AGRICULTURE GLOBAL PRACTICE TECHNICAL ASSISTANCE PAPER

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GHANA: AGRICULTURAL SECTOR RISK ASSESSMENT

RISK PRIORITIZATION

Vikas Choudhary, Garry Christienson, Henri Josserand, and Stephen D'Alessandro

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Cover Photos from left to right:

1. Neil Palmer (CIAT), Failed maize crops in Ghana's Upper West Region.
2. Nana Kofi Acquah (CGIAR), Using a petrol pump to pump ground water for watering plants. Buying petrol is a more expensive way to farm.
3. IITA, Infected dried maize cobs in a farm store in Ghana.
4. Lava Kumar (IITA), Field training on yam virus disease indexing at CRI, Kumasi Ghana.

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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
AAGDS	Accelerated Agricultural Growth and Development Strategy
AfDB	African Development Bank
ARMT	Agriculture Risk Management Team
ASF	African Swine Fever
CABI	Centre for Agricultural Bioscience International
CBPP	Contagious Bovine Pleuri-Pneumonia
CFA	Communauté Financière Africaine
CFSVA	Comprehensive Food Security and Vulnerability Assessment
CIAT	Center for Tropical Agriculture
CNRM	National Centre for Meteorological Research
COCOBOD	Ghana Cocoa Board
CPUE	Catch per Unit Effort
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSSVD	Cocoa Swollen Shoot Virus Disease
DFID	Department for International Development
DSSAT	Decision Support System for Agrotechnology Transfer
DVO	District Veterinary Officers
ECHAM	European Centre Hamburg Model
EWB	Engineers Without Borders
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics Division
FFW	Food for Work
GAO	Gross Agricultural Output
GCM	Global Climate Model
GDP	Gross Domestic Product
G-8	Group of Eight
GSGDA	Ghana Shared Growth and Development Agenda

Monetary amounts are Ghanaian cedi (GH¢) unless otherwise indicated.

Acronym	Definition
GOG	Government of Ghana
GFDRR	Global Facility for Disaster Risk and Response
HA	Hectares
HPAI	Highly Pathogenic Avian Influenza
ICT	Information and Communication Technology
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IPCC AR4	Intergovernmental Panel on Climate Change Fourth Assessment Report
IPM	Integrated Pest Management
LEAP	Livelihood Empowerment Against Poverty program
METASIP	Medium Term Agricultural Sector Investment Plan
MIROC	Model for Interdisciplinary Research on Climate
MoFA	Ministry of Food and Agriculture
mt	Metric Ton
NADMO	National Disaster Management Organization
NAFCO	National Food Buffer Stock Company
NCAP	Netherlands Climate Assistance Programme
NCCSAP2	Netherlands Climate Change Studies Assistance Programme Phase 2
NGO	Nongovernmental Organization
NRM	Natural Resource Management
PPP	Public Private Partnership
PPR	Peste des petits ruminants
PPRSD	Plant Protection and Regulatory Services Directorate
SECO	Swiss Secretariat of Economic Affairs
SST	Sea Surface Temperature
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VSD	Veterinary Services Directorate

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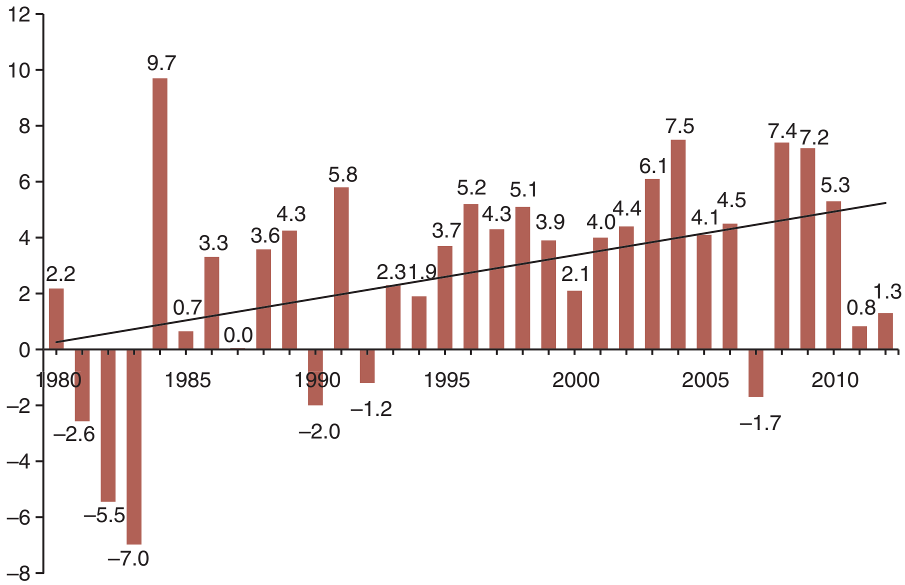
EXECUTIVE SUMMARY

In Ghana, the agricultural sector remains a backbone of the economy. Nearly two decades of productivity growth, beginning in the early 1990s, has helped put Ghana back on a path to recovery following more than a decade of economic uncertainty. With the exception of millet and sorghum, output for most crops has increased at a faster rate than population growth. During the 18-year period between 1993 and 2010, the sector experienced only 1 year (2007) of negative growth. During the same period, it recorded 3 years when growth exceeded 7 percent. The sector's remarkable recovery, facilitated in part by sustained public and private sector investments, has helped pull thousands of rural households out of extreme poverty. In the early 1990s, nearly two out of every three (63.6 percent) rural Ghanaians lived below the national poverty line. By 2006, the ratio had dropped to roughly two in five (39.2 percent), according to the National Statistical Service. Ghana is now well on track to reach the first Millennium Development Goal to halve poverty by 2015.

Sustaining the sector's growth trajectory is a top priority for the recently elected administration of President John Dramani Mahama. Success will depend, in part, on the government's ability to manage the country's ongoing transition to a more diversified economy while ensuring that the country's smallholder farmers, food processors, and other sector actors have what they need to remain competitive. It also hinges upon the ability of all stakeholders to recognize, respond, and adapt to a changing landscape: one characterized by climate change, increasing weather variability, increasing threats from pests and diseases, and higher food price volatility, among other risks. The catastrophic flooding of 2007 and more recent food price shocks served as stark reminders of the importance of effective risk management. The government recognizes more than ever the need to strengthen existing risk management systems not to only ensure continued sector growth, but also, and more important, to protect the most vulnerable communities and strengthen their resilience to future shocks.

Improved agricultural risk management is one of the core enabling actions of the Group of Eight's (G-8's) New Alliance for Food Security and Nutrition. The Agricultural Risk Management Team (ARMT) of the Agriculture and Environment Services Department of the World Bank conducted an agricultural sector risk assessment to

FIGURE ES.1. AGRICULTURE SECTOR GROWTH (%), 1980–2012



Source: Bank of Ghana 2013.

better understand the dynamics of agricultural risks and identify appropriate responses, incorporate agricultural risk perspective into decision-making, and build capacity of local stakeholders in risk assessment and management. This activity was requested by the G-8 and principally financed by the United States Agency for International Development (USAID) and Feed the Futures programs. Contributions were also received by the Multi-Donor Trust Fund on risk management, financed by the Dutch Ministry of Foreign Affairs and the Swiss Secretariat of Economic Affairs (SECO).

The objective of this assessment was to assist Ghana's government to 1) identify, analyze, quantify, and prioritize the principal risks facing the agricultural sector (that is, production, market, and enabling environment risks); 2) analyze the impact of these risks on key sector stakeholder groups (for example, farmers, vulnerable populations, food processors, government); and 3) identify and prioritize appropriate risk management interventions (that is, mitigation, transfer, coping) that will help improve stability, reduce vulnerability, and increase the resilience of agricultural systems. The analysis covers priority crops (and livestock) that are most important to farming families and other stakeholders in Ghana. This report presents a summary of the assessment's key findings.

1. The analysis shows that although risk is a permanent feature of agriculture in Ghana, its impact on output and growth is relatively low at the broader, sector level. In the 1980–2012 period, agriculture sector growth was positive in 24 out of 31 years (figure ES.1). Certain inherent strengths reduce the sector's overall vulnerability to risk while limiting associated losses. First, the diversity of agro-climatic conditions in Ghana, of production systems, and of the crops and seeds used within those systems lowers the level of aggregate risk for the agricultural sector as a whole. Second, this diversity also reduces impacts on livelihoods when production shocks occur. However, it also means that the causes, frequency, and severity of risks vary between regions, commodities, and years, with strong implications for risk management.
2. Disaggregated analysis by region and by crop showed a higher frequency of adverse production and price events. The indicative losses were also proportionally much higher than losses at the sector level. Adverse events occur in most years for some regions and commodities. However, these events are usually offset by above-trend production in other regions and other crops, so reducing the overall impact of risk.
3. Whereas the adverse impact of agricultural risk at the broader sector level is low, its frequent occurrence causes significant income volatility, especially for low-income rural households engaged

in rain-fed agriculture. It is also the principal cause of transient food insecurity, especially in the northern regions.

4. Multiple shocks cause the greatest losses, particularly when they are precipitated by drought or other weather-related risk events. For example, widespread wildfires in 1983 following a severe, multiyear drought (1981–82) caused colossal crop losses across the country, including 60,000 hectares (ha) of cocoa trees. Catastrophic flooding in 2007 following prolonged drought conditions resulted in negative sector growth for the first time since 1994.
5. Low-income, rural households, especially in the northern regions, are most susceptible to production and price shocks. With scant coping capacity, they are also the most vulnerable to the impacts of such shocks. Regional risk analysis (see appendix G) further showed that Upper East, Upper West, and Northern regions are most prone to drought and flooding, whereas the Eastern Region is relatively susceptible to fluctuations in maize and cassava production.
6. Given Ghana's heavy reliance on rain-fed agriculture, drought causes the highest level of cumulative losses with the greatest impact on livelihoods, particularly in the northern savannah zones. Drought events include the late onset of rains, the early cessation of rains, and low cumulative rainfall, and are most likely to affect sorghum, millet, maize, and groundnuts. In addition, flash flooding resulting from excessive rainfall occurs with relative frequency across Ghana, but rarely causes widespread destruction. Crops most affected include cassava, rice, yams, and groundnuts. Existing capacity among stakeholders to mitigate such risks or cope in their aftermath is severely limited.
7. Posing a constant threat to both crops and livestock, pests and diseases constitute the second most important production risk after drought. Cassava, cocoa, and plantain are among those crops most susceptible to attack (see appendix H). However, current control measures, in some cases with cocoa and cassava, have been relatively effective.
8. Price volatility poses the most important market risk facing agricultural stakeholders. This is especially true for maize; growing maize exports in recent years have contributed to higher levels of price volatility in domestic food markets. In addition to maize, plantain, cassava, and yams are among the crops most susceptible to adverse impacts from price variability.
9. Among enabling environment risks, the assessment calls attention to concerns over weak capacity among state-level institutions tasked to manage and respond to the most important risks facing the agricultural sector. First, the analysis calls into question the Ghana Cocoa Board's (COCOBOD's) ability to move forward to effectively manage both production and price risk for cocoa; this is occurring within a context of declining international prices and current budget shortfalls. Second, the assessment raises questions over the National Disaster Management Organization's (NADMO's) operational funding and its capacity to respond to multiple risk events.

This assessment offers the following preliminary recommendations for consideration based upon its analysis of risks to various commodities, the regional distribution of vulnerability to risks, and the filtering of potential risk management measures:

1. Promoting improved farming practices (for example, integrated pest management, or IPM), especially in the south, and conservation agriculture measures (especially in the north).
2. Strengthening improved seed (that is, drought, pest, and disease resistant) development and distribution systems.
3. Upgrading information systems to ensure availability of timely and relevant weather, prices, and pest and disease information to farmers, traders and other stakeholders, coupled with relevant technical advice and knowledge. This also includes market information about production, stocks, and trade of different commodities.
4. Promoting improved water management (for example, soil and water conservation measures) and irrigation (especially micro-level) and drainage infrastructure (especially, in flood-prone areas).
5. Strengthening extension systems (for example, face-to-face, information communications technology based, peer to peer) to ensure that farmers

have better access to technology, agronomic advice, and other resources needed to put in place new mitigation measures and improve existing methods.

6. Improving infrastructure (on-farm and off-farm storage, warehouses, roads, and so on) to improve productivity, reduce post-harvest losses, and help manage the risk of price volatility.
7. Considering recent news about phased withdrawal of COCOBOD from a centralized disease control system and its potential consequences on pest and disease outbreak and cocoa production, a more systemic approach of pest and disease management is required to 1) ensure a smooth transition from a centralized system of pest and disease control to an effective decentralized model that is managed at the farmer and community levels: 2) improve farmer access to affordable and quality fungicides and insecticides; 3) strengthen effectiveness of fungicide applications against black pod; and 4) facilitate improved insecticide application techniques against capsids and mirids, with an emphasis on combining good spray coverage with minimal spray volumes.

It is hoped that this study will contribute to a better understanding among policy makers, government officials, including at the Ministry of Food and Agriculture (MoFA), and the wider development community of the most important risks facing the agricultural sector in Ghana. It is expected that the outputs of this assessment will serve to inform the Medium-Term Agricultural Sector Investment Plan (METASIP) and its various components to ensure sustainability of agricultural investments and enhanced agricultural resilience. It is also hoped that the findings of this report will lead to improved decision making and successful implementation over time of a comprehensive, coordinated, and ultimately effective risk management framework.

Many of the recommendations suggested in the report are already being considered or implemented and are having positive impacts, albeit at a lower, localized level. Greater emphasis should be placed on scaling up these interventions to the national level to make a more meaningful impact on the agricultural sector in Ghana. This would require understanding the landscape of these interventions, assessing their relative efficacy, understanding principal barriers and challenges to success and scale up, and identifying leverage points and necessary interventions to increase access to a majority of agricultural sector stakeholders. Assessing solutions to help prioritize specific interventions, scaling up priority programs, and putting in place a risk management road map will be the next steps in the process of building resilience and reducing the vulnerability of households adversely affected by agricultural risks.

CHAPTER ONE
INTRODUCTION

By most measures, agriculture remains a vital sector to the Ghanaian economy. The sector in 2012 accounted for 23 percent of gross domestic product (GDP), 56 percent of the labor force, and 35 percent of foreign exchange earnings.[1] Following more than a decade of economic instability (1980–1992) punctuated by 5 years of negative growth, the sector has since grown at an average annual rate of 4.0 percent. Although falling well short of growth targets under the Comprehensive Africa Agriculture Development Programme (CAADP), the sector has nonetheless made an important contribution to economic growth and poverty reduction in recent decades.

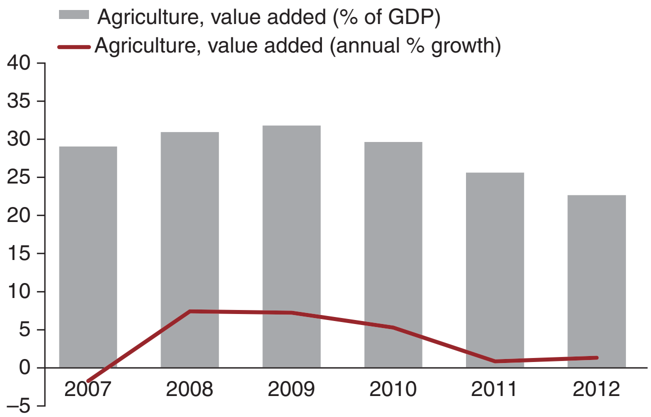
Moving forward, raising agricultural productivity—particularly among smallholder farmers who dominate the agricultural landscape—remains central to the government's rural sector growth and overall economic development strategy, as outlined in its Medium-Term Agricultural Sector Investment Plan (METASIP). Continued growth is expected, driven by new investments in productivity-enhancing technologies and yield gains.

The above narrative, however, masks uncertainties that pose a notable challenge to continued sector growth. The agricultural sector's performance and share in most key socioeconomic indicators has been declining in recent years amid strong expansion in other sectors of the economy (figure 1.1; see also appendix H). Yields have mostly stagnated with increases in output mainly due to the expansion of cultivated area. The share of agriculture raw materials exports among total merchandise exports has dropped by roughly half since the mid-1990s, whereas imports have increased nearly fivefold during the same period. This slide is partly due to a seemingly unbreakable cycle of inadequate input supplies, inappropriate technology, low levels of savings and on-farm investment, and low output and productivity growth.

Compounding these challenges is the high level of uncertainty that characterizes all things agricultural. Owing to a strong reliance on rain-fed, small-scale production systems that predominate, the sector is susceptible to downside risks. It is also

[1] Statistical Review, Bank of Ghana, June 2013.

FIGURE 1.1. AGRICULTURE SECTOR PERFORMANCE, 2007–12



Source: Bank of Ghana; World Development Indicators Database 2014.

TABLE 1.1. METASIP'S (2011–15) SIX PROGRAM AREAS AND AGRICULTURAL RISKS

METASIP (2011–16) Program Areas	Relevance for Agricultural Risk Management
1. Food security and emergency preparedness	Crop failures (due to droughts, pest/disease outbreaks, flood, and so on) and price spikes are two principal causes of transient food insecurity.
2. Increased growth in incomes	Agricultural risk causes income volatility for agricultural households.
3. Increased competitiveness and enhanced market integration	Risk management is crucial for sustained competitiveness and market integration may increase exposure to market risks.
4. Sustainable management of land and water	Sustainable management of land and water resources is one of the important instruments for managing production risks.
5. Science and technology application	Many risk management solutions require application of science and technology.
6. Improved institutional coordination	Integrated risk management will necessitate improved institutional coordination.

Source: Ministry of Food and Agriculture (MoFA); authors' notes.

due to variations in markets and to other events outside the ambit of agriculture. Smallholder farmers, market traders, agro-dealers, and other agricultural stakeholders often have limited capacity to manage such risks or cope with resulting losses when shocks occur. Setting the sector firmly on a path for future growth will thus require effective ways to manage risks within Ghana's agriculture systems. It will also require strengthening the resilience of all stakeholders and ensuring that appropriate risk management mechanisms (that is, mitigation, transfer, and coping) and related institutions are in place to support them. Furthermore, attaining METASIP objectives will require an explicit focus on agricultural risk since it cuts across all METASIP program areas (see table 1.1).

Improved agricultural risk management is one of the core enabling actions of the Group of Eight's (G-8's) New Alliance for Food Security and Nutrition. In 2012, the G-8 highlighted the need for conducting national agricultural sector risk assessments in close partnership with the New Alliance countries (Ghana, Ethiopia, Tanzania, Mozambique, Ivory Coast, and Burkina Faso) to provide a robust analytical underpinning to the countries' agricultural development strategies and investment plans.

It is within this context that the World Bank, with support from the G-8 and the United States Agency for International Development (USAID), commissioned the present study. It is one of a series of agricultural sector risk assessments that the World Bank agreed to conduct within the framework of the G-8's New Alliance for Food Security and Nutrition and in close partnership with partner countries. The objectives of this study are 1) to analyze the frequency and severity of different types of agriculture risk (that is, related to production, market, enabling environment) in Ghana; 2) to determine the indicative cost of these adverse events; and 3) to develop recommendations on how best to manage the risks of greatest importance to Ghana's agricultural economy.

Owing to the diversity of agro-climatic conditions and related production systems in Ghana, the risk analysis required a combination of regional and commodity-specific approaches (see appendixes A and B). The study focuses on all 10 of Ghana's administrative regions and a select basket of priority crops: cocoa, cassava, maize, yams, groundnuts, plantain, sorghum, millet, and rice. These crops accounted for approximately 81 percent of the area cropped and 76 percent of the value of gross agricultural output in 2011 (FAOSTAT). Risks to livestock

FIGURE 1.2. AGRICULTURAL SECTOR RISK MANAGEMENT PROCESS FLOW

Source: Agricultural Risk Management Team of the World Bank.

production were also analyzed but to a lesser extent due to the limited availability of suitable statistics. The relative effectiveness of existing risk management measures was also assessed via: 1) an appraisal of public interventions in the rural sector, 2) discussions with rural stakeholders directly involved in risk management, and 3) a technical consultation on the relative benefits of risk mitigation interventions (for example, scalability, sustainability, impact on poverty reduction).

The study draws on, among other resources: rainfall data for the period 1981–2011 from the Ghana Meteorological Service; national crop production data for the period 1991–2011 and national producer price data for the period 1991–2010 from FAOSTAT; regional crop production data for the period 1992–2008 from the Ministry of Food and Agriculture (MoFA); archives of the National Disaster Management Organization (NADMO); and qualitative data collected through direct consultations with stakeholders.

The report begins with an overview of agriculture in Ghana in chapter 2, followed by an assessment of the main agricultural risks in chapter 3. Chapter 4 analyzes the frequency and severity of the major risks identified and assesses their impact. Stakeholder perception of these risks is examined in chapter 5. The study concludes in chapter 6 with an assessment of the priorities for risk management and a discussion of risk management measures.

The prescribed methodology contains logical steps within two consecutive phases (figure 1.2). Phase I, for which this study is the primary deliverable, has focused on identifying and prioritizing the major risks that cause adverse shocks to the sector. Following in-depth analysis of baseline data, the team conducted broad-based, in-country consultations with stakeholders in May–June 2013. These included individual farmers, farmer groupings, input suppliers, market traders, food processors, and representatives of the government and of research institutes. The results of this assessment will provide the conceptual basis for Phase II, during which a team of specialized experts will be fielded to deepen the analysis and develop a multitiered strategy for managing the priority risks.

By the end of this activity, the World Bank in coordination with the government of Ghana (GOG) and sector stakeholders will have developed and validated a matrix of priority interventions related to risk mitigation, transfer, and coping, within a comprehensive risk management framework. The outputs of this assessment will serve to inform the ongoing METASIP and its various components to ensure sustainability of agricultural investments and enhanced agricultural resilience over time.

CHAPTER TWO

OVERVIEW OF AGRICULTURAL SYSTEMS IN GHANA

Providing context for analysis and discussion of agricultural sector risk, this chapter presents an overview of the agricultural sector in Ghana. Sector characteristics most pertinent to risk are thus given particular attention. Analysis primarily covers the period 1991–2010 to assess the frequency and severity of the most important risks.

The agriculture resource base is characterized by an abundance of land and diverse agro-ecological conditions. Of the 13.7 million hectares of agricultural land, only 7.85 million hectares (58 percent) are under cultivation. Owing to the diversity of agro-ecological conditions, crop production ranges from millet and sorghum in the semi-arid north, to maize, cassava, and other root crops in central Ghana, and cocoa, plantain, palm oil, and rubber in the forest zones of the south. These conditions also facilitate surplus production of most crops. Livestock production is of lesser importance, representing 7.5 percent of agricultural GDP (including cocoa).

The high proportion of unused agricultural land also highlights some of the major constraints that the sector faces: low levels of mechanization, low soil fertility, and limited access to water for irrigation. Roughly 90 percent of farms in Ghana are small (< 2 ha) and rely on manual labor or animal traction. Much of the land in the north and center of Ghana (approximately two-thirds of the total land area) consists of highly weathered soils with low fertility and low water-holding capacity. Only 30,000 hectares are irrigated, equivalent to 0.2 percent of total agricultural land. These constraints limit the ability to raise output and increase vulnerability to drought.

AGRO-CLIMATIC CONDITIONS

There are six agro-ecological zones (figure 2.1), of which five are important for agriculture. They range from the hot, dry savannah conditions in the north to tropical and deciduous forests in the south and southwest (table 2.1). The northern savannah regions are hot and dry with a uni-modal rainfall distribution, and a growing season of 200 to 240 days. Agriculture is demanding in these regions. Agro-climatic

FIGURE 2.1. ADMINISTRATIVE REGIONS AND AGRO-ECOLOGICAL ZONES

Source: Adapted from World Food Programme 2009.

conditions improve gradually moving from north to south, with increasing rainfall and the emergence of a bi-modal rainfall distribution. The central and southern regions have a longer growing season (250–330 days) and greater potential for double cropping. The exception is the small coastal savannah region in the south, including greater Accra, which has very low rainfall and is highly prone to drought. This region is of limited importance for agriculture.

The savannah and transitional zones are mostly flat to undulating, broken only by the shallow drainage basins of the Volta river system in the center and to the west. Vegetation is light savannah forest. The soils are light, highly weathered loams or sandy loams with low organic matter, low mineral fertility, and low water-holding capacity. Topography, vegetation, and soil types then change when moving south into the forest zones. The land becomes more undulating and deciduous forests predominate in most areas except for the rain forest zone in the southwest. Soil fertility improves due to higher organic matter and mineral fertility and the soils are more friable and better suited to agriculture. The large deciduous forest zone is highly suited to production of cocoa, other tree crops (palm, rubber), plantain, root crops, and high-value fruit and vegetable crops for export.

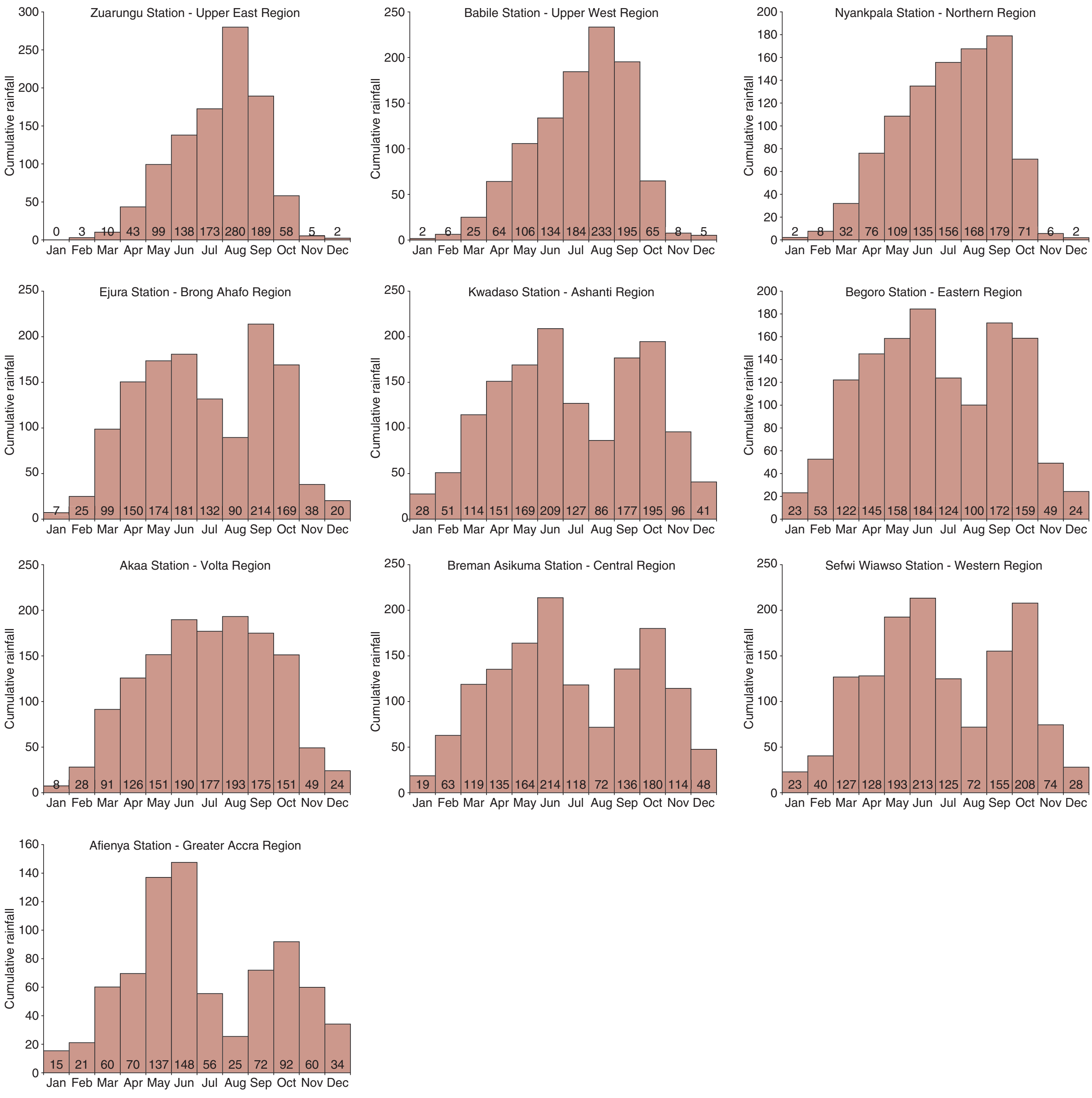
These characteristics have three important implications for agricultural sector risk. First, the diversity of agro-climatic conditions significantly reduces the level of covariate risk for the sector as a whole. Second, the wide diversity of crops grown enhances the level of variability in the frequency, severity, and causes of production risk between regions and between years. Drought and fire risks are much higher in the northern regions, for example, owing to lower rainfall and the uni-modal rainfall distribution. The drier conditions in the north also

TABLE 2.1. AGRO-ECOLOGICAL ZONES OF GHANA (NORTH TO SOUTH)

Zone	Rainfall (mm)	Production System	Area (km^2)
Sudan savannah	800–1,200 (unimodal)	Sorghum, millet, groundnut, cattle, small ruminants	2,200 (0.9%)
Guinea savannah	800–1,200 (unimodal)	Sorghum, millet, maize, groundnut, cattle, small ruminants	147,900 (61.9%)
Transitional zone	1,100–1,400 (bi-modal)	Maize, cassava, yam, small ruminants	8,400 (3.5%)
Deciduous forest	1,200–1,600 (bi-modal)	Cocoa, cassava, maize, plantain, small ruminants	66,000 (27.8%)
Rain forest	800–2,800 (bi-modal)	Cassava, yam, plantain, small ruminants	9,500 (4.0%)
Coastal savannah	600–1,200 (bi-modal)	Not applicable	4,500 (1.9%)

Source: MoFA 2010.

FIGURE 2.2. MONTHLY RAINFALL PATTERNS BY REGION



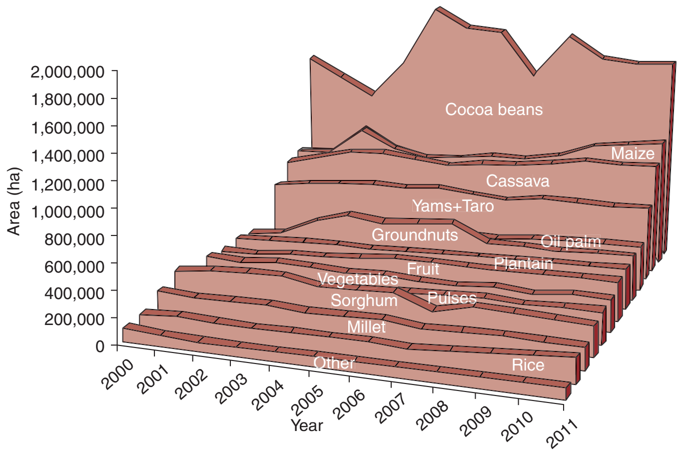
Source: Ghana Meteorological Service; World Bank.

increase the risk of insect pests such as armyworm and variegated grasshopper. Drought risk falls moving from north to south, but the risk of pests and diseases such as stem borer, capsid, black pod, sigatoka, and fruit fly increases because of higher temperature and humidity. Third, diversified livelihood systems and income levels make some regions less prone and less vulnerable to risks than other regions.

RAINFALL PATTERNS AND TRENDS

Analysis of rainfall patterns for the period 1981–2010 confirms the regional differences in rainfall distribution (figure 2.2). In the savannah zones, most rainfall occurs during the summer months (June–September), followed by a prolonged low rainfall period from

FIGURE 2.3. COMPOSITION OF CROP PRODUCTION



Source: FAOSTAT 2011.

TABLE 2.2. TRENDS IN CROP PRODUCTION, 1990–2011

	Production	Area	Yield
Sorghum	70%	6.5%	62%
Millet	131%	8.7%	110%
Maize	133%	84%	28%
Rice	287%	151%	54%
Cassava	217%	106%	58%
Yam	243%	125%	63%
Plantain	261%	118%	67%
Groundnuts	449%	207%	82%
Cocoa	155%	133%	9%

Source: FAOSTAT; average of 1990–91 vs 2009–11.

November–March. A bi-modal rainfall pattern is observed in the transitional and forest zones with the main rainfall from March–July, followed by a minor rainy season from September–November.

Analysis of the main growing season (May–July) rainfall data for the period 1970–2008 shows that there has been no secular trend in rainfall for any of the 10 regions (see appendix I).

CROP PRODUCTION SYSTEMS

Three commodities dominate production: cocoa, with 24 percent of total area, maize with 15 percent, and cassava at 13 percent (figure 2.3). Cocoa accounts for the largest area and the bulk of agriculture export earnings, whereas maize and cassava are the main food staples. The remaining land is planted to more than 40 other food and cash crops, with yams, oil palm, groundnuts, vegetables, and plantain the most important. With the exception of cocoa and groundnuts, where the area has fluctuated in the past, the composition of crop production is fairly stable. This combination of diversity and stability ensures an adequate supply of staple foods at aggregate level.

There is less diversity at the regional level, especially in the north where agro-climatic conditions are less favorable. Sorghum and millet are the main food crops in the Sudan savannah, with groundnuts as the main cash crop (table 2.2). Livestock production, especially cattle. is also important. As rainfall increases, maize gradually replaces sorghum and millet as the major food crop in the Guinea savannah, the largest agro-climatic zone.

Moving south into the transition zone, cassava and yam begin to replace maize as the major food crops and livestock production becomes less important. Cocoa dominates land use in the deciduous forest zone, with cassava, maize and plantain as the main food crops. These food crops also predominate in the high rainfall forest zone, which is less suited to cocoa production. The small coastal savannah region is unsuited to agricultural production.

Most farmers grow a range of food and cash crops. Production risks are reduced as a consequence, both at the farm level and for the agricultural sector as a whole. Farmers' ability to diversify also allows them to change their crop composition quite readily in response to changes in the profitability of any given crop.

PRODUCTION TRENDS

Crop production has grown steadily, with an average annual increase in the crop production index of 12.9 percent from 1990–2011 (see figure 3.1), according to the World Development Indicators. This growth has been driven largely by area expansion, with the total cultivated area increasing from 2.9 million ha in 1990 to 6.76 million ha in 2011 (FAOSTAT). Crop yields increased little for most of this period, but have risen since the mid-2000s. Yields remain relatively low, despite this increase. The area expansion appears to be largely a result of population increase in the rural areas. This has resulted in a

TABLE 2.3. COEFFICIENTS OF VARIATION FOR CROP PRODUCTION, 1990–2011

	Production	Area	Yield
Sorghum	0.20	0.13	0.16
Millet	0.23	0.10	0.18*
Maize	0.13	0.08*	0.07*
Rice	0.15*	0.11*	0.22*
Cassava	0.09*	0.06*	0.06*
Yam	0.13*	0.11*	0.10*
Plantain	0.07*	0.05*	0.06*
Groundnuts	0.24*	0.25*	0.15*
Cocoa	0.17	0.15*	0.14

Source: FAOSTAT.
*Adjusted for trend using the Cuddy-Della Valle Index.

limited overall change in the nature and composition of production, as the small-scale subsistence farmers who dominate production tend to retain a diversified crop mix when they expand.

Production of root crops, plantain, groundnuts, and rice has increased the most, whereas that of traditional cereal crops has grown less rapidly. This gradual shift to root crops has improved the stability of the food supply and resulted in a more varied food diet—both of which improve food security.

PRODUCTION VARIABILITY

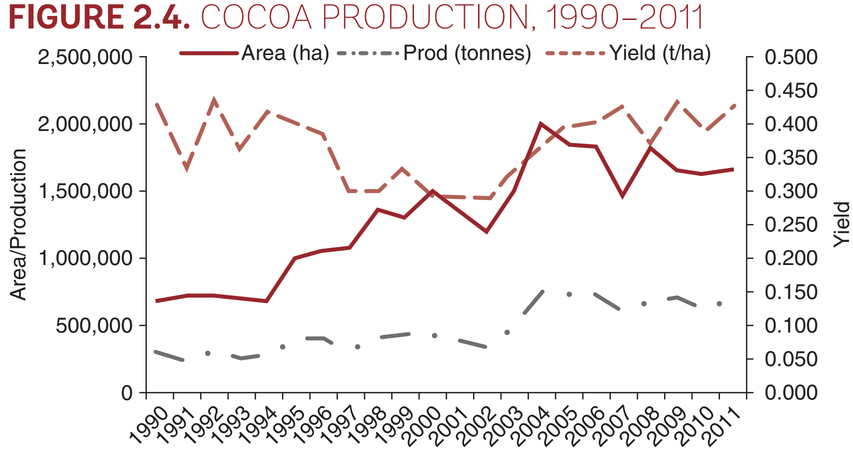
Comparisons of production variability, as measured by coefficients of variation, show that most of the main crops exhibit moderate to low levels of interannual variation (table 2.3). Variability is highest for the crops that predominate in the drier, savannah zones (sorghum, millet, groundnuts), as would be expected. Cassava, yam, and plantain exhibit the lowest levels of variability, consistent with the higher drought resistance of root crops and the higher rainfall zones in which these crops predominate. The variability of cocoa and maize production is intermediate between these two groups.

Trends in production and production variability are illustrated further for the three main crops (that is, cocoa, maize, and cassava), and in figures 2.4, 2.5, and 2.6. The higher levels of variability of cocoa relative to maize and cassava are evident, and variability in both area and yield are responsible for the interannual variation of cocoa production. Yield variation appears to be the main determinant of variability in maize production. Cassava production is characterized by low levels of variation in both area and yields and hence in overall production. It is also notable that production drops for the three crops occur in different years; evidence of the generally low levels of covariate risk in Ghana as a result of its agro-ecological diversity.

FOOD SUPPLY AND DEMAND

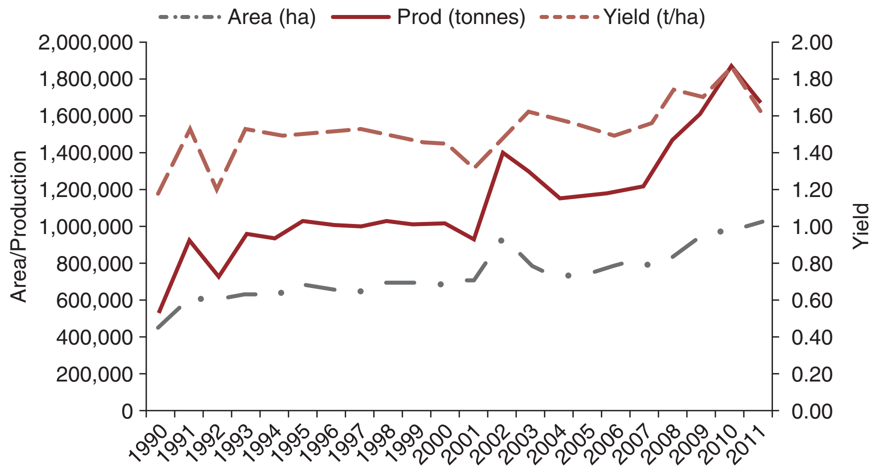
Ghana currently produces a surplus of most food crops (table 2.4). Rice is the only food staple for which there is a structural deficit, with imports accounting for approximately 55 percent of total consumption. Ghana also imports about half of its meat requirements, both through imports of meat from the world market and substantial (and under-reported) flows of live animals from

FIGURE 2.4. COCOA PRODUCTION, 1990–2011



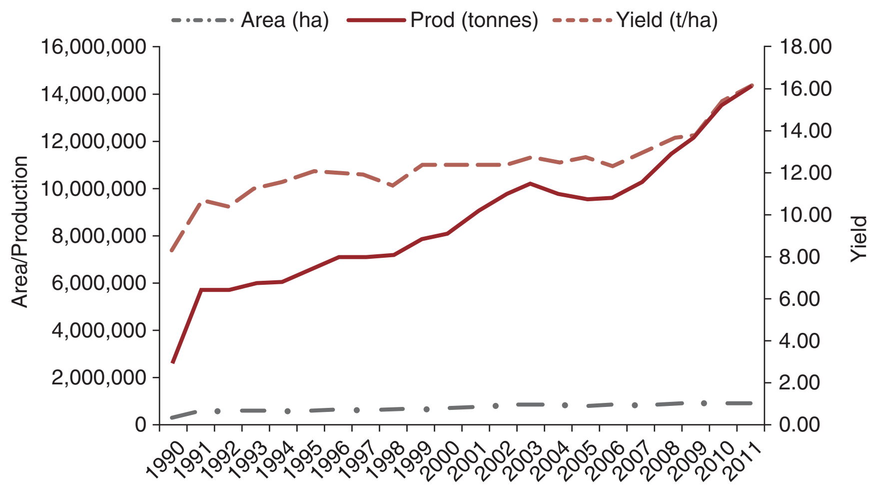
Source: FAOSTAT.

FIGURE 2.5. MAIZE PRODUCTION, 1990–2011



Source: FAOSTAT.

FIGURE 2.6. CASSAVA PRODUCTION, 1990–2011



Source: FAOSTAT.

TABLE 2.4. DOMESTIC FOOD SUPPLY AND DEMAND FOR FOOD STAPLES

Commodity	Domestic Production (000 mt)		Available for Human Consumption (000 mt)		Estimated Aggregate Demand (000 mt)		Deficit/Surplus (000 mt)	
	2009	2010	2009	2010	2009	2010	2009	2010
Maize	1619.6	1871.7	1197.7	1310.2	1052.1	1060.9	145.6	249.3
Rice (milled)*	234.9	294.9	204.3	256.6	576.5	581.4	−372.2	−324.8
Millet	245.5	218.9	213.6	190.5	24.0	24.2	189.6	166.3
Sorghum	350.5	324.4	304.9	282.3	12.0	24.2	292.9	258.1
Cassava	12,230.6	13,504.1	8,561.4	9,452.9	3,672.9	3,703.7	4,888.6	5,749.2
Yam	5,777.8	5,960.5	4,622.2	4,768.4	1,006.5	3,027.9	3,615.7	1,740.5
Cocoyam	1,504.0	1,354.8	1,428.8	1,287.1	960.9	968.9	467.9	318.2
Plantain	3,562.5	3,537.7	3,028.1	3,007.1	2,030.0	2,054.1	991.12	953.0
Groundnut	204.9	530.9	174.2	477.8	120.1	290.7	54.1	187.1

Sources: MoFA, *2009 Annual Progress Report*; *Agriculture in Ghana: Facts and Figures* (2010).
Note: mt = metric ton.
*Sixty percent of paddy rice.

Burkina Faso, Mali, Niger, and other countries. Ghana's agricultural sector is also closely linked to major regional flows of primary commodities. Maize flows across the border according to the year and season. In addition to live animals, inflows of cowpeas may also be significant. As in neighboring countries, significant shifts in regional food production directly impact prices and other market dynamics in Ghana.

AGRICULTURAL MARKETS AND PRODUCER PRICE TRENDS

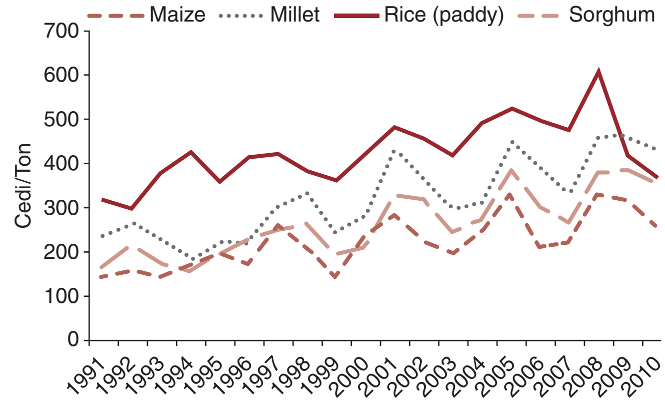
There are active markets for all major commodities, including a strong demand from international markets for Ghanaian cocoa. Surplus food commodities are exported to neighboring countries, particularly to the food deficit countries north of Ghana such as Burkina Faso, Niger, and Mali. Trade with the border regions of Côte d'Ivoire and Togo is also active, but on a much smaller scale. Private traders buy surplus production at the village level for sale at regional markets throughout Ghana. They appear to collude in some cases (for example, yams) to keep producer prices low, and to limit the number of traders to preserve their monopsony powers. Domestic markets have become deeper and more efficient, nevertheless, in response to improved infrastructure (roads, communications) and the growth of numerous regional market centers in northern and central Ghana.

The analysis of price trends was based on national prices for the period 1991–2010, using FAOSTAT data. Real prices are used for analysis (deflated by the consumer price index), as very high inflation during this period makes it difficult to draw useful conclusions from trends in nominal prices.

FOOD CROPS

The cereals market is dominated by maize and rice, but the markets for all cereals are active and competitive. Maize is the second most important food staple after cassava and is sold on domestic markets and for export to neighboring countries. Demand for maize for feed is also increasing for the poultry industry. The poultry feed market is dominated by imported yellow maize, however, with domestically produced white maize purchased intermittently for animal feed. Sorghum and millet are grown in the northern regions, as these crops are more tolerant of moisture stress. Both commodities are actively traded, including export to neighboring countries.

FIGURE 2.7. TRENDS IN REAL CEREAL PRICES, 1991–2010

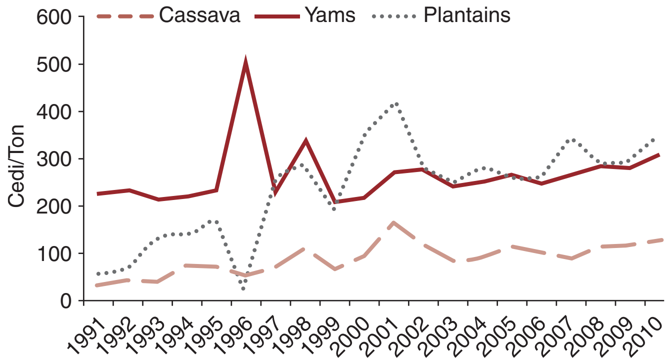


Source: FAOSTAT.

Real producer prices for cereals have increased steadily since 1991, accompanied by an increase in price variability (figure 2.7). Note also the extent to which cereal prices track each other, indicating how close they are as food substitutes. The price spike in 2001 is due to the combined impact of high inflation and devaluation of the cedi (World Food Program 2002), and in 2005 to localized droughts and bushfires in northern Ghana. In contrast, the price spike in 2008 was exogenously driven, reflecting the impact of the global food price crisis. In general, rice prices exhibit lower interannual variability as the reliance on imports results in a more stable supply. This pattern was broken by the global food crisis, however, which resulted in sharp price changes both during and after the crisis.

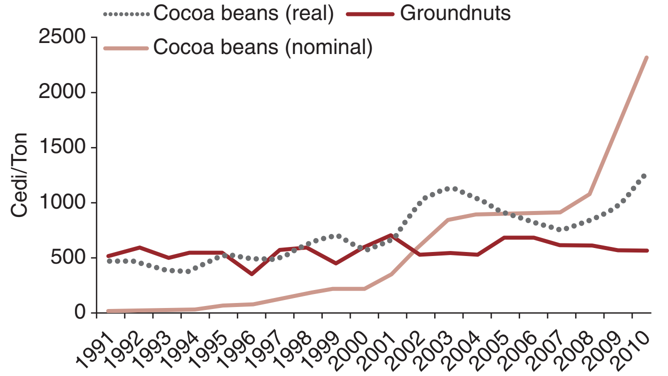
Producer prices of the main root crops also tend to move together (figure 2.8) as they are close substitutes for consumption and are grown in similar agro-climatic zones. Root crop prices have become more stable since 2000 in response to increased supply and greater potential for exports. The higher variability of plantain production, as a result of frequent storm damage, results in more variation in producer prices. Plantain is also sold on domestic markets and for export.

FIGURE 2.8. TRENDS IN REAL PRICES FOR ROOT CROPS AND PLANTAIN, 1991–2010



Source: FAOSTAT.

FIGURE 2.9. PRODUCER PRICES FOR COCOA AND GROUNDNUTS, 1991–2010



Source: FAOSTAT; COCOBOD.

The increasing volume of food crop exports has introduced an additional source of price volatility to domestic food markets. This is particularly true for cereal crops, first because production is concentrated in the more drought-prone transition and northern regions, which results in substantial variation in the size of the marketable surplus. Second, the level of demand for cereal imports from Burkina Faso, Niger, and Mali is also highly variable because of the even more drought-prone conditions in which cereals are produced in these countries.

CASH CROPS

The markets for cash crops differ, depending on the reliance on domestic versus export markets and the extent to which government intervenes in these markets. There is a high demand for Ghanaian cocoa on international markets. Producer prices for cocoa beans are set by the Ghana Cocoa Board (COCOBOD) in local currency, based on international prices. Nominal producer prices have never been reduced, although they frequently fall in real terms when the annual adjustment is insufficient to compensate for inflation (figure 2.9). Despite these variations, real producer prices have increased by more than 170 percent since 1991. The risk associated with variation in international prices is assumed by COCOBOD.

A high proportion of groundnuts were exported to western markets until the mid 2000s when this market was lost due to high alfatoxin levels. Most production is now sold locally and it remains an important cash crop for farmers in the north. Groundnut prices are set freely, with minimal increase in real prices since 1991.

Of the other main cash crops, most palm fruit is sold for processing for the domestic market. Four large-scale, privately owned, corporate farming and processing entities meet the domestic demand for refined oil (170,000–180,000 tons per year) and small-scale informal processors supply a similar volume of lower quality (unrefined oil). There is no government intervention in the palm oil markets. Cotton is also sold on international markets but prices are set freely, with no government intervention.

LIVESTOCK PRODUCTION

The livestock sub-sector is estimated to account for about 7 percent of the nation's agricultural gross domestic product. However, anecdotal evidence suggests that official livestock projections are overly conservative, given large inflows and settling in Ghana of livestock from neighboring countries (large and small ruminants). The proportion is likely somewhat higher (approximately 8.6 percent, according to authors' estimates). Nonetheless, the sub-sector is a significant source of income, meat, milk, organic fertilizer, and means of savings for rural households, especially in the northern part of the country.

