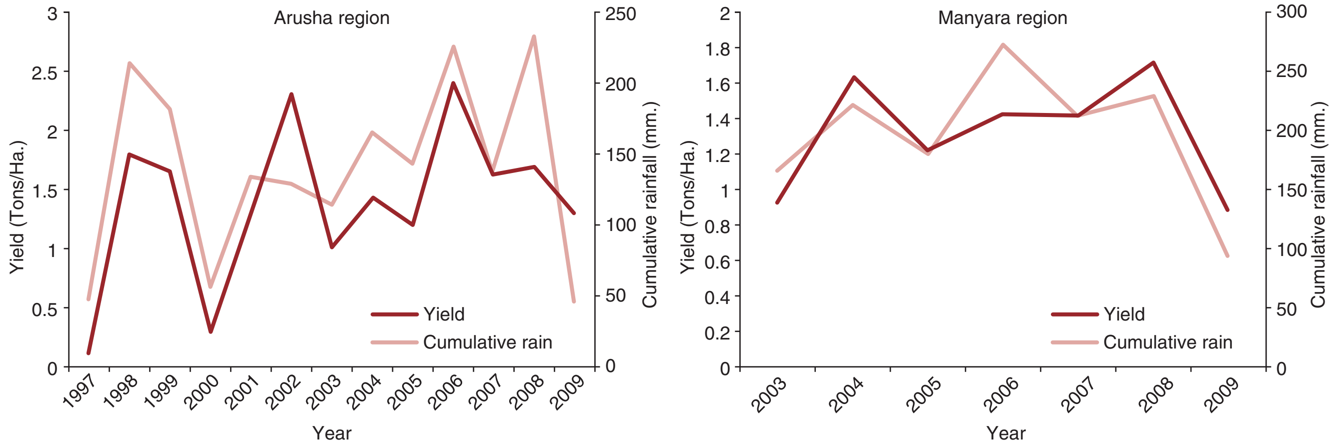
Lastly, for stage 3 the relationship between the harvest stage cumulative rainfall (July–August) and yield are not significant for both regions because the determination coefficient is very low in both cases (see figure A.11).

For the second rainfall pattern, table A.3 summarizes the determination coefficient of each stage and region.

Table A.3 shows that cumulative rainfall for the sowing stage (December–January) is significant only for the Morogoro and Kagera regions but with a very low determination coefficient, meaning that less than 20 percent of variation in yield can be explained by sowing season rainfall.

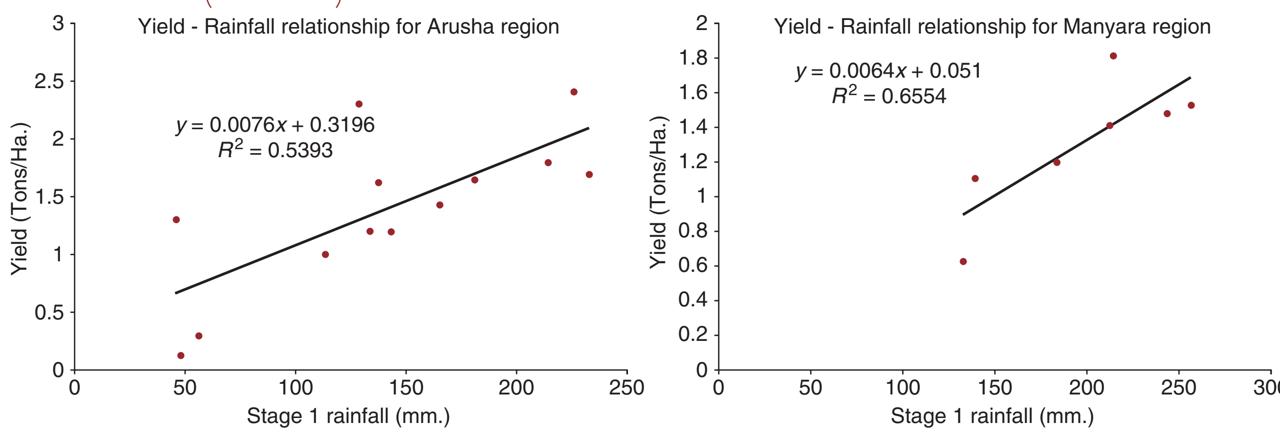
For the mid-season stage, cumulative rainfall is significant for Manyara and Arusha. This can be

FIGURE A.8. SOWING SEASON RAINFALL AND YIELD TIME SERIES FOR ARUSHA AND MANYARA REGIONS



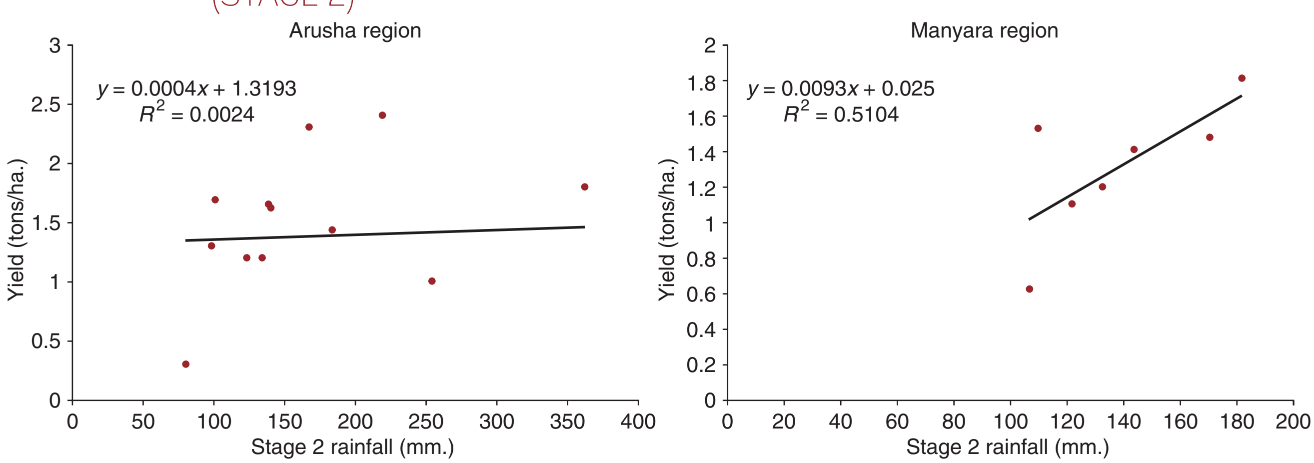
Source: MAFC, GPCP.

FIGURE A.9. LINEAR REGRESSION MODELS FOR ARUSHA AND MANYARA REGIONS (STAGE 1)



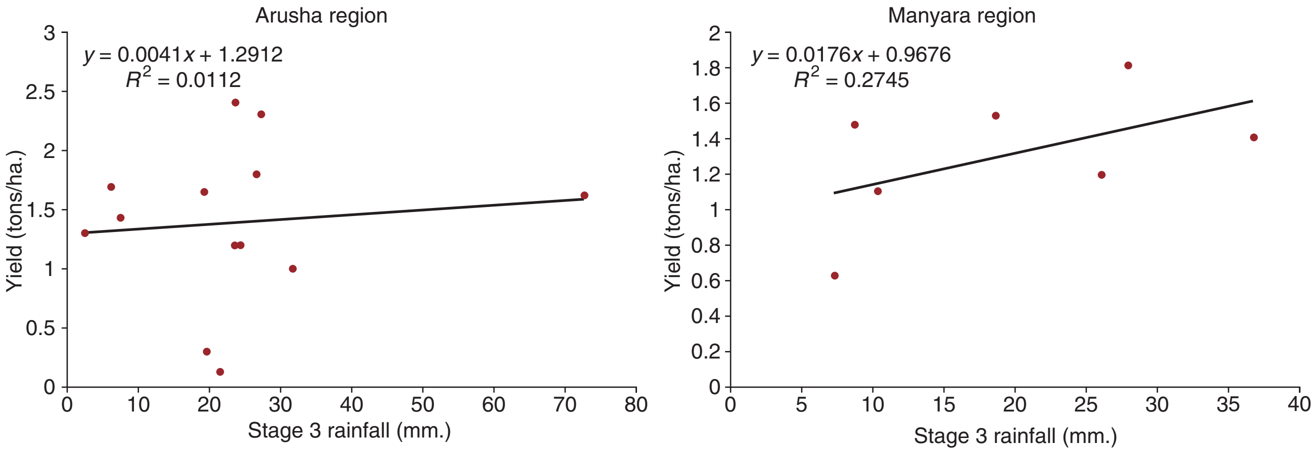
Source: MAFC, GPCP, author's calculations.

FIGURE A.10. LINEAR REGRESSION MODELS FOR ARUSHA AND MANYARA REGIONS (STAGE 2)



Source: MAFC, GPCP, author's calculations.

FIGURE A.11. LINEAR REGRESSION MODELS FOR ARUSHA AND MANYARA REGIONS (STAGE 3)



Source: MAFC, GPCP, author's calculations.

TABLE A.3. DETERMINATION COEFFICIENTS FOR EACH STAGE AND REGION

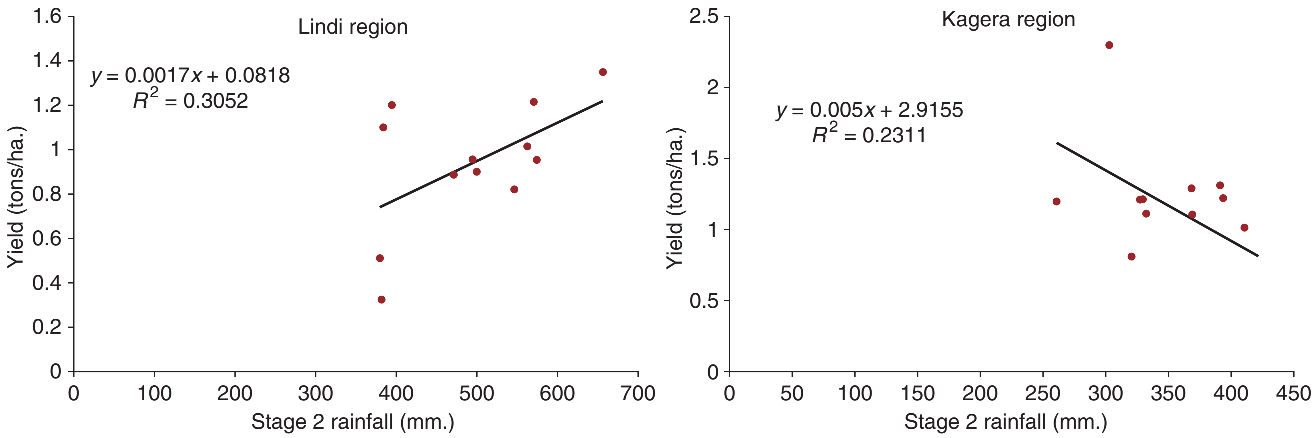
		Determination Coefficient R^2		
Number	**Region**	**Sowing (%)**	**Mid-Season (%)**	**Harvest (%)**
1	Arusha	0	40	0
2	Dar es Salaam	5	5	12
3	Dodoma	5	4	6
4	Iringa	8	0	0
5	Kagera	16	23	3
6	Kigoma	9	3	1
7	Kilimanjaro	0	8	2
8	Lindi	2	31	0
9	Manyara	0	53	27
10	Mara	2	18	21
11	Mbeya	4	7	1
12	Morogoro	19	9	4
13	Mtwara	3	1	5
14	Mwanza	5	0	0
17	Rukwa	1	4	0
18	Ruvuma	4	10	0
19	Shinyanga	3	1	11
20	Singida	1	2	0
21	Tabora	7	5	23
22	Tanga	10	0	1

Source: Author's calculations.

explained because the stage runs from February to April, almost matching the sowing season of the first exercise (February–March). But the Lindi, Kagera, and Mara regions show a significant relationship as well.

For the Lindi region, figure A.12 shows significance and two data points with low rainfall and low yield corresponding to the 2003 and the 2005 cycles in which rainfall was 382 mm and 380 mm, respectively, while yield was 324 kg and 510 kg, respectively (though a level of 380 mm is hardly an

FIGURE A.12. LINDI AND KAGERA REGIONS MID-SEASON RAINFALL MODELS



Source: MAFC, GPCP, author's calculations.

indication of drought. For the Kagera region, the slope of the line seems to indicate that excess rainfall affects yield. In 2006, less than 100 kg were obtained with 420 mm of rainfall, the highest amount of rainfall in the region. Still, the determination coefficient is not very high, indicating that other factors could be the cause of the low yield.

The harvest season has a lower significance, and is only relevant for the Manyara, Tabora, and Mara regions. Figure A.13 shows the linear regression model for yield in the Tabora region against harvest season cumulative rainfall.

The chart shows that even though the determination coefficient is low, yet significant (23 percent), the slope is negative indicating that the more rain, the less yield. Particularly notice year 2005, during which cumulative rainfall is 56 mm but yield was 466 kg per hectare. This would seem to indicate that excess rainfall is the main threat in this region, but the determination coefficient is not high enough nor does 56 mm seem to be an indication of excess rainfall.

PADDY RICE

Paddy rice is sown throughout the whole country but the surface has been increasing steadily. The whole country sowed less than 500,000 hectares per year in the 1980s. Since the turn of the century, the surface sown has increased up to a maximum of 1,136,000 hectares in year 2010, the most recent data available. Figure A.14 illustrates the yearly increase:

Rice yield has been quite steady, oscillating around an average of 1.65 tons per hectare, the worst seasons being the 1990–91 cycle when 1.12 tons per hectare were obtained and year 2000–01 when yield was exactly 1 ton per hectare, because 323.500 tons were produced in 323,500 hectares (figure A.15 illustrates the yearly national yield).

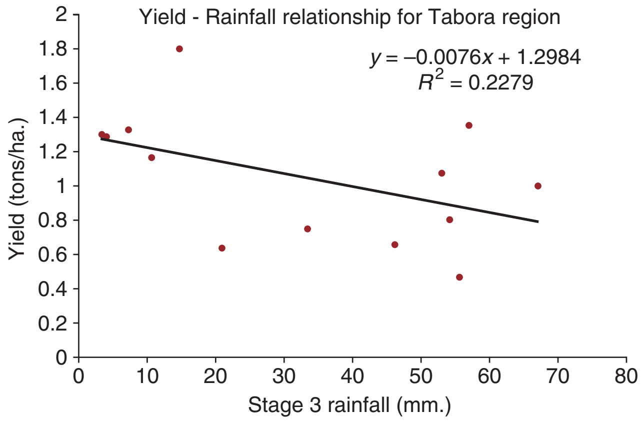
The main regions where rice is sown are Shinyanga, Morogoro, and Mwanza with 91,500, 74,200, and 62,500 hectares, respectively, sown on average each year (see figure A.16).

To establish the rainfall-yield relationship, the same algorithm used for maize will be used for all crops. Rice has the following sowing schedule: sowing stage from January 15 to March 15; mid-season stage from March 16 to June 30; and a harvest stage from July–August. Table A.4 summarizes the regression analysis using the cumulative rainfall of all three stages as regressors against yield.

