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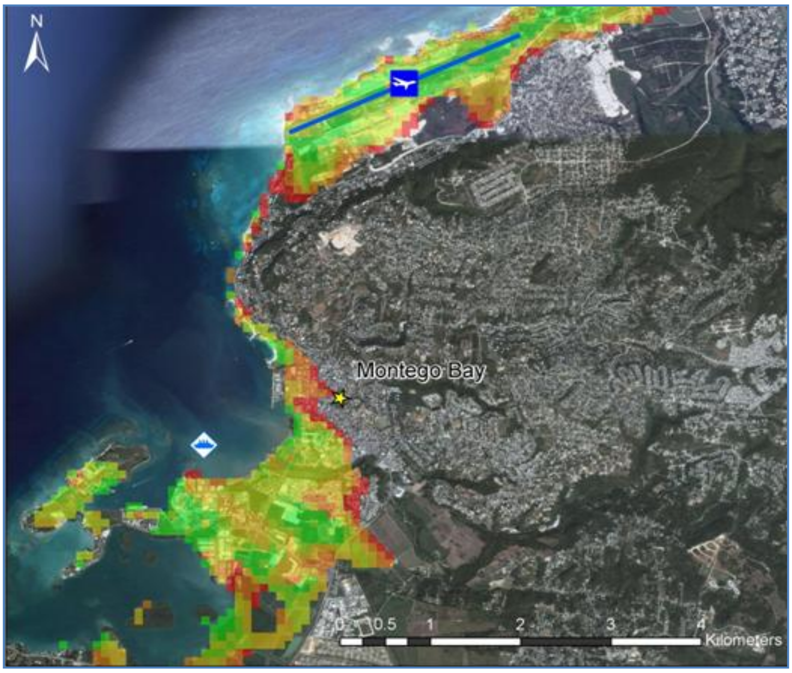
Protecting and enhancing the livelihoods, environments and economies of the Caribbean Basin

THE CARIBSAVE CLIMATE CHANGE RISK ATLAS (CCCRA)

Climate Change Risk Profile for Jamaica



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PROJECT BACKGROUND AND APPROACH

Contribution to Climate Change Knowledge and Understanding

Climate change is a serious and substantial threat to the economies of Caribbean nations, the livelihoods of communities and the environments and infrastructure across the region. The CARIBSAVE Climate Change Risk Atlas (CCCRA) Phase I, funded by the UK Department for International Development (DFID/UKaid) and the Australian Agency for International Development (AusAID), was conducted from 2009 – 2011 and successfully used evidence-based, inter-sectoral approaches to examine climate change risks, vulnerabilities and adaptive capacities; and develop pragmatic response strategies to reduce vulnerability and enhance resilience in 15 countries across the Caribbean (*Anguilla, Antigua & Barbuda, The Bahamas, Barbados, Belize, Dominica, The Dominican Republic, Grenada, Jamaica, Nevis, Saint Lucia, St. Kitts, St. Vincent & the Grenadines, Suriname and the Turks & Caicos Islands*).

The primary basis of the CCCRA work is the detailed climate modelling projections done for each country under three scenarios: A2, A1B and B1. Climate models have demonstrable skill in reproducing the large scale characteristics of the global climate dynamics; and a combination of multiple Global Climate Model (GCM) and downscaled Regional Climate Model (RCM) projections was used in the investigation of climatic changes for all 15 countries. RCMs simulate the climate at a finer spatial scale over a small area, like a country, acting to 'downscale' the GCM projections and provide a better physical representation of the local climate of that area. As such, changes in the dynamic climate processes at a national or community scale can be projected.

