ISSN 2071-0992

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Climate Change and Agriculture in Jamaica

Agriculture Sector Support Analysis

ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT SERIES

ENVIRONMENT [CLIMATE CHANGE] ENERGY MONITORING AND ASSESSMENT

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Climate Change and Agriculture in Jamaica

Agricultural Sector Support Analysis

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Food and Agriculture Organization of the United Nations Rome, 2013

ISBN 978-92-5-107894-5 (print)
E-ISBN 978-92-5-107895-2 (PDF)

ACKNOWLEDGEMENTS

This report is part of a series of studies conducted by the Investment Centre Division (TCI) of the Food and Agriculture Organization of the United Nations (FAO) in the context of a programme of support by the Inter-America Development Bank (IDB) to the agriculture sector in Jamaica. This study was part of a series of three studies in Jamaica, which also involved "Agricultural Taxation" and "Agriculture Sector Support Analysis". This particular study is aimed at increasing knowledge on climate change and agriculture in Jamaica, and in particular discussing options for improvements to the current policy mix.

The report is part of the IDB's on-going commitment to address the challenges of agriculture and climate change in Latin America, in this case financing work that was conducted under a contract with the FAO, under the technical supervision of the Bank. The IDB staff who participated in the coordination of the study with the Government of Jamaica include Paul Trapido (Team Leader), and Mateo Molina and Juan de Dios Mattos (IDB Country office Specialists).

The report "Climate Change and Agriculture in Jamaica" was written by Mr. Selvaraju Ramasamy, Natural Resources Officer, Climate, Energy and Tenure Division (NRC) of FAO, with contributions by Ms. Alicia Hayman, National Expert at Kingston, Jamaica and Ms. Maria del Mar Polo Lacasa, Agricultural Economist from the FAO's Investment Centre Division. The work was coordinated by Mr Nuno Santos, Economist at FAO's Investment Centre Division.

The report was initially reviewed by the technical experts from the Investment Centre Division (TCI) of FAO and Ms. Doris Soto and Ms. Tarub Bahri from the Fisheries and Aquaculture Department of FAO. Subsequently, it was extensively reviewed by technical staff at the Inter-American Development Bank (IDB) and suggestions were incorporated into the final report.

The author acknowledge the extremely useful contributions and enormous support provided by Mr. Hopeton Peterson, Mr. Albert Daley and Ms. Le-Anne Roper, from the Planning Institute of Jamaica (PIOJ), Ms. Zuleikha Budhan, Mr. Georgia Marks-Doman and Ms Sharlene Findley from the Ministry of Agriculture and Fisheries (MOAF); Mr. Phillip Chung, Mr. Al Powell and Ms. Marina Young from the Rural Agricultural Development Authority (RADA). Special thanks go to Mr. Ronald Jackson from the Office of the Disaster Preparedness and Emergency Response (ODPEM); Ms. Hyacinth Douglas from UNDP; Mr. Basil Fernandez and Mr. Geoffrey Marshall from the Water Resources Authority of Jamaica (WRI) for their valuable suggestions during the consultation process.

The report also benefitted from inputs and suggestions by Mr Michael Taylor, Mr Anthony Chen, Mr David Smith and Mr Anthony Clayton from the University of the West Indies (UWI), Ms Cavell Francis from Oxfam/ International Center for Tropical Agriculture (CIAT), Ms Leslie Simpson from the Caribbean Agriculture Research and Development Institute (CARDI) and Mr. Peter Laderach from the International Center for Tropical Agriculture (CIAT). Ms Katrine Smith and Ms Shannon Russell provided editorial support. Guidance and suggestions provided by Mr Jerome Thomas and Ms Gillian Smith from FAO Representation in Jamaica are greatly acknowledged.

Special thanks to Mr. Christopher Stevens and Mr. Peter Mullins, FAO consultants; as well as to Ms. Olga Shik and Ms. Serova Eugenia of TCID for their support throughout the preparation of the report. The team thanks Ms Suzanne Raswant, Chief, Latin America, the Caribbean, East Asia and the Pacific Service of Investment Center Division (TCI) for overall support and guidance throughout the report preparation exercise.

ABSTRACT

Climate change is likely to have adverse effects on the agriculture sector in Jamaica. Increase in the intensity and frequency of climate-related natural hazards, escalating rainfall variability, droughts and floods combined with fragile ecosystems and coastal zones, and agriculture-dependent livelihoods all contribute to Jamaica's overall vulnerability to climate change. Jamaica's Vision 2030 highlights these vulnerabilities as a threat to sustainable development, and provides the framework within which corrective and preventive actions should be undertaken.

Climate change adaptation is one of the outcomes of the Vision 2030 Jamaica-National Development Plan. In the context of this plan, there is need for more analysis of the likely climate change impacts in the short and medium term, along with identification of agricultural adaptation strategies. These need to be understood in order to inform policy interventions and agriculture support institutions.

Within this context, the objectives of the study are: (i) to review current knowledge on vulnerability, past trends in climate, and impacts of climate variability and change on agriculture sector, and (ii) to explore technical and policy alternatives in order to cope with and adapt to impacts of climate variability and change more effectively. The study identified what the potential impacts are, considered what interventions are appropriate, and if and where they should occur. The scope of the study focused on broader policy directions and investment priorities in relation to climate change adaptation.

The first two chapters of this book present overall background on the agriculture sector and vulnerability context. **Chapter 2** specifically presents vulnerability of agro-ecosystems and food production systems in both temporal and special dimensions. **Chapter 3** elaborates on the nature of climate variability and expected future changes in climate. The past trends in climate were described based on observation, analysis and also local perception of the communities.

Chapter 4 presents the results of analysis of past extreme climate events on agriculture, ecosystems, biodiversity, and fisheries and aquaculture. This chapter also gives an overview of the impacts of climate change on fragile ecosystems, crop suitability, land degradation, water resources, biodiversity, fisheries and aquaculture, and the economy.

Efforts to advance climate change adaptation should focus on support for decision-making and capacity building processes. These shape implementation of location-specific traditional and improved adaptation practices aimed at reducing the impacts of climate variability and climate change. In particular, this process of adaptation needs to address the needs of marginalized groups that are most vulnerable to climatic and socio-economic changes.

Chapter 5 presents several coping strategies adopted by the local communities. It also proposes a series of types of adaptation strategies that are relevant to address multiple risks of climate change. The adaptation typologies range from assessment of vulnerability and risks to strengthening data collection, monitoring and forecasting, and promoting agricultural linkages to supply chains, weather risk insurance, and research and development linkages.

Institutional capacity building and organizational networking with clear definitions of roles and responsibilities are essential to advance adaptation efforts. **Chapter 6** elaborates the institutional and policy contexts to respond to climate change. This chapter highlights the importance of mainstreaming of climate change concerns into agriculture policies, programmes and plans.

Agriculture and Climate Change in Jamaica
Agricultural Sector Support Analysis

By Ramasamy Selvaraju

128 pages, 16 figures, 13 tables, 12 pictures
FAO Environment and Natural Resources Service Series, No. 20 – FAO, Rome, 2013

Keywords:
Climate change, agriculture, food security, vulnerability, impacts of climate variability and change, extreme climate events, coping and adaptation strategies, institutional and policy contexts, good practices examples.

CONTENTS

AGRICULTURE IN THE MOUNTAINS OF JAMAICA. *Jamaica is particularly susceptible to watershed degradation, as approximately 80 percent of the land surface is hilly or mountainous, with more than 50 percent having slopes greater than 20 degrees. Small farming occupies the uplands and mountains of the central parishes and climate change threatens agriculture in these areas.*

EXECUTIVE SUMMARY

Although agriculture's contribution to Jamaica's gross domestic product (GDP) has steadily declined over the past two decades – and in 2009 stood at 5.2 percent – this sector absorbs 20 percent of the country's employed labour force. The agricultural economy is dualistic, comprising large-scale commercial plantations that produce primarily for the export market under a system of monoculture, and small-scale mixed farms that produce for household subsistence and the domestic market. This dualism extends beyond production orientation, and is also reflected in farm size, access to agricultural resources and infrastructure. Small-scale farmers are the most vulnerable to hydro-meteorological hazards and as such, must be the main target of interventions to mitigate impacts and promote sustainability of the sector.

Climate change is a major challenge to agriculture development in Jamaica due to the country's small land mass, fragile ecosystems, high dependence on food imports and increasing impacts of frequent natural disasters. Extreme climate events have a significant negative influence on the agriculture sector in the country. The major events affecting agriculture sector are: hurricanes, floods, landslides, droughts and heavy winds. The damage and loss to the agriculture sector due to major climate events between 1994 and 2010 is estimated to have amounted to J$14.4 billion. On average, the impact of major climate extremes on agriculture accounts for nearly 20 percent of the total impact on the country. The proportion is very high when individual events are considered.

The mean temperature over Jamaica has increased by around 0.6 °C since 1960, an average rate of 0.14 °C per decade. The mean precipitation over Jamaica has decreased in JJA (June – August) and SON (September – November) by 6.2 and 4.5 mm per month per decade respectively, although these trends are not statistically significant. Tropical cyclones in the region show an increase since 1995, especially category 4 and 5 hurricanes. The mean annual temperature is projected to increase by 0.47 °C to 1.17 °C by 2030, and 0.6 °C to 2.3 °C by the 2060s. The projections of mean annual rainfall from different models indicate decreasing rainfall for Jamaica.

Jamaica is already experiencing the impact of climate variability – most significantly in terms of the frequent occurrence of drought, the frequency and magnitude of hurricanes, and associated secondary events such as floods, landslides and seawater intrusion. The agriculture sector is also prone to crop yield loss and damage to livestock, fishery and aquaculture, and irrigation structures. The in-depth analysis of the agriculture sector in Jamaica identifies two critical impacts of climate change – reduced water availability for agriculture systems, especially for small-scale agriculture; and increased extreme climate-related events such as hurricanes, floods, landslides, water stagnation and saltwater intrusion. In all cases, these impacts significantly affect not only agriculture, but also rural livelihoods and value chains.

A study on the impact of climate change on Jamaican hotel industry supply chains and on farmers' livelihoods (CIAT-OXFAM, 2011) predicted that the suitability of crops such as cabbage, carrot, ginger, sweet potato and tomato is expected to decline by 2050. The Water Resources Authority of Jamaica reported that water demand for agriculture will increase by 18 percent in 2030. The sustainable water yield may decline by 20 percent during the same period. As the agriculture sector is the major user of freshwater resources (75 percent), it is expected to be affected severely. The high value crops such as coffee, citrus, sugarcane and banana are highly vulnerable to extreme climate events. However, limited studies have been conducted to assess the impact of climate change on these crops.

The financial impact of extreme climate events on the agriculture sector from 1994 to 2010 amounted to J$14 390 million. The climate change impacts will add additional costs. By the year 2025, the annual losses in Jamaica in the low impact scenario are projected to be 3.4 percent of baseline (2004) GDP. The agriculture sector's share in the overall loss would be significant due to the sector's exposure and vulnerability.

There are a number of coping strategies currently employed by farmers and fishermen in terms of managing water scarcity, and reducing the impacts of hurricanes, floods and landslides. However, these practices are not sufficient to counter the increasing climate risks. Many improved

adaptation practices have been tested to cope with the climate extremes, including those which contribute to reducing the risks of drought (e.g. growing alternate crops, rainwater harvesting, rehabilitation of existing water storage structures, conjunctive use of surface and ground water, mulching for water conservation, reduced tillage practices, drip irrigation); of floods (e.g. construction of raised beds, network drains, check dams); of landslides (e.g. contour planting of crops, hedgerow alley cropping); and of strong winds associated with hurricanes (planting low profile crops, periodical pruning of trees, triangular bracing mechanism for bananas).

There are very few investments that directly address climate change adaptation and disaster risk management in agriculture. Many ongoing interventions follow a "business as usual" development-oriented approach and seldom integrate climate change impacts and adaptation priorities in agriculture. That said, there are some broader investment proposals in development which seek to address the climate change impacts in the country. However, programmes directly targeting agriculture, fisheries and food security are uncommon. The Government of Jamaica's Vision 2030 highlights the impacts of climate variability and change as a threat to sustainable development, and provides the framework within which corrective and preventive actions should be undertaken (Planning Institute of Jamaica [PIOJ], 2009). Within this framework, a more detailed account of current coping practices and adaptation strategies should be prioritized to address the impacts of climate change.

The consultations held for this report with government agencies on the prioritization of adaptation responses in agriculture, highlights the potential for improvement of various investment windows in the country. For example, institutional strengthening within the Ministry of Agriculture and Fisheries (MOAF) through development of a comprehensive database management system on livelihoods, production, marketing and climate impacts could help share and increase access to data island-wide for risk reduction and adaptation planning. A dedicated unit within MOAF, which works on issues related to climate change and disaster risk management

could add value to overall capacity development, coordination and collaboration mechanisms at the national level.

Investments in agriculture infrastructure with multiple rural development objectives would help reduce the impacts of increasing climate variability and climate change. Protecting the livelihoods exposed to climate-related extreme events might also sustain the agriculture sector. Adaptation measures which are proposed include up-scaling community-based adaptation initiatives in agriculture; strengthening agriculture, fisheries and aquaculture services agencies; and advancing research on crop improvement, management technologies and diversified livelihood strategies, especially in mountains and coastal areas.

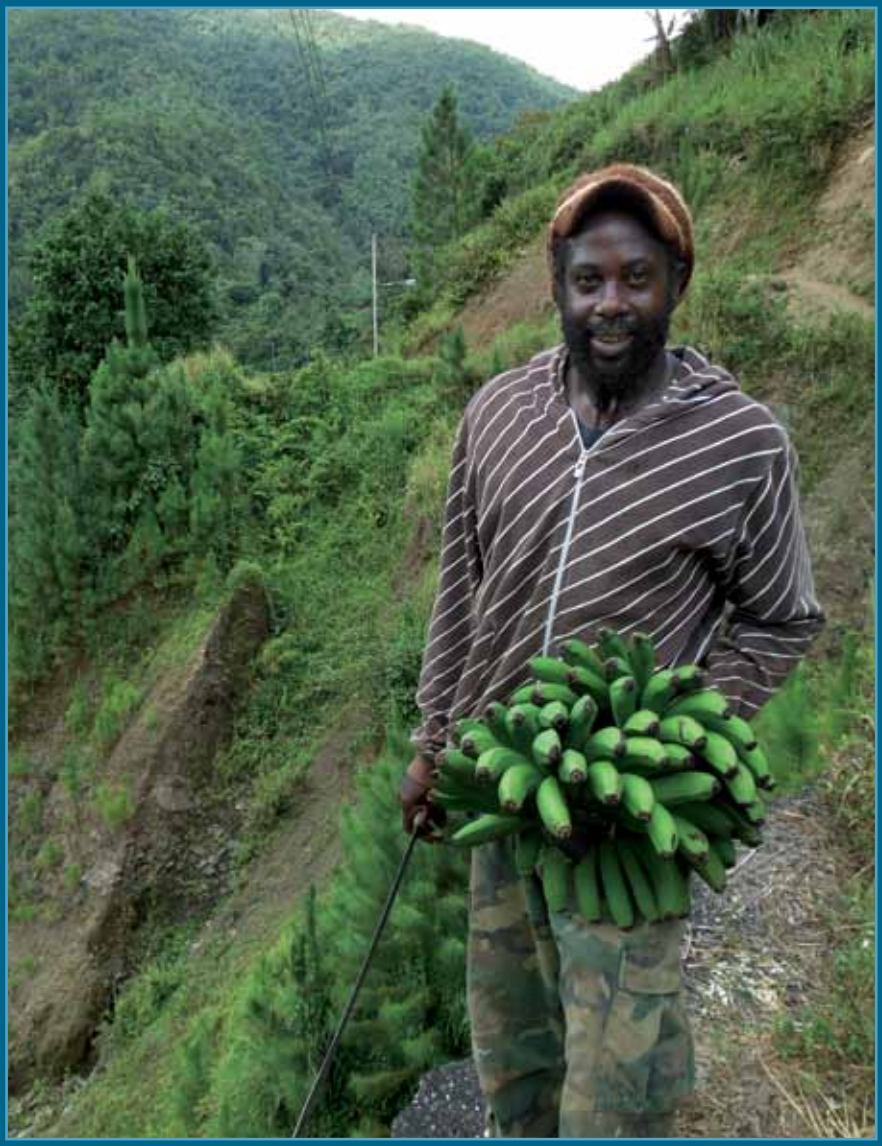
The priority areas of action include strengthening of linkages between local food production and tourism sector, production and productivity programmes for domestic food crops, development and promotion of agricultural systems and practices suitable for agroclimatic conditions, providing value added climate information services for agriculture and improved water resources development, conservation and management.

ACRONYMS

ADRM	Agricultural Disaster Risk Management
AEZ	Agro-Ecological Zones
AIC	Agro-Invest Corporation
ALIGN	Arable Lands Irrigated and Growing for the Nation
ALUP	Agricultural Land Utilization Policy
API	Agriculture Production Index
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community and Common Market
CBD	Convention on Biological Diversity
CC	Climate Change
CCCCC	Caribbean Community Climate Change Centre
CCCRA	Climate Change Risk Atlas country profile
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CCSG	Climate Change Studies Group
CEATA	Centre of Excellence for Advanced Technology in Agriculture
CEPAT	Continuing Education Programme in Agricultural Technology
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CIAT	International Centre for Tropical Agriculture
CIDA	Canadian International Development Agency
CRFM	Caribbean Regional Fisheries Mechanism
CSGM	Climate Studies Group Mona, West Indies
DAP	Disaster Assistance Programme
DJF	December, January and February
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EC	European Commission
ECA	Economics of Climate Adaptation
ENSO	El Niño Southern Oscillation

EUBSP	European Union's Banana Support Programme
FAO	Food and Agriculture Organization
FI	Fisheries and Aquaculture Division
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GOJ	Government of Jamaica
HRR	Hazard Risk Reduction
HRRACC	Hazard Risk Reduction and Adaptation to Climate Change
IDB	Inter-American Development Bank
IICA	Inter-American Institute for Cooperation on Agriculture
IJAP	Improving Jamaica's Agricultural Productivity Project
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
ISD	Institute for Sustainable Development, University of the West Indies
JJA	June, July and August
JICA	Japan International Cooperation Agency
MACC	Mainstreaming Adaptation to Climate Change
Met Service	Meteorological Service Jamaica
MOAF	Ministry of Agriculture and Fisheries of Jamaica
NEPA	National Environment and Planning Agency
NGOs	Non-Governmental Organizations
NIC	National Irrigation Commission
NIDP	National Irrigation Development Plan
NRC	Climate, Energy and Tenure Division of FAO
NWC	National Water Commission
ODPEM	Office of Disaster Preparedness and Emergency Management
OXFAM	Oxford Committee for Famine Relief
PBPA	Portland Bight Protected Area
PEO	Public Education Outreach

PIOJ	Planning Institute of Jamaica
PPCR	Pilot Program for Climate Resilience
PRECIS	Providing Regional Climates for Impact Studies
RADA	Rural Agricultural Development Authority
RCM	Regional Climate Models
RiVAMP	Risk and Vulnerability Assessment Methodology Development Project
SCJ	Sugar Company of Jamaica
SDSM	Statistical Downscaling Model
SIDS	Small Island Developing States
SON	September, October & November
SPCR	Strategic Plan on Climate Resilience
SPI	Standardized Precipitation Index
SRES	IPCC Special Report Emissions Scenarios
SST	Sea Surface Temperature
TCI	Investment Centre Division of FAO
TCP	Technical Cooperation Project
TWG	Thematic Working Group
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	United Nations Institute for Training and Research
URCR	Upper Rio Cobre
USAID	United States Agency for International Development
UWI	University of the West Indies
WRA	Water Resources Authority
WRI	World Resource Institute



BANANA FARMER IN THE GREEN HILL, CASCADE, JAMAICA. *Banana cultivation is susceptible to storms and hurricanes. The damage caused by Hurricane Dean in August 2007 was significant across the major banana growing areas. In terms of crop production, there was an 85% loss of the standing crops and 95% loss of maiden suckers. It is estimated that Hurricane Dean has directly caused a loss in export earnings estimated at US$15 million.*

CHAPTER 1

INTRODUCTION

This paper forms part of a series of studies conducted by the Food and Agriculture Organization (FAO) and financed by the Inter-American Development Bank (IDB), with the overall objective of reviewing the performance of current key agricultural policies and programmes to increase knowledge on agriculture and climate change in Jamaica. The studies have resulted in three papers: (1) Agricultural taxation, (2) Agricultural sector support analysis, and (3) Agriculture and climate change.

The findings and analysis in this "Climate Change and Agriculture in Jamaica" paper are based on the work conducted by a team of experts of the Climate, Energy and Tenure Division (NRC) and the Investment Centre Division (TCI) of the FAO.

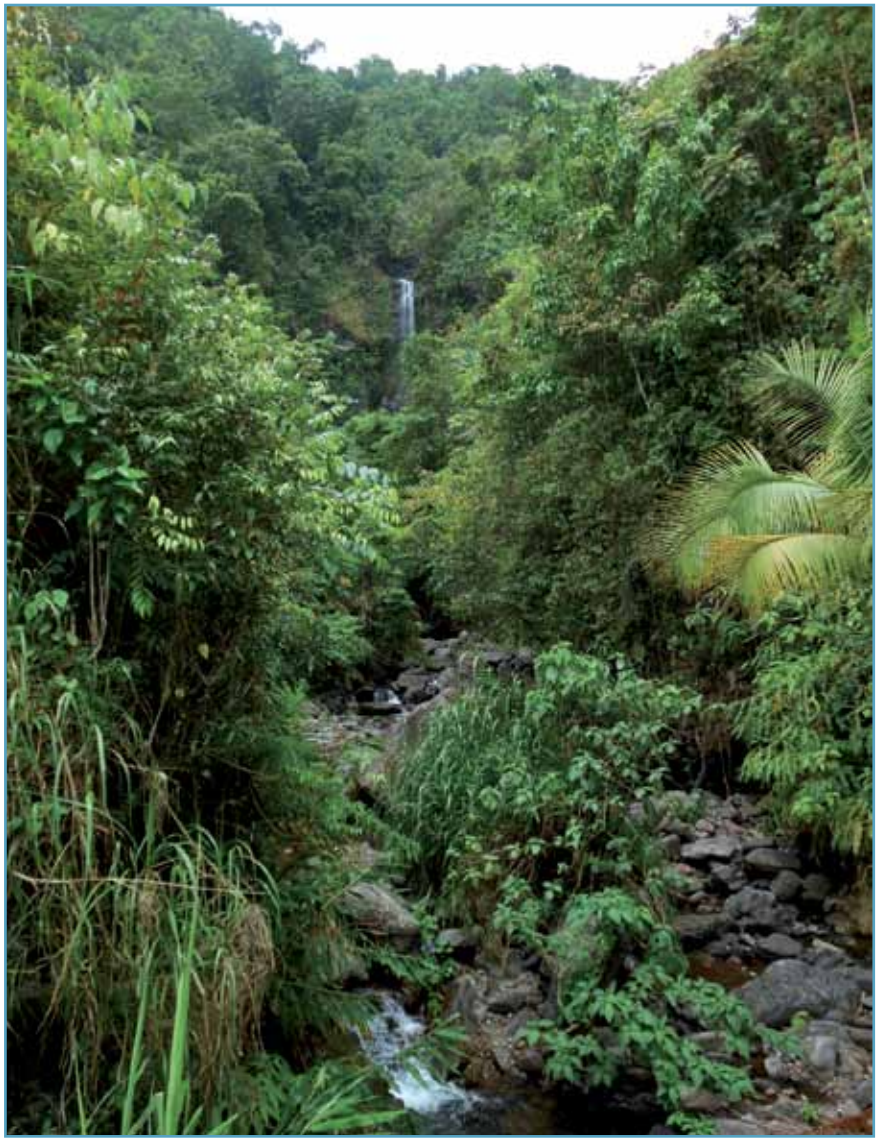
Global climate change is projected to increase the vulnerability of Small Island Developing States (SIDS) to natural hazards because of their small size, high population densities, poorly developed infrastructure, and limited natural, human and economic resources. Climate change is also expected to influence external forces such as food imports. Jamaica is likely to suffer adverse affects from climate change in combination with these vulnerabilities due to increases in the intensity and frequency of natural hazards, drought and the rise of sea levels.

Warming trends have already had considerable impacts in Jamaica – most significantly in terms of increased occurrence of drought and the frequency and magnitude of extreme climate events. These have resulted in increased crop yield loss as well as damage to livestock, fishery and aquaculture infrastructure and irrigation structures. The country's small-scale farmers and fishermen are, in fact, resource deficient and highly vulnerable to climate impacts.

Adaptation measures need to be prioritized to respond to the growing threat of climate change. The investments in adaptation to reduce the impacts of climate change in agriculture and fisheries should consider the recent developments and priorities related to food security, high value agriculture, value chains, environment protection, agriculture support services, enabling institutions, risk mitigation and risk transfer initiatives. Adaptation actions are required at multiple levels from policy to farm and to household.

Within this overarching context, this report seeks to contribute to the understanding of climate change and its impact on agriculture in Jamaica. By compiling several studies conducted on climate change and agriculture, the report aims to identify key policy and technical issues as well as priorities on climate change, including the country's key supply chains. The areas and priorities for reducing the impacts of climate change and enhancing adaptive capacity of agriculture-dependent livelihoods are also discussed.

To present a contextual setting, Chapter 2 outlines the vulnerability of Jamaican agriculture to climate variations. Chapter 3 provides key features of climate variability, past climate trends and future climate change scenarios. In Chapter 4, an overview is given of the impact of extreme climate events and climate change on agriculture and its subsectors. Chapter 5 discusses coping and adaptation strategies. Chapter 6 contains the institutional arrangements for climate change adaptation and the key features of policies, programmes and projects focusing on climate change. It summarizes integrated approaches with technologies and climate-responsive policies. Chapter 7 provides the conclusions derived from this study.



A WATERFALL IN PORTLAND, JAMAICA DURING DRY SEASON

The water demand for agriculture in Jamaica is estimated to increase by 18 percent in 2030. The sustainable water yield may decline by 20 percent during the same period. As the agriculture sector is the major user of freshwater resources (75 percent), it is expected to be affected severely by climate change.

A FARMER HARVESTS MAIZE IN THE NEW MARKET REGION OF JAMAICA. *The parish of St. Elizabeth, in Jamaica referred to by many Jamaicans as the bread basket of the country, is vulnerable to a number of natural hazards, namely storms, storm surges (along the coast) wind damage and flooding. Flooding have frequently impacted the livelihoods and income generation activities. There is a need for detailed analysis of vulnerability of different livelihood groups in the region.*

CHAPTER 2

AGRICULTURE AND ITS VULNERABILITY TO CLIMATE CHANGE

2.1 AGRICULTURE AND CLIMATE-RELATED DISASTERS IN JAMAICA

The agriculture sector, including fisheries and aquaculture, represents about 5 percent of Jamaica's GDP (PIOJ, 2010). Although the contribution of agriculture to national GDP has steadily declined over the last two decades, this sector supports 20 percent (FAO, 2007) of the total population and is still one of the most labour-intensive. The agricultural economy is dualistic, comprising: large-scale commercial plantations that produce primarily for the export market under a system of monoculture; and small-scale mixed farms that produce for household subsistence and the domestic market.

Agriculture has a particularly important role to play in income growth and poverty reduction, in rural development, in the maintenance of the environment and biodiversity, and in food security. Despite the critical importance and increasing role of agriculture in economic development (9.7 percent expanded agriculture GDP share), public sector budgetary allocations and actual expenditures in the agricultural sector continue to be low (1.4 percent) and inadequate (Segura, 2010).

The climate variability and extreme climate events have a strong influence on the agriculture sector of Jamaica (Beckford, Barker and Bailey, 2007). The years 2002 to 2008 witnessed the greatest damage to the sector (Table 1) when the passages of Hurricane Charley and Ivan (2004) were followed by a seven-month drought in late 2004 and early 2005.