The sowing stage cumulative rainfall explains 72 percent of the variability in the Dar es Salaam region. Figure A.17 illustrates this relationship.

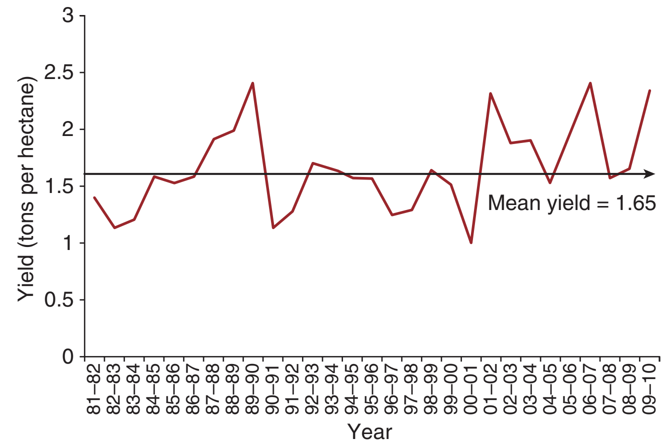
The relationship is quite clear, with a positive slope, meaning that the more rainfall, the better yield. It is worth noting that the worst yield was in year 2003 when 396 kg per hectare were obtained; cumulative rainfall for that stage was a mere 29 mm, a clear indication that drought in the sowing season affected yield that year.

FIGURE A.13. TABORA REGION HARVEST SEASON MODEL



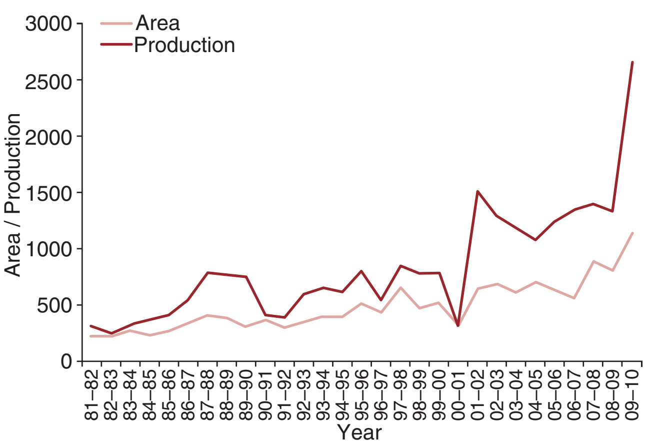
Source: MAFC, GPCP, author's calculations.

FIGURE A.15. YEARLY NATIONAL PADDY RICE YIELD



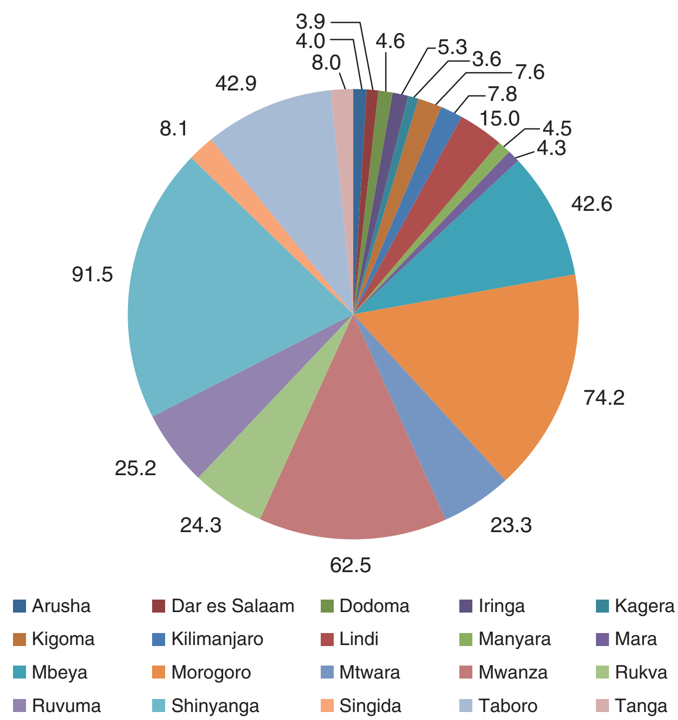
Source: MAFC, author's calculations.

FIGURE A.14. YEARLY NATIONAL PADDY RICE SURFACE AREA SOWED AND PRODUCTION



Source: MAFC.

FIGURE A.16. AVERAGE DISTRIBUTION OF SURFACE SOWN PER REGION



Source: MAFC.

For the mid-season stage, only the Kilimanjaro region shows significance, with a much lower determination coefficient of 38 percent (figure A.18).

In this case, the slope is negative; the more cumulative rainfall, the worse the yield, suggesting that excess rainfall is the main threat in this stage. The worst yield year, 2001, when only 1 ton per hectare was obtained, was not the year with most rainfall. In 1998, 383 mm fell and yield was also low at 1.81 tons per hectare, representing about half the mean yield of the region (3.93 tons per hectare).

For the harvest stage, many regions show significance, but Rukwa and Manyara stand out with a determination coefficients higher than 50 percent. The charts in figure A.19 illustrate the relationship for these regions.

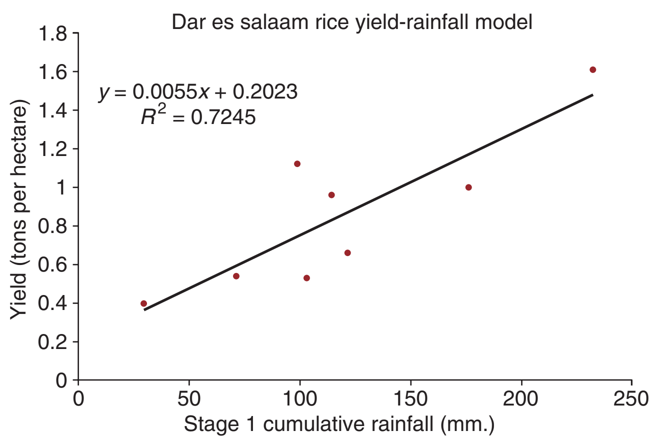
In both cases, the slope is positive, meaning that drought is the main threat. But this stage is the dry season, as shown by the low amounts of rainfall that accumulate in two months (July and August); so rain is hardly expected in this time of the year.

TABLE A.4. SUMMARY OF RICE REGRESSION ANALYSIS RESULTS

Number	Region	Determination Coefficient (R^2)		
		Sowing (%)	Mid-Season (%)	Harvest (%)
1	Arusha	4	8	42
2	Dar es Salaam	72	4	0
3	Dodoma	1	4	0
4	Iringa	11	2	9
5	Kagera	7	3	26
6	Kigoma	4	15	0
7	Kilimanjaro	0	38	0
8	Lindi	13	0	10
9	Manyara	4	17	51
10	Mara	21	5	43
11	Mbeya	0	0	11
12	Morogoro	5	19	19
13	Mtwara	0	18	0
14	Mwanza	25	0	5
17	Rukwa	9	10	57
18	Ruvuma	0	8	0
19	Shinyanga	1	0	0
20	Singida	33	12	29
21	Tabora	18	1	32
22	Tanga	5	1	4

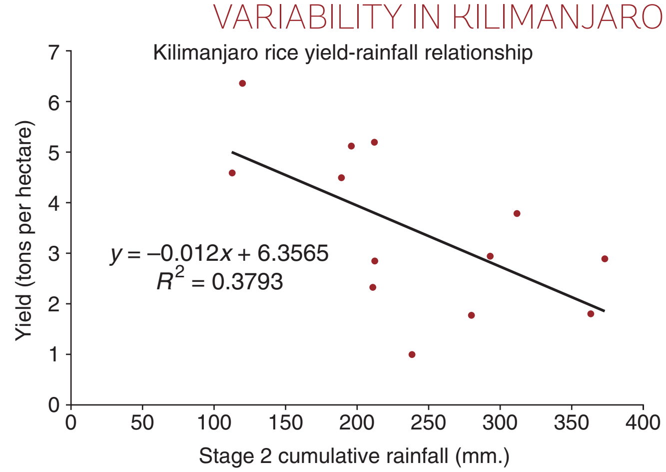
Source: Author's calculations.

FIGURE A.17. RELATIONSHIP BETWEEN RICE YIELD AND RAINFALL VARIABILITY IN DAR ES SALAAM



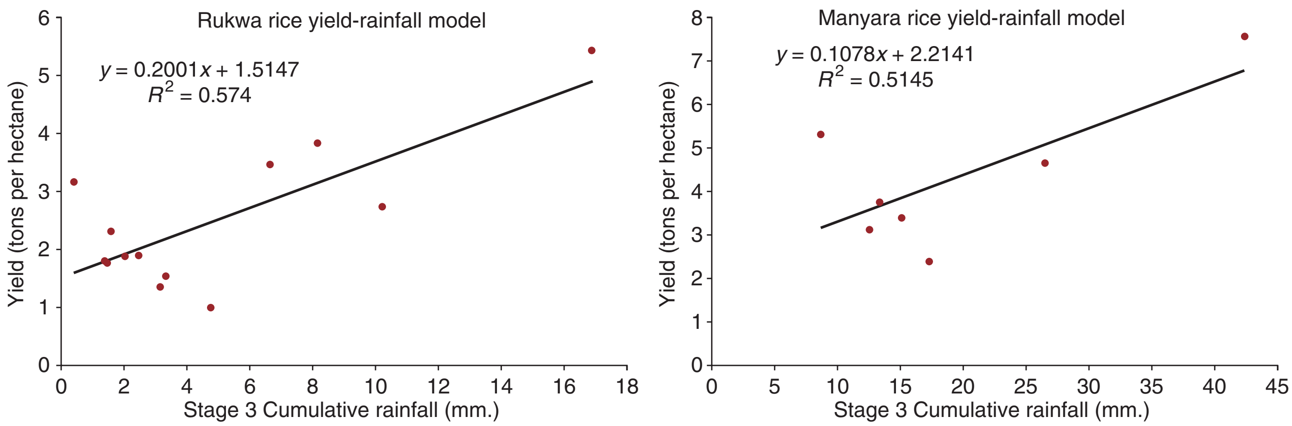
Source: MAFC, GCPC, author's calculations.

FIGURE A.18. RELATIONSHIP BETWEEN RICE YIELD AND RAINFALL VARIABILITY IN KILIMANJARO



Source: MAFC, GCPC, author's calculations.

FIGURE A.19. RELATIONSHIP BETWEEN RICE YIELD AND RAINFALL VARIABILITY IN RUKWA AND MANYARA



Source: MAFC, GCPC, author's calculations.

COTTON

Cotton is sown in 14 regions of the country. Unfortunately, surface sown data are not available from the 1992–93 cycle to the 2000–01 cycle, although production data are available those years. Figure A.20 shows the time series of area sowed and production for the available years.

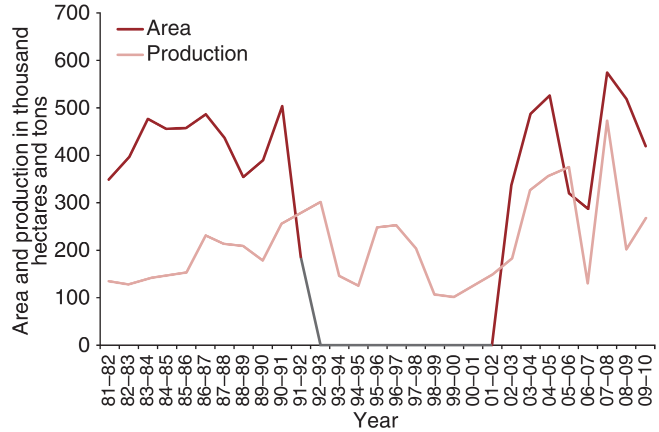
On average, 419,000 hectares are sowed nationally, steadily oscillating between 300,000 and 500,000 hectares. But because sowed area is not available from the years in blue, the mean area was used to estimate the yield. Figure A.21 shows the yield, with the blue line indicating estimated figures using mean area.

The chart in figure A.21 shows that yield has not been steady; it was approximately 400 kg per hectare in the 1980s but it almost tripled to 1.5 tons per hectare in 1991–92. Since 2000, the mean yield is 671 kg per hectare, with year 2005–06 almost doubling that mean with 1.18 tons per hectare.

Cotton areas are concentrated mainly in two regions, with Shinyanga (220,000 hectares mean surface sowed) and Mwanza (132,000 hectares mean surface sowed) accounting for approximately 85 percent of the total surface.

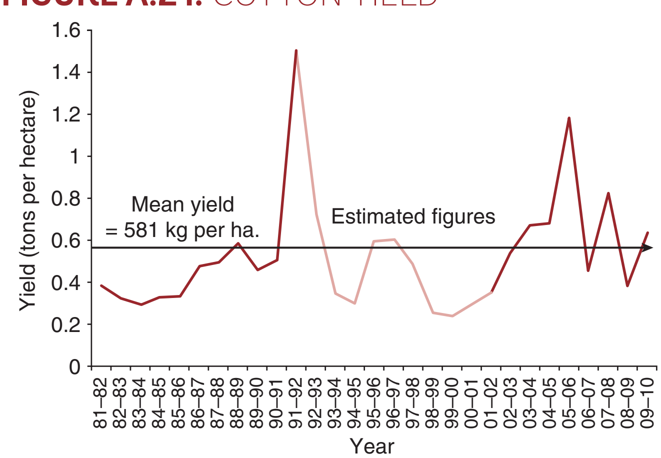
The sowing schedule for cotton has the following stages: sowing season from November 15 to January 31;

FIGURE A.20. COTTON AREA AND PRODUCTION



Source: MAFC.

FIGURE A.21. COTTON YIELD



Source: MAFC, author's calculations.

mid-season from February to June 15; and harvest season from June 16 to August 31. Regression models were run using cumulative rainfall in these stages against yield. Table A.5 summarizes the results.

It is worth noting that all regions are systematically lacking data for surface in the same years as the national data above, so some of the yield values were estimated using the mean surface for the region.

For the sowing season, Arusha and Mbeya regions have a significant coefficient higher than 40 percent, but surface sowed in those regions is of much significance.

For the mid-season stage, Iringa has a high coefficient of 60 percent, but Mwanza, one of the most important regions, also has a significant coefficient. The charts in figure A.22 illustrate the model for these two regions.

Iringa has few data points but rainfall in the low yield years (2001 and 2005, when loss in yield was less than 100 kg per hectare cumulative rainfall) was relatively low at about 400 mm for the whole stage, although 400 mm can hardly be considered a catastrophic drought event. For Mwanza, even though the determination coefficient is lower, several data points align perfectly within the line of the model. The worst yield year (2000) with 239 kilograms per hectare is an estimated figure (area data are not available for that year), but cumulative rainfall was the lowest for the stage at 356 mm; again, hardly a drought event.

For the harvest season, Iringa and Manyara have high significance. The charts in figure A.23 illustrate the relationship.

Determination coefficients are remarkably high, especially for Iringa, mainly due to the high point in 2004 when yield was 1.66 tons per hectare, three times as high as the other cycles, whereas rainfall was 32 mm, the highest of all points. A similar pattern occurred in Manyara, where the outstanding cycle in 2006 (when almost 4 tons per hectare were obtained) correlates with a relatively high amount of precipitation (70 mm).