SRES storylines and scenario families used for calculating future greenhouse gas and other pollutant emissions

Storyline and scenario family	Description
A2	A very heterogeneous world; self reliance; preservation of local identities; continuously increasing global population; economic growth is regionally oriented and per capita economic growth and technological change are slower than in other storylines.
A1B	The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The three A1 groups are distinguished by their technological emphasis. A1B is balanced across all sources - not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.
B1	A convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

(Source: Adapted from the IPCC Special Report on Emissions Scenarios, 2000)

The CCCRA provides robust and meaningful new work in the key sectors and focal areas of: Community Livelihoods, Gender, Poverty and Development; Agriculture and Food security; Energy; Water Quality and Availability; Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements; Comprehensive Disaster Management; Human Health; and Marine and Terrestrial Biodiversity and

Fisheries. This work was conducted through the lens of the tourism sector; the most significant socio-economic sector to the livelihoods, national economies and environments of the Caribbean and its' people.

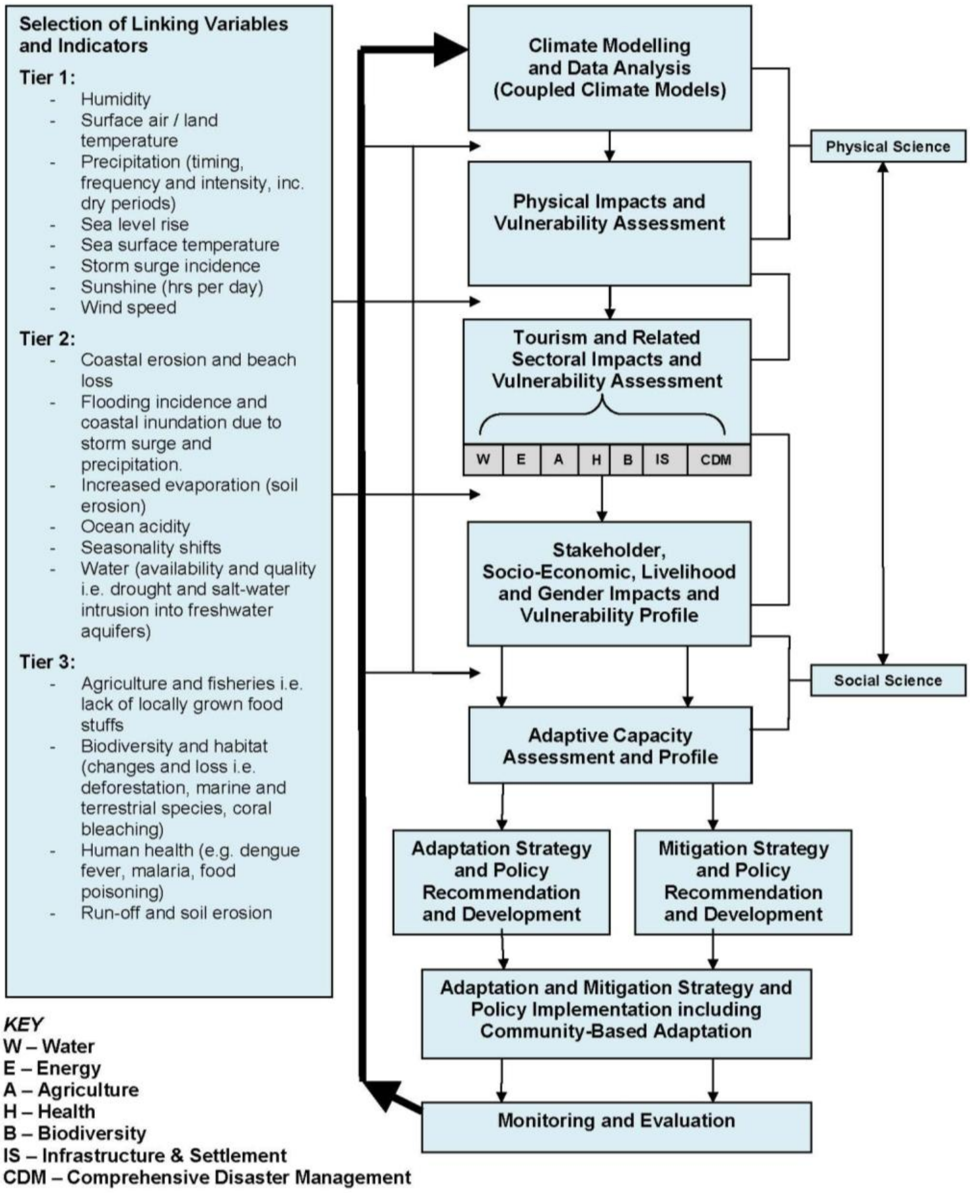
The field work components of the research and CARIBSAVE's commitment to institutional strengthening in the Caribbean have helped to build capacity in a wide selection of ministries, academic institutions, communities and other stakeholders in the areas of: climate modelling, gender and climate change, coastal management methods and community resilience. Having been completed for 15 countries in the Caribbean Basin, this work allows for inter-regional and cross-regional comparisons leading to lesson learning and skills transfer.