Livestock distribution and production systems have been strongly influenced by geography and climate.

The greatest numbers of large and small ruminants have historically been found in the Guinea and Sudan savannah ecological zones spanning the Northern, Upper West, and Upper East regions (together making up just over 40 percent of Ghana's land area). Conditions there remain very favorable to extensive animal husbandry; 10-year cumulative rainfall averages in these regions range from 1,200 mm per year in the Northern Region to about 940 mm per year in the Upper East and West.

According to the 1996 national livestock census, the spatial distribution of livestock was well established, with nearly three-quarters of all cattle concentrated in the Northern, Upper West, and Upper East regions. Cattle density is highest in the Upper East, where land is less suitable for agricultural production relative to other northern regions.

Pastoralism is the dominant form of livestock system, especially in the northern part of the country. Large-scale north-south-north migration of livestock constitutes an important vector for contagious diseases. Farmers with farmland in or near the traditional grazing corridors also complain widely of damage to their crops from cattle that graze or trample cropland in their path. Itinerant herders are typically Fulani herdsmen who bring their cattle south from Niger, Mali, and Burkina Faso each year. This migration follows a tradition of transhumance grazing that extends from the Sahel to the northern reaches of the forest zones in Ghana, Côte d'Ivoire, Togo, and Benin. They move south after the rainy season as the pasture in the Sahel dries out, selling many of their cattle for slaughter in the larger urban markets as they go. They then return north when the rainy season starts again. Their herds are typically large, often with several hundred cattle, many of which are owned by farmers who contract the Fulani to herd them.

Swine production is widespread; most pig stock is held at the household level but there is some industrial production in peri-urban areas. Swine ownership is also widespread in northern regions where the average livestock-owning rural household keeps two pigs.[2] With an estimated 800,000 swine in the northern regions, the national total is also likely well above official estimates.

The poultry sector is sharply divided between family holdings and small- to large-scale industrial poultry farms (for broilers, layers, and even a few chick or guinea fowl hatcheries).[3] Smallholder production is highest in the forest agro-ecological zone and in northern savannah areas. Nationwide, chicken production (ranging from the extensive village systems to semicommercial groups) represent between 11 percent and 13 percent of rural household incomes.[4]

Most poultry (an estimated 80 percent) is traditionally raised; the remainder is produced commercially, especially in the Ashanti and Greater Accra regions. Commercial birds are primarily raised for eggs, as domestic production for poultry meat currently faces stiff competition from U.S., Brazilian, and European imports. Most commercial poultry operations are located around the urban areas of the Greater Accra and Ashanti regions. There are an estimated 380 large-scale farms, each stocking more than 10,000 birds. Most are egg producers, although a limited number raise exotic breeds of broiler chickens, guinea fowl, and turkeys for meat. Such operations manage their own feed mills, and some maintain hatcheries and parent stocks. In addition, there are nearly 1,000 small- to medium-scale facilities (consisting of 50 to 10,000 birds) that rely on external suppliers for day-old chicks and feed. Currently, there are an estimated 11 million chickens in industrial operations. Their annual feed consumption can amount to 600,000 tons of maize per year. Some portion of this is imported as yellow maize,[5] a major source of feed for commercial poultry producers, but the majority comes from domestic production (white).[6]

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[2] CFSVA 2012, WFP-MoFA.

[3] Approximately 87 percent of chicken producers are in rural areas, of which 97 percent are smallholders with less than 500 birds (IFPRI/DFID 2008).

[4] IFPRI/DFID 2008.

[5] Annual maize imports in the past 10 years have ranged between 10,000 and 60,000 tons.

[6] Aside from Nigeria (50 percent of West Africa's total), Ghana is by far the largest regional producer of maize, but the relative share of maize in total human cereal consumption in Ghana is only 37 percent (FAO 2008, 2009 commodity balances).

PRINCIPAL CONSTRAINTS TO AGRICULTURAL PRODUCTION

Ghana relies heavily on rain-fed agriculture and low-input, low-output smallholder systems (90 percent, or less than 2 ha). Soils are coarse with low water-holding capacity. In the absence of good water management (less than 0.2 percent, or 30,000 ha, of agricultural land is irrigated), crops are often subject to water stress during the growing season. Low agricultural productivity in Ghana is largely attributed to low soil fertility and limited farmer use of fertilizers, improved seeds, and agro-chemicals (for example, insecticides). There is a high reliance on family labor in the absence of mechanized equipment and services. Poor access to inputs and financial services further contributes to low adoption of productivity-enhancing technologies. Underdeveloped road networks, especially rural feeder roads, constrain farmers' access to markets. Inadequate storage infrastructure further reduces farmer incentives to invest in modern inputs. For the livestock sub-sector, chief constraints include low-performing breeds; insufficient feeding; high cost of poultry feed; poor husbandry management; strong competition from imports; and poor post-production management. These constraints hinder sector growth by limiting producer ability to raise output. They can also amplify the impacts of adverse shocks when they occur by weakening the capacity of various stakeholders to manage their exposure and recover from resulting losses.

CHAPTER THREE

AGRICULTURAL SECTOR RISKS

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

PRODUCTION RISKS

Drought, floods, bushfires, and pests and diseases are the main sources of production risk. The incidence of these and other adverse events is shown in figure 3.1, based on reports of adverse events for 1980–2011. Drought emerges as the most common source of major production shocks, followed by pests and diseases and floods. Related risk events may occur in isolation, but can also present as multiple, overlapping shocks, with far greater impacts and higher associated losses.

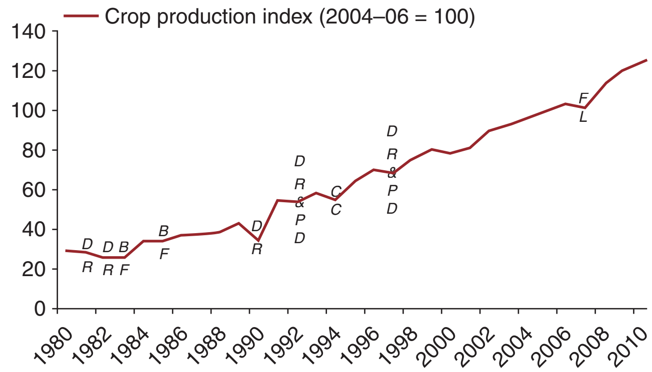
WEATHER VARIABLES

Drought

An agricultural drought occurs when a deficit of soil moisture significantly reduces crop yields. It can occur in response to low overall annual rainfall or to abnormalities in the timing and distribution of annual rainfall. Inadequate rainfall at key periods during the crop production cycle (seeding, flowering, and grain filling) affects crop yields, even when overall rainfall is comparable to long-term norms. During these periods, a soil moisture deficit as short as 10 days can have a major impact on crop yields.

Drought is typically defined relative to some long-term average balance between precipitation and evapotranspiration, which is considered "normal" for a particular location at a particular time of year. Drought is thus a relative concept in that sub-optimal soil moisture levels and crop yields in one agro-climatic area may be acceptable in another. For purposes of analysis, standardized cumulative rainfall for the period March–October for each region was calculated for the period 1981–2010, with drought defined as rainfall less than one standard deviation from the mean and severe drought as rainfall less than two standard deviations from the mean. The results are presented in table 3.1. The authors also conducted an in-depth analysis of rainfall patterns and crop production using data collected from Ghana's weather stations (box 3.1).

FIGURE 3.1. ADVERSE CROP PRODUCTION EVENTS, 1980–2010



Source: FAOSTAT.
Note: DR = Drought; BF = Bushfire; PD = Pests and Disease; CC = Civil Conflict; FL = Flood.

In absolute terms, the risk of drought increases from south to north, as agro-climatic conditions change from the higher rainfall, bi-modal rainfall distribution in the south and center to the lower rainfall and uni-modal rainfall pattern in the north. All regions experience drought measured in relative terms, however, as indicated in table 3.1. Since 1980, severe, countrywide droughts have occurred in 1982, 1983, 1990, and 1998. The 1982–83 drought was particularly severe and was followed by huge bushfires. Further, regional droughts occurred in 1986, 1992, and 2005. In Ghana, droughts result in a severe, but not catastrophic, impact on cereal production. Figure 3.2 highlights the adverse impact of droughts and flood on national cereal production and yield, particularly in 2007.

A closer analysis of the relationship between rainfall and crop yield, described in detail in appendix I, shows that the volume of rainfall, starting date of the rainy season, and the intensity of rainfall are most closely related to yield. The impact of these three parameters on yield varies by region and by crop. But they are never a major determinant of yield, even in the savannah regions where their impact is strongest. In the southern regions, the variance of rainfall explains very little of the variation in yield, suggesting that factors such as pests and diseases may be more important determinants of yield.

Floods

Flooding also poses a risk for agriculture production, in the form of flash flooding as a result of sudden, high-intensity rainfall or river valley flooding along the main waterways. Both can cause severe damage to property and livelihoods, although usually with a localized and therefore limited impact on aggregate crop production. Localized flash flooding occurs in most years but it was marked in 1989, 1991, 1994, and 1999. Areas located within the Volta River basin in the Northern Region and in the southwestern river system in the Western and Central Regions are particularly prone to seasonal flooding.

The most severe recent flood occurred in 2007, when heavy late rains in September led to the inundation of vast areas across West Africa (see table 3.2). In Ghana, the problem was exacerbated by the release of water from the Bagre Dam in Burkina Faso into the White Volta River. A MoFA and United Nations Joint Preliminary Assessment Report estimated that the floods, which followed a prolonged drought, destroyed about 70,500 hectares of farmland. Approximately 160,000 metric tons of crops (including corn, sorghum, millet, peanuts, cowpea, yams, cassava, and rice) were lost. A subsequent assessment estimated a 7 percent decline in the national harvest, primarily due to a drop of approximately 15 percent in the drought- and flood-affected northern regions.[7] This shortfall resulted in acute food shortage in affected communities.

River flooding has subsequently assumed a higher profile because of the continued release of surplus water from the Bagre Dam, which causes flooding downstream in northern and eastern Ghana. This also occurred in 2009 and 2010, resulting in the loss of many lives and extensive property damage. Ghana is currently trying to reach an agreement with Burkina Faso to time and manage this release so that it is not a risk to lives and property.

Bushfires

Fire is widely used by rural people to clear land for cultivation, improve grazing, and facilitate hunting. Burn-offs also help to control pests and diseases such as grasshoppers, locusts, ticks, anthrax, and livestock parasites. In forested areas, fire affords an easy (low-labor) way to open up new land, facilitate mechanized cultivation, and provide

[7] Ghana Grain and Feed Update 2008, USDA Foreign Agricultural Service, GAIN Report, Global Agriculture Information Network, January 22, 2008.

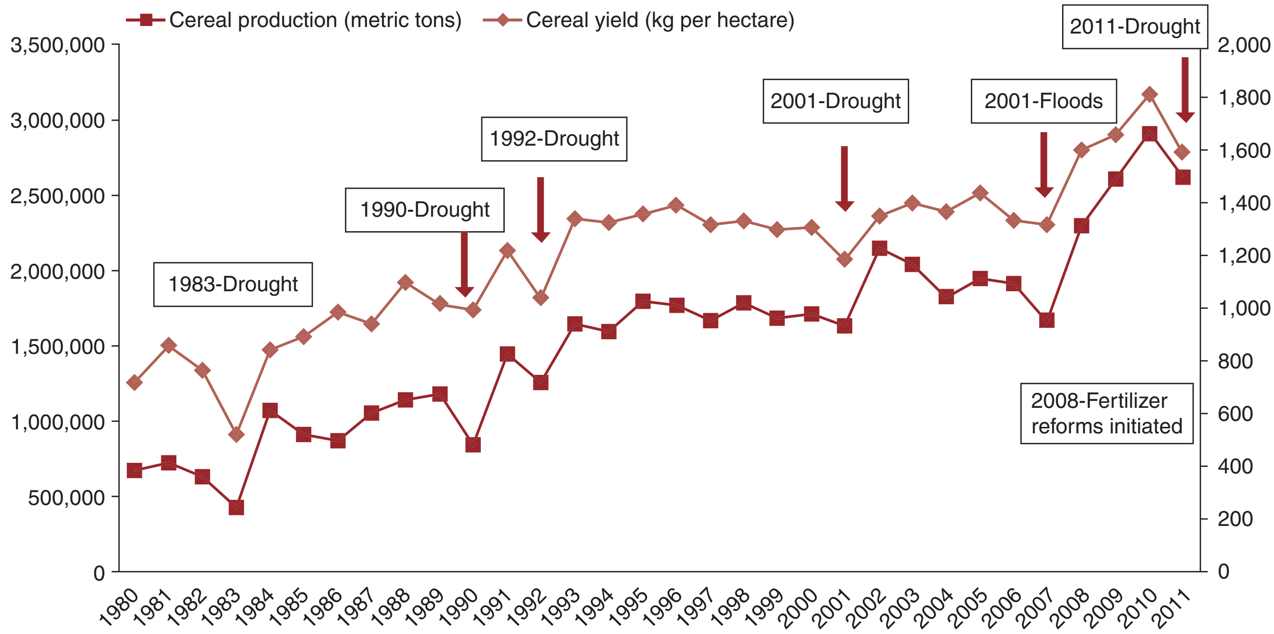
TABLE 3.1. FREQUENCY OF LOW RAINFALL EVENTS BY REGION,* 1981–2010

Year	Upper West	Upper East	Northern	Brong-Ahafo	Volta	Ashanti	Eastern	Western	Central	Greater Accra	Number of Events
1981	−0.75	−1.56	0.01	−0.50	0.17	0.27	0.10	0.55	1.03	0.52	1
1982	−0.07	−0.03	−0.78	−1.33	−1.83	−1.73	−1.77	−0.98	−0.05	0.62	4
1983	−3.07	−0/81	−1.55	−1.24	−2.09	−1.99	−1.90	−1.58	−2.57	−2.39	9
1984	−1.91	−1.53	−0.26	−0.17	0.95	1.78	0.77	1.72	0.50	0.84	2
1985	−0.09	−0.98	0.28	0.57	−0.20	0.85	0.74	−0.04	−0.14	0.50	0
1986	0.69	−0.42	−0.66	−0.26	−0.88	0.73	−1.07	−1.31	−1.79	−1.18	4
1987	0.11	−0.46	−0.27	0.75	0.49	0.83	1.38	2.15	1.40	0.86	0
1988	−0.57	−0.20	0.29	−0.35	0.47	−0.90	−0.06	−0.12	−0.06	0.40	0
1989	0.12	1.39	2.23	1.35	1.30	0.25	0.40	0.92	0.80	0.80	0
1990	—	−1.22	−1.00	−0.86	−0.30	−1.51	−1.02	0.06	−1.38	−0.68	5
1991	−0.38	0.58	2.06	0.14	1.03	−0.26	1.85	−0.17	1.62	2.45	0
1992	−0.23	0.57	−1.20	−1.27	−0.97	−0.86	−0.85	−1.05	−0.91	−0.96	3
1993	0.28	−0.31	0.04	-0.26	−0.09	−0.35	1.16	−0.31	−0.35	−0.42	0
1994	0.22	1.18	0.05	−1.51	−0.41	−0.46	−0.04	−1.64	0.24	−0.88	2
1995	1.19	−0.72	0.31	0.37	1.76	0.48	1.71	0.03	0.77	0.47	0
1996	−0.81	1.07	0.60	0.01	−1.00	−0.71	−0.46	0.66	0.21	0.92	0
1997	0.62	−0.18	−0.01	0.36	0.09	−0.42	−0.58	−0.31	0.28	0.91	0
1998	−0.52	0.45	−2.08	−0.01	0.16	−0.51	−0.30	−1.28	−1.01	−1.17	4
1999	1.45	1.78	1.43	0.63	0.74	1.50	−0.09	−0.11	0.52	0.51	0
2000	1.85	−0.09	0.01	−0.07	0.71	−0.56	−0.35	0.07	−1.07	−1.53	2
2001	−0.57	0.10	−0.94	−0.61	−1.39	−0.34	−0.46	0.19	−0.71	0.08	1
2002	0.36	−0.68	−0.13	1.03	0.49	1.22	0.44	1.76	0.62	0.65	0
2003	0.45	0.45	0.05	−0.88	0.58	−0.35	0.00	−0.03	0.08	−0.31	0
2004	—	−1.07	−0.24	0.93	−0.66	−0.75	−0.19	−0.74	−0.30	−0.98	1
2005	0.46	-0.42	−0.72	0.02	−2.04	−0.71	−1.97	−0.60	−1.07	−0.99	3
2006	1.01	−0.19	−0.62	−0.44	0.22	0.73	−0.21	0.06	0.61	−0.09	0
2007	—	2.62	−0.39	0.80	1.25	1.84	1.47	1.13	1.44	0.83	0
2008	—	−1.05	1.49	−0.25	1.02	1.39	0.90	0.98	0.85	0.54	1
2009	0.10	1.00	0.50	−0.51	0.46	0.36	−0.12	−1.17	−0.55	−0.89	1
2010	0.06	0.72	1.51	3.59	−0.04	0.19	0.52	1.16	0.98	0.56	0
					Frequency of Low Rainfall Events						
Moderate	1/30	5/30	3/30	4/30	2/30	3/30	5/30	6/30	5/30	3/30	37
Severe	1/30	0/30	1/30	0/30	2/30	0/30	0/30	0/30	1/30	1/30	6

Source: Ghana Meteorological Service; annual rainfall for March–October.

*Light shading indicates rainfall of more than one standard deviation below normal; dark shading indicates rainfall of more than two standard deviations below normal.

FIGURE 3.2. IMPACT OF RISKS ON CEREAL PRODUCTION AND YIELDS, 1980–2011



Source: FAOSTAT; authors' notes.

BOX 3.1. RAINFALL PATTERNS AND CROP PRODUCTION

The risk assessment included an in-depth analysis of rainfall data collected from 99 weather stations located throughout the country. (Appendix I provides a summary of the analysis.) It provided useful information on the level and distribution of rainfall by region, highlighting impacts of six different rainfall characteristics on crop yields. The influence of rainfall on yield was examined using regional production data for maize, rice, millet, groundnuts, cassava, and yams for 1992–2009. The analysis showed that the volume of rainfall, starting date of the rainy season, and intensity of rainfall are most closely related to yield but they are never a major determinant of yield, even in the savannah regions where their impact is strongest. Second, the impact of individual rainfall parameters is most apparent for the production of rice and groundnuts in the Upper East Region. Maize and yam yields are particularly vulnerable to drought in the Brong-Ahafo Region; yam yields are vulnerable to drought in the Central Region; and maize yields are vulnerable to excess rainfall in the Ashanti Region.

nutrients (ash) for crops. In the drier savannah zones, it is used to burn off old vegetation and promote the growth of younger trees and grasses for fodder for cattle and small ruminants. Hunters use fire to drive game out of the bush into open areas where it is easier prey.

Burning poses a risk when fires get out of control. This risk is highest when vegetation is dry and the Harmattan is blowing. The incidence and severity of bushfires is thus highest in the savannah zones of northern and central Ghana, where the rainy season is short (3–5 months) and drought is more frequent. The low population density in these areas makes it more difficult to control fires set by hunters and herdsmen, and means that uncontrolled fires tend to burn over larger areas. The immediate economic losses are generally limited, as few people live in such areas, but the longer-term environmental costs can be high as frequent burning changes the vegetative cover. Where bushfires occur in farmed areas, they are a major risk to late crops such as rice, particularly when planting has been delayed by late rains.

In the forest zones, most bushfires result from uncontrolled land clearing and tend to be smaller in terms of the area affected. They can have a significant impact on people's livelihoods, nevertheless, because they are more likely to occur in inhabited, farmed areas. In addition to the loss of surface crops, farmers also lose cocoa trees (which do not regenerate after fire damage and must be replaced), and

TABLE 3.2. FREQUENCY OF EXCESS RAINFALL EVENTS BY REGION,* 1981–2010

Year	Upper West	Upper East	Northern	Brong-Ahafo	Volta	Ashanti	Eastern	Western	Central	Greater Accra	Number of Events
1981	−0.75	−1.56	0.01	−0.50	0.17	0.27	0.10	0.55	1.03	0.52	1
1982	−0.07	−0.03	−0.78	−1.33	−1.83	−1.73	−1.77	−0.98	−0.05	0.62	0
1983	−3.07	−0/81	−1.55	−1.24	−2.09	−1.99	−1.90	−1.58	−2.57	−2.39	0
1984	−1.91	−1.53	−0.26	−0.17	0.95	1.78	0.77	1.72	0.50	0.84	2
1985	−0.09	−0.98	0.28	0.57	−0.20	0.85	0.74	−0.04	−0.14	0.50	0
1986	0.69	−0.42	−0.66	−0.26	−0.88	0.73	−1.07	−1.31	−1.79	−1.18	0
1987	0.11	−0.46	−0.27	0.75	0.49	0.83	1.38	2.15	1.40	0.86	3
1988	−0.57	−0.20	0.29	v0.35	0.47	−0.90	−0.06	−0.12	−0.06	0.40	0
1989	0.12	1.39	2.23	1.35	1.30	0.25	0.40	0.92	0.80	0.80	4
1990	—	−1.22	−1.00	−0.86	−0.30	−1.51	−1.02	0.06	−1.38	−0.68	0
1991	−0.38	0.58	2.06	0.14	1.03	−0.26	1.85	−0.17	1.62	2.45	5
1992	−0.23	0.57	−1.20	−1.27	−0.97	−0.86	−0.85	−1.05	−0.91	−0.96	0
1993	0.28	−0.31	0.04	−0.26	−0.09	−0.35	1.16	−0.31	−0.35	−0.42	1
1994	0.22	1.18	0.05	−1.51	−0.41	−0.46	−0.04	−1.64	0.24	−0.88	1
1995	1.19	−0.72	0.31	0.37	1.76	0.48	1.71	0.03	0.77	0.47	3
1996	−0.81	1.07	0.60	0.01	−1.00	−0.71	−0.46	0.66	0.21	0.92	1
1997	0.62	−0.18	−0.01	0.36	0.09	−0.42	−0.58	−0.31	0.28	0.91	0
1998	−0.52	0.45	−2.08	−0.01	0.16	−0.51	−0.30	−1.28	−1.01	−1.17	0
1999	1.45	1.78	1.43	0.63	0.74	1.50	−0.09	−0.11	0.52	0.51	4
2000	1.85	−0.09	0.01	−0.07	0.71	−0.56	−0.35	0.07	−1.07	−1.53	1
2001	−0.57	0.10	−0.94	−0.61	−1.39	−0.34	−0.46	0.19	−0.71	0.08	0
2002	0.36	−0.68	−0.13	1.03	0.49	1.22	0.44	1.76	0.62	0.65	3
2003	0.45	0.45	0.05	−0.88	0.58	−0.35	0.00	−0.03	0.08	−0.31	0
2004	—	−1.07	−0.24	0.93	−0.66	−0.75	−0.19	−0.74	−0.30	−0.98	0
2005	0.46	-0.42	−0.72	0.02	−2.04	−0.71	−1.97	−0.60	−1.07	−0.99	0
2006	1.01	−0.19	−0.62	−0.44	0.22	0.73	−0.21	0.06	0.61	−0.09	1
2007	—	2.62	−0.39	0.80	1.25	1.84	1.47	1.13	1.44	0.83	6
2008	—	−1.05	1.49	−0.25	1.02	1.39	0.90	0.98	0.85	0.54	3
2009	0.10	1.00	0.50	−0.51	0.46	0.36	−0.12	−1.17	−0.55	−0.89	1
2010	0.06	0.72	1.51	3.59	−0.04	0.19	0.52	1.16	0.98	0.56	3
					Frequency of Excess Rainfall Events						
Severe	4/30	5/30	3/30	2/30	5/30	5/30	5/30	4/30	4/30	0/30	37
Catastrophic	0/30	1/30	2/30	1/30	0/30	0/30	0/30	1/30	0/30	1/30	6

Source: Ghana Meteorological Service; annual rainfall for March–October.

*Light shading indicates rainfall of more than one standard deviation above normal; dark shading indicates rainfall of more than two standard deviations above normal.

root crops such as yams, because the tubers are rendered inedible by high soil temperatures.

The most severe bushfires occurred in 1983 and again in 1984–85. The bushfires of 1983 followed the nationwide drought of 1982 and burned throughout the country. The social and economic consequences were immense, not only due to the direct loss of food crops but also because 60,000 ha of cocoa trees were destroyed—a considerable loss which deepened and prolonged the collapse of Ghana's cocoa sector. No bushfires of this magnitude have occurred since 1984–85, probably due to public action to educate rural people on the dangers of uncontrolled burning and on how to manage burning. Less severe bushfires still occur, however, particularly in the northern and transition zones. Bushfires were reported as a problem in these regions in 1997, 2003, 2005, 2008, and 2009.

Windstorms

Storm damage is a constant risk for plantains, an important food crop, as the trees break easily in high winds. The damage is highly localized, however, and is only apparent at regional level (see appendix F). At national level, plantain production exhibits a very smooth trend, indicating that storm damage in one region is offset by above average production in others.

Climate Change

There is no shortage of analysis on the probable impacts of climate change on agriculture production systems in Ghana and within the region (see appendix D for a synopsis). Broadly, the research suggests that if climate change does reduce rainfall, its impact is likely to be greater in the center and south of the country than in the north. Another shared belief is that temperatures will likely increase more in the north than in the south. A recent study by the International Food Policy Research Institute (IFPRI 2013) finds that food crop production could be affected by these changes in precipitation and temperature. Models show a general decrease in maize yields in 2050, compared to the 2000 baseline. Yield losses are lower for rice, with some models showing extensive areas of yield gains. Groundnut yield and production is projected to fall markedly, diminishing a major source of income and food for producers in the far north. Studies also suggest that cocoa production would likely be the major victim of any reduction in precipitation, which could compound the impact of higher temperatures on evapotranspiration and access to soil moisture and exacerbate the impact of increased temperature on pests and disease.

In addition to the scientific community, farmers and livestock keepers in Ghana have their own perceptions about climate change based on direct experience. Anecdotal evidence collected for this study suggests that erratic rainfall patterns in recent years have made it increasingly difficult for farmers to predict optimal planting times. Rains arrive much earlier, or later, than expected. Rainfall during the season is poorly distributed. Also, once the growing season is underway, rains can stop for extended periods at critical stages in the crop development cycles, leading to poor yields, or in extreme cases, crop failure. At times, when the rains return, heavy torrents cause flooding, inundating crops and compounding earlier losses. Some farmers have tried to adapt by staggering their planting or switching to alternative, more drought-tolerant crops.

PESTS AND DISEASES

Pests and diseases are a permanent feature of Ghanaian agriculture, for both crop and livestock production. Most can be controlled but farmers do not always use the control techniques available, due either to lack of information, access to needed inputs or financial resources, or acceptance of the losses as a cost of agricultural production.

Crop Pests and Diseases

The main pests and diseases, the crops they damage, and available information on the incidence of major outbreaks is summarized in table 3.3.

Of the numerous pests and diseases that affect non-cocoa crops, the four most serious are classified as "agricultural calamity" pests by government. Farmers who suffer crop damage from these four (locusts, variegated grasshopper, African armyworm, and oil palm leaf minor) receive

TABLE 3.3. PESTS AND DISEASE RISKS FOR GHANAIAN AGRICULTURE

Pest and Diseases	Crops Damaged	Incidence
African armyworm	Cereals, root crops, vegetables, pasture	First, countrywide outbreak in 1987. Further outbreaks in 1994, 1997, 1999, 2001, 2002, 2005, 2006, 2009, 2010.
Variegated grasshopper	Cereals, root crops, vegetables	Major outbreak in 1994. Minor outbreaks since in 1992, 1997, 2009.
Oil palm leaf mite	Oil palm	Outbreaks in 1970, 1987, 1993–97, 2005–08.
Locusts	Cereals, root crops, vegetables	No outbreaks since 1980.
Black pod	Cocoa	Outbreaks since 1996.
Capsid	Cocoa	Annual outbreaks.
Cocoa swollen shoot virus disease (CSSVD)	Cocoa	Outbreaks since 1993.
Stem borer	Maize	No information.
Large grain borer	Maize	Under control since 1990s.
Sigatoka	Plantain	First outbreak in 1992. Minor outbreaks in 1997, 2003.
Striga	Cereals	
Papaya mealybug	Papaya	First outbreak in 2008. Has decimated production.
Fruit fly	Papaya, pineapple, mangoes	Recent outbreaks. Prevents exports.
Rice blast	Rice	No information.
White fly	Vegetables	No information.
Rosette	Groundnuts	No information.
Coconut wilt	Coconuts	First outbreak in 1982. Minor outbreaks since.

Source: MoFA Annual Reports; Plant Protection and Regulatory Services Division, MoFA.

assistance from government in the form of free chemicals, advice and assistance with control and free materials for replanting.

Overall, armyworm poses the greatest risk in terms of both the incidence and severity of crop damage. But as the capacity of the Plant Protection and Regulatory Services Division of the Ministry of Food and Agriculture (MoFA) to control armyworm it is now quite strong, even the worst attacks damage no more than 2,000 hectares of crops in a given year. Less severe attacks damage no more than 10 hectares, as in 1994. However, armyworm is moving further and further south, with recent outbreaks being highest in Volta region, Ashanti, and Brong-Ahafo. Armyworm outbreaks also tend to occur when the rains are late for planting, thus compounding the effect of drought.

Pests and disease are the major production risk for cocoa. The control and eradication of these pests and disease is administered by COCOBOD. Blackpod is the main cause of crop loss among cocoa producers. During the period 2008–10, blackpod infected an average of 1.1 million hectares per year (World Bank 2012). Caused by a fungus (*Phytophtora*) that attacks and eventually destroys the pods, it can be controlled if treated with three to six sprays of fungicide. However, the quality and timing of spraying is critical to successful control.

Cocoa pests such as mirids (or capsids) constitute another major threat to cocoa production. They infect approximately 2 million hectares annually, with estimated losses of 83,400 tons in 2010. These insects feed on tree sap, destroying growing shoots and often the tree itself. Regular spraying with insecticides and good tree maintenance afford effective control.

Yet another notable threat, swollen shoot virus (CSSVD) is a highly infectious virus spread by the mealybug, which infected 15,000–25,000 ha annually during 2007–10, with crop losses ranging from US$10 million to US$20.8 million. Control is based on removing and replacing the infected trees, which adds significantly to the costs of this disease as farmers income losses are compounded for

4 to 5 years until the new trees reach maturity. The breeding of disease-resistant trees is viewed as the only long-term solution.

To reduce production risks, COCOBOD has also assumed wide-ranging responsibility for controlling pests and disease. This program was initiated in 2000 and now involves the monitoring and spraying of more than 3 million hectares for capsid and blackpod, together with support for the rehabilitation of cocoa plots that are old or infected with disease. Expenditure on these programs amounted to 524.7 million cedi in 2009/10 (US$366.7 million), equivalent to 20 percent of total cocoa revenues (IFPRI, 2012 op cit.). While these measures have yet to provide complete protection, they have nevertheless facilitated a 67 percent increase in the area planted to cocoa and a doubling of cocoa production since 2002 (see figure 3.3). Notwithstanding, COCOBOD's recent announcement of cost-cutting plans to phase out its flagship spraying program raises significant concerns over the future of cocoa production in Ghana, though some studies suggest that the withdrawal of public-led spraying services could lead to improvements in service delivery and farmer access (World Bank 2012).

Livestock Pests and Diseases

Traditional agro-pastoralists, commercial farmers, government officials and others who participated in stakeholder consultations all highlighted diseases as among the top four risks facing livestock producers. Livestock pest and disease risk is difficult to assess for two main reasons. First, incidence is not precisely known because of poor reporting. Secondly, livestock diseases have multiple effects; in addition to mortality of young and adult animals, there are economic losses due to reduced calving rates, decreased milk production, lower animal offtake rates and market prices, and lesser draught efficiency. Direct losses can already be quite substantial.

Rinderpest has been eradicated, but such diseases as contagious bovine pleuropneumonia (CBPP), tuberculosis, brucellosis, anthrax, foot-and-mouth disease (FMD) and blackleg remain endemic which mainly affect cattle. Anthrax is a particularly serious threat given reported deaths in northern Ghana from consumption of contaminated meat. Other common diseases include trypanosomiasis, tick-borne diseases and endoparasites. Official records are far from comprehensive, but most disease related mortalities of cattle are attributed to anthrax and CBPP.

Among small ruminants, the *peste des petits* ruminants (PPR), mange, and internal parasites remain major diseases, with PPR being the main cause of reported mortalities. The relevant literature suggests that a PPR outbreak can cause up to 50 percent mortality among small ruminants in any affected area; during the past 5 years reported losses ranged from 100 to 800 annually. Consequently, the number of vaccinations has been relatively high, amounting to several hundreds of thousands per year, with a peak of 1 million in 2008. PPR vaccines require cold chain handling and cost about GH¢5 per dose.

For swine, mange and internal parasites are widespread. However, the highest numbers of losses appear to be caused by African Swine Fever (ASF). In 1996, ASF killed about 25 percent of the pig population in neighboring Côte d'Ivoire, with mortality and eradication costs estimated between US$15–30 million. The disease spread to Ghana in the following years. In 2004, the Director of Veterinary Services reported that since the 1999 outbreak of ASF, the government had paid nearly 850 million cedis (approximately US$120,000) as compensation to farmers whose pigs had been destroyed in efforts to control the spread of the disease. There is no vaccine against ASF yet and there have been two recent outbreaks in 2002 and 2007.

For poultry, Newcastle and Gumboro diseases are dominant, with reported losses equally attributed to each. Over the last five years, between 6 and 10 million poultry have been vaccinated annually against Newcastle disease. Reported losses have been a few thousand a year, with a maximum of nearly 19,000 in 2011. Several outbreaks of highly pathogenic avian influenza (HPAI) occurred in 2007 (near Tema and in the Volta region). While there have been no outbreaks since, risk assessment studies indicate that the threat remains high.

MARKET RISKS

Among common market risks are domestic and international price variability, exchange rate and interest rate volatility and counterparty risk.

PRICE VARIABILITY

The analysis of producer price variability is based on inter-annual price variability for 1991–2010, measured by coefficients of variation (CV). Where necessary, these CVs are adjusted for trend using the Cuddy-Delle Valle Index. Real prices,[8] in cedis/ton, are used for the analysis of domestic producer prices as high inflation during this period precluded any meaningful analysis of nominal prices. The variability of international cocoa prices is based on nominal prices in U.S. dollars. Annual producer price data are drawn from FAOSTAT and the international cocoa price data is drawn from the World Bank commodity data series.

TABLE 3.4. INTER-ANNUAL CROP PRICE VARIABILITY, 1991–2001

Coefficients of Variation					
Cereal Crops		**Root Crops and Plantain**		**Cash Crops**	
Maize	0.18*	Cassava	0.26*	Cocoa (dom)	0.20*
Sorghum	0.13*	Yams	0.24	Cocoa (int)**	0.24*
Millet	0.15*	Plantain	0.31*	Groundnuts	0.14
Rice (paddy)	0.16*				

Source: FAOSTAT.
*Adjusted for trend using Cuddy-Della Valle Index.
**International prices in US$.

The inter-annual variability of real cereal prices is relatively low, due probably to the slower 3–5 year cycle of prices that has occurred since the late 1990s (table 3.4). Variability is also similar between cereal crops as they are close substitutes and are grown in similar (mostly savannah) agro-climatic conditions. The higher overall price variability of cassava and yams is attributed to high price volatility from 1995–99 (figure 2.8). Real prices have been relatively stable since 2000 and have moved in unison. This is consistent with their production in similar agro-climatic conditions and their role as substitutes for consumption. Note also that while prices of both cassava and yams rose in 2001 and 2005 in response to domestic production and market shocks (as for cereals), they were not affected by the global food crisis. Plantain exhibits quite high inter-annual price variability due to its vulnerability to storm and insect damage, although prices have been more stable since the early 2000s. This has also been the case for the other food crops.

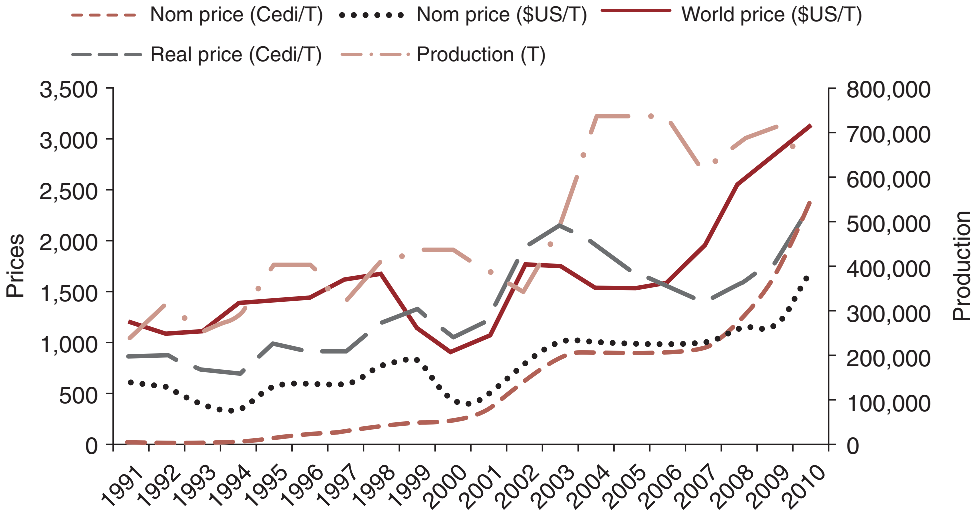
The variability of both domestic and international prices for cocoa is examined given that these risks are assumed by different actors. Comparison of international cocoa prices and the nominal cocoa price set by COCOBOD (figure 3.3) shows the extent to which COCOBOD protects domestic producers from volatility in international markets. Real producer prices fluctuate nevertheless, although inter-annual price variability is moderate and still less than the variability of international prices. Note also that real prices declined from 2003–07, and have increased slowly since, while international prices have increased quite rapidly. This general upward trend in nominal and real prices has also been facilitated by COCOBOD's commitment to raise producers' share of world market prices. This share averaged 54 percent of the free on board (FOB) price from 2006–10 (IFPRI 2012).[9]

The risk of adverse movements in international cocoa prices is assumed by COCOBOD. To mitigate this risk, COCOBOD forward sells 60–80 percent of the expected crop to international buyers. The value of these forward contracts then provides the basis for fixing the producer price at the beginning of each season. Forward selling does not remove all risk. A lower-than-expected harvest would force COCOBOD to buy cocoa beans elsewhere to fulfill its contract, and the residual (non-contracted) harvest would remain subject to the vagaries of international markets. Forward contracts also expose COCOBOD to counterparty risk, in that the international buying agents may not honor their contracts. Adverse outcomes from these risks have been minimal in the 1991–2010 period used for analysis. COCOBOD appears to have met all of its forward contracts, and nominal producer prices (in U.S. dollars) have always been lower than international prices (figure 3.3). One international buyer defaulted on a forward contract in 1991/92, with a loss of £856,278—equivalent to US$10 million in 2010 prices. COCOBOD

[8] Deflated by the consumer price index.

[9] "The Partially Liberalized Cocoa Sector in Ghana: Producer Price Determination, Quality Control and Service Provision." IFPRI, Development Strategy and Governance Division. Discussion Paper 01213 (September 2012).

FIGURE 3.3. COCOA PRICES AND PRODUCTION, 1991–2010



Sources: FAOSTAT; COCOBOD; World Bank Commodity Reports; authors' calculations.

continues to seek ways to mitigate these risks, nevertheless, including forward contracts to multiple buyers as a means to reduce counterparty exposure. There is also scope to use futures contracts to mitigate the price risk incurred by that portion of the crop not covered by forward contracts.

Seasonal price variability is also reviewed for food crops, using nominal monthly retail prices for 2004–08 from MoFA monthly retail price data (see table 3.5). There is no discernible pattern to seasonal price variability, either across years or by commodity. It is probably this erratic pattern of seasonal price variability that leads farmers to perceive it as a major source of price risk.

TABLE 3.5. SEASONAL PRICE* VARIABILITY FOR FOOD CROPS, 2004–08

	2004	2005	2006	2007	2008
	Coefficients of Variation				
Maize	0.17	0.18	0.27	0.12	0.24
Sorghum	0.28	0.14	0.07	0.10	0.23
Millet	0.17	0.18	0.27	0.12	0.24
Local rice	0.14	0.08	0.03	0.07	0.19
Imported rice	0.11	0.08	0.02	0.18	0.17
Cassava	0.13	0.08	0.09	0.12	0.23
Yam	0.12	0.34	0.10	0.17	0.16
Plantain	0.16	0.20	0.13	0.31	0.27

Source: Ministry of Food and Agriculture.
*Based on nominal monthly prices.

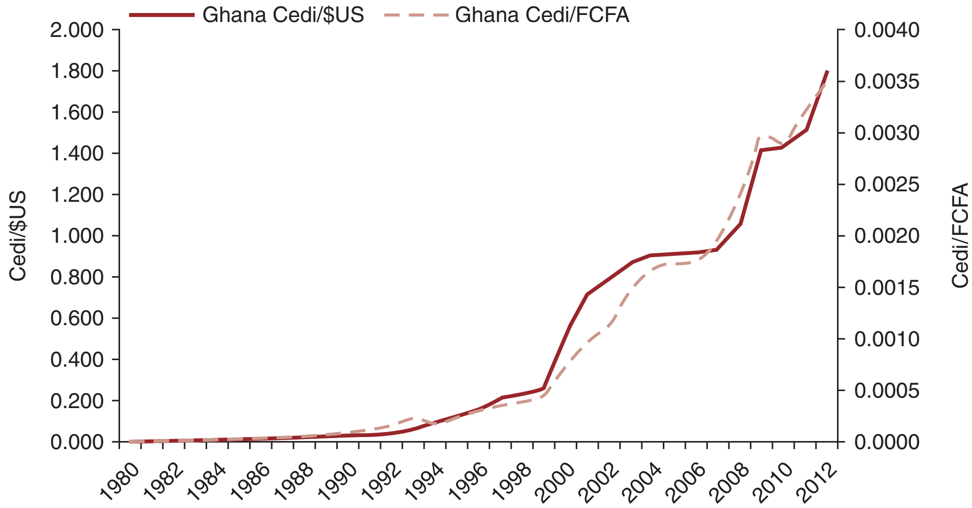
MARKET ACCESS

The abrupt loss of access to certain international markets has also adversely impacted the sector during the past 10 years. Groundnut exports to the European Union were decimated after 2004–05 when shipments were rejected due to unacceptable levels of aflatoxins. Total exports of groundnuts (with and without shell) have since fallen, from 14,583 mt in 2004 to 837 mt in 2010 (FAOSTAT). Domestic production continues but now focuses on lower-value commodities that are sold on the domestic market. An important source of export earnings has thus been lost. Similarly, pineapple exports fell from 56,094 mt in 2004 to 9,971 mt in 2010 as a result of the introduction of a new variety that was highly sought after in European markets but not produced in Ghana (although this variety is now being grown in Ghana).

EXCHANGE RATE RISKS

The variability of exchange rates is highly important for an export-oriented agricultural sector. This applies not only to dollar-denominated exports such as cocoa and cotton, but also to food crop exports in franc CFA (Communauté Financière Africaine) to countries such as Burkina Faso, Niger, and Mali. The franc CFA exchange

FIGURE 3.4. NOMINAL EXCHANGE RATES, 1980–2012



Source: World Bank Development Indicators Database 2014.

rate is also important for trade with Côte d'Ivoire, for both legitimate trade and the smuggling of cocoa and fertilizer.

Ghana effected a gradual realignment of its (highly overvalued) exchange rate from 1983–1990, under a program with the International Monetary Fund (IMF). It subsequently benefited from a floating exchange rate policy and a period of exchange rate stability until 1999–2000 (figure 3.4). This included adjustment to a 50 percent devaluation of the franc CFA in 1994. A sharp exchange rate depreciation occurred in 1999–2000 due to a terms-of-trade shock caused by a simultaneous increase in oil prices, fall in cocoa prices, and decline in donor receipts. World gold prices were also very unstable during this period and domestic inflation and interest rates increased sharply. Exchange rates then stabilized in 2004, only to experience another sharp depreciation in 2009 in response to another terms-of-trade shock, this time associated with the global food crisis. A more gradual depreciation has occurred, against both major trading currencies, since 2009.

Moving forward, ongoing development of Ghana's oil and gas sector could have strong implications for the future growth of its agricultural sector. Any resulting appreciation of the exchange rate linked to inflation could expose the agricultural sector to Dutch Disease. This phenomenon commonly refers to the adverse consequences of a large increase in a country's wealth resulting from a boom in a natural resource sector of an economy. This can lead to an appreciation of the exchange rate and a fall in the price that domestic producers receive for agriculture exports and for products competing with imports. This loss of trade competitiveness would also lead to a decline in exports and loss of an important source of foreign exchange.

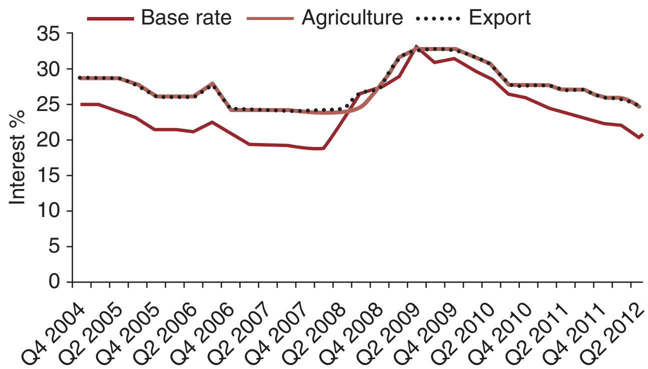
INTEREST RATE VOLATILITY

Both nominal and real interest rates are high in Ghana, although analysis of quarterly interest rates for commercial banks for 2005–12 shows that interest rate volatility is relatively low (figure 3.5). The coefficient of variation for interest for both agricultural loans and export loans is 0.10 and the coefficient of variation for base interest rates for commercial banks is 0.16. A marked increase in interest rates occurred from 2008–09 as a result of high inflation and the impact of the global food crisis, but interest rates returned to their longer-term level by late 2010. Access to credit and high underlying interest rates thus appear to be a bigger constraint than short-term volatility in the costs of this credit.

COUNTERPARTY RISK

Producers and agricultural commodity traders in Ghana, as elsewhere, face counterparty risks. This refers to the risk to each party participating in a transaction that the counterparty will not live up to its obligations. In the absence of commodity exchanges, well-developed warehouse receipts

FIGURE 3.5. COMMERCIAL BANK INTEREST RATES, 2004–12



Source: Bank of Ghana.

systems, and reliable contract enforcement mechanisms, traders have limited means to effectively manage default risks. Given this environment and to minimize exposure, the vast majority of farmers and traders prefer to operate exclusively on a cash-and-carry basis.

As the biggest exporter of agricultural commodities in Ghana, COCOBOD faces considerable counterparty risks and has accordingly developed effective mechanisms to manage them. First, in selling the crop forward, COCOBOD enters into fixed price contracts with a select number of buyers (that is, international merchants, processors, and chocolate manufacturers). In the event of a high volume default by one of these buyers, COCOBOD's financial results could be severely undermined. In order to limit to the greatest extent possible its exposure to any one individual buyer, COCOBOD typically tries to allocate available volumes among a wide range of buyers. To a lesser extent, COCOBOD also faces default risks on the seed funding that it extends to licensed buying companies (LBCs) at the beginning of the season for the purchase of the cocoa crop. However, it has been largely able to manage such risks via local bank guarantees.

ENABLING ENVIRONMENT RISK

Other sector risks arise from changes in the broader political and economic environment in which agriculture operates. These changes can be both internal and external. Agriculture sector policy and regulation are a source of risk when public involvement in sector activities has unexpected, adverse consequences.

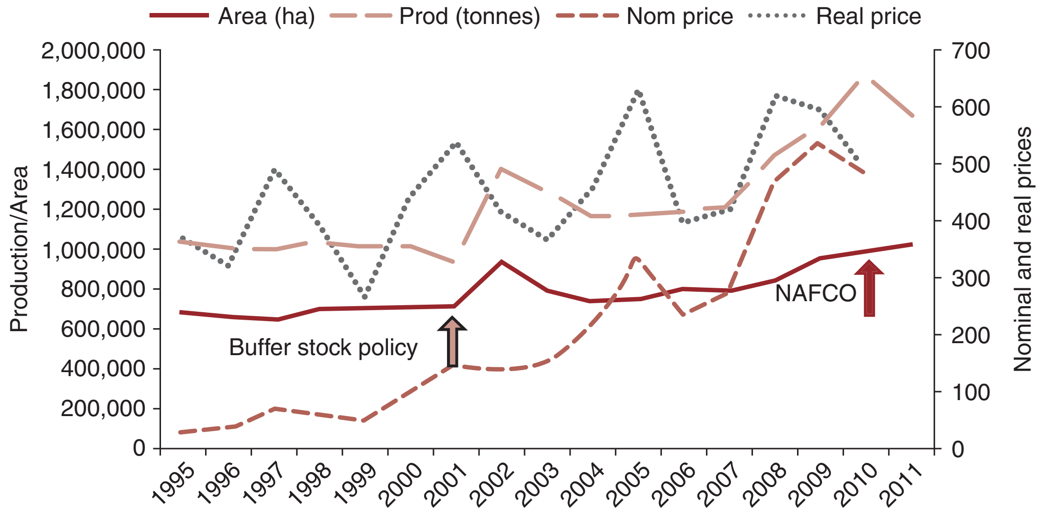
POLICY MAKING

Ghana began the 1980s with a highly interventionist policy stance, based on high levels of public expenditure and budget support to strategic sectors (including agriculture), extensive price controls, and a fixed exchange rate. These policies resulted in high inflation, an overvalued exchange rate, a shortage of foreign exchange, and poor economic performance. An IMF structural adjustment program was initiated in 1983 to address these issues. By the early 1990s, this program had achieved a realignment of the exchange rate, the liberalization of prices, the termination of subsidies (including fertilizer subsidies) and minimum prices for agricultural commodities, and a large reduction of public employment. It was further consolidated in 1995 when Ghana joined the World Trade Organization (WTO), setting modest levels of import protection. This included tariffs of 10 percent or 20 percent on most agricultural commodities. The initial social costs of these changes were high, however, with high unemployment, and inflation that has yet to be brought under control.