SORGHUM

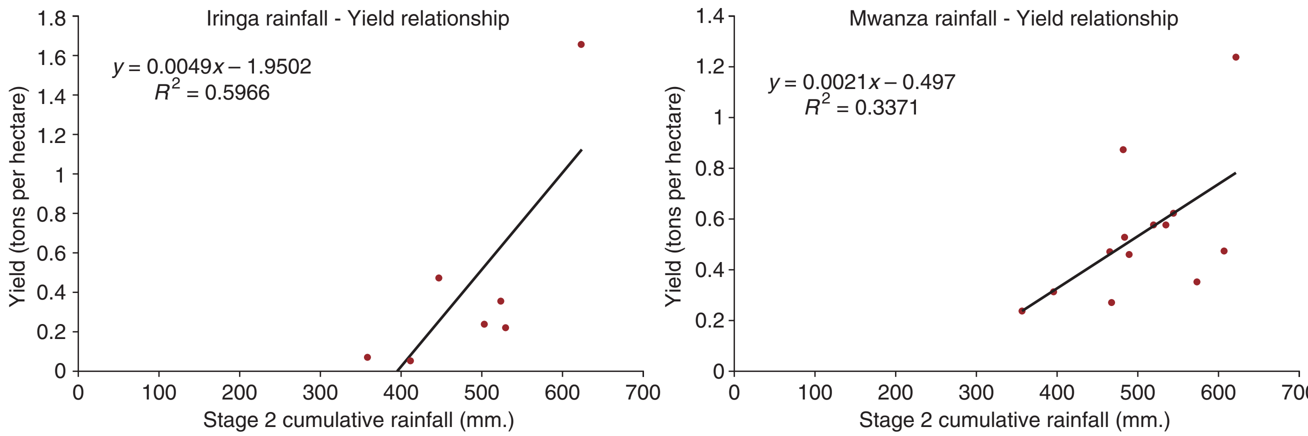
Sorghum is sown in most of the country. Total surface sown increased during the 1990s and has been steady since then, up to an average of about 600,000 hectares sown nationwide (figure A.24).

TABLE A.5. COTTON REGRESSION ANALYSIS RESULTS

		Determination Coefficient R^2		
Number	Region	Sowing (%)	Mid-Season (%)	Harvest (%)
1	Arusha	44	0	19
4	Iringa	6	60	84
5	Kagera	3	7	4
6	Kigoma	4	7	0
7	Kilimanjaro	1	1	45
9	Manyara	13	37	74
10	Mara	3	5	14
11	Mbeya	40	36	9
12	Morogoro	6	9	18
14	Mwanza	7	34	4
19	Shinyanga	9	14	0
20	Singida	5	4	3
21	Tabora	8	34	9
22	Tanga	22	1	9

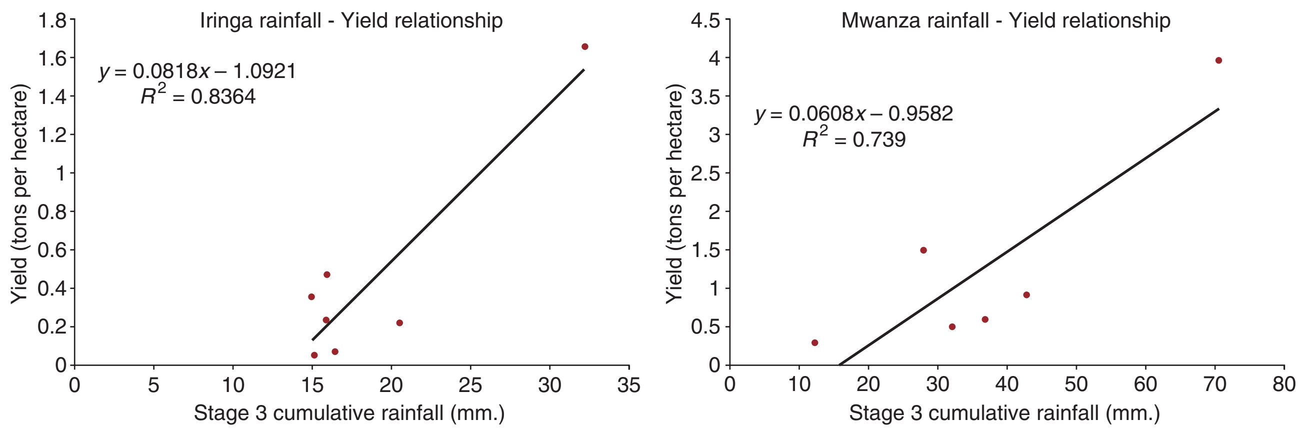
Source: Author's calculations.

FIGURE A.22. LINEAR REGRESSION MODELS FOR IRINGA AND MWANZA REGIONS



Source: MAFC, GCPC, author's calculations.

FIGURE A.23. LINEAR REGRESSION MODELS FOR IRINGA AND MANYARA REGIONS



Source: MAFC, GCPC, author's calculations.

Production figures have been very similar to surface sown; thus, yield has been very steady for an average of 1.02 tons per hectare (figure A.25).

As illustrated in figure A.25, yield on a national basis has never been too low, as the lowest it has been was in the 1983–84 cycle when yield was 840 kg per hectare, just barely below the mean of 1,020 kg per hectare. But neither has yield been too high. The best year in terms of yield was 2010, when it reached 1.86 tons per hectare.

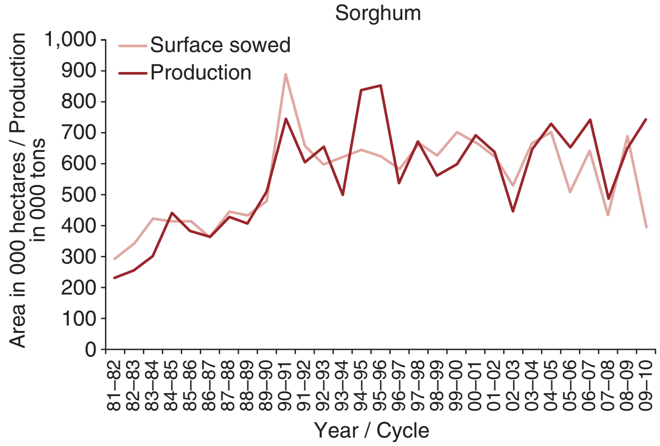
Although sorghum is sown in most of the country, the following regions stand out regarding the average surface of sorghum sown: Shinyanga, Dodoma, and Singida with 107,000, 85,800, and 69,900 hectares, respectively.

The sowing calendar for sorghum is very similar to that for maize: A sowing season from December–January; a mid-season from February–April; and a harvest season from May–June. The same analysis was performed to establish the rainfall-yield relationship. Table A6 summarizes the determination coefficients of each stage.

As shown in table A.6, neither the sowing nor the mid-season cumulative rainfall explains a significant amount of yield; only the harvest season rainfall explains a significant variation of yield for the Manyara and Ruvuma regions. The charts in figure A.26 illustrate these relationships.

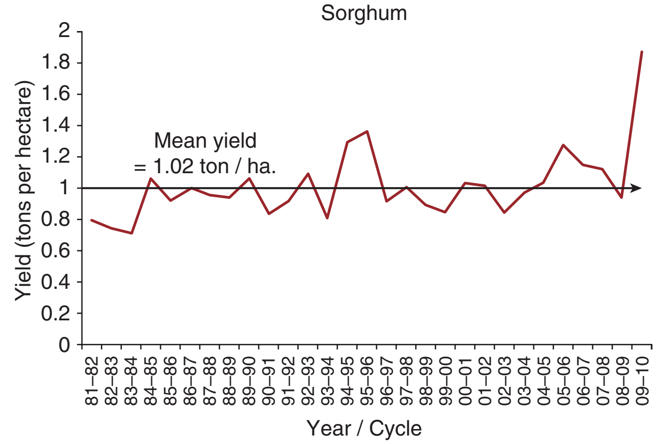
In both cases, the slope is positive, indicating that the more rainfall, the more yield while also showing that drought in this stage could be harmful for the crop. For Manyara, the linear relationship is quite clear, although it has fewer data points. However, the worst yield year (2009, with

FIGURE A.24. SORGHUM SURFACE SOWN AND PRODUCTION VOLUME



Source: MAFC.

FIGURE A.25. SORGHUM YIELD, 1981–82 AND 2009–10



Source: MAFC, author's calculations.

TABLE A.6. SORGHUM REGRESSION ANALYSIS RESULTS

Number	Region	Sowing (%)	Mid-Season (%)	Harvest (%)
1	Arusha	2	1	3
2	Dar es Salaam	3	4	0
3	Dodoma	23	2	8
4	Iringa	9	11	0
5	Kagera	22	12	0
6	Kigoma	0	1	4
7	Kilimanjaro	3	5	0
8	Lindi	1	3	0
9	Manyara	6	2	80
10	Mara	20	6	12
11	Mbeya	19	0	9
12	Morogoro	1	10	18
13	Mtwara	3	4	0
14	Mwanza	0	8	18
17	Rukwa	1	6	0
18	Ruvuma	21	1	50
19	Shinyanga	4	14	0
20	Singida	2	6	6
21	Tabora	2	11	13
22	Tanga	2	1	16

Source: Author's calculations.

765 kg per hectare) matches the lowest amount of rainfall, with only 18 mm.

For the Ruvuma region, the relationship is not as clear. It is highly influenced by one data point, which is suspect. The average yield in the region is 1.26 tons per hectare but during 2006 the yield was 5.5 tons per hectare, matching the year with the most cumulative rainfall in the harvest stage with 71 mm. But it is questionable that rainfall in the harvest season can produce such a high yield relative to other years.

MILLET

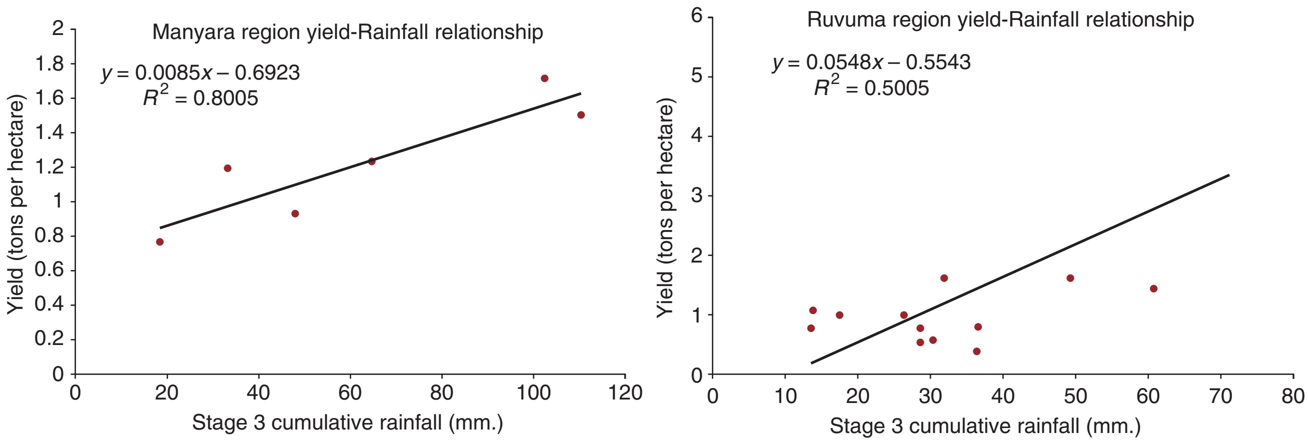
Millet is also sown in many regions of the country, with an average surface sown of 271,000 hectares. Figure A.27 illustrates the surface and total production for each year.

Apparently there are data missing for year 1990–91, whereas in the mid-1990 decade, surface reached its maximum of 473,000 hectares sown, but has not reached that level again.

Yield has been steady as well as for sorghum, oscillating around 600 kg and 1,200 kg per hectare, with a mean yield of 874 kg per hectare (see figure A.28).

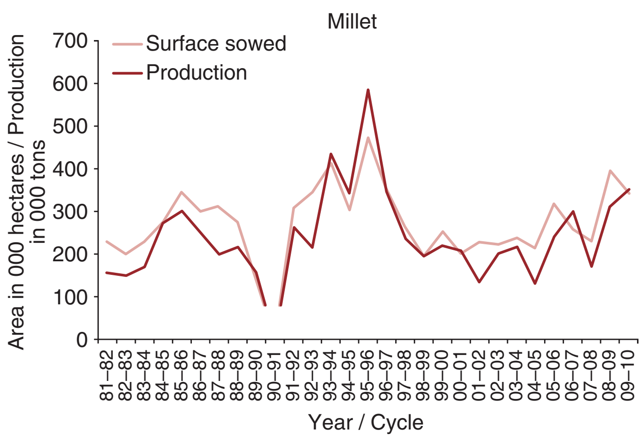
One region stands out as the most important in terms of surface. Dodoma has recently sown the most surface in the country with a yearly average of 90,000 hectares,

FIGURE A.26. LINEAR REGRESSION MODELS FOR MANYARA AND RUVUMA REGIONS



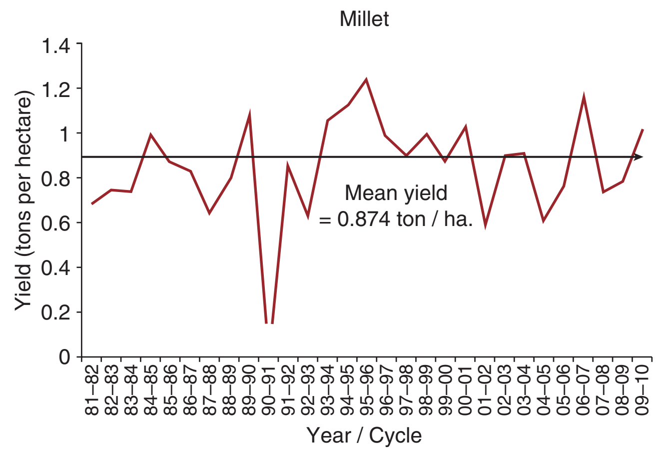
Source: MAFC, GCPC, author's calculations.

FIGURE A.27. MILLET SURFACE SOWED AND PRODUCTION VOLUME



Source: MAFC.

FIGURE A.28. MILLET YIELD 1981–2010



Source: MAFC, author's calculations.

roughly representing 33 percent of the total surface sown. Rukwa and Shinyanga follow Dodoma with approximately 30,000 hectares sown on average each.

The sowing calendar for millet follows the *masika* rainfall pattern, with a sowing season from February–March; a mid-season from April–June; and the harvest season of July–August. A similar regression analysis was performed using cumulative rainfall during these stages. Table A.7 summarizes the determination coefficient of each stage.

Apparently Lindi has a very good fit (100 percent), but only because there are just two available years of data in this region, thus forcing a line with perfect fit. As such, the result should be disregarded. For the sowing season, Kagera has a significant relationship (figure A.29).