A further very important aspect of the CCCRA is the democratisation of climate change science. This was conducted through targeted awareness, tools (e.g. data visualisation, GIS imagery, animated projections and short films), and participatory approaches (workshops and vulnerability mapping) to improve stakeholder knowledge and understanding of what climate change means for them. Three short films, in high-resolution format of broadcast quality, are some of the key outputs. These films are part of the *Partnerships for Resilience* series and include: '*Climate Change and Tourism*'; '*Caribbean Fish Sanctuaries*'; and '*Living Shorelines*'. They are available at www.youtube.com/Caribsave.

Project Approach to Enhancing Resilience and Building Capacity to Respond to Climate Change across the Caribbean

Processes and outputs from the CCCRA bridge the gap between the public and private sectors and communities; and their efforts to address both the physical and socio-economic impacts of climate change, allowing them to better determine how current practices (which in fact are not isolated in one sector alone) and capacities must be enhanced. The stages of the CCCRA country profile protocol (see following page) are as follows: a) Climate Modelling and Data Analysis (including analysis of key 'Tier 1' climate variables linking the climate modelling to physical impacts and vulnerabilities) b) Physical Impacts and Vulnerability Assessment c) Tourism and Related Sector Vulnerability Assessments (including examination of the sectors of water, energy, agriculture, biodiversity, health, infrastructure and settlement, and comprehensive disaster management) d) Development of Vulnerability Profile with stakeholders taking account of socio-economic, livelihood and gender impacts (including evaluation of 'Tier 2' linking variables and indicators such as coastal inundation) e) Adaptive Capacity Assessment and Profiling f) Development of Adaptation and Mitigation Strategies and Policy Recommendations (action planning). The final stages depicted in the flow chart focusing on the implementation of policies and strategies at ministerial/government level and the implementation of actions at community level, using a community-based adaptation approach, are proposed to be implemented as part of the forthcoming CCCRA process as projects to be funded by other donors post the country profile stage.

The work of the CCCRA is consistent with the needs of Caribbean Small Island and Coastal Developing States identified in the document, "*Climate Change and the Caribbean: A Regional Framework for Development Resilient to Climate Change (2009-2015)",* published by the Caribbean Community Climate Change Centre (CCCCC); and supports each of the key strategies outlined in the framework's Regional Implementation Plan.



CCCRA Profiling Flow Chart

The CCCRA continues to provide assistance to the governments, communities and the private sector of the Caribbean at the local destination level and at national level through its primary outputs for each of the 15 participating countries: National Climate Change Risk Profiles; Summary Documents; and high-resolution maps showing sea level rise and storm surge projections under various scenarios for vulnerable coastal areas. It is anticipated that this approach will be replicated in other destinations and countries across the Caribbean Basin.