The more liberal, market-oriented polices introduced by these reforms remain largely in place. Trade policy was temporarily modified during the global food crisis by removing the 20 percent import tariff on rice and other imported foods in 2008. But these tariffs were restored in December 2009. Fertilizer subsidies (50 percent subsidy for urea and compound fertilizers) were reintroduced in 2009, and the government has subsidized the price of tractors since 2006. In 2000, commercial farmers also benefited from a reduction of corporate tax from 75 percent to 25 percent.

Policy changes pose a risk when they are made quickly and erratically, giving farmers, business agents, and consumers little time to adjust. Fortunately, this does not appear to be the case (largely) in Ghana. The painful reduction of public support for agriculture during structural adjustment, including exchange rate realignment, was implemented

FIGURE 3.6. TRENDS IN MAIZE PRODUCTION AND PRICES, 1995–2011



Sources: FAOSTAT; authors' calculations.

gradually. The government also responded to the 2008 food price crisis in a balanced way. The removal of import taxes on imported rice was coordinated with traders and businesses, as was the subsequent reintroduction of these taxes.

FOOD SECURITY POLICY

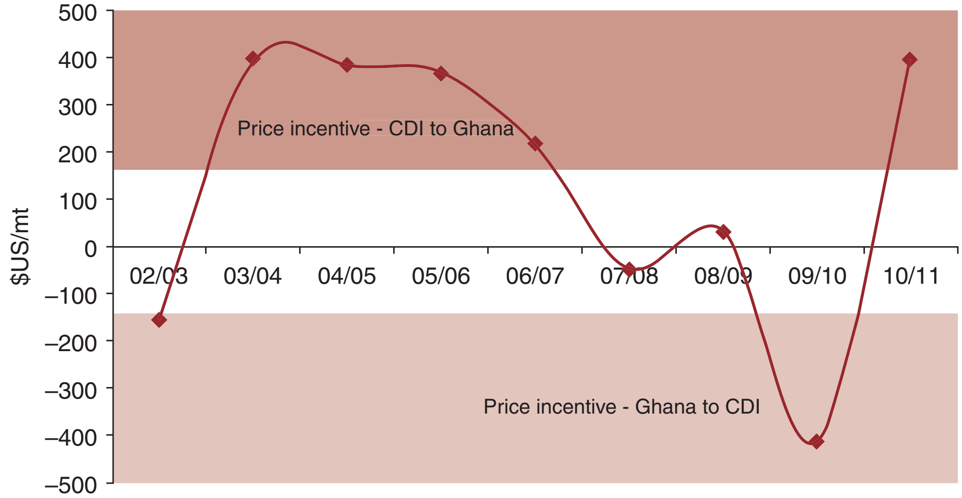
Government involvement in the production and marketing of cereals is based on the operation of public food reserves. This began in 2001 with the creation of a public buffer stock in response to a perceived need for emergency food reserves. The announcement of this policy led producers to increase the area planted to maize by 32 percent (figure 3.6). In combination with favorable growing conditions this resulted in a 49 percent increase in production for the 2001/02 crop year. But as government only purchased 10,000 mt of maize for the buffer stock, this increase in production saturated the market and maize prices fell by 22 percent in real terms. Farmers then reduced the area under maize production for two successive years, and switched to other, more profitable crops. This policy-induced "shock" to production and prices was ultimately the result of inadequate information to producers. Their expectation was that all maize would be purchased by the government at guaranteed prices, rather than just the 10,000 mt required for the buffer stock. This approach to public food reserves was subsequently discontinued.

In 2010, the government reestablished an agency for public food reserves with formation of the National Food Buffer Stock Company (NAFCO). The broad objectives of this agency are to 1) ensure that any "excess cereal production," resulting from current measures to increase cereal production through the subsidization of fertilizers and improved seeds, can be sold by farmers at guaranteed prices; 2) to stabilize the demand and supply for cereals; and 3) to ensure a stock of food reserves to meet emergency needs in the event of food crises or national disasters. The target for operational stocks for 2012 was 15,000 mt white maize, 15,000 mt yellow maize, 15,000 mt paddy rice, and 1,000 mt soya. For emergency stocks, the targets were 10,000 mt white maize, 10,000 mt milled rice, and 1,000 mt soya. The impact of NAFCO's activities on the stability of cereal prices and production has yet to be ascertained.

INSTITUTIONAL RISKS: COCOBOD

The government retains wide-ranging control of the internal and external marketing of cocoa through the Ghana Cocoa Board. The policies and regulations used to exert this control have a significant influence on the sources and level of risk associated with cocoa production and marketing, including the level and stability of producer prices, the response to pests and disease, and the capacity to export cocoa profitably on international markets.

FIGURE 3.7. GHANA/CÔTE D'IVOIRE COCOA PRODUCER PRICE DIFFERENTIAL



Source: World Bank 2012b.

Cocoa Smuggling

Smuggling was for many years the main source of risk to profitable operation by COCOBOD. It was the result of the differential between producer prices in Ghana and Côte d'Ivoire and the difficulty of controlling illicit trade along the long, porous border separating the two countries. Until 2012, Ivoirian prices were set according to spot prices in international markets. Thus, they fluctuated above and below the fixed prices in Ghana. As shown in figure 3.7, these price differentials created the incentives for smuggling from Côte d'Ivoire to Ghana from 2003/04–2006/07 and in 2008/09; and from Ghana to Côte d'Ivoire in 2002/03, 2007/08, and 2009/10.

Provided that it met COCOBOD quality standards, cocoa smuggled from Côte d'Ivoire to Ghana would generate the same profit as Ghanaian cocoa. The resulting higher volume of exports would also increase COCOBOD's ability to cover its fixed costs and increase returns. The risks incurred by inward smuggling stemmed from the increased liquidity requirement generated by the purchase of additional cocoa, and the increased consequent difficulty of making timely payment to Ghanaian producers. Outward smuggling from Ghana to Côte d'Ivoire incurred greater costs and higher risks as it reduced the volume of exports. This had the potential to compromise COCOBOD's capacity to honor its forward contracts and reduce overall profitability.

Measures to prevent smuggling through increased border control were difficult to enforce given the difficulty of monitoring the border between the two countries. A reduction of smuggling risk will thus ultimately rely on measures to reduce the disparities between Ghanaian and Ivorian producer prices. The Government of Côte d'Ivoire introduced cocoa sector reforms in 2012 and created a system offering a state-issued minimum price guarantee, backed by forward sales in international markets. This is likely to bring more certainty over prices and mitigate the level of cocoa smuggling between the two countries.

DOMESTIC CONFLICT

Internal conflict has been a significant source of risk for agriculture, notably civil unrest in the Northern Region during 1994–95. In addition to the human suffering caused, these events led to a significant decline in both regional crop production and regional trade, which had a wide-ranging impact on agricultural markets and access to food. A further, smaller civil conflict occurred in 2002.

MULTIPLE SHOCKS

The most severe shocks usually involve a succession or combination of adverse events. Private households and public agencies typically have sufficient resources to respond to a single shock and effect a partial recovery, but these resources are seldom adequate to cope with multiple shocks. Multiple shocks to agriculture occurred in the following periods:

1981–85: The catastrophic drought of 1981–82 was followed in 1983 by massive bushfires that destroyed crops throughout the country, including 60,000 ha of cocoa trees. The impact of these natural disasters was compounded in 1983 by the expulsion of more than 1 million Ghanaian migrant workers from Nigeria and the initiation of a structural adjustment program with large-scale reduction of public employment. A further severe outbreak of bushfires occurred in 1984–85.

1992: A combination of localized floods and pest outbreaks in various regions throughout the country; plus the political and economic uncertainty associated with national elections.

1994: Civil conflict, devaluation of the franc CFA, outbreaks of variegated grasshopper and armyworm.

1997: Drought, bushfires, and pest outbreaks in central and northern Ghana.

2007: Drought and severe flooding in the northern and central zones, and a collapse in world cotton prices.

CHAPTER FOUR

ADVERSE IMPACT OF AGRICULTURAL RISK

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

CONCEPTUAL AND METHODOLOGICAL BASIS FOR ANALYSIS

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

This concept differs from the common perception of "risk" by farmers and traders, based on the year-to-year variability of production and prices. It should also be distinguished from constraints, which are predictable barriers or limitations to agricultural production that farmers face every year. In Ghana, these constraints include poor access to farm inputs, limited access to markets, limited credit, poor infrastructure, and so on.

LOSS THRESHOLDS

As agricultural production is inherently variable, the immediate step for analysis is to define "loss thresholds," which distinguish adverse events from smaller, interannual variations in output. This is achieved by first estimating a time trend of "expected" production in any given year, based on actual production, and treating the downside difference between actual and expected production as a measure of loss. Loss thresholds are then set for these downside deviations from trend, to distinguish between losses due to adverse events and those that reflect the normal costs of doing business. Two thresholds are used to represent differing levels of severity—severe losses and catastrophic losses. These below threshold deviations from trend allow estimation of the frequency, severity and cost of loss for a given time period.

For purposes of analysis the threshold for severe losses was set at 0.33 standard deviations from trend, and catastrophic losses at 0.66 standard deviations from trend. These thresholds captured the differing levels of adversity of known adverse events during the period of analysis. The frequency and severity of losses derived in this manner were also checked against historical records to ensure consistency with actual adverse events.

THE INDICATIVE VALUE OF LOSSES

Available data on actual losses due to adverse events are not always accurate or sufficiently consistent to facilitate comparison and ranking of the costs of adverse events. Analysis was thus based on estimates of the "indicative" value of losses, which provide a more effective basis for comparison. Indicative loss values are also compared with the value of agricultural GDP in the relevant year to provide a relative measure of the magnitude of loss. Although these estimates draw on actual data as much as possible, it is emphasized that they represent indicative rather than actual losses. Indicative losses were calculated as follows:

For production risks, the total value of gross agricultural output (GAO) "lost" for each event was first calculated in cedi as the difference between the actual and trend value of the relevant crop or crops, using constant producer prices (2004–06). The proportion of this total loss value in excess of the threshold for trend production losses was deemed to represent the loss attributable to the adverse event. The resultant value was converted into U.S. dollars at 2010 exchange rates, and also expressed as a percentage of the value of gross agricultural output to indicate the magnitude of losses in relative terms. This methodology was applied to each of the nine major crops and then to each region (based on trends in the aggregate value of the nine crops at constant prices).

Production risks were analyzed for crops only as the available livestock data were considered inadequate. Reported annual livestock numbers and production are based on a series of coefficients, which remain fairly constant irrespective of actual production conditions. Hence, livestock production losses due to drought or disease are not adequately captured.

For price risks, the trend level of production for the relevant crop was used as the point of reference. The total loss due to a price fall was then calculated in cedi at real prices (2010 = 100) as the difference between GAO at trend prices minus GAO at actual prices, and the remainder of the calculation was derived as for production risks. This use of "normalized" (trend) production (rather than actual production) as the basis for analysis allows the loss due to adverse price events to be captured more independently of losses due to an adverse change in production. Although this approach does not fully remove the joint endogeneity of prices and production, it was considered a reasonable proxy for the impact of price risk given that factors other than production appear to cause most (downward) price shocks, measured in real terms. The available data suggest that in most cases changes in international prices and exchange rates, inflation, policy, and externally driven changes in demand (for example, by importing countries) were more powerful determinants of prices than were changes in supply.

DATA SOURCES

Analysis of this nature requires a consistent set of data on both production and prices for an extended period of time. Of the various sources of data available, FAOSTAT's data series on the value of gross agricultural production (1991–2011), crop production (1991–2011), and crop producer prices (1991–2010) was considered the most suitable. These data allow the analysis of risk over a 20- to 21-year period. The analysis of risk at the regional level was based on data provided by MoFA for the nine major crops for 1992–2009.

CORROBORATION OF ANALYSIS

The below-trend "adverse events" derived using this methodology were not all unambiguously due to adverse conditions. Each identified adverse event was thus checked against climatic data, production and price data, information from annual MoFA reports, and other sources to confirm that it was due to adverse conditions. Events not consistent with this information were excluded from further analysis. Some were due to anomalies in the data, particularly for the early 1990s. In other cases, a drop in production for a particular crop resulted from a decision to switch to other crops. These cross-checks also facilitated the attribution of adverse events to specific causes (drought, floods, and so on), although a full attribution was not possible. Gaps in the corroborating evidence (missing MoFA reports for 1993, 1995, 2000–03; and the limited detail of the MoFA reports prior to 2000) plus the difficulty of accurately recalling past events precluded a full attribution.

In some instances, adverse events were followed by several years of below-trend production, even though the immediate cause of the shock was no longer extant. These post-shock years were not considered when determining the frequency and cost of the initial adverse event, as the below-trend production could not be unambiguously attributed to the initial shock.

AGGREGATE CROP PRODUCTION RISKS

Measured in terms of gross agricultural output (GAO) at constant prices,[10] the volume of crop production was substantially reduced only once by adverse events during 1991–2011—a low frequency of 0.05 (table 4.1). This occurred in 2007, a year of multiple shocks including drought, floods, and crop pest and disease outbreaks. The indicative cost of this production shock was modest relative to the total value of agricultural output (equal to just 1.0 percent of GAO). There were no catastrophic crop production events at aggregate level.

The frequency and severity of adverse events increased slightly when the combined impact of changes in production and producer prices was measured, with the loss threshold exceeded in 1999 and 2007—a frequency of occurrence of 0.10. The indicative cost increased to 1.9 percent of gross agricultural output for 2007—a moderate cost to the sector. This suggests that price instability increases both the frequency and cost of adverse events, as would be expected, but not sufficiently to cause catastrophic shocks.

[10] FAOSTAT: Constant producer prices calculated as average for 2004–06.

TABLE 4.1. SEVERITY AND COST OF ADVERSE EVENTS FOR AGGREGATE CROP PRODUCTION

Year	Severity[a]	Indicative Loss Value[b,c] (2010)			Context
		cedi (m)	US$ (m)	% GAO	
Production Risk *(measured at constant prices)*					
2007	Severe	−137	−96	1.0%	Major floods, localized drought

Sources: FAOSTAT; authors' calculations.
Note: m = millions.
[a]Severe: Production more than 0.33 standard deviation below trend.
[b]Calculated as the value of actual minus trend production, less the threshold for "normal" losses.
[c]In 2010 values based on real cedi prices (2010 = 100), and US$ to cedi exchange rates for 2010.

The absence of catastrophic events is consistent with the perception that agricultural sector risk is low at the aggregate level because of Ghana's broad range of agro-climatic conditions and the associated ability to produce a wide range of food and cash crops.

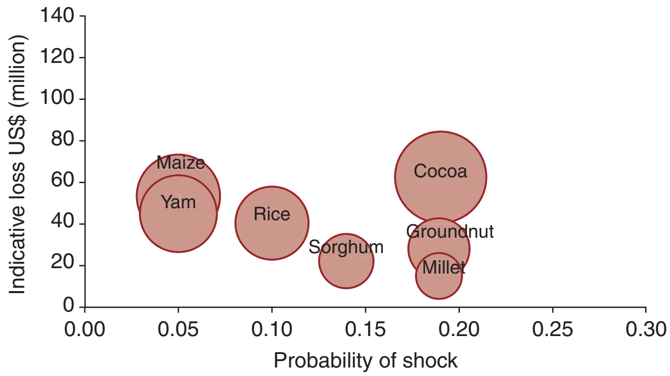
PRODUCTION RISKS FOR MAJOR CROPS

Analysis of adverse production events by crop provides insight into crop-specific risk. Year-specific adverse events were derived first and categorized into severe or catastrophic events (see appendix G, tables G.1 and G.2). These events were then used to derive the probability of a production shock during the 21-year period analyzed (1991–2011), and the average indicative cost of these shocks. The results are presented in figure 4.1.

Adverse production events occur with a low to medium frequency, with cassava and plantain exhibiting no production shocks at all during the period of analysis. Yams and maize also exhibit a low frequency of production shocks, although with a medium level of indicative loss. As cassava, yams, plantain, and maize together account for around 60 percent of crop GAO, the relative stability of production for these crops accounts for much of the observed stability in aggregate crop production.

Rice, sorghum, millet, and groundnuts exhibit a higher frequency of adverse production events, as would be

FIGURE 4.1. FREQUENCY AND SEVERITY OF ADVERSE PRODUCTION EVENTS BY CROP



Sources: FAOSTAT; authors' calculations.

expected given that they are produced in the more risk-prone savannah regions. Their risk profile is moderate nevertheless, with a low to medium frequency and severity of risk. They are more prone to catastrophic production events, although the indicative costs are generally low (see appendix G, tables G.1 and G.2). But as these crops account for only 10 percent of aggregate crop output, production shocks have a limited impact on aggregate production. Note, however, that the higher incidence of production shocks for these crops has a major impact in the three northern provinces where they predominate. The catastrophic production shocks for these crops in 2007 also show that these crops are more prone to covariate production risk.

Cocoa is the most prone to production shocks, with a medium frequency of 0.2 (2 years in 10), and the highest average indicative loss. The higher indicative loss is due to the high value of cocoa production, and the impact of a catastrophic event in 2002. The indicative loss for this catastrophic event was low in relative terms, nevertheless, at 1.7 percent of GAO (see appendix G, table G.2). The other adverse production events for cocoa incurred low-moderate losses, suggesting that in most years, cocoa acts as a stabilizing influence on aggregate crop production.

All crops (except cassava and plantain) experience "severe" production shocks, although the frequency of these shocks is low to moderate. This is true even for the more risk-prone crops (groundnuts, sorghum, and millet). A different pattern is evident for "catastrophic" production events, which are dominated by the low frequency–high cost production shocks for cocoa. Millet exhibits the highest incidence of catastrophic production shocks, but the indicative costs are low. Overall, the results confirm the important stabilizing role of root crops and plantain for aggregate production. Cocoa faces the biggest production risk, although this too is moderate.

PRODUCER PRICE RISK FOR MAJOR CROPS

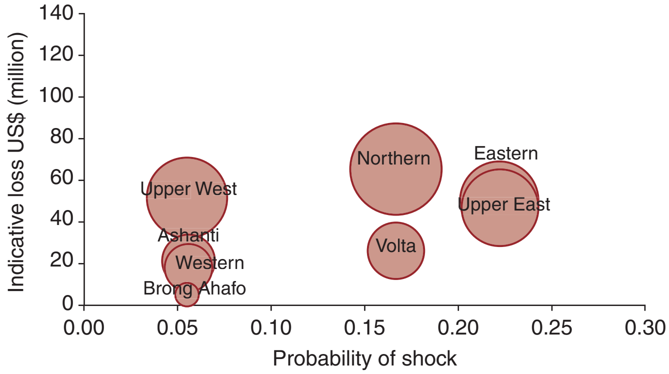
A crop-specific analysis of price shocks was used to derive a similar set of data as that for production shocks. Detailed results are presented in appendix G, tables G.3 and G.4. No price shocks are observed for cocoa, as would be expected given that COCOBOD sets prices and ensures (nominal) price stability. Price shocks occur with a low frequency for most other crops, although the indicative losses of these shocks vary markedly. Low frequency–higher cost shocks occur for cassava and yams, although even the largest of these shocks (for cassava) incurred losses of only 1.6 percent of GAO (see appendix G, table G.4). It is worth noting here that prices for cassava and yams have been much more stable within the most recent decade. The higher cost of these shocks is commensurate with their contribution to GAO. Maize, sorghum, and millet exhibit a medium frequency–low loss risk profile and rice, groundnuts, and plantain exhibit a low frequency–low loss profile.

A comparison of "severe" versus "catastrophic" price shocks shows that all crops (except cocoa) experience severe price shocks, with maize as the most volatile. Catastrophic shocks are observed for sorghum, millet, and rice. Traditional cereal crops (maize, sorghum, millet) are the most likely to experience price shocks. The price shocks for these cereals also tend to occur simultaneously, suggesting that they are covariate.

REGIONAL CROP PRODUCTION RISKS

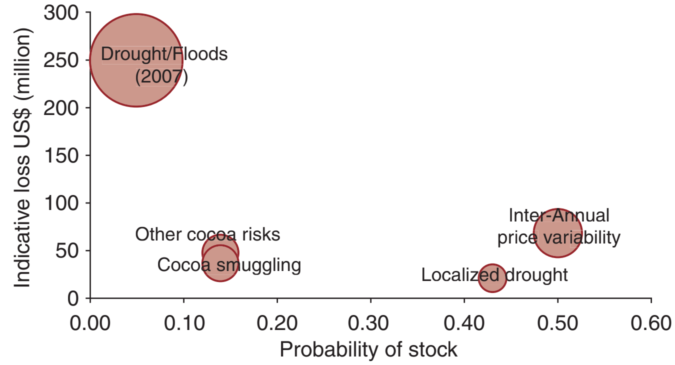
Production of the major crops was aggregated for each region to facilitate analysis of the impact of adverse crop production events at the regional level. Analysis was based on constant national prices (average for 2004–06) for each crop, as regional prices were not available. It thus measures production changes only, independent of price changes in

FIGURE 4.2. CROP PRODUCTION SHOCKS BY REGION, 1992–2009



Sources: MoFA; FAOSTAT; authors' calculations.

FIGURE 4.3. FREQUENCY AND SEVERITY OF DIFFERENT CROP RISKS



Sources: MoFA; FAOSTAT; authors' calculations.

regional markets. Detailed results are presented in tables G.5 and G.6 of appendix G and summarized in figure 4.2 in this section.

No production shocks were observed in the Central Region. Each of the other regions experienced one or more production shocks during the period of analysis, although in most cases the indicative costs were low to moderate in both absolute terms and measured as a percentage of GAO. Upper East, Northern, Volta, and Eastern regions were the most prone to production shocks, in terms of both frequency and severity. Production variability in the Upper East, Northern, and Volta regions is attributed to the risks associated with drought and floods. Fluctuations in maize and cassava production explain both the frequency and severity of losses in the Eastern Region. The frequency of adverse production shocks is low in the remaining regions, although the severity of loss differs. Medium-level losses were observed in the Upper West owing to the high-impact shock that occurred in 2007. Losses in the Ashanti, Western, and Brong-Ahafo regions were low. Catastrophic losses were observed in the Upper East, Upper West, Northern, and Volta regions. This is commensurate with their vulnerability to drought and floods.

SOURCES OF RISK

The analysis of different types of risk provides useful insight into their relative importance. The high loss–low frequency impact of catastrophic events caused by multiple shocks is evident from the consequences of drought and floods in 2007 (figure 4.3). This shock has recently been reported by the MoFA as the only adverse event to have significantly affected agricultural sector growth in the past 10 years. Its low frequency (once every 20 years), multiple causes, and high impact suggest that shocks of this nature are best addressed by a combination of emergency and mitigation measures.

The other shocks all incur low to moderate indicative losses, although with differing frequencies. On average, adverse (interannual) producer price shocks affect at least one of the major crops every second year. Some crops are more prone to these shocks than are others, with maize, sorghum, and millet as the most vulnerable. Adverse shocks from pests and diseases occur with regular frequency, and with some crops result in substantial losses year after year. However, such losses are not well documented and so are difficult to quantify. Localized droughts also occur with a high frequency, particularly in the savannah regions. These droughts result in relatively low indicative losses, as the crops they impact (sorghum, millet, groundnuts) account for a small component of GAO. They have a major impact at the local and district levels, however, and continue to impede growth and poverty reduction in the northern regions.

Shocks to cocoa production occur with medium frequency (four times in 21 years). Losses due to smuggling are identified as a separate category as they are inadequately reported, although they do not account for all of the indicative losses observed. Residual cocoa production losses are thus reported as a separate "undefined" category as there is not enough information to attribute them to a specific cause. Production shocks due to pests and diseases account for part of this undefined loss, particularly in the period before mass control programs were introduced in the early 2000s.

IMPACT OF LIVESTOCK DISEASES

In 2010, Ghana's real agricultural GDP was calculated at GH¢7.1 billion, including some GH¢474 million (or 6.7 percent) for the livestock sector. The latter can be recalculated by component species and adjusting for the aforementioned estimated increases in national herd numbers. This would raise the value of the contribution of livestock to GH¢610 million (or 8.6 percent of agricultural GDP, assuming no upward adjustment in other sub-sectors).

Based on the information provided in chapter 3, in a normal year, diseases affecting various species can be expected to result in losses of 25 percent in value overall.[11] An occasional significant outbreak (for example, HPAI or ASF) could lead to additional losses of 20 million cedis, whereas a severe drought event affecting ruminants in northern regions could imply losses amounting to twice that amount.[12] However, the impact of diseases and other adverse impacts on livestock could be much greater in the northern parts of the country, where poorer households depend on livestock to a larger extent, as discussed in chapter 5.

[11] Through mortalities, lower market prices, and reduced milk or offspring productivity, and so on.

[12] Assuming an additional 10 percent loss in value to ruminants in northern regions through mortalities, reduced market prices, and reduced milk production.

CHAPTER FIVE
ASSESSMENT OF STAKEHOLDER VULNERABILITY

As highlighted earlier, Ghana's agricultural systems vary within the five different agro-ecological zones and across the country's 10 regions (see appendix A). As a result, the nature and severity of agricultural risks can vary greatly from one area to the next. The ability to deal with those risks among different stakeholders also varies, based on myriad factors, including prevailing production systems, household income levels, and the relative diversity of income sources. Assessing levels of vulnerability among specific groups thus requires an understanding of their level of exposure as well as their risk management capacity. This includes their capacity to cope with and recover from resulting losses.

During the field portion of the assessment, the team met with a range of stakeholders[13] and sought individual as well as focus group assessments of production, market, and enabling environment risks. Discussions covered main risks, impact, relative ranking in terms of severity, and mitigation measures undertaken as well as their relative effectiveness. Based on this input, this chapter identifies common agricultural systems, profiles some of the key stakeholders and their perceptions of agricultural risks, and evaluates levels of vulnerability to risks (see appendix E for a broader discussion of vulnerability among various livelihood groups in Ghana). It also presents some common strategies they employ to manage these risks.

Stakeholder groups included government and nongovernmental organization (NGO) technicians, agriculturalists operating under rain-fed or a mix of irrigated and rain-fed conditions, agro-pastoralists, commercial farmers, traders, and processors. As usual, stakeholder groups were not homogeneous; for instance, some adjustments had to be made to reflect the fact that a "government technicians" group often includes people

[13] The information covered in this chapter is largely based on interviews with 28 rain-fed farmers in two locations, 15 agro-pastoralists in three locations, 24 traders in Wa, 2 commercial farm enterprises in Tamale, and 3 processors in Wa and Tamale as well as meetings with nearly 20 government technicians from MoFA, SADA, the Pong-Tamale livestock station, and the Wa RDA.

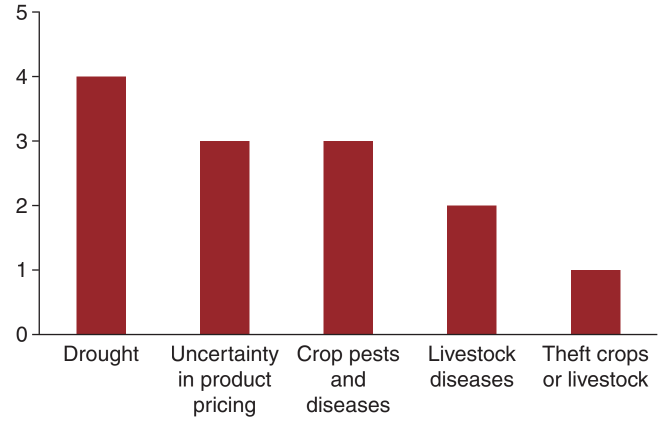
with a lifelong interest and experience in agriculture as well as others similarly vested in animal husbandry issues. Commercial farmers also face some of the same risks that smallholders face. Still, it was possible to obtain clearly differentiated viewpoints on the types of risks affecting various production systems (see table 5.1). The analysis highlights that rain-fed farms in Ghana's northern regions are by and large the most vulnerable to agricultural risks.

RAIN-FED AGRICULTURE

This production system applies to the majority of rural populations in Ghana, the vast majority of which cultivate food crops and cash crops. About 2.74 million households either operate small family farms (most of them less than 2 hectares) or keep livestock (MoFA 2008). Most households in northern regions keep backyard livestock, small ruminants, and sometimes cattle, in addition to cultivating cereal and other crops. According to the 2009 Comprehensive Food Security and Vulnerability Assessment (CFSVA), food crop farmers have the lowest annual per capita income. Seventy-two percent of them cultivate less than 2 hectares and are primarily reliant on rainfall for water. Almost half of the heads of households have no educational background, and women head 22 percent of these households. Among cash crop farmers, the most vulnerable are in the Upper West Region where they constitute 17 percent of the population. The majority of cash crop farmers live in the forest zone. Their second income source is food crop production. They have the highest annual per capita income, but more than half are in the poorest wealth quintile; women head 18 percent of these households.

Risks mentioned by individuals, farmer groups, and government technicians linked to this system and who provided feedback for this assessment and their ranking are depicted in table 5.1.

TABLE 5.1. RISK RANKING, RAIN-FED FARMING*



Source: Authors' notes.

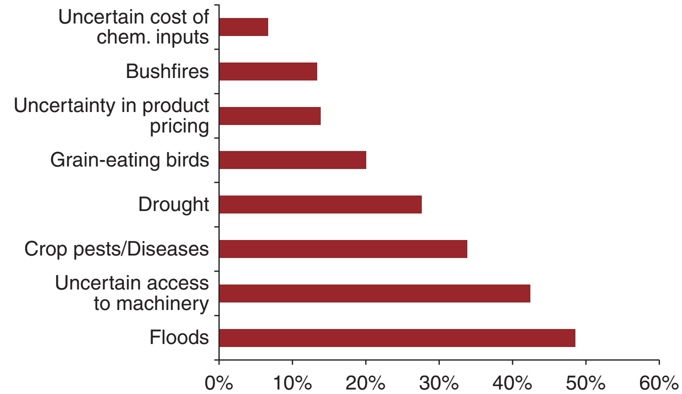
*Number of respondents citing risk type as most and second most important.

Having focused on the worst risks, farmer groups were then asked about mitigation measures and their relative effectiveness. Mitigation measures against drought or weather uncertainty included crop diversification, especially with tubers/root crops; combining short-cycle and longer-cycle crops (for example, early maturing millet, "Chinese" groundnuts); and integrating drought-tolerant maize varieties (for example, CSIR-Aburohemaa and CSIR-Omankwa). Other effective but localized drought-related measures cited by respondents included soil moisture conservation (half-moons, bunds, ridging); water harvesting (for example, small pond or levy construction); and small-scale irrigation.

Mitigation measures against uncertainty in product pricing included more and better on-farm storage; switching to crops for which there appears to be stronger effective demand (for example, soya beans, yams, groundnuts); and establishing better linkages to markets. Most respondents, however, agreed that their capacity to implement these measures was very limited. With regard to mitigating the impact of crop pests and diseases, there was generally broad consensus among respondents on the application of chemicals as well as recognition that few had the financial means to do so. The importance of crop rotation was also widely cited as a way to reduce the risk of striga.

Given relatively limited incomes, meager savings, and lack of alternative income sources, households that depend on rain-fed production are by and large the most vulnerable to adverse shocks such as drought, excessive rainfall, pest/disease outbreaks, and price volatility. Not only are they least equipped to manage the risks before they are realized, they are also the least able to cope with losses in the wake of adverse shocks. Depending on the severity of the shock event (or series of events), the loss of income and assets can have myriad and devastating impacts on livelihoods, both immediately following the event and over the medium to long term. Immediate impacts can include loss of crops and related income that finances household needs such as clothing, education, health services, and food. The worst affected households are often forced to turn to emergency savings or sell off assets to secure basic foodstuffs and other essentials, responses that weaken their resilience to future shocks. Similarly, owing to lack of storage options, adverse price shocks can often leave such households with significantly reduced income or even losses on their farming investments if they are forced to sell. For these reasons, investments should be prioritized that strengthen the capacity of the most vulnerable communities to manage these risks and build their resilience to withstand and recover from shocks in their aftermath.

TABLE 5.2. RISK RANKING, IRRIGATED FARMING*



Source: Authors' notes.
*Share of respondents citing risk type as most important or second most important.

IRRIGATED AGRICULTURE

The vast majority of agriculture in Ghana is rain-fed. With abundant cultivable land and sufficient surface water and groundwater resources, Ghana offers ample scope for irrigation-based intensification. However, at present, roughly 30,000 hectares, or just 0.2 percent of total agricultural land,[14] is irrigated. Approximately one-third of this lies within 22 public schemes developed by the government and various nongovernmental organizations. The remaining two-thirds are made up of informal irrigation schemes, the location, development, and management of which are not well documented. These are for the most part developed and run by private entrepreneurs and farmers. Such schemes are thought to be expanding at a rapid rate, fueled in part by improved access to newer and cheaper pumping technologies.

Informal systems include tube well irrigation, small motor-based irrigation, and out-grower systems. Surface-water, pumping-based private and communal irrigation systems are widely dispersed across all of Ghana's 10 administrative regions, and are particularly abundant in the Eastern, Ashanti, Brong-Ahafo, and Volta regions. Sub-surface and groundwater-based irrigation systems are not evenly distributed across the regions but are fast spreading beyond traditional enclaves such as the Volta region's Keta strip (IFPRI 2011). IFPRI classified Ghana's irrigation systems into several typologies based on several criteria including ownership/management, source of water, type of infrastructure or technology involved, and source of power for abstracting, conveying, and distributing water. Common types are public-owned surface irrigation systems; public-private partnership commercial systems; small reservoir- and dugout-based systems; group-based river-lift systems; groundwater-based irrigation systems; and lowland an inland valley rice water capture systems. Figure App.E.2 in appendix E illustrates the geo-distribution of various types of irrigation systems in Ghana.

The largest of Ghana's public irrigation schemes, totaling about 2,490 hectares, is located in the Upper East Region. On some 1,500 ha of irrigated land about 2,500 farmers grow mostly rice and soya beans during both the rainy and dry seasons. Many also cultivate rainy-season groundnuts and maize on their off-perimeter land holdings. Dry-season crops include onions, tomatoes, peppers, and leafy vegetables. All farmers associated with this irrigation scheme own some livestock as well. Although there are as yet limited areas under irrigation, it is often mentioned as a way to mitigate the risk of drought. Thus, it is worth considering risks that affect irrigation directly.

Key risks highlighted by a farmer group and government technicians regarding this system and their ranking are depicted in table 5.2.

Mitigating measures against flooding consisted of improved drainage, but all respondents recognized their limited ability in this regard. There were no clear

[14] World Development Indicators.

mitigation measures identified against uncertainty in access to mechanized equipment, which was regarded as a serious risk, especially because labor costs are either unpredictable or likely to be high at the same time. Mitigation measures highlighted against crop pests and disease risk were the same as they were for rain-fed farms. Finally, to mitigate uncertainty in product pricing, one large group of rain-fed farms had tried to contract with large institutional clients (for example, schools, the World Food Programme), but with limited success.

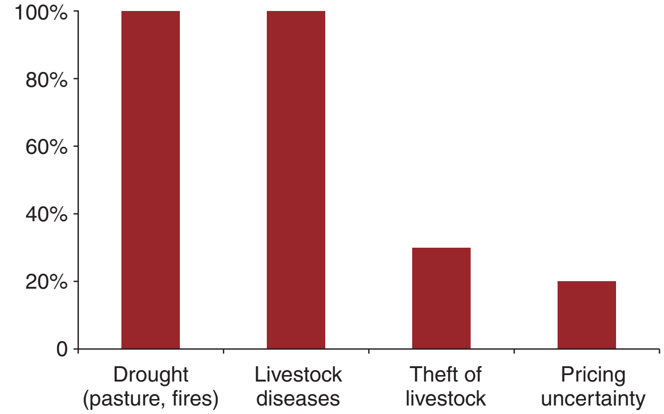
Irrigation enables farmers to make better use of available water resources. It also facilitates year-round production. Better control of resources and higher output means that households practicing irrigated agriculture have both a much higher capacity to manage production risks and to recover from shocks in their aftermath. Higher and more predictable revenue streams empower such households to invest in risk mitigating (for example, on-farm storage, pest-resistant varietals), and coping measures (for example, agro-chemicals, borrowing), thus reducing overall impacts from adverse shock events. For these reasons, investments in irrigation development, particularly in areas that are prone to extreme weather events, could go a long way in reducing levels of community vulnerability and strengthening resiliency.

AGRO-PASTORALISM

For many households, particularly in the northern part of the country, livestock production contributes largely toward meeting food needs. It also provides draft power, manure to maintain soil fertility, and cash income. Ruminant livestock more widely play a major role in the sociocultural life of rural communities. It acts as a source of household savings and insurance in times of difficulty. According to surveys conducted in 2008, 59 percent of agro-pastoralists live in the Northern Region and 21 percent in the Upper East Region. Sixty percent of their average income is derived from livestock and animal husbandry. Food crop production accounts for another fifth. Four out of five households (88 percent) were identified as poor (CFSVA 2009). Table 5.3 depicts the main perceived risks among these households and their rankings.

Some agro-pastoralists, especially in the Upper East, argued that a better integration of agriculture and livestock

TABLE 5.3. RISK RANKING, AGRO-PASTORALISTS*



Source: Authors' notes.
*Share of respondents citing risk type as most important or second most important

was one way to mitigate drought by ensuring that well-fertilized fields could do reasonably well, even with poor rainfall. Transhumance also was quoted as a way to deal with uncertainty in weather. Regarding mitigation strategies against animal diseases, respondents complained that access to vaccines is difficult, and that the reliability (that is, quality) of both vaccines and other medicines bought locally constitutes a risk in itself. Respondents had similar responses with regard to possible measures to reduce theft of livestock. Vaccinations as well as medical control of endo- and exo-parasites were deemed generally effective in mitigating losses from livestock diseases. However, these measures were considered to be not entirely reliable and not always accessible. With regard to limiting losses from theft of crops and livestock, respondents highlighted a range of measures that were generally reckoned to have a positive but limited impact. These included community watches, ear tags, and cold branding for cattle.

Livestock production offers myriad benefits. It provides supplemental and diversified income, a supplemental food source, and valuable household assets. It enhances household food security. By acting as a source of fertilizer and labor, it also contributes to more resilient crop production systems. Given these and other benefits, households owning livestock are often better equipped to face and overcome adversity than those households who rely exclusively on rain-fed agriculture. For example, well-fertilized crops can better withstand stress from water or pests and diseases, resulting in fewer losses. Thus, promoting livestock ownership among vulnerable communities, particularly in the northern savannah regions, could be an effective measure in building resiliency against risk events.

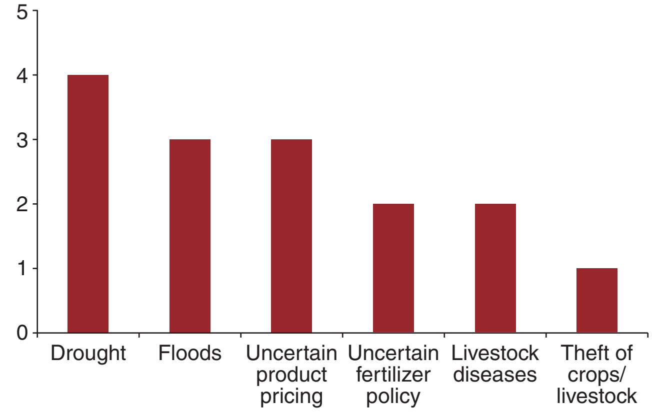
COMMERCIAL FARMERS

Larger commercial farmers, who account for roughly 10 percent of agriculture production in Ghana, highlighted risks similar to those faced by the more traditional smallholders. However, their ranking gave more prominence to product pricing and uncertainty in the timing of access to agro-chemical inputs (see table 5.4). In decreasing order of severity, they cited drought, floods, and uncertainty in product pricing (as equally serious), uncertainty in access to fertilizer (time and price), and livestock diseases. In addition to the mitigating measures mentioned against drought by smallholders, they also cited the practice of increasing organic matter content in soils by plowing under crop residues or manure from livestock. Commercial farmers are also more likely to build small water reservoirs. Commercial farmers were better able than smallholders to rely on storage and contract sales to mitigate product price uncertainty, but with limited effectiveness. To mitigate the risk of uncertainty in access to fertilizer, commercial farmers had greater financial means than did smallholders, allowing them to partly circumvent any delays in the delivery of subsidized fertilizers. When adversity strikes, impacts among commercial farmers are often much less significant, given their relatively limited exposure to risks and their ability to respond quickly and effectively to minimize losses.

TRADERS AND PROCESSORS

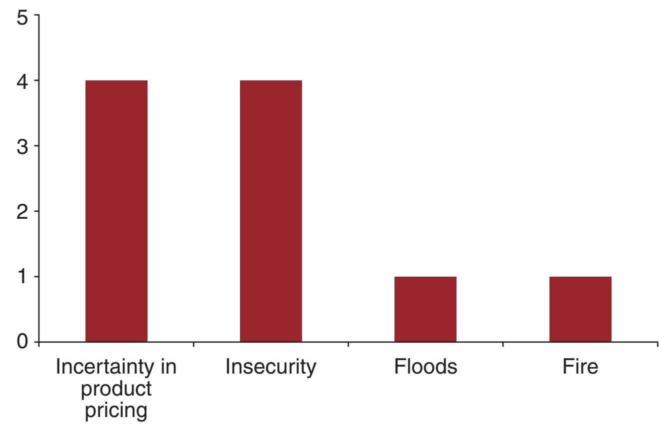
In declining order of importance, main risks cited by market traders included uncertainty over market prices (especially in 2013), when the prices of several basic commodities—including maize and groundnuts—have sharply fallen from harvest time to planting season),[15] and insecurity. These risks were distantly followed by risks

TABLE 5.4. RISK RANKING, COMMERCIAL FARMERS*



Source: Authors' notes.
*Number of respondents citing risk type as most important or second most important.

TABLE 5.5. RISK RANKING, GRAIN TRADERS*



Source: Authors' notes.
*Number of respondents citing risk type as most important or second most important.

to their stocks such as flooding (of warehouses) and fire. Other risks, such as exchange rate fluctuations or weevil attacks, were mentioned but deemed relatively minor. For their part, processors were mostly concerned about uncertainties in quantity and quality of supply, and the reliability of electric power supply (table 5.5).

Among group members who participated in the informal surveys, more and better storage was also viewed as the most effective way to deal with uncertainty in product pricing. Interestingly, traders did not feel that value chain improvements could reduce this risk significantly. Measures designed to mitigate the rising risk of insecurity

15 Maize fell from an average GH¢52 a bag in late 2012 to GH¢32 in early June 2013. This unusual trend was attributed by most observers to large shifts into maize after the bad 2011/12 growing season and relatively abundant local and regional supplies. Good production in 2012 also allowed some producers to store maize until the next planting season, at which time a great quantity came on the market to finance the purchase of agricultural inputs.

TABLE 5.6. STAKEHOLDERS' RISK PERCEPTIONS AND RANKINGS*

Risk/Stakeholder Group	Rain-Fed Agriculturalists	Irrigated Agriculturalists	Agro-Pastoralists	Commercial Farmers	Government Technicians	Traders	Processors
Drought/long dry spells, late start	1	4	1	1	1	—	—
Uncertainty in product pricing	2	6	4	3	2	1	—
Crop pests/diseases	3	3	—	—	3	—	—
Livestock diseases	4	—	2	5	4	—	—
Excessive rainfall, flooding	x	1	—	2	—	3	—
Thefts of crops or livestock	5	x	3	6	6	—	—
Bush fires (or in storage)	x	—	x	—	5	4	—
Grain-eating birds	x	5	—	—	—	—	—
Uncertain access to machinery	—	2	—	—	—	—	—
Insecurity/conflicts	—	—	—	—	x	2	—
Uncertainty in fertilizer policy	—	—	—	4	—	—	—
Uncertain electricity supply	—	—	—	—	—	—	1
Uncertain cost of chemical inputs	—	x	—	—	—	—	—
Uncertainty in labor costs	—	x	—	—	—	—	—
World market price risk	—	—	—	—	x	—	—
Exchange rate risk	—	—	—	—	—	x	—
Storage losses	—	—	—	—	—	x	—

Source: Authors' notes.

*Numbers indicate the number of responses citing each risk type as the most important.

consisted of reducing amounts of cash transported, either by bartering goods at the point of purchase, or relying more on bank transfers. Neither was judged to be fully effective.

RANKING OF STAKEHOLDER RISK PERCEPTIONS

Table 5.6 summarizes risk perception, by group, indicating the ranking by type of stakeholder. Price risk and drought are widely shared perceptions, the latter because of its severity and of a widespread perception that droughts are becoming more frequent. Livestock diseases and thefts of crops and animals (also on the rise) figure prominently, just before floods and crop pests/diseases.

Many respondents mentioned that specific risks often cluster together, and this was taken into account in the overall ranking. Drought, for instance, is often associated with increased severity of bushfires, because of much drier vegetation. The same phenomenon can be associated with attacks by grain-eating birds, because their usual sources of food are more limited under arid conditions. Drought and floods are often mentioned together because weather patterns in the recent past have often led to a series of dry spells in the first half of the season followed by spates of torrential rainfall in the latter part.

CHAPTER SIX

RISK PRIORITIZATION AND MANAGEMENT

RISK PRIORITIZATION

This assessment has highlighted key risks facing the agricultural sector in Ghana. These risks are both myriad and complex. They manifest with varying levels of frequency and severity, resulting in losses to crops and livestock and leading to income volatility. To identify an effective risk management strategy that maximizes available resources, it is necessary to prioritize these risks. This requires an understanding of which risks occur most frequently and which cause the biggest financial losses.

Chapter 4 identifies priority risks, using quantitative measures, for the crop and livestock sub-sectors. Owing to the paucity of data, some of the risks could not be quantified. Chapter 5 further highlights key risks based on anecdotal evidence collected directly from stakeholders. Based on the team's combined quantitative and qualitative assessment, table 6.1 prioritizes the most important risks for each crop, for livestock, and for poultry. Overall, this prioritization identified 1) drought, 2) pests and diseases, and 3) price volatility as the most important risks. Flooding from excessive rainfall and bushfires associated with drought were also deemed important, but to a lesser extent. Commodity profiles in appendix B offer a more detailed sub-sector analysis of risks.

It is worth noting that a single type of risk can affect one or several commodities (for example, armyworms impacting maize, rice, and millet yields, or drought damaging both crops and livestock pasture). However, as this report highlighted earlier, Ghana at the aggregate level is not particularly vulnerable to agriculture risk while related costs to the economy are relatively low. This is due to the diversity of agro-climatic conditions and agricultural systems (that is, crops, seed varieties) across the country's 10 regions. The probability that a single risk event could adversely impact a large number of commodities and regions at once is extremely low.

Despite this diversity, the analysis highlights that Ghana's agricultural sector is highly susceptible to downside risks associated with multiple shocks. This refers to, for example, times when extensive pest attacks and bushfires cause further losses to crops already damaged by prolonged drought conditions. Although less frequent, such

TABLE 6.1. RANKING OF RISKS BY SUB-SECTOR

Commodity	Risk		
	Priority #1	Priority #2	Priority #3
Cocoa	Pests and diseases	Price volatility (International)	Smuggling
Cassava	Diseases and pests	Flooding/excessive rainfall	Drought
Maize	Drought	Price volatility	Pests/diseases
Yams	Diseases/pests	Flooding/excessive rainfall	Price volatility
Groundnuts	Drought	Diseases and pests	Flooding/excessive rainfall
Plantain	Winds and storms	Diseases and pests	Price volatility
Sorghum	Drought	Pests and diseases	Price volatility
Millet	Drought	Pests and diseases	Price volatility
Rice	Drought	Flood	Price volatility
Livestock	Diseases	Drought	Theft/conflict
Poultry	Regulatory risks (imports)	Diseases	Price volatility
Aggregate for sector	Drought	Pests and diseases	Price volatility

Source: Authors.

multiple shock events cause the greatest financial losses to livelihoods across the sector. This is especially true when they are associated with drought. These findings will ideally have a direct bearing on future risk management interventions.

RISK PRIORITIZATION BY REGION

As noted earlier, regional diversity helps mitigate aggregate-level risk. However, it also implies that each region faces a different set of risks, with varying levels of vulnerability and strong implications for risk management. Northern regions, for example, are more prone to drought events, which can impact a large share of households; this occurs within a context in which relative poverty makes it more difficult for people to mitigate risks and cope with shocks (see the vulnerability analysis in appendix E). Thus, it was necessary to assess key risks at the regional level (see annex F). Table 6.2 details the team's ranking of key agricultural risks (among priorities identified above) for all 10 regions and its assessment of the level of regional vulnerability to each risk type (see appendix A for a detailed regional risk profile).

The region-level analysis and filtering reveal that low-income rural households in the northern regions (Upper West, Upper Eastern, Northern) are most prone to key production and price shocks and most vulnerable to their impacts. The assessment also highlighted considerable levels of vulnerability among smallholder producers across the country's cocoa belt. This is especially true in light of growing concerns over COCOBOD's finances, punctuated by its recent announcement of cost-cutting measures. This includes a 5-year planned phaseout of its flagship spraying program, which for more than a decade has covered the costs of fungicide and pesticide applications aimed at controlling blackpod disease and capsid infestations.