The chart in figure A.29 shows a negative slope, which indicates that the more rainfall, the less yield; it also signals that excess rainfall during this stage affects yield. Two particularly poor years stand out: 2006, with zero yield and 251 mm rainfall, and 2009, with 150 kg per hectare and 248 mm rainfall. But it is also worth noting that the year with the highest cumulative rainfall (2007) with 269 mm does not have such a low yield.

For the mid-season stage, rain only shows significance for the Tabora region (figure A.30).

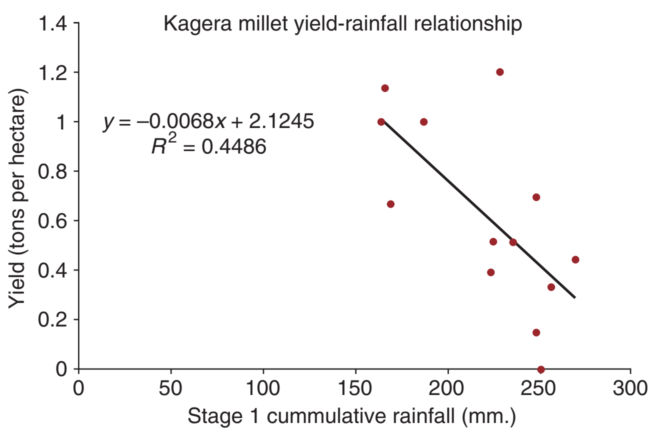
As with the chart for Kagera, the slope is negative, signaling an excess rainfall problem. The worst years in terms of yield (2003 and 1997, with less than 100 kg per hectare) match with high precipitation (148 mm and 194 mm, respectively).

TABLE A.7. MILLET REGRESSION ANALYSIS RESULTS

Number	Region	Sowing (%)	Mid-Season (%)	Harvest (%)
1	Arusha	8	0	20
3	Dodoma	5	9	14
4	Iringa	9	1	4
5	Kagera	45	12	6
6	Kigoma	24	1	9
7	Kilimanjaro	3	17	0
8	Lindi	100	100	100
10	Mara	3	7	25
11	Mbeya	25	0	1
12	Morogoro	1	6	10
13	Mtwara	8	12	0
14	Mwanza	1	0	14
17	Rukwa	5	6	0
18	Ruvuma	10	0	9
19	Shinyanga	8	0	0
20	Singida	3	0	18
21	Tabora	12	35	2

Source: Author's calculations.

FIGURE A.29. LINEAR REGRESSION MODEL FOR THE KAGERA REGION



Source: MAFC, GCPC, author's calculations.

TOBACCO

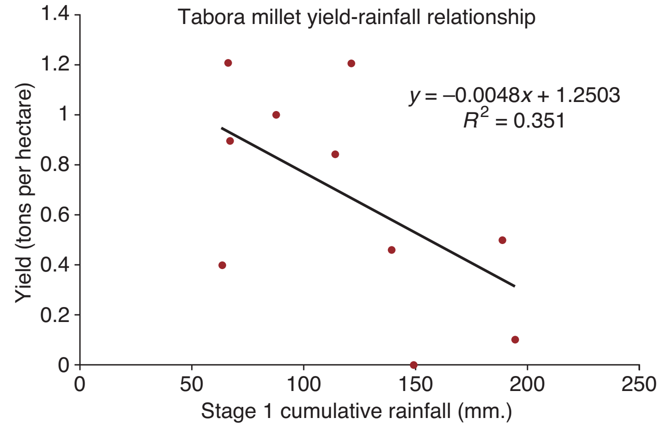
Tobacco is sown mostly in the southern highlands with an average of 74,700 hectares sown each year nationwide (figure A.31).

Unfortunately, data are only available for five cycles, from 2005 to 2010. In 2006–07, the highest amount of surface was sown with 116,000 hectares. Three regions make up 72 percent of the surface sown: Tabora, Ruvuma, and Shinyanga, with 30,000, 13,000 and 10,000 hectares sown on average, respectively, each year.

The sowing calendar for tobacco runs December–January for the sowing season, February–April for the mid-season, and May–June for the harvest season, which will be considered as stages one through three for the rainfall analysis. Table A.8 summarizes the determination coefficient of the regression analysis performed.

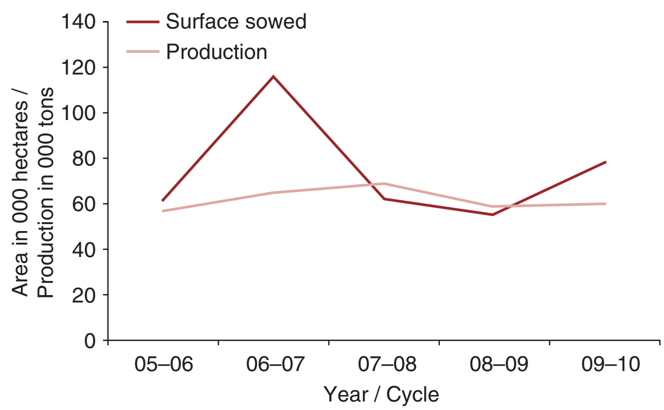
As a general note, coefficients were higher because of the low number of observations available; there were only four data points with which to run regressions, so the coefficients should be viewed with care. For the sowing

FIGURE A.30. LINEAR REGRESSION MODEL FOR THE TABORA REGION



Source: MAFC, GCPC, author's calculations.

FIGURE A.31. TOBACCO SURFACE SOWED AND PRODUCTION VOLUME



Source: MAFC.

TABLE A.8. TOBACCO LINEAR REGRESSION RESULTS

Number	Region	Sowing (%)	Mid-Season (%)	Harvest (%)
1	Arusha	11	3	91
4	Iringa	77	77	3
5	Kagera	49	76	0
6	Kigoma	53	38	70
11	Mbeya	74	28	63
17	Rukwa	95	40	67
18	Ruvuma	8	67	21
19	Shinyanga	21	37	21
20	Singida	14	8	20
21	Tabora	26	21	7

Source: Author's calculations.

season, Rukwa, Iringa, and Mbeya stand out with high coefficients. Figure A.32 illustrates the model for Mbeya and Rukwa.

The slope is negative in both charts, indicating that excess rainfall is the main threat. For Mbeya, however, the slope is not significantly different from zero, meaning that despite the fact that the R^2 is high, rainfall does not influence yield but for Rukwa the model resembles the relationship quite well. It should be noted that only four observations are considered. The lowest production year—2007, the only one with less than 1 ton per hectare—matches the highest accumulated rainfall with 469 mm.

For the mid-season rainfall Iringa, Kagera, and Ruvuma have a high coefficient. Figure A.33 shows the relationship for Ruvuma, because it is one of the most important tobacco regions.

Again, the slope is negative, clearly indicating that the higher the rainfall, the lower the yield. But rainfall in this stage had low variability in the four years considered, varying from 535 mm to 600 mm. Coincidentally, in 2007 when 600 mm fell, the lowest yield was observed at 309 kg per hectare. In 2006, 580 mm fell and almost 500 kg per hectare were recorded. This explains why the determination coefficient is so high, but again, only four data points were considered. A larger sample size should be used to draw more solid conclusions.

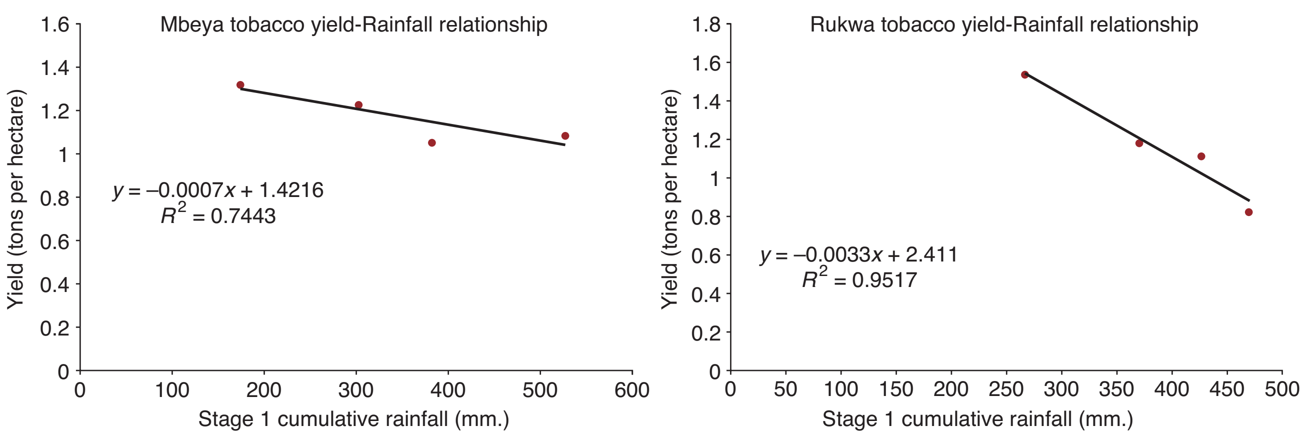
For the harvest stage, Arusha and Kigoma were significant. Figure A.34 shows the relationship for Kigoma.

Again, a negative slope indicates excess rainfall. In particular, the worst yield year—2006, when only 650 kg per hectare was recorded—matches the year with most rainfall, with 83 mm.

MAIZE (BASED ON A SPECIFIC CALENDAR FOR EVERY REGION)

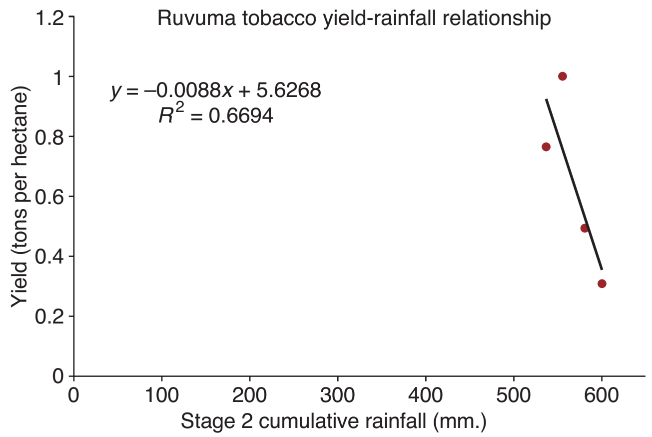
Because planting and harvesting take place in different times throughout the year, the specific calendar for each region was used (table A.9).

FIGURE A.32. LINEAR REGRESSION MODELS FOR MBEYA AND RUKWA REGIONS



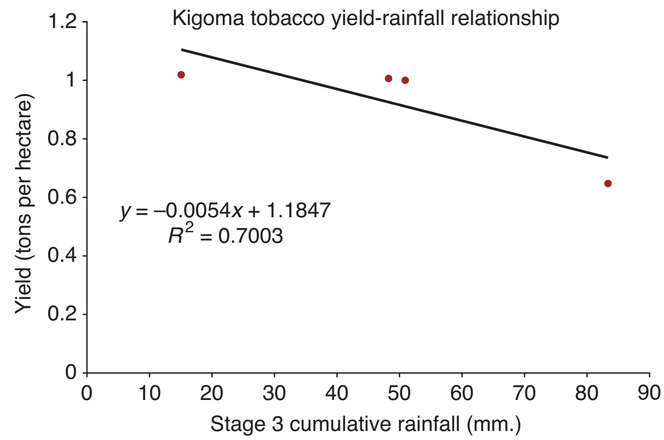
Source: MAFC, GCPC, author's calculations.

FIGURE A.33. LINEAR REGRESSION MODEL FOR THE RUVUMA REGION



Source: MAFC, GCPC, author's calculations.

FIGURE A.34. LINEAR REGRESSION MODELS FOR THE KIGOMA REGION



Source: MAFC, GCPC, author's calculations.

TABLE A.9. MAIZE SOWING CALENDAR

Region	Sowing	Mid-Season	Harvesting
Kilimanjaro	February–March	April–July	August
Arusha	February–March	April–July	August
Manyara	February–March	April–July	August
Kagera	November–December	January–February	March
Mwanza	November–December	January–March	April
Kigoma	November–December	January–March	April
Tabora	November–December	January–March	April
Shinyanga	November–December	January–March	April
Singida	November–December	January–March	April
Dodoma	November–December	January–March	April
Morogoro	February–March	April–June	July–August
Rukwa	November–December	January–June	July–August
Mbeya	November–December	January–June	July–August
Iringa	November–December	January–June	July–August
Pwani	March	April–June	July–August
Dar es Salaam	March	April–June	July–August
Lindi	March	April–June	July–August
Mtwara	March	April–June	July–August
Ruvuma	March	April–June	July–August
Tanga	March	April–June	July–August

Source: MAFC.

Linear regression models were built to establish the relationship between yield, expressed in tons per hectare, and the cumulative rainfall of each of the crop seasons above. The model can be expressed as follows:

$$Yield = {}_0 + {}_1 Rain_i$$

Table A.10 summarizes the determination coefficient (R^2) obtained for each region.

The determination coefficient is a measure of the proportion of the variance in yield that can be explained by the cumulative rainfall in each season. So, for instance, in

TABLE A.10. MAIZE REGRESSION ANALYSIS RESULTS

Region	Sowing (%)	Mid-Season (%)	Harvest (%)
Arusha	54	1	1
Dar es Salaam	12	2	15
Dodoma	0	33	0
Iringa	6	14	0
Kagera	9	6	10
Kigoma	2	0	2
Kilimanjaro	2	1	1
Lindi	2	23	10
Manyara	72	75	8
Mbeya	1	29	0
Morogoro	6	3	17
Mtwara	7	6	0
Mwanza	2	0	0
Coast	2	3	8
Rukwa	1	9	1
Ruvuma	3	24	12
Shinyanga	1	7	0
Singida	3	14	1
Tabora	15	2	1
Tanga	48	1	14

Source: Author's calculations.

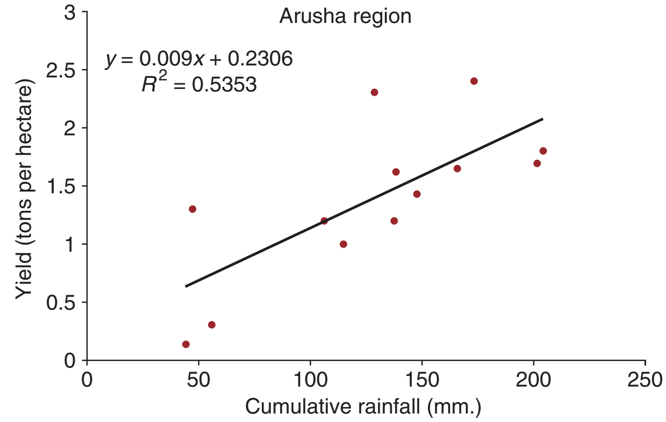
the Manyara region, both the sowing and the mid-seasons explain a significant amount of the variability in yield.

For the sowing season, cumulative rainfall shows significance for three regions: Arusha, Manyara, and Tanga. The regression charts for these regions follow in figures A.35, A.36, and A.37.

For the Arusha region, the relationship is quite clear, with a determination coefficient (R^2) of 54 percent, meaning that 54 percent of the variability in yield can be explained by the cumulative rainfall of the sowing season alone. The slope is positive; the more rain, the higher the yield, signaling that drought is the main threat here.