The CCCRA explored recent and future changes in climate in each of the 15 countries using a combination of observations and climate model projections. Despite the limitations that exist with regards to climate modelling and the attribution of present conditions to climate change, this information provides very useful indications of the changes in the characteristics of climate and impacts on socio-economic sectors. Consequently, decision makers should adopt a precautionary approach and ensure that measures are taken to increase the resilience of economies, businesses and communities to climate-related hazards.

This report was created through an extensive desk research, participatory workshops, fieldwork, surveys and analyses with a wide range of public and private sector, and local stakeholders over 18 months.

LIST OF ABBREVIATIONS AND ACRONYMS

ADA ---------------------------Austrian Development Agency
ADP----------------------------Air Passenger Duty
AHC----------------------------Acute Haemorrhagic Conjunctivitis
AIC-----------------------------Aviation-induced Clouds
ALIGN -------------------------Arable Lands Irrigated and Growing for the Nation
AOSIS -------------------------Alliance of Small Island Developing States
API-----------------------------Agricultural Production Index
ASTER-------------------------Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAU ---------------------------Business as Usual
BBC----------------------------British Broadcasting Corporation
BPOA--------------------------Barbados Programme of Action
BOE----------------------------Barrel of oil equivalent
CARDI -------------------------Caribbean Agricultural Research and Development Institute
CAREC ------------------------Caribbean Epidemiology Centre
CARICOM --------------------Caribbean Community
CBA----------------------------Community Based Adaptation
CBC----------------------------Canadian Broadcasting Corporation
CBO----------------------------Community Based Organisation
C-CAM ------------------------Caribbean Coastal Management Area
CCDM -------------------------Climate Change Disaster Management
CCCCC------------------------Caribbean Community Climate Change Centre
CCCRA ------------------------CARIBSAVE Climate Change Risk Atlas
CCRIF--------------------------Caribbean Catastrophe Risk Insurance Facility
CDB----------------------------Caribbean Development Bank
CDC----------------------------Centre for Disease Control and Prevention
CDEMA -----------------------Caribbean Disaster Emergency Management Agency
CDM---------------------------Clean Development Mechanism (in the context of Energy/Emissions)
CDM---------------------------Comprehensive Disaster Management
CEHI ---------------------------Caribbean Environmental Health Institute
CEP ----------------------------Caribbean Event Programme
CEPF---------------------------Critical Ecosystem Partnership Fund
CHENACT --------------------Caribbean Hotel Energy Efficiency Action Project
CIA-----------------------------Central Intelligence Agency
CIAT ---------------------------International Centre for Tropical Agriculture
CIMH--------------------------Cuban Institute of Meteorology
CITES --------------------------Convention on International Trade in Endangered Species
COP----------------------------Conference of Parties
CPACC ------------------------Caribbean Planning for Adaptation to Climate Change
CRFM -------------------------Caribbean Regional Fisheries Mechanism
CRI -----------------------------Climate Risk Index
CRID--------------------------- Regional Disaster Center – Latin America and the Caribbean
CROSQ------------------------CARICOM Regional Organisation for Standards Quality
CSGM -------------------------Climate Studies Group Mona
CTO----------------------------Caribbean Tourism Organization