TABLE 1

Impact of Extreme Climate Events on Jamaica's Agriculture Sector between 2002 and 2008

YEAR	ANNUAL CHANGE IN AGRICULTURAL GDP (%)	ANNUAL CHANGE IN DOMESTIC FOOD PRODUCTION (%)	EVENT
2002	-8.3	-11.3	Heavy rainfall May/ June and September
2004	-10.4	-15.6	Drought first half year; Hurricane Charley, Ivan
2005	-7.3	-3.4	Drought first 4 months; Hurricanes Dennis; Emily and Tropical Storm Wilma
2007	-8.7	-9.5	Hurricane Dean
2008	-5.2	-	Drought first 3 months; Hurricane Gustav

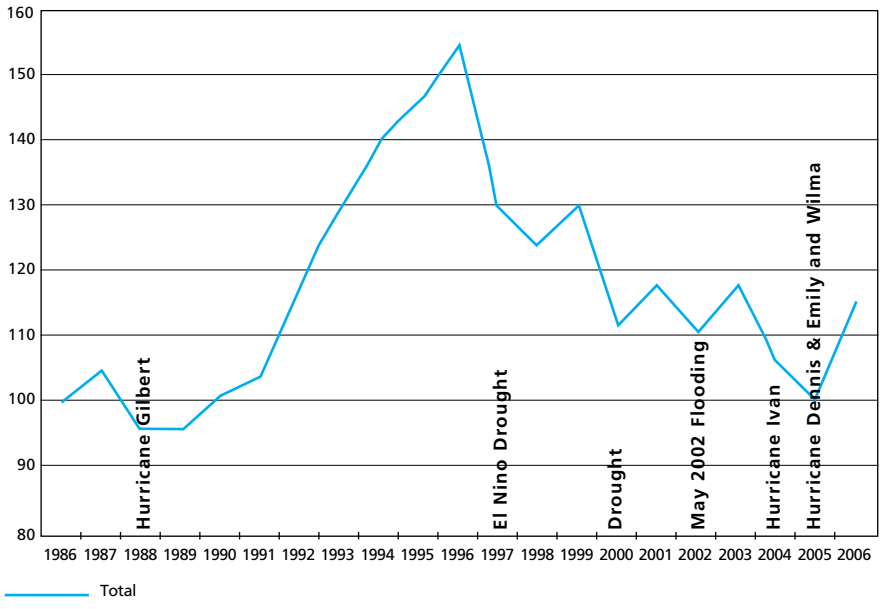
Source: Campbell, Barker and McGregor, 2011; PIOJ, 2010a.

The drought was accompanied by a number of bush fires followed by the effects of Tropical Storm Wilma and Hurricanes Dennis and Emily. In 2007, Hurricane Dean was followed by two weeks of continuous rainfall emanating from the passage of Tropical Storm Noel which caused agriculture GDP to decline by 8.7 percent in the last six months of the year (Campbell *et al.*, 2011). In early 2008, the sector was affected again by a three-month long drought.

The agriculture production index (API) provides a measure of relative performance in the sector across the export, domestic, meat, poultry and fisheries subsectors. The average API from 1986 to 2006 shows a close relationship with extreme climate events (Figure 1). The strong correlation between movements in the API and the occurrence of the extreme climate events (Futter, 2007) shows high levels of exposure and the vulnerability of the sector to climate variability and change. The average loss from climate risks in Jamaica is 6 percent of GDP (Caribbean Catastrophe Risk Insurance Facility, 2010).

FIGURE 1

Agriculture production index (API) and major events 1986–2006 (1986 = 100)



Source: PIOJ, 2010a.

2.2 VULNERABILITY[1] OF AGRO-ECOSYSTEMS

Jamaica's coastal ecosystem is a narrow strip along the island's approximately 1 200 kilometres of shoreline. Sea level rise resulting from climate change would likely increases coastline erosion and saline contamination of coastal aquifers. Increases in the intensity of tropical storms and hurricanes could further exacerbate these threats. Higher sea surface temperature is likely to increase incidence of coral bleaching. This increase will threaten the survival of coastal ecosystems like coral reefs, mangroves and seagrass beds, fisheries and marine biodiversity.

1 Vulnerability refers to the degree to which a system or society is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity.

Mangroves provide a buffer against storm surges and strong winds from hurricanes and protect marine biodiversity. Deforestation of mangroves is rendering the coastline more vulnerable to erosion. A case study (United Nations Environment Programme (UNEP), 2010), which focused on ecosystem degradation and coastal vulnerability, indicated that deforestation has increased flooding in the coastal areas.

Deforestation, as a result of urbanization and housing development, has increased flooding downhill. Several sections of the Whitehall Community have been affected (UNEP, 2010). Hurricane impact on coral reefs, illegal sand mining activities and unsustainable practices (e.g. destructive fishing practices, removal of mangroves, seagrasses and other types of coastal vegetation, and runoff) have contributed to beach degradation and increased storm surge vulnerability in Little Bay.

Ecosystem degradation combined with beach erosion and the increasing impact of tropical storms may, over time, undermine assets and livelihoods. These include fishing, farming and tourism which are vital to the local and national economies. For instance, declining fish stocks in Little Bay over the past decade have forced many women and men out of the fishing sector, contributing to unemployment (UNEP, 2010).

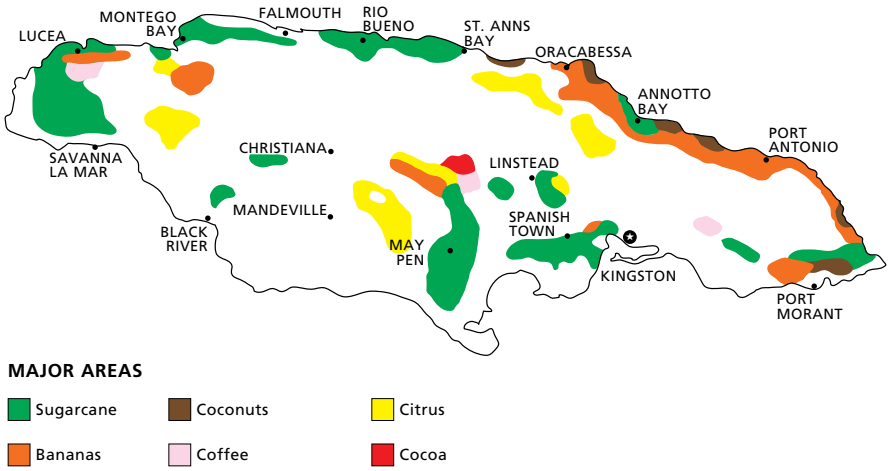
Similar to the coastal zone, vulnerability of mountainous steep slopes is caused by unsustainable agriculture practices. Much of the land occupied by small farmers is located on steep slopes where inappropriate farming practices result in soil erosion and loss of biodiversity. Farmers often advance further up hillsides, clearing forested areas to expand land under cultivation thereby causing further negative impact on biodiversity. Slash and burn agriculture in the mountains increases erosion, decreases soil fertility and degrades soil. Increasing deforestation and other land use changes on steep slopes have exposed the mountain agriculture to climate change impacts.

2.3 VULNERABILITY OF FOOD PRODUCTION SYSTEMS

Arable land in Jamaica is 0.17 million hectares (ha) (16 percent of the total land area) (FAO, 2007). The southern lowlands are dominated by livestock activity; the Blue Mountains are characterized by the exploitation of pine and coffee farming; sugarcane production is predominant in the Western Lowlands; and there is a wide array of crops on the Manchester Plateau (Figure 2).

FIGURE 2

Spatial distribution of crops in Jamaica



Source: University of Texas Thematic Maps, accessed December 2011 through UT Library *Online:* http://www.lib.utexas.edu/maps/americas/jamaica_ag_1968.jpg.

Increasing pressure on farmland, small-holding size and climate-related extreme events have resulted in devastating losses of agricultural crops and erosion of farmlands. In describing the level of vulnerability of the agriculture sector, FAO noted that damages in 2004 as a result of Hurricane Ivan accounted for 62 percent of total earnings from the sector (FAO, 2010a).

As the land use in most parishes remains mainly agricultural, events of flooding and landslides affect agriculture-based livelihood activities and also contribute greatly to agricultural loss. The communities most affected are often located in perennial flood- and landslide-prone areas.[2]

The high value crops like bananas, coffee and sugarcane are more vulnerable to hurricane risks. Coffee is affected by loss of berries, defoliation and damage to coffee and shade trees. The extended flooding associated with hurricanes in addition to water scarcity and drought all affect sugarcane growth. The citrus growing regions are susceptible to sustained winds, soil erosion, and flower and fruit dropping.

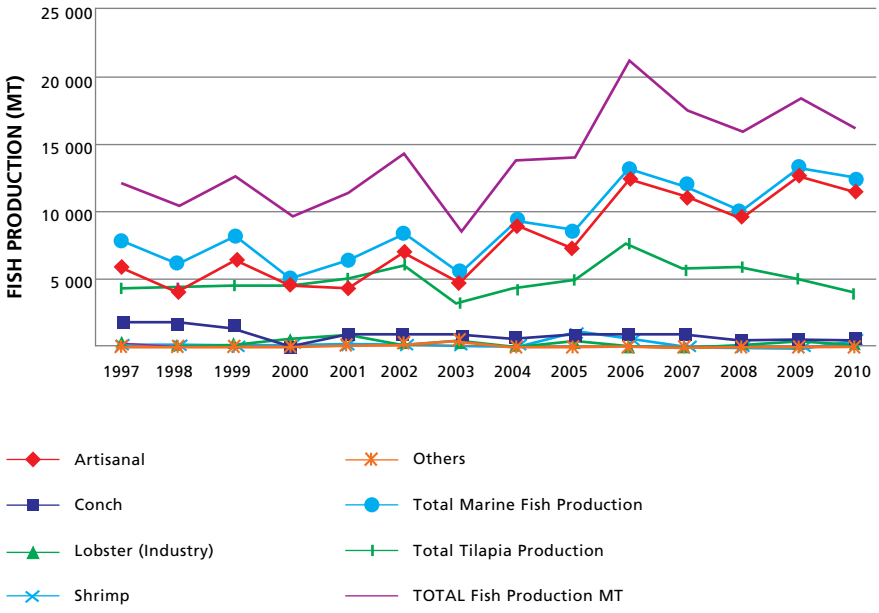
2 Jamaica's ODPEM listed high-risk areas based on their vulnerability to floods, landslides and other natural hazards.

Fisheries – an important sector for the economy – also face a number of challenges. While official data show that overall national trends in fish catch volume and value have been relatively stable in recent years (Figure 3), studies also show that the quality and average size of fish landed are declining. Fishermen are having to travel further out to sea to maintain their level of catch. Increasing climate variability has compounded local vulnerability of Jamaica's fishery sector.

The impacts of increasing climate variability and climate change are felt more severely by coastal communities in Jamaica as warming coastal

FIGURE 3

Fish Production in Jamaica (1997-2010)



Source: Fisheries Division, 2011.

waters and the destruction of coral reefs have resulted in dwindling catches. Increasingly frequent hurricanes often mean destruction of fishing infrastructure, while also making it too dangerous to go to sea. In addition to these extreme climate events, the use of destructive fishing gear, unsustainable fishing practices (including spear fishing, use of small seine nets, and dynamite on reefs) and lack of awareness by fishermen about fisheries management are contributing to the vulnerability. These practices negatively impact the coral reefs resulting in degradation of breeding grounds for juvenile fish. The United States Agency for International Development's (USAID's) study on sustainable interventions for Negril fisher families found that coral reefs were under moderate to severe stress from algal, sponge and soft coral overgrowth, sediments, nutrients and coral bleaching (Christophersen *et al.*, 1997).

Loss of habitat for fish due to coastal degradation and pollution are the main concern. A report from a regional Fisheries Management Data Systems Terminal Workshop in 2000 cited issues of lack of awareness of fisheries management issues; poaching by foreign fishing vessels and fishers not respecting closed seasons and other regulations (Christophersen *et al.*, 1997). According to the World Resources Institute's Working Paper "Coastal Capital Jamaica", overfishing has nearly eliminated large predatory fish species, such as groupers and snappers (World Resources Institute, 2011). The fishing-dependent communities are more vulnerable to impacts of climate due to poorly planned coastal development and sedimentation resulting from land-based sources of pollution.

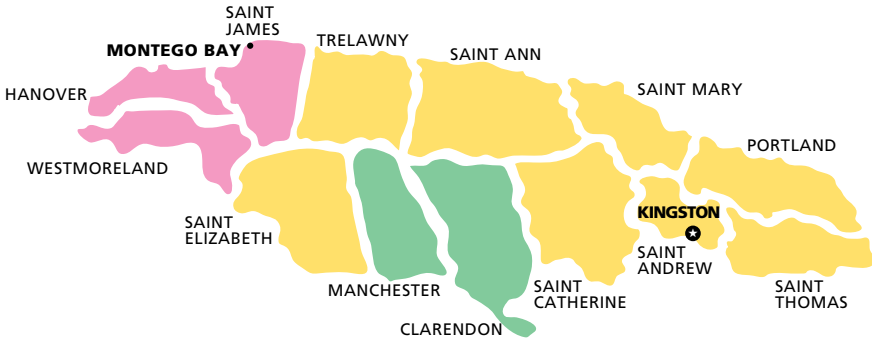
2.4 REGIONAL DIFFERENCES IN VULNERABILITY

Vulnerability is often related to the local conditions and occurrence of a specific hazardous event at a period of time. However, in terms of geographical damage to the sector, the areas most affected by the passage of the hurricane have been concentrated in the southern and eastern sections of the island. Reportedly, damage to crops and livestock in these areas was due to the effects of gusty winds in excess of 100 miles per hour, rather than flooding. However, considering the risk index, the western part of the country (Hanover, St James and Westmoreland) has the highest risk, compared to medium risk in eastern and central parts of the country (St

Thomas, Portland, St Andrew, St Mary, St Catherine, St Ann, Trelawny and St Elizabeth) and lowest risk in the southern parishes (Manchester and Clarendon) (Figure 4).

FIGURE 4

Geographical distribution of climate-related risk in Jamaica [3]



Lowest risk (risk index < 0.5%)

- Clarendon 10%
- Manchester 8%

Highest risk (risk index > 1.0%)

- Hanover 3%
- Westmoreland 8%
- Saint James 9%

Mid-risk (risk index between 0.5 and 1.0%)

- Kingston 2%
- Portland 3%
- Saint Andrew 18%
- Saint Ann 7%
- Saint Catherine 13%
- Saint Mary 4%
- Trelawny 4%
- Saint Elizabeth 8%
- Saint Thomas 3%

Source: CCRIF, 2010.

3 *Enhancing the climate risk and adaptation fact base for the Caribbean*, An informational brochure highlighting the preliminary results of the ECA Study, Caribbean Catastrophe Risk Insurance Facility, Cayman Islands, August 2010.

The island is characterized by mountains running along the island's east-west axis and narrow coastal plains. The regional differences in vulnerability are also strongly affected by elevation and physiographic characteristics. For example, the mountainous steep slopes are particularly vulnerable because of the prevalence of unsustainable agriculture practices.

BOX 1

Factors that contribute to vulnerability of agriculture sector to climate variability and change

Marginal production environments and land use: Crop cultivation on steep slopes and unsustainable farming practices have led to soil erosion, flooding and degradation of watersheds. Insecure land tenure, un-equal distribution of agricultural land among rural people and farming in marginal hillside land contributes to vulnerability. Approximately 60% of all farming lands are located on the south western half, the leeward side of the island which experiences semiarid climate.

Rural population and dependence on agriculture: About 47% of the Jamaican population live in rural areas and 16.5% live below poverty line and majority are women. The agriculture sector mainly comprises of small and medium sized farmers with 5 hectares or less, who account for 85% of total agricultural holdings. In general, agriculture dependent parishes have the highest incidence of poverty in Jamaica.

Scarce resources and livelihood assets: The added pressure on natural resources especially on land and water significantly increases the susceptibility of agriculture to the impacts of climate change. The proportion of irrigated agriculture is less than 30% in agriculturally important parishes such as St. Thomas, St. Elizabeth, Trelawney and Westmoreland. Poor irrigation water supply systems, inefficient water management and runoff losses lead to low irrigation efficiency.

A FARM WOMAN FEEDING CHICKENS. *The small poultry farmers – who account for approximately 30 to 35% of national production experiences worst damage during the passage of Hurricanes. The small-scale poultry producers are highly vulnerable to the impacts of climate variability and climate change.*

CHAPTER 3

CLIMATE VARIABILITY AND CHANGE

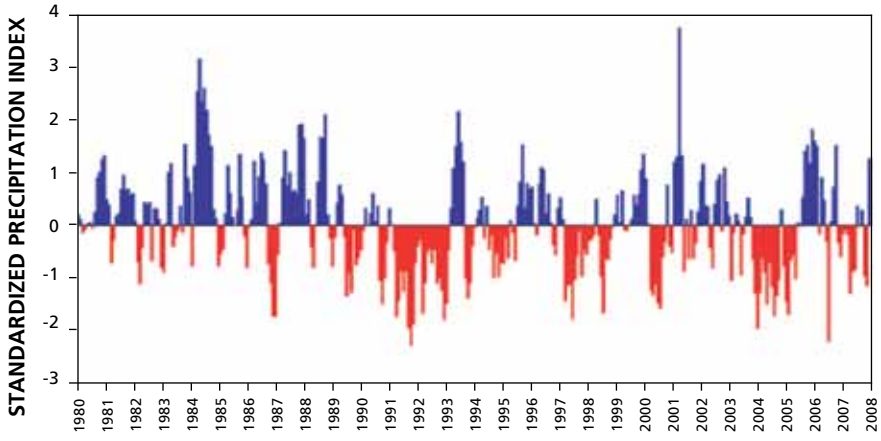
3.1 CLIMATE AND ITS VARIABILITY

The climate of Jamaica is broadly characterized as having a dry winter and a wet summer, with orography and elevation being significant modifiers on the subregional scale. The primary rainfall season is from June to November, and roughly coincides with the mean Caribbean rainy season. Around July, a temporary decline in rainfall causes the midsummer drought (Chen and Taylor, 2008).

The interannual climate variability in Jamaica is very large. An example of this variability is illustrated in the monthly standardized precipitation index (SPI) time series from 1980–2007 for the parish of St Elizabeth, which shows strong oscillation between wet and dry conditions (Figure 5; Gamble *et al.*, 2010). However, the frequency of longer drought events appears to change in the early 1990s.

FIGURE 5

Standardized precipitation index for the parish of St Elizabeth, Jamaica



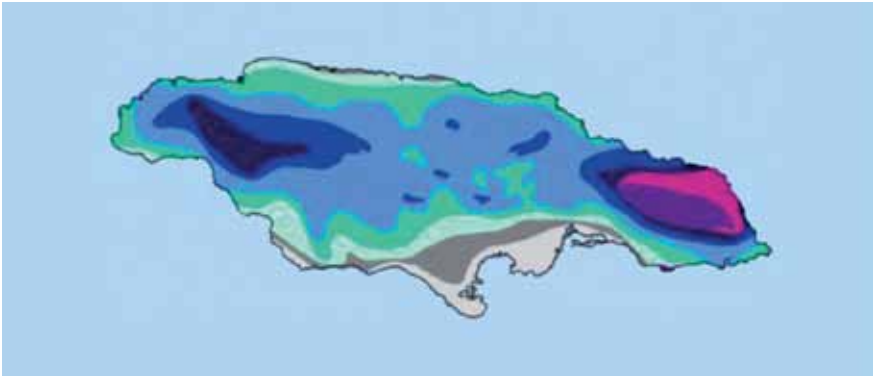
Source: Gamble *et al.*, 2010.

The dominant mode of interannual variability in precipitation is associated with El Niño Southern Oscillation[4] (ENSO). The early rainfall season (May to July) is anomalously wet during the year after an El Niño event, and anomalously drier during a La Niña event (Chen *et al.*, 1997). The late rainfall season (August to November) tends to be drier in El Niño years, and wetter in La Niña years. Tropical cyclone activity diminishes over the Caribbean during El Niño summers.

Similar to temporal rainfall variability, spatial variability of rainfall is also considerable. The annual moisture regimes for Jamaica show very wet to wet conditions in the northeastern part of the island and in the northwest, especially on the higher elevations. The southern coast, with a rain-shadow effect, is distinctively arid (Figure 6).

FIGURE 6

Annual moisture regimes in Jamaica



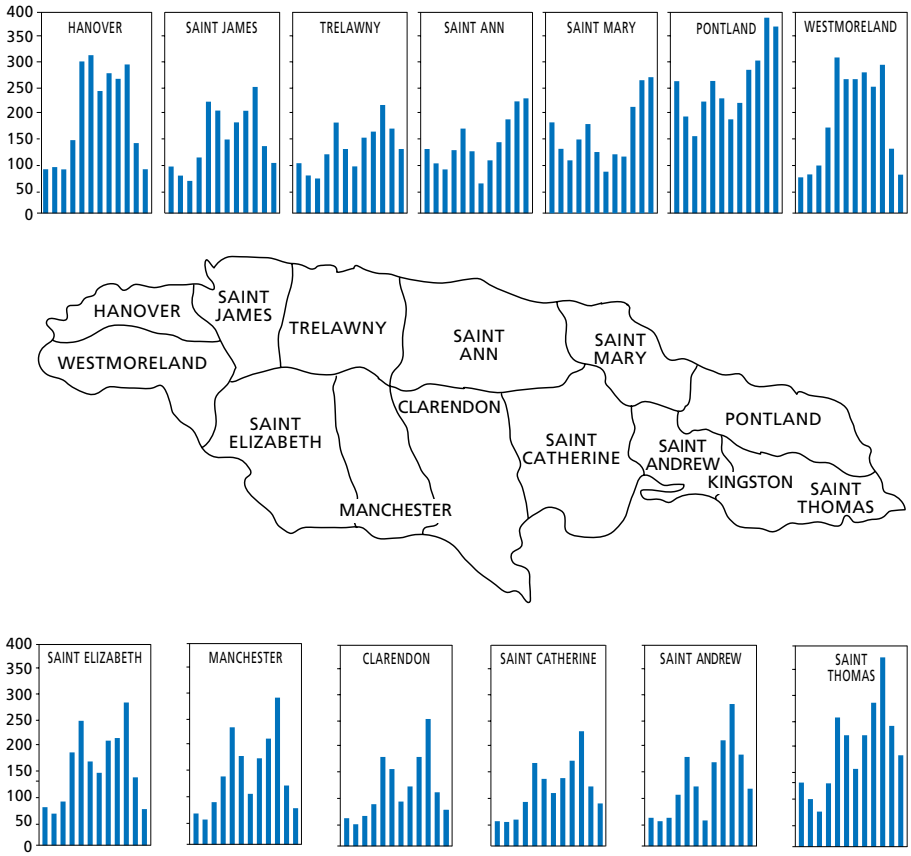
Source: Ministry of Agriculture and Fisheries, 2009.

4 The ENSO signal consists of a warm phase (El Niño) and a cold phase (La Niña). The term *El Niño* was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation.

The average monthly rainfall distribution of all parishes provides a snapshot of spatial rainfall variability in Jamaica (Figure 7).

FIGURE 7

Average Monthly Rainfall of Parishes in Jamaica



Source: Monthly average rainfall data collected from Jamaica Meteorological Services, Kingston, Jamaica.

3.2 PAST CLIMATE TRENDS: OBSERVATIONS, ANALYSIS AND LOCAL PERCEPTIONS

Global temperatures have increased by about 0.74 ˚C since the nineteenth century (Intergovernmental Panel on Climate Change, 2007). There has been a warming trend from 1950 to 2001 with minimum temperatures increasing at a higher rate than maximum (Alexander *et al.*, 2006). Peterson *et al.* (2002) found that the difference between the highest and lowest temperatures for the year (i.e. the diurnal range) is decreasing, but is not significant at the 10 percent significance level. Temperatures falling at or above the 90th percentile (i.e. very hot days) are also increasing, while those at or below the 10th percentile (very cool days and nights) are decreasing. Both of these values are important at the 1 percent significance level. These results indicate that the region has experienced some warming over the past fifty years. McSweeney *et al.* (2008) reported that the mean temperature has increased by around 0.6 °C since 1960, an average rate of 0.14 °C per decade.

Peterson *et al.* (2002) reported that the highest five-day precipitation total increased over the period under analysis (10 percent significance level) while the number of consecutive dry days decreased (1 percent significance level). Using several observed data sets, Neelin *et al.* (2006) noted a modest but statistically significant drying trend for the Caribbean's summer period in recent decades. McSweeney *et al.* (2008) also found that the mean precipitation over Jamaica has decreased in JJA and SON by 6.2 mm and 4.5 mm per month per decade, respectively, but these trends are not statistically significant.

Analysis of observed tropical cyclones in the Caribbean and wider North Atlantic Basin shows an increase since 1995. This increase, however, has been attributed to the region being in the positive (warm) phase of a multi-decadal signal, and is not necessarily due to global warming (Goldenberg *et al.*, 2001). Attempts to link warmer sea surface temperatures (SSTs) with the increased number of hurricanes have proven to be inconclusive (Peilke *et al.*, 2005).

Webster *et al.* (2005) found that only the North Atlantic Ocean shows a statistically significant increase in the total number of hurricanes since 1995, and noted an almost doubling of the category four and five hurricanes in the same time period. While the number of intense hurricanes has been rising, the maximum intensity of hurricanes has remained fairly constant over the 35-year period examined.

The perceptions of the local farming and fishery communities in Jamaica corroborated well with the results of the analysis presented above. The Office of Disaster Preparedness and Emergency Management's (ODPEM's) study on "Economic and community vulnerability of climate change in Jamaica", published in 2011, focused on a dialogue regarding the identification of cost-effective and feasible adaptation strategies to climate change in Westmoreland (Darliston - agriculture; Whitehouse - fishing) and St Elizabeth (Flagaman - agriculture; Black River - fishing). Farmers in these locations perceived that the droughts are longer and rainfall patterns in the region are more irregular and reduced. They face difficulty in planning for planting as droughts often reduce seed germination. In addition, changes in growing season length as well as the pest and disease infestations common after long-dry spells all serve to reduce the crop yield.

Small-scale fishermen exhibit a fair understanding of climate-related risks. They frequently observe a decline in marine life and habitats around the island. Fish landings are also perceived to be declining while the operating costs of fishing were shown to be increasing. The local perceptions are:

- increased sea surface temperatures are causing decreased fish catch;
- more rains could mean more fish;
- more frequent and stronger storms mean fewer fishing days and possible damage to habitats, vessels and infrastructure;
- stronger currents and unpredictable winter swells mean more disruption in fishing activities;
- migratory sea birds are decreasing.

The local fishing communities added that climate change may be triggering illegal fishing (such as dynamiting) and also leading to the importation of Honduran fish which has compromised the local market. They also reported the loss of coral reef, changes in abundance, size and variety of fish, increased coastal erosion and loss of mangroves. Furthermore, they anticipate further changes in terms of the cost of inputs such as petrol, insufficient disposable income, lack of jobs and increased costs of products and services.

McGregor, Barker and Campbell (2010) assessed the local perception of impacts, using a case study in southern St Elizabeth in their paper "Environmental change and Caribbean food security: recent hazard impacts and domestic food production in Jamaica". They found that local

communities perceive an increase in drought frequency due to below normal rainfall during the rainy season and that the most severe dry month in terms of potential for crop damage is July.

A study was conducted to reach a basic understanding of drought and climate change in southwestern Jamaica through an integration of local knowledge and perception of drought and its physical characteristics manifested in remotely-sensed precipitation and vegetation data (Gamble *et al.*, 2010; Campbell *et al.*, 2011). The participatory analysis with 60 farmers in St Elizabeth highlighted their concern about an increase in drought occurrence. Their perception of climatic and non-climatic stresses is presented in Table 2.

Gamble *et al.* (2010) concluded that the Jamaican farmers' perceptions of drought are not driven by the magnitude and frequency of dry months alone, but rather by the difference between growing seasons. Any development of drought adaptation and mitigation plans for this area must not focus solely on drought; they must also compare moisture conditions between months and seasons to be effective.