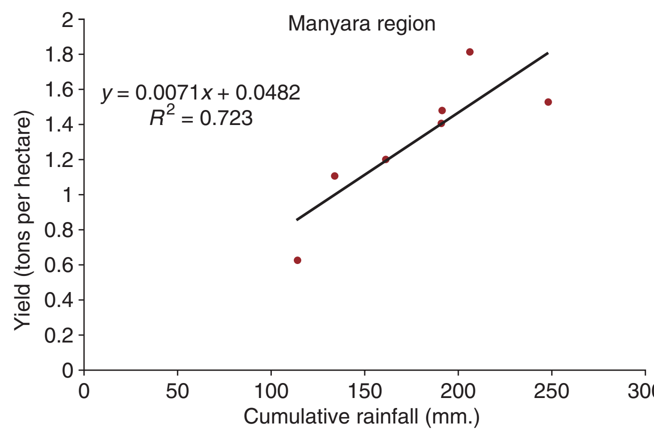
It is also clear that the worst years in terms of rainfall, which were 1997 and 2000, when only 44 mm and 55 mm fell through each entire season, were also the worst years in terms of yield with 129 kg and 300 kg per hectare,

FIGURE A.35. LINEAR REGRESSION MODEL FOR THE ARUSHA REGION



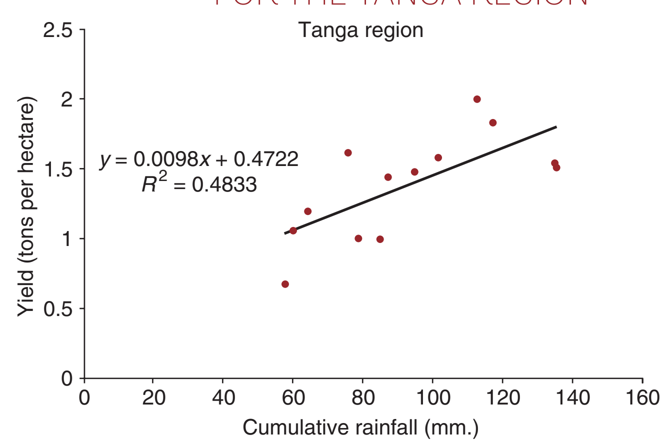
Source: MAFC, GCPC, author's calculations.

FIGURE A.36. LINEAR REGRESSION MODEL FOR THE MANYARA REGION



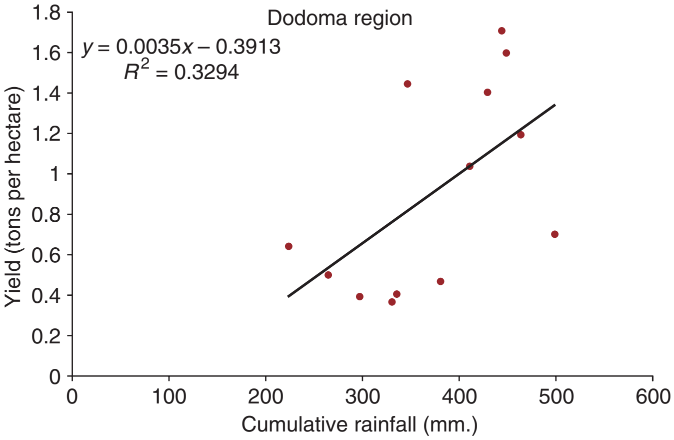
Source: MAFC, GCPC, author's calculations.

FIGURE A.37. LINEAR REGRESSION MODEL FOR THE TANGA REGION



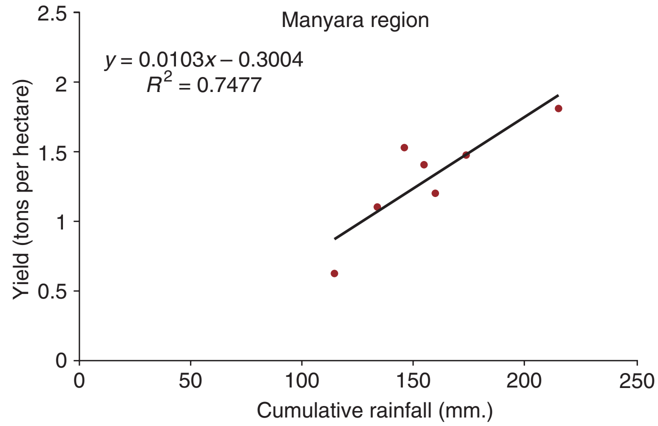
Source: MAFC, GCPC, author's calculations.

FIGURE A.38. LINEAR REGRESSION MODEL FOR THE DODOMA REGION



Source: MAFC, GCPC, author's calculations.

FIGURE A.39. LINEAR REGRESSION MODEL FOR THE MANYARA REGION



Source: MAFC, GCPC, author's calculations.

respectively. So it is clear that drought in the sowing season has an important effect in maize yield in the Arusha region.

For the Manyara region, the determination coefficient is even higher, which means that roughly 72 percent of the variance in yield can be explained by cumulative rainfall in the sowing season alone.

The slope is also positive, which signals that drought is also the main threat here. It is also clear that the worst year in terms of rainfall, which was 2009 when 113 mm fell, was also the worst year in terms of yield, with only 626 kg per hectare. But it seems that drought has not been very frequent in this region, because the lowest rainfall in this region was 113 mm. This also explains why yield has not been lower than 626 kg per hectare in the years observed.

The same pattern is observed in the Tanga region. Almost 50 percent of the variability in yield can be explained by cumulative rainfall in the sowing season alone. The slope is also positive, signaling a drought effect.

The year with least rain, 2004, when only 57 mm fell, matches the lowest yield with 674 kg per hectare.

It can be concluded that for Arusha, Manyara, and Tanga, cumulative rainfall in the sowing season is a very important driver for yield, and that drought can threaten the yield obtained.

As for the midseason, rainfall explained the variability in yield only in Dodoma, Manyara, Mbeya, and Ruvuma (figures A.38, A.39, A.40, and A.41).

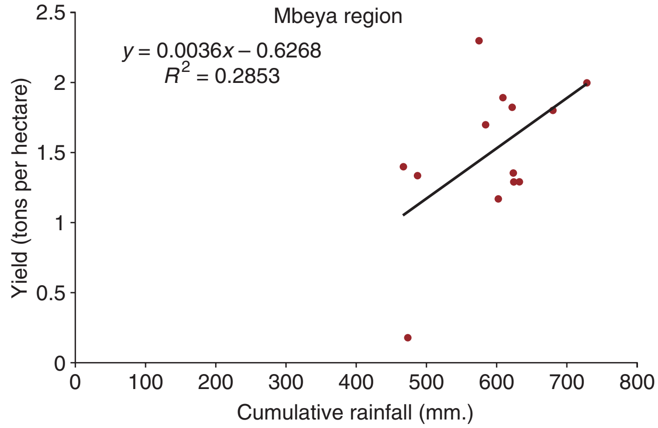
For Dodoma, even though the determination coefficient is not very high (33 percent), it is clear that there are two different groups of points: those with low rainfall and low yield, and the opposite group.

But in this case, the worst rainy year (1997 at 223 mm) is not the worst yield year (642 kg/ha). There are observations with lower yield, for example, 2003 and 2005 with approximately 400 kg per hectare, respectively, but with cumulative rainfall of 297 mm and 335 mm. This season is long for Dodoma (at three months) but 300 mm would not be considered a drought event.

For the Manyara region, the mid-season cumulative rainfall was also significant in explaining variability in yield. It was the only region in which both the sowing and the mid-season were important, although the high R^2 can be explained because this is also the region with fewest observations available.

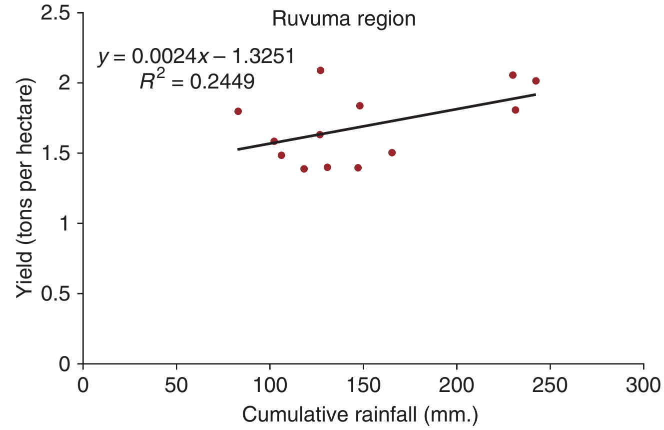
Again, the slope is positive, implying that drought is the main threat. Clearly the worst year (2009) when only 626 kilograms per hectare were recorded, was the year with the lowest rainfall (114 mm). Hence, Manyara is susceptible to drought not only in the sowing season, but also in the mid-season.

FIGURE A.40. LINEAR REGRESSION MODEL FOR THE MBEYA REGION



Source: MAFC, GCPC, author's calculations.

FIGURE A.41. LINEAR REGRESSION MODEL FOR THE RUVUMA REGION



Source: MAFC, GCPC, author's calculations.

In Mbyea, the determination coefficient is not very high (29 percent), but the relationship is skewed by one extreme observation: during 2003, the yield was only 181 kg per hectare. Although rain was relatively low, compared with how much rain falls regularly in this region, 472 mm would not be considered the cause for such a low yield. There were other years with similar amounts of rain, but yields were higher.

For Ruvuma, not only is the determination coefficient low (24 percent) but also it is clear that the slope is almost equal to zero, signaling that rainfall is not significant in this region. Rainfall was not significant for any region in the harvest season, because the highest determination coefficient was 17 percent for Morogoro.

APPENDIX B

IMPACT OF CLIMATE CHANGE ON AGRICULTURAL SECTOR

INTRODUCTION

Agriculture is highly vulnerable to climate change in Tanzania, although the effects are heterogeneous across regions and crops/livestock. Some 80 percent of the population is involved in agriculture (CIA Fact Book 2013), and the majority of those on an informal, small-scale nature without many chemicals or mechanizations. Agriculture composes almost 28 percent of Tanzania's gross domestic product (GDP) (CIA Fact Book 2013). If climate change is left unaddressed, progress in agricultural development, food security, and poverty alleviation in general will be reversed.

In the *Mapping the Impacts of Climate Change* index under "Agricultural Productivity Loss," the Center for Global Development ranks Tanzania 68 out of 233 countries globally for "direct risks" due to "physical climate impacts" and 33 out of 233 for "overall vulnerability" due to "physical impacts adjusted for coping ability" (Wheeler 2011).

However, the impacts of climate change vary widely based on what assumptions are made, and which scenarios are played out. There are direct impacts, such as changes in crop yields due to precipitation changes, and indirect impacts, such as rising food prices due to production changes and conflict over land tenure based on shifting agro-climatic zones. The newest installment of the International Panel for Climate Change (IPCC) did not narrow expected results from climate change, but rather widened the frame of variability. This, in combination with various approaches to impact studies, makes it difficult to generalize regarding the effects of climate change on agriculture in Tanzania. This appendix discusses the various possible outcomes.

PRINCIPAL FINDINGS

As Tanzania is highly dependent on rain-fed agriculture, shifts in precipitation and temperature patterns due to climate change will have significant impacts on the sector.

A high level of variability both geographically and between scenarios makes it difficult to generalize about the impact of climate change. Because of high levels of variation, there is a need for subnational assessments, particularly for the design of climate change policy responses.

The literature generally agrees that climate change will have negative impacts on key food crops for domestic consumption, such as maize, while it may not have significant impact or possibly have positive impacts on cash crops such as coffee and cotton.

Although there is regional variability (and possible increases in some areas), on a national average, maize yields are likely to decrease.

Cotton will not be affected by changes in temperature, but changes in precipitation may affect yields.

Agriculture and food security, including livestock, is listed in the National Adaptation Program of Action (NAPA) as the most important sector to address in climate change adaptation.

BRIEF HISTORY OF CLIMATE CHANGE IMPACT ASSESSMENTS

Many climate change agricultural impact assessments have been done at the regional (eastern and Sub-Saharan Africa) and global levels; however, there are few specific analyses of Tanzania at a national or subnational level. In 1994, the United States Country Studies Program (in partnership with of the Global Environmental Facility and the United Nations Environmental Programme) supported a vulnerability and climate change impact study (called The National Vulnerability and Adaptation Assessment of Tanzania). It was conducted by the Centre for Energy, Environment, Science and Technology (CEEST), and results were published in 1997. These studies were the basis for the government of Tanzania's Initial National Communication (INC) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2003 and the National Adaptation Programme of Action to the UNFCC in 2007.

Three other assessments have been completed recently. In 2009, Review of Development Economics published an article, "Agriculture and Trade Opportunities for Tanzania: Past Volatility and Future Climate Change," supported by Stanford University. In September 2012, the World Bank published the working paper, "Climate Change, Agriculture and Food Security in Tanzania," which was a continuation of the 2009 United Nations University Working Paper. Finally, in December 2012, the International Food Policy Research Institute (in collaboration with the Association for Strengthening Agriculture Research in Eastern and Central Africa, and the Consultative Group on International Agricultural Research [CGIAR] Research Program on Climate Change, Agriculture and Food Security) released a summary of their upcoming publication, "East African Agriculture and Climate Change: A Comprehensive Analysis—Tanzania."

Throughout all of these studies, most data and models came from the United Kingdom, the United States, or Canada. The older assessments rely primarily on agricultural crop models, while some of the newer assessments seek to quantify impacts through economic growth accounting or other various models. In most analyses, projections are made through the mid-21st century.

METHODOLOGIES

The INC and NAPA used the assessments supported by the United States Country Studies Program, global environmental facility (GEF), and United Nations Environment Program (UNEP) that were carried out by CEEST. The scenarios used were developed from the General Circulations Models (GCMs).[21] The base climate data came from 1951–1980, and were used to create 30-year climate scenarios. The scenarios projected an increase in the mean daily temperatures by 3.5°C. One scenario doubles CO_2 concentration, resulting in an annual temperature increase of 2.1°C in the northeast to 4°C in the central and western areas. Under these scenarios, the bimodal rainfall areas (the northeast and northwest, the Lake Victoria basin, and the northern part of the coastal belt) would see rainfall increases for both seasons from 5 to 45 percent. The unimodal rainfall areas (the south,

[21] In particular from UK 89, CCCM, GFD3, GFDLOI, and GISS.

southwest, west, central, and east) would see decreases in annual rainfall of 5 to 15 percent with greater volume or rain during the long rains, and less during the short rains. Rain is expected to increase by 5 to 45 percent annually in the southeast. In looking at particular crops, relevant regression models were used for cotton and coffee, but the Crop Environment Resource Synthesis (CERES) model and GCMs were used for maize.

In "Agriculture and Trade Opportunities for Tanzania: Past Volatility and Future Climate Change," the authors used the Coupled Model Intercomparison Project (CMIP3). This is the same model which Working Group I of the Fourth Assessment Report of the IPCC used for the 2007 publication (Ahmed and others 2012).