RISK MANAGEMENT MEASURES

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

1. **Risk mitigation (ex ante).** Actions designed to reduce the likelihood of risk or to reduce the severity of losses (for example, water harvesting and irrigation infrastructure, crop diversification, extension).

TABLE 6.2. RANKING OF RISKS AND VULNERABILITY BY REGION

Region	Priority Risks	Level of Vulnerability
Ashanti	1. Crop pests and diseases	Medium
	2. Flooding and excessive rainfall	Medium
	3. Drought	Low
Brong-Ahafo	1. Crop pests and diseases	Medium
	2. Drought	Low
	3. Flooding and excessive rainfall	Low
Central	1. Drought	Low
	2. Crop diseases and pests	Medium
	3. Flooding and excessive rainfall	Medium
Eastern	1. Drought	Low
	2. Crop diseases and pests	Medium
	3. Flooding and excessive rainfall	Low
Greater Accra	1. Drought	Low
	2. Crop, livestock, and poultry diseases	Medium to high
	3. Flooding and excessive rainfall	Medium
Northern	1. Drought/flooding	High
	2. Price volatility	Medium
	3. Crop and livestock pests and diseases	Medium
Upper East	1. Drought and flooding	High
	2. Price volatility	Medium
	3. Crop and livestock pests and diseases	High
Upper West	1. Drought and flooding	High
	2. Price volatility	Medium
	3. Crop and livestock pests and diseases	High
Volta	1. Drought	High
	2. Crop pests and diseases	Medium
	3. Flooding and excessive rainfall	Medium
Western	1. Crop pests and diseases	Medium
	2. Flooding and excessive rainfall	Medium
	3. Windstorms	Low to medium

Source: Authors.

2. **Risk transfer (ex ante).** Actions that will transfer the risk to a willing third party. These mechanisms usually will trigger compensation in the case of a risk-generated loss (for example, purchasing insurance, reinsurance, financial hedging tools).
3. **Risk coping (ex post).** Actions that will help the affected population to overcome crises and build their resilience to future shocks. Such interventions usually take the form of compensation (cash or in-kind), social protection programs, and livelihood recovery programs (for example, government assistance to farmers, debt restructuring, contingent risk financing).

Table 6.3 highlights some potential interventions that could help address key risks identified by this assessment. These are classified under three types: 1) risk mitigation, 2) risk transfer, and 3) risk coping measures. The list is by no means exhaustive, but is meant to illustrate the type of investments that, based on the analysis, have good potential to improve agricultural risk management in Ghana. Unlike drought or livestock diseases, which have a

TABLE 6.3. INDICATIVE RISK MANAGEMENT MEASURES

	Mitigation	Transfer	Coping
Drought	Promoting crop diversification (for example, tubers and root crops, seed varieties) Combining short-cycle (for example, millet and Chinese groundnuts) and longer-cycle crops Promoting adoption of soil and water conservation and NRM techniques Developing community-level food and fodder and forage (that is, livestock) banks Improved farming techniques (for example, intercropping, conservation tillage) Promoting development of small-, medium-, and large-scale irrigation; water harvesting Community outreach programs on tree cutting and reforestation	Macro-level crop insurance Farm-level crop insurance	Use of weather index to trigger early warning and response Decentralized disaster contingent fund for rapid response to local emergencies Contingent financing and other instruments to support coping measures Cash-for-work and Food-for-Work (FFW) programs to support soil and water conservation Facilitating temporary migration or permanent relocation Promoting development of social safety net programs (for example, food aid, FFW) Promoting household and community savings
Pests and diseases (crops)	Strengthening early outbreak detection and response systems Promoting crop rotation and transition to more pest- and disease-resistant crops Promoting IPM techniques, including biological control Diversifying seeds varietals within crops Strengthening of pest- and disease-tolerant seed development and distribution systems Improving farmer access to high-quality and affordable agro-chemicals	Crop insurance (yield-based)	Developing social protection programs Use of savings and borrowing Direct compensation to affected farmers
Pests and diseases (livestock)	Strengthening early detection and response systems Improving access to vaccination services and supplies Developing improved exo- and endo-parasite control measures Vaccination or prophylactic treatment (for example, CBPP, blackleg, foot/mouth, PPR) Quarantining of animals or culling to reduce risk of contagion Developing animal tracking systems (for example, via branding)	Direct compensation	Strengthening quarantine measures Direct compensation to farmers Disposal of carcasses to avoid contagion Borrowing money (food, feeder stock) Selling animals to buy medicine, fodder
Price volatility	Promoting farmer adoption of crops with strong market (domestic, export) demand Strengthening value chain linkages Improving market information systems Improving trade facilitation and promoting cross-border trade Improving access to quality marketing infrastructure (that is, storage, roads) Promoting enhanced role of private sector in marketing services and policy making		Social safety net programs (for example, food aid, FFW) Direct cash payments to affected households Promoting household savings Substitutions or reductions in household diet

Source: Authors.

generally negative impact on almost everyone, price risk may be more specific to certain stakeholder groups. For example, the atypical drop in maize prices in 2013 ahead of the new planting season can be considered both a risk to traders with large inventories and a windfall for consumers. It is also worth noting that many of these interventions, if implemented concurrently, can help address multiple risks with positive spillover effects across the sector.

DESCRIPTION OF PRIORITY RISK MANAGEMENT MEASURES

The following section provides a brief description of select interventions highlighted in table 6.3.

IMPROVED FARMING PRACTICES

Strengthening farmers' capacity, knowledge, and self-reliance through training in improved agricultural practices not only increases productivity, but also reduces farmers' vulnerability to agricultural risks. For example, promoting seed varietal diversity within mixed-cropping systems, the use of short-cycle and longer-cycle crops and drought-tolerant varieties, and staggered or succession planting are all interventions that could help mitigate risks associated with increasingly erratic rainfall patterns. Improved farmer use of integrated pest management practices, such as 1) crop rotation and crop sequencing to provide disease breaks for susceptible crops; 2) use of resistant cultivars and varieties; and 3) application of non-chemical control practices (for example, thermal), would help maximize biological prevention of pests and diseases without the need for high-cost, synthetic agro-chemicals. Where agro-climatic conditions permit, these measures might also include encouraging farmers to transition to more pest-resistant crops, for example, from millet and sorghum to maize, which has a relatively high yield as well as resistance to pre-harvest pest attacks.

SOIL AND WATER CONSERVATION

As elsewhere, decreasing soil fertility, land use pressures, and highly variable rainfall patterns (often associated with climate change) pose a significant threat to farmers' livelihoods and incomes. These challenges also expose farmers to considerable risk. Extension training on improved soil and water management measures, including the construction and use of small-scale dams, gravity irrigation schemes, semicircular or contour stone bunds, permeable zai holes, and hand-dug trenches, can help make farmers better prepared to cope with and build their resilience to weather-related shocks, particularly droughts. Training in mulching, composting, zero tillage and other conservation agriculture techniques can also help. Other measures may focus on the development of public-private partnerships designed to improve smallholder farmers' access to appropriately sized and affordable (for example, micro) irrigation technologies. While helping farmers to increase productivity and overcome climate uncertainty, irrigation development can also help to improve drainage of flood-prone areas.

STRENGTHENING EXTENSION

Agricultural extension, whether delivered via face-to-face demonstrations or via information and communication technology (ICT), is generally recognized as a strong contributor to agricultural development. It can also play a useful role in improving agronomic practices for managing risks. The primary focus of extension has traditionally been the transfer of technology and agronomic advice to farmers, as well as information and access to resources, which are all essential components for improved on-farm agricultural risk management. However, ensuring effective agricultural extension can be both resource intensive and challenging in a multi-stakeholder, resource-constrained environment. According to a 2011 survey of MoFA extension officers in the Upper East Region's Bongo District, as much as 71 percent of their working time was spent facilitating farmer access to donor resources (EWB 2011). There is need to refocus their efforts on improving farmers' agronomic practices, facilitating technology transfer, and enhancing information access to help them improve productivity and reduce risks. Deployment of ICT can supplement face-to-face interaction and reduce transaction costs associated with extension.

IMPROVING VETERINARY SERVICES

The provision of quality livestock health services is critical to safeguarding animal health. Such services also serve as the primary system for early detection and emergency response in the event of disease outbreaks to combat their spread and reduce related losses. They are also crucial for managing disease prevention and eradication efforts. In Ghana, veterinary services are currently centralized under MoFA's VSD (see box 6.1). A 2008 performance assessment of veterinary services in Ghana highlighted 1) concerns over the capacity of veterinary professional and paraprofessional staff to deliver critically important clinical services; and 2) significant weaknesses, notably inadequate transport and insufficient operational funds, adversely affecting VSD staff capacity to undertake effective and sustainable epidemiological-surveillance and disease control activities. Key recommendations included 1) the restructuring of VSD extension to make it more independent and to separate it from other extension services; 2) the return of Animal Production and Animal Health into one technical unit; and 3) the contracting out of selected VSD activities to the private sector and the mobilization of community-based delivery systems (Diop, Daborn, and Schneider 2011). Community-based participation often involves training community-selected and community-based representatives in basic animal health care and livestock production techniques. Several studies of the approach and its role in animal health services delivery have concluded that community-based approaches offer viable alternatives to the resource-constrained and poorly functioning public veterinary services. Experiences from these programs indicate that such programs encourage the participation of the local communities in the design and delivery of animal health care services. They can also empower individuals to determine the type of animal health services they receive. In some areas, conditions may exist that would permit full privatization using this approach.

BOX 6.1. VETERINARY SERVICES IN GHANA

The Veterinary Service Directorate (VSD) is mandated to check meat and live animal imports for contagious diseases, and conduct surveillance (that is, inspections, surveys) and prevention (that is, preparations of vaccines, vaccinations). It also controls the quality of services provided by private veterinarians, animal health assistants, community livestock workers, and so on. Most districts in the northern regions reportedly have one or several technical agents, but not every district has a District Veterinary Officers (DVO). There are currently four DVOs in Upper West region (nine districts with an average population of 12,500 animals), and three or four in Upper East Region (nine districts with an average population of nearly 33,000). The Northern Region, on the other hand, has an average of one DVO per district for an average population of 12,000.

A common complaint in the VSD is that MoFA institutional reforms have complicated and lengthened the chain of command: DVOs and regional veterinary officers do not report directly to the VSD, but through the Regional Director of Agriculture. When prompt resource allocation and action is required (for example, to confront an anthrax or CBPP outbreak) reaction time can therefore be much longer. Another issue flagged to the team in northern regions is that due to the late release of MoFA operational funds, the central veterinary laboratory requests up-front payment from regional offices in exchange for vaccines. This also risks delaying critical interventions. Finally, another common complaint heard from both VSD staff and some producers is that poorly labeled veterinary supplies and medicines of questionable effectiveness are readily found on local markets.

ENSURING QUALITY INPUTS

Relative to its regional neighbors, Ghana boasts properly functioning markets for agricultural inputs. For most crops and in most production zones, farmers can easily obtain improved seeds, fertilizers, agro-chemicals (for example, herbicides, insecticides), and farming equipment. With government support as well as help from the Alliance for a Green Revolution in Africa and other development partners, agro-dealer networks have expanded in recent years, penetrating deeper into rural markets and making inputs and related services more readily available to smallholder farmers. These investments were designed to help farmers raise productivity by increasing yields. They were also meant to improve farmers' access to more affordable crop protection products to help them control threats from pests and diseases. However, as markets have expanded, so too have illicit practices in the production and marketing of inputs. Although reliable statistics are not available, anecdotal evidence would suggest that counterfeited and adulterated products have proliferated in recent years. This trend poses a significant risk to cash-strapped farmers and agro-pastoralists who are looking for ways to reduce pest- and disease-related losses. This situation engenders distrust among farmers and can discourage farmer investments into productivity-enhancing inputs. Improved product tracking systems and stronger monitoring and enforcement mechanisms could help tamp down abusive behavior by input product manufacturers, importers, wholesalers, and retailers. Private-sector-funded training and awareness-building programs targeting input retailers and farmers and instructing them in how to spot and report adulterated products might also help.

MICRO-IRRIGATION DEVELOPMENT

Reliance on rain-fed agriculture for the majority of farming households in Ghana makes them highly vulnerable to weather-related risks. As noted earlier, this exposes them to droughts and other types of unseasonable weather. Micro-irrigation expansion in Ghana holds promise in some areas with highly variable rainfall but with sufficient access to water resources (for example, surface, ground) to help farmers better manage such risks. It also can help them to improve their yields, facilitate yearlong production, increase household incomes, and strengthen food security. The development of better and cheaper pumping technologies in recent years is opening up new opportunities for manufacturers and distributors to tap into growing demand among farmers in micro- and small-scale irrigation. Any irrigation development strategy would greatly benefit from the identification of appropriate finance mechanisms to improve smallholder access to new technologies.

UPGRADING INFORMATION SYSTEMS

The ability to respond to potential threats before they manifest or crises as they unfold depends on ready access to reliable and timely information and effective communication. Improving farmers' access to more and better weather forecasting, market prices, technical farming advice, and other critical information strengthens their capacity to make optimal, productivity-enhancing decisions while increasing their resiliency. It can also help mitigate inter-seasonal price volatility by enabling farmers to respond more directly and readily to shifting weather patterns and market signals. Similarly, applying localized pest and disease forecasting techniques could greatly reduce the response time needed to ward off large-scale crop and livestock losses. Ghana's recent introduction of field-based, farmer-monitored pheromone traps for the monitoring of armyworm infestations is one example of low-cost but effective early warning systems that could be scaled up and replicated.

Upgrading information management systems at district and regional levels would better enable the National Meteorological Service, NADMO, the Plant Protection and Regulatory Services Directorate (PPRSD), the Veterinary Services Directorate, the Crop Research Institute (CRI), and allied institutions to better monitor, analyze, and share information and mount more rapid, more coordinated, and more effective relief efforts when adversity strikes. It would also help ensure that available resources reach the most affected communities. Resulting improved flows of information would also strengthen linkages with international centers for better weather forecasting and pest and disease surveillance. In addition, broader input by stakeholders in the development and implementation of weather forecast programs would encourage decentralized (that is, based on local agro-ecological conditions), demand-driven, and more effective weather forecast production and information dissemination. All such initiatives would ideally include systematic institutional capacity strengthening and awareness building to link climate information to multimedia communication systems (for example, cellphones, radio, television) and tailor information to different audiences.

INFRASTRUCTURE DEVELOPMENT

Ghana currently ranks well behind the best-performing African countries in terms of infrastructure quality (AfDB 2012). This deficiency remains a critical constraint to agricultural sector growth. It also is an important source of price risk for stakeholders. In addition to better access to knowledge and information, improved access to marketing infrastructure such as on-farm storage for farmers, warehousing and covered market stalls for traders, and well-maintained rural feeder roads can help attenuate variability in market prices. By making it less costly and easier to store, transport, and process agricultural products, improved infrastructure can enable more efficient arbitration and price discovery, fewer ruptures in supply and demand, and more predictable pricing. Potential gains can also have significant positive spillovers in terms of enhanced food security and lower retail food prices for consumers.

COMMODITY EXCHANGES

By reducing transaction costs, exchange trading (physical and futures) could benefit counterparties by guaranteeing for sellers payment for what is sold while concurrently assuring buyers the delivery of goods. This guarantee by the exchange, based on guarantees by warehouse operators, reduces the risk of nonperformance of trade contracts. The greater security in trade transactions leads to significantly lower costs associated with contract enforcement, especially in markets in which litigation is time consuming and expensive. It also opens up new opportunities in the area of trade finance, and can also help in improving price discovery and provide a platform for hedging price risk. With an eye to successful models developed beyond the region, the government has promoted the development of warehouse receipts systems and has been studying the feasibility of establishing a national commodities exchange. However, successful development of such an exchange requires a number of prerequisites (homogeneous and standardized commodities; presence of warehouse infrastructure; transparent commodity policies and regulations; limited government interventions; and so on), many of which currently do not exist in Ghana. It might be helpful to address the fundamental building blocks first to help improve the chances of success of any potential commodity exchange.

INSTITUTIONAL REFORM AND STRENGTHENING

Institutional transformation within NADMO designed to strengthen its operational management, staff awareness and technical know-how, access to resources, and communication systems (as noted previously) could go a long way to improving Ghana's ability to prepare for and respond to natural hazards and other threats. It would also help to improve the country's vulnerability (and resiliency) to multiple shocks. Such reform would require that national disaster management policies and strategies be coordinated with sector programs in terms of policy making, related legislation, and processes. It would also need to better exploit existing synergies and ensure mutual reinforcing measures across ministries and agencies at the national, regional, and district levels. Such efforts would also greatly benefit from community outreach and engagement mechanisms. Similarly, COCOBOD and other cocoa stakeholders could potentially benefit from the development of a more systemic pest and disease management approach, especially in light of ongoing budget constraints. This might include, inter alia, reforming existing regulations that govern the import and distribution of fungicides and insecticides crucial to the control of blackpod and capsid and mirid infestation. Anecdotal evidence suggests that these regulations may be hindering farmer access (due to poor market availability and high cost) to these critical inputs, thereby compromising farmers' risk management capacity.

CROP INSURANCE

Agricultural insurance could be a useful tool to transfer the risk of low frequency–high impact events (for example, drought) in Ghana. A number of agricultural insurance initiatives (largely weather index insurance) have been piloted; however, these are experiencing severe challenges and there are questions about their sustainability. The issue of multiplicity of risks, basis risks, unavailability of robust yield data, limited access to agricultural credit (agriculture, forestry, and fishing loans making up only 5.9 percent of the total lending portfolio in Ghana[16] and only 10 percent of rural households have access to credit[17]), lack of rural distribution channels, and limited affordability due to high poverty (especially in the northern regions) are some of the challenges for scaling up agricultural insurance. Appendix D provides further details on agricultural risk financing and insurance options for Ghana.

SOCIAL SAFETY NET PROGRAMS

Social protection programs are typically designed to build the assets of poor households to withstand shocks and provide support when widespread shocks occur. Given high levels of vulnerability and weak coping capacity among low-income households, particularly those inhabiting Ghana's northern savannah zones, provision of social safety nets is typically an integral part of effective risk management. Such measures can take many forms, from programs that promote household savings to direct ex-post cash payments and food aid delivery to affected communities. The Livelihood Empowerment Against Poverty (LEAP) program, for example, is a social cash transfer program that provides cash and health insurance to extremely poor households across Ghana. Its objective is to alleviate short-term poverty and encourage long-term

[16] Bank of Ghana annual report.

[17] GFDRR Country DRM Plan for Ghana.

human capital development. Other social safety net initiatives can include Food-for-Work programs that provide relief while facilitating the recovery of affected communities and enhancing their future resiliency. Community-level food and fodder banks can greatly enhance community access to food and livestock feed in times of emergency while speeding up food distribution and relief efforts. Other possible measures include micro- and meso-level crop insurance schemes tailored to the needs of smallholder farmers. Appendix D provides a more in-depth look at the potential for the development of such schemes in Ghana, which the analysis suggests may be limited at present.

FILTERING AND PRIORITIZING INTERVENTIONS

Some mitigation, transfer, and coping strategies fall within the purview of the state (for example, financing a countrywide animal disease eradication campaign, providing infrastructure), whereas others are implemented at the household level, often with support from government institutions. Effective risk management requires that priorities be identified and solutions implemented within the framework of a comprehensive risk management strategy.

It is important to highlight that almost all of the measures described in table 6.3 are complementary in nature and will contribute to improved risk management in the short, medium, and long terms. However, decision makers are compelled to find the quickest, cheapest, and most effective measures among myriad policy options. Ideally, a detailed, objective, and exhaustive cost-benefit analysis will help in selecting the most appropriate intervention options. But conducting a cost-benefit analysis of so many different options in itself is often costly and time consuming.

An alternative approach, using decision filters to evaluate and prioritize among a list of potential interventions, can aid decision makers in making rational resource allocation decisions in lieu of a detailed cost-benefit analysis. The filters described in tables 6.4 and 6.5 are indicative only and incomplete. Nonetheless, they present a useful first step in the right direction. The government and its development partners could choose other criteria as filters, but it is important to ensure clarity, consistency, and objectivity while using them to evaluate decision options. The following decision filters were developed and used by the World Bank team. The study team applied these filters to facilitate a rapid assessment to obtain a first order of approximation, based on its assessment of the

TABLE 6.4. RELATIVE BENEFITS OF RISK MANAGEMENT INTERVENTIONS

	Reduces the Risk	Reduces the Losses	Compensates after the Loss	Addresses Multiple Risks	Improves Yields	Climate Change Mitigation	Climate Change Adaptation
Strengthening extension support	1	1	2	1	1	3	3
Improving farming practices	1	1	2	1	1	3	1
Soil and water conservation	1	1	2	3	1	1	1
Strengthening seed systems	1	1	2	1	1	1	1
Improving veterinary services	1	1	2	2	1	2	2
Ensuring quality inputs	3	1	2	3	1	2	3
Irrigation development	1	1	2	1	1	1	1
Upgrading information systems	1	3	2	1	3	3	3
Infrastructure development	1	1	2	1	2	2	2
Commodity exchanges	1	3	3	1	2	2	2
Crop insurance	2	2	1	1	2	2	2
Social safety net programs	2	2	1	2	2	2	2

Source: Authors.

TABLE 6.5. DECISION FILTERS FOR RISK MANAGEMENT MEASURES

	Scalability	Replicability	Cost	Implementation Difficulty	Return Time for Impact	Sustainability of Benefits	Sustainability of Intervention
Strengthening extension	High	High	Medium	Medium	Medium	Medium to high	Medium
Improving farming practices	High	High	Medium	Medium	Short	High	Medium
Soil and water conservation	High	High	Medium	Medium	Short	High	Medium
Strengthening seed systems	High	High	Medium	Medium to high	Medium	Medium	Low
Improving veterinary services	High	High	High	Medium	Short	Medium	Low
Ensuring quality inputs	High	High	Medium to high	Medium	Medium	High	Low
Irrigation development	Medium	Medium	High	High	Short	High	Low to medium
Upgrading information systems	High	Medium to high	High	Medium	Short	Medium	Medium
Infrastructure development	Low	High	High	High	Short to medium	High	Low
Commodity exchanges	Low	Low	Medium	Medium to high	Medium	High	Low
Crop insurance	High	High	Medium	High	Short	High	Medium

Source: Authors.

situation on the ground. The team presented preliminary results to government officials and other stakeholders at a roundtable in Accra in early June, during which it solicited feedback that was subsequently incorporated into the final results. They are illustrated in tables 6.4 and 6.5.

In table 6.4, interventions are rated according to the following: 1) Yes, 2) No, 3), Maybe (it depends), and 4) Not Certain, based on the following criteria:

- *Reduce the risk:* Would this activity lead to reduced exposure (that is, probability of negative event happening and its impact), thereby reducing risk?
- *Reduce the losses:* Would this activity lead to reduction of losses (that is, financial, crops, livestock), if a risk event were to occur?
- *Compensate after the loss:* Would this activity lead to compensation to the affected stakeholders after they have suffered losses?
- *Address multiple risks:* Would this activity concurrently address multiple risks (for example, drought, pests and diseases, flood, price volatility) or would it address only a single risk?
- *Improve yields:* Would the activity also lead to yield improvement in normal years?
- *Mitigate climate change:* Would the activity help mitigate climate change (that is, by reducing greenhouse gas emission or facilitating carbon sequestration)?
- Climate change adaptation: Would this activity help stakeholders better adapt to changing climate (for example, increasing heat or extreme weather events)?

For table 6.5, interventions were rated based on the following criteria:

- *Scalability (Low, Medium, High):* What is the potential outreach (possibility of reaching scale or reaching 50–60 percent of the farming population)?
- *Replicability (Low, Medium, High):* How replicable is this intervention to the wider Ghanaian agriculture? Is this a niche intervention with relatively limited applicability in a selected area or can it be replicated widely throughout the country?

» *Cost (Low, Medium, High):* What is relative cost of this intervention (in comparison with all the other interventions listed in table 6.5)?

» *Difficulty of implementation (Low, Medium, High):* In general, how difficult is this intervention to implement? Is this a complicated and technically sophisticated intervention or is this a relatively simple intervention to implement?

» *Return time for impact (Short, Medium, High):* How long does it take to see results from the intervention?

» *Sustainability of benefits (Short, Medium, Long):* How long do the benefits continue to accrue once the intervention has taken place?

» *Sustainability of intervention (Low, Medium, High):* How sustainable is the intervention over time?

Based on the prioritization of risk in table 6.5 and intervention measures in table 6.4, the following interventions have been identified as having significant potential to help confront the most important risks facing Ghana's agricultural sector, namely, drought, crop and livestock pests and diseases, and price volatility:

1. Improved farming practices (for example, promoting integrated pest management, especially in the south) and conservation agriculture measures (particularly in the north) to manage risks.
2. Strengthening tolerant seed (drought, pest, and disease tolerant) development and distribution systems.
3. Upgrading information systems to ensure availability of timely and relevant weather, prices, and pest and disease information to the farmers, traders, and other stakeholders, coupled with advice and knowledge disbursement on ways to manage them. This also includes market information about production, stocks, and trade of different commodities.
4. Improved water management (for example, soil and water conservation measures and irrigation, especially micro-level irrigation) and drainage infrastructure in flood prone areas.
5. Strengthening extension systems (face-to-face, ICT-based, peer-to-peer, and so on) to enable farmers to gain access to technology, agronomic advice, and resources to put in place risk mitigation measures.
6. Improving infrastructure (on-farm and off-farm storage, warehouses, roads, and so on) to improve productivity, reduce post-harvest losses, and help manage the risk of price volatility.
7. Strengthening institutional capacity of NADMO, COCOBOD, and other relevant agencies to manage agricultural risks, especially multiple shocks in the same year.

It is worth noting here that northern regional departments of agriculture extend technological packages very much in line with many of the risk management measures mentioned by respondent stakeholders and outlined in chapter 5. These measures include:

» Use of improved certified seeds
» Proper farmer use of pesticides and other agro-chemicals
» "Fodder banks"—harvesting and storage of crop residue for livestock
» Use of agro-industrial by-products to fatten livestock
» Adoption of hybrid maize varieties
» Appropriate use of inorganic fertilizers
» Water-harvesting techniques
» Soil conservation practices
» Composting
» Improvement of post-harvest storage (yams, legumes, grains)
» Crop rotation, inter-cropping (grain/legume)
» Reforestation
» Training of agro-chemical input dealers in safe product management

This assessment highlights a need both to improve and to scale up these and other risk mitigation measures already in place as well as integrate new and complementary measures that will empower more communities, particularly those identified as the most vulnerable, to access and benefit from them.

CONCLUSION

This document aims to contribute to and enrich the existing knowledge base of the agricultural sector in Ghana. It systematically analyzes agricultural risks and impacts over time (1980–2012). It helps place drought and other natural hazards within the context of other agricultural risks. It prioritizes the most important agricultural risks for the country based on objective criteria. It offers a framework for the development of a more comprehensive, integrated risk management strategy to strengthen existing mitigation, transfer, and coping measures. Finally, it provides a filtering mechanism to select an appropriate set of best possible interventions for agricultural risk management.

Most of the proposed intervention areas are already covered under various components of METASIP (see table 6.6) and are being implemented, albeit on a much smaller scale, by government agencies and development partners.

TABLE 6.6. INTEGRATION WITH METASIP

Indicative Interventions	METASIP Components
Improved farming practices (for example, IPM, on-farm practices, crop rotation)	Program 1.1, Program 1.4, Program 1.6, Program 2.1, Program 2.3, Program 4.1, Program 5.1
Improving information systems (for example, price, weather, early warning, extension)	Program 1.1, Program 1.4, Program 1.5, Program 2.2, Program 2.3, Program 3.1, Program 5.1, Program 5.2, Program 6.1, Program 6.3
Infrastructure improvement	Program 1.1, Program 1.3, Program 1.4, Program 1.6, program 1.7, Program 2.2, Program 2.3, Program 2.5,
Access to quality inputs (that is, agro-chemicals, vaccines, tolerant seeds)	Program 1.1, Program 1.4, Program 2.1, Program 2.3, Program 5.1

Source: Authors.

Greater emphasis should be placed on scaling up these interventions and looking at systemic changes on the national level to make a meaningful impact on agricultural sector risks in Ghana.

Scaling up of these approaches would require understanding the landscape of interventions, assessing their relative efficacy, understanding principal barriers and challenges to success and scale, and identifying leverage points and necessary interventions to increase their access to a wide majority of agricultural sector stakeholders. Assessing solutions to help prioritize specific interventions to scale up priority programs and putting in place a roadmap will be the next steps in the process of building resilience and reducing vulnerability of stakeholders and the agricultural sector in Ghana more broadly.

Overall, this assessment highlights that Ghana's agricultural sector, from a risk standpoint, rests on sound footing. The diversity of Ghana's agro-climatic conditions, farming systems, and productive assets within those systems shields the sector in the aggregate from massive debilitating shocks. Sectorwide vulnerability to risks is thus limited. However, a deeper analysis of crop- and region-specific risks reveals a number of insights with important implications for agricultural risk management in Ghana. Among these, interventions should aptly focus on reducing the vulnerability of communities in the country's three northern regions to production shocks such as drought and floods while increasing their resiliency to recover in their aftermath. Other priorities include improving systems for pest and disease management and strengthening farmers' capacity to manage these risks and improving information systems and infrastructure to help manage price volatility. In addition, strengthening the capacity of government institutions at the national, regional, and district levels to withstand and respond to multiple shock events will have the biggest impact on sector growth, rural livelihoods, and food security.

REFERENCES

AfDB (African Development Bank). 2012. "Republic of Ghana: Country Strategy Paper, 2012–2016." Country Operations Department (April).

Amissah, L., B. Kyereh, and V. K. Agyeman. 2010. *Wildfire Incidence and Management in the Forest Transition Zone of Ghana: Farmers Perspective*. CSIR-Forestry Research Institute of Ghana.

Anim-Kwapong, G. J., and E. B. Frimpong. 2004. *Vulnerability and Adaptation Assessment under the Netherlands Climate Change Studies Assistance Programme Phase 2 (NCCSAP2): Vulnerability of Agriculture to Climate Change—Impact of Climate Change on Cocoa Production* (Ghana: Cocoa Research Institute of Ghana).

Antwi-Agyei, Phillip, Evan D. G. Fraser, Andrew J. Dougill, Lindsay C. Stringer, and Elisabeth Simelton. 2011. "Mapping the Vulnerability of Crop Production to Drought in Ghana Using Rainfall, Yield and Socioeconomic Data," Centre for Climate Change Economics and Policy Working Paper No. 55, Sustainability Research Institute Paper No. 25.

Aryeetey, Ernest, and Ravi S. Kanbur. 2004. *Macroeconomic Stability, Growth and Poverty Reduction*. Accra, Ghana: Institute of Statistical, Social and Economic Research (ISSER).

Baba, A., N. Musah, E. Mumuni, O. Abayomi, and M. B. Jibrel. 2013. "Effects of Floods on the Livelihoods and Food Security of Households in the Tolon/Kumbumgu District of the Northern Region of Ghana." *American Journal of Research Communication* 1 (8): 160–171.

Bank of Ghana. 2012. *Statistical Bulletin* (June). IDPS Department, Bank of Ghana. Accra: Ghana.

———. 2013. *Statistical Bulletin* (June). IDPS Department, Bank of Ghana. Accra: Ghana.

Ben Ltaifa, Nabil, Stella Kaendera, and Shiv Dixit. 2009. "Impact of the Global Financial Crisis on Exchange Rates and Policies in Sub-Saharan Africa." *African Department* 09/3. Washington, DC: International Monetary Fund.

Biderlack, Lisa, and Jonathan Rivers. 2009. *Comprehensive Food Security & Vulnerability Analysis (CFSVA) Ghana* (VAM World Food Programme Food Security Analysis).

Birol, E., and D. Asare-Marfo. 2008. "Impact of HPAI on Ghanaian Rural Chicken Producers' Incomes." DFID, IFPRI, ILRI.

———. 2008. Impact of HPAI on Ghanaian Rural Chicken Producers' Incomes. IFRPRI/DFID. http://r4d.dfid.gov.uk/PDF/Outputs/HPAI/IFPRI_ILRI_rbr01.pdf.

"Bushfires in Ghana." 1996. *International Forest Fire News (IFFN)* 15 (September): 24–29.

CIAT. 2011. "Predicting the Impact of Climate Change on the Cocoa-Growing Regions in Ghana and Cote d'Ivoire" (September).

Comprehensive Food Security and Vulnerability Assessment (CFSVA), MoFA/WFP, 2012.

Diop, B., C. Daborn, and H. Schneider. 2011. "PVS Gap Analysis Report." World Organization of Animal Health (August).

Dontwi, Joyce, I. K. Dontwi, F. N. Buabeng, and S. Ashong. 2008. *Vulnerability and Adaptation Assessment for Climate Change Impacts on Fisheries* (Ghana: Netherlands Climate Assistance Programme [NCAP]).

EWB (Engineers Without Borders). 2011. "Agricultural Extension in Bongo District (UER)." Survey data collected for IFPRI, June–July.

Environmental Protection Agency. 2002. National Action Program to Control Drought and Desertification (April). Accra, Ghana.

FAO/WFP Crop and Food Supply Assessment Mission to Northern Ghana. March 13, 2002. http://www.fao.org/docrep/005/y6325e/y6325e00.htm#P1318_35461.

FAOSTAT. 2008. Commodity Balances. and FAOSTAT. 2009. Commodity Balances.

FAO (Food and Agriculture Organization). 2005. *Fertiliser Use by Crop in Ghana*. Rome, Italy: FAO.

———. 2013. Current Worldwide Annual Meat Consumption per capita, 2013.

Frederick, A., O. David, T. Genesis, O. Justice, and Ernest K. A. Afrifa. 2010. "Impact of Floods on Livelihoods and Vulnerability of Natural Resource Dependent Communities in Northern Ghana." University of Cape Coast, Cape Coast, Ghana.

Ghana Statistical Service. 2009a. "Digest of Macroeconomic Data." Statistical Abstract 2009. Accra.

———. 2009b. "Ghana's Economic Performance." Accra.

IFPRI (International Food Policy Research Institute). 2011. "Irrigation Development in Ghana: Past Experiences, Emerging Opportunities, and Future Directions." GSSP Working Paper No. 27 (March). IFPRI, Washington, DC.

———. 2012. "The Partially Liberalized Cocoa Sector in Ghana: Producer Price Determination, Quality Control and Service Provision." Discussion Paper 01213 (September). IFPRI, Washington, DC.

———. 2013. *West African Agriculture and Climate Change: A Comprehensive Analysis*. Monograph (April). Washington, DC: IFPRI.

"Improved Animal Health for Poverty Reduction and Sustainable Livelihoods, Animal Production and Health." 2002. Paper 153. Food and Agriculture Organization of the United Nations.

Josserand, H. 2013. "Volumes and Values of Regionally Traded Staple Commodities—Current and Prospective Analysis." Paper presented at the Food Across Borders Conference, Accra, Ghana, January. USAID.

Laderach, Peter. 2011. *Predicting the Impact of Climate Change on the Cocoa-Growing Regions in Ghana and Cote d'Ivoire* (CIAT, Climate Change, Agriculture, and Food Security).

Masters, G., P. Baker, and J. Flood. 2010 "Climate Change and Agricultural Commodities," CABI Working Paper 2 (38 pp.).

McSweeney, C., M. New, and G. Lizcano. 2008. *UNDP Climate Change Country Profiles: Ghana* (The United Nations Development Programme).

MoFA (Ministry of Agriculture and Food). *Annual Progress Reports*. 1992, 1994, 1996, 1997, 1998, 1999, 2003, 2004, 2005, 2006, 2007, 2008, 2009. Accra, Ghana: MoFA.

———. 2008. "Ghana National Investment Brief." High Level Conference on Water for Agriculture and Energy in Africa: The Challenges of Climate Change. Sirte, Libyan Arab Jamahiriya, December 15–17.

———. 2010. "Agriculture in Ghana: Facts and Figures." Statistics Research and Information Directorate (April). Accra, Ghana: MoFA.

———. 2011. *Annual Progress Report, Northern Region*. Accra, Ghana: MoFA.

Namara, R. E., L. Horowitz, and B. Nyamadi. 2011. "Irrigation Development in Ghana: Past Experiences, Emerging Opportunities, and Future Directions." Ghana Strategy Support Program (GSSP), Working Paper No. 0026. International Food Policy Research Institute (IFPRI), Accra, Ghana.

OECD/Sahel and West Africa Club. 2008. "The Future of Livestock in the Sahel and West Africa: Potentialities and Challenges for Strengthening the Regional Market." Paris, France: OECD.

Ofori-Sarpong, E. 1986. "The 1981–1983 Drought in Singapore." *Singapore Journal of Tropical Geography* 7 (2).

Oteng-Darko, P., N. Kye-Baffour, and E. Ofori. 2012. "Simulating Rice Yields under Climate Change Scenarios Using the CERES-Rice Model," *African Crop Science Journal* (CSIR-Crops Research Institute, Department of Agricultural Engineering, KNUST, Kumasi, Ghana) 20, no. S2: 401–408.

de Pinto, Alessando, Ulac Demirage, Akiko Haruna, Jawoo Koo, and Marian Asamoah. 2012. "Ghana Strategy Support Program: Climate Change, Agriculture, and Foodcrop Production in Ghana*."* IFPRI Policy Note No. 3.

Republic of Ghana. 2011. "Second National Communication under United Nations Framework Convention on Climate Change." (Ghana: Environmental Protection Agency).

Rushton, J., D. Pilling, and C. L. Heffernan. 2002. "A Literature Review of Livestock Diseases and Their Importance in the Lives of Poor People." Nairobi, Kenya: International Livestock Research Institute.

Sagoe, Regina. 2006. *Climate Change and Root Crop Production in Ghana: A Report Prepared for Environmental Protection Agency (EPA), ACRA-Ghana* (Kumasi, Ghana: The Crops Research Institute).

Sarpong, Daniel Bruce, and Samuel Asuming-Brempong. 2004. "Responding to Shocks in Ghana: The Agricultural Sector as a Social Safety Net." *eJADE. Electronic Journal of Agricultural and Development Economics* 1 (1): 117–137.

Sarris, Alexander, and Panayiotis Karfakis. 2006. "Household Vulnerability in Rural Tanzania" (paper presented at the CSAE conference, Reducing Poverty and Inequality: How Can Africa Be Included?).

Schmitz, C., and D. Roy. 2009. "Potential Impact of HPAI on Ghana: A Multi-Market Model Analysis." DFID, IFPRI, ILRI.

Seini, A. Wayo. 2002. "Agricultural Growth and Competitiveness under Policy Reforms in Ghana." Technical Publication No. 61. Institute of Statistical, Social and Economic Research (September).

Sudharshan, Canagarajah, and Claus C. Porter. 2003. "Evolution of Poverty and Welfare in Ghana in the 1990's: Achievements and Challenges." Africa Region Working Paper Series No. 61, World Bank, Washington, DC.

Vabderpuye-Orgle, Jacqueline. 2004. "Economy and Poverty in Ghana in the 1990's: A Review." Discussion Paper No. 29, Institute of Statistical, Social and Economic Research, University of Ghana, Legon.

Wheeler, David. 2011. "Quantifying Vulnerability to Climate Change: Implications for Adaptations Assistance," CGD Working Paper 240 (Washington, DC: Center for Global Development).

World Bank. 2005. "Managing Agricultural Production Risk: Innovations in Developing Countries." Agriculture and Rural Development Department. Washington, DC: World Bank.

———. 2006. "Managing Food Price Risks and Instability in an Environment of Market Liberalization." Agriculture and Rural Development Department. Washington, DC: World Bank.

———. 2010. *Disaster Risk Management Programs for Priority Countries: Ghana*. Washington, DC: World Bank.

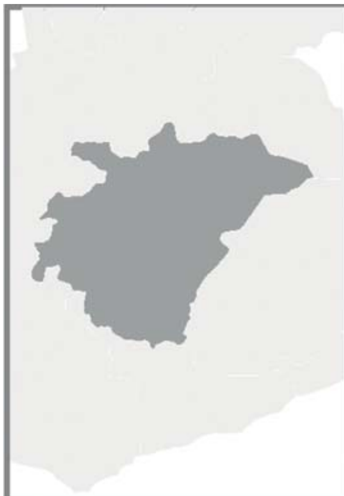
———. 2012a. "Republic of Ghana: Cocoa Sector Policy Brief" (May 24). Washington, DC: World Bank.

———. 2012b. "Supply Chain Risk Assessment: Cocoa in Ghana." Agriculture and Rural Development Department. Washington, DC: World Bank.

APPENDIX A

REGIONAL RISK PROFILES[18]

[18] *Source:* Authors' analysis based on meteorological data from weather stations in Ghana and historical data from MoFA.



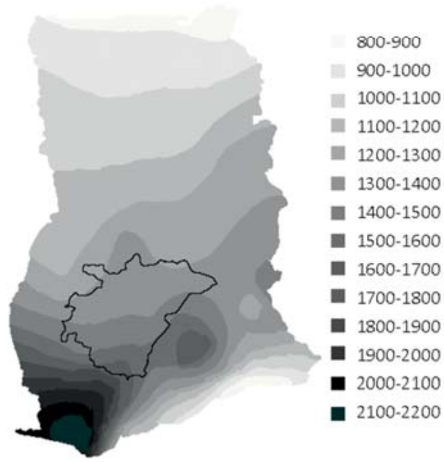
REGIONAL RISK PROFILE: ASHANTI

Occupying a total of 24,389 km2, or 10.2 percent of Ghana's total land area, the Ashanti region is the country's third largest, after Northern and Brong-Ahafo. However, its 4.88 million inhabitants (19.1% of total) make it Ghana's most populous region. It also boasts the second highest population density after Greater Accra. A bimodal rainfall pattern assured an average of 1,337 mm per year (2001-09). Agriculture production dominates the region's economy. Along with Brong-Ahafo and Eastern, Ashanti is among the largest food crop producers. Key crops include maize, cassava, and plantains. It is also the second largest cocoa producer, accounting for nearly one-sixth of the national cocoa crop. One of Ghana's wealthiest regions, poverty levels are among the lowest in Ghana. An estimated 7% of the population is categorized as food insecure, while 10% are considered vulnerable.

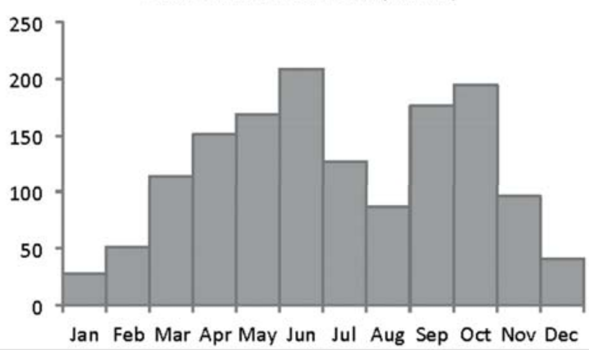
The region's agricultural risk profile exhibits a lower than average susceptibility to adverse production shocks for most crops. Resulting losses also tend to be lower. During the period 1981-2010, the region experienced 8 weather-related shocks. Of these, five (5) were caused by excessive rainfall. While this can lead to localized flooding and damage to maize and root/tubers, excessive rainfall poses perhaps the most significant threat to cocoa. This is because high humidity levels create ideal conditions for the spread of pests and diseases such as capsids/mirids and blackpod. Resulting losses are estimated to amount to as much as 30% of the total crop per year. During the period 1992-2008, there were an estimated seven (7) food crop loss events, according to the analysis. Yams and maize were among the most affected. Another notable threat, seasonal windstorms can cause severe damage to young plantain trees often weakened by the long dry season.

AGRO-ECOLOGICAL ZONES

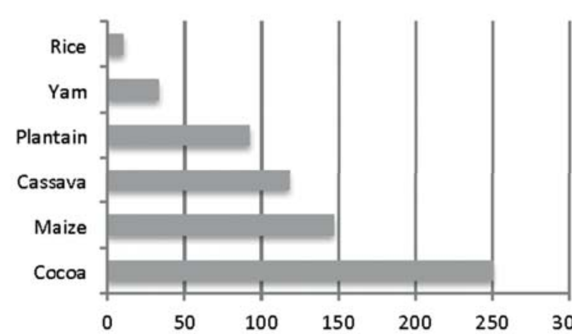
ANNUAL RAINFALL (in mm)



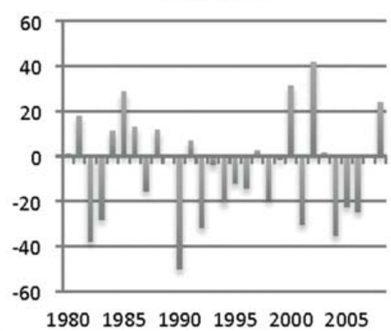
CUMULATIVE RAINFALL (in mm)



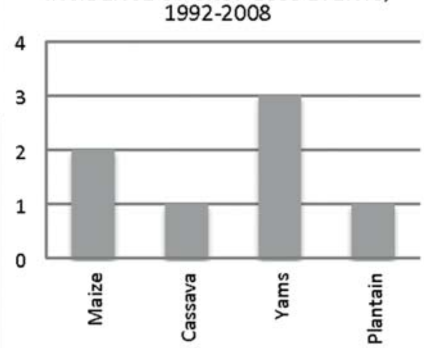
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Crop diseases (cocoa: blackpod, CSSVD; cassava: ACMD, CBB, CAD, brown streak; maize: streak virus, leaf blight, stalk rot, etc.)
2. Crop pests (cocoa: capsids/mirids; cassava: African armyworm, grasshopper; maize: stem borer, larger grain borer, armyworm, grasshopper, etc.)
3. Excessive rainfall/flooding
4. Drought
5. Windstorms (i.e., plantains)

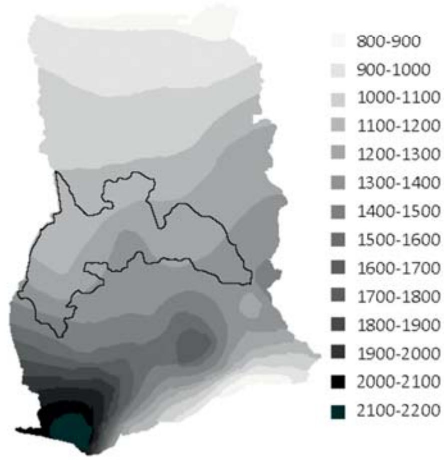
REGIONAL RISK PROFILE: BRONG-AHAFO

Ghana's Brong-Ahafo region is the country's second largest. It accounts for approximately one-sixth of Ghana's total landmass but less than one-tenth (9.6%) of its population. Located within the high forest and transition zones, the region boasts relatively good soils and a bimodal rainfall pattern that assures ample rainfall for most of the year. Not suprisingly, Brong-Ahafo is one of the largest food and cash crop producers in Ghana and agricultural production is a mainstay of the regional economy. The region accounts for more than one-quarter (27%) of the nation's maize, more than one-fifth (22%) of its cassava, and nearly 10% of its cocoa output. Other important crops include yams and plantains. Only 3% of households in the region are considered to be food insecure.

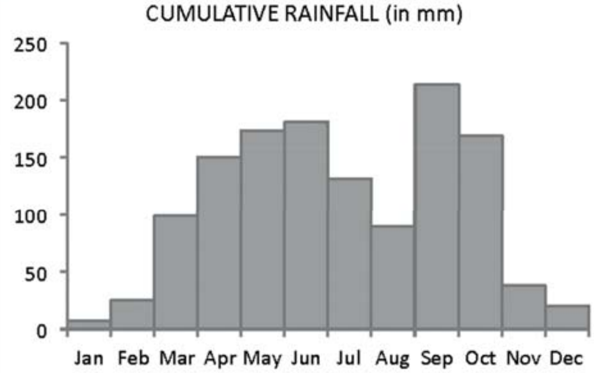
Like its southern neighbors, Brong-Ahafo region is one of the regions that is least prone to adverse production shocks, both in terms of frequency and severity. During the period 1981-2010, the region experienced a total of four (4) periods of drought and three (3) periods of excessive rainfall. The worst of these was in 1994 when drought-induced crop losses, worsened by widespread grasshopper infestation, amounted to an estimated 3.2% of GAO. At the other extreme, total rainfall in 2010 as recorded was roughly three and a half times the normal average, leading to widespread flooding and crop damage. Beyond weather-related risks, sector growth in the region is threatened by a wide range of crop pest and diseases. Among the most notable are African Cassava Mosaic Diseases (ACMD) and Cassava Bacteria Blight (CBB), the African armyworm, maize stem borer and larger grain borer, and blackpod and Swollen Shoot virus disease. Control efforts in recent years have focused on the development of disease resistant cassava cultivars and early-warning systems to mitigate the damage in the event of an outbreak.