Satellite precipitation time series also suggest that the early growing season is becoming drier as compared to the primary growing season, especially since 1991 (Gamble *et al.*, 2010). This recent divergence in growing season moisture conditions might add to farmers' observations that drought is becoming more prevalent.

The Risk and Vulnerability Assessment Methodology Development Project (RiVAMP), Linking Ecosystems to Risk and Vulnerability Reduction, was initiated by UNEP in collaboration with the PIOJ in 2010 as a pilot testing initiative. The RiVAMP project was conceived to develop a methodology that takes into account environmental factors in the analysis of disaster risk and vulnerability. It recognizes ecosystems and climate change in the risk assessment process.

The local perception of the risks linking climate change to ecosystems are: degradation of coral reefs, increase in sea level, invasive species and destruction of coastal vegetation, wetland degradation and deforestation. The proposed coping strategies highlighted in the study include: strengthening environmental governance; environmental education for behavioural change; and employing the ecosystems approach (ecological-based solutions to reducing risk).

TABLE 2

Local Perception of Climatic and Non-Climatic Stresses Perceived by the Farmers in St Elizabeth, Jamaica

STRESS	MAIN PROBLEMS	BRIEF EXPLANATION	SOME IMPACTS
Water	Lack of irrigation water; poor water supply system; high cost of water	Lack of reliable supply of irrigation water; water is bought from a government agency and is unreliable	Reduction in the number of crops produced per year; Crop failure; Forced to buy water from private vendors who sell at a higher price.
Guinea grass	High cost of Guinea grass	Importance of Guinea grass (used for mulching) to farmers in southern St. Elizabeth has led to its commodification, thereby making the grass expensive.	Use other grasses that are generally less effective; Change cash crop – grow crops that are more resilient to drought; cultivate on a smaller scale.
Market	Lack of reliable market for produce; erratic and unreliable higglers	Lack of reliable marketing facilities has relegated farmers to a dependence on higglers[5] as the main outlet for their produce; higglers are often unreliable and deceptive.	Spoilage of produce; reduced profits; left to the mercy of higglers.
Farm inputs	High price of fertilizers, seeds and chemicals	Three-fold increase in price of fertilizer in less than 1 year, which has occurred alongside the increase in prices of other farm inputs such as hybrid seed, pesticides and equipment	Decreased output per crop; use of alternate methods that are sometimes less effective; cultivate lower varieties input; reduction in area under cultivation.
Food imports	Increased competition from imported food	Importation of cheap produce (e.g. onions, tomato, carrot and cabbage) in the farming communities is a major concern to farmers. For example, the onion farmers of Flagaman were virtually eliminated over a 3-year period with total acreage falling from 800 acres in 1996 to an almost negligible value in 1999.	Lower price for produce; change of cash crop – cultivate non-imported crop; loss of buyers (from higglers to importers)
Environmental conditions	Rain shadow effect – very low rainfall	Even though farmers have adapted well to the marginal environmental conditions in their area, the cost of adaptation is a major stress to farmers; the dry conditions demand the use of Guinea grass and more water than the typical farming region in Jamaica.	General added expense of adapting to dry conditions (e.g. Buying Guinea grass). Limited capacity for livestock production (e.g. cattle, sheep, goat). Higher than usual demand for irrigation water.

Source: Campbell *et al.*, 2011.

5 For the purpose of this report, "higglers" are defined as market traders and middlemen who buy farm products and sell in the markets.

BOX 2

Local knowledge contributes to design climate change public education outreach

Caribbean Community Climate Change Centre's (CCCCC) Mainstreaming Adaptation to Climate Change (MACC) project was initiated in 2005 with an objective to assess the Jamaican population's knowledge, attitude and behavioural practices with regard to climate change. This information was to be used as input for the drafting of a National Climate Change Public Education Outreach (PEO) strategy, which was intended to assist in better preparing communities for the effects of climate changes in all 14 parishes of Jamaica.

A sample of six stakeholder groups was selected, and 1 700 questionnaires administered. The main findings are:

- a general feeling of complacency and indifference towards climate change and its effects;
- only 15 percent of the adult respondents indicated that their homes were insured;
- the most common theme among the respondents' perception of climate change was of a change or variation in climate accompanied by changes in temperature and weather patterns;
- the majority of respondents felt that they were only somewhat at risk to climate change;
- droughts and floods were mostly associated with climate change;
- strong to moderate interest in knowing how climate change affected the various climatic conditions they were asked about:
- most persons believed that the government should play a stronger role in addressing the impacts of climate change on communities;
- a clear trend is seen where people feel that climate change is less important to their own communities than to the country, in general;
- primary responsibility for addressing climate change rests with government.

Source: Caribbean Coastal Data Centre for Marine Sciences, 2010.

The Pilot Program for Climate Resilience (PPCR) was initiated in 2011 as a collaboration between the PIOJ, PANOS Caribbean, and the National Environmental Education Committee. The purpose of this initiative is to provide a forum for stakeholders to share information on the (i) level of awareness of climate change at the community level; (ii) impacts of climate change on various communities and parishes; (iii) coping strategies adopted at the community and parish levels; and (iv) recommendations for the strengthening of climate change resilience at the parish and national levels across sectors.

FAO (2010b) looked into the local perceptions of the impacts of climate change in its Livelihood Assessment Tool-Kit training of the Rural Agricultural Development Authority (RADA). The major impacts noted by local communities were: higher agricultural prices; food shortages and scarcity; reduction of local food production; famine and hunger; damage to, and loss of crops and livestock; and devastation of income streams through pests and diseases. These facts were echoed by the focus group sessions organized by the trainees during their fieldwork in Kingston, Portland, Mandeville and Negril. During these sessions, participants spoke of the changes which they considered were linked to climate change, including: coastal erosion; infrastructural damages; habitat loss; changes in cropping season; increase in bush fires; changes in river course and channels, and thus greater erosion of river banks; significant decrease in soil fertility due to loss of top soil; high rates of sedimentation; loss and unavailability of crops; disruption in farming practices; increase in pests and diseases; and reduction in biodiversity.

Beckford (2011) studied sustainable food production systems and food security in small-scale farming communities in Trelawny with particular reference to economic and environmental imperatives of yam cultivation. The study's findings, based on 40 yam farmers in Trelawny showed that high winds from hurricanes toppled yam sticks and affected yields. The impact depended on the stage of growth and maturity of the yam sticks.

3.3 FUTURE CLIMATE CHANGE SCENARIOS

3.3.1 Climate change projections for the Caribbean region

The Intergovernmental Panel on Climate Change (IPCC) scenarios of temperature change for the Caribbean between the present (1980–1999) and the future (2080–2099) project continued warming through until the end of the current century (IPCC, 2007). Simulated annual temperature increases for the Caribbean at the end of the twenty-first century range from 1.4 °C to 3.2 °C.

The results of the Caribbean Providing Regional Climates for Impact Studies (PRECIS) climate model indicate that the annual mean temperature across the Caribbean by the 2080s is projected to be between 1 °C and 5 °C warmer (Taylor *et al.*, 2007).

BOX 3

Climate change projections for the Caribbean

Based on the SRES A1B scenario, the following summary can be made about future climate conditions within the Caribbean:

- Sea levels are likely to continue to rise during the century around the small islands of the Caribbean sea. Models indicate that the rise will not be geographically uniform, but large deviations among models make regional estimates across the Caribbean uncertain.
- All Caribbean islands are very likely to warm during this century. The warming is likely to be somewhat smaller than the global annual mean warming in all seasons.
- Summer precipitation in the Caribbean is likely to decrease in the vicinity of the Greater Antilles, but changes elsewhere and in winter are uncertain.
- It is likely that intense tropical cyclone activity will increase, although the tracks and the global distribution are uncertain.

Source: Christensen *et al.*, 2007.

There will be greater warming in the summer months, especially in the late summer months during which over 3 °C in a low emission scenario and 4 °C in a high emission scenario will be experienced (Taylor *et al.*, 2007). Data from the CARIBSAVE project, which has used regional climate models (RCM) simulations from the PRECIS project driven by two different climate models, suggest increases of 2.9 °C and 3.4 °C in Jamaica by the 2080s (CARIBSAVE, 2009).

The IPCC (2007) scenarios of percentage precipitation change for the Caribbean show a decrease in annual precipitation, although a few models suggest increases. Generally, the change varies from –39 to +11 percent. In December, January and February (DJF), some areas of increases are evident; but by June, July and August (JJA), the decrease is region-wide and of greater magnitude.

The results of the PRECIS project on precipitation indicate that rainfall begins to decrease in most regions by the 2050s; and the decrease in precipitation by the 2080s becomes significant in all regions, ranging from 25 percent to 40 percent.

Using a high-resolution global 20 km grid atmospheric model, Oouchi *et al.* (2006) simulated tropical cyclones. In their study, tropical cyclone frequency decreased 30 percent globally, but increased by about 34 percent in the North Atlantic. The strongest tropical cyclones with extreme surface

winds increased in number while weaker storms decreased. It must be noted, however, that these regional changes are largely dependent on the spatial pattern of future simulated SST changes. The projected increases in sea level within the Caribbean and around the coasts of Jamaica vary from 0.17 m to 0.24 m by 2050 (IPCC, 2007). Others (Rahmstorf, 2007) have given higher magnitudes of 0.25 m to 0.36 m against 1990 sea level.

3.3.2 Climate change projections for Jamaica

An analysis of data based on PRECIS and other RCMs indicates positive average temperature changes over Jamaica in 2015, 2030s, 2050s and 2080s relative to the 1961–1990 average. The overall average temperature increases by 0.53 °C in 2015 to 2.45 °C in the 2080s (Chen *et al.*, 2009).

Based on PRECIS data, rainfall "begins to decrease in most regions [in Jamaica] by the 2050s, and the decrease in rainfall becomes significant by the 2080s" (Chen *et al.*, 2009). Statistical downscaling model (SDSM) results obtained by the PRECIS RCM show a general pattern of decreased rainfall in Jamaica based on data from three rainfall stations: at the Norman Manley and Sangster International Airports, and Upper Rio Cobre (URCR). This decrease in annual rainfall is almost linear, except for the 2015s and the 2050s at [the Norman] Manley [International Airport] and the 2050s at URCR (Chen *et al.*, 2009).

The estimated reduction in rainfall in the 2050s is 10 percent and the average percentage change in rainfall in 2015, 2030s, 2050s and 2080s across Jamaica ranges from an estimated low of -2.28 percent in 2015 to a high of -40 percent in the 2080s (Chen *et al.*, 2009). Results from the CARIBSAVE Project for Jamaica show that most models indicate decreases in rainfall (CARIBSAVE, 2009). The projection ranges from -35 percent to +17 percent for annual rainfall by 2030s and -65 percent to +22 percent by 2090s.

McSweeney *et al.* (2008) reported that the mean annual temperature is projected to increase by 0.6 to 2.3 °C by 2060s, and 1.1 to 3.5 °C by 2090s. All projections indicate substantial increase in the frequency of days and nights that are considered "hot" in current climate. The projections of mean annual rainfall from different models indicate decreasing rainfall for Jamaica in June, July and August and March, April and May.

TABLE 3

Scenarios of Future Climate - Temperature and Precipitation

SEASON	2030			2060			2090		
	Min	Median	Max	Min	Median	Max	Min	Median	Max
CHANGE IN TEMPERATURE (°C)									
ANNUAL	0.47	0.97	1.17	1.0	1.73	2.03	1.73	2.37	2.97
DJF	0.43	0.90	1.20	0.97	1.63	1.93	2.27	2.27	2.93
JJA	0.47	1.0	1.33	1.0	1.77	2.17	2.47	2.47	3.03
CHANGE IN PRECIPITATION[6] (%)									
ANNUAL	-30.3	-4.0	12.0	-43.3	-7.3	11.0	-43.7	-11.0	12.0
DJF	-26.7	-2.0	21.7	-36.7	-5.0	15.7	-36.3	-3.3	25.3
JJA	-34.0	-11.7	13.0	-15.3	-15.3	-2.30	-69.7	-23.7	0.0

Source: McSweeney *et al.*, 2008.

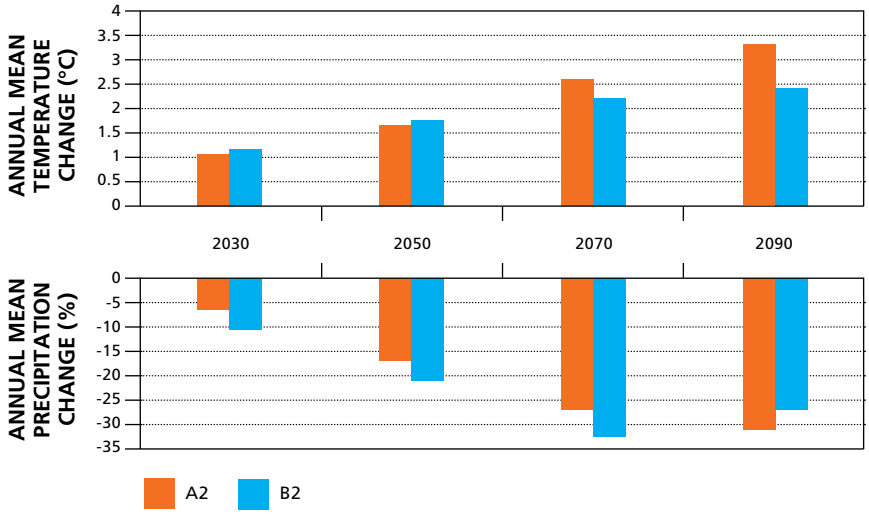
The report by McSweeney *et al.* (2008) further states that tropical cyclones are likely to become, on the whole, more intense under a warmer climate as a result of higher sea-surface temperatures. There is, however, greater uncertainty in the changes in frequency, and changes to storm tracks as well as their interactions with other features of climate variability.

Figure 8, gives the values for change in mean annual and maximum temperature and rainfall for Jamaica for 2030, 2050, 2070 and 2090 for both A2 and B2 scenarios (ECLAC 2011). By the end of the century, mean annual surface temperature is projected to change by 3.34 °C (A2 Scenario) and 2.44 °C (B2 scenario). The corresponding projected increase in maximum temperature is 3.3 (A2) and 2.56 (B2). With respect to precipitation, the drying trend is consistent with other projections discussed above.

6 Projections of annual and seasonal mean temperature and precipitation changes: All values shown are anomalies, relative to the 1970–1999 mean climates. The values are the average of an ensemble of 15 models under three emission scenarios.

FIGURE 8

Trends in annual mean temperature and precipitation changes for Jamaica (A2 and B2 scenarios)



Data Source: ECLAC 2011

BOX 4

Summary of climate change projections for Jamaica

The summary below is drawn based on currently available projections. Care must be taken when interpreting these results since they do not represent consensus of multiple realizations and uncertainties.

- The projected annual mean temperature change under the A2 and B2 scenarios for 2050 indicate increase of 1.66 to 1.73 °C. The projected mean annual maximum temperature change is in the magnitude similar to the annual mean temperature change.
- The projected annual mean precipitation change under the A2 and B2 scenarios for 2050 indicate reduction of precipitation by 16.9 to 20.8%. The greatest contribution to the annual drying comes from change during summer i.e. during June, July and August.
- Estimates over the period 1950 to 2000 supports that sea levels rise in the Caribbean has been near the global mean (1.2-2.2 mm/year or 2.4-3.8 mm/year in the post satellite era). In the future, sea level rise in the Caribbean may be more pronounced because of its proximity to the equator.
- Tropical storms and hurricane intensity is likely to increase under climate change but not necessarily through increase in frequency of storms

Source: ECLAC 2011; Taylor *et al*. (2011); Simpson *et al*. (2012)

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FARMERS DRAINING SALINE WATER FROM A BASIN INTO A CANAL. *Sugar canes in the coastal plains are often at risk of flooding caused by continuous rains and saline water intrusion from the sea which causes high degree of salinity. In addition, the high water table, about one foot below the surface, is detrimental for sugar cane cultivation.*

© S.Ramasamy

A FARMER PREPARING THE LAND FOR CROP CULTIVATION IN CASCADE, JAMAICA. *Expansion of agriculture under climate change will affect biodiversity through the impact of land cultivation on habitats and fragile ecosystems. For example, large-scale cultivation of crops has replaced some of the most biodiverse habitats in the mountains.*

CHAPTER 4

IMPACT OF CLIMATE VARIABILITY AND CHANGE ON AGRICULTURE

4.1 EXTREME CLIMATE EVENTS

4.1.1 Impact on agriculture

Events such as hurricanes, flooding, landslides, inundations, droughts and bush fires have long caused significant damages to agricultural infrastructure and crop and livestock production losses. Table 4 presents the damages and losses in agriculture due to major extreme climate events between 1994 and 2010 in Jamaica. The total agriculture losses incurred over this 16-year period has been estimated at J$14 390 million.

The proportion of impacts on agriculture to the total is very high when individual events are considered (Figure 9).

Tropical depressions often produce heavy showers across the entire island, resulting in multiple impacts in almost all parishes. For example, Tropical Storm Nicole caused heavy rainfall; parts of the island experienced over 500 mm of rainfall over five days from 25–30 September 2010 (Figure 10); and winds repeatedly reached 60 knots (PIOJ, 2010b).

The total damages and losses to the agriculture sector following a week-long intense rainfall from Tropical Storm Nicole were estimated at J$564 million. Crop damage accounted for J$532 million, while damage to livestock was put at J$32 million. In addition, damage to greenhouses was estimated at J$13 million. Damage to the infrastructure (farm roads) was estimated at J$575 million. The total damage to the agriculture sector per parish is presented in Figure 11.

TABLE 4

Damages and Losses in Agriculture Due to Recent Extreme Climate Events in Jamaica[7]

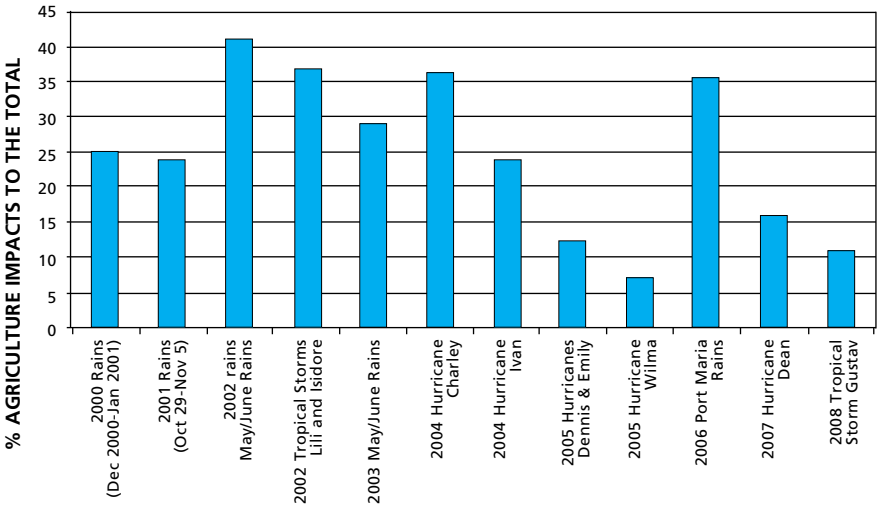
EXTREME EVENTS	FARMERS	CROPS (HA)	CROPS (VALUE J$)	LIVESTOCK (VALUE J$)	TOTAL ESTIMATED (VALUE J$)
HURRICANES					
Charley-August 2004	986	792	181 721 225	3 747 400	185 468 625
Ivan-September 2004	117 698	11 130	4 988 959 007	1 389 387 398	6 378 346 405
Dennis - July 2005	6 700	610	224 259 000	52 388 460	276 647 460
Wilma-October 2005	19 973	1 572	348 881 160	71 377 020	420 258 180
Emily-August 2007	1 499	656	56 455 200	604 800	57 060 000
Dean-August 2007	63 707	5 473	1 302 297 120	75 556 800	1 377 853 920
TOTAL	**210 563**	**20 233**	**7 102 572 712**	**1 593 061 878**	**8 695 634 590**
TROPICAL STORMS					
Gustav-August 2008	24 255	2 777	639 600 000	32 841 000	672 441 000
Nicole September 2010	18 601	3 741	531 632 000	32 415 000	564 047 000
TOTAL	**42 856**	**6 518**	**1 171 232 000**	**65 256 000**	**1 236 488 000**
FLOOD RAINS					
1994		2 250	304 378 500		304 378 500
1998		210	69 090 525		69 090 525
2000		327	136 307 220	7 655 760	143 962 980
2001	13 350	1 911	1 033 003 697	78 158 850	1 111 162 547
November 2006	811	50	34 074 600	4 653 600	38 728 200
TOTAL	**14 161**	**4 748**	**1 576 854 542**	**90 468 210**	**1 667 322 752**
BUSH FIRES					
March 1996	60	63	7 500 000		7 500 000
April 2000		46	33 222 000		33 222 000
July 2001	38	41	10 450 000		10 450 000
February 2005	100	74	30 886 500	780 570	31 667 070
TOTAL	**198**	**224**	**82 058 500**	**780 570**	**82 839 070**
DROUGHTS					
1999/2000	8 278	2 779	730 194 864		730 194 864
1995		1 817	521 594 798		521 594 798
1997		5 907	889 932 470		889 932 470
2005	14 269	2 058	524 005 137		524 005 137
2008	70	79	41 966 370	787 200	42 753 570
TOTAL	**22 617**	**12 640**	**2 707 693 639**	**787 200**	**2 708 480 839**
GRAND TOTAL	**290 395**	**44 363**	**12 640 411 393**	**1 750 353 858**	**14 390 765 250**

Source: RADA, 2011.

7 Value of damage and loss adjusted to 2010 cost and prices using adjustment factors.

FIGURE 9

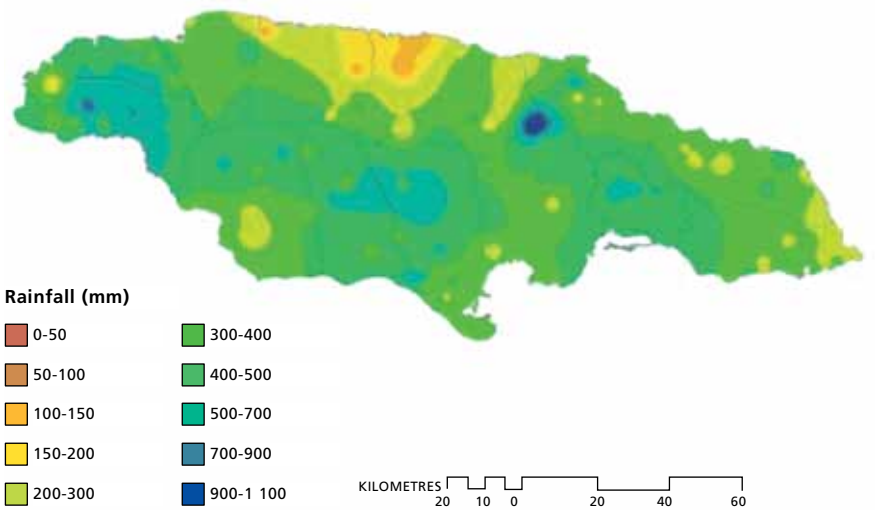
Percentage of Agricultural Impacts to the Overall Impacts of Extreme Climate Events (2000-2008)



Source: Data compiled for this study based on several country-level reports from 2000–2008.

FIGURE 10

Quantity of five-day rainfall over Jamaica caused by Tropical Storm Nicole[8]

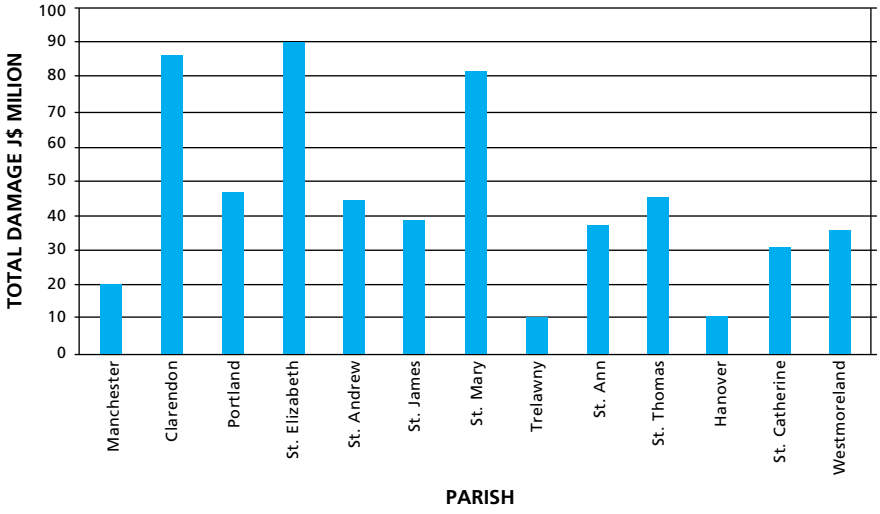


Source: PIOJ (2010).

8 Jamaica macro-socio-economic and environmental assessment of the damage and loss caused by tropical depression no.16/Tropical Storm Nicole. Prepared by the PIOJ, November 2010.

FIGURE 11

Total damage caused by Tropical Storm Nicole to the agriculture sector by parish in Jamaica



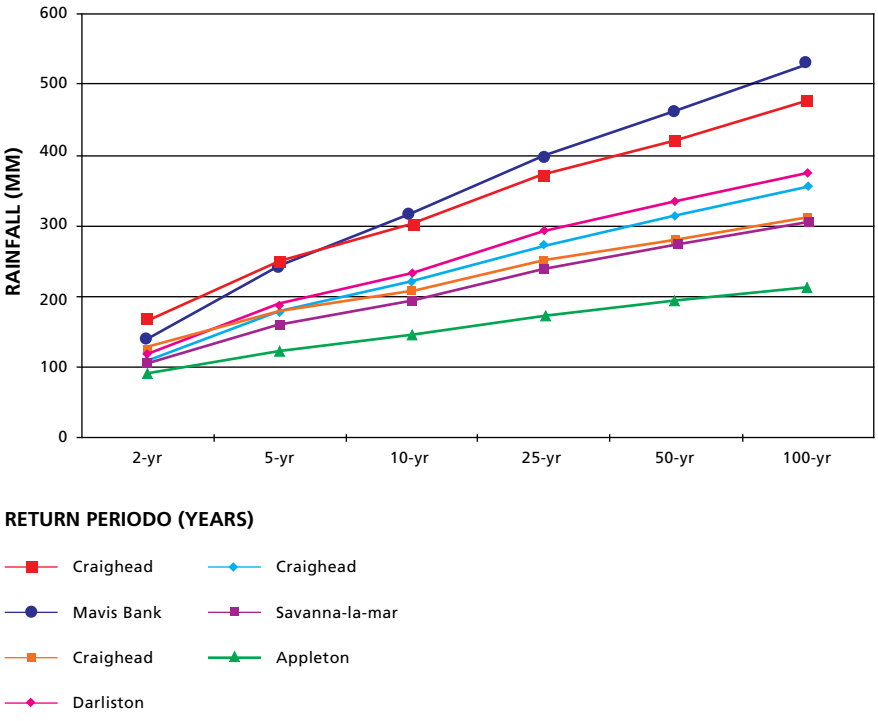
Source: PIOJ (2010)

Crops are often at risk of flooding caused by continuous rains. The severity of flooding depends on previous rains, the saturation of the soils as well as the rock materials. Continuous and high intensity rains during the hurricane seasons reduce the absorptive capacity of the soil. As a result, the surface runoff increases. During the passage of hurricanes, one-day rainfall often exceeds ten-year return period. The ten-year return period one-day rainfall for many rain gauge stations in Jamaica is more than 200 mm, except for two stations (Figure 12). For example, during Tropical Storm Michele in 2001, the daily rainfall values exceeded the long-term mean rainfall and caused severe damage to the agriculture sector. During the passage of Hurricane Ivan in 2004, the one-day rainfall figures exceeded the ten-year return period values.

On several occasions, the passage of hurricanes has caused up-welling; and dangerous waves driven by the very strong winds have caused flooding in coastal areas.