The International Food Policy Research Institute (IFPRI) analysis took four downscaled global climate models (GCMs) from the IPCC AR4 and projected agricultural yields out to 2050 (IFPRI 2012). The scenarios modeled include changes in precipitation and temperature. The Model for Interdisciplinary Research on Climate (MIROC) model is the wettest, with increased rainfall across the country, and a median 200 mm increase in precipitation per year (with some areas seeing a 300 mm increase.) The Commonwealth Scientific and Industrial Research Organisation (CSIRO) model did not note significant precipitation change over the majority of Tanzania (60 percent), but projected increases over the east of 50 to 100 mm (IFPRI 2012). All four models projected higher temperatures by 2050, with the lowest median temperature increases of around 1°C in the CSIRO and MIROC models, and 2°C or higher in the other models (MIROC showed spatial variability.) The report notes that temperature increases could have negative consequences for agricultural productivity owing to the spread of diseases and crop pests.

The IFPRI analysis then used the Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling software projections for rain-fed maize and compared 2000 crop yields with projected 2050 crop yields that resulted from climate change (IFPRI 2012). IFPRI also ran the IMPACT global model for food and agriculture "to estimate the impact of future GDP and population scenarios on crop production and staple consumption, which can be used to derive commodity prices, agricultural trade patterns, food prices, calorie consumption, and child malnutrition." They used an optimistic scenario with high per capita income growth and low population growth, and corresponding pessimistic and intermediate scenarios.

The World Bank analysis found four limitations in previous studies: (1) Most assessments are conducted at a global/regional level, and more information is needed at national and subnational levels because impacts vary widely geographically; (2) many assessments rely on only a few projections despite the great uncertainty in climate change; (3) autonomous adaptation, which may offset damage due to climate change, is not included in calibrated agronomic crop models; and (4) assessments may exclude indirect and general equilibrium effects (such as household income changes, price, and inter-sector linkages) (Arndt and others 2012).

In the World Bank study, agricultural production changes brought about because of climate change on a subnational level are projected using four GCMs through 2050. The assessment takes the climate projections and inserts them into calibrated crop models that predict changes in yield, and then imposes them on a "highly-disaggregated, recursive dynamic economywide model of Tanzania." The economic model thereby evaluates both availability (production) and accessibility (income) as crucial components of food security. All four scenarios assume an increase in temperature between 1 and 2 percent. HOT projects a 5.67 percent increase in precipitation; COOL, a 5.37 percent increase; WET, a 13.3 percent increase; and DRY, an 11.14 percent decrease (Arndt and others 2012). The model captures indirect effects and allows for some autonomous adaptation (Arndt and others 2012).

The generic crop model the World Bank study uses is called CLICROP. It simulates the impacts of climate change on rain-fed and irrigated crops as well as on demand for irrigation water. CLICROP has a daily time scale and includes both water-logging and crop-specific parameters. The FAO model CROPWAT is a simpler (earlier) such model. CLICROP indirectly measures the effects of the atmosphere through evatranspiration and infiltration to the soil layers. Fertilization via CO_2 is not considered in this analysis and therefore yield losses may be overestimated. Within CLICROP, they used four

scenarios/projections: COOL, WET, HOT, and DRY. The CLICROP analysis was performed for nine crops (cassava, groundnuts, maize, millet, potatoes, sorghum, soybeans, sweet potatoes, and wheat), with a focus on maize as a principle food crop (Arndt and others 2012). Similar to other models, there is a considerable degree of variability both between the four climate scenarios, and across the subnational regions.

Finally, the Haggar and Schepp desk study of coffee builds upon the INC, but is a valuable addition because it takes into account results from farmer surveys and also addresses the impact of El Niño and La Niña cycles.

GENERAL FINDINGS

There were several confluences of results throughout these assessments. All of the assessments agreed that dependency on rain-fed agriculture in Tanzania made it acutely vulnerable to climate change. The assessments all reiterated impact variations across geographical areas, between models/scenarios, and among agricultural sectors. There was a wide consensus that maize yields would generally decline.

Several generalizations are made about climate change impacts. First, increased rainfall leads to nutrient leaching, topsoil erosion, and water logging, thereby affecting plant growth and yield. Second, climate change will favor pests and diseases because of increased temperature and rainfall. Farmers will therefore be inclined to use costly agrochemicals and disease resistant cultivars, placing vulnerable and poor small-scale farmers at a disadvantage. Third, agro-climatic zones will shift, and areas with less rainfall will require irrigation (which is costly because of reduced river runoff and shallow well vulnerability) and drought resistant plant varieties (Republic of Tanzania 2003).

The NAPA notes that in Tanzania there would be a shift from perennial crops to annual crops, and global warming that accelerated plant growth would reduce the length of growing seasons (Republic of Tanzania 2007). Agricultural vulnerabilities include: decreased crop production exacerbated by climatic variability and unpredictability of seasonality, erosion of natural resource base, and environmental degradation (Republic of Tanzania 2007).

The Tanzania NAPA listed the following additional vulnerabilities in the agricultural sector due to climate change: (1) unpredictable rainfall, resulting in cropping pattern uncertainty; (2) prolonged dry spells leading to drought; (3) increased competition between weeds and crops for moisture, light, and nutrients; (4) ecological changes in pests and diseases; and (5) vulnerability in the agriculture/livestock sector (Republic of Tanzania 2007).

The World Bank study found that, relative to a no climate change baseline with the principal impact channel being domestic agricultural production, "food security in Tanzania appears likely to deteriorate as a consequence of climate change." It also found significant impact differences by region, income category, and across households.

The Review of Development Economics article found that more than 50 percent of Tanzania's dry years might coincide with nondry years in selected African trading partners between the early 2000s through the 2050s (Ahmed and others 2012). The article goes on to suggest that there is great potential for Tanzania to benefit from the heterogeneous climate impacts on agriculture. It notes that these benefits can only be realized through a removal of export restrictions or movement to a rules-based policy mechanism. These steps will remove policy uncertainty and the resultant price instability (Ahmed and others 2012).

COTTON

The only study that directly addresses cotton is the National Vulnerability and Adaptation Assessment of Tanzania, which is referenced in the INC, the NAPA, and various other climate change impact-related documents. The study assessed the impacts of climate change on cotton, using relevant regression models, finding no significant impact on cotton growth due to temperature. However, with increased rainfall, yield will rise by 17 percent whereas decreased precipitation will result in a 17 percent yield drop. In the studied areas (Mwanza and Morogoro regions), rainfall is projected to increase by 37 percent and 7 percent respectively. With a doubling of the CO_2 levels, the average temperature increase would be 2.7°C, which still falls in optimal cotton conditions

of 18°C to 30°C. Pests and disease are a side effect of increased rainfall that may adversely affect production (Republic of Tanzania 2003).

For both cotton and coffee, the NAPA notes a projected increase by 18 percent in bimodal rainfall areas and 16 percent in unimodal rainfall areas due to a 2°C to 4°C increase in temperature (Republic of Tanzania 2007). The NAPA also suggested that cotton yields could be negatively affected by pests and diseases, resulting in a 10 to 20 percent loss.

MAIZE

Maize is the most important staple food in East Africa, and the most widely-traded agricultural commodity (World Bank 2009b). Similarly, maize is the primary staple crop in Tanzania, and is greatly important to food security. There is broad agreement that maize production will be adversely affected by climate change. Further, it appears that poor producers will be particularly affected, as they may not be able to afford the required cost of irrigation, varieties, or chemicals needed to adapt. As noted in the World Bank assessment, in regards to food availability, yield impacts on the major producing areas should be examined. The future of maize as a staple crop and continued reliance upon it may be at risk (Haggar and Schepp 2009).

The INC and NAPA (as a result of the CEEST study) reported that increases in temperature and reduced rainfall would lead to increased moisture loss and a reduced growth period thereby affecting maize growth and yields. Using the CERES model and GCMs, the projections suggest that farmers may move away from corn production because of lack of control over temperature, and the added cost of irrigation to supplement rainfall. Using the CERES maize model, maize yields will be lower than under a baseline climate projection by about 33 percent across the country. This varies across regions; the central regions (Dodoma and Tabora) (Republic of Tanzania 2007) would see a projected 84 percent production decrease, with a 22 percent decrease in the northeastern highlands, a 17 percent decrease in the Lake Victoria basin, and a 12 percent decrease in the southern highlands (Republic of Tanzania 2003) (or rather, in the southern highlands, Mbeya and Songea were estimated to see 10 to 15 percent decreases) (Haggar and Schepp 2009). As with cotton and coffee production, increased temperatures and rainfall would increase pest and disease incidence, negatively affecting production as well.

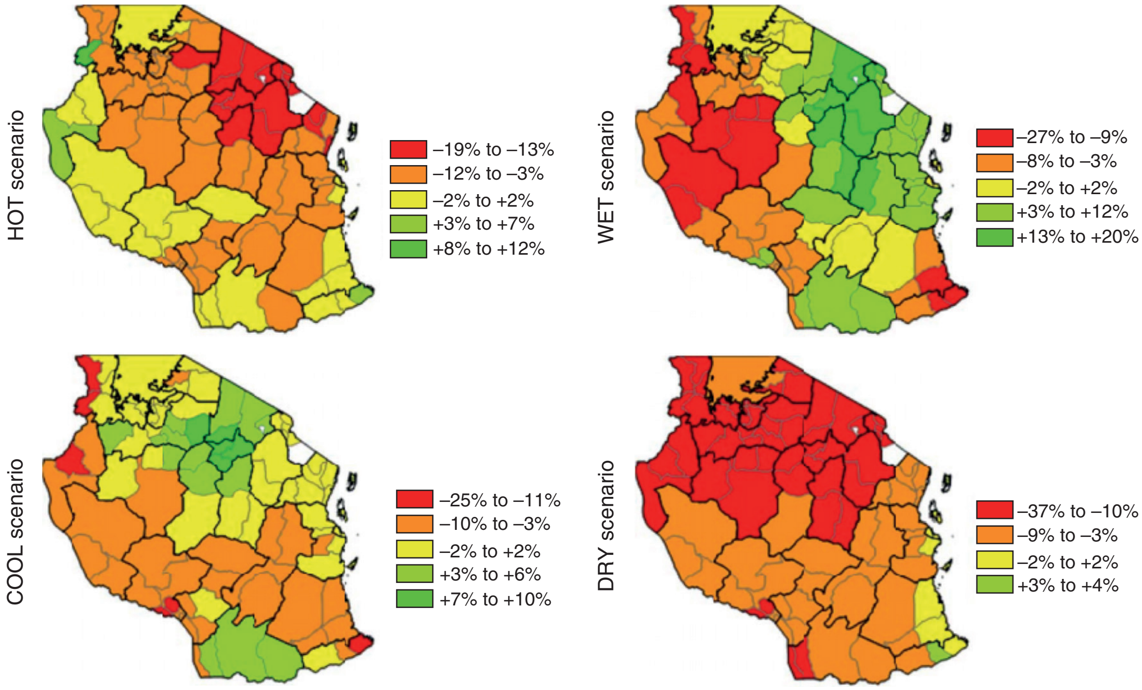
In the article "Robust Negative Impacts of Climate Change on African Agriculture," Schlenker and Lobell are cited as suggesting that there will be a 22 percent decline in average maize productivity across Sub-Saharan Africa by 2050 (Schlenker and Lobell 2010). The article goes on to argue that if global and regional maize production and supply are low, Tanzania can take advantage of high prices, even if producing at a rate below trend. A historical analysis suggests that Tanzania may be only mildly affected by dry conditions while its major trading partners are severely affected, giving them a comparative advantage in exports. As noted previously, these advantages cannot be realized without a removal of export restrictions and other policy measures (Ahmed and others 2012).

The World Bank models found that there were heterogeneous impacts geographically and between scenarios, but there will be regional correlations; essentially, favorable climate outcomes for maize farmers in a specific region will likely favor farmers in neighboring regions. The same can be said of unfavorable impacts. In general, yield declines are more prevalent than yield increases throughout the scenarios and across regions. Also the coastal islands generally appear to remain fairly unaffected (Arndt and others 2012).

In the WET scenario, maize yields in the Northern Zone increase substantially. Maize yields are projected to increase by 15 percent in Manayara in the Northern Zone, but to decline by 12 percent in Tabora in the Central Zone. The WET scenario also saw mean increased yields near Mount Kilimanjaro and its southern slope, with very significant decreases in the west near Lake Tanganyika. In the COOL scenario, yield increases in the Northern Zone (around Mount Kilimanjaro), but results in slight yield declines in the southern coast and southern highlands (Arndt and others 2012).

Maize yields are generally more favorable under WET and COOL, than HOT and DRY scenarios. Maize yields

FIGURE B.1. MEAN ANNUAL DRY-LAND MAIZE YIELD CHANGES UNDER HOT, COOL, WET, AND DRY SCENARIOS, 2041–50



Source: World Bank 2012.

decrease in the Northern Zone under the HOT and DRY scenarios. Yield increases in very few areas and only by small percentages. Under HOT, there is damage to the yields in the vast majority of Tanzania, particularly in the north and in the Lake Victoria region (Arndt and others 2012).

COFFEE

Outside of climate change, the coffee sector in particular has been historically rather unstable owing to global prices and climate. A few characteristics exacerbate coffee production vulnerability to climate change impacts: (1) intercropping with bananas in the north and west with low plant densities, productivity, and replanting rates; (2) coffee is a major crop in the southern highlands with high density and replanting rates; (3) minimal management of coffee trees and shrubs (agrochemicals only used in the southern highlands, and by less than half of producers); (4) pre-existing vulnerability to variability in the El Niño/La Niña cycles. Further, the National Coffee Development Strategy does not address climate change risks, but aims to double coffee production by 2020 (Haggar and Schepp 2009).

The INC also assessed the impacts of climate change on coffee using relevant regression models, looking at the major producing areas of Lyamuno in the northeast and Mbozi-Mbeya in the south. The INC assumes that the rainfall increase is 37 percent in the northeast and there is a rainfall decrease of 10 percent in the south. An increase of 2°C in both areas would put coffee production within the optimal values, and changes in rainfall would determine production. An increase in rainfall would correspond with increased yield. The model shows only a minimal decrease in rainfall in the southern areas and yield would not be affected. As such, the INC finds that yield will increase by an average of 17 percent in each area (taking into account and increase in pests and diseases that would reduce yield by 20 percent on average). In Lyamungo, rainfall is bimodal and yields are expected to see an 18 percent increase, whereas Mbozi has unimodal rainfall and is expected to see a 16 percent increase.

If, however, there was a 4°C increase in temperature, coffee production would be "significantly reduced" and particularly limited in the southern highlands. Irrigation, training, and drought/disease resistant coffee varieties

would be needed to keep coffee as a major cash crop. Generally, coffee may be more successful in areas with increases in rainfall, such as the northern, northeastern, and southeastern areas (Republic of Tanzania 2003).

In a comparative analysis with findings from neighboring Kenya and Uganda, the Haggar and Schepp (2009) desk study found that climate change would result in a "significant redistribution" of viable coffee-growing land. For example, the study concluded that the minimum altitude for arabica production would increase by as much as 400 m, and robusta cultivation would need to shift to areas with higher rainfall (most likely in the north). Coffee growing may become unviable in lower altitudes or lose quality (Haggar and Schepp 2009). The study also suggests that the robusta growing region in Tanzania would move toward the Rwandan border, away from Lake Victoria.