AGRO-ECOLOGICAL ZONES

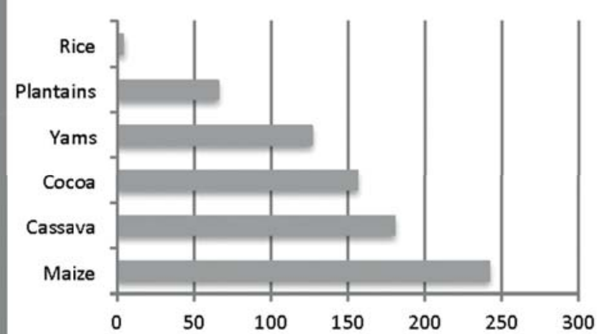
ANNUAL RAINFALL (in mm)



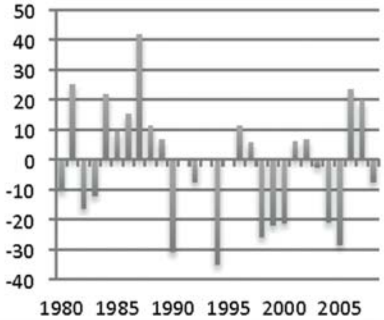
CUMULATIVE RAINFALL (in mm)



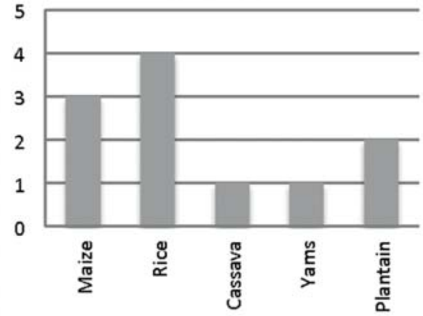
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Crop diseases (cassava: ACMD, CBB, CAD, brown streak; maize: streak virus, leaf blight, stalk rot, etc.; cocoa: blackpod, CSSVD)

2. Crop pests (cassava: African armyworm, grasshopper; maize: stem borer, larger grain borer, armyworm, grasshopper, etc.; cocoa: capsids/mirids;)

3. Drought

4. Excessive rainfall/flooding

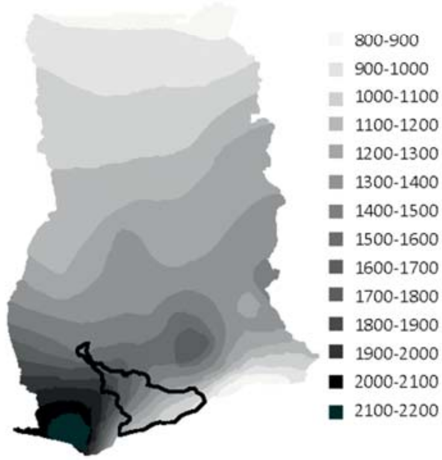
REGIONAL RISK PROFILE: CENTRAL

Comprising about 4.1% of Ghana's land mass and 8.45 of its population, the Central region is one of the country's smallest region and its third most populous. It spans the country's deciduous forest and coastal savana zones. It has a bi-modal rainfall pattern averaging 800 mm to 1500 mm, with the coast receiving the least. The region's economy is dominated by services (e.g., tourism, education), followed by mining, fishing and agriculture. Principal crops include cocoa, maize, cassava, plantain, and rice. After Volta (36%), the Central region is the second largest producer (27%) of cassava. According to a 2008 survey, just over half (51%) of households cited food production as among the top three most important income-generating activities. Nineteen percent (19%) included cash crops. Eighteen percent (18%) of sampled households produced cocoa. In part due to favorable agroclimatic conditions, the Central region registers among the lowest poverty rates (20%) among all 10 regions and only 2% of the population is considered to be food insecure.

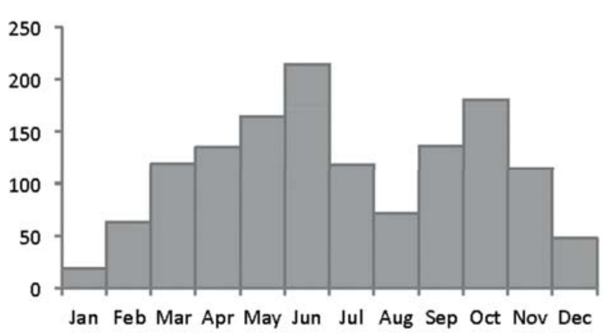
Weather related shocks pose the greatest risks to the region's agricultural economy. During the period 1981-2010, the region was subject to a total of 10 adverse rainfall shocks, 6 of which were due to insufficient rainfall: of these, only the drought of 1983 was thought to be severe, causing widespread crop damage. The other four (4) were due to excessive rain, such as in 2006 when widespread flooding followed by an outbreak of armyworm contributed to a 11% drop in maize production. During the period 1992-2008, the Central region experienced a total of 7 crop loss events (excluding cocoa). These occurred in 1997, 1998, 2001, 2005 and 2006. Plantains were most affected (3 shocks), followed by cassava (2), maize and yams. Beyond weather, crop pest and diseases pose a serious threat. An outbreak of swollen shoot virus during 1983/84 led to the cutting of 10 million cocoa trees over 580,000 hectares in Central and neighboring Eastern regions.

AGRO-ECOLOGICAL ZONES

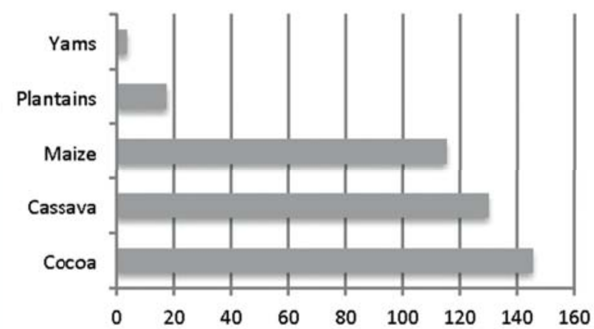
ANNUAL RAINFALL (in mm)



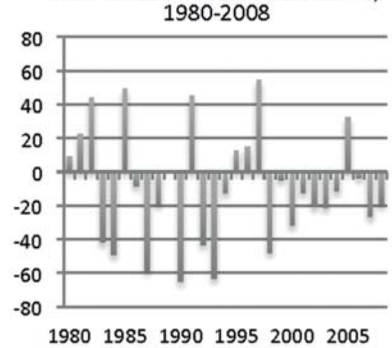
CUMULATIVE RAINFALL (in mm)



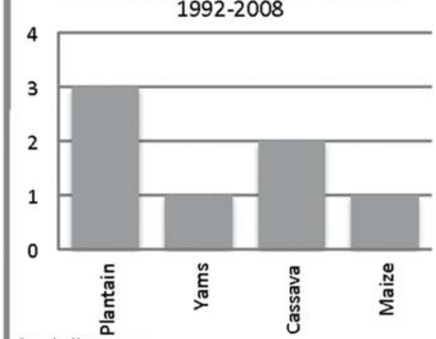
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



*excluding cocoa

KEY RISKS

1. Drought
2. Crop diseases (cocoa: blackpod, CSSVD; cassava: ACMD, CBB, CAD, brown streak; maize: streak virus, leaf blight, stalk rot, etc.)
3. Crop pests (cocoa: capsids/ mirids; cassava: African armyworm, grasshopper; maize: stem borer, larger grain borer, armyworm, grasshopper, etc.)
4. Excessive rainfall/flooding
5. Windstorms (i.e., plantains)

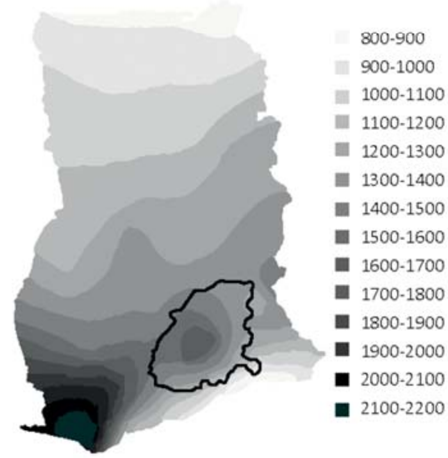
REGIONAL RISK PROFILE: EASTERN

Comprising approximately 8.1% of Ghana's land mass and 11% of its population, the Eastern region is the country's sixth largest. It is the 4th most populous (123.6 persons per square kilometer) among the 10 regions. It spans the country's deciduous forest and transition zones and benefits from a bi-modal rainfall pattern. It receives an average of 1260 mm of rainfall per year. The region's economy is largely driven by electricity generation from the Akosombo Dam, but farming and fishing activities provide the bulk of employment. Along with Brong-Ahafo and Ashanti, the Eastern region is among Ghana's top food crop producers. Roots/tubers, maize, and plantain are among the region's most important crops. The region accounts for roughly one-firth of Ghana's cassava crop. It also produces one-tenth of the country's cocoa crop. Poverty rates are the second lowest in Ghana, after Greater Accra.

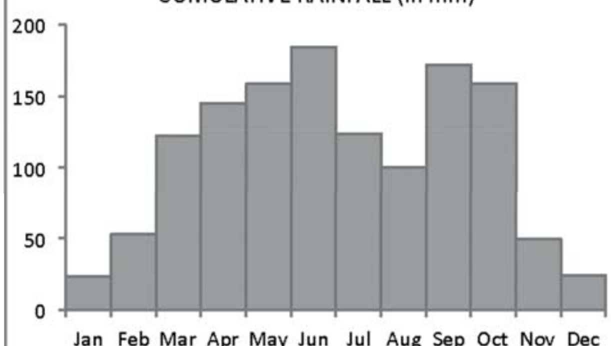
Sector growth in Ghana's Eastern region faces some notable risks. These include unpredictable and erratic rainfall patterns punctuated by periods of extremely low or excessive rainfall. During the period 1981-2010, the region was subject to 10 weather-related shocks. The most severe of these was in 2005 when a 45% drop in rainfall contributed to an estimated 14% loss in rice production. A similar drought in 1993 resulted in part in a 19% drop, according to the analysis. Other risks facing sector stakeholders include pests and diseases that attack root crops (e.g., cassava, yams), maize, and cocoa. Overall, the current analysis found that the incidence of risk-related crop losses in the Eastern region was the second lowest (after Western) among the ten regions. Also, associated crop losses tend to be less severe. During the period 1992-2008, there were five (5) crop loss events, representing less than 4 percent of the total observed across the 10 regions. For plantains, windstorms are a constant seasonal threat but are rarely thought to lead to severe, widespread crop damage.

AGRO-ECOLOGICAL ZONES

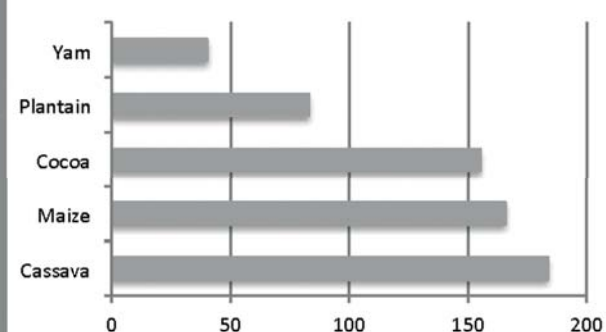
ANNUAL RAINFALL (in mm)



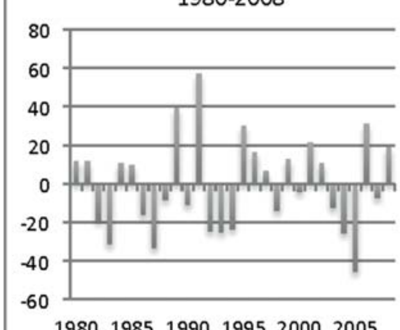
CUMULATIVE RAINFALL (in mm)



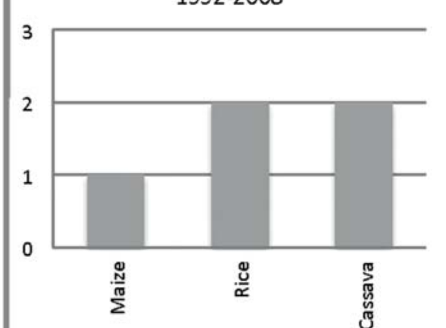
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Drought/unpredictable rainfall
2. Crop diseases cassava: ACMD, CBB, CAD, brown streak; maize: streak virus, leaf blight, stalk rot, etc.; (cocoa: blackpod, CSSVD;)
3. Crop pests (cassava: African armyworm, grasshopper; maize: stem borer, larger grain borer, armyworm, grasshopper, etc. (cocoa: capsids/mirids)
4. Excessive rainfall/flooding
5. Windstorms (i.e., plantains)

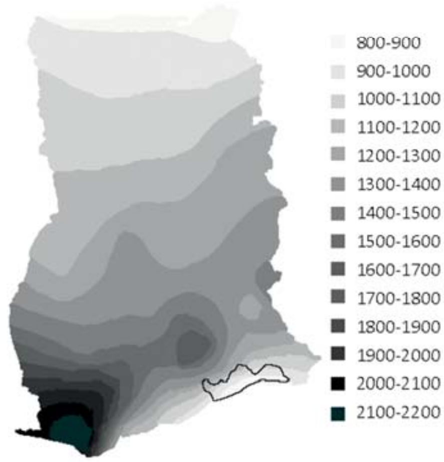
REGIONAL RISK PROFILE: GREATER ACCRA

Greater Accra is by far the smallest of Ghana's ten regions. It covers approximately 3,600 square kilometers, or just 1.5% of the country's total landmass. Despite its small size, it is the second most populous region after Ashanti; one in six Ghanaians live there. Consequently, it also has the highest population density in Ghana, more than 1,320 persons per square kilometer. The region is also the most urbanized: roughly five out of every six inhabitants lives in or around urban centers such as Accra and Tema. About 10% of the population is actively engaged in agriculture. Situated within the country's coastal savanah zone, the region has a major and minor season but receives the least amount of cumulative annual rainfall (during 2001-09, an average of 781 mm) among all 10 regions. The regional economy is driven primarily by public administration and goods and services trade; the agricultural sector is small by comparison. Leading agricultural activities include livestock and poultry production, fishing, and production of maize, cassava, and fruits/vegetables.

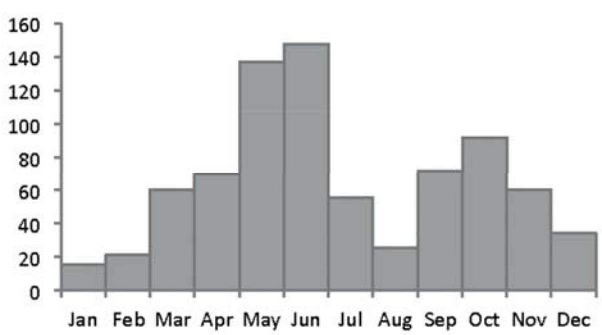
The region's agricultural profile highlights a slightly higher than average susceptibility to adverse crop production shocks. During the period 1981-2010, the region experienced 7 extreme weather-related events: among these, a drought in 1983 and excessive rainfall in 1991 were deemed catastrophic. During 1992-2008, the region was subject to fourteen (14) crop loss events impacting key crops maize (5), rice (5) and cassava (4). A severe drought in 1998, for instance, contributed to a 43.7%, 39.5%, and 10.4% drop in rice, maize, and cassava production respectively. However, given limited production volumes, such shocks tend to have limited impact on GAO at the national level. At the other extreme, excessive rainfall periodically leads to flooding of valleys as well as coastal wetlands, especially on occasions when the Weija dam is opened to relieve pressure. Other key risks include common pest and diseases affecting cassava, maize, rice, livestock and poultry.

AGRO-ECOLOGICAL ZONES

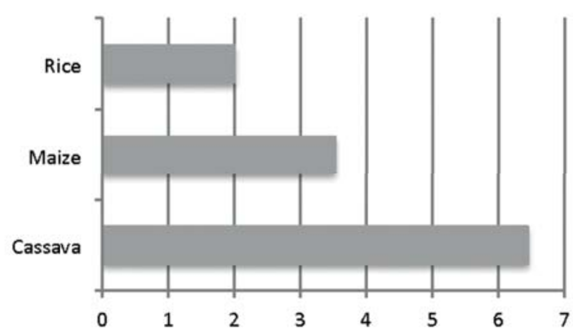
ANNUAL RAINFALL (in mm)



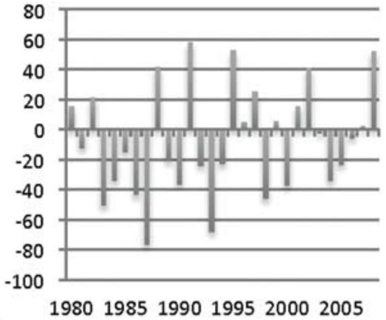
CUMULATIVE RAINFALL (in mm)



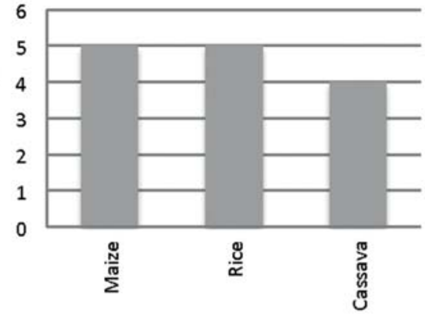
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Drought/unpredictable rainfall
2. Crop/livestock diseases (cassava: ACMD, CBB, CAD, brown streak; maize: streak virus, leaf blight, stalk rot; livestock/poultry: Newcastle and Gumboro)
3. Crop pests (cassava: African armyworm, grasshopper; maize: stem borer, larger grain borer, armyworm, grasshopper; livestock/poultry: PPR, ASF, parasites)
4. Excessive rainfall/flooding

REGIONAL RISK PROFILE: NORTHERN

With 70,380 square kilometers, about 29.5% of total land area, the Northern region is Ghana's largest. The population is nearly 2.5 million, with the lowest density among all ten regions. The region spans the Northern Savannah zone and receives on average approximately 1,150 mm per year. Agriculture dominates the regional economy. Main crops include maize, yams, groundnuts, rice, millet, sorghum, and cashew nuts. The livestock sector has traditionally made a major contribution to the rural economy; at the time of the last national census, some 34% of the nation's cattle herd were found in Northern Region.

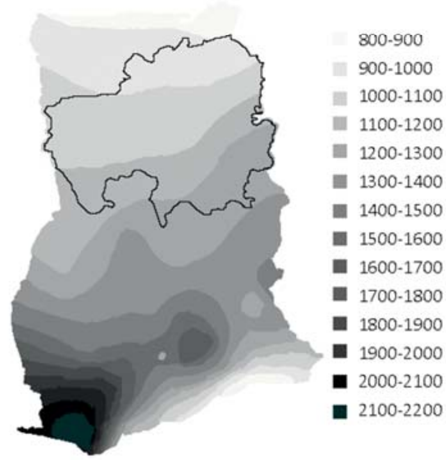
The percentage of organic matter in soils is lower in Northern than in Ashanti or West regions so that over 30% of north savannah households use inorganic fertilizer, compared to 15% in the Coast and Forest zones. Irrigation potential and development are limited, representing about 7% of national total.

Average household incomes were lower here in 2008 than the national average (GHc 296, compared to GHc397). Typical production constraints reported by households include low soil fertility and limited access to agro-chemicals. However, the main risks facing producers in the region, based on farmers' input, were unpredictable and changing rainfall patterns, price volatility, crop pests and diseases, livestock diseases, excessive rainfall, and uncertain availability of quality and affordable inputs.

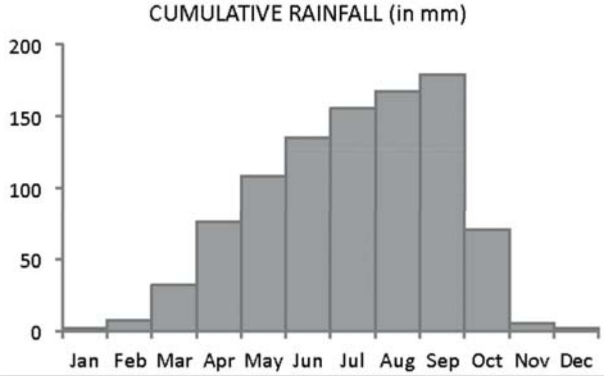
During the 1992-2012 period, the region experienced single or combined crises during 12 years, including 7 years of general or localized drought (1 catastrophic, 2 severe and 4 moderate). Others crises included national instability, ethnic conflicts, bush fires, and localized flooding.

AGRO-ECOLOGICAL ZONES

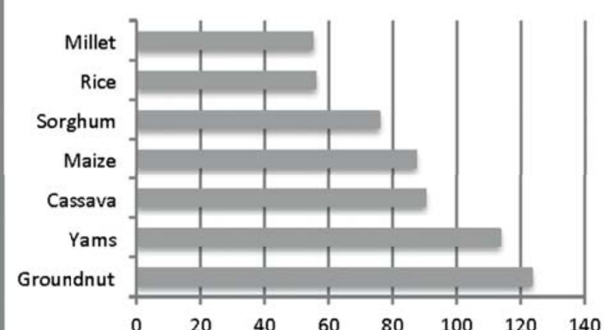
ANNUAL RAINFALL (in mm)



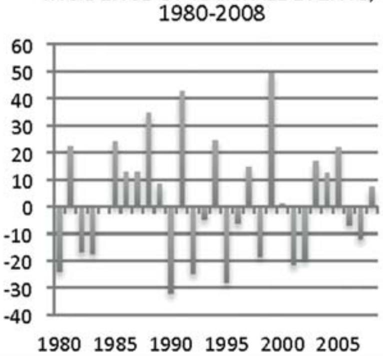
CUMULATIVE RAINFALL (in mm)



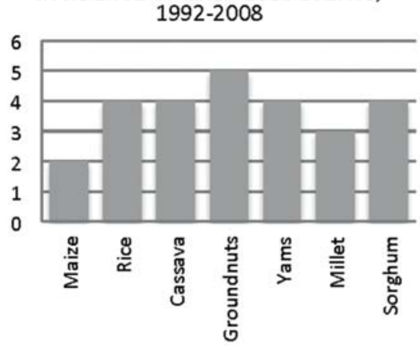
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Unpredictable rainfall
2. Price volatility
3. Crop/livestock pest and diseases
4. Excessive rainfall/flooding
5. uncertain input supply (i.e., quality, availability, prices)

REGIONAL RISK PROFILE: UPPER EAST

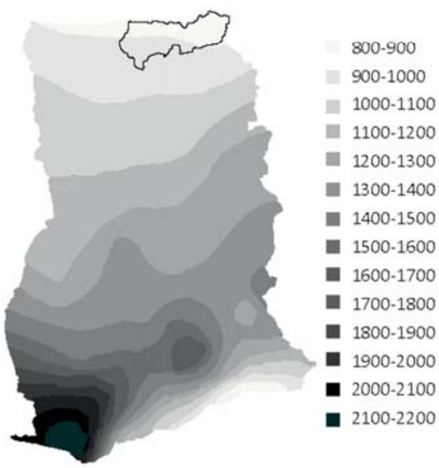
The smallest in land area, Ghana's Upper East region is approximately 8,800 square kilometers, or 3.7 percent of total land area. With a population of 1,032,000, it falls within the country's sudano-sahelian zone. Average annual rainfall over the 1981-2010 period has been 912 mm. Agriculture dominates the regional economy. The principal crops are millet, maize, sorghum, and groundnuts. Average household incomes were much lower here in 2008 than the national average (GHc 124, compared to GHc397).

The percentage of organic matter in soils is lower in Upper East than in Ashanti or West regions. More than 30% of north savannah households use inorganic fertilizer, compared to 15% in the Coast and Forest zones. There is, however, good potential for irrigation development, representing an estiamted 44% of total national potential. In addition, many farming communities rely on large ruminants to supply significant amounts of manure for their fields. The livestock sector has traditionally made a major contribution to the rural economy; at the time of the last national census, some 17% of the nation's cattle herd were found in Upper East Region (on less than 4% of Ghana's land area).

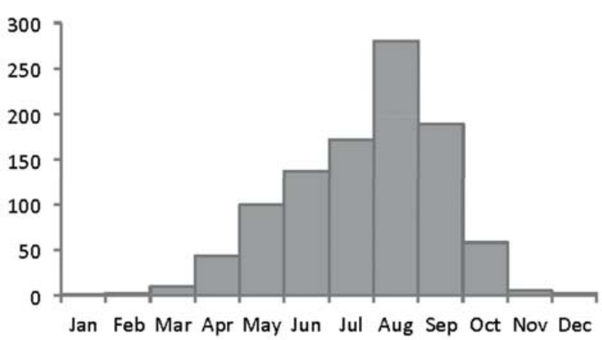
Major production constraints include low soil fertility and limited farmer access to agro-chemicals. The most oft-cited risks among farmers and others who provided input for this assessment were uncertain rainfall, price volatility, crop pests and diseases, livestock diseases, flooding/excessive rainfall, and uncertain availability of inputs. During the 1992-2012 period, the region experienced single or combined crises during 12 years, including 7 years of general or localized drought (1 catastrophic, 1 severe and 5 moderate). Others crises included national instability, ethnic conflicts, bushfires, and localized flooding.

AGRO-ECOLOGICAL ZONES

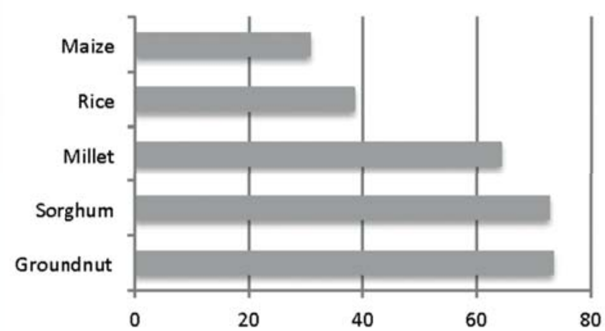
ANNUAL RAINFALL (in mm)



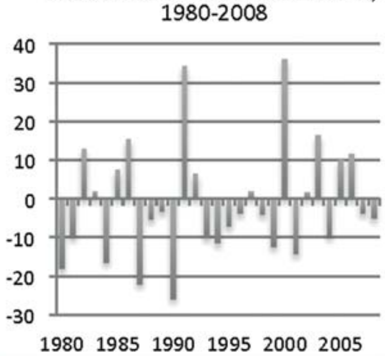
CUMULATIVE RAINFALL (in mm)



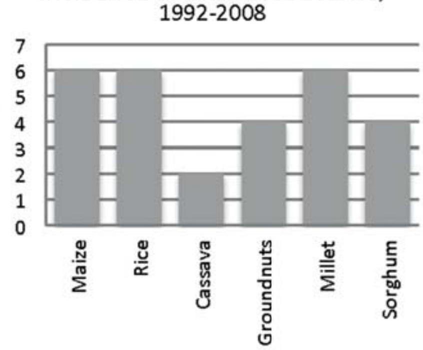
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Drought, unpredictable rainfall
2. Price volatility
3. Crop/livestock pest and diseases
4. Excessive rainfall/flooding
5. uncertain input supply (i.e., quality, availability, prices)

REGIONAL RISK PROFILE: UPPER WEST

With over 18,480 square kilometers, the Upper West region covers about 7.7 percent of Ghana's total land area. It's population amounts to 678,000, implying a very low population density. The region falls within the country's sudano-sahelian zone with an average rainfall of approximately 1022mm. Agriculture dominates the regional economy. Main crops include maize, groundnuts, millet, sorghum and rice. The livestock sector has traditionally made a major contribution to the rural economy; at the time of the last national census, some 23% of the nation's cattle herd were found in Upper West.

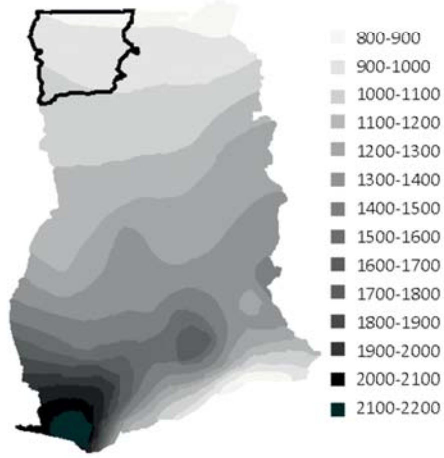
The percentage of organic matter in soils is lower in Upper West than in Ashanti or West regions so that over 30% of north savannah households use inorganic fertilizer, compared to 15% in the Coast and Forest zones. There is deemed to be little to no irrigation potential in Upper West Region.

In 2008, average regional household incomes were the lowest among all ten regions: GHc 106, compared to the national average of GHc397. Typical production constraints reported by households include low soil fertility and limited access to agro-chemicals. Key risks highlighted were uncertain rainfall, price volatility, crop pests and diseases, livestock diseases, flooding/excessive rainfall, and uncertain availability of inputs.

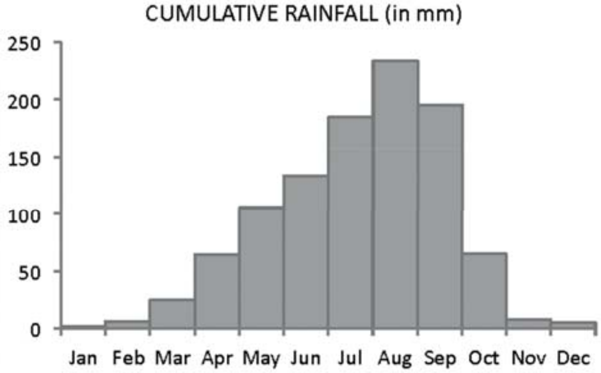
During the 1992-2012 period, the region experienced single or combined crises during 13 years, including 8 years of general or localized drought (1 catastrophic, 3 severe and 4 moderate). Others crises included national instability, ethnic conflicts, bush fires, and localized flooding.

AGRO-ECOLOGICAL ZONES

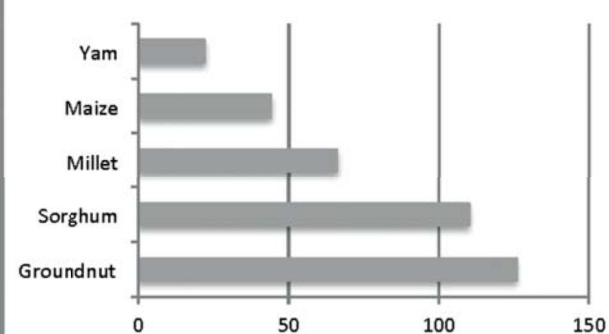
ANNUAL RAINFALL (in mm)



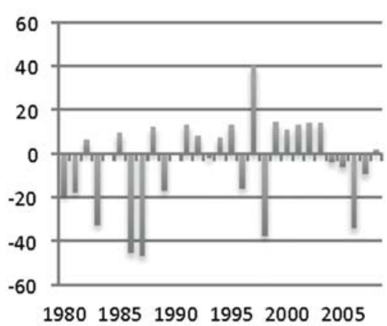
CUMULATIVE RAINFALL (in mm)



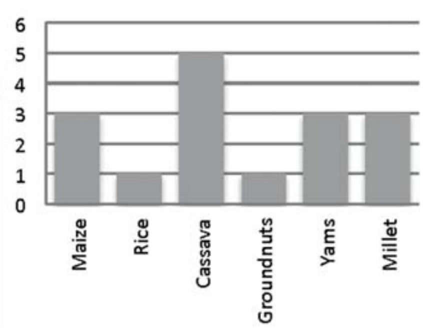
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1990-2008

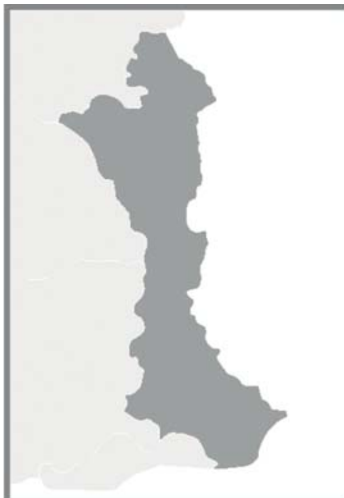


INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Drought/uncertain rainfall
2. Price volatility
3. crop/livestock pests and diseases
4. Excessive rainfall/rainfall
5. uncertain input supply (i.e., quality, availability, prices)



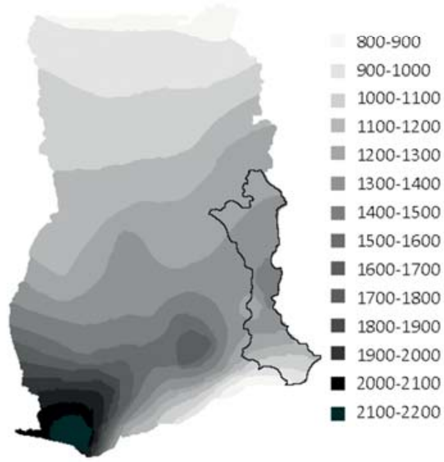
REGIONAL RISK PROFILE: VOLTA

Ghana's Volta region is the country's 5th largest. It accounts for 8.6% of the country's land area and roughly an equal share of its population. Stretching from the Atlantic coast in the south to the Guinea Savana in the north, the Region spans nearly all the country's vegetation zones. It is subject to a unimodal rainfall pattern and receives an average of 1337 mm of rainfall per year. Agriculture is the largest sector in the region and accounts for nearly 61% of the workforce. The sector is dominated by the production root crops (e.g., cassava, yam), maize and rice. Fishing is also an important source of income and livelihoods due to the region's proximity to the sea and the Volta river. Given favorable water access, nine percent (12%) of households, the highest share in Ghana, use some form of irrigation. Roughly fifty-nine percent (59%) of households own livestock. Nonetheless, the poverty rate (30%) in the Volta region is exceeded only by those persisting in the northern regions.

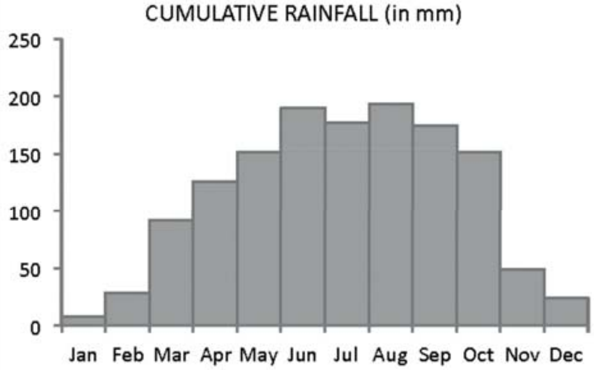
The Volta region is one of the regions most prone to production shocks, in terms of both frequency and severity. During the period 1981-2010, the Volta region experienced four (4) extreme drought events; two (2) of these, occurring in 1983 and 2005, were categorized as catastrophic. The latter event contributed to a 45% drop in regional maize and rice production, according to the analysis, amounting to an estimated 0.44 decline in GAO. The Volta region was also subject to five (5) excessive rainfall events during the same period, puntuted by flooding. Overall, the region was subject to a total of nine (9) adverse production shocks during the 18-year period 1992-2009, only 1 of which led to significant losses (1993). Yams were most susceptible, followed by cassava, rice, maize and plantain. Other notable risks facing the region's agriculture sector are pests and diseases, particularly those that threaten root crops, maize and livestock. These include the African Cassava Mosaic Disease (ACMD), the African armyworm, contagious bovine pleuropneumonia (CBPP), and anthrax.

AGRO-ECOLOGICAL ZONES

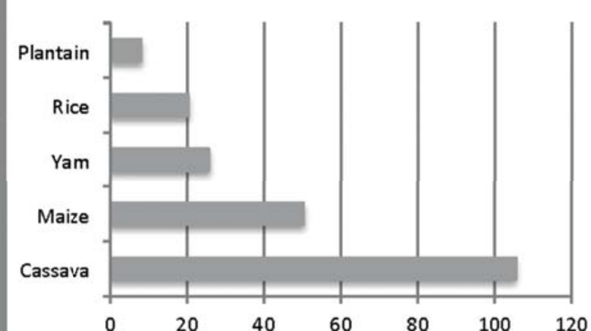
ANNUAL RAINFALL (in mm)



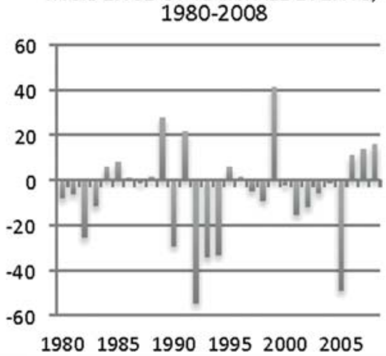
CUMULATIVE RAINFALL (in mm)



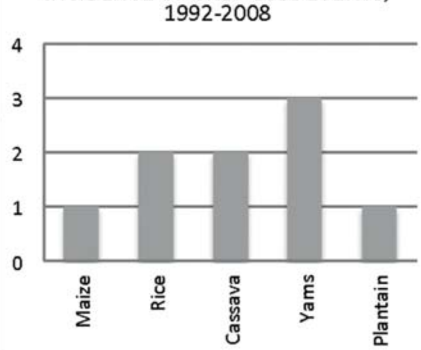
TOP CROPS (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1980-2008



INCIDENCE OF CROP LOSS EVENTS, 1992-2008



KEY RISKS

1. Drought/unpredicatble rainfall
2. Crop/livestock diseases (cassava: ACMD, CBB, CAD, brown streak; maize: streak virus, leaf blight, stalk rot; livestock: CBPP, anthrax, tuberculosis, brucellosis, FMD, blackleg, PPR, parasites, ASF, Newcastle, Gumboro)
3. Crop pests (cassava: African armyworm, grasshopper; maize: stem borer, larger grain borer, armyworm, grasshopper, etc.)
4. Excessive rainfall/flooding

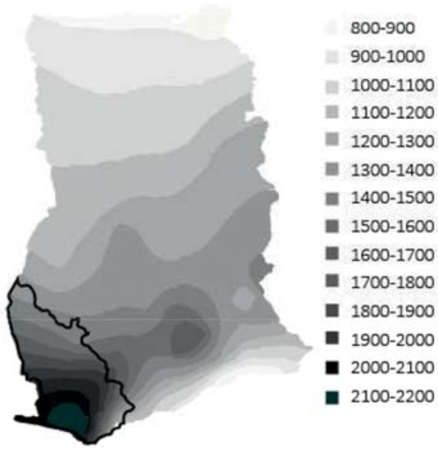
REGIONAL RISK PROFILE: WESTERN

Ghana's Western Region covers an area of approximately 2,391 square kilometres--about 10 per cent of Ghana's total land area. It is the third most populous region with a population of approximately 2.5 million. It spans the country's high forest zone, favoring moderate temperatures, fertile soils, and bi-modal rainfall distribution. It is the wettest region of Ghana with an average rainfall of 1,600mm per annum. Mining, oil/gas exploration, and agriculture dominate the economy. Cocoa, cassava, maize, plantain, rice, and yam are among the region's most important agricultural crops. It is Ghana's top cash crop producer, alone accounting for more than half (56%) of national cocoa production. A result in part, poverty rates are among the lowest in Ghana and less than 1% of the population is considered to be food insecure.

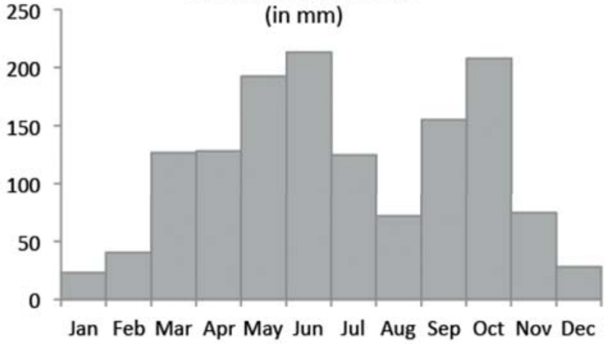
The Western Region faces myriad risks that hinder the growth of its agricultural sector. Erratic rainfall is chief among these risks. During the 30-year period 1981-2010, the Western Region experienced six (6) years of drought. Drought conditions in 1998, in particular, resulted in significant losses to the region's maize crop. In 2005, poor rainfall contributed to more crop losses in maize, and in rice. However, drought is not the only weather-related risk. Excessive rainfall, which occurered in 1984, 1987, 2002, 2007, and again in 2010, often leads to flooding of cropped lands and, in some cases, significant aggregate crop losses. Other natural hazards include localized windstorms (i.e., storm damage to plantain crops) and bushfires. Given the importance of cocoa in the region, by far the biggest source or risk comes from pests (i.e., capsids/mirids) and diseases (e.g., blackpod, swollen shoot virus), which destory an estimated one-third of total output per year. Small and large-scale mining activities--contributing to loss of farmland, deforestation and degradation of agroecosystems--also pose a considerable threat to sector growth in the region.

AGRO-ECOLOGICAL ZONES

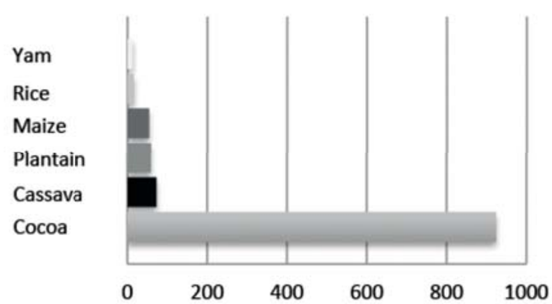
ANNUAL RAINFALL (in mm)



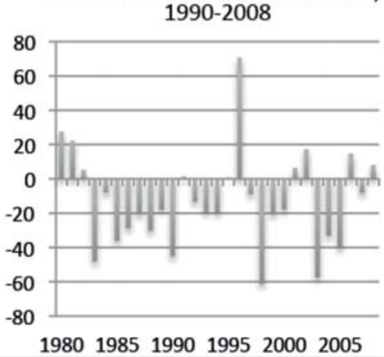
CUMULATIVE RAINFALL (in mm)



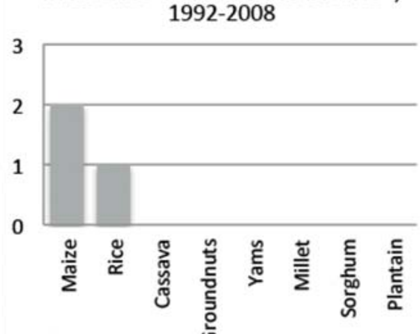
TOP CROPS, 2009 (acreage in 000's of Ha)



INCIDENCE OF RAINFALL EVENTS, 1990-2008



INCIDENCE OF CROP LOSS EVENTS*, 1992-2008



*excluding cocoa

KEY RISKS

- Pest and diseases (i.e., capsids/mirids, blackpod, swollent shoot)
- Flooding/Excessive rainfall
- Windstorms (i.e., plantains)
- Mining activities

APPENDIX B
COMMODITY RISK PROFILES[19]

[19] Sources: FAOSTAT; MoFA; World Development Indicators Database 2014; authors' calculations.

COMMODITY RISK PROFILE: CASSAVA

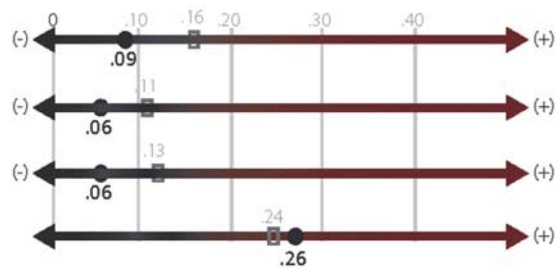
Cassava is Ghana's dominant food staple. It is a main source of carbohydrates and a regular source of income for most rural households. It contributes substantially (22%) to Agricultural GDP. It is highly drought-tolerant and is capable of growing on marginal soils. The root crop is typcially grown within mixed farming systems, most extensively across Ghana's southern transitional, deciduous forest and rainforest zones. Important to food security, cassava is grown by more than 4 out of every 5 Ghanaian households. It is the most widely consumed food crop in Ghana; annual per capita consumption in 2009 was nearly 220 kg. In reponse to growing demand in domestic and neighboring markets, production has more than quadrupled in recent decades. Output exceded 14.2 million metric tons in 2011, up from 2.7 million in 1990.

Cassava exhibits a relatively low production production risk profile, with medium frequency-medium loss production shocks. Cassava's adaptability to a range of climatic and edaphic conditions limit its vulnerability. Among the nine (9) priority crops, cassava exhibits among the lowest levels of variability in both area and yield. Consequently, production varaibaility is also among the lowest, second only to plantains. This is consistent with the higher drought resistance of root crops and the higher rainfall zones in which cassava is grown. Despite its robustness, diseases and pests can cause severe yield losses, especially in areas where susceptible cultivars are grown. The biggest production threats to the crop in Ghana are the African Cassava Mosaic Disease (ACMD), Cassava Bacterial Blight (CBB), Brown Streak Disease (CBSD), and Cassava Anthracnose (CAD). Collaborative research efforts by CRI, IITA and other to develop and release new disease-resistance cultivars have curbed losses significantly in the last decade. No catastrophic production shocks occurred during the period of analysis (1991-2011). The highest indicative loss (in 2007), caused by drought, localized flooding and depressed market prices, was equivalent to 1.63% of GAO, or approximately US$184 million.

KEY FACTS

- Total output (2011) - 14.2 million MT
- Gross output value (2011) - $1.48 billion
- Share of Agricultural GDP (2011) - 22%
- Output growth (1990-2011) - 217%
- Area planted (2011) - 889,360 ha
- Share of total area planted - 13%
- Area growth (1990-2011) - 106%
- Average yield (2011) - 14.8 Mt/ha
- Acheivable yield - 48.7 Mt/ha
- Yield growth (1990-2011) - 58%

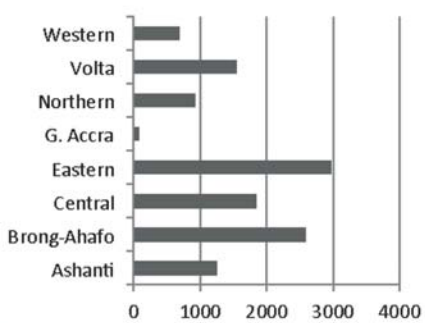
MEASURE OF VARIABILITY (1990-2011)*



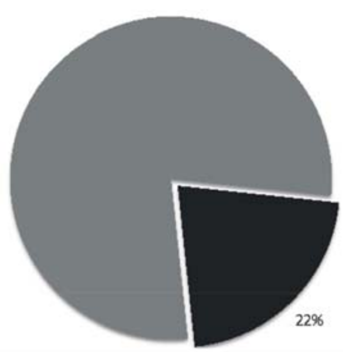
▯ - 9 crop average

*see Figure 3 and 8 of the report

PRODUCTION BY REGION, 2009 (in '000s MT)



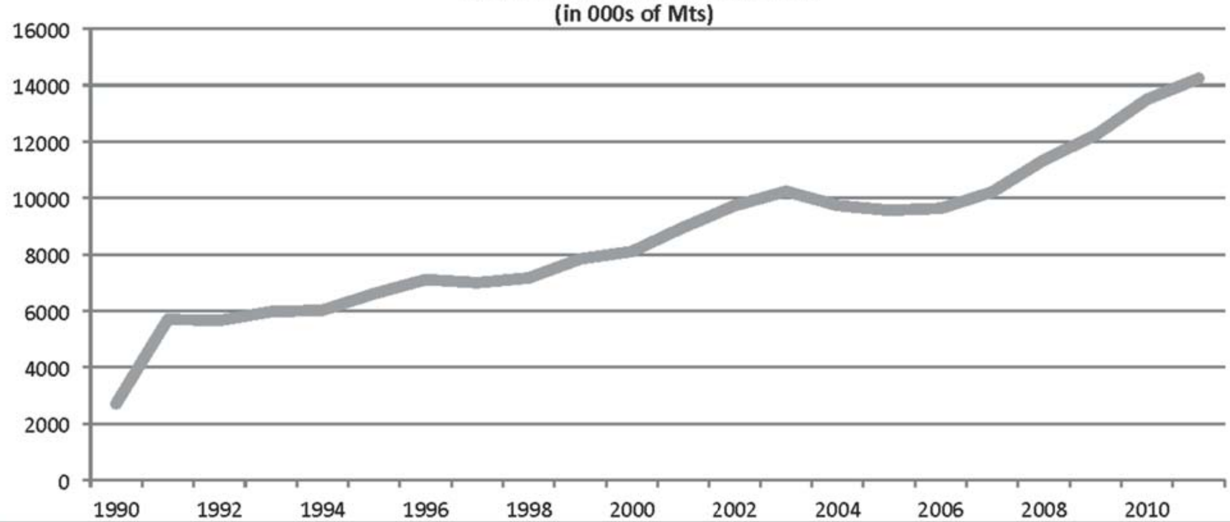
SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Diseases (e.g., ACMD, CBB, CAD, CBSD)
2. Pests (e.g., African army worm, variegated grasshoper, millipedes)
3. Flood/excessive rain
4. Drought
5. Domestic price volatility

CASSAVA PRODUCTION, 1990-2011 (in 000s of Mts)



COMMODITY RISK PROFILE: COCOA

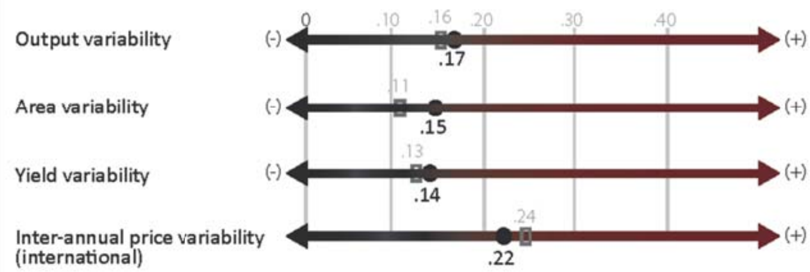
Cocoa dominates Ghana's agricultural sector. It accounts for more than one-tenth of agricultural GDP. It is a major source of income for approximately 800,000 smallholder farmers and others engaged in trade, transportation, and processing of cocoa. It is also a major source of foreign exchange. In 2010-11, Ghana exported more than 630,000 tons of cocoa beans, generating over US$2 billion. Cocoa grows best in humid and wet tropical climates, such that predominates in Ghana's decidouous forest zone where annual rainfall is 1200-1600mm and year-round temperatures are moderate. The Western Region accounts for more than half (56% in 2009-10) of national ouput in 2011. Ashanti (15.4), Brong-Ahafo (9.6%), Eastern (9.5%) and Central (8.9%) account for the rest.

Among crops analyzed, cocoa is the most prone to production shocks. Production is subject to moderate levels of inter-seasonal variability in both area and yield. Production shocks occur regularly and result in sizable crop losses: an estimated one-third of production is lost to pest and diseases (most notably-- blackpod, mirids/capsids, swollen shoot) each year. Control and eradication is primarily administered by COCOBOD. For the cocoa bean trade, price variability is a major source of risk. This risk is assumed and largely managed by Cocobod through it's fixed pricing and forward marketing programs. Smuggling is an important source of risk that handicaps Cocobod's ability to forecast output and manage price risk. Following a major drought in 1992, 60,000 hectares of cocoa trees were lost to widespread bushfires. During the period of analysis (1991-2011), the cocoa sub-sector was subject to a total of four (4) adverse production shocks. These occured in 1997, 2001, 2002, and 2010. Only the 2002's event was catastrophic, with an indicative loss estimated at 1.64% of GAO, or approximately US$151 million.