FIGURE 12

Rainfall Amounts for Rain Gauge Stations in Jamaica for Climatological Return Periods



Source: PIOJ (2004).

Damage and loss to the agricultural sector caused by hurricanes and associated flooding impacts the physical infrastructure and equipment, domestic crops (mainly legumes, vegetables, condiment, fruits, plantains, potatoes, yam and other tubers) as well as traditional export products (such as cocoa, citrus, coffee, banana, pimiento and sugarcane). For example, in September 2004, Hurricane Ivan damaged J$4 560 million worth of traditional export production (PIOJ, 2004). Furthermore, as agricultural activities are highly labour intensive, hurricanes also impact employment.

The impact of Hurricane Dean on various crops is discussed in further detail below (PIOJ, 2007):

- *Coffee*: In August 2007, Hurricane Dean caused the loss of approximately 45 percent of the total coffee crop and an estimated direct damage of J$ 1 231 million. (Table 5) It also reduced the production of sugarcane by 21 percent.

TABLE 5

Damages and Losses Caused by Major Climate Extremes to the Coffee Industry in Jamaica[9]

EVENT	DAMAGE (J$ IN MILLIONS)
Hurricane Ivan - September 2004	3 608
Hurricane Dean - August 2007	1 231
Tropical Storm Gustav – August 2008	133

Source: Data compiled from various assessment reports (PIOJ, 2004; PIOJ, 2007; and PIOJ, 2008).

- *Banana*: During the past six years, four major storms have caused severe damage to the banana industry in Jamaica. The damage caused by Hurricane Dean in August 2007 was significant across the major banana growing areas. In terms of crop production, there was an 85 percent loss of the standing crops and 95 percent loss of maiden suckers. It is estimated that Hurricane Dean has directly caused a loss in export earnings estimated at US$15 million, while the loss in domestic earnings over the similar period was US$25 million. The cost of full recovery as a result of Hurricane Dean was estimated at US$7.5 million dollars.
- *Sugar*: In terms of sugar, the factories of the Sugar Company of Jamaica (SCJ) incurred losses of approximately J$ 761 million during Hurricane Dean in 2007. As a result, it was estimated that total sugar production for the 2007/08 season was reduced by about 29 000 tonnes (21 percent), which represents lost revenue of about J$ 1.1 billion.
- *Dairy*: Dairy farmers located in the southern parishes of Jamaica were most vulnerable to the hurricanes. Hurricane Dean caused widespread dislocation in electricity and water supplies, and resulted in island-wide negative impacts on the dairy sector, either directly or as a result of the suspension of milk purchases by the distributive trade. It was estimated

9 Value of damage and loss adjusted to 2010 cost and prices using adjustment factors.

that direct losses in milk production were approximately 25 percent of daily production.

- *Poultry*: The passage of Hurricane Dean in 2007 resulted in moderate damage to the poultry subsector. The small poultry farmers – who account for approximately 30 to 35 percent of national production – experienced the worst damage. On the other hand, large farmers suffered minimal damage due mainly to better infrastructure facilities. In general, the impact of extreme events on small-scale poultry producers is greater than that on large-scale producers.

4.1.2 Impact on fisheries and aquaculture

The coastline, infrastructure such as buildings, utility poles and fences, and fishing equipment such as gear, boats and engines are highly exposed to hurricanes and associated secondary hazards. For example, in September 2004, Hurrican Ivan affected the south coast marine environment due to storm wave activity. The action of the sea, through the storm surge, caused severe damage to coastal line resources as well as to artisan and industrial fishery fleets and equipment. During Hurricane Ivan, 44 percent of the total number of traps was lost, and aquaculture facilities including the ponds, fish stock and inputs were affected.

The southern coast suffered the most substantial damage due to hurricane Dean (in 2007). Many beaches were inundated by copious amounts of sand and debris, changing the landscape, while some beaches were totally eroded. Many traps and other fishing gear were lost at sea. This loss is likely to lead to "ghost-fishing"[10] which poses a major threat to the viable existence of the fishery.

Access roads and fishing beaches have also been affected by recent hurricanes. Examples include Great Bay, Alligator Pond, Rocky Point (St Thomas), Rocky Point (Clarendon), Port Morant and Cow Bay (St Thomas). In 2007, losses within the fisheries sector due to Hurricane Dean were estimated to be J$9.8 billion (PIOJ, 2007), of which the aquaculture subsector was J$106 million (Table 6). In addition, the income-generating capacity of fishermen in these areas was severely interrupted.

10 "Ghost fishing" is the term used for lost or abandoned fishing gear that continues to catch fish. It is detrimental to the environment, and the fish caught are wasted.

TABLE 6

Damages to Fisheries and Aquaculture from Recent Hurricanes and Tropical Storms in Jamaica[11]

EVENTS	FISHERIES (J$ MILLIONS)	AQUACULTURE (J$ MILLIONS)
Hurricane Ivan - 2004	627	74
Hurricanes Dennis and Emily – 2005	584	-
Hurricane Dean – 2007	9 806	106
Tropical Storm Gustav - 2008	17	83

Source: Data compiled from PIOJ reports (PIOJ, 2004; PIOJ, 2005; PIOJ, 2007; and PIOJ, 2008).

In 2008, the impact of Tropical Storm Gustav on the fisheries sector is estimated at approximately J$17 million. The damage was related mainly to the loss of fishing gear, particularly fish traps and pots that were at sea during the passage of the storm. The aquaculture subsector reported losses totalling J$83 million. Some tilapia fish farms were flooded, infrastructure was damaged, and fish were lost, leaving fish farmers with a much reduced harvest or no harvest at all. The heaviest impacts were the loss of food-fish, fingerlings and damage to dykes and access roads. These losses occurred primarily in St Catherine which has the largest cluster of fish farmers in the island. Damage to the aquaculture sector was reported for the Hill Run, Bushy Park and Hartland areas (PIOJ, 2008). The total cost of damage to the subsector is presented in Table 7.

TABLE 7

Summary of Estimated and Reported Losses to the Aquaculture Sector Caused by Tropical Storm Gustav, 2008

LOCATION	FOOD FISH (LBS)	FINGERLINGS	OTHER DAMAGE/LOSS	NO. OF FARMERS REPORTING LOSS	COST (J$)
Hill Run	424 300	608 000	Broken dykes, damaged roadways, loss of brood stock and mature Koi, damaged ponds.	15	65 143 260
Bushy Park	110.833		Loss of dykes, damage to roadways	9	14 370 459
Hartland	14.670	61 000	Loss of material for ornamental building shed, shade cloth	10	3 865 890
Total Total	**549 803**	**669 000**		**34**	**83 379 609**

Source: PIOJ, 2008.

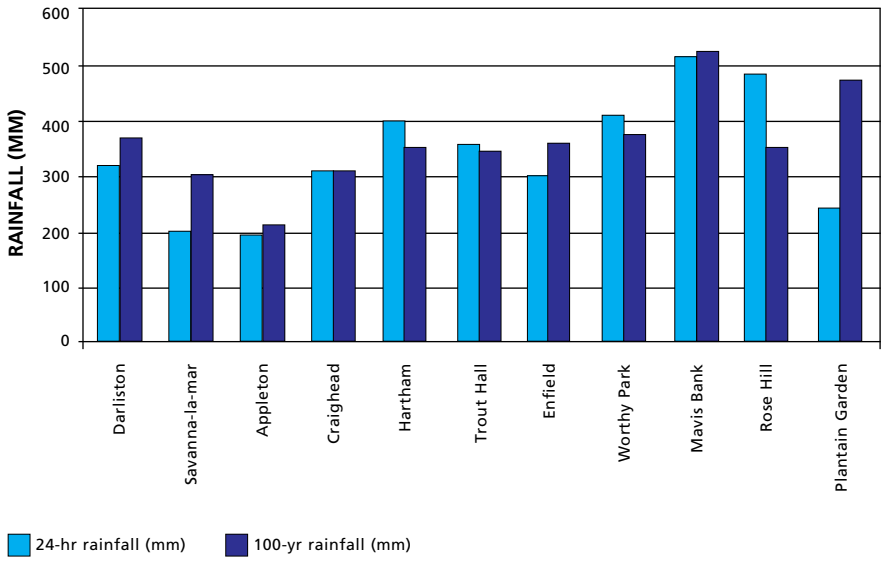
11 Value of damage and loss adjusted to 2010 cost and prices using adjustment factors.

4.1.3 Impact on arable land and infrastructure

Due to the action of strong winds and floods, physical infrastructure and equipment for the agriculture and livestock sectors sustain significant damage and destruction, including that to farm buildings and equipment, farm roads and irrigation equipments. Damage to the land is also common during hurricanes on account of the upstream erosion and silting, and uprooting of permanent plantations. Sustained and high intensity rainfall events often cause severe damage to land, mainly as a result of soil erosion. For example, 24-hr rainfall during Hurricane Ivan (2004) exceeded 100-year return period rainfall amounts in some areas (Figure 13). Farm roads are often damaged, mainly because of the heavy rainfall and subsequent erosion. A total of 739.6 km of farm roads were damaged by the heavy rains during Tropical Storm Nicole in 2010 (PIOJ, 2010).

FIGURE 13

Comparison of 24-hr Rainfall Amount During the Passage of Hurricane Ivan and 100-yr Return Period Rainfall in Southern Parishes of Jamaica



Source: PIOJ, 2004.

4.2 IMPACTS OF CLIMATE CHANGE ON ECOSYSTEMS, AGRICULTURE AND ECONOMY

4.2.1 Fragile ecosystems

Many impacts of climate change can currently be observed in the Portland Bight Protected Area (PBPA) including: damage to marine and wetland ecosystems, reduction of marine ecosystem services, coral bleaching and coast line erosion resulting in loss of beaches. Until 2003, the mangroves of the PBPA included some of the largest red mangrove trees in Jamaica (more than 20 m in height). Almost all were destroyed by the high winds during Hurricanes Ivan and Dean (PIOJ 2004; PIOJ 2007). This destruction can contribute to declining fish catches, erosion of cays and, specifically, loss of nesting habitats for sea turtles and seabirds.

Hurricanes are also causing severe damage to the tropical dry forests of the PBPA. The destruction of most of the trees on Portland Ridge by Hurricane Ivan was followed by severe drought. The fallen trees and leaves dried out, and most of the area was ravaged by fire in 2005. This destruction caused damage to habitats of endangered species of wildlife. Other problems include increased soil erosion from hills and increased salinization of coastal aquifers; the latter consequence is also associated with reduction of recharge and over-pumping of aquifers. The increased sediments in runoff may cause increased damage to coral reefs.

4.2.2 Crop suitability

The study, "Impact of climate change on Jamaican hotel industry supply chains and on farmer's livelihoods" conducted by the International Centre for Tropical Agriculture (CIAT) and Oxford Committee for Famine Relief (OXFAM) (2011), used focus group discussions to identify crops and to undertake a participatory analysis of the current and future biophysical suitability of crops under a changing climate. A mechanistic model based on the Ecocrop database (FAO, 1998)[12] was used to predict spatially, crop suitability. The model essentially uses minimum, maximum, and mean monthly temperatures, and total monthly rainfall to determine a suitability index.

The results from this study are given in Table 8, showing the climate suitability of 14 crops. Models indicate suitability index between 80 and 100 for most crops values, which means excellent growing conditions on current climate data.

12 Ecocrop database available at http://ecocrop.fao.org/ecocrop/srv/en/home.

TABLE 8

Average Suitability Change of Examined Crops by 2030 and 2050

CROP	AVERAGE CURRENT SUITABILITY	AVERAGE SUITABILITY FOR 2030	AVERAGE SUITABILITY FOR 2050	AVERAGE SUITABILITY CHANGE BY 2030	AVERAGE SUITABILITY CHANGE BY 2050
Banana	69	82	87	13	18
Cabbage	91	73	57	-19	-35
Carrot	88	66	53	-22	-35
Cucumber	74	86	93	13	19
Ginger	81	53	34	-27	-47
Irish potato	82	69	59	-13	-22
Lettuce	92	76	64	-16	-28
Mango	63	69	62	7	-1
Orange	59	61	53	2	-5
Sweet Potato (low altitude)	70	85	92	15	22
Sweet Potato (high altitude)	91	72	56	-19	-36
Tomato (low altitude)	68	84	91	16	23
Tomato (high altitude)	88	74	64	-14	-25
Zucchini	77	90	95	13	18
Average all crops	78	74	69	-4	-9

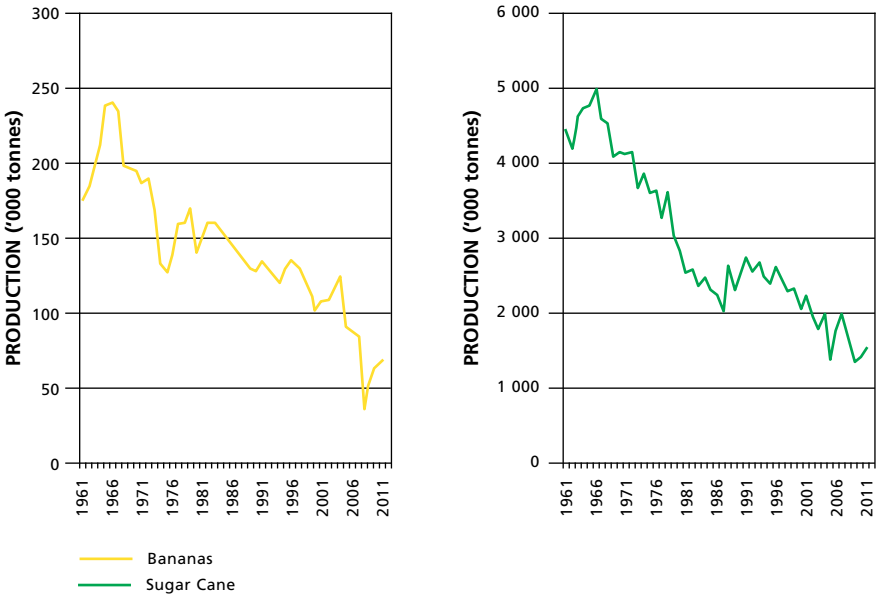
Notes: - Sweet potato is calculated for two different altitude levels (low: mostly red skin, white flesh; high: mostly red skin, yellow flesh).

Source: CIAT-OXFAM (2011)

For 2030, predictions show suitability values between 60 percent and 80 percent. Suitability is still very good and remains excellent for banana, cucumber, sweet potato (low altitude), tomato (low altitude) and zucchini. In fact, the study concluded that there will be slight increases by 2030 in the overall climate suitability of banana with more inland production. Currently, the main banana production areas are located in lower regions and coastal areas. However, this distribution is expected to change and mountainous regions will gain climate suitability of approximately 13 percent.

FIGURE 14

Banana and Sugar cane production in Jamaica (1961 – 2011)



Source: FAOSTAT

The traditional export crops such as sugarcane, banana and coffee are most important in terms of employment and foreign exchange earnings. The production of these crops are variable and there has been a decline in banana and sugar cane production over the years (Fig 14). These crops have historically sustained the most losses during extreme weather and climate events. Any future shift in crop suitability due to climate change may further influence the export earnings.

For 2050, suitability is predicted with ongoing decline. Cabbage, carrot, Irish potato, orange and yellow sweet potato (high altitude) have values of climate suitability between 40 and 60, which indicates that the climate will be suitable for their cultivation. Crops with values below 40 on climate suitability (e.g. ginger) end up in marginal conditions for crop development and are considered to have insufficient productivity.

The change in suitability, as presented in Table 8, indicates that the most affected crops will be cabbage, carrot, ginger, sweet potato (high altitude) and tomato (high altitude), with declining climate suitability between 25 percent to 47 percent.

4.2.3 Land degradation and deforestation

Degradation of agricultural land and decline in soil fertility are long-term threats to food security and sustained agricultural productivity. Soil productivity can decline as a result of a range of factors including wind and water erosion of exposed topsoil, soil compaction, loss of soil organic matter and water holding capacity, salinization of soil and irrigation water, and overgrazing. Deforestation also is a threat, resulting from clearing of hillsides, illegal settlements, conversion to monoculture farming and uncontrolled harvesting. Increasing temperature and altered rainfall pattern would reduce potential area for crop production.

The impacts of deforestation include watershed and water quality degradation, increased soil erosion, siltation of coral reefs, loss of biodiversity and habitats, and increased flooding effects. An analysis of forest cover estimates over time for Jamaica showed that the total forest area in Jamaica fell from 365 244 ha in 1989 to 325 000 ha in 2000, representing an annual deforestation rate of 0.1 percent (Evelyn and Camirand, 2003). Conversion of forest land to agriculture in order to meet the growing demand for food will place additional threats on both forests and biodiversity.

4.2.4 Water resources

Jamaica is divided into 26 watershed management units, all of which have portions considered to be very degraded. Higher levels of soil erosion, increasing siltation and turbidity, and reduced quality of water are experienced in 19 of the 26 watershed management units.

Agriculture is the major user of the island's water resources accounting for 75 percent of annual water consumption, compared with 17 percent for urban domestic water supply and 8 percent for other uses including industrial use, rural domestic water supply and tourism (FAO, 1997). The demand for water resources is projected to increase under climate change scenarios (Table 9).

Agriculture may affect the quality of freshwater in several ways, including through over-intensive cultivation on steep slopes, resulting in soil erosion where proper soil conservation techniques are not used. The poisonous residues from agricultural chemicals affect freshwater sources, and leakages of fertilizers also contribute to water pollution.

TABLE 9

Limestone Aquifer Estimated Supply-Demand Balance under the 2030s, 2050s and 2080s Scenarios for Southern Clarendon, Jamaica

	BASELINE SCENARIO (M3/D)	2030S SCENARIO (M3/D)	2050S SCENARIO (M3/D)	2080S SCENARIO (M3/D)
Sustainable Yield	296 000	236 000	187 000	74 000
Agriculture Demand	222 000	262 000	262 000	262 000
Domestic demand	50 000	67 000	76 000	900 00
Industrial demand	24 000	24 000	24 000	240 00
Total demand	296 000	353 000	362 000	376 000
Supply/Demand Balance	0	-117 000	-175 000	-302 000

Source: Water Resources Authority (WRA), 2008.

4.2.5 Biodiversity

Expansion of agriculture under climate change will affect biodiversity through the impact of land cultivation on habitats and fragile ecosystems. For example, large-scale cultivation of coffee has taken place in the Blue Mountains over the past three decades, replacing some of the most biodiverse habitats in the mountains with an almost monoculture system.

Jamaica's marine resources are also threatened by unsustainable harvesting, inadequate fisheries management and loss of fish habitats, such as mangroves or coral reefs. According to National Environment Action Plan (1995), the CARICOM (Caribbean Community and Common Market) Fisheries Resource Assessment and Management Programme (CFRAMP) has declared Jamaican waters to be the most overfished in the English-speaking Caribbean. Poverty in many coastal populations is probably an important driver for fishermen to carry on with over-fishing. Additionally, biodiversity may be affected over the long term by unforeseen effects of climate change.

4.2.6 Fisheries and aquaculture

While there is a dearth of research on the specific effects of climate change on commercial and artisanal fisheries in the Caribbean, valuable insights can be gleaned from observations and projections. In contrast with some projections in middle and higher latitudes, the consequences of climate change on Caribbean fisheries are expected to be mostly negative. Adverse

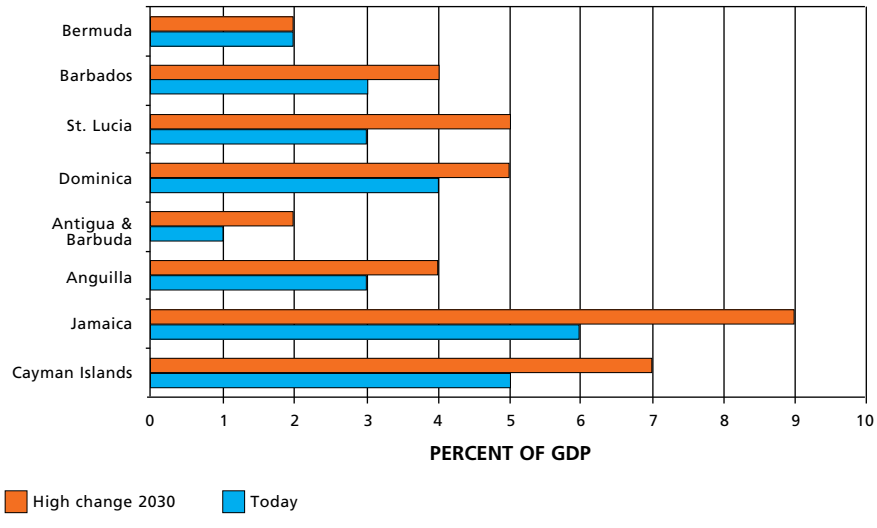
impacts on regional fisheries are likely to manifest themselves through habitat alteration and loss, reduced abundance and diversity, and possibly shifts in distribution induced by changes in ocean currents.

4.2.7 Expected impact on economy

The damage potential of climate change under current climatic and economic conditions is already high, with annual expected losses totalling to 6 percent of GDP in Jamaica (Caribbean Catastrophe Risk Insurance Facility, 2010), the highest among the eight countries analysed. The Caribbean Catastrophe Risk Insurance Facility's (CCRIF's) Economics of Climate Adaptation (ECA) initiative projects that climate change has the potential to exacerbate these risks, and could increase expected loss by 1 to 3 percent of GDP by 2030 (Figure 15). Among the hazards considered for the above analysis, hurricane-induced wind damage has the largest damage potential and accounts for up to 90 percent of the overall damage. The contribution of coastal flooding/storm surge to total damage is greater in low-lying regions.

FIGURE 15

Expected Loss in GDP from Climate Risk Today and by 2030



Source: Caribbean Catastrophe Risk Insurance Facility, 2010.

Jamaica's economic costs under the low- and high-impact scenarios are presented in Table 10. By the year 2025, the annual losses in Jamaica in the low-impact scenario is projected at 3.4 percent of current Jamaica's GDP (US$ 8.77 billion); and in 2100, is estimated at 11.2 percent. The cost of inaction under the high impact scenario is calculated as 17.3 percent in 2025 and 68.1 percent in 2100. The percent of current GDP at risk in Jamaica by 2050 will be much higher compared to the average Caribbean values.

TABLE 10

Jamaica's Costs of Climate Inaction (as % of current GDP)

	IMPACT SCENARIO	GDP (BILLION US$)	2025	2050	2075	2100
Jamaica	Low impact	8.77	3.40%	6.00%	8.60%	11.20%
	High impact		17.30%	33.90%	50.90%	68.10%
Caribbean	Low impact	212.4	1.80%	2.70%	3.60%	4.50%
	High impact		6.80%	13.00%	19.50%	26.30%

Source: Bueno *et al.*, 2008.

BOX 5

Crop groups of Jamaica based on their use

Export crops: Traditional export crops are sugar, coffee, pimento, bananas, and citurs; and non traditional export crops are yams, fruit juices, ackee, papayas, sweet potato, dasheen, mangoes and pumpkin

Crops for domestic use: Fresh produce include greens and ripe bananas, yam, dasheen, sweet potato, Irish potato, cassava, legumes, vegetables, herbs and spices and fruits.

Crops for supply to tourism sector: Fresh produce include red cabbage, sweet corn, zucchini, yellow crooked neck squash, red and yellow sweet peppers, snow peas, salad tomatoes, yams; Exotic fruits include pawpaws, melons, pineapples, cantaloupes, otaheiti apples, naseberries, mangoes, oranges, grapefruits, start apples and june plums.

Source: Simpson *et al.* (2012)

FISHERMAN IN OLD HARBOUR BAY, ST. CATHERINE, JAMAICA.
Jamaica's near shore waters are among the most overfished in the Caribbean. Many artisanal fishermen have few alternative sources of income, creating a high level of dependence on near shore fisheries. Use of fish pots or traps with small mesh sizes, mechanization, along with a rapid increase in spear-fishing and compressor diving have all exacerbated the overexploitation of Jamaica's fisheries.

WOMAN FARMER PLACING YAMS IN A BASKET. *Farmers grow a variety of crops (e.g. yams, cassava, escallion) to cope with climate variability. Technical support, capacity development and awareness raising are critical to strengthen the coping strategies and advance adaptation to climate change.*

BREADFRUIT CULTIVATION FOR MARKET IN THE NORTH CLARENDON AREA. *Promotion of alternate livelihood and income generation activities are important to cope with climate risks. Though several alternate options are already available, additional options for livelihood diversification are required.*

CHAPTER 5

COPING AND ADAPTATION STRATEGIES

5.1 LOCAL COPING STRATEGIES

Local communities develop their own coping strategies to reduce the impacts of climate variability regardless of interventions from outside. The indigenous and traditional coping practices are normally passed down from generation to generation over many years. Through community dialogue and participative consultations by Gamble *et al.* (2010), many coping strategies were documented in Jamaica. For example, the ODPEM reported that farmers in Jamaica are already practising strategies such as improvising informal irrigation systems, mulching for retention of soil moisture, crop diversification, and changes in crop season and water storage (ODPEM, 2010).

Farmers in southern St Elizabeth followed a variety of adaptation measures to manage drought, including: planting quick crops (e.g. escallion); planting more drought-resistant crops (e.g. escallion, cassava); scaling down production during dry season; edging (e.g. perimeter planting with guinea grass); careful timing of water application; sacrificing proportions of crops; and sharing water, drip irrigation, trucked water and use of black tanks to store water (Campbell *et al.* 2011).

Community dialogue conducted as part of the PPCR identified coping measures followed by the farmers, such as soil erosion control (e.g. tyre bonding), community risk mapping, sustainable farming techniques, water management/rainwater harvesting, protective agriculture (greenhouses),

selected cropping during dry season (e.g. some farmers plant gungo peas and cassava in Mavis Bank) and adjustment of planting seasons (in Bushy Park much cultivation takes place between December and August). In addition, improved soil and crop management (e.g. use of organic materials), reforestation, establishment of boundaries/reserves to regulate the forest cover, agroforestry, engagement of the community, data gathering and use, public awareness, training of farmers in climate resilient best practices and mangrove replanting are all considered suitable coping practices (PPCR, 2011a and 2011b).

Through its livelihood-based impact assessment, FAO (2010b) identified local community-level coping practices, which included: sharing seeds with other farmers; requesting food scraps from restaurants and other places to supplement livestock feed for hogs and cattle; repairing sheds and structures with temporary natural materials (broom thatch etc.); participating in more "lend a day" farm labour activities to get and give help; reducing farm inputs such as fertilizers and pesticides; cutting grass for extra fodder for cattle; and keeping watch over remaining crops and livestock to fend of praedial larcenists (e.g. taking turns keeping guard, setting up traps and security systems). Switching to dwarf varieties of fruit trees, planting hedgerows around and between high risk/vulnerable crops (such as banana) to reduce wind impact and growing root tuber crops during hurricane season are some of the coping practices reported by FAO (2010b). Good practice examples of coping strategies are provided in Appendix 1 to this report.

Agricultural practices such as integrated farm management and organic agriculture, management of low-intensity pasture systems, preservation of landscape and historical features such as woods, marshes and mangroves, rivers and streams, and conservation of natural habitats and their associated biodiversity can enhance resilience against climate impacts. These measures can have a range of beneficial environmental effects including soil conservation, improved soil fertility, carbon sequestration and improved water availability.

5.2 TYPOLOGY OF ADAPTATION STRATEGIES TO COPE WITH CLIMATE CHANGE

Given the high level of vulnerability to climate-related shocks and the dependency of the rural population on agriculture and fisheries for livelihoods, Jamaica is particularly threatened by the potential impacts of climate change. Alleviating poverty and ensuring household-level food security under a changing climate is a major challenge. Ensuring institutional and community participation in climate change adaptation as well as institutional development and policy support is crucial. An integrated approach is important for managing future climate risks at the community-level, in general, and in the agriculture sector, in particular. This chapter presents the priority areas that need attention.