CZMU --------------------------Coastal Zone Management Unit
DEFRA ------------------------Department for Environment, Food and Rural Affairs
DF------------------------------Dengue Fever
DFID---------------------------Department for International Development
DHF----------------------------Dengue Hemorrhagic Fever
DJF-----------------------------Seasonal period of December, January, February
DNA ---------------------------Designated National Authority
DRM---------------------------Disaster Risk Management
DRR----------------------------Disaster Risk Reduction
ECE ----------------------------Energy Conservation and Efficiency
ECLAC-------------------------Economic Commission for Latin America and the Caribbean
EFJ -----------------------------Environmental Foundation of Jamaica
EHF ----------------------------Environmental Health Foundation
EIA -----------------------------Environmental Impacts Assessment
EM-DAT ----------------------The International Disaster Database
ENSO --------------------------El Niño Southern Oscillation
ESL-----------------------------Environmental Solutions Limited
EU------------------------------European Union
EU ETS ------------------------European Union Emissions Trading System
EWS ---------------------------Early Warning System
FAO----------------------------Food and Agriculture Organization
FDI -----------------------------Foreign Direct Investment
GCM---------------------------Global Circulation Model
GCP----------------------------Ground Control Point
GDEM-------------------------Global Digital Elevation Model
GDP ---------------------------Gross Domestic Product
GEF ----------------------------Global Environment Fund
GHG ---------------------------Global Greenhouse Gas
GIS -----------------------------Geographic Information System
GOJ ----------------------------Government of Jamaica
GPS ----------------------------Global Positioning System
HFA ----------------------------Hyogo Framework for Action
HDI ----------------------------Human Development Index
HDR ---------------------------Human Development Report
IAASTD-----------------------International Assessment of Agriculture Knowledge, Science and Technology for Development
IATA ---------------------------International Air Transport Association
ICAO--------------------------International Civil Aviation Organisation
ICOADS -----------------------International Comprehensive Ocean-Atmosphere Data Set
ICT -----------------------------Information and Communication Technologies
IDB-----------------------------Inter-American Development Bank
IEA -----------------------------International Energy Agency
IFRC ---------------------------International Federation of Red Cross
IGA ----------------------------Income Generated Activity
IICA ----------------------------Inter-American Institute for Cooperation on Agriculture
IMET --------------------------Italian Ministry of the Environment and Territory
IMF ----------------------------International Monetary Fund

INSMET------------------------Meteorological Institute of the Republic of Cuba
IPCC ---------------------------Intergovernmental Panel on Climate Change
IPPM --------------------------Integrated Production and Protection Management
ISCCP--------------------------International Satellite Cloud Climatology Project
ISDR ---------------------------International Strategy for Disaster Reduction
ITCZ----------------------------Inter-Tropical Convergence Zone
IUCN --------------------------International Union for Conservation of Nature
IVM----------------------------Integrated Vector Management
JAS-----------------------------Jamaican Agricultural Society
JCDT---------------------------Jamaica Conservation and Development Trust
JCRMN------------------------Jamaica Coral Reef Monitoring Network
JET -----------------------------Jamaica Environmental Trust
JIS------------------------------Jamaica Information Service
JJA -----------------------------Seasonal period of June, July, August
JNRWP------------------------Jamaica Network of Rural Women Producers
JOAM -------------------------Jamaica Organic Agriculture Movement
JPAT---------------------------Jamaica Protected Areas Trust
JTB-----------------------------Jamaica Tourist Board
LDUC--------------------------Land Development and Utilisation Commission
LGPD --------------------------Livelihoods, Gender, Poverty and Development
MACC-------------------------Mainstreaming Adaptation to Climate Change Project
MAM--------------------------Seasonal period of March, April, May
MDGs -------------------------Millennium Development Goals
MEAs--------------------------Multilateral Environmental Agreements
MEM --------------------------Ministry of Energy and Mining, Jamaica
MFAFT------------------------Ministry of Foreign Affairs and Foreign Trade, Jamaica
MHW -------------------------Ministry of Housing and Water
MLE ---------------------------Ministry of Land and Environment
MOH --------------------------Ministry of Health, Jamaica
MPA---------------------------Marine Protected Areas
MSJ ---------------------------Meteorological Services of Jamaica
NASA--------------------------National Aeronautics and Space Administration
NCOCZM ---------------------National Council on Ocean and Coastal Zone Management
NDC ---------------------------National Disaster Committee
NEPA--------------------------National Environmental Protection Agency
NGOs--------------------------Non-Governmental Organisations
NHIA --------------------------National Hazard Impact Assessment
NIC----------------------------National Irrigation Commission
NOAA -------------------------National Oceanic and Atmospheric Administration
NRCA--------------------------Natural Resources Conservation Authority
NSWMA ----------------------National Solid Waste Management Authority
NWC --------------------------National Water Commission
OAS----------------------------Organization of American States
ODIPERC ---------------------Office of Disaster Preparedness and Emergency Relief Coordination
ODPEM -----------------------Office of Disaster Preparedness and Emergency Management
ODPM------------------------Office of Deputy Prime Minister
OE ----------------------------Operational Entities