KEY CROP FACTS

- Total output (2011) - 700,000 MT
- Gross output value (2011) - $727 million
- Share of Agricultural GDP (2011) - 11%
- Output growth (1990-2011) - 155%
- Area planted (2011) - 1.65 million ha
- Share of total area planted (2011) - 24%
- Area growth (1990-2011) - 133%
- Yield (2011) - .04 MT/ha
- Achievable yield - 1 MT/ha
- Yield growth (1990-2011) - 9%

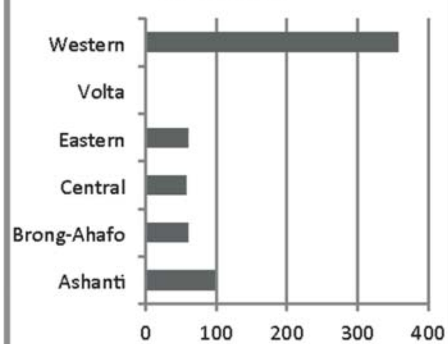
MEASURE OF CROP VARIABILITY (1990-2011)*



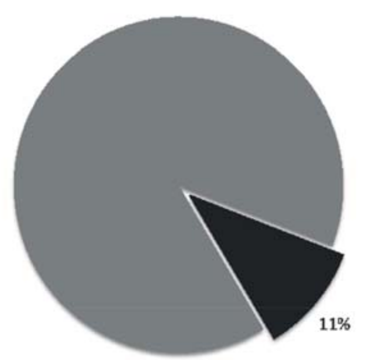
▯ - average for 9 crops

*Coefficients represent the degree of inter-anual variation against 9-crop average during the period 1990-2011; see Figure 3 and 8 of the report.

PRODUCTION BY REGION, 2009-10 (in '000s MT)



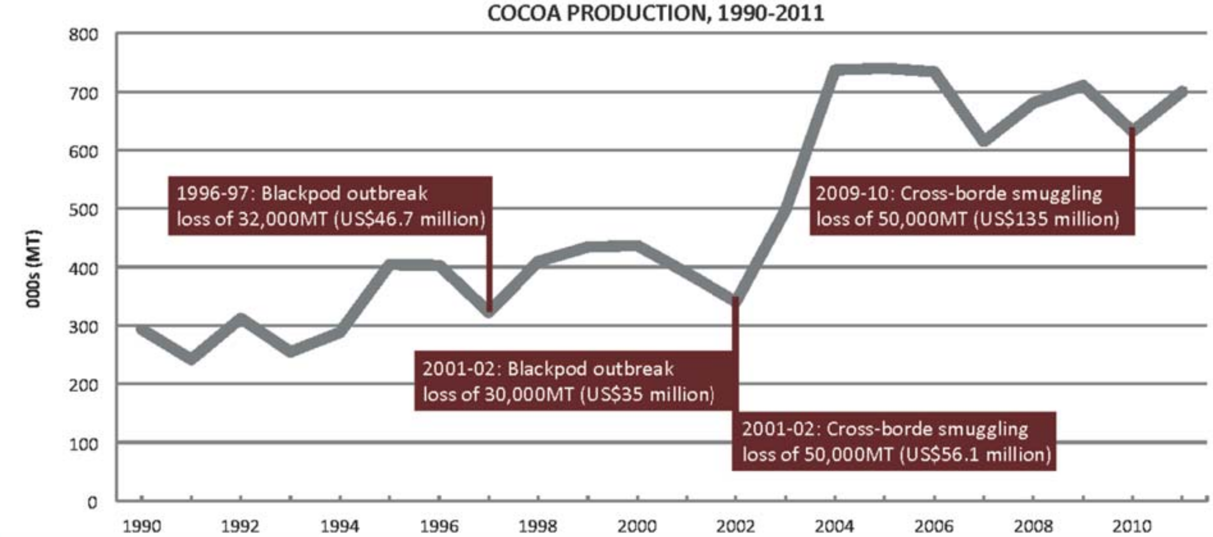
SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Blackpod disease
2. Capsids/mirids
3. Swollen shoot virus disease
4. Price volatility
5. Smuggling
6. Drought/bushfires

COCOA PRODUCTION, 1990-2011



COMMODITY RISK PROFILE: GROUNDNUTS

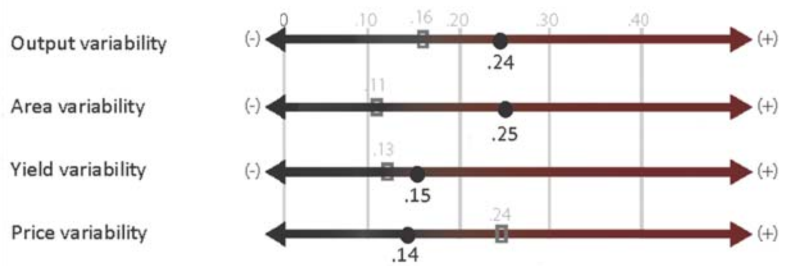
In northern Ghana, groundnut is an important cash crop. According to IFPRI, nearly two out of every three farmers cultivate the crop in Ghana's three northern regions. It is typically grown within mixed cropping systems intercropped with cereals (e.g., maize, millet, sorghum). It remains a key ingredient in Ghanaian cuisine and to household dietary needs. Since 1990, production has grown exponentially (449%), more than any other crop. Area planted has varied widely and yields have been growing thanks to the introduction of new, higher yielding cultivars.

Like rice, millet and sorghum, groundnuts exhibit a higher frequency of adverse production events, as would be expected given their epicenter of production in the more risk prone savanah. However, the risk profile for groundnuts is moderate, with a low to medium frequency and severity of risk and with low to moderate indicative losses. However, groundnuts like cereals exhibited a higher incidence of catastrophic shocks relative to the other crops. Such shocks appear more likely to be covariate. The biggest threat to groundnuts is the vagaries of weather. Drought occurs with regular frequency in the northern savannah zones and can have drastic impact on local livelihoods. In addition, erratic and poor distribution of rainfall over the season is making it increasingly difficult for farmers to predict optimal planting time. It also can lead to flooding and severe crop damage, as happened in 1999 and again in 2007. Among non-natural hazard risks, diseases and pests constitute major risks to the groundnuts. Farm surveys in the three northern regions conducted in 2002 revealed high incidences and severities of leaf spot and leaf rust. Other diseases observed included rosette virus. Pod loss due to leaf spot was estimated to be as high as 78%, whilst losses due to rust alone was 23%. Major pest threats include aphids, brown groundnut hopper, and other pod-sucking insects. In the mid-2000s, high incidences of Aflatoxin contamination found in groundnut shipments led to the loss of export markets.

KEY FACTS

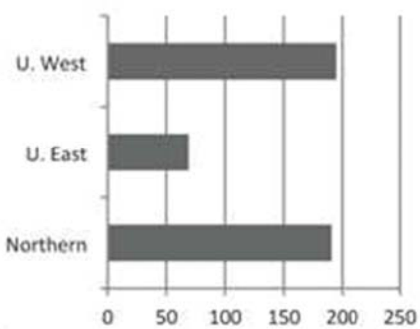
Total output (2011)	465,103Mt
Gross output value (2011)	$209.8m
Share of Agr. GDP (2011)	3.0%
Output growth (1990-2011)	449%
Area planted (2011)	356,780Ha
Share of total area planted	5.3%
Area growth (1990-2011)	207%
Average yield (2011)	1.3Mt/Ha
Acheivable yield	2.5Mt/Ha
Yield growth (1990-2011)	82%

MEASURE OF VARIABILITY (1990-2011)*

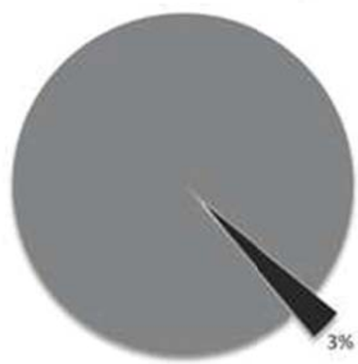


*Coefficients represent the degreee of inter-anual variation against 9-crop average during the period 1990-2011; see Figure 3 and 8 of the report.

OUTPUT BY REGION, 2009 (in '000s MT)



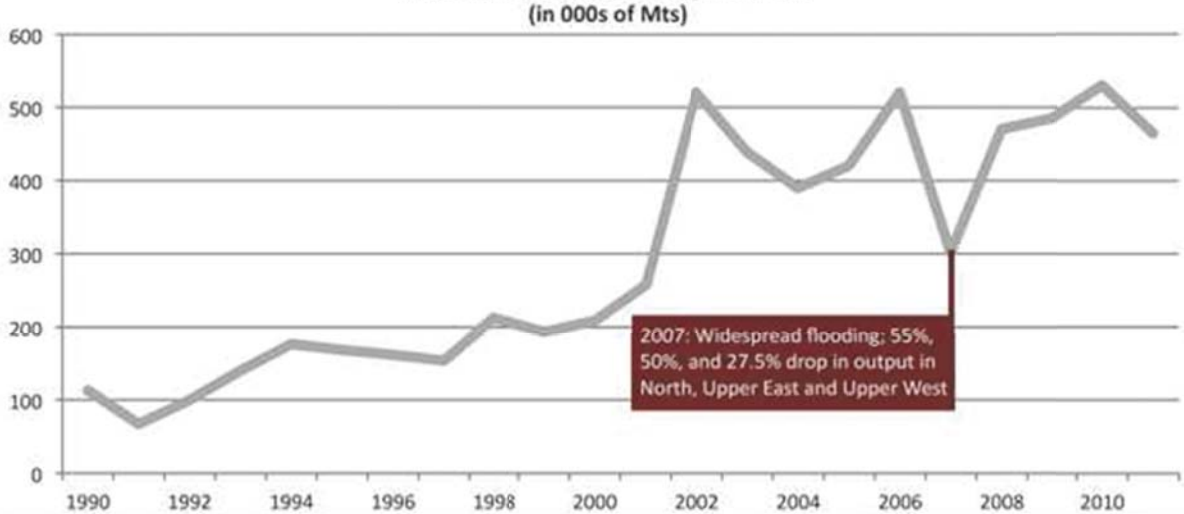
SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Drought/erratic rainfall
2. Diseases and pests (leaf spot, leaf rust, rosette virus, aflatoxin, aphids, brown groundnut hopper, pod-sucking insects.
3. Flooding/excessive rain
4. Price volatility
5. Loss of market access

GROUNDNUTS PRODUCTION, 1990-2011 (in 000s of Mts)



COMMODITY RISK PROFILE: MAIZE

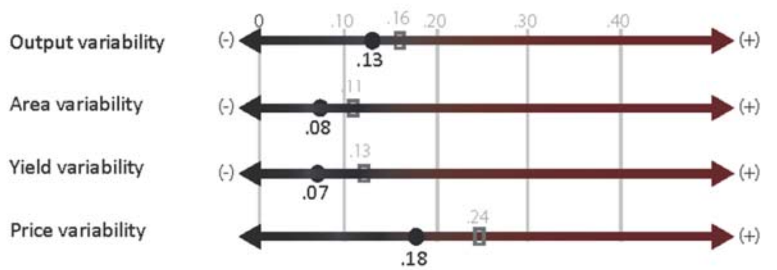
Maize is Ghana's most important cereal crop as well as the second most important staple after cassava. As with cassava, smallholder farmers dominate production. However, unlike cassava, it is grown by the vast majority of rural households in all parts of the country. The exception is in the far North's Sudan savannah zone where rainfall is inadequate and where coarse grains (i.e., millet, sorghum), groundnut, and cowpea predominate. Maize is capable of growing in areas with as little as 300mm of rainfall but 500-1200mm is optimal. In most areas, maize has a major and minor season and is typically grown in association with other crops such as cassava, plantain, and cocoyam. Maize is also by and large the most widely traded commodity in Ghana, with direct linkages to both rural and urban food security.

Maize exhibits a moderate frequency, medium loss risk profile. Both area planted and yield have increased over time, although the upward trends have been characterized by high year-to-year variability, typical of rain-fed crops. Rainfall is the single most important determinant of yields. This is especially true in the northern regions. According to IFPRI, the average range of district-level maize yields in the north during the period 1992-2005 was 35 percent higher than in forest zones and 55 percent higher than in costal zones. This variability partly explains why maize is the most vulnerable to adverse price shocks among the nine target crops. It also explains why drought represents the most significant risk to maize production in Ghana. Drought conditions also enhance the crop's vulnerability to a wide range pests and diseases that cause substantial production and post-harvest losses. Chief among these is the larger grain borer. CRI in collaboration with SARI and IITA developed and released in 2010 new drought-tolerant, higher yielding maize hybrids to better equip farmers to face these challenges. However, farmer investments of improved seeds, fertilizers and other productivity-enhancing technologies are hampered not only by high costs but also by growing distrust linked to the growing proliferation of counterfeited products within input supply markets.

KEY FACTS

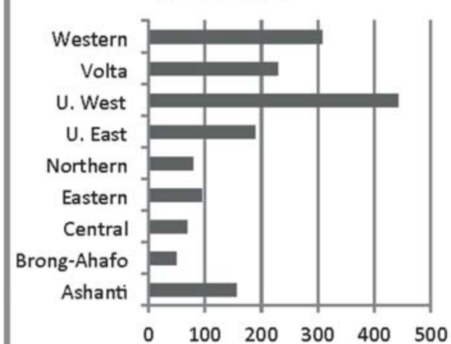
- Total output (2011) - 1.68 million Mt
- Gross output value (2011) - $238 million
- Share of Agricultural GDP (2011) - 3.4%
- Output growth (1990-2011) - 133%
- Area planted (2011) - 1.02 million Ha
- Share of total area planted - 15%
- Area growth (1990-2011) - 84%
- Average yield (2011) - 1.64 Mt/ha
- Acheivable yield - 6 Mt/ha
- Yield growth (1990-2011) - 28%

MEASURE OF VARIABILITY (1990-2011)*

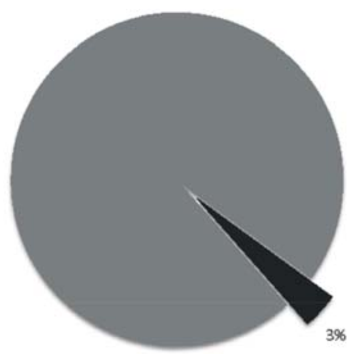


*Coefficients represent the degree of inter-anual variation against 9-crop average during the period 1990-2011; see Figure 3 and 8 of the report.

PRODUCTION BY REGION, 2009 (in '000s MT)



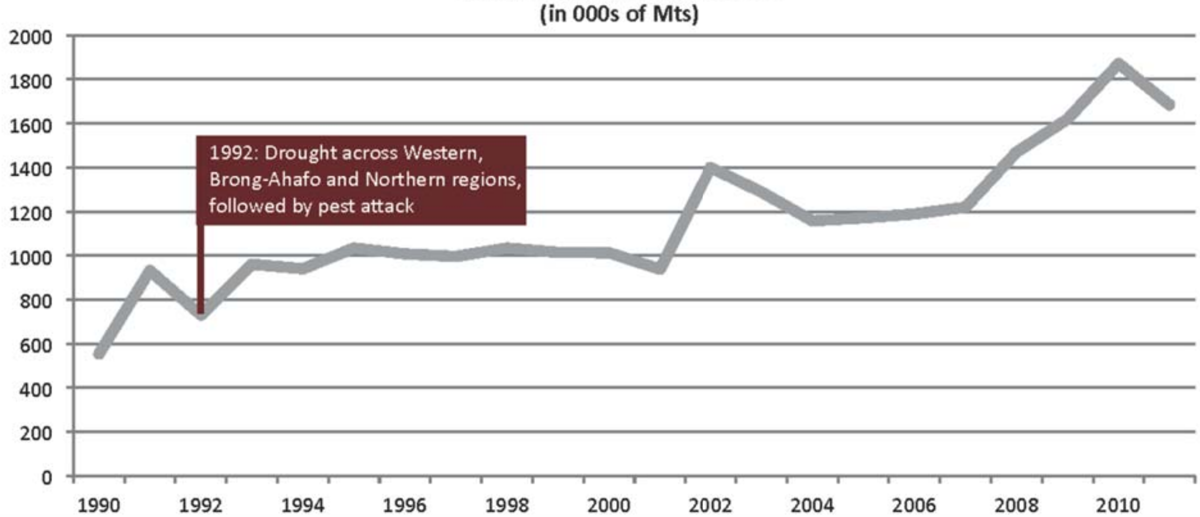
SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Drought; erratic rainfall
2. Price volaitility
3. Pest and diseases (stem borer, larger grain borer, armyworm, grasshopper, grain weavil, termites, nematodes, maize streak virus, striga, leaf blight, stalk rot, ear rot, corn rust, dwarf mosaic virus, aflatoxin)
4. Input risk (i.e., price, quality)
5. Excessive rainfall/flooding

MAIZE PRODUCTION, 1990-2011 (in 000s of Mts)



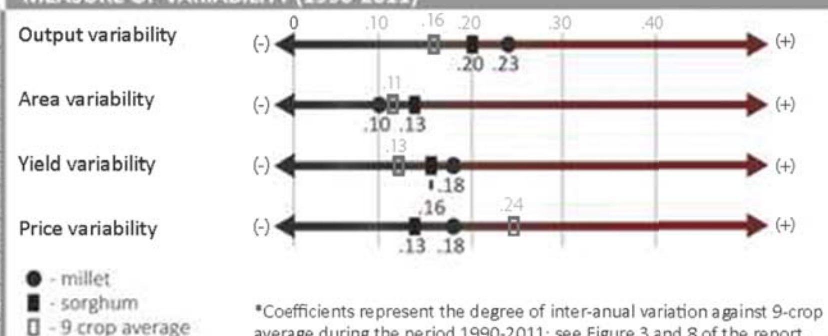
COMMODITY RISK PROFILE: MILLET/SORGHUM

Members of the coarse grain family, millet and sorghum are the primary food staples among households in Ghana's semi-arid north. Vital to the region's food security, these crops produce grain for human consumption and fodder for livestock. They are well adapted and highly resistant to drought, capable of growing in harsh environments such as that found across Ghana's extreme northern savannah zones where other cereal crops such as maize can often fail. The three northern regions produce all the millet and virtually all of the sorghum. Despite robust population growth, production for both cereals, dominated by subsistence smallholders, has increased little in recent decades. Planted acreage has grown a mere 6.7% and 8.5% for millet and sorghum respectively. Low yields and underdeveloped commercial markets for the grains remain a challenge.

Millet and sorghum share similar risk profiles. Along with groundnuts, they exhibit the highest levels of production variability among the crops analyzed for this assessment. Like other crops cultivated in the more risk prone savannah regions, millet and sorghum also exhibit a relatively high frequency of adverse production events, though indicative costs tend to be relatively low. However, the higher incidence of production shocks for these two crops can nonetheless have a major impact among communities in the three northern provinces where they predominate. The biggest shock during the period of analysis came in 2007 when drought followed by widespread floods caused an estimated $92.7 million in crop losss. Covariate shocks also occurred in 2011. Households surveys in 2012 suggest a 15-20% decrease in production for millet, and even higher losses for sorghum (MOFA UWR reported a 25% decrease). Beyond drought and excessive rainfall, millet and sorghum production is threatened by an array of diseases and pathogens that dampen yields and cause significant economic losses. These include downy mildew, smut and ergot in the case of millet and for sorghum: grain mold, stalk rots, anthracnose, and sooty stripe. The crops are also highly vulnerable to a range of insects including head bug, sorghum midge, stem borers and shoot fly, among others. Armyworms are occasional pests but when they occur, the devastation is at times significant. Yield loss studies in the mid-90s showed that insect pests broadly can cause over 50% yield reduction. Striga infestation also posses a significant and pervasive crop risk.

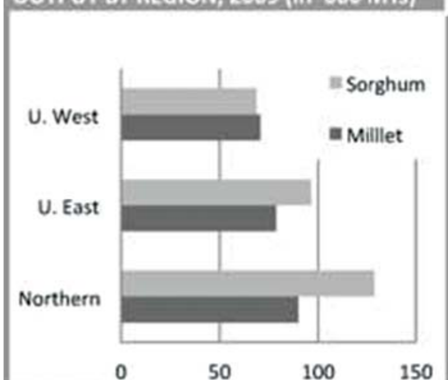
KEY FACTS	M	S
Total output (2011)	183,921	287,069
Gross output value (2011)	$33.4m	$44.1
Share of Agr. GDP (2011)	0.48%	0.64%
Output growth (1990-2011)	70%	131%
Area planted (2011)	178,676	243,482
Share of total area planted	2.6%	3.6%
Area growth (1990-2011)	6.5%	8.7%
Average yield (2011)	1.3m	1.2m
Acheivable yield	2.0Mt/ha	2.0Mt/ha
Yield growth (1990-2011)	62%	110%

MEASURE OF VARIABILITY (1990-2011)*

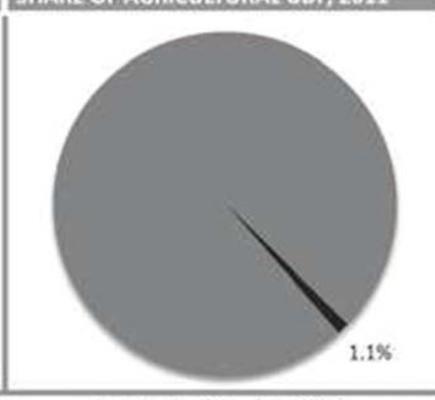


*Coefficients represent the degree of inter-anual variation against 9-crop average during the period 1990-2011; see Figure 3 and 8 of the report.

OUTPUT BY REGION, 2009 (in '000 MTs)

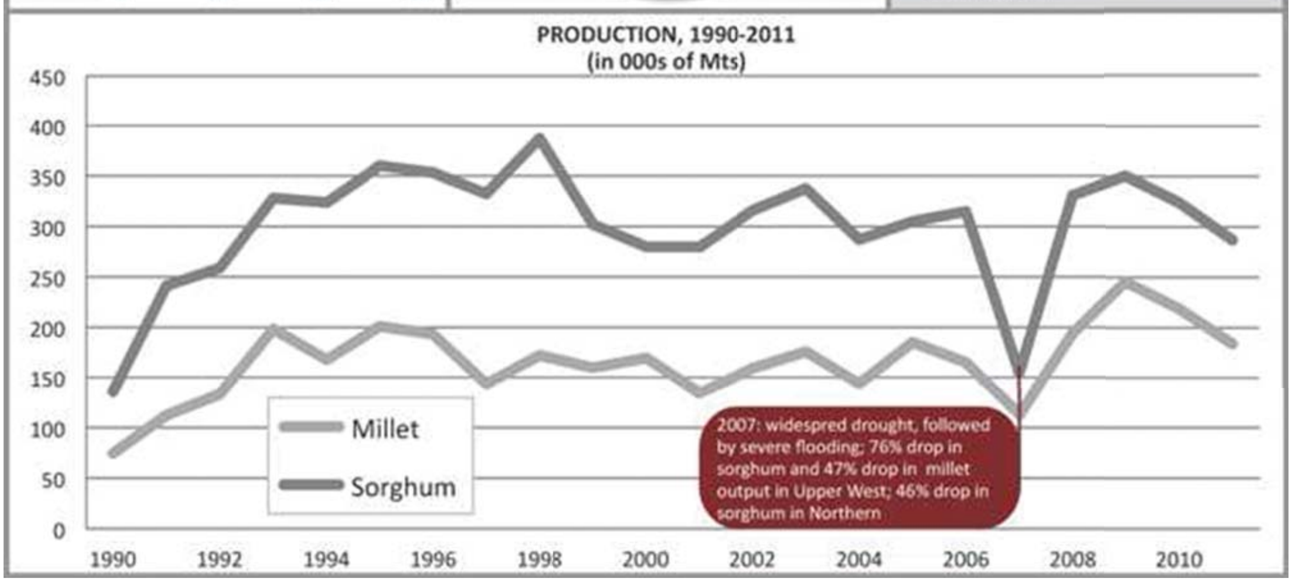


SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Drought/unpredictable rainfall
2. Pests and diseases (rodents, birds, grasshoppers, armyworms, downy mildew, grain weavil, sorghum shoot flies, sorghum midges, stem borers, ergo, striga)
3. Price volatility
4. Flooding/excessive rain
5. Input risk (availability, price, quality



COMMODITY RISK PROFILE: PLANTAINS

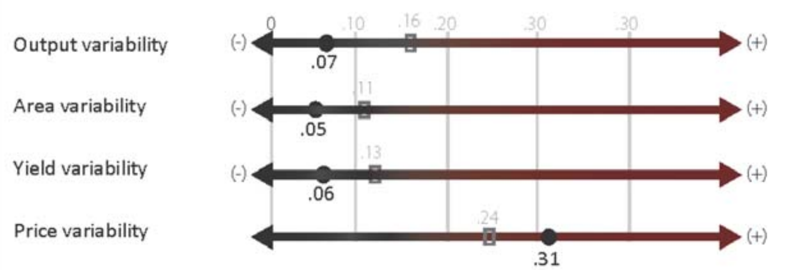
A perennial crop, plantain is a primary food crop and a key component of agricultural systems in the high rainfall zones of southern Ghana. It is a source of income for millions of smallholder farmers who grow it. It is also a strategic food security crop. Plantain is ranked fourth after cocoa, yam and cassava in production volume and contributes approximately 11% to Ghana's Agricultural GDP. At approximately 135kg per capita per annum, consumption within Ghanaian households is among the highest anywhere. Ghana is the largest producer in West Africa and the second largest in Africa, after Uganda. The Eastern Region accounts for nearly one-thirds of output, followed by the Ashanti, Brong Ahafo, Western and Central regions. It is often inter-cropped with cocoa to provide shade and soil nutrients.

Based on an analysis of time series data for the period 1990-2011, plantain exhibits strong resilience to adverse shocks. Production variability ranks lowest among the 9 priority crops. Storm damage is a constant risk for plantains as the trees break easily in high winds that typically coincide with the start of the rainy season. The damage is typically localized but can result in seasonal scarcity. This explains, in part, why plantains exhibit the highest levels of price variability among all 9 crops. In terms of pests, parasitic nematodes pose the most formidable risk to plantain production in Ghana. Weevils are also a common threat. Other key threats include black sigatoka disease (BDS) and banana streak virus (BSV). The first major outbreak of BDS was in 1992. Smaller, more isolated outbreaks occurred in 1997, and again in 2003. Control measures have focused on the establishment of a delivery system for healthy, resistant germplasm and improved extension. However, widespread use of infected planting material and poor crop management have hampered more effective control measures. Plantain exihibited no notable produciton shocks during the 21-year focus period (1990-2011).

KEY FACTS

- Total output (2011) - 3.6 million Mt
- Gross output value (2011) - $747 million
- Share of Agricultural GDP (2011) - 11%
- Output growth (1990-2011) - 261%
- Area planted (2011) - 336,497 ha
- Share of total area planted - 5%
- Area growth (1990-2011) - 118%
- Average yield (2011) - 10.7 Mt/ha
- Acheivable yield - 20 Mt/ha
- Yield growth (1990-2011) - 67%

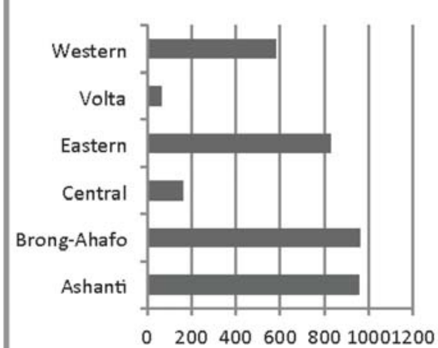
MEASURE OF VARIABILITY (1990-2011)*



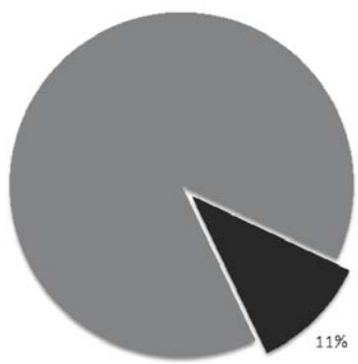
▯ - 9 crop average

*Coefficients represent the degreee of inter-anual variation against 9-crop average during the period 1990-2011; see Figure 3 and 8 of the report.

OUTPUT BY REGION, 2009 (in '000s MT)



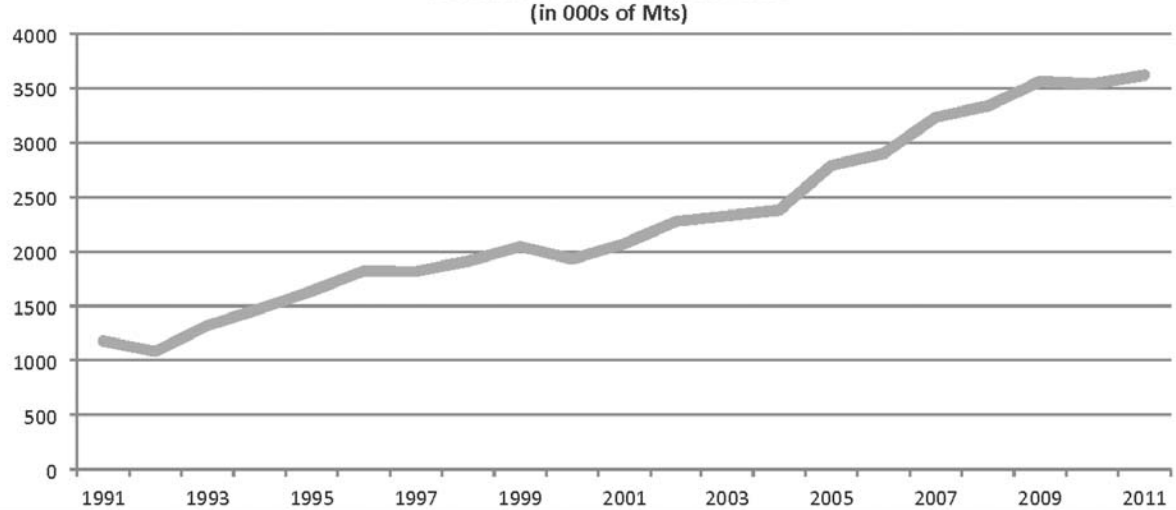
SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Seasonal windstorms
2. Pests (nematodes, banana corm weevils)
3. Disease (black sigatoka (BSD), Banana Streak Virus (BSV),
4. Price volatility

PLANTAIN PRODUCTION, 1990-2011 (in 000s of Mts)



COMMODITY RISK PROFILE: YAMS

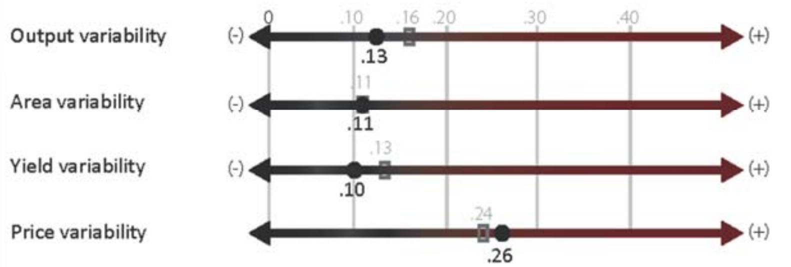
A leading staple, yams are an important source of calories and protein in Ghana. The starchy tubers are widely produced across the country for household consumption, primarily within the transitional, deciduous forest, and rainforest zones where agro-climatic conditions are most favorable. Yams account for only 6% of land under cultivation but contribute approximately 23% to agricultural GDP. With excellent storability, yams are also critical to food security. Per capita consumption of more than 295 kcal/day is second only to Benin and Cote d'Ivoire. After Nigeria, Ghana is the second biggest producer in the world as well as a leading exporter.

Like cassava, yams exhibit a relatively low level of production variabiliy, but with a higher level of indicative loss. Yam crops face considerable pressure from a range of insect pests (e.g., leaf and tuber beetles, mealybugs, scales), fungal (e.g., anthracnose, leaf spot, leaf blight, tuber rots), and viral diseases. As vectors for contagion, nematodes are also a constant threat. All contribute to substanital yield loss and higher levels of post-harvest losses. In the late 90s, a research team concluded that approximately 40% of output was lost annually due to pest and diseases. A decade later, IITA estimates that yields remain a mere 14 percent of potential harvests. Given many pests and pathogens are known to spread via planting material, management efforts have focused on improving farmers' access to affordable and disease-free seeds. During the 21-year period of analysis, yams was subject to only one relatively severe production shock (1994). Following a 5-year period of high price volatility ending in 1999 when associated losses amounted to an estimated 1.07% of GAO, real prices for yams have remained relatively stable.

KEY CROP FACTS

- Total output (2011) - 6.29 million MTs
- Gross output value (2011) - $1.6 billion
- Share of Agricultural GDP (2011) - 23%
- Output growth (1990-2011) - 243%
- Area planted (2011) - 403,798 Ha
- Share of total area planted - 6%
- Area growth (1990-2011) - 125%
- Yield (2011) - 15.6 MT/ha
- Achievable yield - 28.3 MT/ha
- Yield growth (1990-2011) - 63%

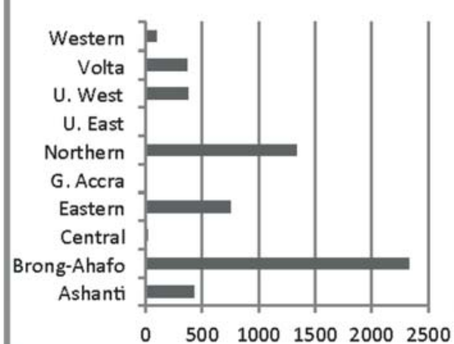
MEASURES OF CROP VARIABILITY (1990-2011)*



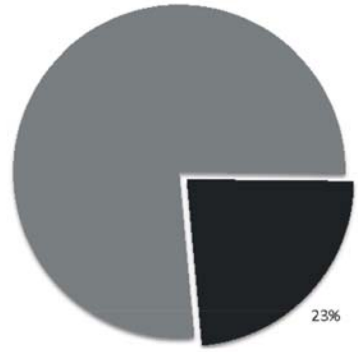
▯ - 9 crop average

*Coefficients represent the degree of inter-anual variation against 9-crop average during the period 1990-2011; see Figure 3 and 8 of the report.

OUTPUT BY REGION, 2009 (in '000s MT)



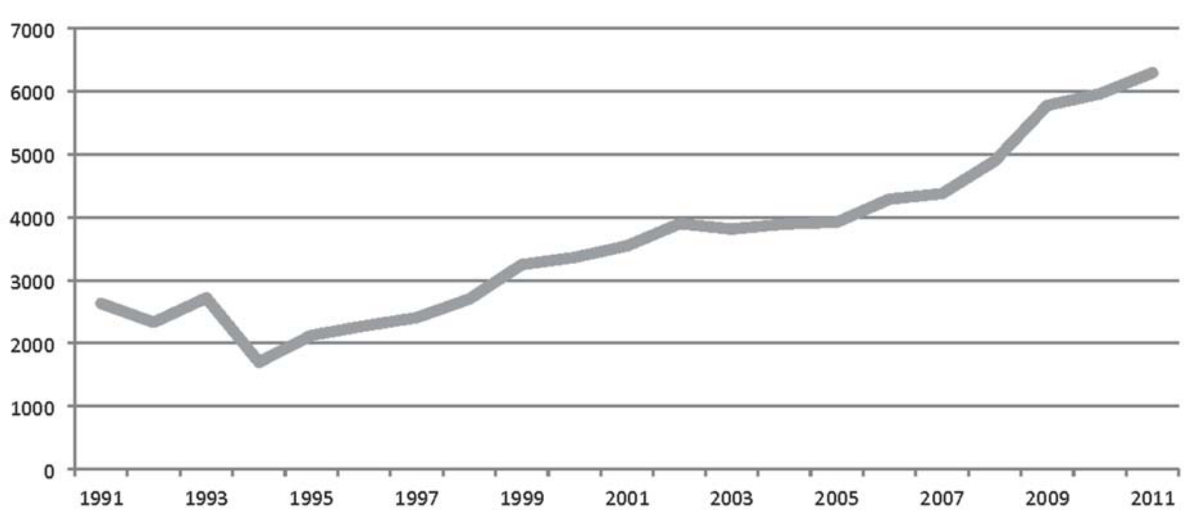
SHARE OF AGRICULTURAL GDP, 2011



KEY RISKS

1. Fungal diseasse (e.g., anthracnose, leaf spot, leaf blot, tuber rots)
2. Pests (e.g., nematodes, leaf/tuber beatles, mealybugs, termites)
3. Flood/excessive rain
4. Price volatility
5. Excessive heat

YAM PRODUCTION, 1990-2011



APPENDIX C

RAINFALL PATTERNS AND IMPLICATIONS FOR CROP PRODUCTION

BACKGROUND

An analysis of rainfall data provided useful information on the level and distribution of rainfall by region and the impact of various rainfall characteristics on crop yields.

Ghana has 99 weather stations located throughout the country, although some regions have a higher density than others. Analysis was based on daily rainfall data from 1981 to 2010. Figure C.1 shows the distribution of the weather stations (orange diamonds).

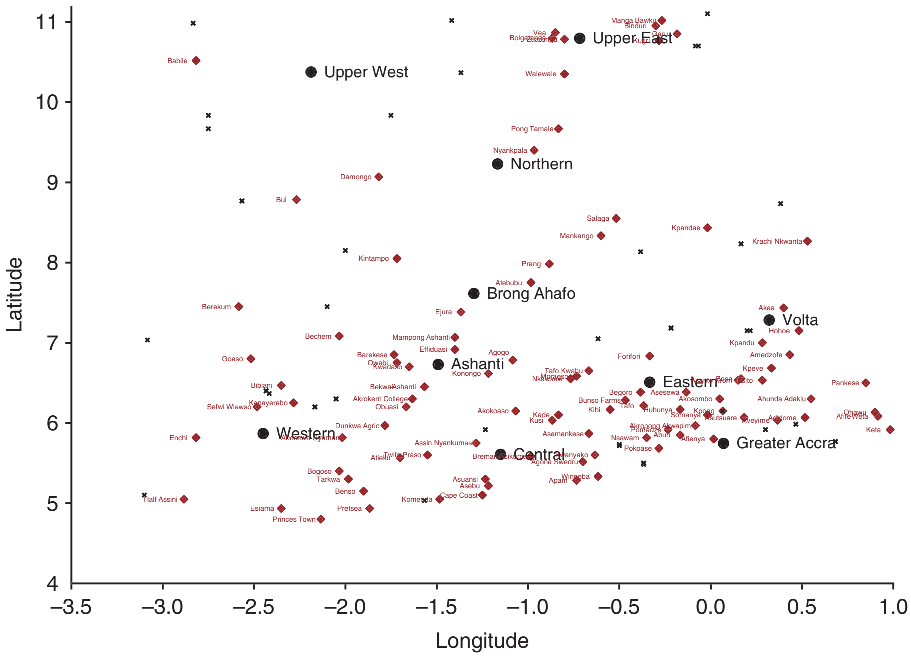
As the weather stations do not have information on the region to which they belong, distance from the centroid of each region (i) was calculated for each station (j) using the Euclidean Distance formula:

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

Where
Dist = Euclidean Distance
x_i = longitude from region's i centroid
x_j = longitude from station j
y_i = latitude from region's i centroid
y_j = latitude from station j

Each station was assigned to the region whose distance to the centroid was the smallest. Reference marks for the centroids of each region are indicated by the navy dots in figure C.1.

FIGURE C.1. WEATHER STATION DISTRIBUTION WITH REGION CENTROIDS



Source: Authors' analysis based on meteorological data from weather stations in Ghana.

RAINFALL DISTRIBUTION

Most rain occurs during the summer months from June to September, followed by a dry winter from November to March. In the south, it is also common to find a dry period during August, which is usually referred to as the "dog days of summer," due to its relationship to the Dog Star of Sirius in the Canis Major constellation. A uni-modal rainfall pattern is thus observed in the lower rainfall northern regions and a bi-modal pattern in the central and southern regions. Figure C.2 shows the monthly distribution of rainfall for each region.

As shown by these charts most rainfall occurs in the March–October period, with an average of more than 100 mm per month, followed by a dry season from November–February. The ensuing analysis focuses on observed rainfall during the period March–October.

DROUGHT AND EXCESS RAINFALL

Cumulative rainfall for all stations was calculated for the March–October period and the average of all stations within a region was used as the basis for analysis. To determine whether a year was dry or humid, a standardized cumulative rainfall variable was calculated for each region, according to the formula:

$$StdRain_i = \frac{\left(\sum_{i=mar}^{oct} Prec_i - \mu_i\right)}{\sigma_i}$$

Where

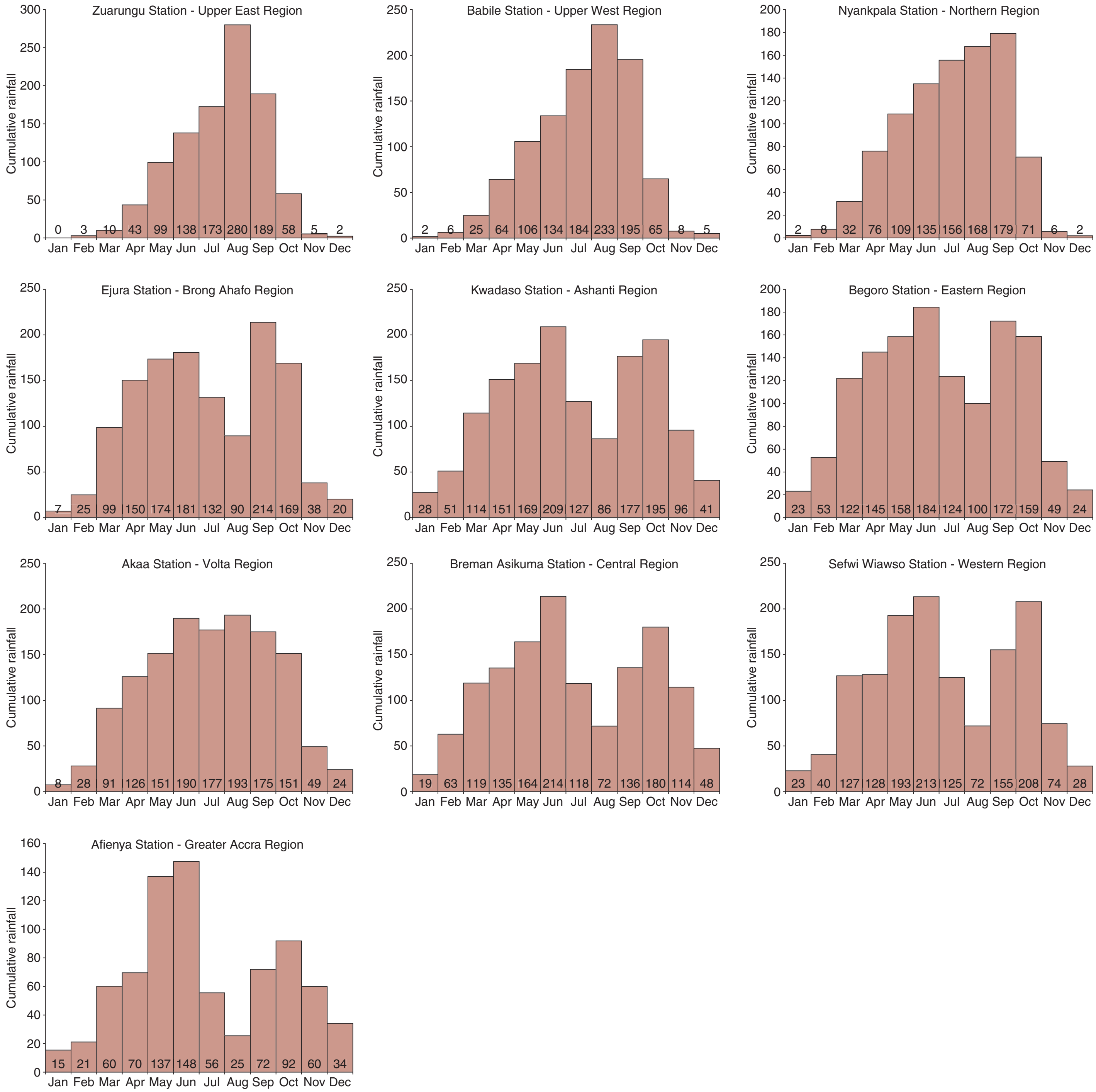
StdRain	standardized cumulative rainfall
Pre	daily rainfall
μ	mean yearly rainfall
σ	standard deviation of yearly rainfall
i	year

This variable makes it easier to discern drought and excess rainfall events. Table C.1 shows the standardized cumulative rainfall by year and region, with red signifying a drought event and green an excess rainfall event.

This analysis shows that drought typically affects numerous regions simultaneously.

Drought years: 1982, 1983, 1986, 1990, 1992, 1998, and 2005. During these years, rain was more than one standard deviation below average in at least three regions. Drought was particularly severe and widespread in

FIGURE C.2. MONTHLY RAINFALL PATTERNS BY REGION



Source: Authors' analysis based on meteorological data from weather stations in Ghana.

1983, with nine regions affected—including several with cumulative rainfall more than two standard deviations below the average. The most recent dry year was 2005 when the Eastern and Volta regions suffering from very low rains. These data suggest that there is a 23 percent probability (7 out of 30 years) that drought will occur in at least one region.

Excess rainfall years: 1987, 1989, 1991, 1995, 1999, 2002, 2007, and 2010. Rainfall was more than one standard deviation above average during these years, meaning that it was more than adequate. The most humid year occurred in 2007, affecting six regions—with rainfall in the Upper East Region more than two standard deviations above the average.

TABLE C.1. STANDARDIZED CUMULATIVE RAINFALL

Year	Up East	Up West	North	Brong A	Ashanti	Eastern	Volta	Central	Western	G Accra	Dry Regs	Exc Regs	Conclusion
1981	−1.56	−0.75	0.01	−0.50	0.27	0.10	0.17	1.03	0.55	0.52	1	1	Neutral
1982	−0.03	−0.07	−0.78	−1.33	−1.73	−1.77	−1.83	−0.05	−0.98	0.62	4	0	Dry
1983	−0.81	−3.07	−1.55	−1.24	−1.99	−1.90	−2.09	−2.57	−1.58	−2.39	9	0	Dry
1984	−1.53	−1.91	−0.26	−0.17	1.78	0.77	0.95	0.50	1.72	0.84	2	2	Neutral
1985	−0.98	−0.09	0.28	0.57	0.85	0.74	−0.20	−0.14	−0.04	0.50	0	0	Neutral
1986	−0.42	0.69	−0.66	−0.26	0.73	−1.07	−0.88	−1.79	−1.31	−1.18	4	0	Dry
1987	−0.46	0.11	−0.27	0.75	0.83	1.38	0.49	1.40	2.15	0.86	0	3	Excess
1988	−0.20	−0.57	0.29	−0.35	−0.90	−0.06	0.47	−0.06	−0.12	0.40	0	0	Neutral
1989	1.39	0.12	2.23	1.35	0.25	0.40	1.30	0.80	0.92	0.80	0	4	Excess
1990	−1.22		−1.00	−0.86	−1.51	−1.02	−0.30	−1.38	0.06	−0.68	5	0	Dry
1991	0.58	−0.38	2.06	0.14	−0.26	1.85	1.03	1.62	−0.17	2.45	0	5	Excess
1992	0.57	−0.23	−1.20	−1.27	−0.86	−0.85	−0.97	−0.91	−1.05	−0.96	3	0	Dry
1993	−0.31	0.28	0.04	−0.26	−0.35	1.16	−0.09	−0.35	−0.31	−0.42	0	1	Neutral
1994	1.18	0.22	0.05	−1.51	−0.46	−0.04	−0.41	0.24	−1.64	−0.88	2	1	Neutral
1995	−0.72	1.19	0.31	0.37	0.48	1.71	1.76	0.77	0.03	0.47	0	3	Excess
1996	1.07	−0.81	0.60	0.01	−0.71	−0.46	−1.00	0.21	0.66	0.92	0	1	Neutral
1997	−0.18	0.62	−0.01	0.36	−0.42	−0.58	0.09	0.28	−0.31	0.91	0	0	Neutral
1998	0.45	−0.52	−2.08	−0.01	−0.51	−0.30	0.16	−1.01	−1.28	−1.17	4	0	Dry
1999	1.78	1.45	1.43	0.63	1.50	−0.09	0.74	0.52	−0.11	0.51	0	4	Excess
2000	−0.09	1.85	0.01	−0.07	−0.56	−0.35	0.71	−1.07	0.07	−1.53	2	1	Neutral
2001	0.10	−0.57	−0.94	−0.61	−0.34	−0.46	−1.39	−0.71	0.19	0.08	1	0	Neutral
2002	−0.68	0.36	−0.13	1.03	1.22	0.44	0.49	0.62	1.76	0.65	0	3	Excess
2003	0.45	0.45	0.05	−0.88	−0.35	0.00	0.58	0.08	−0.03	−0.31	0	0	Neutral
2004	−1.07		−0.24	0.93	−0.75	−0.19	−0.66	−0.30	−0.74	−0.98	1	0	Neutral
2005	−0.42	0.46	−0.72	0.02	−0.71	−1.97	−2.04	−1.07	−0.60	−0.99	3	0	Dry
2006	−0.19	1.01	−0.62	−0.44	0.73	−0.21	0.22	0.61	0.06	−0.09	0	1	Neutral
2007	2.62		−0.39	0.80	1.84	1.47	1.25	1.44	1.13	0.83	0	6	Excess
2008	−1.05		1.49	−0.25	1.39	0.90	1.02	0.85	0.98	0.54	1	3	Neutral
2009	1.00	0.10	0.50	−0.51	0.36	−0.12	0.46	−0.55	−1.17	−0.89	1	1	Neutral
2010	0.72	0.06	1.51	3.59	0.19	0.52	−0.04	0.98	1.16	0.56	0	3	Excess
Dry Years	5	2	4	4	3	5	4	6	6	4			
Exc Years	6	4	5	3	5	5	5	4	5	1			

Source: Authors' analysis based on meteorological data from weather stations in Ghana.