The desk study also does some qualitative analysis as well of the potential impact of climate change, with an analysis of coffee farmer surveys. The farmers generally agreed that the climate is changing, particularly with irregular rainfall patterns and less rain in turn resulting in lower productivity.

The desk study warns of potential environmental impacts as coffee production expands at higher altitudes and competes with forestry and natural ecosystems. There is particular concern over the Mount Kilimanjaro region.

LIVESTOCK

The INC also conducted a climate change vulnerability assessment for grasslands and livestock, finding changes in foliage associations and a shift in foliage species as the "most palatable species" in semiarid areas are grazed out and replaced with more climate-tolerant species. It also found that the rangeland carrying capacity would be low, but that the carrying capacity for areas with increased rainfall as CO_2 doubles will rise (the northern, northwestern, and northeastern regions of Kigoma, Mwanza, Musoma, and Same, and some southern areas such as Iringa). In areas with increased precipitation, there would be surplus foliage, but crude protein content would be lower. As a result, grazing animals would have poor performance, and there would be negative impacts on milk and meat production. These problems would be compounded by pests and diseases, forcing farmers to adjust grazing habits and rangeland management (Republic of Tanzania 2003). These problems would be multiplied as farmers employ various strategies which may cause further environmental degradation or have large economic losses.

Climate change is already shrinking rangelands vital to livestock producers and communities. The loss of rangelands will be aggravated because around 60 percent is infested by tsetse fly, making it unsuitable. As a result, Tanzania may see increased conflicts between livestock producers and farmers (Republic of Tanzania 2007).

In the NAPA, vulnerability in the livestock sector is projected to increase owing to the effects of increased temperature and rainfall: changes in plant species compositions affecting grazing; a general increase in dry matter yields, a favorable condition for pests and disease; long droughts and disease outbreaks limiting pasture size; and heat waves directly leading to livestock deaths (Arndt and others 2012).

OTHER CROPS

The IFPRI crop modeling projected that rice production would be geographically variable, making it hard to generalize. There might be gains in some regions while losses may occur in others. Under the IMPACT model, rice yields would "roughly double between 2010 and 2050" (IFPRI 2012).

Using the IMPACT model, IFPRI found that cassava yields will remain largely unchanged between 2010 and 2050, but with population growth, demand will greatly exceed supply. The same model found yields tripling for sorghum, factoring in both climate change and technological improvements. If it is assumed that the area under production expands by 40 percent, allowing total production to increase fourfold, 70 percent of sorghum production in 2050 could be exported (IFPRI 2012).

BEYOND CROP IMPACT STUDIES

Several of the recent climate change impact assessments seek to quantify the economic impact of agricultural

changes in the broader economy. Generally, they find that climate change has a negative impact on agriculture, which results in a negative impact on the economy and a deterioration of food security.

The World Bank study uses a dynamic computable general equilibrium model (DCGE) of mainland Tanzania to project economywide effects (including indirect effects and economywide linkages) of the agricultural impact channel and potential indirect impact channels such as agro-processing. In the DCGE model, predicted annual yield deviations for rain-fed crops estimated by CLICROP affects domestic agricultural production, economic growth, and household incomes. The net effect of climate change in this model is a significant reduction in national GDP in the HOT and DRY scenarios, with a slight decrease in COOL, and a slight increase in WET (Arndt and others 2012).

In the DRY scenario, agricultural GDP is 11.5 percent below the baseline by the end of the 2040s. This contracts the supply of raw inputs such as grain for the agro-processing sectors (for example, milling). The agro-processing GDP is then 7.8 percent below the baseline. Food imports, however, are expected to increase, offsetting declined domestic production and potentially benefiting some traders. The HOT and DRY scenarios project large agricultural GDP reductions in the Northern and Central Zones around Lake Victoria. These areas currently account for a large portion of Tanzanian agriculture; therefore, future changes have implications nationwide. In the WET scenario, there is significant variation on the regional level (increases in the northern coast and Northern Zone with falls in other areas including the Lake Victoria region) and within agro-climatic zones, but overall agricultural production rises (Arndt and others 2012).

In the DCGE models, households are affected by climate change both through consumer prices and agricultural incomes. Household adaptation decisions are based on both supply and demand. They might adapt by reallocating resources and changing livelihoods. Or, because of rising consumer prices (from falls in agricultural production), some resources may be reallocated to affected agricultural sectors in hopes of benefiting from the high prices.

Changes in food consumption are less pronounced than changes in agricultural GDP. The paper accounts for this with assumptions of ability to import food and developed transport systems by 2050. For example in the DRY scenario there is an 11.5 percent decline in national agricultural production offset by a 37.1 percent increase in net food imports, and food consumption falls only 8 percent. Outcomes are also variable due to region-specific impacts of climate change, crop-specific impacts (and thereby incomes and ability to reallocate farm resources), and the percentage of household income composed of agriculture and a consumption basket composed of food. For further details, and region specific numbers, refer to the World Bank Report (Arndt and others 2012).

CONCLUSION

On a general level, a review of the literature suggests that there will be a decline in agricultural production because of climate change that in turn will affect various components of the national GDP. The production declines will occur in food production principally, while there are opportunities for increases in some production (such as coffee). These changes may limit export growth and household income, which in turn reduces Tanzania's ability to import food.

Climate change is likely to alter the makeup of Tanzania agriculture. Shifts in production and cropping will also have large socioeconomic impacts due to changes in livelihoods. In particular, there is widespread reliance on corn among subsistence farmers, who may not have the resources available to invest in different crops to feed their families. Further, the crops with the greatest potential for increased favorable conditions such as coffee and cotton are export-oriented cash crops. This may contribute to the overall economy, but not to the increasing food insecurity due to climate change.

In conclusion, because of the impacts of climate change, Tanzania may see problems related to land tenure, agricultural incomes, food availability, food prices, and food security, among others. These changes demand better crop (Republic of Tanzania 2003) and land management strategies, and their incorporation into agricultural development approaches is crucial.

MAJOR STAKEHOLDERS

This group includes the Tanzania Meteorology Agency, the MAFC, regional institutions (river basin management offices, and regional and district government offices in charge of land use planning and investment promotion), the Tanzania Coffee Research Institute, farmers and producers, and the University of Dar es Salaam.

LIMITATIONS

This literature review does not consider impact studies focusing on the minor islands or coastline of Tanzania where a rising sea level and resulting coastal erosion are of concern. Also omitted are summaries of various vulnerability studies and poverty analyses as to the effects of climate change. There are several such studies, including a joint study from CEEST and The Netherlands Climate Assistance Program using the United Kingdom Department for International Development (DFID) Sustainable Livelihood Framework. The IMPACT model used by IFPRI also accounts for projections in international prices of crops, which is not mentioned in this review, but could provide important insights for food security. This assessment could benefit from crop-specific analysis. In particular, there appear to be no studies on the impact of climate change on cashew nuts in Tanzania, a major commodity. Further research should be done on these topics.

APPENDIX C
VULNERABILITY ANALYSIS

INTRODUCTION

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 they lack 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). In Tanzania, shocks and stresses that will trigger a decline or drop in well-being may be on the household/micro-level (crop disruption, malaria, HIV/AIDs), at the community/meso-level (refugee populations competing for resources, food price shocks), and at the national/macro-level (climate change, natural disasters). Vulnerability is discussed here particularly in the context of food security.

Major findings:

- **Demography:** The primary vulnerable populations in Tanzania are women, children, widows, and the elderly, the disabled, poor, and ill.
- **Location/Livelihoods:** The primary vulnerable areas are rural subsistence-based agricultural communities. Other particularly vulnerable rural groups include those dependent on aid, daily workers, and those with little access to assets.
- The **major shocks** to these vulnerable groups include
    - Climate and other natural disasters (particularly drought and pests)
    - High food prices (international commodity price shocks)
    - Pests and plant disease
    - Human illness (HIV/AIDS, malaria, and so on)
- **Other shocks and stresses** to these vulnerable groups might include changes in aid flows, refugee populations competing for resources (particularly in the northwest regions), governance changes, and others (to be discussed).
- The population can be vulnerable on an individual level as well as meso- and macro-levels.

- » Vulnerability is context specific and difficult to measure in Tanzania, but addressing vulnerability and poverty appears to be a high priority of government and donor agencies.
- » Many valuable impact studies and vulnerability assessments are out of date.

LITERATURE

The government of Tanzania, in partnership with international development organizations such as the World Bank, has been focusing on reducing vulnerability over the past decade. The Tanzania government (the Ministry of Finance, the President's Office of Planning and Privatization, and the National Bureau of Statistics) has been deeply involved in vulnerability and poverty assessments, the foremost of which are the participatory poverty assessments. Other assessments include the Food Crop Production Forecast and Vulnerability Assessments. The 2002–03 Participatory Poverty Assessment in particular, performed by the United Republic of Tanzania, resulted in a comprehensive qualitative assessment of households' risk environments, coping strategies, and vulnerabilities. Surveys make up the substance of these assessments.

The 2009/10 United Republic of Tanzania Comprehensive Food Security and Vulnerability Analysis (CFVSA/MKUKUTA), published by the World Food Program, gives an in-depth assessment of vulnerability as it relates to good security. Their analysis was based on data obtained through surveys conducted during a "relatively lean period" in both unimodal and bimodal regions—capturing food consumption patterns while food was less available. For more recent assessments of vulnerability, particularly as it relates to food security, the Famine Early Warning System Network (FEWS NET) and the Food and Agricultural Organization of the United Nations (FAO) provide remote monitoring.[22]

DIMENSIONS OF POVERTY AND VULNERABILITY IN TANZANIA

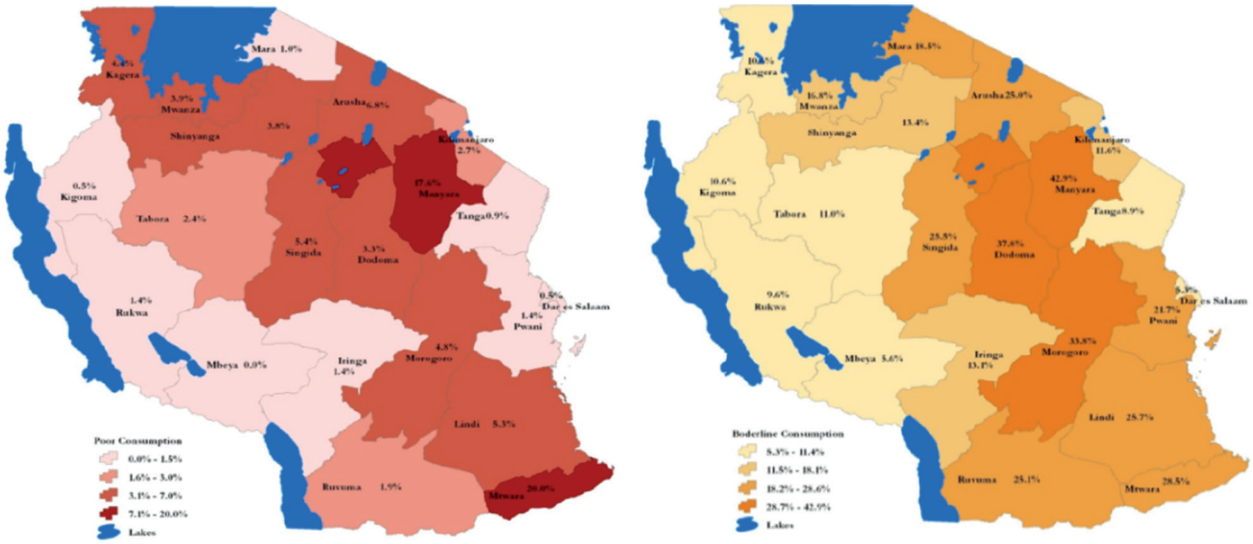
In 2011, Tanzania's GDP per capita (PPP) was US$1,600 and the country was ranked 199 out of 228 in terms of wealth. Around 80 percent of the labor force works in agriculture, and agricultural production accounts for 27.8 percent of gross domestic product (GDP) (CIA Factbook 2013). Agriculture is extremely important to the Tanzanian economy and is the primary income source for the poor. The poor are composed primarily of the rural populations and are small-scale or subsistence farmers.

In 2010, 74 percent of the population was rural, with a rate of 5 to 10 percent annual rate of change (urbanization), depending upon the source. Food crop producers are generally poorer than cash crop producers ("Enabling Poor Rural People" 2012). These poor rural households are particularly vulnerable to extreme weather shocks (such as drought and flood), and price shocks in international commodity markets. These groups lack links to markets, inputs, credit, and irrigation, making them less resilient and more vulnerable to shocks.

According to International Fund for Agricultural Development (IFAD), approximately 90 percent of the poor live in rural areas, and poverty is highest among those living in arid and semiarid regions that depend entirely on livestock and food crop production for survival. Although there is not one significantly worse off or better region in Tanzania, generally, the most severe poverty can be found near the coast and in the southern highlands, and the most poorly nourished people live in the central and northern highlands ("Enabling Poor Rural People" 2012). Dependence on rain-fed agriculture makes households in the semiarid areas (the central and northern regions) particularly vulnerable to weather shocks because it affects access to food (Enabling Poor Rural People" 2012). Food insecurity in turn leads to further vulnerability to disease, livelihood loss, and so on. According to the most recent World Bank data, the poverty head count ratio at US$1.25 a day (PPP) is 68 percent (World Bank 2007), the poverty head count ratio at the rural poverty line (percentage of rural population) is 37%, and the poverty head count ratio at the urban poverty line (percentage of urban population) is 22%. Life expectancy at birth in Tanzania is 57, malnutrition in terms of height-for-age of children younger than five years is 17 percent, there are approximately 230,000 children (0–14) living with HIV, and countless others orphaned by HIV/AIDS (World Bank Data Bank 2013).

[22] For the FEWSNet updates: http://www.fews.net/east-africa/tanzania.

FIGURE C.1. DISTRIBUTION OF POOR AND BORDERLINE FOOD CONSUMPTION HOUSEHOLDS



Source: CFSVA 2009/10.

Tanzania is ranked 152 on the Human Development Index (HDI, and has a 0.332 inequality adjusted HDI value), the mean years of schooling (of adults) is 5.1 years, and the country scored a 0,606 on the Gender Inequality Index. Inequality also contributes to vulnerability in that unequal access to productive assets such as land, finance, livestock, and education affects the ability to cope with shocks and stresses. Overall, the UN Development Programme places Tanzania in the "low" human development category (although above the average for countries in Sub-Saharan Africa), with significant levels of gender inequality (Human Development Index 2013).

FOOD SECURITY AND VULNERABILITY

The 2009/10 CFVSA found 4.1 percent of households in rural mainland Tanzania with poor food consumption, meaning diets primarily are cereal based with almost no animal protein and little else. It also found 18.9 percent of households with borderline food consumption (meaning a marginally better diet including pulses, vegetables, and fruits at least one more day a week than poor consumption households), and 77 percent of households with acceptable food consumption (a threefold increase in pulse and fruit consumption, larger increases in milk and animal protein) (World Food Programme Food Security Analysis Service [ODXF] 2010).