5.2.1 Strengthening of institutional mechanisms and technical capacities

There is a need to strengthen MOAF to advance climate change adaptation and disaster risk management in the sector. The creation of a focal unit within MOAF has been proposed, possibly consisting of three to four trained technical staff. Initially, this unit could be set up as part of a project-based intervention. Later, it could be integrated within the institutional system with committed government support. The experts in the focal unit could assist in reviewing the adaptation practices as well as validating and integrating them into the programmes and projects. Such a unit within MOAF could promote information communication and knowledge sharing as pertains to climate change and agriculture. Currently, knowledge management and communication on climate change is weak within the agriculture sector, so reinforcement of the possibility for information exchange is vital. Reports, data and information are spread among many organizations and are not being shared. The unit could also carry out capacity development programmes for agriculture, fisheries and aquaculture. However, an initial training of trainers programme on climate change is a prerequisite.

Institutional capacity building and strengthening of organizational networks across all levels in the agriculture sector is a basic precondition to advance adaptation. Provision of a comprehensive approach with concrete

roles for action is necessary to motivate change in local perceptions and to ensure meaningful interventions through agriculture service providers, including government institutions. The areas of technical capacity development are: community mobilization, climate risk and vulnerability assessment, prioritization of adaptation interventions, and monitoring and evaluation. However, retention of highly trained technical staff is important if Jamaica is to develop the necessary skills, to design adaptation interventions and programmes, and to create policies to support the implementation of programmes related to climate change adaptation in agriculture.

5.2.2 Mainstreaming of climate change priorities into policies, plans and programmes

Jamaica has developed a National Hazard Mitigation Policy (National Hazard Mitigation Policy Development Committee, 2005) which focuses on reduction of vulnerability to both natural hazards and those caused by humans. According to this policy, the sources of hazard vulnerability in Jamaica are varied and complex, and are related to: population growth and dynamics; inappropriate land use; environmental damage; inappropriate/insufficient conceptualization and implementation of policy initiatives aimed at hazard-risk reduction; high levels of poverty, inequity and exclusion in terms of access to resources for hazard-risk reduction; low levels of institutional/organizational collaboration and partnerships to effect hazard-risk reduction; and a paucity of environmental, technological and social data to support the formulation of strategies for hazard risk reduction.

While new initiatives are required to advance adaptation, the agriculture sector can begin by strengthening existing management practices and by mainstreaming adaptation into policies, programmes and projects. As such, the existing platform can provide the basis for sound adaptation policies and legislation.

Efforts towards adaptation in the fisheries subsector should include enforcement of existing marine pollution control, protocols and abatement of contamination from land-based sources as well as expansion of habitat protection and restoration. For example, as this region is prone to hurricanes and storms, the use of biodegradable fishing traps would contribute to reduce ghost fishing of the traps lost during extreme weather events.

In the context of mainstreaming adaptation within agriculture, fisheries and aquaculture policies, the following priorities need to be considered:

- The thrust towards developing a strategy for climate change in the agriculture sector should consider and build upon work already done with Agricultural Disaster Risk Management (ADRM).
- Appropriate zoning and planning within production areas is needed to ensure that risk and vulnerability are minimized.
- Hazard mapping is needed for the most critical areas to assist in better planning and adaptation to climate change.
- There is a need to update land suitability and capability maps to ensure that land in production is suitable for specific crops being planted, and that areas are not vulnerable.
- A suite of adaptation measures needs to be developed that are culturally relevant, suitable for the Jamaican context and which are short-, medium- and long-term. RADA's capacity should be built to assist with implementation of these measures.
- Studies such as the one conducted by CIAT-OXFAM (2011) on climate change and agriculture should be disseminated to MOAF and RADA to be utilized in decision-making with farmers.
- Water is a major issue associated with climate variability and change. There is a need for additional studies such as the WRA vulnerability and capacity assessment for other agricultural areas, especially those affected by drought, which should then be considered as part of the planning process.
- Efforts at climate change adaptation must be coupled with watershed and coastal area management, as impacts are often exacerbated by poor practices. The implementation of holistic and integrated approaches such as the ecosystem approach to fisheries and the ecosystem approach to aquaculture should be promoted.

To sustain livelihood activities, long-term planning and the implementation of preventative measures must be pursued. Priorities that require policy support include: development/enactment of a comprehensive and integrated watershed management plan for the island; development of community disaster preparedness, livelihood assessments and mitigation plans to

empower communities to respond to natural disasters; hazard mitigation mapping and zoning; preservation of natural drainage systems, maintenance of drainage systems and construction of new drainage in areas, where necessary. Implementation of these priorities should consider the projections of climate change and its associated impacts.

5.2.3 Assessment of vulnerability and impacts of climate change on key agricultural subsectors and strengthening of climate information services

There has been very little work related to assessing vulnerability and impacts of climate change on key agricultural subsectors in Jamaica. There are some indications about possible changes of hazard frequency and magnitude, and predictions for likely future scenarios. However, this research does not consider subsequent impacts on livelihood base. Therefore, the social, economic and environmental risks and vulnerabilities associated with these hazards are not clearly known across various agricultural production systems in the country. It is important to note that the impact of natural disasters on the agriculture sector is underestimated as soil erosion and soil loss, along with other effects, are not usually quantified in impact assessments.

FAO has initiated a capacity building programme to train RADA officers through its Integrated Livelihood Based Impact Assessment Toolkit (FAO, 2010b). The main purpose of this training is to build capacity through the development of livelihood assessment skills among key staff of key agencies so that they may be better able to respond to disasters in the agricultural sector. The programme aims to ensure that good baseline data is collected before a disaster occurs. Having such data on families and communities before and after a disaster occurs provides a robust basis for making estimates on the livelihood impacts of disasters. Such data can feed into a flash appeal, or give a 'head start' to and provide a basis for, immediate post-disaster assessments.

Climate information products and services should be developed to promote decision-making in agriculture sector. Establishment of User Interface Platform (UIP), capacity development for interpretation of climate information and building partnership between Jamaica Weather Services, MOAF and user communities are crucial.

5.2.4 Strengthening of data collection, monitoring and forecasting

There are significant gaps in data collection and data availability for adaptation planning. Without such data, it is difficult to understand the existing stresses in agriculture systems. It is important to possess such data to develop coping strategies for current climate challenges and to assist with forecasting what future climate might mean with respect to sustainable agriculture. Decision-making related to the implementation of technical or engineering measures requires data on vulnerabilities and risks in order to promote proactive adaptation planning and implementation of risk-reduction measures. Risk maps addressing different threats could be very useful in better planning the location of new activities (e.g. aquaculture) and crops.

Although MOAF collects climate and crop data, that information is currently not used for any forecasting purposes. Policy-makers and farmers often seek information about crop prospects for proactive decision-making. Any climate variability and change initiative by MOAF should involve crop data analysis and forecasting to provide farmers with the necessary information to alter their practices in order to reduce their vulnerability.

5.2.5 Investment in climate risk reduction measures to protect livelihood assets

There are problems associated with the management of hazards mainly because of absence of proper planning and implementation of risk-reduction measures. Hazard mapping, development of zoning plans, and land-use planning are not being utilized in mitigation. Increased access to new technology has made reporting more accurate and has also allowed for provision of detailed information regarding the effects of events on particular sectors. However, direct investment in climate risk reduction has been weak to date. While activities can be linked to addressing climate risks, there is little direct consideration of climate change in programmes and projects.

A review of projects in agriculture suggests that various projects are linked to addressing climate change adaptation and climate risk reduction. These efforts are supported mainly by backing from external sources,

by grants and by government funding. Efforts to garner information on investment in traditional export crops in the private sector were not forthcoming. Aligning agriculture sector priorities to Jamaica's climate change strategy (part of the Vision 2030: National Development Plan) can leverage additional resources for implementing climate risk-reduction measures to protect livelihood assets.

5.2.6 Investment in water resources development, conservation and management

There are investments in the agricultural sector with respect to improved methods of irrigation, development of high-value agriculture crops and agriculture infrastructure. Enhancing irrigation water use efficiency and water productivity are potentially important means of reducing overall water requirement. Therefore, such approaches should be explored, especially by organizations such as the National Irrigation Commission (NIC), as a means to encourage efficiency by their customers.

To assist with the management of water supply for agricultural purposes, small-scale water harvesting ponds are the most suitable means of water supply to small farmers during water scarcity and dry spells. *In situ* moisture conservation practices improve soil moisture conditions as well as the crop yield during dry spells. Development of small-scale reservoirs to replenish ground water is one of the important strategies to enhance efficient water resource management. Potentially, the development of such infrastructure offers alternative surface water sources that could be used conjunctively with the existing groundwater sources to maximize yields. In addition, such infrastructure would help to ensure that water resources are managed in a long-term sustainable manner, allowing for positive responses to the challenges presented by climate change and sea level rise. However, the risks associated with extreme climate events need to be assessed in order to design such an infrastructure.

Improving the connectivity of the existing water supply system is linked with the intervention recommended above, as there is a need to offer more than one potential source of supply to a particular agriculture zone. These

links are important for water supply reliability and also offer the potential to blend sources to improve water quality. Similarly, expansion of the water trading market offers a ready means of redistributing water between different sectors. It could be a relatively simple means of developing new sources for the municipal sector, which generally has higher water quality requirements.

5.2.7 Strengthening of production and productivity programmes for improved domestic food crops

The positive growth in the domestic food crop subsector in 2009 compared to 2008, reflects a recovery of this subsector which had recorded a 6.4 percent decline in 2008. Domestic crops have been benefiting from interventions from the MOAF, and in 2009 there was a 20 percent growth. The growth in this subsector was attributed to: MOAF's Production and Productivity Programme; to the National Irrigation Development Programme (NIDP); to other programmes which offered support in areas of marketing and extension services; as well as to expansion of protected agriculture (greenhouses) along with more efficient and increased use of irrigated lands. MOAF reported that there was a 64 percent increase in the volume of crops produced using protected cultivation (greenhouses).

MOAF's Production and Productivity Programme is aimed at improving best practice methodologies among groups of farmers engaged in the production of a selected group of crops. The programme, which started in 2008, included 16 crops. An important strategy was the use of drip irrigation systems which were integrated with the use of 'black tanks' in areas without access to irrigation schemes. This system assisted in reducing the impact of drought on crop yields. In addition, the increased production resulted in increased consumption of domestic crops and reduced levels of imports.

MOAF has crafted policies to support critical subsectors including sugar, bananas, citrus, coffee, cocoa and domestic food crops. The agriculture sector is comprised mainly of small- and medium-sized farmers with 5 ha of land or less, who account for 85.6 percent of total agricultural holdings.

In his 2010 budget speech, the Minister of Agriculture estimated that 25 percent of Jamaica's agricultural land has been lost to other forms of development. Currently, an Agricultural Land Utilization Policy (ALUP) is being developed. It is expected to protect prime agricultural land from being utilized for purposes besides farming.

5.2.8 Promotion of livelihood adaptation to climate variability and change

The sustainable livelihoods and assets of several vulnerable livelihood groups were significantly affected by the passage of tropical storms. These included actors along the value chains, such as retailers, small shopkeepers, truckers and haulers, farmers and market vendors. According to the Government of Jamaica's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), the small-scale farmers (0 to 5 ha) are the most resource-deficient. They account for nearly 85 percent of all farms in Jamaica and are the most vulnerable to climate-related hazards (Government of Jamaica, 2011).

Applying a livelihoods perspective to climate change adaptation is helpful to understand and promote local-level adaptation to climate change. Community and household assets are influenced by the institutions, organizations, policies and legislation that shape livelihoods. The institutions and processes operating in both public and private spheres and from household to national levels determine access to assets, livelihood strategies and vulnerability to climate change. Adding climate change adaptation through a livelihood perspective improves the adaptive capacity of farmers by increasing household access to assets and services.

Promotion of alternate livelihood activities is important to cope with climate risks. Though several alternate livelihood patterns are already available, additional options for livelihood diversification are required. These will enhance the applicability of localized alternate livelihoods taking into consideration particular natural resource endowments.

5.2.9 Use of traditional and local knowledge to speed up adaptation planning

Traditional knowledge related to managing climate-related risks and enhancing resilience is important for the knowledge base when designing adaptation interventions. This "on the ground" reality coupled with science offers a basis for sound adaptation planning and decision-making. Various studies have been conducted on agriculture and climate change, but there is little evidence of follow-up on recommendations.

Although farmers often rely on proven local practices and indigenous knowledge to reduce climate impacts, it is necessary to assess the real value of these practices in the context of managing future risks. Many practices such as land-use planning, watershed management, plant production, farming systems research, development of drought-tolerant varieties and small-scale water harvesting are already in place. Factoring existing knowledge about climate risks into new approaches in the context of climate change adaptation is a good entry point.

5.2.10 Raising of awareness at the grassroots level to enhance adaptive capacity

Awareness-raising is a key step to encourage farmers and local communities to cope with climate variability and climate change risks. Awareness-raising activities can be enhanced through government and non-governmental interventions. Provision of essential support needs to become an integral part of enhancing adaptive capacity. Such support includes information, technology, technical expertise, alternative sources of income and employment, credit facilities, insurance mechanisms, health facilities and information on markets, and dissemination of all awareness messages in local languages. The awareness-raising strategy should be embedded into the existing agriculture services systems such as agriculture extension services provided by RADA.

5.2.11 Strengthening of agricultural linkages to supply chains

Although agriculture is a small contributor to GDP, it has the potential for greater linkages with other sectors, especially the tourism sector. While primary crop production is important, value-added products also have the potential to be major earners in foreign and domestic markets.

IICA's study of the Contribution of Agriculture to Sustainable Development in Jamaica (2010) concluded, from data analysed between 1997-2007, that the rest of the economy (i.e. not including agriculture) grew at the expense of agriculture. In fact, resources had been withdrawn from agriculture and shifted to other economic sectors.

The Sandals Group is one hotel chain that has successfully made the link between farmer and the hotel. Sandals's approach to developing agricultural supply linkages has been quite distinctive, going beyond just increasing their own demand for local products. Developing good working relationships between farmers and hotels is possible by improving the quality of produce, developing proper pricing arrangements and facilitating communication between farmers and hotels.

There is increased recognition of further linkages between these two sectors through the promotion of agritourism, i.e. attracting travellers or visitors to areas used primarily for agricultural purposes. These are commercial enterprises at working agricultural facilities operating for the enjoyment of visitors while generating income for the owner.

5.2.12 Development of agriculture weather risk management

Jamaica is a high weather risk country, and thus requires weather risk transfer mechanisms. MOAF has taken the initial steps to move from an unplanned system of responding to natural disasters, to an *ex ante* financial risk management framework that addresses the risks of the agriculture sector in a more efficient and effective manner. The findings of a pre-feasibility assessment (MOAF, 2010) present possible options for introducing alternative risk management mechanisms. These aim to improve agriculture risk mitigation practices and coping mechanisms to small farmers in order to reduce volatility of agricultural incomes.

The assessment has found that lower levels of risk (i.e. frequent droughts) can be covered by savings, farming practices and assets of farmers, through additional credit, or through risk-mitigation measures. However, for higher risk levels that have caused more damage to the agricultural sector (i.e. hurricanes or severe droughts that are less frequent), MOAF, through RADA, has stepped in to support farmers in the past. The recent assessment by MOAF (2010) considers the following options: (i) improving the existing Disaster Assistance Programme (DAP) for the provision of disaster assistance; (ii) strengthening the risk financing of the DAP; (iii) improving the risk financing system for the farmers' DAP through a public-private scheme; and (iv) developing commercial agricultural insurance markets and fostering agriculture risk management innovation. The assessment made by MOAF presented considerations to advance the risk insurance for various hazards. It is presented in Table 11.

5.2.13 Strengthening of research and development links

Consultations conducted for this study strongly recommended that participatory and practical learning and action research and development platforms be improved. These were needed to develop and replicate innovative adaptation practices jointly with farmers, RADA, and international and national research institutions. Emphasis should be on demand-driven research and should focus on mutual learning among farmers.

The research-development linkages have been partially addressed through strengthening existing institutional technical capacity and by promoting new coordination and collaboration mechanisms. The key areas for which the research institutions can provide support to MOAF are: collection, analysis and management of data on livelihoods, risks and vulnerabilities, spatial-temporal mapping of risks, provision of innovative adaptation technologies and cost-benefit analysis of investments in adaptation.

TABLE 11

Considerations for Introducing Innovative Agriculture Weather Risk Management Mechanisms for Small Farmers

WEATHER RISKS	TYPE OF INSURANCE CONTRACT	IMPLEMENTATION
Flood	Index-based insurance from satellite imagery/ river gauges (Index payout scale)	Not suitable in the short-term. Further studies are needed to assess the various possible options, such as payouts based on indexed insurance for extreme river flows (possibly at the meso-level). Implementation may be challenging since data on well-mapped rivers will be required before any other action.
Extreme Rainfall (non-cyclonic)	Index-based insurance (Index payout scale)	Not suitable in the short-term. Possible options for the medium term would be based on current studies being undertaken for the Blue Mountain region. Extreme rainfall could potentially be indexed, but indexed-based insurance may not capture localized flood events affecting small farmers, or local landslides as a consequence of excess rainfalls. Nevertheless, at a meso and macro level, such products could be useful (CCRIF is in the process of designing this type of coverage for individual governments).
Drought	Index Insurance (Index payout scale)	Possible, but further analysis is needed. - For recurrent droughts events, technical considerations about the suitability of drought index insurance is secondary, in particular, since these are recurrent events related to a deficit in the irrigation system. - Extreme drought events are technically able to be implemented using index-based insurance. A deficit rainfall (drought) is the most developed hazard for which index insurance has been developed internationally, making this a feasible option. However, implementing this type of insurance for small farmers in Jamaica could be challenging and costly for the impossibility to design insurance payouts for small production structures with a wide variety of short-term crops and without a well defined seasonality.
Hurricane (wind)	Index Insurance for mortality coverage (Index payout scale)	Possible to implement for high intensity weather events. This is because the size of the shock outweighs the cost of premiums in the case of systemic high loss events that affetct all farmers. Furthermore, index-based insurance in the case of hurricanes is easier to measure; reducing the possibility that the parametric index chosen (i.e. wind speed) will not match farmers' expected losses (basis risk).

Source: MOAFC, 2010.

BOX 6

Climate change adaptation recommendations for the agriculture sector

A number of key recommendations on the way forward to address issues of climate vulnerability and the development of adaptation projects, programmes and policy were developed as part of the Government of Jamaica's Second National Communication to the UNFCCC (Government of Jamaica, 2011). The list of recommendations include these priorities:

- leverage and coordinate international funding to maximize benefits within the agricultural sector;
- improve access to loan/grant funding to domestic crop producers;
- raise awareness of the potential impacts of climate change on the agricultural sector, food security and cultural practices;
- review approaches to integrated cropping and management systems under climate change;
- develop regional links to fund and promote plant breeding programmes for common crops and livestock;
- support and fund increased water use efficiency across irrigated agriculture;
- support and expand funding of the IWCAM programme as well as internationally-hosted coastal zone management and other related initiatives;
- initiate a Climate Change Working Group for Agriculture;
- develop modelling approaches and tools to allow assessment of impacts of climate change on export and domestic crops and meat production;
- review role of financial instruments to provide insurance

Source: Jamaica's Second National Communication to the UNFCCC (Government of Jamaica, 2011).

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STAFF OF A LOCAL INSTITUTION IN CASCADE, PORTLAND EXPLAINING LOCAL VULNERABILITIES AND RISKS. *Civil Society Organizations and Government Institutions have an important role to play in spear-heading climate change adaptation at the community level. Community-based activities are needed to package good practices and new mitigation/adaptation practices and technologies for replication. Resources and working partnerships with private sector and research institutions need to be forged for successful adaptation.*

CHAPTER 6

INSTITUTIONAL AND POLICY CONTEXTS TO RESPOND TO CLIMATE CHANGE

6.1 NATIONAL AND REGIONAL INSTITUTIONS

There are numerous organizations that have been or are currently involved in climate change related activities. They work to direct efforts towards addressing the impacts of climate change in Jamaica. At a national level, institutions working on climate change issues include the PIOJ, the University of West Indies (UWI), the Climate Change Studies Group (CCSG), ODPEM, the National Environment Planning Agency (NEPA), the National Water Commission (NWC), the WRA, the Institute for Sustainable Development (ISD, UWI) and MOAF.

At a regional level, the Caribbean Agricultural Research and Development Institute (CARDI), Caribbean Community Climate Change Centre (CCCCC) and CIAT have conducted Caribbean-wide studies on climate change related issues.

In Jamaica, the PPCR – approved in November 2008 under the Strategic Climate Fund (SCF) – is intended to strengthen institutional framework and capacity development, among other things. The key sectors include: a) water resources; b) agriculture and food security; c) tourism; d) human health; e) human settlements and coastal resources. Other important sectors are: a) terrestrial resources and terrestrial biodiversity and b) the financial sector – in relation to risk insurance and comprehensive risk assessment.

6.2 AGRICULTURE SECTOR INSTITUTIONS

It is MOAF which is responsible for the formulation of policies related to agriculture, livestock and fisheries. It oversees climate change-related programmes and projects through its institutions in the sector. However, there are no institutional arrangements in MOAF with specific roles and responsibilities to provide technical assistance and to coordinate work related to climate change in agriculture. The general opinion is that the gap in institutional arrangements for climate change adaptation is largely due to the absence of a legislative framework. Thus, current work related to climate change in agriculture is *ad hoc* and highly fragmented.

In an effort to stimulate investment in agriculture and to promote agriculture as a viable business opportunity, MOAF merged the Agricultural Development Corporation with the Agricultural Support Services and Productive Project Fund Limited to form the Agro-Invest Corporation (AIC) in 2007. The AIC functions as the Ministry's business facilitation entity. It has overall responsibility for investment promotion, market development and industry development. The AIC offers services through the departments of Project Development, Joint Venture, Industry Development and Marketing Development. The role of AIC can be broadened to include promotion of climate change related investments and through the mainstreaming of climate change priorities into investment projects and programmes.

In order to strengthen the nexus between research and development and technological dissemination, MOAF has established the Centre of Excellence for Advanced Technology in Agriculture (CEATA). This Centre of Excellence will: provide training for extension officers, farmers and relevant stakeholders in agricultural technologies; coordinate active research by various bodies in the agricultural sector; facilitate the dissemination of research findings; and provide the latest technologies in agricultural production, including crop irrigation systems, soil fertility management, agricultural education and training.

The Hazard Risk Reduction and Adaptation to Climate Change (HRRACC) Thematic Working Group (TWG) led the development of climate change and the Disaster Risk Reduction (DRR) component of Vision 2030 (PIOJ, 2009). This group consists of up to 25 organizations and key

individuals appointed by the chair under the advice of the PIOJ. Members are drawn from a cross-section of stakeholders with technical interest in and knowledge of hazards, risk and climate change issues. This TWG also provides a coordinating, monitoring and advisory role. However, it should be noted that the HRRACC TWG does not have a representative from the agriculture sector, even though agriculture has been identified as a critical sector in the First and Second National Communication.

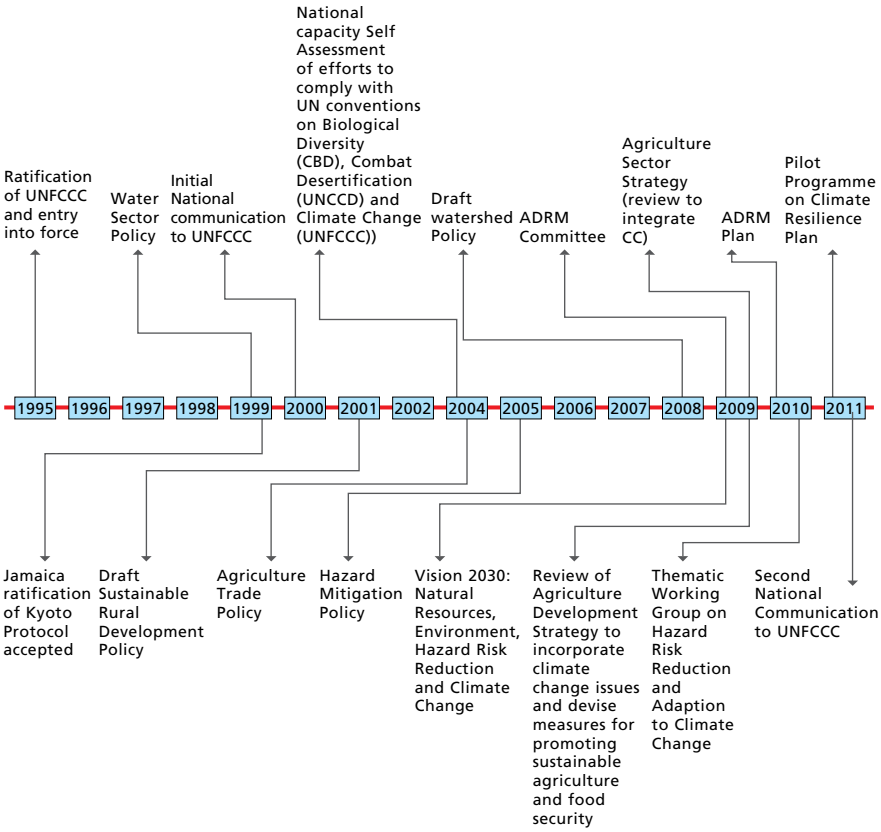
The development of the aforementioned PPCR resulted in the establishment of a PPCR Steering Committee in 2011. The PPCR has recognized the HRRACC TWG as a critical component of the institutional arrangements for climate change in Jamaica given that the group coordinates and monitors activities related to the National Outcome of HRRACC under Vision 2030. Consequently, it is expected that most members of the HRRACC TWG will be on the PPCR steering committee. However, the lack of agricultural stakeholder(s) in the TWG remains problematic, given that agriculture is one of the critical sectors for the PPCR.

The ADRM plan provides a listing of key institutions involved in ADRM. Many of the same institutions would also be involved in climate change initiatives within the agricultural sector. Efforts through the CCCCC and CARDI are underway to train individuals in agro-meteorology.

A timeline of efforts in addressing climate change with respect to institutional and policy development is presented in Figure 16. A positive outcome of the recognition of the impact of climate change is the implementation of adaptation measures at various scales.

FIGURE 16

Timeline of efforts to address climate change in Jamaica



Source: Compiled for this study from various government documents and reports.

6.3 PROGRAMMES AND PROJECTS RELEVANT TO CLIMATE CHANGE

MOAF's Operational Plan 2010–2011 outlines its programmes for this two-year period. There are some specific programmes and projects that can contribute to adaptation to climate change, albeit indirectly. For example, MOAF has embarked on a Production and Productivity Programme to enhance food security. The programme aims to boost to production and productivity through the application of good agricultural practices, technology transfer and pest management for selected vegetables and food

crops. In addition, productivity improvement is being supported by soil testing to determine the best fertilizer regime. Farmers are also trained in best practices. Twelve priority crops have been targeted in this programme.

Similarly, the Dairy Revitalization Programme aims to stimulate expansion and increased productivity within the dairy subsector. This programme seeks to enable sustained international competitiveness and to enhance this subsector's contribution to national food security, livelihood protection and rural development. The programme is being implemented by the Jamaica Dairy Development Board. Three main components of the project are: expansion of national dairy herd, increase of productivity levels and institutional support through the provision of low-cost loans to farmers.

MOAF has made some interventions to help farmers deal with climate change issues through special programmes such as the Arable Lands Irrigated and Growing for the Nation (ALIGN) initiative launched on 9 February 2010. The programme is designed (a) to engage landowners of prime agriculture lands that are either underutilized or unutilized to encourage them to put these lands back into production; and (b) to focus on the areas where the irrigation infrastructure already exists to reduce competition for precious water resources. To date, four irrigation districts and 5 153 acres of previously idle land are being prepared for productive use.

Additionally, the Ministry is exploring on-farm water management systems to deal with drought. FAO is currently funding a J$20 million pilot project to implement a rainwater harvesting system in south St Elizabeth. This area is the most productive territory in Jamaica, but also the most severely challenged by water deficits. Further priorities include: development of small-scale catchments, drip irrigation systems, rehabilitation of water storage structure and development of tubewells under national irrigation development plans. Other strategies within the MOAF's 2010-2011 Operational Plan include Integrated Pest Management (IPM) and the development of disease resistant crop varieties. In the fisheries sector, the rebuilding of reefs and replanting of mangroves as well as the designation of areas as fish sanctuaries are all efforts to adapt to and mitigate the effects of climate change.