THE IMPACT OF RAINFALL ON CROP YIELD

RAINFALL PARAMETERS

Crops are sensitive to rainfall in different ways. Low cumulative rainfall is the main determinant of yield, but crops can also be affected by late onset of the rainy season or an early cessation of rains. Prolonged periods without rain can also reduce yields, as can excess rainfall. The following variables were thus calculated for each weather station and year as the basis for closer analysis of the relationship between rainfall and crop yield:

1. Cumulative rainfall (cumrain). The sum of rainfall from March to October, it measures the total amount of rain that accumulates yearly from March to October. It is expressed in millimeters.
2. Onset date (onset). The time of the year in which the rainy season starts, defined as the first day of the year with 20 mm or more. It is measured as the number of days from the start of the year.
3. Cessation date (cessation). The day the rainy season ends is defined as the day in which 90 percent of total rainfall period occurs. It is measured as the number of days from the start of the year.

TABLE C.2. IMPACT OF RAINFALL PARAMETERS ON CROP YIELD

Parameter	Upper East	Upper West	Northern	Brong-Ahafo	Ashanti	Eastern	Volta	Central	Western
Cum rain	Rice (−) (32%)			Maize (+) (24%)					
	GNuts (−) (35%)			Yams (+) (23%)					
Onset of rain	GNuts (+) (27%)	GNuts (+) (39%)							
Number of rainfall days	Rice (−) (26%)								
Cessation date									
Length of rainy season									
Dry spell								Yams (−) (46%)	
Max days	Rice (−) (42%)				Maize (−) (26%)				
	GNuts (−) (28%)								

Source: Authors' analysis.
Note: GNuts = groundnuts.

4. Length (length). The length of the rainy season is defined as the difference between the cessation date and the onset date. It is measured as number of days.
5. Rain days (events). The number of days in the period when rainfall was higher than 1 mm.
6. Dry spell (drysp). The longest number of consecutive days without rain.
7. Extreme excess rainfall (max 10 days). The yearly maximum amount of cumulative rainfall in any 10 consecutive days.

The influence of rainfall on yield was examined using regional production data for maize, rice, millet, groundnuts, cassava, and yams for 1992–2009.

REGRESSION ANALYSIS

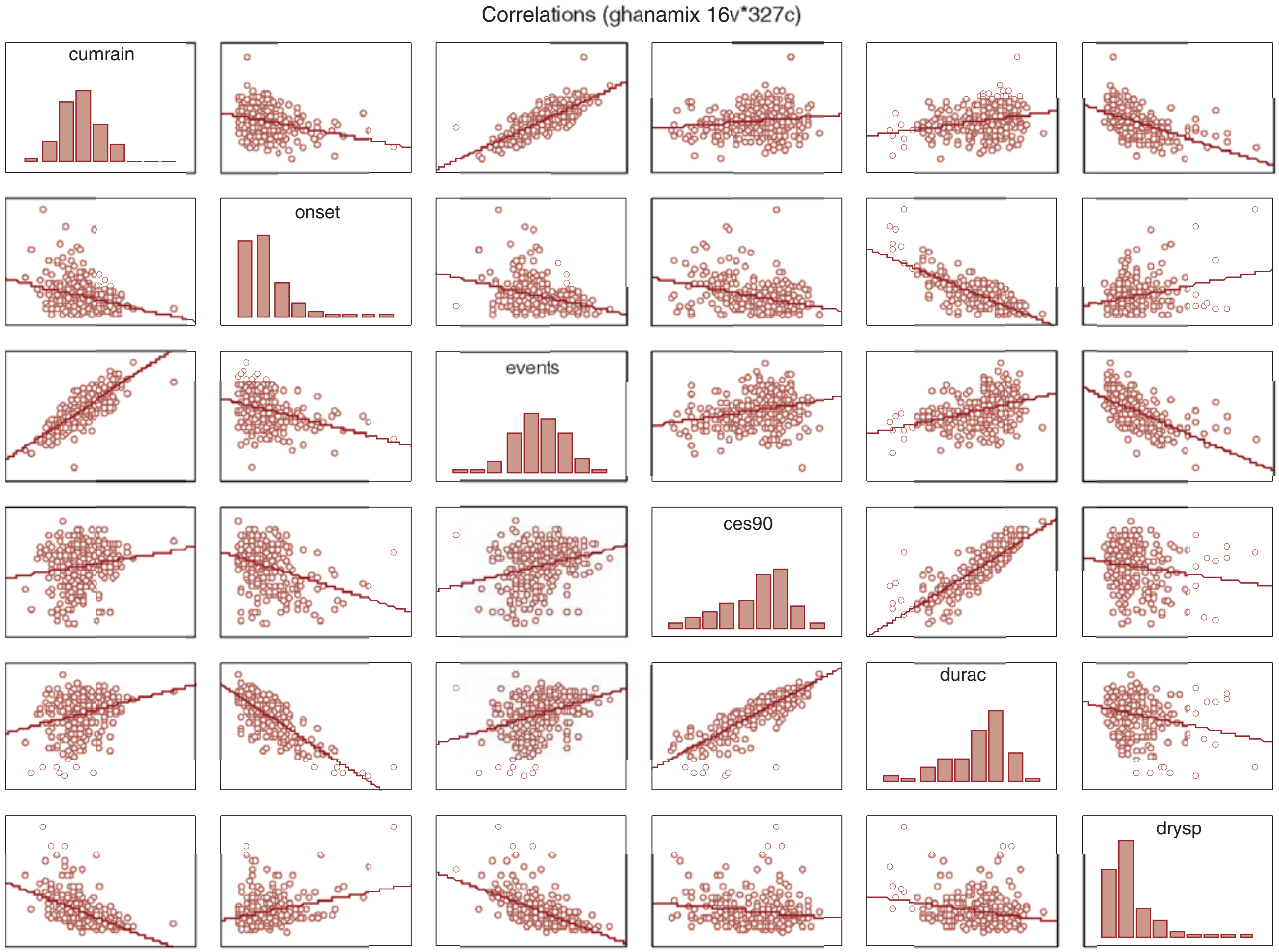
The rainfall parameters described above were averaged across the weather stations in each region and regressed on yield, as described below.

$$Yield = \beta_0 + \beta_1\ cumrain$$
$$Yield = \beta_0 + \beta_2\ onset$$
$$Yield = \beta_0 + \beta_3\ events$$
$$Yield = \beta_0 + \beta_4\ cessation$$
$$Yield = \beta_0 + \beta_5\ length$$
$$Yield = \beta_0 + \beta_6\ drysp$$
$$Yield = \beta_0 + \beta_7\ max\ 10\ days$$

Results are reported in table C.2 for those crops and regions where the regression coefficient was statistically significant (at 5 percent). The coefficient of determination, which measures the proportion of the variability in yield explained by each rainfall variable, is also reported (in brackets) to indicate the magnitude of this impact. The short time period for analysis and limited variability of some of the data limited the explanatory power of these regressions, although some general trends are apparent.

The impact of individual rainfall parameters is most apparent for the production of rice and groundnuts in the Upper East Region. Excess rainfall is the major risk, rather than drought, as shown by the negative signs for the impact of cumulative rainfall, number of rainfall days, and the maximum rainfall in any 10-day period. Groundnut yields respond positively to the earlier onset of rain in both the Upper East and Upper West regions.

FIGURE C.3. CORRELATION MATRIX PLOT



Source: Authors' analysis.

The impact of rainfall in other regions is limited. Maize and yam yields are vulnerable to drought in the Brong-Ahafo Region, yam yields are vulnerable to drought in the Central Region, and maize yields are vulnerable to excess rainfall in the Ashanti Region. This suggests that factors other than rainfall may be more important determinants of yield in these regions.

PRINCIPAL COMPONENT ANALYSIS

As the variables used for analysis are all different attributes of the same weather phenomenon (rainfall), some will be correlated. Figure C.3 shows the correlation matrix for the first six variables.[20]

[20] The excess rainfall variable was not used in the Principle Component Analysis as it was introduced at a later stage.

Some variables are closely related, such as the length of the rainy season (durac) and the cessation date (ces90)—the higher the cessation date, the longer the rainfall period. These correlations can also be highly negative—such as the correlation between the length of the rainy season (durac) and the onset date, because the later the rainy season starts the shorter the duration of the rainy season will be.

Owing to this high correlation, principal component analysis was used as a further means to analyze the impact of these parameters on crop yield. Table C.3 shows the first three eigen-values and the corresponding proportion of variance explained.

The first component explains 52 percent of the total variance for which the six variables account, and the second component explains an additional 25 percent of the variance so that the cumulative variance explained is more

TABLE C.3. PCA ANALYSIS: THREE EIGEN VALUES AND PROPORTION OF VARIANCE EXPLAINED

	Eigen-value	% Total Variance	Cumulative %
1	3.1297	52.16	52.16
2	1.5165	25.27	77.44
3	0.6384	10.64	88.08

Source: Authors' analysis.

than 77 percent. This reduces the dimensionality of the original problem from six variables into two components with a reduction of variability of only 23 percent (100 percent−77 percent). A third component would add another 10 percent of the variability explained. The usual practice is to retain as many components as eigen values are higher than one, which suggests retaining the first two components. Table C.4 shows the correlation (factor loadings) of each component, with each of the variables in the two-factor solution (retaining the first two components, meaningful loadings marked in red):

Figure C.4 shows that the length of the rainy season (durac), cessation date (ces90), and onset date (onset) are highly correlated among themselves, and so constitute the first factor together with the negatively correlated onset date. This factor can be taken to represent the length of the rainy season given that the length is high, the onset date is low, and the cessation date is also high. Hence, when this factor is large, the rainy season was very long.

Factor 2 consists of cumulative rainfall (cumrain), number of rainy days (events), and length of the dry spell (drysp), which are positively correlated, together with dry spell, which is negatively correlated. This means that when the dry spell is very long, cumulative rainfall and number of events will be low. This second factor represents the intensity of rainfall during the year.

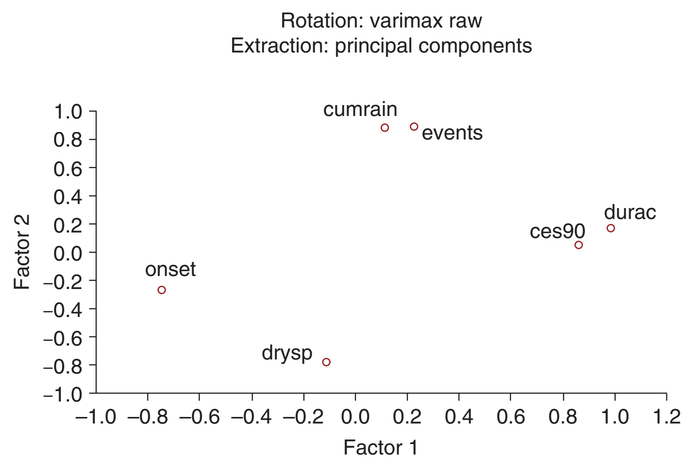
These two factors (or principal components) by definition are built orthogonally, meaning that they are independent between each other. They suggest that rainfall in Ghana has two main attributes: the length of the rainy season (factor 1) and the intensity of rainfall (factor 2).

TABLE C.4. CORRELATION OF COMPONENTS

Variable	Factor 1	Factor 2
cumrain	0.114	0.893
onset	−0.746	−0.263
events	0.228	0.895
ces90	0.861	0.053
durac	0.984	0.174
drysp	−0.113	−0.777

Source: Authors' analysis.

FIGURE C.4. FACTOR LOADINGS PLOT

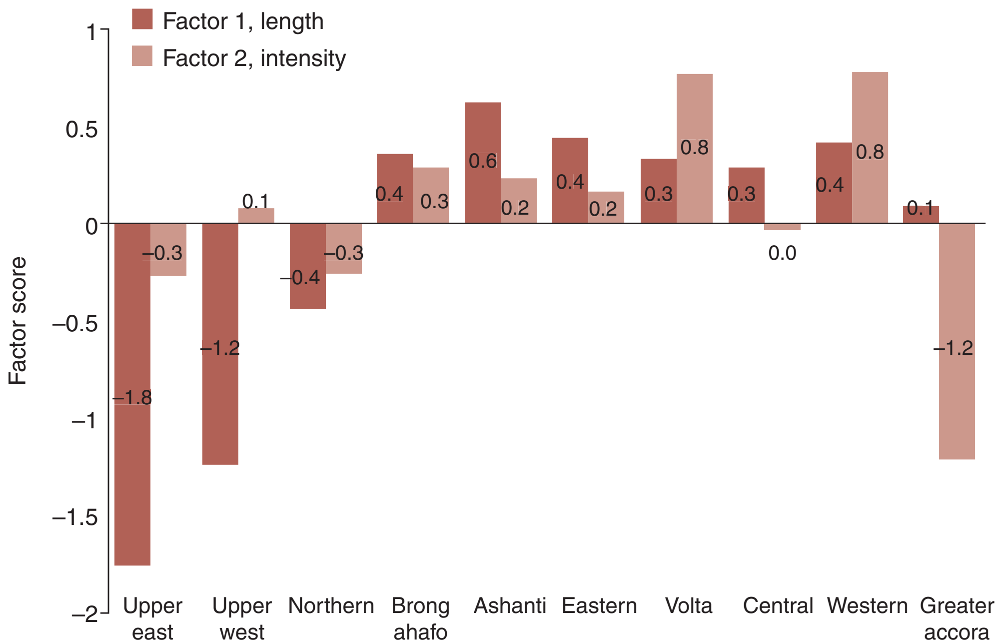


Source: Authors' analysis.

Based on this two-factor solution, it is possible to derive factor scores, which are the transformations of the original six variables into the two new variables (factors). These scores are standardized, so that the mean is equal to zero and the standard deviation is equal to one. Figure C.5 shows the mean scores for each factor by region.

The length of the rainy season is shorter than normal in the Upper East and Upper West regions, as their mean factor scores are smaller than −1. By contrast, the Ashanti Region has the highest mean score for factor 1, meaning that the season is usually longer. For the intensity factor, the Volta and Western regions seem to have the most intense rainfall because their mean score is almost one standard deviation above the mean (0.8), whereas the Greater Accra Region has the lowest intensity of rainfall. The Brong-Ahafo, Ashanti, Eastern, Volta, and Western regions have similar rainfall conditions.

FIGURE C.5. MEAN FACTOR SCORES BY REGION



Source: Authors' analysis.

The relative impact of these two rainfall factors was then examined for years of below average yield, with the results summarized below. Although consistent with the results obtained from the regression analysis, they did not add substantially to an understanding of the impact of rainfall on yield.

- Cereal and groundnut yields are affected by adverse patterns and events in both the length of the rainy season and the intensity of rainfall. Moreover, yields can be adversely affected when the rainy season is both too long and too short. Both high and low intensity rainfall can also reduce yields, but excess rainfall appears to pose the highest risk. Together, these results confirm the vulnerability of cereal and groundnut yields to a range of adverse rainfall patterns and events in the lower rainfall zones in which they predominate.
- Cassava and yam yields are vulnerable to shorter rainfall seasons and lower intensity rainfall, although neither set of factors had a substantive impact. This may result from the higher and more reliable rainfall patterns in the transition and forest zones where these crops predominate.
- The impact of both sets of factors was higher in the drier savannah zones, particularly in the Upper East and Upper West regions, as would be expected.

APPENDIX D
CLIMATE CHANGE IMPACT ASSESSMENT OF AGRICULTURE IN GHANA

INTRODUCTION

Agriculture is vulnerable to climate change in Ghana, although the effects are heterogeneous based on model assumptions and also across regions, socioeconomic groups, and crops and livestock. Agriculture accounts for 25.6 percent of the GDP and 56 percent of the labor force are involved in agriculture.[21] The agricultural sector is composed of crops (primarily rain-fed), livestock, and fisheries. The single most important cash crop is cocoa. Cassava and maize are the primary food crops. The agricultural sector is largely composed of smallholders (more than 85 percent of holdings are 2 hectares or less) (Masters, Baker, and Flood 2010). Cocoa in particular seems to be adversely affected by climate change and will have negative implications on development strategies and the overall economy if left unaddressed.

In the *Mapping the Impacts of Climate Change* index under "Agricultural Productivity Loss," the Center for Global Development ranks Ghana 106th out of 233 countries globally for "direct risks" due to "physical climate impacts" and 68 out of 233 for "overall vulnerability" due to "physical impacts adjusted for coping ability" (Wheeler 2011).

The impacts of climate change on agriculture in Ghana 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 due to shifting agro-climatic zones. The newest installment of the 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

[21] "Ghana," *CIA Fact Book* (January 26, 2013).

generalize regarding the effects of climate change on agriculture in Ghana. This appendix will discuss the various possible outcomes.

PRINCIPAL FINDINGS

- The agricultural sector in Ghana is highly vulnerable to climate change, in large part due to dependence on rain (dryland farms are particularly sensitive). Climate change will create water and heat stress, resulting in pest and disease outbreaks; ecosystem deterioration, resulting in the loss of productive lands; and increased burdens to supply chains (from post-harvest losses in storage and distribution) (De Pinto et al. 2012).
- Consequences for the agricultural sector include yield reductions, decreased livestock values, post-harvest losses, reduced food accessibility, and reduced consumption levels.
- Across all models and projects there are signs of warming, usually within the range of a 1.5°C–3°C temperature increase by 2080 (De Pinto et al. 2012).
  - Warming appears to be most rapid and occurring to a greater degree in the north (McSweeney, New, and Lizcano 2008).
- Climate change will result in increased pressure on water, soil, and other inputs.
- The agricultural sector is expected to see shifting agro-climatic zones, and generally decreasing yields due to climate change.
  - Ghana's primary cash crop, cocoa, will be negatively affected by climate change, resulting in a decrease in national revenue.
  - Reduction in productivity and yield is also expected in root and tuber crops.
  - Rice, maize, and groundnuts will also generally decrease in yield.
- These decreases may lead to increased poverty and food insecurity (Republic of Ghana 2011).
- Changes in temperature and precipitation also affect the fishing system, directly affecting the productivity, catchability, and growth rates—varying from species to species. Saltwater fish were more affected by sea surface temperature, whereas freshwater fish were more affected by precipitation.

BRIEF HISTORY OF CLIMATE CHANGE IMPACT ASSESSMENTS

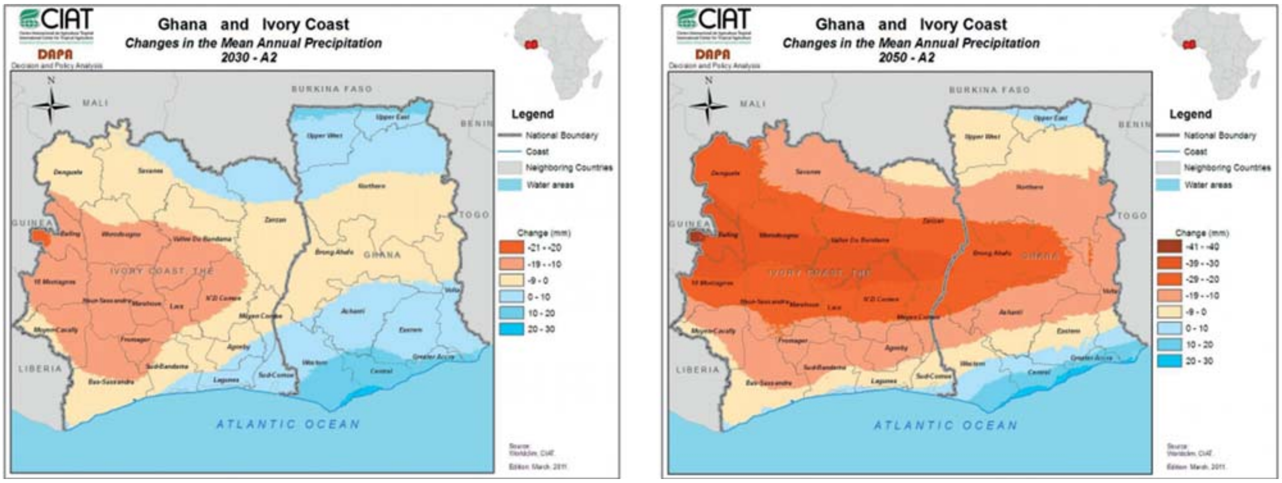
Ghana has been involved with climate change assessments since the early stages, ratifying the United Nations Framework Convention on Climate Change (UNFCC) in 1995. Ghana hosted the 6th Working Group III session for the IPCC assessment in 2001. Ghana has submitted two national communications (the most recent in 2011) to the conference of parties to the UNFCC, and has completed a National Climate Change Adaptation Strategy.

METHODOLOGIES AND TEMPERATURE/ PRECIPITATION PROJECTIONS

The Netherlands Climate Assistance Programme (NCAP) completed several climate change assessments for Ghana. In its assessment of the impact on fisheries, it used regressions of historical rainfall data and sea surface temperature scenarios (SST) combined with dynamic production models (both a Cost per Unit Effort [CPUE]-based model and r-based models) (Dontwi et al. 2008).

IFPRI's study is based on the four downscaled global climate models (GCMs) from the IPCC AR4—the CNRM, ECHAM, CSIRO, and MIROC models. Based on these models, the IFPRI study uses the Decision Support System for Agrotechnology Transfer (DSSAT) crop modeling software projections for crop yields, comparing yield projections for 2050 against real 2000 yields. The CNRM model predicts little change in annual precipitation, and a uniform temperature increase of 2°C–2.5°C across the country. ECHAM also predicts little change in annual precipitation (with an increase in the southeastern part of Ghana), but an increase in temperature of 1.5°C–2°C across the country. CSIRO predicts a general reduction in annual rainfall (100–200 mm in the middle belt, 50–100 mm in the northern savannah, and an increase at or above 50 mm in the southwestern corner), a temperature increase of 1.5°C–2°C in the north, and an increase of 1°C–1.5°C in the south. Finally, the MIROC model predicts decreased precipitation in the south and increased precipitation in the north, and an increase in temperature of 1°C–1.5°C across the country. Based on precipitation

FIGURE D.1. CHANGES IN MEAN PRECIPITATION BY 2030 (*LEFT*) AND CHANGES IN MEAN PRECIPITATION BY 2050 (*RIGHT*)



Source: International Center for Tropical Agriculture (CIAT) 2011.

projects, CSIRO and MIROC appear to present significant challenges for agriculture (IFPRI 2013).

The study on roots and tubers conducted for the Ghana Environmental Protection Agency also used DSSAT, version 4, to evaluate root crops for their vulnerability and implications for impacts. Its scenarios were built on national climatic data from 1960–1990, and the approach assumed mono-cropping (Sagoe 2006).

The Netherlands Climate Change Studies Assistance Programme Phase 2 (NCCSAP2) looked at the impacts of climate change across various crops in helping with the preparation of Ghana's submission of the second national communication to the conference of parties to the UNFCCC. For the assessment of impact on cocoa, NCCSAP2 used climate change scenarios for the semideciduous forest and evergreen rain forest zones of Ghana based on process-based methods relying on the General Circulation Models and Simple Climate Models. The projected mean annual rainfall in the semideciduous forest zone would be projected to decline by 2.8 percent in 2020, 10.9 percent in 2050, and 18.6 percent in 2080. Similarly, in the evergreen rain forest zone, mean annual rainfall will decrease by 3.1, 12.1, and 20.2 percent. Projected increases in temperature for 2020, 2050, and 2080 were, respectively, 0.8°C, 2.5°C, and 5.4°C for the semideciduous forest, and 0.6°C, 2.0°C, and 3.9°C for the evergreen rain forest.

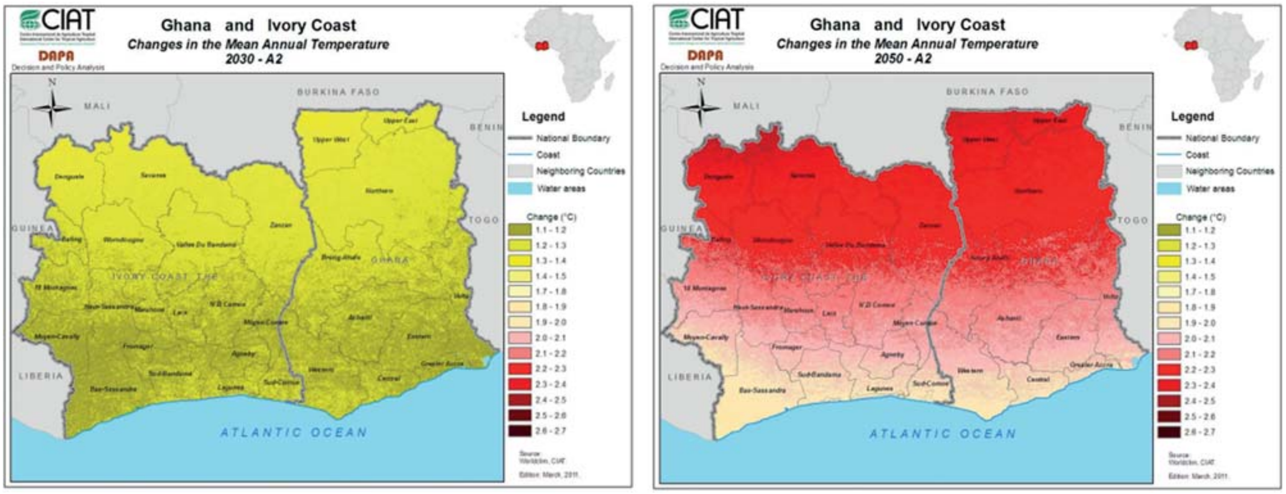
The International Center for Tropical Agriculture (CIAT) published an analysis of the impact of climate change on cocoa-growing regions for the Bill & Melinda Gates Foundation. CIAT combined current climate data with future climate change predictions from 19 GCMs for 2030 and 2050 (emissions scenario SRES-A2). These data were then used in MAXENT, a crop prediction model. The model finds that temperatures will increase by 1.2°C in 2030 and by 2.1°C by 2050 (see figure D.2). Rainfall decreases only slightly, down 12 millimeters by 2050 (Laderach 2011). Figure D.1 shows the change in mean precipitation across Ghana and the Ivory Coast by 2030 and 2050.

Other models used to assess the impact of climate change on agriculture include CERES-Rice (Crop Environment Resource Synthesis Model, version 4.0), using data from the Anum Valley Irrigation Project, and the Centre for Agricultural Bioscience International (CABI), which assumes a 2.5°C–3.2°C increase across the country, with a decrease in annual rainfall by 9–27 percent by 2100.

GENERAL FINDINGS

Climate in Ghana is influenced by the Inter-Tropical Convergence Zone, and its interaction with the West African monsoon. Generally, there has been a warming trend in Ghana, with change occurring more rapidly in the north. Annual temperatures have risen by 1°C since 1960, and the frequency of "hot" days and nights has increased (McSweeney, New, and Lizcano 2008). Climate change

FIGURE D.2. CHANGES IN MEAN ANNUAL TEMPERATURE 2030 (*LEFT*) AND CHANGES IN MEAN ANNUAL TEMPERATURE 2050 (*RIGHT*)



Source: International Center for Tropical Agriculture (CIAT) 2011.

will affect the various regions in Ghana differently. The Global Climate models (GCMs) broadly agree that there will be an increase in mean temperatures, but precipitation changes are highly variable throughout the models.

An IFPRI Policy Note reviewed 15 different models, and found the mean annual temperature increase to be 1°C–3°C by 2060, and 1.5°C–5.2°C by 2090. It also noted the various negative impacts of climate change on production, supply chains, and vulnerable population (particularly in the north) (De Pinto et al. 2012). The later IFPRI impact assessment itself found general losses in yield over the vast majority of Ghana for rain-fed maize, rice, and groundnuts (IFPRI 2013).

The Netherlands Climate Change Assistance Programme in 2008 showed wide variability, and great vulnerability to climate change in Ghana. In the north, increased aridification and exposure to intense rainfall are expected, which would result in decreased agricultural productivity, flooding, and migration. In the south, cocoa production is projected to decline, and as the primary cash crop on which both the entire economy and individual smallholders alike depend, the impact will be great. Sea level rise of 1 m by 2100 would result in the loss of more than 1,000 km^2 of land (displacing 132,000 people), particularly along the east coast.[22]

[22] African Adaptation Programme, *Ghana*, http://www.undp-aap.org/countries/ghana#Pro Doc.

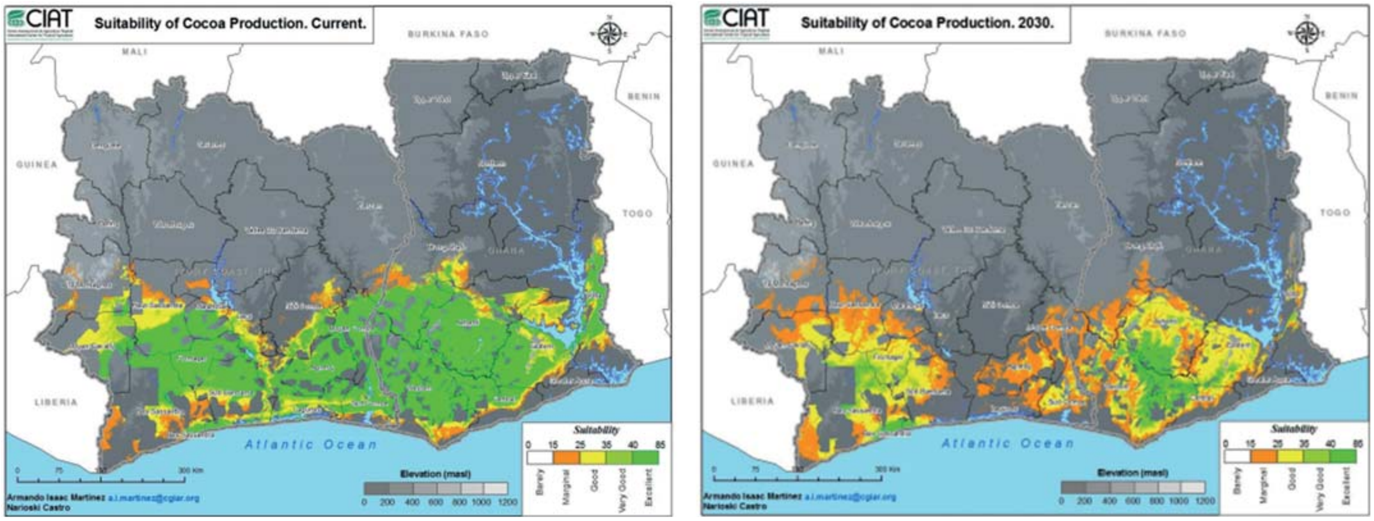
COCOA

Cocoa is the principal cash crop in Ghana. It accounts for 60–70 percent of agricultural foreign export earnings, or 20–25 percent of total foreign export earnings. CABI claims that more than 800,000 smallholder families (mainly in the western region) depend on cocoa production for their livelihood, and do not use significant technology or inputs.

Cocoa is highly susceptible to climate change (particularly temperature and intense dry seasons), and changes in production will have a large impact on Ghana's overall economy. The appropriate temperature for cocoa is 18°C–32°C, and the trees are highly sensitive to light variations. CABI concludes that there will be shifts in the geographic distribution of cocoa and related pests, overall crop yields will decrease, and there will be a greater incidence of crop loss, in turn affecting farm income, livelihoods, and farm-level decision making. (Four months of dry weather alone will lead to seedling mortality, reduced bean size, and increased pest attack.) Not least of the cocoa industry's problems will be the spread of black pod disease (*Phytophthora megakarya*), which thrives in humid conditions, as a result of changing precipitation (Masters, Baker, and Flood 2010).

The NCCSAP2 study found that projected climatic changes would exacerbate soil moisture conditions during

FIGURE D.3. CURRENT SUITABILITY OF COCOA GROWING AREA (*LEFT*) AND FUTURE SUITABILITY OF COCOA GROWING AREA (*RIGHT*)



Source: International Center for Tropical Agriculture (CIAT) 2011.

the dry season, thereby increasing the vulnerability of cocoa trees. Using a process-oriented computer model, CASE2 (CAcao Simulation Engine 2), this regression model used to estimate the production of dry cocoa beans in the Koforidua/Tafo cocoa district was extrapolated for the national production. Results showed a 14 percent and 28 percent decrease in yield for 2020 and 2050, respectively, based on a year 2000 baseline. The model also projects that moisture levels in 2080 would "not be adequate for profitable cocoa production." The study asserts that "since cocoa is highly sensitive to drought in terms of growth and yield, it is reasonable to anticipate consistent decrease in output from 2020 to 2080" (Anim-Kwapong and Frimpong 2004).

Problems with cocoa are exacerbated by difficulties in reestablishment and replanting worsened by climate change, the fact that about 25 percent of current cocoa tree stocks are 30+ years old, and more than 60 percent of the farmers are older than 50 years.

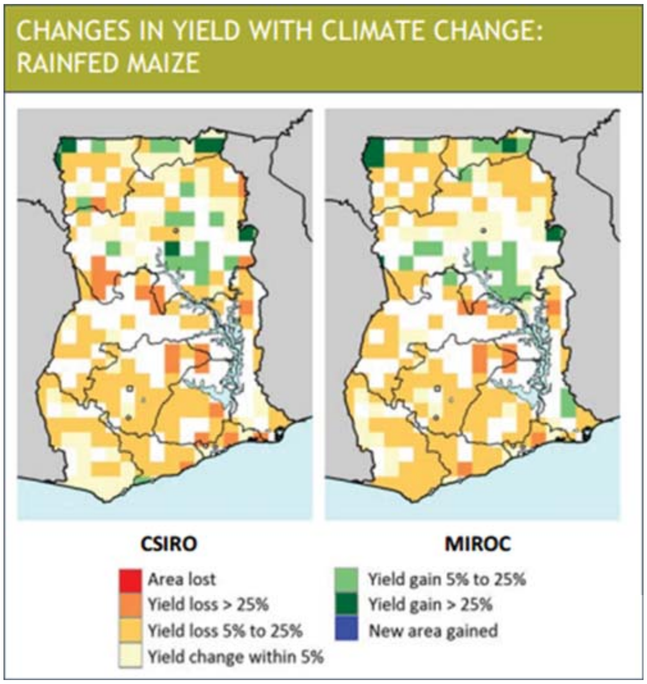
CIAT adds that increased temperatures will increase evapotranspiration of the cocoa trees. With overall climates becoming less seasonal, increased temperature and less seasonal precipitation, CIAT finds that current cocoa-growing areas in Ghana will decrease quite seriously by 2050. This shift is primarily attributed to the increase in temperature. According to their predictions, by 2030 suitable cocoa growing areas will start shifting, primarily in the western regions, and Brong-Ahafo in the south (see figure D.3). By 2050, production will be concentrated in two areas, in the mountain ranges of the Kwahu Plateau (between the Eastern and Ashanti regions), and between the Central and Ashanti regions. Rising above the 2°C mark increases in temperature puts cocoa in Ghana in severe jeopardy (Laderach 2011).

A study published in the *British Journal of Environment and Climate Change* found a significant shift in the Wenchi Municipality in the forest and savannah transitional agro-ecological zone from cocoa to maize cropping systems (humid to drought tolerant). This shift stemmed from decreases in the yield of cocoa attributed by the study primarily to changing rainfall patterns, but it was also the result of other factors such as declining producer price, land tenure, and declining soil fertility. Interestingly, the same paper suggests that prevailing climatic conditions and deforestation in Wenchi will prevent future shifts (Adjei-Nsiah and Kermah 2012).

ROOT AND TUBER CROPS

In Ghana, important root and tuber food crops include cassava, yams, and cocoyams. In a report prepared for Ghana's Environmental Protection Agency, the Crops Research Institute in Kumasi used projected climate scenarios and crop models (CROPSIM-cassava and CROPCRO-tanier) and found negative impacts on yields of cassava and cocoyams. Cassava is expected to

FIGURE D.4. YIELD CHANGES 2010–50



Source: IFPRI 2012.

see a reduction in productivity or yield by 3 percent in 2020, 13.5 percent in 2050, and 53 percent by 2080. Reductions in cocoyam are projected to be 11.8 percent in 2020, 29.6 percent in 2050, and 68 percent by 2080 (Sagoe 2006).

MAIZE

Under the IFPRI projections, rain-fed maize will suffer across the country, but particularly in the south (IFPRI 2013) (see figure D.4). There may be limited areas in the north that will see an increase in yield. Most of the decreases will be small, under 25 percent. Other models, such as from the Centre National de Recherches Météorologiques, reflect this prediction of a possible increase in the Upper East, Upper West, and Northern regions (De Pinto et al. 2012).

RICE

A study run by the Crops Research Institute in Ghana concluded that an increase or decrease in temperature of 4°C from the maximum or minimum would decrease rice yields by 34 percent in relation to the year 2006 as a base scenario. The study concluded that planting dates are an instrumental tool in increasing rice yields under climate change, along with more temperature-tolerant rice varieties, farmer training, and other agronomic practices (Oteng-Darko, Kye-Baffour, and Ofori 2012).

IFPRI found that there would be a moderate yield decrease for rain-fed rice, but there was variation between models. The Centre National de Recherches Météorologiques was the most optimistic out of models reviewed, whereas the Microindustry Credit Rural Organization's model showed a decrease in yield up to 25 percent in many areas (De Pinto et al. 2012).

GROUNDNUTS

IFPRI found high rates of decrease in yield for rain-fed groundnuts. Their literature review noted several variations on results in the north. The European Centre Hamburg Model (ECHAM5) projected high loss rate, whereas other models saw some increases. When the Commonwealth Science and Industrial Research Organization ran both the CSIRO and MIROC models, projections of more than a 25 percent loss were found in the central and southern regions (De Pinto et al. 2012).

FISHERIES

The impact of climate change on fisheries will be felt along the coast in Ghana, as almost 25 percent of the population lives in the coastal zone, with around 10 percent dependent on fishing for their livelihood. The impacts of climate change will result in generally warmer air and sea surface temperatures, along with decreased precipitation, affecting the industry. When combined with overfishing and population growth, a triangle of production constraints appears (McSweeney, New, and Lizcano 2008). When analyzed, most studies suggest that a rise in SST and changes in precipitation will correlate with an increase or decrease in catch rates dependent on the variety of fish. However, there is wide variability, and multiple factors outside of climate change make it hard to generalize.

Saltwater fish studied seem to show change in catch rates due to temperature (anchovies and the Round Sardinella). According to the NCAP vulnerability assessment for climate change impacts on fisheries, the anchovy shows the highest sensitivity to climatic changes. Owing to a temperature increase of 1°C, the estimates for catch rate increases vary from 2.8 percent under the CPUE-based model, to around 169 percent under the r-based model. Precipitation had minimal effects (McSweeney, New, and Lizcano 2008).

For the Round Sardinella, the SST negatively affected CPUE. An increase in temperature of 1°C resulted in a 4.2 percent catch rate decrease under the CPUE-based model, and a 102 percent decrease under the r-based model. Precipitation also seemed to have a minimal effect.[23]

Conversely, precipitation did seem to matter for the freshwater or brackish water fish studied under the NCAP assessment (tilapias, cat fish, and Flat Sardinella). The Flat Sardinella showed less response to SST, and is more tolerant to changes in SST and salinity, but more sensitive to precipitation. Overall, however, the study concluded that the distribution and catchability of Flat Sardinella are "hardly affected by changes in the ocean climate" (McSweeney, New, and Lizcano 2008).

BEYOND CROP IMPACT STUDIES

International Food Policy Research Institute (IFPRI) took its assessment a step further, using 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" (IFPRI 2013) The IMPACT model projects maize yields increasing by almost 60 percent between 2010 and 2050, but suggests that consumer demand and technological improvements drive productivity (with harvested land only increasing by around 10 percent).

The model found smaller increases in productivity (yield) for cassava at 30 percent. Projections also included harvested land growing by 7 percent, and production rising by one-third, but demand surpassing supply around 2025. The IMPACT model shows average increases of 54 percent for sweet potatoes and yams, but differences between climate models in the intermediate scenario.

CONCLUSION

On a general level, a review of the literature suggests that there will be a decline in agricultural production based on climate change, which in turn will affect various components of the national GDP. The results vary across crops (and fish varieties), and by region.

LIMITATIONS

There are many variations between climatic models and regions. These assessments could benefit from more in-depth regional impact assessment and further research on food crops. Finally, there are several studies that assess the impact of climate change based on land management techniques. They have not been included in this discussion but may offer important insights into possible adaptation techniques, and risk intervention strategies, for example,

D. S. MacCarthy and P. L. G. Vlek, "Impact of Climate Change on Sorghum Production under Different Nutrient and Crop Residue Managment in Semi-Arid Region of Ghana: A Modeling Perspective," *African Crop Science Journal* (African Crop Science Society, Uganda) 20, no. S2 (2012): 243–259.

[23] Ibid.

APPENDIX E
STAKEHOLDER 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 or resources to deal with a realized risk. It is generally accepted that in low-income countries, rural populations are both poor and vulnerable, and that primary risks to these populations may include climate and market shocks (Sarris and Karfakis 2006). Vulnerability is a useful lens through which to view shocks, as it allows for determination of impacts on populations, and who will be most affected. Vulnerability is discussed here particularly in the context of food security.

Ghana saw the number of people living in poverty halved between 1998/99 and 2005/06, but the depth of poverty has increased, and there are significant regional differences. According to the Ghana Living Standard Survey in 2005/06, 18 percent of the population has an income less than the costs of the minimum food basket, making them extremely vulnerable to food price shocks (Biderlack and Rivers 2009).

There is a significant amount of information available in Ghana, including the Ghana Living Standard Survey, the Multiple Indicator Cluster Survey, and the Demographic Health Survey. Ghana also has a Food Security Monitoring System operated jointly by the World Food Program, the Ministry of Food and Agriculture, and the Ministry of Health, providing monthly updates on food security in three northern regions as well as a frequent Comprehensive Food Security and Vulnerability Analysis. Therefore, there are strong information systems related to vulnerability and food security in Ghana.

TABLE E.1. FOOD INSECURITY AND VULNERABILITY BY REGION

	Food Insecure		Vulnerable to Food Insecurity	
Regions	**No. of People**	**% Pop**	**No. of People**	**% Pop**
Western rural	12,000	1%	93,000	6%
Central rural	39,000	3%	56,000	5%
Greater accra rural	7,000	1%	14,000	3%
Volta rural	44,000	3%	88,000	7%
Eastern rural	58,000	4%	116,000	8%
Ashanti rural	162,000	7%	218,000	10%
Brong ahafo rural	47,000	3%	152,000	11%
Northern rural	152,000	10%	275,000	17%
Upper east rural	126,000	15%	163,000	20%
Upper west rural	175,000	34%	69,000	13%
Urban (acca)	69,000	2%	158,000	4%
Urban (other)	297,000	4%	572,000	8%
Total	1,200,000	5%	2,007,000	9%

Source: Ghana CFSVA, 2009.

GENERAL TRENDS IN VULNERABILITY

- The national averages for food insecurity and related indicators mask drastic regional differences.
- Food insecurity is concentrated in the areas prone to extreme weather events and with the highest levels of poverty.
- Generally, the people most vulnerable to becoming food insecure live in the Upper West, Upper East, and Northern regions (see table E.1). Other vulnerable populations are spread out in the rural and urban areas of the other seven regions.

VULNERABLE GROUPS (BIDERLACK AND RIVERS 2009)

Certain populations have characteristics that make them more vulnerable to shocks than others, particularly agricultural workers. More than half of Ghana's workforce is engaged in agricultural activities, and according to the 2000 census, more than 90 percent of farms are smallholdings of less than 2 ha in size. These farms contribute 80 percent of Ghana's agricultural output. Table E.2 highlights sources of vulnerability for various groups involved in Ghana's agricultural sector.

UNDERLYING FACTORS OF FOOD SECURITY IN GHANA

MACRO-LEVEL FACTORS

- High food price volatility (particularly as 80 percent of all households rely on markets as their main source of food).
- The lingering impact of the global financial crisis, particularly in terms of diminished export demand and declines in ODA and remittances.
- Natural hazards such as floods and droughts, which could reduce resilience, leading into a downward spiral.

HOUSEHOLD-LEVEL FACTORS

- Lack of education.
- High dependency on agricultural livelihood activities as the primary source of income.
- Lack of access to output markets.
- Poverty and malnutrition.

TABLE E.2. VULNERABLE GROUPS

Food crop farmers	• Food crop farmers have the lowest annual per capita income, and 72% of them cultivate less than two hectares and are primarily relient on rain for water. Almost half of the heads of households have no educational background, and 22% are headed by women. • Location: 48% of the population in the Northern Savannah zone, primarily in the Upper East region.
Cash crop farmers	• The most vulnerable cash crop farmers are in the Upper West region where they comprise 17% of the population. (The majority live in the Forest zone.) • Their second income source is food crop production. • Among agriculturalists, they have the highest annual per capita income, but more than half are in the poorest wealth quintile. • 18% of the households are headed by women.
Agro-pastoralists	• 59% live in the Northern region, and 21% in the Upper East region. • 63% of their income comes from livestock and animal husbandry (primarily cattle and poultry), with 1/5th coming from food crops. • 83% of the heads of households have not received any schooling, 88% of households were poor, and 9% are headed by women.
Food processors (millers, brewers, and shea nut producers)	• Their second income source is food crop production. • 56% of households are poor, and have the largest share of households with loans or debt (46%). • 41% of the households are headed by women.
Unskilled laborers	• The majority live in urban areas, and urban poor spend about 67% of their income on food (15% higher than the national average). The unskilled laborers who live in rural areas are concentrated in Ashanti and the Upper East. • Their second income source is food crop production. • The average income per capita is the second lowest among livelihoods. • 33% of households have single heads, and 22% are headed by women.

Source: Ghana CFSVA 2009.

LIVELIHOOD AS AN INDICATOR OF VULNERABILITY

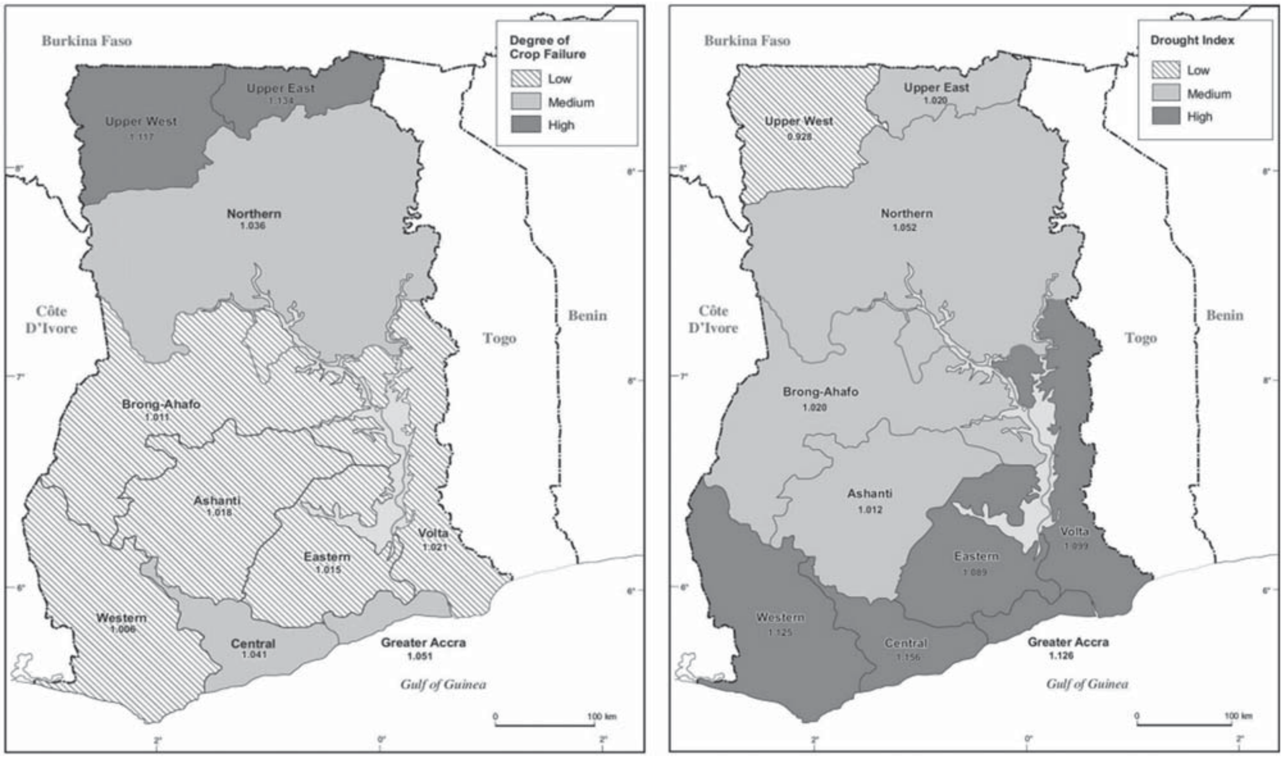
Figures E.1 and E.2 illustrate how livelihood activities are intimately linked to geography and agro-climatic conditions in Ghana. Producers in zones 1, 2, and 3 rely heavily on cereal and livestock for their livelihoods, whereas producers farther south may engage in more diversified agricultural activities. People living in zones 1, 2, and 3 are also the most likely to experience inadequate food consumption, as shown in figure E.3, and are extremely vulnerable to agricultural shocks and exhibit the highest degree of crop failure.

CROP VULNERABILITY TO DROUGHT IN GHANA

The vulnerability of millet and sorghum crops to drought is shown below, disaggregated by district. A crop's vulnerability depends on yield sensitivity, geographic exposure to drought, and adaptive capacity. In northern Ghana, sorghum is more vulnerable to drought than is millet in 10 of 13 districts.