The CFSVA produced the two maps above (figure C.1), diagraming the frequency of poor food consumption and borderline food consumption regionally. Poor and borderline consumption centered in a "band of vulnerability" running from the central northern regions down to the southeast. As expected, acceptable consumption prevailed along the coast and in the west (ODXF 2013).

There is some geographical overlap between regional distribution of maternal and child malnutrition rates and poor food consumption households. But it should be noted that several regions, such as Kigoma, reported elevated wasting and underweight prevalence and yet had a high level of acceptable consumption. Stunting was also not correlated regionally with food consumption patterns (ODXF 2013).

Table C.1 lists the factors that the CFSVA found to be associated with food security, both positively and negatively. The regions indicated are most affected by the variables, resulting from interactive models. Based on multivariate analyses, after controlling for the variables below, the CFSVA found that small subsistence farmers were "significantly worse off" than the most food secure individuals (salaried workers) (ODXF 2013).

TABLE C.1. FACTORS ASSOCIATED WITH FOOD SECURITY BY REGION

Factors Significantly Associated With Food Security	Regions Where Factors Show a Strong Positive Association with Food Security	Regions Where Factors Show a Strong Negative Association with Food Security
Illiteracy of household head		Mwanza and Mara
Access to livestock	Tanga, Mtwara, and Ruvuma	Kagera
Cultivating four or more crops	Dodoma, Arusha, Kilimanjaro, Singida, Rukwa, Shinyanga, Kagera, and Mara	
Using chemical fertilizers	Arusha and Shinyanga	
Asset wealth	Arusha	

Source: CFSVA 2009/10.

THE VULNERABLE POPULATIONS

According to the 2009/10 CFVSA, the food insecure (poor food consumption households) and thereby those vulnerable to shocks, had the following characteristics: (1) dependent on aid, daily work, small subsistence farming, and agro-pastoralism for their livelihoods; (2) female-headed households and illiterate households; and (3) poor, with the least access to assets. Specifically, poor consumption households have access to fewer livestock, cultivate less diverse crops, cultivate less than one hectare of land, and are less likely to use chemical fertilizers (ODXF 2010).

The Tanzania Participatory Poverty Assessment found the following social groups to be the most vulnerable because of having the "least freedom of response" to shocks and stresses: children (especially orphans), child-bearing women and women with young children, widows, the elderly, people with disabilities, people with chronic illnesses, people in HIV/AIDS-affected households, and destitute persons. Other studies agree with this assessment, and other social groups might include drug addicts, unemployed youths, and alcoholics. These groups all have low access to assets, which limits their capacity to cope (Sarris and Karfakis 2006).

WOMEN

In Tanzania, women are particularly vulnerable owing to a lack of rights and various physical, social, and financial inequalities. For example, female genital mutilation affects 15 percent of women in Tanzania and is particularly common in regions such as Manyara, Dodoma, and Arusha. Women affected are generally the poor and elderly (Research on Poverty Alleviation [REPOA] 2007). In 2010, Tanzania had the 23rd highest maternal mortality rate globally: 460 deaths to 100,000 live births (CIA Factbook 2013). Malnutrition has effects that are cumulative and intergenerational. Maternal health is intrinsically linked with child health, and maternal mortality rates have not significantly improved over the last few decades.

CHILDREN

Children are a particularly vulnerable group in Tanzania (over 18 million Tanzanians are under 18 years old). The 2009/10 CFVSA found that nationally 5.7 percent of children 0 to 59 months old were wasted, 36.6 percent stunted, and 14.3 percent underweight (ODXF 2010). The depth of vulnerability for children is weighted heavily toward rural populations. According to the National Bureau of Statistics, Population Census in 2002 and the Tanzania Demographic and Health Survey (TDHS) 2004/05, around 41 percent of children are stunted under-five in rural areas, whereas only 26 percent are in urban areas. These trends are similarly mirrored in malnutrition and mortality rates. More than 1 in 10 children die before they turn five years old. Many children live in households that do not have income sufficient to provide minimum nutritional requirements, resulting in physical and mental problems, serious economic and social well-being consequences, and distortions of their potential contribution to national development. Particularly vulnerable groups of children are those with disabilities, orphans (especially those orphaned due to HIV/AIDs and subsequently stigmatized), and others (such as child laborers and street children) (REPOA 2007).

MAJOR SHOCKS AND STRESSES

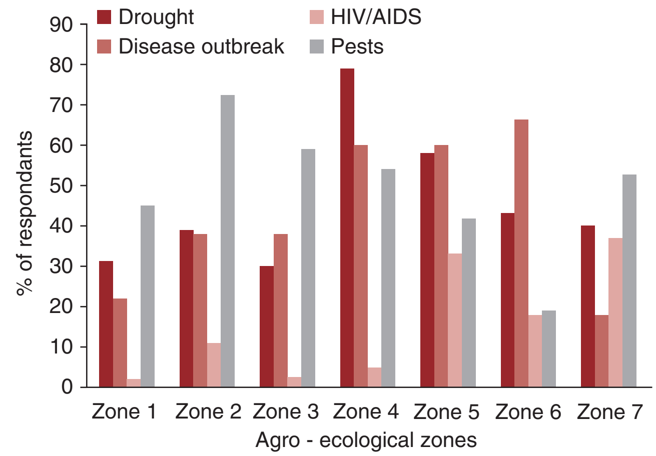
Based on the 2009/10 CFSVA study, the top three shocks to household consumption were drought (at 58.4 percent), high food prices (at 53.4 percent), and plant disease/animal pests (at 34.7 percent). Drought was most frequently reported in the northern regions (Arusha, Tanga, Manyara, Kilimanjaro, and Mara) central regions (Dodoma and Morogoro), and southeastern regions (Mtwara and Lindi). The "increasingly bimodal" tendencies and rainfall patterns in the north corresponds with this finding (ODXF 2010). Across the varying shocks, invariably, the most vulnerable were the most affected.

High food prices as a shock were most reported across Tanzania, but with particularly high percentages in Kilimanjaro, Mara, Dodoma, Singida, Lindi, and Mtwara (western regions reported this shock with less frequency). Groups disproportionately affected by the high food price shocks included daily workers, fishermen/hunters, households reliant on aid, and "others." Those least affected were large producers of both food and cash crops (ODXF 2010).

Plant diseases and animal pests acted as shocks most frequently in regions adjacent to bodies of water, specifically, Lindi, Kigoma, Mara, Mtwara, and Mwanza. The Shinyanga, Ruvuma, and Arusha regions were least affected. Looking through the lens of livelihoods, the households most affected were large subsistence farmers and "others" (ODXF 2010).

Participants in the 2002–03 Participatory Poverty Assessment cited having vulnerabilities to material well-being (such as money, land, farming gear, and so on) and physical well-being (health, security, dignity and freedom of choice and action, and so on). According to this and subsequent studies, the significant shocks and impoverishing forces include drought and other natural disasters, environmental degradation, worsening terms of trade, corruption, inappropriate taxation, lack of physical security, HIV/AIDs, malaria, and aging. The most significant category of shock/stress varied from community to community, but three cases emerged as having the greatest impact: governance, macroeconomic influences, and environmental forces ("Tackling Vulnerabilty" 2004).

FIGURE C.2. HAZARD OCCURRENCE IN THE AGRO-ECOLOGICAL ZONES



Source: United Nations University.

Legend: Zone 1 = Coastal; 2 = Eastern plateau and mountain blocks; 3 = Southern highlands; 4 = Northen rift valley and volcanic highlands; 5 = Central plateau; 6 = Rukwa-Ruaha rift zone; 7 = Inland Sedimentary; Ufipa plateau and western highlands.

Other recent vulnerability studies cite environmental and macroeconomic conditions, governance, ill health, life-cycle conditions and cultural beliefs and practices as being important impoverishing forces (Sarris and Karfakis 2006). Ill health makes populations vulnerable as it reduces the capacity to work, resulting in a loss of production and income as well as generating treatment costs, which reduces their ability to cope with further shocks (that is, a poverty trap). Vulnerability also increases as populations sustain successive shocks.

NATURAL DISASTERS

Tanzania has a long history of natural disasters throughout its seven differing agro-ecological zones (see figure C.2), diverse and varied as the geography, physical, social, and economic factors throughout the country. A disaster vulnerability assessment carried out in 2006 used both perceptions and a regression analysis wherein the 1992 United Nations Development Programme (UNDP) formula for vulnerability was used $v \quad \frac{hazard \quad Risk}{\text{manageability and coping strategies}}$.

The resulting vulnerability index suggests that the Rukwa-Ruaha rift zone was most vulnerable to disease outbreak; the central plateau to drought; and the southern highlands, eastern plateau, and mountain blocks to pests (Birkmann 2006).

Commonly occurring disasters occur as a result of epidemics, pests, flood, and drought leading to famine, fire, accidents, cyclones and strong winds, refugees, conflicts, landslides, explosions, earthquakes, and technological hazards. The disaster vulnerability assessment identified 15 hazards. The most commonly occurring were pests, drought, and disease outbreaks. At the household and village levels, pests received the highest scores, whereas at the district level disease outbreaks (including HIV/AIDS) were most common (followed by pests, drought, and strong winds) (Birkmann 2006). All of these disasters can lead to food crises, livelihood failures, and deeply negative impacts for vulnerable populations.

CLIMATE CHANGE

There is both individual and collective vulnerability to climate change across Tanzania. The Centre for Energy, Environment, Science and Technology (CEEST) provides some indicators of vulnerability to climate change. For individuals, useful indicators include poverty indexes, the proportion of income dependent on risky resources, dependency, and stability. Collective indicators might include GDP per capita, relative inequality, qualitative indicators of institutional arrangements, levels of infrastructure, availability of insurance, and formal or informal social security (Meena and O'Keefe 2007). Coastal communities are particularly vulnerable to sea rise and flooding. Increased pests and diseases are likely the result of increased temperature and moisture in some areas. (See appendix B on climate change.)

HIV/AIDS

HIV/AIDS has been considered by international organizations and the government of Tanzania to be the primary threat to human development in Tanzania. Estimates in 2009 ranked Tanzania 12th in global prevalence of HIV, with a 5.6 percent rate (CIA Factbook 2013). HIV/AIDs can create localized crises, such as in the Makete district, Iringa region, where there was a livelihood collapse owing to the high prevalence of AIDS. Estimates range up to a potential 20 percent negative impact on GDP. Small-scale studies across Sub-Saharan Africa and Tanzania have found that HIV/AIDS also causes serious losses at the household level, including lower income, decreased food cultivation, and depletion of assets. Rural households and communities are disproportionately affected by the epidemic, with livelihoods unsustainable in sickness, ill adults relocated, and orphaned children sent to villages to be cared for by relatives (Tumushabe 2005).

A 2006 World Bank report studied the effect of HIV/AIDS as a shock on short- and long-term consumption among surviving households. Over a 13-year period, the study found that affected households saw a 7 percent consumption drop within the first five years after an adult death, and had a 19 percent growth gap with unaffected households. The effects of shocks may last for 13 years, and adult female death has a particularly severe impact on a household (Beegle, De Weerdt, and Dercon 2006).

HIV/AIDS has become a long-term stress in Tanzania, and the interaction effect means that concurrent shocks (such as price shocks) will have a greater impact. The epidemic has affected vulnerability in Tanzania by creating a new underclass of highly vulnerable and disadvantaged people (the majority of whom are children, women, and the elderly who fell into poverty because of the impact of HIV/AIDS at the household level) and devastating particular local economies (Tumushabe 2005).

CHILDREN

The major shocks for children include being orphaned, encountering natural disasters and other disruptions, and illness. Children are particularly susceptible to malaria, other diarrheal diseases, and respiratory infections. All of these illnesses affect appetite, which in turn affects nutrition and may affect their physical and mental development, thereby increasing their future vulnerability. Children, particularly those who have been orphaned, are vulnerable to a lack of education and exploitation, including child labor in mining, sex work, commercial agriculture, and domestic work. Those orphaned as a result of HIV/AIDS also are vulnerable to being ostracized because of social stigma. Studies have suggested there are geographical area–specific factors that play a role beyond common determinants (education, income, and risk of malaria). Under-five mortality rates are four times higher in Lindi and Mtwara than they are in Kilimanjaro and Arusha. Higher percentages of children with fever are reported along the coast and in Mara and Kigoma (both on large lakes) (REPOA 2007).

EXISTING COPING METHODS

There are various coping methods depending on the type of shock, but one of the first reactions is to either sell or use assets, whether they are human, social, political, natural, physical, or financial (Sarris and Karfakis 2006). A presentation by the Tanzania MUCHALI[23] team to the Southern Africa Vulnerability Initiative in July 2010 identified the following various coping strategies in response natural disasters and food insecurity: reduction in the number and size of meals; increased livestock sales; increased sale of charcoal, handcrafts, and firewood; increased consumption of wild-food; sales of household assets; sending children to relatives; urban migration; government collaboration with development partners (free food aid, school feeding programs, nutrition and food, cash transfers, food fortification, and input subsidies).

HIV/AIDS

Coping strategies to deal with the socioeconomic impacts of HIV/AIDS include selling assets such as livestock, drafting in new adults to the household, strong social cohesion for the transfer of assets, assistance from non-governmental organizations and government interventions, and burden-shifting (such as moving the dying to rest in better-off households). In relation to food security, farming systems with low labor requirements are less vulnerable (particularly if there is good rain and a reliance on tree crops, which does not work in unimodal rainfall areas). Other food security coping strategies include cutting the number of meals consumed and cultivating short season crops such as cassava, sweet potatoes, cabbage, beans, and groundnuts for both small-scale consumption and sale. Coping strategies have resulted in casual labor by surviving adults and orphans, changes in gender roles and the division of labor (for example, one study found men learning to cook, women collecting firewood, and both sexes participating in decision making) (Tumushabe 2005).

NATURAL DISASTERS

Coping strategies for natural disasters and climate change are similar and reflect the capacities of vulnerable groups. They include selling assets, migration, reduction in consumption, income and crop diversification, and other various strategies listed here. One study listed coping strategies at the zonal level for drought and pests. Listed in order of decreasing frequency, these are pesticides, selling assets, employment elsewhere, and drought resistant crops (Birkmann 2006).

CONCLUSION

The various studies reviewed here have found varying types of vulnerability and vulnerable groups across Tanzania, as well as a plethora of coping strategies. Factors which contribute to vulnerability, but have not been discussed here include larger distances from medical services (lack of access), lack of access to finance, and other assets that would foster resiliency. Understanding local and circumstantial vulnerabilities is imperative in designing policy and agricultural development strategies so that they may be more effectively targeted.

LIMITATIONS

Although a primary focus of the government, many of these vulnerability assessments were conducted several years ago, and updating is recommended. Further, this appendix does not discuss coping strategies that have been put in place by the government, such as safety nets that reduce vulnerability.

[23] MUCHALI is the Swahili abbreviation for the Food Security and Nutrition Information System implementation framework. MUCHALI team members are analysts from government ministries, Sokoine University, FAO, and FEWS NET.

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