RADA has provided information to farmers on integrated pest management for sweet potato. There is also an information and sensitization programme on disaster risk management for coffee, fruit tree crops, livestock,

pesticide management, short-term crops and sugarcane. Furthermore, RADA has developed livelihood protection guidelines, emergency response measures, and recovery strategies for various agricultural subsectors including livestock, forestry, fruit trees, short-term crops, sugarcane and greenhouses.

Other efforts related to climate change include land husbandry (watershed management, reducing soil erosion etc.), crop care, small-scale on-farm irrigation systems, greenhouse technology, livestock training and hurricane relief. In 2008, a Greenhouse Unit was established in RADA which provides training and expertise in the development of this technology.

Climate data collection is being strengthened by RADA with 16 portable weather stations and laptops to be installed in major production areas under FAO's EC Food Facility. Under the European Union's Banana Support Programme (EUBSP), ten weather stations have been provided to the Meteorological Service.

Projects currently being implemented (2009-2011) include Improving Jamaica's Agricultural Productivity Project (IJAP Project) funded by the Canadian International Development Agency (CIDA). The Ministry of Agriculture and Fisheries, through its agencies RADA and Fisheries Division, is the implementing agency for the project, while Inter-American Institute for Cooperation on Agriculture (IICA) is the executing agency on behalf of CIDA. The purpose of the project is to strengthen sustainable agriculture productivity in Jamaica by improving the productivity of Jamaican agriculture and fisheries and aquaculture sectors. The project supports the use of more durable greenhouses and improved environmental management in small-scale fisheries. IJAP has two components, namely: (1) greenhouses and (2) sustainable fisheries and modern technologies.

As a mitigating measure against the problem of depleting marine resources attributed to increased fishing pressure and land-based non-point-source pollution (among other stressors), eight new fish sanctuaries were declared in 2009. These were additions to two existing fish sancturaries in the Bogue Island Lagoon (western Jamaica) and the Bowden Inner Harbour (eastern Jamaica).

In the aquaculture division, there is an ongoing study (2010–2011) to formulate a plan for sustainable use of fisheries resources for coastal communities. The objectives are: (1) to develop a Regional Aquaculture Master Plan, and (2) to improve the farming practices of twenty-five local

small-scale farmers in rural communities through training and extension monitoring. The lead agencies for this project are Japan International Cooperation Agency (JICA)/Caribbean Regional Fishery Mechanism (CRFM). It is supported by the Fisheries Division (Jamaica) and IC Net Limited. To date, 25 small farmers have been trained and 10 selected for full extension services, which include post-harvest follow-up. A regional training course has also been conducted with a view to developing a regional aquaculture master plan.

FAO has recently finished a Technical Cooperation Project (TCP) facility that resulted in the formulation of a National Aquaculture Development Plan considering short-, medium- and long-term spans. MOAF's implementation of the plan should begin by 2012 (FAO, 2010a).

In 2011, the EU committed grant resources for the implementation of a Climate Change Adaptation and Disaster Risk Reduction Project in Jamaica. The project will be implemented by PIOJ, and will focus on increasing resilience and reducing risks associated with natural hazards in vulnerable areas. The four principal areas in addressing climate change include: the rehabilitation of watershed areas through reforestation; improvement in the management of coastal ecosystems; forest resource management and improving climate change awareness. Partner agencies include the Meteorological Service, NEPA, ODPEM, WRA, MOAF, the Ministry of Energy, and the Forestry Department.

Table 12 summarizes the projects and programmes reviewed. Although by no means exhaustive, it gives an idea of the types of initiatives being undertaken to mitigate against and adapt to climate change. An extensive list of completed, ongoing and pipeline programmes and projects on climate change is presented in Appendix 2 to this report.

Reforestation and agroforestry projects involve many non-governmental organizations (NGOs), with additional support from the Forest Conservation Fund and the Global Environment Facilty (GEF)-Small Grants Programme. Agriculture and food security projects have been minimal, mostly implemented by government, mainly through RADA and MOAF's Fisheries and Aquaculture Division. Water resources projects have included new infrastructure as well as rainwater harvesting.

TABLE 12

Climate change projects and programmes in Jamaica by type of institution

AGENCY	FORESTS & WATERSHEDS	AGRICULTURE & FOOD SECURITY	COASTAL & MARINE RESOURCES	HUMAN SETTLEMENTS	WATER RESOURCES	TOURISM	ENERGY	DATA MANAGEMENT	POTENTIAL REGIONAL PROJECTS	SMALL PROGRAMMES	TOTAL
Government	4	8	6	3	7			5		11	44
NGOs	19	2	1			1	3			10	36
Regional/ International agency		2	1	2		1				5	11
Academic/ Research institutions	3		1		1			4		3	12
Private sector							1				1
Joint academic/ Govt.								1			1
Joint academic/ Regional									1	1	2
Joint govt./ NGO								1			1
Joint govt./ Regional								1	1		2
Total	26	12	9	5	8	2	4	12	2	30	110

Source: Compilation of data from project reports and government documents.

Donors such as the Forest Conservation Fund (agroforestry); the Small Grants Programme (adaptation to climate change) and the Environmental Foundation of Jamaica have been very responsive to the needs of farmers and communities, island-wide. Much of the work supported by these donors involves mitigation measures including reforestation and agroforestry as well as biodiversity conservation.

CARDI has undertaken various initiatives to assist farmers with techniques and technologies to deal with climate change. Through United Nations Institute for Training and Research (UNITAR) and FAO, the data collection capabilities of RADA are being improved with the rehabilitation of weather stations. Staff members have been trained in crop modelling,

but there is a need for dedicated staff to conduct location-specific impact assessment. In collaboration with the CCCCC, CARDI has worked to train agrometeorologists in the region to improve their support to the agriculture sector, including the determination of better planting dates.

There has also been staff training in climate related to pests and diseases, where a pest and a disease have been selected and modelled in relation to climate change, and in order to predict future outbreaks. CARDI will also be working to train farmers to deal with the risks associated with climate change especially as it relates to pests and diseases and food safety. Though several new programmes are in the pipeline, the level of intervention taken up by the government, donor agencies and NGOs focusing on climate change issues in the agriculture sector is very low compared to population dependence for livelihood activities. The programmes and projects grouped under major thematic areas of intervention are presented in Table 13.

TABLE 13

Major Areas of Interventions to Address Climate Change in Agriculture in Jamaica

MAJOR AREA OF INTERVENTION	PRINCIPAL INSTITUTIONS INVOLVED	TOTAL INVESTMENT (US$)
Disaster Risk Management and Hazard Risk Reduction	ODPEM, NEPA, FD, PIOJ, OPM,EMD	6.32
Crop Management (incl. Bananas)	RADA, Met Office	3.07
Fisheries	Fisheries Division of MOAF	3.45
Irrigation Management and Water harvesting and conservation	NIC, FAO	15.10
Input supply	Alba Bank	2.16
Pest and diseases management	CIDA	0.37
Rural Development	EU, JISF	15.00
Food Security	EU, MOAF, FAO	8.15
Capacity development	UNDP, GEF, JCDT, Forestry, MOAF	5.56
Total		**59.18**

Source: List of projects and programmes compiled through this study.

The interventions presented in the Table 13 provide some "business-as-usual" interventions linked to agriculture sector. A detailed review of key components of these programmes and projects clearly shows that climate change concerns are not being prioritized.

With the absence of institutional arrangements for addressing climate change in national development, there is also no database or national record of work being undertaken to address climate change. The database compiled as part of this study (Appendix 2) provides a wealth of information to all engaged in work related to climate change in Jamaica.

6.4 THE POLICY CONTEXT

In light of the historical and anticipated impacts of climate change, the Vision 2030 Jamaica: National Development Plan (PIOJ, 2009) outlined the national priorities and actions with regard to climate change in the combined sector plan on Natural Resources and Environmental Management, and Hazard Risk Reduction and Climate Change (2007).

A primary focus of Vision 2030 is to adapt to climate change through mainstreaming climate risks into government policies and plans, identifying strategic priorities and adoption of best practice, as well as promoting greater public awareness of the issues. The Second National Communication further complements the National Development Plan. Among other things, it sets out the steps taken or envisaged to facilitate adequate adaptation to climate change for water resources, coastal resources, human health, human settlement and agricultural sectors.

Based on the strategic framework set out in the Vision 2030 Jamaica and the Second National Communication, a Strategic Plan on Climate Resilience (SPCR) is to be developed. The objective of this plan is to develop and implement climate change strategies and action plans effectively. Such strategies are to be incorporated in key national development plans and policies, particularly those related to resource usage and consumption, energy usage and conservation, land use and coastal zone planning and management, economic and fiscal management and human health.

Against this background, therefore, the PPCR is seen as an initiative to catalyze support that will contribute significantly towards Jamaica's climate change resilience goals and outcomes. It must be noted that the Vision 2030 has an outcome (#14) on hazard risk reduction and adaptation to climate change under the Goal #4: Jamaica has a healthy natural environment. In the

Strategic Business Plan (2012 – 2015) for the Ministry of Agriculture and Fisheries, climate change is not visible and "Strengthened Risk and Hazard Mitigation for the Sector" is prioritized as one of the outcomes under Goal #6: An Environmentally Sustainable Sector. The outcome has an objective to implement appropriate disaster mitigation measures, ensuring a high level of preparedness within farming communities, effectively carrying out damage surveys and developing appropriate strategies to restore productivity (Ministry of Agriculture and Fisheries 2012). There are three strategies listed, namely: (i) create mechanisms to enable all government policies and plans to give full consideration to the implementation of climate change; (ii) identify strategic priorities for climate change; and (iii) adopt best practices for climate change adaptation.

The Vision 2030-Agriculture Sector Strategy 2009–2030 does not mention climate change. Its focus in terms of the goal for "an environmentally sustainable sector" is on "strengthened risk and hazard mitigation for the sector" (p. 48). Under the Agriculture Sector Plan, the vision is for the dynamic transformation of the Jamaican agricultural sector through a sustained, research-oriented, technological, market-driven and private sector-led revolution. The goal is to revitalize rural communities and create strong linkages with other sectors while emphatically repositioning the sector in the national economy to focus on production of high-value commodities and to contribute to national food security.

The Vision 2030 Sector Plan (PIOJ, 2009) also makes reference to a draft Sustainable Rural Development Policy which was formulated by PIOJ in 2004 because of the importance of agriculture to local rural societies. While the plan notes that "the vision for any sustainable rural development policy must include the preservation of the character of rural life", it has missed the opportunity to discuss adjustments which may have to be made in recognition of the need for climate change adaptation.

A review of MOAF's policies indicates that there is no coherent approach to dealing with the impacts and associated effects of climate change. Likewise, the issue of climate change is not directly addressed in these policies. MOAF's operational policies/guidelines that have linkages to climate change adaptation and mitigation, include: food security; reduction of environmental degradation; promoting market-driven and priority-based research and development programmes to increase competitiveness and output in the agricultural sector; the development of strategies and approaches to promote

the sustainable use and management of agricultural lands; development and strengthening of the fisheries sector; and policy development. However, the desired outcomes do not clearly reflect adaptation or mitigation measures. This study will provide necessary background to develop/strengthen preparation of ongoing strategies on climate change and agriculture.

Through assistance from FAO, MOAF has developed an ADRM plan which seeks to build on the existing disaster risk management functions of MOAF as well as other agencies that play a role in agricultural DRR. It takes into account existing measures, such as the:

- Drought Management Plan
- ODPEM's Community Training Manual
- Jamaica's Animal Disease Preparedness Plan
- Jamaica's Agricultural Good Practices for the Mitigation of Hydro-meteorological hazards

An ADRM framework has become operational. It has been judged to be effective given that after Tropical Storm Nicole, in 2010, a rapid reconnaissance was completed within 48 hours after the storm. Since the establishment of the ADRM programme within RADA, hurricane risk management measures for various subsectors have been published in pamphlet format, including those for: short-term crops; sugarcane; coffee; fruit trees; livestock; marine fisheries; aquaculture; apiculture; pesticides and bush fires. Posters have also been developed covering hurricane, drought and bush fires. RADA has also trained key stakeholders in the use of a Livelihood Assessment Tool in pre- and post-disaster events. A multistakeholder ADRM committee has been established to spearhead the development of the ADRM Plan. Although *ad hoc*, the ADRM committee has continued to exist in order to coordinate ADRM initiatives. RADA is central to this committee and the implementation of the ADRM plan.

Along with the Hazard Mitigation Policy, other legislative frameworks relevant to ADRM include:

- The Disaster Preparedness and Emergency Management Act (1993)
- The Fire Brigade Act and Regulations
- Natural Resources Conservation Authority Act (1991)
- Forest Act (1996); Forest Regulations (2000)
- Water Resources Act (1995)

- Land Development and Utilization Act (1966) (Policy is presently being updated to protect agricultural lands from use for housing development, but no provision for climate change adaptation measures yet exists)
- Watershed Protection Act (1963)
- Severe Weather Orders (1990)

Focusing on the fisheries sector, MOAF has developed a Draft National Fisheries Policy with the assistance of FAO. While no specific mention is made of climate change adaptation, this draft policy addresses three main goals which have linkages to climate change adaptation: (1) safeguarding food and nutritional security by ensuring sustainable production in both culture and capture fisheries; (2) safeguarding the economic viability of the fishing industry, which includes optimizing returns from all markets, both local and export; and (3) the welfare of fishers.

BOX 7

Climate information services for food and agriculture

With its Agricultural Disaster Risk Management Plan (ADRMP) now in place, Jamaica is focusing on developing its agro-meteorology programme. The Rural Agricultural Development Agency (RADA), with technical guidance from the Jamaica Meteorological Services (JMS) and assistance from FAO, has acquired and installed automated weather stations in all major production areas of the country. This is expected to develop into a comprehensive agro-meteorology programme with the following objectives:

- guide development of agro-meteorology forecasts/advisories,
- enable farmers to better determine and time operations that are weather/climate-dependent, for example planting, irrigation, fertilizer application, pest management,
- provide farmers with agro-meteorological information for efficient and competitive agricultural production; and
- enable better assessments and estimates of crop productivity/production levels.

RADA's comprehensive national agro-meteorological database should also be strengthened to support parametric risk insurance. The value added services may include area-specific weather and climate forecasting, forecasting crop yield and production levels, scheduling of crop planting and irrigation dates, estimation of crop irrigation needs, development of pest and disease management including early warning systems, determination of crop and livestock production potential, agricultural drought management advisories and wind monitoring for parametric agricultural risk insurance. RADA is expected to extend the climate information services to facilitate crop assessment, natural resource management and improved services to most vulnerable communities.

BANANA CULTIVATION IN THE PLAINS OF JAMAICA'S NORTH COAST. *The adaptation intervention should aim to make agriculture more efficient to compete effectively in local and to contribute to export markets through traditional export crops. The demand in local markets can be enhanced by strengthening value chains through appropriate institutional and policy support.*

CHAPTER 7

CONCLUSIONS

Farmers and fishers in Jamaica have considerable experience in coping with climate variability. Over the years, they have adopted a number of proactive risk reduction and coping strategies to lessen the impacts of climate variability. Appendix 1 to this report lists the wide range of coping and adaptation practices, and their hazard specificity, benefits and environment suitability. These practices were considered insufficient to reduce the impact of climate-related risks as both vulnerability and hazard frequency and intensity are increasing due to climate change. Significant research has been undertaken to consolidate these location-specific practices, improve them for risk reduction and then provide them as a package to farmers in different regions of Jamaica. However, the major concern is that hurricanes and associated extremes often destroy the assets of farmers/fishers by affecting domestic food crops, traditional export crops, and agriculture and fisheries infrastructure. The economic estimates of these impacts, especially due to damage to infrastructure and loss of crops, are significant. In addition, the impacts on livelihoods are much bigger and largely invisible.

The foregoing analysis clearly indicates that the agriculture sector in Jamaica is already experiencing the impacts of increased climate variability and climate change. In addition, the future projections for Jamaica are disturbing. These factors indicate that small-scale farmers and fishers need help to adapt to changes in rainfall patterns, temperature, and impacts of drought, floods, landslides, water stagnation and sea water intrusion. Analysis of the ongoing and completed projects and programmes on climate change adaptation in agriculture provides an indication that responses to the impacts of hazards such as drought, floods and landslides have been inadequate. Past experiences clearly show that the poor response of Jamaica's institutions to the impact of Hurricane Ivan in 2004 prompted some farmers to abandon, or partially withdraw from, farming (McGregor *et al.*, 2009). The policy support for the small-farm sector in Jamaica has been weak (Beckford *et al.*, 2007; Spence, 1999). The present study reiterates the fact

that the agriculture and fisheries and aquaculture policies, strategies and plans need to consider integrating climate change concerns and priorities.

The study clearly brought out multiple dimensions of vulnerability of food production systems, and the climate-related extreme events are only one driver of that vulnerability. Though the paper did not address the issues related to trade, small-scale agriculture and climate nexus, there are several research works that present the persistent influence of the global food economy and trade liberalization. These reports indicate that trade liberalization has produced a surge of cheap food imports, including items traditionally produced by the farmers in Jamaica (Weis, 2004). The government faces the challenge of implementing measures that reduce vulnerability drivers faced by the farmers. Government must put into action policies that explicitly address the strategy for long-term support for agriculture, as well as the recurring effects of extreme climate events such as hurricanes.

While a number of policies, plans and programmes exist and address the issues related to agriculture and fisheries, they deserve a renewed look in order to prioritize domestic food production, traditional export crops, and the needs of small farmers. This reconsideration is important given farmers' vulnerability, exposure, adaptive capacity and coping strategies. There has been a change in policy direction in recent years. Greater importance is now given to strategies and measures that address climate change impacts. However, these interventions are not adequately targeting the agriculture sector. The first priority should be to strengthen domestic food production so as to reduce the food import bill and the country's import dependence. New directions should build on fresh ideas and renewed efforts to attract new investments such as greenhouse technology, slope land stabilization, *in situ* moisture conservation, alternative surface water source development and water harvesting for the benefit of small-scale agriculture.

Equal consideration at the policy level, should be given to reducing vulnerabilities created by the global economic environment, institutional strengthening to support the livelihood adaptation to climate change and implementing risk-reduction measures. The pilot experiences from the community-level initiatives through the GEF-Small Grants programme in Jamaica can provide insights on local vulnerabilities. These initiatives can help to prioritize the measures to reduce the vulnerability and risks, enhancing

the resilience to climate impacts. The interventions at the community-level should consider livelihood diversification and building livelihood assets to improve resilience. Recently, there have been greater efforts made to shift from a reactive emergency response approach to proactive disaster risk reduction within the MOAF, as well as ODPEM. The latter's initiatives on alternate livelihoods, community risk profiles, packaging of good practice examples of risk reduction, and other strategic priorities such as disaster risk management (DRM) information, monitoring and evaluation, infrastructure and support mechanisms can provide better platforms to treat climate risks appropriately. The ADRM plan clearly identified needs and prioritized measures to address disaster risk management in agriculture.

There is a wealth of information on coping and adaptation strategies available for farmers, fishermen and policy-makers to respond to the increasing risks of climate variability and climate change. However, these practices need further improvement. To be effective, they must build on the traditional and local knowledge and scientific understanding of climate change impacts on ecosystems, agriculture, fisheries and aquaculture. ECA studies conducted by CCRIF (2010) outline two main groups of interventions: risk mitigation measures and risk transfer solutions. Risk mitigation measures are adaptation measures aimed at reducing damage, and include asset-based structural measures (e.g. dikes) and behavioural measures (e.g. enforcing construction codes). Risk transfer solutions include risk insurance and adaptation measures aimed at limiting the financial impact for people affected by distributing the risk to other players in the market. The study highlights that risk transfer solutions are particularly effective in the case of low frequency and high severity events such as strong hurricanes. It concludes that some countries in the Caribbean can avoid up to 90 percent of the expected damage by implementing cost-effective adaptation measures.

The aim of the adaptation interventions should be to make agriculture more efficient to compete effectively in local markets and to contribute to export markets through traditional export crops. The demand in local markets can be enhanced by strengthening value chains through appropriate institutional support and policy mechanisms. A renewed focus on agro-processing, value-added to farm produce, local agro-enterprises, post-harvest processing and storage in fisheries and aquaculture could benefit the

small-scale farm and fishery and aquaculture sectors under increasing climate variability and changing climate. The adaptation typology linking value chain, export and trade should consider the regional perspectives as Jamaica is dependent on imports from other countries. Those imports are equally vulnerable to climate change impacts within the Caribbean region.

Multiple challenges emerge when addressing vulnerabilities at the community-level to impacts of climate variability and change, including extreme climate events. The review above provides strong evidence that the farmers' and fishermen's perceptions of changing weather patterns broadly corresponds to changes in rainfall patterns, among other factors. However, hazard exposure, vulnerabilities, impacts of increasing climatic variability and climate change at the local level are not uniform owing to the high spatial difference in types of agriculture activity. This variation warrants a comprehensive vulnerability and impact assessment, the lack of which is a major weakness that needs to be addressed in order to plan for suitable adaptation interventions. Such interventions need to build on the ongoing efforts by various organizations in the country. The interventions at the community-level should explicitly link the measures for reducing vulnerability, managing risks and enhancing resilience, providing synergies to livelihood protection, risk mitigation and sustainable natural resources management.

REFERENCES

Alexander, L., Zhang, X., Peterson, T. *et al.* 2006. Global observed changes in daily climate extremes of temperature and precipitation. *Journal of Geophysical Research*. 111 (D5) 5109 DOI: 10.1029/2005JD006290.

Beckford, C., Barker, D. & Bailey, S. 2007. Adaptation, innovation and domestic food production in Jamaica: some examples of survival strategies of small-scale farmers. *Singapore Journal of Tropical Geography*. 28: 273-286.

Beckford, C., Campbell, D. & Barker, D. 2011. Sustainable food production systems and food security: economic and environmental imperatives in yam cultivation in Trelawny, Jamaica. *Sustainability.* 3: 541 – 561.

Bueno, R., Herzfeld, C., Stanton, E. *et al.* 2008. *The Caribbean and climate change: the costs of inaction*. Stockholm Environment Institute-US Center, Global Development and Environment Institute, Tufts University, May 2008. Medford, MA, USA.

Campbell, D., Barker, D. & McGregor, D. 2011. Dealing with drought: small farmers and environmental hazards in southern St Elizabeth, Jamaica. *Applied Geography*. 31: 146-158.

Caribbean Catastrophe Risk Insurance Facility. 2010. *Enhancing the climate risk and adaptation fact base for the Caribbean*: *an informational brochure highlighting the preliminary results of the ECA study*. Caribbean Catastrophe Risk Insurance Facility, Grand Cayman, Cayman Islands: Caribbean Catastrophe Risk Insurance Facility.

Caribbean Coastal Data Centre for Marine Sciences. 2010. *Mainstreaming adaptation to climate change (MACC) project: strengthening of the climate and coral reef monitoring network. Coral reef monitoring for climate change impacts Jamaica 2001-2003*. Digital edition 2010. Kingston, Jamaica: Caribbean Coastal Data Centre for Marine Sciences, University of the West Indies.

CARIBSAVE. 2009. *Climate change risk atlas country profile: Montego Bay, Jamaica.* Final report. Bridgetown, Barbados: CARIBSAVE.

Chen, A. & Taylor, M. 2008. *Enabling activities for the preparation of Jamaica's Second National Communication to the UNFCCC: climate scenarios for vulnerability and adaptation*. Report by the Climate Studies Group Mona (CSGM), University of the West Indies, August 2008, Kingston, Jamaica.

Chen, A., Roy, A., McTavish, J. *et al.* 1997. *Using seas surface temperature (SST) anomalies to predict flood and drought conditions for the Caribbean: COLA final report.* No. 49, 24 pp. Center for Ocean-Land-Atmosphere Studies, Calverton, Maryland, USA.

Chen, A., Taylor, M., Stephenson, T. & Batchelor, T. 2009. *Modelling needs for small islands based on Jamaican scenarios*. Paper presented at Jamaica Institute of Environmental Professionals (JIEP) 4th Conference on the Environment: Climate Change-Caribbean Response. Kingston, Jamaica.

Christensen, J., Hewitson, B., Busuioc, A. *et al.* 2007. Regional Climate Projections. *In* S. Solomon, D. Qin, M. Manning *et al.*, eds. *Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, United States: Cambridge University Press.

Christophersen, K.A., Homer, F. & Grant, S. J. 1997. *Sustainable interventions for Negril fisher families*. Prepared for USAID/Jamaica, Development of Environmental Management Organizations (DEMO). 51 pp.

CIAT-OXFAM. 2011. *Impact of climate change on Jamaican hotel industry supply chains and on farmer's livelihoods. Case study: Jamaica*. International Centre for Tropical Agriculture (CIAT), Cali, Colombia.

ECLAC. 2011. The Economics of Climate Change in the Caribbean. United Nations Economic Commission for Latin America and the Caribbean (ECLAC). Subregional Headquarters for the Caribbean, Port-of Spain, Trinidad and Tobago.

Evelyn, O.B. and Camirand, R. 2003. Forest cover and deforestation in Jamaica: an analysis of forest cover estimates over time. *International Forestry Review* 5(4): 354-363.

Fisheries Division. 2011. Jamaica Fish Production Trend (1997-2010). Ministry of Agriculture and Fisheries, Kingston, Jamaica.

Food and Agriculture Organization. 1997. Aquastat: FAO's Information System on Water and Agriculture. Rome, Italy: FAO.

----. 2007. *The state of food and agriculture: paying farmers for environmental services*. Rome, Italy: FAO.

----. 2010a. *Agricultural disaster risk management plan-Jamaica*. Rome, Italy: FAO.

----. 2010b. *Training report on the Livelihood Assessment Tool-Kit: analyzing and responding to the impact of disasters on the livelihoods of people*. Technical Cooperation Project (TCP) TCP/JAM3202 (D) National Disaster Preparedness and Emergency Response Plan for the Agricultural Sector. Rome, Italy: FAO.

Futter, M. 2007. *Enabling activities for the preparation of Jamaica's Second National Communication to the United Nations framework convention on climate change, water resources and agriculture*. Kingston, Jamaica: Water Resources Authority.

Gamble, D., Campbell, D., Allen, T. *et al.* 2010. Climate change, drought, and Jamaican agriculture: local knowledge and the climate record. *Annals of the Association of American Geographers*. 100 (4): 880–893.

Government of Jamaica. 2011. Second National Communication of Jamaica to the United Nations Framework Convention on Climate Change (UNFCCC). Government of Jamaica, Kingston, Jamaica: GOJ.

Intergovernmental Panel on Climate Change. 2007. Regional climate projections. *In* S. Solomon, D., Qin, M., Manning, Z. Chen *et al.*, eds. *Climate Change 2007: the physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, United States: Cambridge University Press.

McGregor, D., Barker, D. and Campbell, D. 2009. Environmental change and Caribbean food security: recent hazard impacts and domestic food production in Jamaica.. *In* D. McGregor, D. Dodman, & D. Barker, eds. *Global change and Caribbean vulnerability: environment, economy and society at risk?* Kingston, Jamaica: University of the West Indies Press.

McSweeney, C., New, M., & Lizcano, G. 2008. *UNDP Climate Change Country Profile Jamaica*. Oxford, UK: School of Geography and Environment, University of Oxford.

Ministry of Agriculture & Fisheries. 2009. *Towards a strategy for financial weather risk management in agriculture, Jamaica*. Kingston, Jamaica: World Bank.

----. 2010. *Introducing innovative agriculture weather risk management mechanisms for small farmers: pre-feasibility assessment for St Elizabeth And Portland parishes*. Kingston, Jamaica: MOAF.

---, 2012. Strategic Business Plan (2012 – 2015) Ministry of Agriculture and Fisheries, Government of Jamaica, Kingston, Jamaica: MOAF.