Vulnerability = [(crop yield sensitivity index + exposure index) − adaptive capacity] (Antwi-Agyei 2011).

FIGURE E.1. CROP YIELD SENSITIVITY INDEXES (*LEFT*) AND REGIONAL VULNERABILITY INDEXES (*RIGHT*)

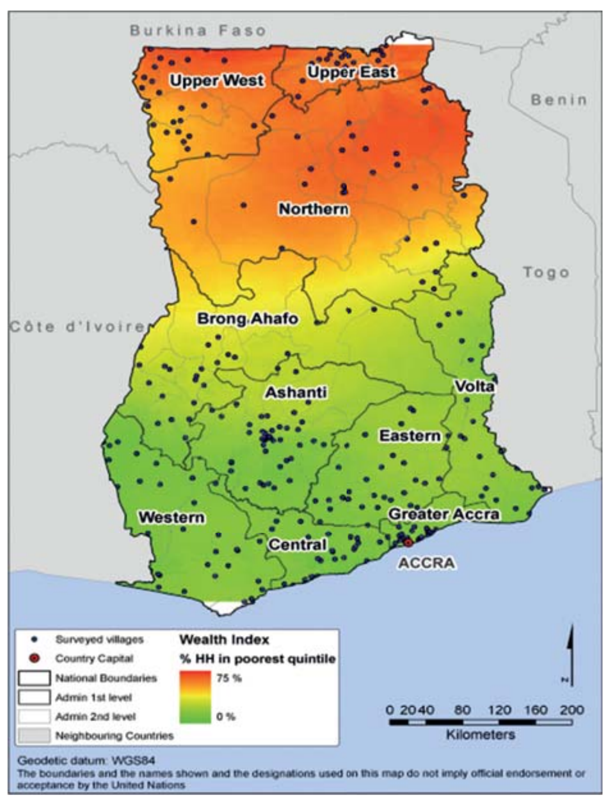


Source: Centre for Climate Change Economics and Policy 2011.

FIGURE E.2. LIVELIHOOD ZONES

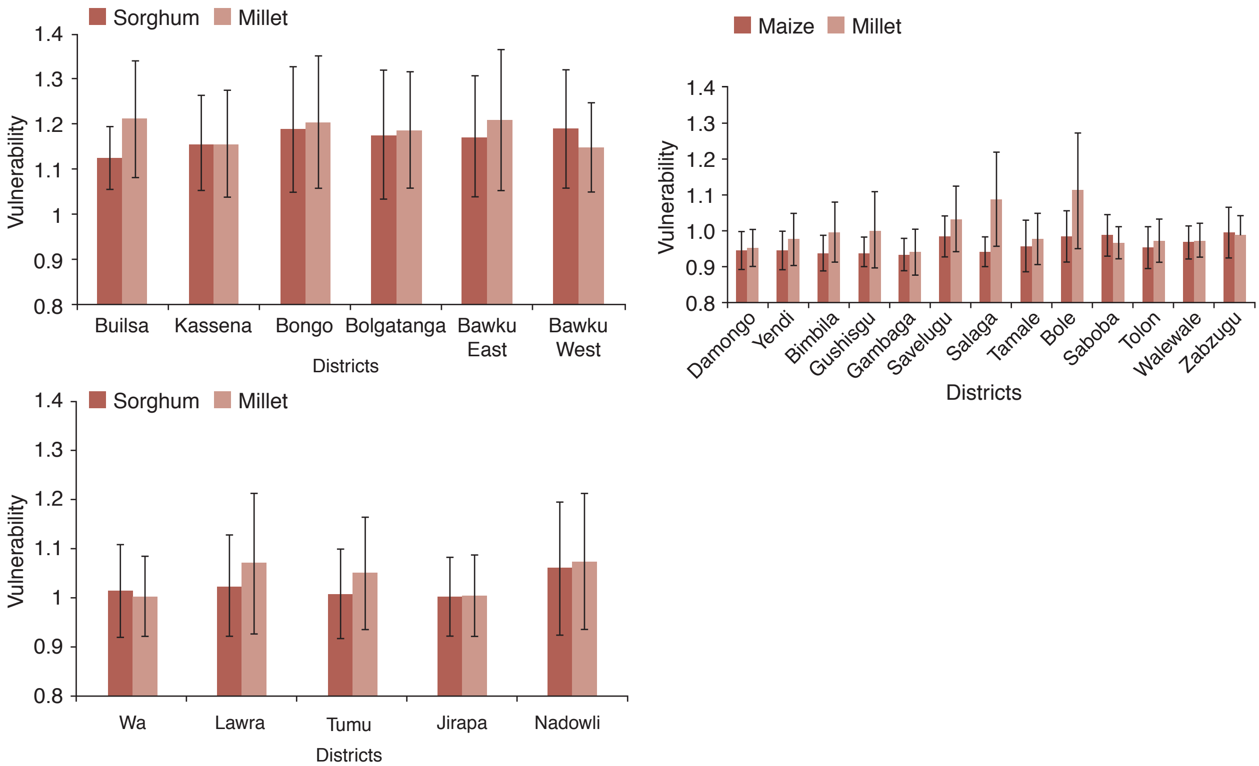
Source: FAO 2010.

FIGURE E.3. FOOD CONSUMPTION



Source: CFSVA 2009.

FIGURE E.4. MEAN VULNERABILITY INDEXES OF UPPER EAST DISTRICTS (*TOP LEFT*), UPPER WEST DISTRICTS (*BOTTOM LEFT*), AND NORTHERN DISTRICTS (*BOTTOM RIGHT*)



Source: Centre for Climate Change Economics and Policy 2011.

APPENDIX F
AGRICULTURAL RISK FINANCING AND INSURANCE FOR GHANA: OPTIONS FOR CONSIDERATION

MICRO-LEVEL OPTIONS:

Public-Private Partnerships (PPP) in Agricultural Insurance for Farmers

1. **Developing a viable PPP in agricultural insurance would require significant public investments in data and would most likely need to be accompanied by substantial reform in credit utilization.** Developing a PPP in agricultural insurance is a long-term objective, which requires long-term leadership and engagement as well as high levels of investment from both sectors. In addition, to achieve sustainable and meaningful uptake, it relies on several key pillars. One key pillar is an effective distribution channel to rural farmers, through which insurance can be sold. These distribution channels can take many forms, such as input suppliers or social welfare payment systems; however, the most commonly used, and which have the highest potential, are rural lending institutions. Despite this, there are several significant challenges for this distribution channel in Ghana. Rural credit levels are low, with agriculture, forestry, and fishing loans making only 5.9 percent of the total lending portfolio in Ghana[24] and only 10 percent of rural households having access to credit.[25] Rural finance has also experienced challenges in the past in terms of high rates of nonrepayment.[26] Agricultural data make up another key pillar. Experience from other countries suggests that yield data are required to provide farmers with reliable protection, which can be enhanced by weather and satellite data. Currently, a limited amount of yield data is collected in Ghana by the Statistics, Research and Information department at the Ministry of Food and Agriculture, and significant increase in resources

[24] Bank of Ghana Annual Report.

[25] GFDRR Country DRM Plan for Ghana.

[26] World Bank 2009 analysis of commercial bank lending by sector showed that the poorest performing sector was agriculture, forestry, and fishing with 23.1 percent of loans classified as nonperforming.

would be required to collect such data on a large-scale basis. Although the Ghana meteorological department has an established weather station network, the majority of the weather stations are manual, which need to be upgraded to automatic stations for insurance purposes. Moreover, the audit procedures for these types of data are not in line with international reinsurance standards. Thus, significant financial and human resources would be required to develop the agricultural data to an acceptable standard.

2. **Given the significant fiscal burden of developing a PPP in agricultural insurance, other risk management options may be more cost effective at this time.** The investments in data mentioned previously, as well as the intuitional and market investments required to reform and develop distribution channels to a level that could achieve critical mass, would be high relative to other investment options in agricultural risk management currently available to Ghana. In the future, any investments in agricultural insurance would be coupled with other initiatives; for example, should the Government of Ghana aim to increase rural productivity levels, this could be achieved by providing farmers access to better information, improved extension services, enhanced inputs (improved seeds, for example), and access to the credit required to purchase them. This would require development of multiple markets in Ghana, one of which is the rural credit market. Agriculture insurance would be an excellent partner for such a venture as, if effectively developed, it can protect vulnerable farmers against shocks as well as rural lending institutions against covariate risks that can lead to bankruptcy, increasing their resilience.

MESO-LEVEL OPTIONS

Meso-level Agriculture Risk Financing

3. **Weather index–based meso-level agricultural insurance products have been piloted in Ghana; however, the pilots are experiencing severe challenges and there are questions about the sustainability of these schemes.** The insurance product covered only drought risk for rural lending institutions. Discussions with such institutions indicated that drought risk is only one of the many risks they face (others include flood, pests and diseases, bushfires, inability to enforce contracts, changes to agricultural policy, and so on). In addition, practitioners noted there was considerable basis risk with the product, because weather data were used to trigger insurance payments. These two significant issues led institutions to believe that the use of the product did not cover the cost.
4. **To develop products that cover more of the risks faced by rural banks and that minimize basis risk, investments in yield data would be required, which would face the issues mentioned previously.** Again, given the high levels of investments required, other options available to government could be considered at this stage.

Catastrophe Weather Index–Based Insurance

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

MACRO-LEVEL OPTIONS

Sovereign Agriculture Risk Financing and Insurance

6. **It is unclear what the government considers to be its contingent liability to the agricultural sector, and what it considers to be the responsibility of donors or farmers. However, if government considers its contingent liability to be relatively low, then developing a sovereign agriculture risk financing strategy may have lower impact than other agricultural risk management investments.** The government has taken several steps to increase the protection it offers to vulnerable farmers against agricultural shocks. Disaster risk reduction has its main institutional home within the

National Disaster Management Organization in the Ministry of the Interior. NADMO was established in 1996 under a National Security Council, chaired by Ghana's president. It works with other organizations and ministries to ensure such responses are as effective as possible. That said, given the fact that the government uses grant funding for its annual budget,[27] its contingent liability to the agricultural sector could be considered minimal. Were the government to plan to increase its fiscal expenditure in the aftermath of shocks, then a sovereign agricultural risk financing strategy may become a more attractive option.

Index-Based Social Safety Mechanisms

7. **The government is looking to increase the number of households that receive social welfare payments through the Livelihood Empowerment Against Poverty Program.** The LEAP is a social cash transfer program that provides cash and health insurance to extremely poor households across Ghana to alleviate short-term poverty and encourage long-term human capital development. It is targeted at the 18 percent most vulnerable households in Ghana. Currently, there is a 3-year plan to increase the number of families who receive social cash payments from 70,000 to 1,000,000.
8. **Using insurance principals to automatically scale up social welfare payments in the aftermath of an agricultural shock based on a pre-defined set of rules could be considered in conjunction with LEAP.** An insurance type of product could be established where if there was an adverse climatic shock of a given magnitude in a given location a payment would be triggered. This payment would be directly linked to cash transfer system to families in the effected region, thus immediately transferring funds to those who are in need. Using insurance principals in the scaling up of social safety nets has numerous benefits: i) it brings efficiency to scheme, developing a money trail that minimizes leakages; ii) it increases transparency, enabling both recipients of the benefit and government to have a better understanding of when and how much benefit will be paid, thus enabling better planning; and iii) it disciplines the government to comply with the rules set under the scheme.

[27] Grants account for 9.2 percent of government revenues in 2012—GOG state budget, 2012

APPENDIX G
INDICATIVE LOSSES

TABLE G.1. INDICATIVE LOSSES (US$ MILLION) FOR ADVERSE CROP PRODUCTION EVENTS BY CROP, 1991–2011 (CONSTANT PRICES = 2004–06)

Year	Aggregate (All Crops)	Cocoa	Cassava	Yam	Plantain	Maize	Sorghum	Millet	Rice	Groundnut	Number Events Severe to Catastrophic
	US$ Million (2010 Exchange Rates)										
1991											
1992											
1993											
1994				−45.24							1/0
1995											
1996											
1997		−10.01						−4.27		−5.49	3/0
1998											
1999										−11.45	1/0
2000							−5.45				1/0
2001		−54.17				−52.76		−13.57			1/2
2002		−150.69									0/1
2003									−2.52		1/0
2004							−1.08	−11.55			1/1
2005											
2006											
2007	−96.05						−60.71	−31.73	-76.97	−79.70	0/4
2008											
2009											
2010		−34.68									1/0
2011										−4.44	1/0
Number Events per Time Period											
Severe	1/21	3/21	0/21	1/21	0/21	0/21	2/21	1/21	1/21	3/21	na
Catastrophic	0/21	1/21	0/21	0/21	0/21	1/21	1/21	3/21	1/21	1/21	na
Average Indicative Loss (US$ Million)											
Severe	−96.05	−32.95	0	−45.24	0	0	−3.27	−4.27	−2.52	−10.46	na
Catastrophic	0	−150.69	0	0	0	−52.76	−60.71	−18.95	−76.97	−79.70	na
All Events	−96.05	−62.39	0	−45.24	0	−52.76	−22.41	−15.28	−39.75	−27.77	na

Source: FAOSTAT; authors' calculations.

Note: Severe: Production more than 0.33 standard deviation below trend; Catastrophic: Production more than 0.66 standard deviation below trend.

TABLE G.2. INDICATIVE LOSSES (% GROSS AGRIC. OUTPUT) FOR ADVERSE CROP PRODUCTION EVENTS BY CROP, 1991–2011 (CONSTANT PRICES = 2004–06)

Year	Aggregate (All Crops)	Cocoa	Cassava	Yam	Plantain	Maize	Sorghum	Millet	Rice	Groundnut	Number Events Severe to Catastrophic
	% Gross Agricultural Output (Crops Plus Livestock)										
1991											
1992											
1993											
1994				0.70							1/0
1995											
1996											
1997		0.13						0.06		0.07	3/0
1998											
1999										0.14	1/0
2000							0.07				1/0
2001		0.64				0.63		0.16			1/2
2002		1.64									0/1
2003									0.03		1/1
2004							0.01	0.12			1/1
2005											
2006											
2007	0.97						0.61	0.32	0.78	0.81	0/4
2008											
2009											
2010		0.28									1/0
2011										0.11	1/0
	Number Events per Time Period										
Severe	1/21	3/21	0/21	1/21	0/21	0/21	2/21	1/21	1/21	3/21	na
Catastrophic	0/21	1/21	0/21	0/21	0/21	1/21	1/21	3/21	1/21	1/21	na

Source: FAOSTAT; authors' calculations.

Note: Severe: Production more than 0.33 standard deviation below trend; Catastrophic: Production more than 0.66 standard deviation below trend.

TABLE G.3. INDICATIVE LOSSES (US$ MILLION) FOR ADVERSE PRODUCER PRICE MOVEMENTS BY CROP, 1991–2010 (REAL PRICES 2010 = 100)

Year	Cocoa	Cassava	Yam	Plantain	Maize	Sorghum	Millet	Rice	Groundnut	Number Events Severe to Catastrophic
					US$ Million (2010 Exchange Rates)					
1991										
1992										
1993										
1994						−6.41	−4.13			2/0
1995										
1996									−7.86	1/0
1997										
1998										
1999			−65.10		−69.15	−12.59	−5.01			3/1
2000										
2001										
2002										
2003		−29.06			−37.57	−9.33	−5.01			4/0
2004										
2005				−4.71						1/0
2006					−64.75					1/0
2007		−184.34				−17.17	−9.92			1/2
2008				−49.57						1/0
2009								−16.00		1/0
2010					-29.79			−43.01		1/1
					Number Events per Time Period					
Severe	0/20	2/20	1/20	2/20	4/20	2/20	3/20	1/20	1/20	na
Catastrophic	0/20	0/20	0/20	0/20	0/20	2/20	1/20	1/20	0/20	na
					Average Indicative Loss (US$ Million)					
Severe	0	−106.70	−65.10	−27.14	−50.32	−7.87	−4.72	−16.00	−7.86	na
Catastrophic	0	0	0	0	0	−14.88	−9.92	−43.01	0	na
All Events	0	−106.70	−65.10	−27.14	−50.32	−11.38	−6.02	−29.51	−7.86	na

Source: FAOSTAT; authors' calculations.

Note: Severe: Production more than 0.33 standard deviation below trend; Catastrophic: Production more than 0.66 standard deviation below trend.

TABLE G.4. INDICATIVE LOSSES (% GROSS AGRIC. OUTPUT) FOR ADVERSE PRODUCER PRICE MOVEMENTS BY CROP (REAL PRICES 2010 = 100)

Year	Cocoa	Cassava	Yam	Plantain	Maize	Sorghum	Millet	Rice	Groundnut	Number Events Severe to Catastrophic
	% Gross Agricultural Output (Crops Plus Livestock)									
1991										
1992										
1993										
1994						0.10	0.07			2/0
1995										
1996									0.15	1/0
1997										
1998										
1999			1.07		0.79	0.21	0.08			3/1
2000										
2001										
2002										
2003		0.40			0.36	0.13	0.07			4/0
2004										
2005				0.05						1/0
2006					0.46					1/0
2007		1.63				0.15	0.09			1/2
2008				0.38						1/0
2009								0.12		1/0
2010					0.14			0.30		1/1
	Number Events per Time Period									
Severe	0/20	2/20	1/20	2/20	4/20	2/20	3/20	1/20	1/20	na
Catastrophic	0/20	0/20	0/20	0/20	0/20	2/20	1/20	1/20	0/20	na

Source: FAOSTAT; authors' calculations.

Note: Severe: Production more than 0.33 standard deviation below trend; Catastrophic: Production more than 0.66 standard deviation below trend.

TABLE G.5. INDICATIVE LOSSES (US$ MILLION) FOR ADVERSE CROP PRODUCTION EVENTS BY REGION (CONSTANT PRICES = 2004–06)

Year	Aggregate (All Crops)	Upper West	Upper East	Northern	Volta	Ashanti	Brong-Ahafo	Eastern	Western	Central	Number Events Severe to Catastrophic
	US$ Million (2010 Exchange Rates)										
1992											
1993					−23.95						0/1
1994											
1995											
1996				−22.26							1/0
1997			−8.67	−56.60							2/0
1998							−4.83				1/0
1999			−47.08								0/1
2000								−49.85			1/0
2001											
2002									−18.27		1/0
2003						−21.73					1/0
2004			−3.71		−11.89						2/0
2005					−43.89						0/1
2006											
2007	−96.05	−51.52	−126.15	−118.81							0/3
2008											
2009											
	Number Events per Time Period										
Severe	1/18	0/18	2/18	2/18	1/18	1/18	1/18	1/18	1/18	0/18	na
Catastrophic	0/18	1/18	2/18	1/18	2/18	0/18	0/18	0/18	0/18	0/18	na
	Average Indicative Loss (US$ Million)										
Severe	−96.05	0	−6.19	−39.43	−11.89	−21.73	−4.83	−49.85	−18.27	0	na
Catastrophic	0	−51.52	−86.62	−118.81	−33.92	0	0	0	0	0	na
All Events	−96.05	−51.52	−46.40	−65.89	−26.58	−21.73	−4.83	−49.85	−18.27	0	na

Source: FAOSTAT; authors' calculations.
Note: Severe: Production more than 0.33 standard deviation below trend; Catastrophic: Production more than 0.66 standard deviation below trend.

TABLE G.6. INDICATIVE LOSSES (% GROSS AGRIC. OUTPUT) FOR ADVERSE CROP PRODUCTION EVENTS BY REGION (CONSTANT PRICES = 2004–06)

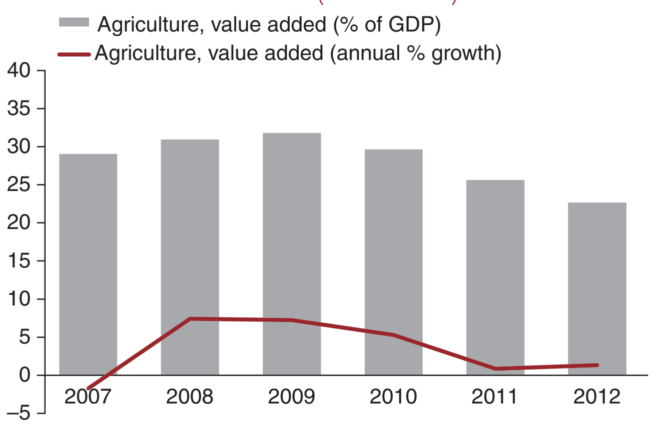
Year	Aggregate (All Crops)	Upper West	Upper East	Northern	Volta	Ashanti	Brong-Ahafo	Eastern	Western	Central	Number Events Severe to Catastrophic
	% Gross Agricultural Output (Crops Plus Livestock)										
1992											
1993					0.36						0/1
1994											
1995											
1996				0.30							1/0
1997			0.12	0.76							2/0
1998							0.06				1/0
1999			0.57								0/1
2000								0.60			1/0
2001											
2002									0.20		1/0
2003						0.23					1/0
2004			0.04		0.12						2/0
2005					0.44						0/1
2006											
2007	0.97	0.52	1.28	1.20							0/3
2008											
2009											
	Number Events per Time Period										
Severe	1/18	0/18	2/18	2/18	1/18	1/18	1/18	1/18	1/18	0/18	na
Catastrophic	0/18	1/18	2/18	1/18	2/18	0/18	0/18	0/18	0/18	0/18	na

Source: FAOSTAT; authors' calculations.

Note: Severe: Production more than 0.33 standard deviation below trend; Catastrophic: Production more than 0.66 standard deviation below trend.

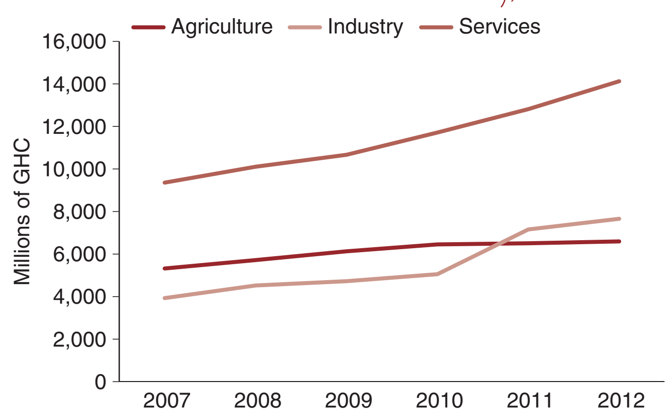
APPENDIX H
ECONOMIC INDICATORS

FIGURE H.1. AGRICULTURE, VALUE ADDED (2007–12)



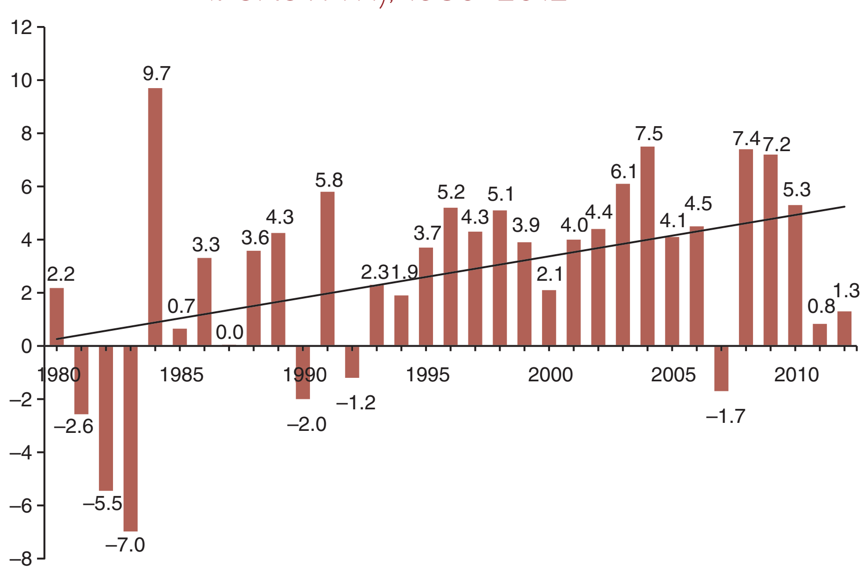
Source: World Development Indicators 2013.

FIGURE H.2. GROWTH IN GROSS DOMESTIC PRODUCT (2006 CONSTANT PRICES), 2007–12



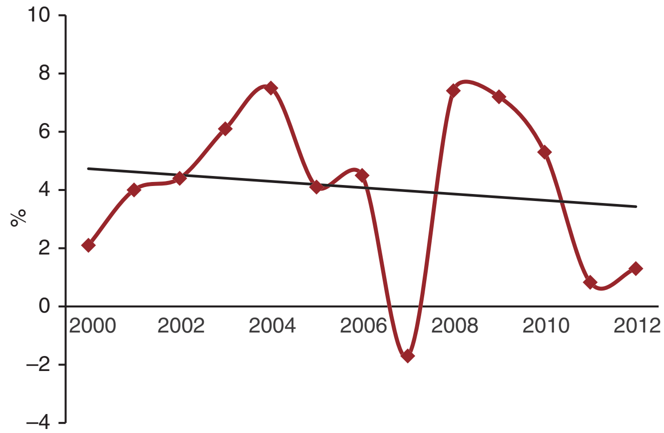
Source: Bank of Ghana 2013.

FIGURE H.3. AGRICULTURE, VALUE ADDED (ANNUAL % GROWTH), 1980–2012



Source: Bank of Ghana 2013.

FIGURE H.4. AGRICULTURE, VALUE ADDED (ANNUAL % GROWTH), 2000–12



Source: Bank of Ghana 2013.

APPENDIX I
TIMELINE OF EVENTS

Year	Region	Events Affecting Agricultural Production
1992	National	Widespread localized flash flooding. First major outbreak of sigatoka disease (plantain).
1992	National	Private traders allowed to buy cocoa for first time in competition with Cocoa Board.
1992	National	National election. Considerable internal instability. Widespread strikes by public sector and civil service. Civil service pay increased by 80%.
1993	Brong-Ahafo	Fall in cassava production. Caused by a decline in area planted in response to low returns in previous year, and good opportunities to plant other crops. Storm damage to plantain.
1993	Greater Accra	Fall in cassava production.
1994	General	Fifty percent devaluation of franc CFA.
1994	Ashanti	Fall in cassava, maize, and plantain production.
1994	Brong-Ahafo	Fall in cassava production due to variegated grasshoppers and localized drought. High black sigatoka.
1994	Northern	Fall in cassava, maize, yam production. Inter-ethnic conflicts.
1994	Upper East	Serious drought from September–October reduced millet, sorghum production.
1995	Northern	Inter-ethnic conflicts.
1996	Northern	Inter-ethnic conflicts, high fertilizer costs reduced production of maize, rice, sorghum.
1996	Upper East	Drought in June–July delayed planting of groundnuts and grain filling of millet.
1997	General	Bushfires in northern and transition zones.
1997	Brong-Ahafo	Drought and erratic rainfall reduced cassava production.
1997	Greater Accra	Drought and erratic rainfall reduced cassava production.
1997	Northern	Drought, erratic rainfall, and high fertilizer costs reduced millet and rice production.
1997	Upper East	Drought reduced production of millet and sorghum.
1998	Upper West	Drought (El Niño year) reduced production of millet.
1998	Central	Drought reduced crop production—all crops.
1999	General	Sharp exchange rate depreciation in response to Russian ruble crisis.
1999	Upper East	Flooding during production period affected production of groundnuts, rice.
2000	Northern	Drought (La Niña) reduced production of maize, millet, sorghum.
2000	Eastern	Big drop in area cultivated, especially for cassava. But appeared to be an adjustment to higher planting in previous year. Not an adverse event.
2001	National	Localized droughts in northern areas.
2002	Greater Accra	Reduced production of rice relative to previous year (but not an adverse event).

(continued)

Year	Region	Events Affecting Agricultural Production
2002	Upper East	Bushfires, late rains, low prices reduced production of rice.
2002	Upper West	Flooding caused reduction in area planted to rice.
2002	Northern	Inter-ethnic conflicts.
2003	General	Bushfires in northern and transition zones.
2003	Ashanti	Erratic rainfall during major and minor seasons. Sigatoka disease hurt plantain; stem borer infestation hurt maize.
2003	Brong-Ahafo	Four-week dry spell during major season hurt crops. NPK* fertilizer prices up 20%.
2003	Central	Newcastle disease affected poultry production. Generally favorable weather.
2003	Eastern	Irregular rainfall hampered fertilizer and herbicide and pesticide application. Cassava price down 33%. Input prices rose significantly.
2003	General	Cassava and gari priced down more than 10%. Prices of most other crops up or little change.
2003	Greater Accra	Four-week dry spell during major season hurt crops. Unfavorable rainfall. Gari prices down 35%. NPK fertilizer, ammonia, and urea prices increased considerably.
2003	Northern	First quarter hot, dry with Harmattan winds. Vigorous rains second–fourth quarters. Localized flooding hurt rice and maize. NPK fertilizer and ammonia prices up more than 25%.
2003	Upper East	Disease destroyed 454 hectares of irrigated tomato fields along the Pwalugu River basin and Tono and Vea irrigation project sites.
2003	Upper West	Rainfall distribution more favorable than previous year.
2003	Volta	Dry spell of 4 weeks during major season adversely affected crop production.
2003	Western	Crop price generally up, except plantain, which exhibited no change. Crop production unchanged from previous year.
2004	Ashanti	Favorable weather for livestock and crops. Maize and legumes did poorly owing to continuous rains during growing period. Armyworm and capsid affected some crops.
2004	Brong-Ahafo	Good distribution of rainfall, boosting crop production and pasture availability. High prices for inputs and agricultural services.
2004	Central	Erratic rainfall during the first half of year was not good for crop production.
2004	Eastern	Weather favored timely land preparation and production of maize, vegetables, plantain, cassava, and cocoyam. Private agencies continued to make inputs available.
2004	Greater Accra	Total rainfall was poor, but well distributed.
2004	Northern	Localized droughts and poor distribution of rainfall. A few districts suffer minor floods, others short droughts. Preparation costs up significantly. Various minor outbreaks of livestock disease.
2004	Upper East	Localized droughts and poor rainfall affected all crops except maize. African swine fever caused 585 deaths in Boltanga district.
2004	Upper West	Localized droughts. Harmattan winds during first quarter. Early rainfall.
2004	Volta	Rainfall of higher intensity but lower frequency. Input prices up appreciably.
2004	Western	Maize, rice, yam, cocoyam, and cassava prices up 30%–60%. Emergence of cocoa purple bean disease caused concern. Newcastle disease major cause of mortality in fowl.
2005	General	Bushfires in northern and transition zones. Loss of access to European markets for groundnuts (alfatoxin).
2005	Northern	Below average rainfall.
2005	Northern	The 2005 MoFA annual report provided less detail regarding production losses than in previous years.
2005	Volta	Below average rainfall.
2006	Ashanti	Erratic major season rains delayed planting 3–5 weeks. Drought in November–December reduced minor season maize yields 50%. Armyworm outbreak.
2006	Brong-Ahafo	Late major season rains, early end to minor season effected maize. Erratic main season rains delayed planting 3–5 weeks. Armyworm outbreak.

Year	Region	Events Affecting Agricultural Production
2006	Central	Erratic main season rains delayed planting 3–5 weeks. Poor fourth quarter rains reduced minor season maize production. Armyworm outbreak.
2006	Eastern	Low July–August rainfall, but quick recovery. Erratic main season rains delayed planting 3–5 weeks. Early end to rain adversely affected minor season maize.
2006	Greater Accra	Late main season rains delayed planting 3–5 weeks. High rainfall caused localized flooding. Dry late third–fourth quarters reduced minor season maize yields 50%.
2006	Northern	Rainfalls generally favorable.
2006	Upper East	Poor rainfall distribution in July and August hurt crops.
2006	Upper West	Intermittent drought in July and August favored cowpeas and early planting of maize.
2006	Volta	Erratic main season rains delayed planting 3–5 weeks. Reduced minor season rains affected maize. Armyworm outbreak.
2006	Western	Poor rainfall in fourth quarter caused maize and other crop failures.
2007	General	Localized droughts in northern areas of country. Collapse of world cotton prices, Redenomination of currency. Flash flooding in many areas.
2007	General	Major floods in Northern, Upper East, and Upper West regions in September 2007. Many killed. Disaster area declared.
2007	Northern	Early drought followed by severe floods, which washed out replanted crops.
2008	General	Sharp exchange rate depreciation and terms of trade shock due to global food price crisis.
2008	Ashanti	Late first quarter rainfall delayed planting, causing most farmers to plant in May. February–May rainstorms destroyed plantain fields.
2008	Brong-Ahafo	Late rains delayed major season planting. Localized flooding. July–November drought stressed maize, wilted vegetables. African swine fever killed one out of nine pigs.
2008	Central	Weather in third and fourth quarters favored planting of oil palm, citrus, cocoa, coconuts, maize, plantain, and cassava.
2008	Eastern	Late first quarter rains delayed planting. Rainfall declined in November–December, reducing yields. Landslide in October destroyed 105 households.
2008	General	Bushfires in northern and transition zones
2008	Greater Accra	Late first-quarter rains delayed planting. Poor distribution of rainfall during first quarter. Farmers plowed during second quarter.
2008	Northern	Rainfall distribution normal, enhancing availability of pasture for livestock. Some flooding in Tolon-Kumbungu and West Mamprusi districts.
2008	Upper East	Rainfall conditions normal.
2008	Upper West	Good rainfall, below normal humidity during second quarter. Flood in June–September destroyed crops and bridges.
2008	Volta	Rainfall distribution normal, but some flooding in valley bottoms.
2008	Western	Heavy June–September rainstorms destroyed most plantain farms, raising prices; caused flooding that destroyed dams.
2009	Ashanti	Fewer bushfires than previous year. Late planting caused wilting and stunting. Rainstorms caused lodging of plantain, reduced yields.
2009	Brong-Ahafo	Sudden decline in rainfall in last quarter affected maize and rice during tasselling and milking stages. Patches of bushfires in November.
2009	Central	Rainfall distribution poor; concentrated at end of May and early June.
2009	Eastern	Drought when maize in tasselling stage. Heavy rainfall in late June resulted in good harvest in the Manya, YiloKrobo, and Asuogyaman districts.
2009	General	Fruitfly menace throughout the country.
2009	General	Outbreak of suspected new species of mealybugs.

(continued)

Year	Region	Events Affecting Agricultural Production
2009	General	Bushfires in northern and transition zones.
2009	Greater Accra	Low rainfall, resulting in dryness and localized bushfires.
2009	Northern	Occasional thunderstorms.
2009	Upper East	Climatic conditions normal. No floods or drought.
2009	Upper West	Early part of the year dry. Localized flooding during rainy season, aggravated by opening of dam in Burkina Faso.
2009	Volta	Dryness as a result of high temperatures, strong winds. These events favored productivity.
2009	Western	Low humidity reduced post-harvest crop losses and livestock disease.

Source: MoFA Annual Reports (1993–2009); interviews with MoFA officials, farmers, and traders; background reports (see References).

* NPK = nitrogen, phosphorus, potassium.

APPENDIX J
ASSESSING VULNERABILITY IN NORTHERN REGIONS

The three northern regions account for just over 40 percent of the country's land area but less than 17 percent of its population (see appendix E). Located in the savannah agro-ecological zones, in a typical year they produce all of the nation's millet and sorghum, 90 percent of its groundnuts, 68 percent of its rice, 30 percent of its yams, and 17 percent of its maize. They also account for approximately 75–80 percent of the national cattle herd.

According to the latest 10-year average data, the Northern Region receives about 1,200 mm of yearly precipitation. The Upper East and Upper West regions receive less, approximately 940 mm. As shown below, however, rainfall distribution over the uni-modal growing season is at least as important as cumulative levels.

Northern regions have consistently recorded higher incidences of poverty, food insecurity, and malnutrition. They are more rural, with household sizes larger than the national average. Compared with a national income per capita figure of GH¢397 in 2008,[28] figures were GH¢106 in the Upper West, GH¢124 in the Upper East, and GH¢296 in the Northern regions.

Among the 8,400 households surveyed in 38 districts within the three northern regions for the 2012 Comprehensive Food Security and Vulnerability Assessment, almost half (46 percent) derived their income from crop cultivation, whereas nearly one-third (29 percent), as agro-pastoralists, relied on a combination of income from livestock (49 percent) and crops. Surveyed households described their main cropping activities as summarized in table J.1.

Most households manage diversified farms that extend over 11 acres of land that belong, for the most part, to household members. The vast majority of remaining households use land that is provided by extended family members. Yields for main

[28] 2008 Ghana living standards survey.

TABLE J.1. HOUSEHOLD CROPPING ACTIVITY

Northern	Maize (75%)	Yam (38%)	Groundnuts (28%)	Rice (25%)
Upper East Region	Millet (57%)	Maize (55%)	Sorghum (44%)	Groundnuts (37%)
Upper West Region	Maize (84%)	Groundnuts (53%)	Sorghum (27%)	Rice and millet (13%)

Source: Ghana CFSVA 2012.

TABLE J.2. DISTRIBUTION OF HOUSEHOLD FARM SIZE, BY REGION (ACRES)

	Large (11+)	Medium (6–10)	Small (5 or Fewer)
Northern	50%	28%	21%
Upper East Region	60%	24%	16%
Upper West Region	84%	12%	4%

Source: Ghana CFSVA 2012.

TABLE J.3. TYPE OF ACCESS TO LAND, BY REGION

	Ownership	From Extended Family	Other (Permission from Chief and the Like)
Northern	53%	27%	20%
Upper East Region	77%	18%	5%
Upper West Region	48%	29%	23%

Source: Ghana CFSVA 2012.

food crops are modest (maize averaging 1.6 tons per ha; millet and sorghum ranging from 1.2 to 1.7 tons per ha) and are highly sensitive to weather conditions. For most agriculturalists and agro-pastoralists, the main sources of food consist of their own production (33 percent) and cash purchases (60 percent).

Finally, a ranking of most common agricultural problems reported by CFSVA respondent households showed that inadequate rainfall (64.5 percent) was considered the primary challenge. More than 40 percent also complained of low soil fertility, whereas over half mentioned lack of funds to buy agricultural inputs (for example, fertilizer, pesticides) and other basic goods. Nearly 10 percent reported a lack of household labor for farming.

ENABLING ENVIRONMENT RISKS FOR NORTHERN REGIONS

A number of respondents, corroborated by official reports, indicated that the following risks affect the enabling environment in northern regions:

» The general aging of the farming population implies that labor available for land clearing or preparation has decreased while become more expensive. This means that some people increasingly rely on herbicides to clear land, implying significant potential risks to groundwater resources and public health.

» Some members of the local research community are concerned that the shift to short-cycle, early

TABLE J.4. AVERAGE YIELD FOR MAJOR CROPS IN THE UPPER WEST REGION, 2010

(Figures in MT/Ha)

	Crops							
Districts	Maize	Rice	Millet	Sorghum	Yam	G/Nuts	Cowpea	Soyabean
Wa west	1.40	2.20	0.50	1.00	11.52	1.60	0.90	1.60
Wa east	1.50	2.08	0.90	1.00	21.00	1.25	0.83	1.30
Wa municipal	1.30	1.40	1.20	1.20	23.89	1.40	1.20	1.40
Lawra	1.00	1.60	1.40	1.10	0.00	1.60	1.10	0.96
Sissala east	2.00	2.08	1.90	1.60	13.00	1.50	1.00	1.93
Sissala west	1.70	2.10	1.00	0.95	15.81	1.90	1.00	1.90
Jirapa-Lambussie	1.40	1.35	0.60	0.70	13.90	1.50	1.05	0.81
Nadowli	1.50	1.66	0.95	1.10	23.00	1.20	1.10	1.00
Average yield	1.70	1.60	0.98	1.06	20.30	1.54	1.17	1.42

Source: Statistics, Research and Info. Directorate (SRID), MoFA, January 2011.

TABLE J.5. AVERAGE YIELD FOR MAJOR CROPS IN THE UPPER WEST REGION, 2011

(Figures in MT/Ha)

Districts	Maize	Rice	Millet	Sorghum	Yam	G/Nuts	Cowpea	Soyabean
	Crops							
Wa west	1.20	1.60	0.40	0.70	11.00	1.40	1.00	1.30
Wa east	1.20	1.50	0.75	0.80	20.00	1.10	0.90	1.00
Wa municipal	1.25	1.30	1.04	0.90	23.80	1.20	1.30	1.20
Lawra	0.70	1.30	1.20	0.88	0.00	1.40	1.30	0.80
Sissala east	1.40	1.80	1.70	1.20	12.50	1.30	1.10	1.50
Sissala west	1.30	1.00	0.90	0.80	15.00	1.60	1.10	1.60
Jirapa-Lambussie	1.00	1.00	0.40	0.54	14.00	1.30	1.00	0.60
Nadowli	1.40	1.20	0.90	0.85	23.00	0.90	1.20	0.80
Regional average yield	1.23	1.35	0.85	0.80	17.96	1.22	1.12	1.13

Source: Statistics, Research and Info. Directorate (SRID), MoFA, January 2012.

TABLE J.6. WEATHER IMPACTS ON KEY CROPS, 2011–12

	Maize	Rice	Millet	Sorghum	Yam	Groundnuts
Northern	−19.2	−9.1	−18.6	−10.5	−27.2	−4.9
UER	−20.9	−19.1	−21.2	−19.7	−23.4	−30.2
UWR	−13.9	−10.5	−15.4	−34.8	−9.4	−17.5

Source: CFSVA 2012.

maturing crops and to certain cash crops (a way to trade price risk for drought risk) may reduce the regional crop genetic stock.

» Most important, growing uncertainty about the timing and amount of operational funds for MoFA activities makes it very difficult to properly plan extension activities and to carry them out at the optimal time. This affects vaccine production and delivery, epidemiological surveillance and action, and the delivery of agricultural inputs (especially fertilizer) to block farms and other producers.

DROUGHT RISK AND IMPACT ON NORTHERN HOUSEHOLDS IN 2011–12

The 2011 growing season is the most recent example of unfavorable weather conditions. There were irregular rains and long dry spells from May through July, leading to poor germination, poor crop development, and low yields. The season was characterized in the Northern Region as the worst in the past 15 years, affecting both crop and livestock output. Most farmers reduced acreage and had lower yields, with a few giving up rainy season production entirely. As a result, the prices of basic foodstuffs rose sharply; local rice and maize prices, for instance, started rising in June, ending up in December at 70 percent over their January–April levels.[29] Table J.6 summarizes respondents' assessments of the impact of this weather on key crops, in terms of the percentage change between 2011 and the previous year. The data strongly support the conclusion that the 2011 disruption of rainfall patterns had a significant impact on production and incomes.

As mentioned previously, 46 percent of households surveyed in the 2012 CFSVA are agriculturalists, and 29 percent are agro-pastoralists. Most of them have a net deficit in food production, but produce cash crops and

[29] 2011 Annual Progress Report, MoFA/Northern Region.

have enough other income to rely on the market for some 60 percent of their basic food supply. In addition, production systems in the Northern Region are globally more diversified. The Upper East, in contrast, which is more densely populated and suffers from poor soils and smaller average farm sizes, relies more on a combination of pastoralism and more effective integration of livestock and agriculture.[30] The Upper West appears more vulnerable to combined shocks, as discussed below.

The 2012 CFSVA provides the best impact assessment of the negative 2011 season at the household level and its results are consistent with this simple characterization. Globally, one-third of households faced difficulties (reduction in production related to drought, basic food prices, or both) that were severe enough to reduce their food access for some time during the marketing year. The combined impact of crop failure and high food prices was most severe for the Upper West region households (nearly twice as much as the average for the other two regions).[31] In terms of crop failure, the Upper East appeared much less affected than the Upper West, and even less than the Northern Region, partly because the proportion of millet and sorghum in production and food intake is higher there than in other northern areas. Globally, whereas 70 percent of households in the Upper East reported that they had managed the crisis well, the percentages were 64 percent in the Northern and 48 percent in the Upper West regions.

The fact that Upper East respondents appeared to have weathered the crisis relatively well does not mean that they are better off than people in other regions in all respects. They have, after all, the highest proportion of food-insecure households. The shock may have set them back relatively less, but from a low base at the outset.

[30] Upper East has also received significant assistance from the Northern Growth Project.

[31] One will recall that UWR has the lowest per capita income of all three northern regions. In addition, "lack of rainfall" was more often quoted as a problem (37 percent) in UWR than in UER (29 percent) and NR (24 percent).

APPENDIX K

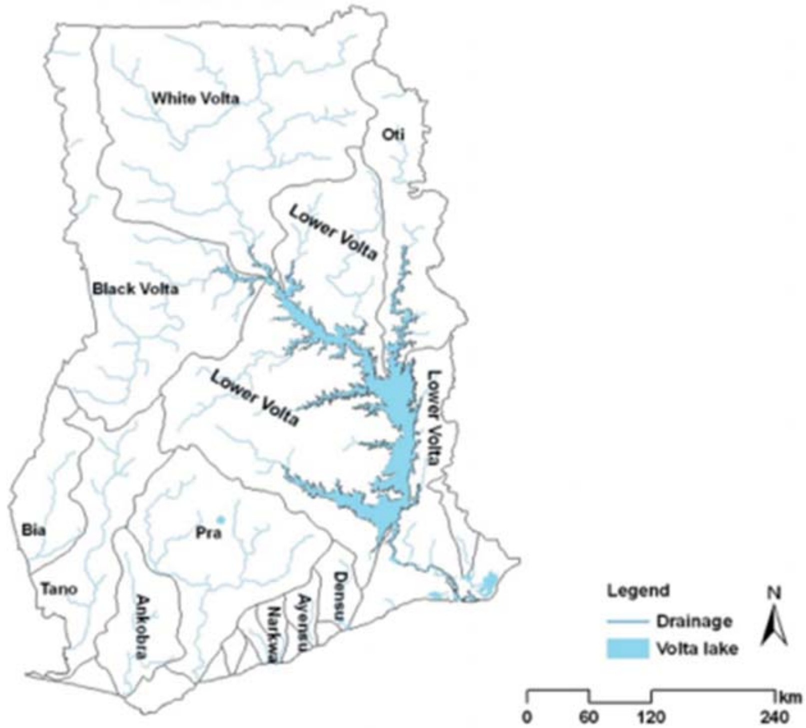
IRRIGATION DEVELOPMENT IN GHANA

Ghana is drained by three main river systems: the Volta, Southwestern, and Coastal river systems (see figure K.1):

- The Volta river system consists of the Oti and Daka rivers, the White and Black Volta rivers, and the Pru, Sene, and Afram rivers—the basin covers 70 percent of the country's area.
- The southwestern river system comprises the Bia, Tano, Ankobra, and Pra rivers and covers 22 percent of the country's area.
- The coastal river system comprises the Ochi-Nakwa, Ochi Amissah, Ayensu, Densu, and Tordzie rivers, covering 8 percent of the country's area.[32]

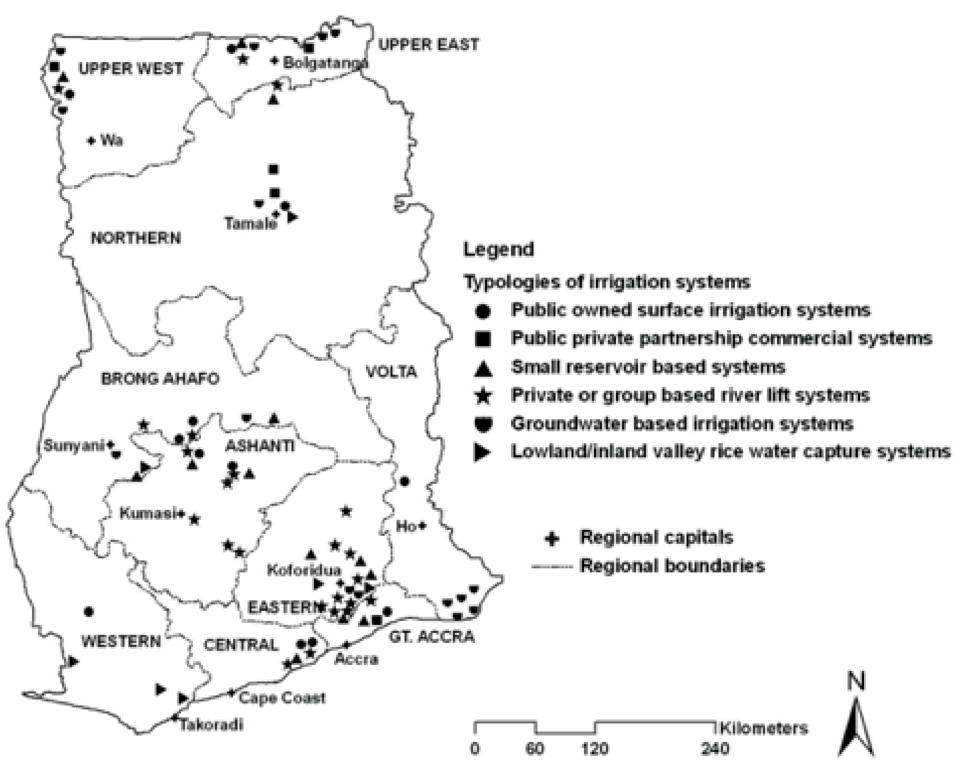
[32] See R. E. Namara, L. Horowitz, and B. Nyamadi, "Irrigation Development in Ghana: Past Experiences, Emerging Opportunities, and Future Directions," Ghana Strategy Support Program (GSSP), Working Paper No. 0026 (Accra, Ghana: International Food Policy Research Institute [IFPRI], 2011.

FIGURE K.1. RIVER BASINS IN GHANA



Source: IFPRI 2011.

FIGURE K.2. DISTRIBUTION OF IRRIGATION SYSTEM TYPOLOGIES IN THE REGIONS OF GHANA



Source: IFPRI 2011.

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