National Hazard Mitigation Policy Development Committee. 2005. *Jamaica National Hazard Mitigation Policy*. Kingston, Jamaica: NHMPDC.

Neelin, J., Munnich, M., Su, H. *et al.* 2006. Tropical drying trends in global warming models and observations. *Proc. Natl. Acad. Sci*. 103: 6110-6115.

National Environment Action Plan. 1995. *Environmental Priorities – Coastal and Marine Resources Management*. Kingston, Jamaica: NEPA.

Office of Disaster Preparedness and Emergency Management. 2011. *Building disaster resilient communities project.* Project Concept document. Kingston, Jamaica: ODPEM.

Oouchi, K., Yoshimura, J., Yoshimura, H., Mizuta, R. *et al.* 2006. Tropical cyclone climatology in a global-warming climate as simulated in a 20 km mesh global atmospheric model: frequency and wind intensity analyses. *J. Meteorol. Soc. Japan*. 84: 259– 276.

Peilke Jr., R., Landsea, C., Mayfield, M. *et al*. 2005. Hurricanes and global warming. Bull. Amer. Meteor. Soc. 86: 1571-1575.

Peterson, T., Taylor, M., Demeritte, R. *et al.* 2002. Recent changes in climate extremes in the Caribbean region. *J. Geophys. Res*. 107 (D21): 4601, doi:10.1029/2002JD002251

PIOJ. 2004. *Macro-socio-economic and environmental assessment of the damage done by Hurricane Ivan Sept 10-12, 2004*. Prepared by PIOJ, Economic Commission for Latin America and the Caribbean, and United Nations Development Programme. Kingston, Jamaica: PIOJ.

----. 2005. *Assessment of the socio-economic and environmental impact of Hurricanes Dennis and Emily on Jamaica*. Kingston, Jamaica: PIOJ.

----. 2007. *Assessment of the socio-economic and environmental impact of Hurricane Dean.on Jamaica*. Kingston, Jamaica: PIOJ.

----. 2008. *Assessment of the socio-economic and environmental impact of Tropical Storm Gustav on Jamaica*. Kingston, Jamaica: PIOJ.

----. 2009. *Jamaica Vision 2030: final draft agriculture sector plan*. Kingston, Jamaica: PIOJ.

----. 2010a. *Economic and social survey Jamaica 2009*. Kingston, Jamaica: PIOJ.

----. 2010b. *Macro socio-economic and environmental assessment of the damage and loss caused by tropical depression No. 16/Tropical Storm Nicole*. Kingston, Jamaica: PIOJ.

Pilot Programme on Climate Resilience (PPCR). 2011a. *Report on regional workshop on climate change resilience*. Pilot Programme on Climate Resilience, Panos Caribbean (PC), National Environmental Education Committee (NEEC), and PIOJ. Negril, Jamaica.

----. 2011b. *Report on regional workshop on climate resilience*. Pilot Programme on Climate Resilience (PPCR), Panos Caribbean (PC). National Environmental Education Committee (NEEC), and PIOJ. Kingston, Jamaica.

Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea level rise. *Science*. 315 (5810): 368-370.

Rural Agricultural Development Authority. 2011. *Damage and loss in agriculture due to extreme climate events: A compilation of impacts of extreme events from 1994–2010*. Kingston, Jamaica: RADA.

Segura, J. 2010. *The contribution of agriculture to sustainable development in Jamaica*. San Jose, Costa Rica: Inter-American Institute for Cooperation on Agriculture.

Simpson, M.C., Clarke, J.F., Scott, D.J., *et al*. 2012. CARIBSAVE Climate Change Risk Atlas (CCCRA) – Jamaica. DFID, AusAID and The CARIBSAVE Partnership, Barbados, West Indies.

Spence, B. 1999. Spatio-evolutionary model of Jamaican small farming. *Geographical Journal*. 165 (3): 296 305.

Taylor, M., Centella, A., Charlery, J. *et al.* 2007. *Glimpses of the future: a briefing from the PRECIS Caribbean climate change project*. Belmopan, Belize: Caribbean Community Climate Change Centre.

Taylor, M.A., Stephenson, K.A., Rankine, D.R. 2011. Climate variability and change and water availability in the Caribbean. CARDI/CTA Technical Paper. 52pp.

United Nations Environment Programme. 2010. *Linking ecosystems to risk and vulnerability reduction the case of Jamaica: results of the pilot assessment under the risk and vulnerability assessment methodology development project (RiVAMP)*. Kingston, Jamaica: UNEP with the PIOJ.

Water Resources Authority. 2008. *Vulnerability and capacity assessment: Southern Clarendon Pilot Project, Jamaica*. Final Project Report prepared under Mainstreaming Adaptation to Climate Change (MACC) Project for the World Bank and the Caribbean Community Climate Change Centre (CCCCC). Kingston, Jamaica: WRA.

Webster, P., Holland, G., Curry, J. *et al.* 2005. Changes in tropical cyclone number, duration and intensity in a warming environment. *Science*. 309: 1844-1846.

Weis, T. 2004. Restructuring and redundancy: the impacts and illogic of neoliberal agricultural reforms in Jamaica. *Journal of Agrarian Change.,* 4 (4): 461–91.

World Resource Institute. 2011. *Coastal capital Jamaica: the economic contribution of Jamaica's coral reefs*. Washington D.C., United States: WRI.

APPENDIX 1

EXAMPLES OF GOOD PRACTICES OF COPING STRATEGIES IN AGRICULTURE

NAME OF PRACTICE	HAZARD SPECIFICITY	BENEFITS	ENVIRONMENT SUITABILITY & FARMING SCALE APPLICABILITY	INSTITUTIONAL REQUIREMENTS
Guinea grass mulching	Drought/ moisture deficit	Moisture conservation, weed control, reduce wind erosion, reduce runoff, reduce soil temperature, improve soil structure, retention of volatile fertilizer material, reduce aberration to trailing fruits and vegetables, facilitate organic farming practices	Flat or sloping land in moisture-deficit agro-ecological zones (AEZ); small scale (<10 ha)	Support from extension services on pest control and quantity and timing of mulch
Minimum tillage	Drought/ rainfall-related soil erosion	Reduced fossil fuel use, reduced soil erosion, increase in soil biodiversity, reduced pesticide and nitrogen leaching, soil moisture conservation	Drier coastal AEZ, with stable soil structure, moderately wet upland AEZ with stable soil structure	Strengthening technical capacity of RADA officers/ other institutions at the Parish level, training to farmers on benefits of minimum tillage
Drip irrigation	Drought	Year round production, improved yields, better crop quality, more efficient use of water resources, lower irrigation cost (compared with sprinkler system)	All annual/ seasonal moisture deficit AEZ with flat to gentle slopes; all farming scales (small farms to plantations)	Strengthening technical capacity of RADA, training to farmers on benefits of technique

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NAME OF PRACTICE	HAZARD SPECIFICITY	BENEFITS	ENVIRONMENT SUITABILITY & FARMING SCALE APPLICABILITY	INSTITUTIONAL REQUIREMENTS
Fire-breaks	Drought-induced bushfires	Reduced crop-loss from bush-fires, added protection against wind damage in storms, reduced soil moisture loss through shading and wind reduction	All annual / seasonal moisture deficits AEZ where bush fires are a threat; all farming scales (small farms to plantations)	Expansion of RADA training capacity, community level fire hazard reduction planning; support to distribute seedlings, equipments etc.
Rainwater harvesting & storage	Drought	Year round production, increased yields, improved crop quality	All annual/ season moisture deficit AEZ, but especially those involved in the farming of high valued seasonal crop (cash crops); Medium to small-scale farming (10 ha and less)	Strengthening capacity of agriculture support services and farmers on installation and maintenance of rainwater harvesting structures; institutional support to build water storage structures
Aquifer recharge	Drought & flood impact reduction	Drought mitigation, flood mitigation, mitigation of saline intrusion, water quality maintenance, sustain water supplies, prevention of well collapse	All annual/ seasonal moisture deficit areas, but especially those involved large scale monoculture on the southern coastal plains; large scale (> 50 ha)	Collaboration among RADA, NIC, and WRA; institutional support on awareness rising
Timing of crop establish-ment	Drought	Drought mitigation, reduced loss from droughts and bushfires, storage and effective utilization of soil moisture resource	All annual/ seasonal moisture deficit areas but especially those involved in the production of annuals; Small scale farming (5 ha and less)	Collaboration between RADA and the Meteorological Service in the provision of reliable hydro-meteorological information to agriculture and training to interpret climate information
Seasonal breeding (Livestock)	Drought impact reduction	Reduced loss from droughts impacts, synchronization between nutritional requirements and feed availability	All flatland to gently-sloping AEZ with seasonal moisture deficit; large scale (> 50 ha)	Collaboration between RADA and livestock breeders

follows on the next page →

NAME OF PRACTICE	HAZARD SPECIFICITY	BENEFITS	ENVIRONMENT SUITABILITY & FARMING SCALE APPLICABILITY	INSTITUTIONAL REQUIREMENTS
Planting of drought-tolerant crops	Drought impact reduction	Reduction of crop loss, maximization of soil moisture use	Upland and lowland AEZ with rainfall deficit; small and large scale	Collaboration between RADA and the Meteorological Service; awareness campaign by RADA on crop options for drought; supply of need-based planting materials
Raised beds/ network drains	Floods	Reduction in the depth and aerial extent of floods, reduce crops loss from flooding, regulation of soil moisture in the root zones	Flatland AEZ with poor drainage and moderate to high annual rainfall and varied cropping systems	Development of collaborative farming groups; supply of drain digging equipments
Contour planting & King grass	Landslides	Slope stabilization, soil loss reduction, sustainable crop production on steep slopes, increased water infiltration, sustainable water supplies	Extremely steep AEZ with high rainfall and slope angles 45-50 degrees; small-scale hillside farming involved in mixed-cropping	Improved watershed management focusing on upstream-downstream linkages; supply of seedlings and training to farmers
Contour planting of pineapples	Landslides	Slope stabilization, soil loss reduction, sustainable crop production on steep slopes, increased water infiltration, sustainable water supply	Steep slopes with high rainfall and angles of 45-50 degrees; Small-scale hillside farming involved in mixed-cropping	Strengthening technical capacity of RADA, provision of seedlings and training to the farmers
Check dams	Landslides, floods	Slope stabilization, soil loss reduction, sustainable crop production on steep slopes, increased water infiltration, sustainable water supply, flood control in lower part of stream	Steep slopes with high rainfall; Small-scale hillside farming involved in mixed cropping	Strengthening technical capacity of parish level government officers responsible for construction work and supply of construction materials

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NAME OF PRACTICE	HAZARD SPECIFICITY	BENEFITS	ENVIRONMENT SUITABILITY & FARMING SCALE APPLICABILITY	INSTITUTIONAL REQUIREMENTS
Hedgerow alley cropping	Landslides	Slope stabilization, soil loss reduction, sustainable crop production on steep slopes, increased water infiltration; sustainable water supply, reduced demand for yam-sticks as sections of hedge can be allowed to 'grow out' and harvested as yam-sticks, reduced chemical fertilizer demand if leguminous plants used for hedgerow	Small-scale hillside farming involved in mixed-cropping or monoculture cultivation of tubers	Training to extension officers; nursery for production of seedlings, subsidized provision of seedlings, training on implementation and maintenance of hedgerow alley cropping; establishment of hedgerow and replenishment of thinned areas in hedge
Tree manage-ment	Landslides, flooding, strong winds	Slope stabilization, soil loss reduction, sustainable crop production on steep slopes, increased infiltration of water, reduce loss from hurricane winds, more efficient harvesting of food trees (can harvest from the ground if sufficiently cut back)	All AEZ in Jamaica; All scales of farming that involve tree fruit crops production	Training to extension system, establishment of nurseries for seedlings, equipment for pruning of trees
Raised floors (for poultry production)	Flooding	Poultry loss reduction from flooding, better ventilation of poultry house, more efficient harvesting of waste	Lowland AEZ that is vulnerable to flooding and where poultry is practiced; all scales of poultry production	Training to farmers and awareness rising activities at the community level
Planting of low-profile crops in areas susceptible to wind damage	Strong winds	Reduced damage to crops by wind	All AEZ in Jamaica; more suitable for smaller farms	Promotion of measures through RADA or local farmers' organizations such as the Jamaica Agricultural Society
Triangular Bracing mechanism for bananas	Strong winds/ hurricane	Reduce damage/loss to banana from wind impact	Sloping lands that are susceptible to strong winds and where banana is extensively grown; small farms (<10 ha)	Strengthening technical capacity of the extension system to provide training to farmers; bamboo, cables and ring

Source: FAO, 2010a&b.

APPENDIX 2

ONGOING AND COMPLETED PROJECTS/INITIATIVES RELATED TO CLIMATE CHANGE & AGRICULTURE IN JAMAICA

SUSTAINABLE LAND MANAGEMENT	
PROJECT TITLE	**CAPACITY BUILDING FOR SUSTAINABLE LAND MANAGEMENT (SLM) IN JAMAICA (JAN.2010- SEPT. 2012)**
Objectives and Outputs	The project enhanced sustainable land management (SLM) by building capacities in appropriate government and civil society institutions and user groups, and mainstreamed SLM into government planning and strategies. Draft SLM Policy documents were completed.
Lead Agency (Supporting) Organizations)	Forestry Dept. (Project Steering Com.: NEPA, Div.of Local Govt, EMD - OPM, RPPD, RADA, JBI, JCDT, Dept.of Mines & Geology, PIOJ, Land Manag. Div. – OPM)
Funding Agency and Total Cost	GEF, GOJ (US$989 890 of which GEF = US$500 000)
PROJECT TITLE	**HIGH TUNNEL HOUSES FOR SUSTAINABLE LAND MANAGEMENT (APRIL 2006 - MARCH 2007)**
Objectives and Outputs	The project provided training for establishment and use of High Tunnel Houses in agriculture for Sustainable Land Management. It also aimed at increasing the productivity and competitiveness of Jamaican agriculture in the global market. Finally, controlled growing environments to mitigate impacts of natural disasters were established. The project trained 100 students and provided 2 000+ sq ft of High Tunnel Houses for demonstration.
Lead Agency (Supporting Organizations)	Santoy Farmers' Cooperative (Ja Farms Project, USAID)
Funding Agency and total cost	GEF-SGP (US$25 000)

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PROJECT TITLE	LAND AND PRESERVATION MEASURES TO COMBAT CLIMATE CHANGE PRESSURES IN COCKPIT COUNTRY'S MARTHA BRAE WATERSHED (JUNE 2009 - DECEMBER 2010)
Objectives and Outputs	The project stabilized and reinforced river bank slopes to protect against the loss of agricultural lands from the threats of climate change-driven increases in flood risks, due to stronger hurricanes and higher-intensity rainfall.
Lead Agency (Supporting) Organizations)	Bunkers Hill CDC
Funding Agency and total cost	GEF-SGP (US$45 000)
PROJECT TITLE	**TRINITYVILLE PREVENTION OF LAND DEGRADATION PROGRAMME (AUGUST 2010 - JUNE 2011)**
Objectives and Outputs	The project implemented a comprehensive land management programme to introduce soil conservation techniques to reduce the effects of natural and man-made disasters such as flooding, soil erosion and fire
Lead Agency	Trinityville Area Development Committee
Funding Agency and total cost	GEF-SGP (US$17 646)

DISASTER RISK REDUCTION/MANAGEMENT

PROJECT TITLE	CLIMATE CHANGE ADAPTATION AND DISASTER RISK REDUCTION (30 MONTHS)
Objectives and Outputs	The project enhanced institutional (human and technical) capacity and facilitated awareness building amongst Jamaica's population to better adapt to climate change. In addition, it implemented activities to improve management of selected watersheds to reduce downstream run-off and associated pollution and health risks, it restored and protected coastal ecosystems to enhance natural buffers and increase resilience and integrated climate change mitigation and adaptation into relevant national policies and plans
Lead Agency (Supporting) Organizations)	UNEP, NEPA, Forestry Dept; EMD, MS, PIOJ (National Environment Education Committee –NEEC-, Panos Caribbean, Environment Foundation of Jamaica –EFJ-, Ministry of Education, National Works Agency –NWA-)
Funding Agency and total cost	EU; GOJ; UNEP (€4.5m)
PROJECT TITLE	**BUILDING DISASTER RESILIENT COMMUNITIES PROJECT (MARCH 2008 -MARCH 2011)**
Objectives and Outputs	The project supported the establishment and strengthening of Community Emergency Response Teams (CERTs) to increase the resilience against natural and man-made disasters
Supporting Organizations	ODPEM
Funding Agency and total cost	CIDA (C$0.617m)

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PROJECT TITLE	NATURAL HAZARD MANAGEMENT IN URBAN COASTAL AREAS IN JAMAICA (MARCH 2008 -MARCH 2011)
Objectives and Outputs	The project improved resilience of coastal towns and cities against natural risks by strengthening institutional capacities. A model for Coastal Community Risk Plans was developed for 28 communities, and the institutional and legal frameworks of ODPEM were reviewed and analyzed. A risks assessment was undertaken for Black River, Savanna-la-mar and Ocho Rios communities
Lead Agency	ODPEM
Funding Agency and total cost	IADB (US$1.0m)
PROJECT TITLE	**AGRICULTURAL DISASTER RISK MANAGEMENT PLAN - JAMAICA**
Objectives and Outputs	The project developed the DRM plan for the agriculture sector seeking to increase local/community-level initiatives for DRM in the relevant subsectors of agriculture
Lead Agency (Supporting) Organizations)	Ministry of Agriculture and Fisheries – RADA, Fisheries Division, Data Bank & Evaluation, Commodity entities, 4-H Clubs, Forestry Department, NADRM committee (ODPEM, JAS, JLA, Private Sector (Agricultural Input suppliers), WRA, NEPA, PDCs, RPPU, Geological Surveys Division, Jamaica Fire Brigade, FD, CASE, NWA,IICA, Met. Office, NGOs/CBOs, Media, Insurance Companies, Financing Institutions)
Funding Agency	FAO

HAZARD MAPPING, RISK AND VULNERABILITY ASSESSMENT AND OBSERVATIONS

PROJECT TITLE	HAZARD MAPPING, DISASTER VULNERABILITY & RISK ASSESSMENT (JUNE 2009 - JUNE 2011)
Objectives and Outputs	The project developed a regional risk Atlas, containing spatial data and high resolution risk maps for hurricanes and earthquakes in selected territories in the Caribbean. Training courses and workshops were carried out to relevant institutions in the governments
Lead Agency (Supporting) Organization)	Disaster Risk Reduction Centre (World Bank)
Total Cost	US$0.5m
PROJECT TITLE	**COASTAL MULTI-HAZARD MAPPING & VULNERABILITY ASSESSMENTS FOR INTEGRATED PLANNING & REDUCTION OF VULNERABILITY IN PORTLAND COTTAGE, MORANT BAY & MANCHIONEAL, JAMAICA (JANUARY 2008-AUGUST 2010)**
Objectives and Outputs	This project completed the multi-hazard assessment & developed maps. It also carried out vulnerability & risk assessments and produced community disaster/risk management plans
Lead Agency	PIOJ
Funding Agency	IBRD

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PROJECT TITLE	RISK AND VULNERABILITY ASSESSMENT METHODOLOGY PROJECT (RIVAMP)
Objectives and Outputs	The project piloted a methodology to integrate ecosystems management with disaster risk reduction at the local (Negril community in Jamaica) and national levels. The final report and adjustments on the methodology are currently being finalized by UNEP
Lead Agency	PIOJ
PROJECT TITLE	**COUNTRY SPECIFIC RISK EVALUATION FOR BOLIVIA, GUATEMALA, JAMAICA, PERU**
Objectives and Outputs	The project identified and quantified the catastrophe risks, providing analyses that identified important issues in the context of the country's development priorities and oriented the setting of risk management frameworks. These assessments serve as the basis for the formulation and updating of the World Bank's Country Strategy and programming dialogue with the countries
Lead Agency (Supporting) Organizations)	IDB through ERN -Evaluación de Riesgos Naturales, AL (IDB, WB and UN-ISDR)
Funding Agency and total cost	IADB, World bank
PROJECT TITLE	**RAPID ASSESSMENT OF 4 COMMUNITIES AND ADAPTATION TO CLIMATE CHANGE**
Objectives and Outputs	This survey aimed at better understanding the effects of climate change and potential adaptation mechanisms. It used participation methods through focus groups, surveys etc. in Westmoreland and St. Elizabeth to garner feedback from farmers and fishermen, with participation by other stakeholders in workshops. Farmers identified overall changes in crop seasons and yields, with longer droughts, reduced and irregular rainfall and slow germination as the main challenges. For the fishing industry, warmer sea water, increased coastal erosion, degraded mangroves, loss of coral reef, reduction in abundance of fish, smaller size fish and less variety of fish were identified as the main challenges
Lead Agency (Supporting) Organizations)	ODPEM (PIOJ)
Funding Agency	OAS
PROJECT TITLE	**IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND ECONOMIC GROWTH IN JAMAICA**
Objectives and Outputs	The project analyzed the anticipated impacts of CC in the agriculture sector and selected the most appropriate adaptation strategies. For this, it collated and validated information on the impacts of CC on Jamaica's natural and human resources (especially women) and generated data on how likely these impacts will affect the supply and demand for locally-grown food for tourism, identifying institutional and technical gaps
Lead Agency	IIED, in collaboration with Oxfam GB-LAC
Funding Agency	IIED/ Oxfam

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PROJECT TITLE	IMPACT OF CLIMATE CHANGE ON TOURISM AND NATIONAL ECONOMIC GROWTH IN JAMAICA (LITERATURE REVIEW)
Objectives and Outputs	This literature and data review was prepared to inform sector discussions aimed at developing adaptation strategies under a joint initiative of the IIED and the CARIBSAVE Partnership
Lead Agency	The International Institute for Environment and Development (IIED) in collaboration with Oxfam GB LAC
PROJECT TITLE	**STRENGTHENING SEA LEVEL OBSERVATION NETWORK & COORDINATION ACTIVITIES IN THE CARIBBEAN**
Objectives and Outputs	The project aimed at developing regional linkages and training for sea level station operators & scientists that use sea level observations. For this, the project upgraded 10 sea level stations in the Caribbean to real-time data delivery as established by the University of Puerto Rico and extended this service to include additional sea level stations in the region
Lead Agency	UNESCO, NEPA
Funding Agency and total Cost	Reg. PPCR (US$0.6m)
PROJECT TITLE	**NETWORK OF AUTOMATED, ONLINE CLIMATOLOGICAL STATIONS AND DATA MANAGEMENT PLATFORM FOR JAMAICA**
Objectives and Outputs	This project established and put in operation a comprehensive climate data collection and management system for the Met. Office. This included the installation and operation of a network of automated, online climatological stations; the development of a data management platform which incorporates remote data access, remote station management and monitoring and automatic generation of basic summary reports and a computer program to enable interface between the weather stations and the Met. Office database
Lead Agency Supporting Organization(s)	Climate Change Group (UNDP; Met. Office; Dept of Physics, UWI; Dept. of Computer Science, UWI)
PROJECT TITLE	**ESTABLISHMENT OF SEA LEVEL GAUGE NETWORK IN JAMAICA**
Objectives and Outputs	This project established a tide gauge network (5) around the island to secure reliable data on the changes in sea level and started institutional arrangements for effective implementation and management
Lead Agency (Supporting) Organizations)	National Council for Ocean and Coastal Zone Management (Met. Office, UWI - Centre for Marine Science)
Funding Agency	CCCCC; Government of the Peoples Republic of China
	LAND SLIDE AND EROSION CONTROL
PROJECT TITLE	**LAND AND PRESERVATION MEASURES TO COMBAT CLIMATE CHANGE PRESSURES IN COCKPIT COUNTRY'S MARTHA BRAE WATERSHED (JUNE 2009 - DECEMBER 2010)**
Objectives and Outputs	This project stabilized and reinforced river bank slopes to protect against the loss of agricultural lands from the threat of climate change-driven increases in flood risk, due to stronger hurricanes and higher-intensity rainfall
Lead Agency	Bunker's Hill Community Development Committee
Funding Agency and total cost	CBA Fund; EFJ (US$0.047m; J$1.35m)

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PROJECT TITLE	REDUCING CLIMATE CHANGE-DRIVEN EROSION AND LANDSLIDE RISKS SUSTAINABLE AGRICULTURE & SAFER SLOPES (OCTOBER 2008-APRIL 2010)
Objectives and Outputs	The project increased the capacity of targeted farming communities on the slopes of the Blue Mountains to adapt to climate change. The agro-technical capacity for applying soil conservation techniques, necessary in steep slope environments were increased, alternative livelihood practices were promoted and forest and tree cover (with appropriate species) were promoted on slopes vulnerable to climate-driven increases in erosion and landslide risks
Lead Agency	JCDT
Funding Agency and total cost	CBA Fund (US$0.05m)
PROJECT TITLE	**GLENGOFFE CLIMATE CHANGE ADAPTATION PROJECT (JANUARY 2010- JANUARY 2011)**
Objectives and Outputs	This project aimed at reducing the risks of landslides and flooding from heavy rain, as well as lessening the effects of extreme drought conditions on crop production. Activities included contour farming, reforestation, fruit tree production and drought mitigation, as well as training of farmers and communities
Lead Agency	Glengoffe Community Development Committee
Funding Agency and total cost	CBA Funds (US$0.042m)
PROJECT TITLE	**REFORESTATION AND PROMOTION OF BEST FARMING PRACTICES TO MITIGATE THE EFFECTS OF LANDSLIDES IN SOMERSET, ST. THOMAS (JULY 2010 - JULY 2013)**
Objectives and Outputs	The project is enhancing the environmental health and living conditions in the Somerset community by addressing erosion, landslides and floods through mixed reforestation on erosion-prone areas of Somerset and the installation of slope stabilization measures. Local farmers are trained in good practices for hilly areas, as well as on environmental stewardship
Lead Agency	Women's Resource and Outreach Centre
Funding Agency and total cost	FCF (J$20.4m)
PROJECT TITLE	**MIXED AGRO-FORESTRY TO ACHIEVE SLOPE STABILITY (JULY 2010-JULY 2013)**
Objectives and Outputs	The project is reducing the frequency of landslides in the Shirley Castle area of Portland through slope stability, applying soil conservation measures including the establishment and production of forest trees, food crops and ornamental plants. Outputs include the planting of seedlings to improve slope stabilization, training to improve farming practices, reducing landslide incidence by 25% through planting of pineapples, & other conservation techniques on forest land
Lead Agency	Portland Environ. Protection Assoc.
Funding Agency and total cost	FCF (J$7.4m)

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LIVELIHOODS	
PROJECT TITLE	**DOLPHIN HEAD REFORESTATION, AGROFORESTRY AND LIVELIHOOD DEVELOPMENT PROJECT (JULY 2010 -JULY 2013)**
Objectives and Outputs	The project is raising awareness on conservation in the Dolphin Head mountain, through promotion of alternative livelihoods, reforestation and creation of eco-tourism sites. Project outputs include 16 has of forest replanted, endemic conservation and showcasing, trail development for improved eco-tourism, 50 agroforestry plots and related products for Dolphin Head communities and improved administrative capacity of DHLFMC
Lead Agency	Dolphin Head Local Forest Management Committee (LFMC)
Funding Agency and total cost	FCF (J$17.9m)
PROJECT TITLE	**MORANT WATERSHED RESTORATION, CONSERVATION AND COMMUNITY DEVELOPMENT PROJECT (JULY 2010 - JULY 2013)**
Objectives and Outputs	The project is protecting and restoring 25 has of forest reserve, raising public awareness through education and training events on the protection and sustainable use of forests
Lead Agency	St. Thomas Environment Protection Association Benevolent Society
Funding Agency and total cost	FCF (J$15.2m)
PROJECT TITLE	**Reforestation and Development of Alternative Livelihood Activities in the Good Hope Region (July 2010 - July 2013)**
Objectives and Outputs	The project is reforesting and developing alternative livelihood activities in the Dallas Castle in East Rural St. Andrew at the foothills of the Blue Mountain Range. Outputs include replanting of 12 ha of degraded forest area with timber and fruit tree seedlings; strengthening of beekeeping by training and certifying resource beekeepers and upgrading apiaries to commercial status, and training new beekeepers; and the establishment of goat houses
Lead Agency	Local Initiative Facility for the Environment (LIFE)
Funding Agency and total cost	FCF; IAF (J$12.9m)
PROJECT TITLE	**CLIMATE WISE COMMUNITIES: STRENGTHENING LIVELIHOODS & INFRASTRUCTURE IN JAMAICA (24 MONTHS)**
Objectives and Outputs	The project developed and tested an integrated community climate change resilience-building model through the strengthening of social capital and infrastructure, as well as increased sustainable livelihood opportunities. For this, baseline data was collected and assessed, training was delivered on climate change, risk identification & disaster management & response, Community adaptation projects were identified & implemented by community institutions & disaster response teams
Lead Agency	ODPEM
Funding Agency and total cost	OAS, PAHO, YABT- Ja (US$1.0m)

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PROJECT TITLE	CARIBBEAN CLIMATE CHANGE TOURISM & LIVELIHOODS: A SECTORAL APPROACH TO VULNERABILITY & RESILIENCE (3-5 YEARS)
Objectives and Outputs	This regional project aims at strengthening, protecting and enhancing the economies and livelihoods of Caribbean nations and sectoral stakeholders who rely directly or indirectly on tourism (including the natural and built assets, and sectors on which the industry is based). In Jamaica, the project assessed the vulnerability, resilience, and adaptive capacity to climate change of the tourism sector in selected areas
Lead Agency (Supporting) Organizations)	CCCCC and OUCE (Caribbean Tourism Association, Caribbean Association of Sustainable Tourism & Caribbean Disaster Emergency Response Agency)
Funding Agency and total cost	FCO, OUCE & CCCCC (US$35m)
PROJECT TITLE	**RENAISSANCE OF FARMING IN THE CHRISTIANA AREA THROUGH DIVERSIFICATION AND USE OF TECHNOLOGY (FEBRUARY 2010- MARCH 2011)**
Objectives and Outputs	The project built the capacity of the Cristiana Potato Growers Association Limited to strengthen the capacities of farmers on farming techniques and inputs, to provide extension services and a market for crops, increasing thus the revenues of farmers
Lead Agency	Christiana Potato Growers Cooperative
Funding Agency and total cost	GEF-SGP (US$40 000)

WATER HARVESTING AND CONSERVATION

PROJECT TITLE	PROMOTING RAIN WATER HARVESTING AND SMALL SCALE IRRIGATION IN SOUTH ST. ELIZABETH (APRIL 2010 - MARCH 2011)
Objectives and Outputs	The project enhanced food security and socio-economic well-being of farmers in South St. Elizabeth promoting increased crop production through rain water harvesting and improved water management, as well as introducing small-scale irrigation technology
Lead Agency	NIC & MOA&F
Funding Agency and total cost	FAO (US$0.217m)
PROJECT TITLE	**EUROPEAN UNION BANANA SUPPORT PROGRAMME (2007 -2011)**
Objectives and Outputs	The programme aims at the economic empowerment of traditional banana and plantain growing communities through the sustainable development of commercially viable banana/plantain and other business enterprises
Lead Agency	NIC
Funding Agency	EU
PROJECT TITLE	**STRENGTHENING CAPACITIES FOR SUSTAINABLE LIVELIHOODS -PHASE 2- (JANUARY 2010 - DECEMBER 2011)**
Objectives and Outputs	The project improved the livelihoods of farmers in Johnson Mountain, Spring Bank, Mount Vernon, Somerset and Trinityville, former banana producing communities of St. Thomas, through the strengthening and empowerment of community and the farmers' organizations to diversify their economic opportunities
Supporting Organizations	Women's Resource and Outreach Centre (WROC) & MOA ODPEM, JAS, RADA and the Forestry Department
Funding Agency and total cost	EU & Christian Aid (€ 0.42m)

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PROJECT TITLE	IMPROVING JAMAICA'S AGRICULTURAL PRODUCTIVITY (2009 - 2011)
Objectives and Outputs	The project strengthened sustainable agriculture productivity of Jamaican farmers and fisher folks, through the use of more durable greenhouses and improved environmental management in small scale fisheries
Lead Agency	MOA&F
Funding Agency and total cost	CIDA (US$5.0m)
PROJECT TITLE	**NATIONAL IRRIGATION DEVELOPMENT PROGRAMME**
Objectives and Outputs	The project aims at increasing crop production, diversity, farm income and rural employment. Activities include building of capacities for farmers and organizations, and building of related infrastructure
Lead Agency	NIC
Funding Agency and total cost	IDB & GOJ (US$2.0m)
PROJECT TITLE	**KMA WATER SUPPLY (2006 -2010)**
Objectives and Outputs	The objectives are the rehabilitation of the pipeline/existing water supply facilities, and exploration of new water resources for the purpose of fulfilling the future demands for potable water in Greater Spanish Town (GST)and South East St. Catherine (SESC) and Southern sections of Kingston
Lead Agency	NWC
Funding Agency and total cost	JBIC/JICA and GOJ (US$64.0m)
PROJECT TITLE	**WATER PROGRAMME FOR ENVIRONMENTAL SUSTAINABILITY II: TOWARDS ADAPTATION MEASURES TO HUMAN AND CLIMATE CHANGE IMPACTS**
Objectives and Outputs	The project develops and implements a Groundwater Management Model to assess and manage the aquifer system on a continuous basis. It also makes recommendations on best practices for the protection and sustainable management of those sites and similar aquifer systems
Lead Agency	WRA
Funding Agency	Italian Ministry of Environment & Territory; GOJ
PROJECT TITLE	**CLIMATE CHANGE MODELING FOR SEA LEVEL RISE ON WATER RESOURCES IN THE CLARENDON PLAINS**
Objectives and Outputs	The study assessed the vulnerability of certain sectors and their capacity to deal with the impacts of global climate change on water resources in the Vere Plains of Clarendon in Jamaica. The model showed that under the present abstraction scenarios and predicted changes in rainfall and evaporation, water levels decrease significantly and water quality changes occur, due to the specific geographical conditions of the fault controlled Vere Plains. Adaptation measures were developed & presented to stakeholders
Lead Agency	WRA
Funding Agency	CCCCC
PROJECT TITLE	**KNOCKALVA WATER HARVESTING PROJECT (FEBRUARY 2010 - DECEMBER 2010)**
Lead Agency	Knockalva Agriculture School
Funding Agency	GEF-SGP
Total Cost	US$38 400

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PROJECT TITLE	RAIN WATER HARVESTING (RWH) PROJECT (APRIL 2009 -AUGUST 2008)
Objectives and Outputs	The project increased awareness of government and the public on the potential for RWH as a sole water supply source in areas of Jamaica presently without access to water and as an augmentation source in areas regularly affected by drought. Activities included analysis of storage requirements, rainfall reliability assessment and the assessment of water demand for the rural areas presently without access and areas without access in drought periods, as well as hillside catchments location mapping
Lead Agency (Supporting) Organizations)	WRA (CBOs)
Funding Agency and total cost	GOJ (US$0.3m)

COASTAL ZONE MANAGEMENT

PROJECT TITLE	STUDY ON THE IMPACTS OF CLIMATE VARIABILITY ON JAMAICAN BEACHES
Objectives and Outputs	The study examines the parameters that influence beach formation and transgression at sites around Jamaica, and develops a methodology/tool to aid in forecasting beach progradation or destruction given predicted climate changes. In addition, the study defines a hurricane vulnerability classification for Jamaican beaches and develops management and planning strategies and plans to address these challenges
Lead Agency	NEPA
Total Cost	US$0.5m
PROJECT TITLE	**NURSERY PROPAGATION OF COASTAL FOREST PLANTS (NOVEMBER 2008-NOVEMBER 2011)**
Objectives and Outputs	The project generated mangrove and sand dune seedlings at the Port Royal Marine Lab. and developed methodical guidelines for successful coastal forest restoration
Lead Agency	UWI-Port Royal Marine Lab
Funding Agency	FCF
Total Cost	J$5.2m
PROJECT TITLE	**RESTORATION WORKS TO MITIGATE AGAINST BEACH EROSION IN NEGRIL (10 MONTHS)**
Objectives and Outputs	The project implemented measures to mitigate the impacts of coastal erosion of the Negril area through restoration/rehabilitation works
Lead Agency (Supporting) Organizations)	NEPA (NWA)
Total Cost	US$13.8m

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PROJECT TITLE	ANALYSIS OF ISLAND WIDE SHORELINE STABILITY (1 YEAR)
Objectives and Outputs	The project seeks to assess the areas that are perceived to be vulnerable to coastal erosion in order to recommend corrective measures to be implemented on selected pilot areas
Lead Agency (Supporting Organizations)	NEPA (UWI- Centre for Marine Sciences)
Total Cost	US$0.30m

PROTECTED AREA MANAGEMENT AND BIODIVERSITY

PROJECT TITLE	INCREASING COMMUNITY ADAPTATION AND ECOSYSTEM RESILIENCE TO CLIMATE CHANGE IN THE PORTLAND BIGHT (JANUARY 2010- JULY 2011)
Objectives and Outputs	The project engaged community stakeholders to work together to minimize risks and reduce impacts associated with climate change. A rainwater harvesting project is also to be implemented
Lead Agency	Caribbean Coastal Area Management Foundation
Funding Agency	CBA Fund
Total Cost	US$0.05m
PROJECT TITLE	**PALISADOES PENINSULA SHORELINE PROTECTION AND REHABILITATION (2010 -2012)**
Objectives and Outputs	This project aims at repairing and protecting the degraded shoreline of the Palisadoes Peninsula. Rock revetment walls were constructed along 2.65 km of shoreline of the Caribbean Sea-side and 3.6 km along the Harbour-side. A total of 4.38 of the roadway were raised and widened (between 8 to 12 m) to accommodate 4 driving lanes
Lead Agency	NWA
Funding Agency	China EXIM Bank
Total Cost	US$65.4m
PROJECT TITLE	**COTTERWOOD/CONTENT ENVIRONMENT PROTECTION (JANUARY 2007 - OCTOBER 2008)**
Objectives and Outputs	This project enhanced the environmental health and living conditions of targeted communities by addressing soil erosion/land slippage and built the capacity of the Benevolent Society to contribute to the sustenance of soil, water and sanitation systems
Lead Agency	Five Star Development Benevolent Society
Funding Agency and total cost	GEF SGP (US$25 000)
PROJECT TITLE	**COMMUNICATING CLIMATE CHANGE AND BIODIVERSITY (MARCH 2008 - DECEMBER 2010)**
Objectives and Outputs	The project sensitized key stakeholders in vulnerable sectors and communities on emerging research and data on climate change and biodiversity issues, helping to the sustainable conservation and preservation of marine and forest ecosystems
Lead Agency	Mocho Community Development Association
Funding Agency and total cost	EFJ (J$0.730m)

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FORESTRY	
PROJECT TITLE	**IDENTIFICATION, PROPOGATION AND DISSEMINATION OF NATIVE FOREST SPECIES (2008-2011)**
Objectives and Outputs	To develop propagation protocols on various tree species. Thirteen trees being considered. Collect seeds and develop most successful protocols. Work with LFMCs to issue seedlings to establish small plots for imporving biodiversity
Lead Agency	Biotechnology Center, UWI
Funding Agency and total cost	FCF (J$14m)
PROJECT TITLE	**NURSERY PROPAGATION OF COASTAL FOREST LAND (2008-2010)**
Objectives and Outputs	The project developed two nurseries, a wet one for mangrove species (with over 10000 seedlings) and a dry one for sand dune species (3000 seedlings) on Palisadoes, Montego Bay. Endemic species are being researched and protocols are developed
Lead Agency	Port Royal Marine Lab, UWI
Funding Agency and total cost	FCF (J$5.22M)
PROJECT TITLE	**ST THOMAS BEE FARMERS ASSOCIATION REFORESTATION AND ALTERNATIVE LIVELIHOOD PROJECT (JULY 2010 - JULY 2013)**
Objectives and Outputs	To contribute to the sustainable reforestation and preservation of biodiversity in the foothills of the Blue and John Crow Mountains by encouraging forest conservation through beekeeping as a sustainable livelihood
Lead Agency	St. Thomas Bee Farmers Association
Funding Agency and total cost	FCF (J$16.4m)
PROJECT TITLE	**REFORESTATION OF DEGRADED FOREST RESERVE (JULY 2010 - JULY 2014)**
Objectives and Outputs	The project is planting new seedlings (12 has) and maintaining in total, 48 has of forest reserve in the Wallenford/Silver Hill area
Lead Agency (Supporting) Organizations)	Lions Club of Mona (Forestry Department)
Funding Agency and total cost	FCF (J$21.1m)
PROJECT TITLE	**REFORESTATION OF 25 HECTARES OF DEGRADED FOREST RESERVE AT CINCHONA IN THE YALLAHS WATERSHED (NOVEMBER 2007 - MAY 2011)**
Objectives and Outputs	The project reforested 33.5 in the Yallahs watershed using 16 000 seedlings. A video documentary was developed on the work done in the area and farmer field days were organized
Lead Agency (Supporting) Organizations)	Lions Club of Mona (RADA, Forestry Department)
Funding Agency and total cost	FCF (J$13.5m)

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PROJECT TITLE	PLANTING OF 12 HA. OF NEW SEEDLINGS AND MAINTENANCE OF A TOTAL OF 48 HA. IN WALLENFORD (JULY 2010 - JULY 2014)
Lead Agency Supporting Oganization(s)	Lions Club of Mona (Forestry Department)
Funding Agency and total cost	FCF (J$21M)
PROJECT TITLE	**BUFF BAY AGRO-FORESTRY PROJECT (FEBRUARY 2008 - FEBRUARY 2011)**
Objectives and Outputs	The project developed an agro-forestry programme among farmers, schools and forest reserves in the Buff Bay Watershed. Activities included the establishment of 3 school plots, the incorporation of 75 farmers in the programme and the restoration of 10 acres of forest reserve with more than 8000 seedlings
Lead Agency	Buff Bay LFMC
Funding Agency and total cost	FCF (J$6.6m)
PROJECT TITLE	**EXPANSION OF THE BUFF BAY AGRO-FORESTRY PROJECT (JULY 2010 - JULY 2014)**
Objectives and Outputs	The project was extended to include 10 school plots in Buff Bay Pencar watersheds; 15 acres of agro-forestry plots in private holding plots; navel string program issuing seedlings to students. In addition, seedlings were acquired for distribution, and workshops and events were held for farmer mobilization and sensitization
Lead Agency	Buff Bay LFMC
Funding Agency and total cost	FCF (J$17.8M)
PROJECT TITLE	**FOREST CONSERVATION IN THE BLUE MOUNTAINS (NOV. 2007 – NOV. 2011)**
Objectives and Outputs	The project rehabilitated 28 has of park/forest reserve land within the upper Yallahs watershed through the control of invasive alien plant species and the replanting with native forest tree species. Outputs also include 2 functional tree nurseries with native and other species; documentation of propagation and replanting methods for 10 native species including 3 of the Island's threatened endemic species
Lead Agency (Supporting Organizations)	Jamaica Conservation and Development Trust -JCDT- (Forestry Department)
Funding Agency and total cost	FCF (J$13.1m)
PROJECT TITLE	**DALLAS FOREST CONSERVATION PROJECT (NOVEMBER 2007 - NOVEMBER 2010)**
Objectives and Outputs	The project aimed at the stabilization of slope incorporating terracing and reforestation with fruit and timber species and installation of gabion baskets. Outputs include 20 terraces formed on the slope, 50 gabion baskets installed, 700 seedlings planted on 3 acres of land restored with vegetative cover with a variety of tree species
Lead Agency	Dallas Castle Community Development Council
Funding Agency and total cost	FCF (J$3.5m)

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PROJECT TITLE	CONTENT GAP FOREST CONSERVATION (JULY 2010 - JULY 2013)
Objectives and Outputs	The project strengthened the capacities of farmers to protect the environment and their livelihoods and improving the standard of living. For this, sustainable land management practices were promoted in deforested areas for watershed protection with seedlings and pineapple suckers; and awareness raising on the use of harmful chemicals and the cutting down of trees
Lead Agency (Supporting Organizations)	Content Gap JAS Farmers Group (RADA)
Funding Agency and total cost	FCF; RADA (J$2.2m)

ENERGY AND MITIGATION

PROJECT TITLE	PROMOTING ENERGY EFFICIENCY AND RENEWABLE ENERGY IN BUILDINGS IN JAMAICA (MARCH 2011 - MARCH 2015)
Objectives and Outputs	This project promotes higher standards of energy and resource-efficiency in building practices and policies in tropical and sub-tropical regions. For this, it is foreseen the construction of a prototype net zero energy, zero-carbon 'smart' building as a demonstration, accompanied with active dissemination and training programmes
Lead Agency (Supporting Organizations)	University of the West Indies (UWI) (The Center of Excellence for Renewable Energy (a division of the PCJ/Ministry of Energy), the Scientific Research Council of Jamaica, the University of Technology, the National Housing Trust, and the PSOJ)
Funding Agency and total cost	GEF Trust Fund (GEF- US$2.39m; Co -fin. US$4.7m)
PROJECT TITLE	**ESTABLISHING THE CARIBBEAN MARITIME INSTITUTE AS A LEARNING CENTRE FOR RENEWABLE ENERGY PRODUCING WIND ENERGY/POTABLE DRINKING WATER**
Objectives and Outputs	This project supports the management of the CMI in the development of a plan to establish a supplemental water efficiency system using the reverse osmosis technology that will provide approximately 1000 gals of potable water daily for the school community. The system also includes a rainwater harvesting component. The facility will be accessible to surrounding communities and other schools for replication
Lead Agency	Caribbean Maritime Institute Trust Fund
Funding Agency and total cost	GEF Small Grant (US$0.04m)
PROJECT TITLE	**DEVELOPMENT OF A NATURE TRAIL WITHIN THE BOGUE FOREST ESTATE AND THE APPLICATION OF SOLAR ENERGY TECHNOLOGY (JULY 2008 - JANUARY 2009)**
Objectives and Outputs	The project developed an ecotourism attraction as an alternative livelihood for the communities of Parry Town, Pimento Walk and Snow Hill. In addition, renewable energy technologies and reforestation activities were implemented
Lead Agency	Hills United Development Organization - HUDO
Funding Agency and total cost	GEF - Small Grant (US$0.03m)

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PROJECT TITLE	BUILDING OF CARIBBEAN PRIVATE SECTOR ENVIRONMENTAL AND ENERGY MANAGEMENT CAPABILITIES (2010-2011)
Objectives and Outputs	The project supports the regional approach to environmental/energy management for positive commercial externalities by strengthening the capacities of the PSOJ, the CAIC and their members. Outputs include companies with better environmental/energy management practices, increased participation in the carbon trading market and greater regional collaboration on environmental/energy management
Lead Agency	PSOJ
Funding Agency	EU- Pro-Invest
PROJECT TITLE	**APPLICATION OF RENEWABLE ENERGY (JULY 2009 - OCTOBER 2010)**
Objectives and Outputs	The project aims at avoiding about 3,000 Kg of CO2-eq of carbon emissions per month, mitigating climate change and improving the air quality. For this, the project fosters the consumption of more than 3,600 kWh of renewable energy per month, generated from an installed Photovoltaic System capacity of 22.4 kW which will be substituting an equivalent capacity of fossil fuel based power being supplied from the Jamaica Public Service
Lead Agency	Foundation for International Self Help - FISH
Funding Agency and total cost	GEF Small Grant (US$0.04m)
PROJECT TITLE	**REDUCING CARBON EMISSIONS THROUGH THE USE OF SOLAR ENERGY TECHNOLOGY IN PROTECTED AGRICULTURE**
Objectives and Outputs	This project introduces the use of solar energy to drive the irrigation systems for the recently constructed greenhouses, instead of gasoline or diesel pumps. This is expected to avoid some 6 tons of Co2-eq emissions
Lead Agency	Mafoota Agricultural Cooperative Society Limited
Funding Agency and total cost	GEF Small Grant (US$0.028m)
PROJECT TITLE	**REDUCING CARBON EMISSIONS THROUGH THE USE OF SOLAR ENERGY TECHNOLOGY IN PROTECTED AGRICULTURE**
Objectives and Outputs	This project introduces the use of solar energy to drive the irrigation systems for the recently constructed greenhouses, instead of gasoline or diesel pumps. This is expected to avoid some 4 tons of Co2-eq emissions
Lead Agency	Sweet Water Agricultural Cooperative Society Limited
Funding Agency and total cost	GEF Small Grant (US$0.017m)
PROJECT TITLE	**REDUCING CARBON EMISSIONS THROUGH THE USE OF SOLAR ENERGY IN PROTECTED AGRICULTURE (AUGUST 2010 - JUNE 2011)**
Objectives and Outputs	The project introduced solar energy technology to drive the irrigation and fertigation systems of recently constructed greenhouses. Training on the use of technology and sustainable methods of farming was undertaken
Lead Agency	Sweet Water Agricultural Cooeprative Society Limited
Funding Agency and total cost	GEF-SGP (US$16854)

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PROJECT TITLE	REDUCING CARBON EMISSIONS THROUGH THE USE OF SOLAR ENERGY IN PROTECTED AGRICULTURE (AUGUST 2010 - OCTOBER 2011)
Objectives and Overview	The project introduced solar energy technology to drive the irrigation and fertigation systems of recently constructed greenhouses
Lead Agency	Mafoota Agricultural Cooperative Society Limited
Funding Agency and total cost	GEF-SGP (US$28 000)
PROJECT TITLE	**APPLICATION OF SOLAR ENERGY-FRIENDLY FARMING TECHNIQUES: REFORESTATION AND SOIL CONSERVATION IN THE UPPER RIO COBRE WATERSHED (JULY 2009 - OCTOBER 2010)**
Objectives and Outputs	This project introduced environmentally friendly farming techniques, including greenhouse farming, application of solar pumping and lighting and soil conservation techniques
Lead Agency (Supporting Organizations)	One Love Farmers Group (RADA, LUMITECH, Greenhouse Growers Association)
Funding Agency and total cost	GEF-SGP (US$22 000)

TRAINING, COMMUNICATION AND KNOWLEDGE MANAGEMENT

PROJECT TITLE	ENHANCING KNOWLEDGE OF COMPREHENSIVE DISASTER MANAGEMENT (3 YEARS)
Objectives and Outputs	The project establishes an effective mechanism for managing and sharing Comprehensive Disaster Management (CDM) knowledge for decision-making. Outputs include the establishment of a regional network that generates, manages and disseminates knowledge on Disaster Management, the development of standardized training materials for university and professional courses, as well as mechanisms, tools, courses and guidelines for mainstreaming CDM into policy development and decision-making in the region
Lead Agency	Institute of Sustainable Development
Funding Agency	CIDA
PROJECT TITLE	**TRAINING ON THE RIVAMP METHODOLOGY**
Objectives and Outputs	This training promotes greater understanding of the role of ecosystems for disaster risk reduction, including climate change-related risks, through integrated assessments that can support policy and land-use planning decisions. The training seeks to enhance national and regional capacities in applying scientific approaches and community-based consultations in a complementary way, to demonstrate how coastal ecosystems in particular (e.g. coral reefs, sea grasses, and mangroves) can mitigate coastal hazard impacts and reduce local vulnerability
Lead Agency	PIOJ, Institute of Sustainable Development, UWI
Funding Agency and total cost	UNEP (US$0.14m)

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PROJECT TITLE	VOICES FOR CLIMATE EDUCATION: A NATIONAL CLIMATE CHANGE COMMUNICATION STRATEGY (JANUARY 2009 - NOVEMBER 2010)
Objectives and Outputs	The project develops and implements a national communication strategy on issues related to climate change. Activities focused on public awareness on the threats posed by climate change and strategies to reduce social and economic impacts through popular artists and sectoral workshops, targeting sectors such as tourism, insurance, agriculture and health
Lead Agency (Supporting Organizations)	NEEC & Panos (NEPA, Forestry Dept, Bureau of Standards, Christian Aid)
Funding Agency and total cost	EFJ, UNDP (J$4.5m, US$0.01m)
PROJECT TITLE	**"TELL IT"-DISSEMINATING CARIBBEAN CLIMATE CHANGE SCIENCE AND STORIES (OCTOBER 2009- DECEMBER 2010)**
Objectives and Outputs	This project gathered the scientific information from CBA projects and disseminated among decision-makers, the academia and to members responsible for the Fifth Assessment Report (IPCC)
Lead Agency	Climate Studies Group -Mona
Funding Agency and total cost	CBA Fund (US$0.025m)
PROJECT TITLE	**2ND NATIONAL COMMUNICATION TO THE UNFCCC (MAY 2006-MARCH 2010)**
Objectives and Outputs	The project prepared the 2nd National Communication to suggest mechanisms and priorities for improving capacity, and prioritize the activities needed to address climate change issues, both in terms of mitigation as well as adaptation and reduction of vulnerability. Capacity building elements were incorporated in all proposed activities
Lead Agency	Met. Services Jamaica
Funding Agency and total cost	GEF; GOJ; UNDP (US$0.525m)
PROJECT TITLE	**CARIBBEAN MODELING INITIATIVE - ADDRESSING CARIBBEAN CLIMATE CHANGE (APRIL 2010-DECEMBER 2015)**
Objectives and Outputs	This initiative has five objectives: – Utilize data already available as output from the PRECIS model and to do further assessment of the value added by using regional climate models in the Caribbean, – Increase the range of analysis performed, including the examination of extreme events & hurricanes and finally, at increasing the number of additional climate variables analysed in order to increase the variety of impact/sectoral studies that can be successfully conducted. – Provide new and additional climate change projection of scale that are harmonized with other regional projection of the Fifth Assessment Report of the IPCC. Undertake comparison and validation studies, to quantify uncertainties and provide a range of model results for use in regional adaptation strategies to climate change.
Lead Agency	Climate Studies Group- Mona; UWI - Cave Hill; CIMH -Barbados; INSMET-Cuba; CCCCC-Belize; Anton de Kom University of Suriname
Funding Agency and total cost	Reg. PPCR (US$0.9m)

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PROJECT TITLE	COMMUNITY WATERSHED EDUCATION PROGRAMME: PUBLIC AWARENESS AND ACTION IN THE DRIVERS' RIVER WATERSHED (JULY 2006-JUNE 2007)
Objectives and Outputs	The education programme for community stakeholders focused on the functions of a watershed, the values of the watershed to the community and the specific actions community members can take to protect the watershed to ensure the continued provision of essential services for economic and/or social development and empowerment. The programme included the development of an aquaculture, vegetable garden and agro-forestry project in various schools, demonstration plots were established and farmers trained and 20 new farmers have registered with the Forestry Department, a craft vendors association was established and marketing seminars were conducted
Lead Agency (Supporting Organizations)	Portland Environmental Protection Association (RADA, Forestry Department)
Funding Agency and total cost	GEF-SGP (US$24850)

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Printed on ecological paper - September 2013 - Design, layout and figures' optimization: studio@bartoleschi.com

Climate change is likely to have adverse effects on the agriculture sector in Jamaica. Increase in the intensity and frequency of climate-related natural hazards, increasing rainfall variability, droughts and floods combined with fragile ecosystems and coastal zones all contribute to Jamaica's overall vulnerability to climate change. Climate change adaptation is one of the outcomes of the Vision 2030 Jamaica-National Development Plan. In the context of this plan, there is need for more analysis of the likely climate change impacts in the short and medium term, along with identification of agricultural adaptation strategies. This report provides detailed information about current knowledge on vulnerability, past trends in climate, and impacts of climate variability and change on agriculture sector. The scope of the study focused on broader policy directions, technical alternatives and investment priorities in relation to climate change adaptation. The report also provides examples of good practices of coping strategies in agriculture and a detailed list of ongoing and completed projects/initiatives related to climate change and agriculture in Jamaica.



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Food and Agriculture Organization of the United Nations (FAO)
www.fao.org

ISBN 978-92-5-107894-5 ISSN 2071-0992

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I3417E/1/08.13