OECD--------------------------Organisation for Economic Co-operation and Development
OUR ---------------------------Office of Utilities Regulation
PA------------------------------Protected Areas
PAHO -------------------------Pan American Health Organization
PDC ---------------------------Parish Disaster Commission
PHC----------------------------Primary Health Care
PIOJ----------------------------Planning Institute of Jamaica
PKM ---------------------------Passenger kilometres
PSOJ---------------------------Private Sector Organisation of Jamaica
PVC----------------------------Poly-vinyl Chloride
RADA--------------------------Rural Agricultural Development Agency
RCM---------------------------Regional Climate Models
RE------------------------------Renewable Energy
RH -----------------------------Relative Humidity
RECC --------------------------Review of the Economics of Climate Change
REM ---------------------------Riley Encased Methodology
ROI ----------------------------Return on Investment
RWH---------------------------Rainwater Harvesting
RWSL--------------------------Rural Water Supply Limited
SIDS ---------------------------Small Island Developing States
SLR-----------------------------Sea Level Rise
SON ---------------------------Seasonal period of September, October, November
SST-----------------------------Sea Surface Temperature
STATIN------------------------Statistics Institute of Jamaica
TIN-----------------------------Triangular Irregular Network
TPD----------------------------Town Planning Department
TPDCo ------------------------Tourism Product Development Company Ltd
UGA ---------------------------University of Georgia
UKERC ------------------------UK Energy Research Centre
UN -----------------------------United Nations
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
UNIFEM ----------------------United Nations Fund for Women
UNSD -------------------------United Nations Statics Division
UNESCO----------------------United Nations Educational, Scientific and Cultural Organisation
UN Women------------------UN Entity for Gender Equality and the Empowerment of Women
UNWTO ----------------------United Nations World Tourism Organisation
USACE ------------------------United States Army Corps of Engineers
USAID-------------------------United States for International Development
UWI ---------------------------University of the West Indies
VAT----------------------------Value Added Tax
WCMC------------------------World Conservation Monitoring Centre
WDPA-------------------------World Database of Protected Areas
WEF --------------------------World Economic Forum
WHO -------------------------World Health Organization

WRA---------------------------Water Resources Authority
WROC-------------------------Women's Resource and Outreach Centre
WTO---------------------------World Tourism Organization
WTTC -------------------------World Travel and Tourism Council
YFEP---------------------------Young Farmers' Entrepreneurship Programme

EXECUTIVE SUMMARY

A practical evidence-based approach to building resilience and capacity to address the challenges of climate change in the Caribbean

Climate change is a serious and substantial threat to the economies of Caribbean nations, the livelihoods of communities and the environments and infrastructure across the region. The CARIBSAVE Climate Change Risk Atlas (CCCRA) Phase I, funded by the UK Department for International Development (DFID/UKaid) and the Australian Agency for International Development (AusAID), was conducted from 2009 – 2011 and successfully used evidence-based, inter-sectoral approaches to examine climate change risks, vulnerabilities and adaptive capacities; and develop pragmatic response strategies to reduce vulnerability and enhance resilience in 15 countries across the Caribbean (*Anguilla, Antigua & Barbuda, The Bahamas, Barbados, Belize, Dominica, The Dominican Republic, Grenada, Jamaica, Nevis, Saint Lucia, St. Kitts, St. Vincent & the Grenadines, Suriname and the Turks & Caicos Islands*).

The CCCRA provides robust and meaningful new work in the key sectors and focal areas of: Community Livelihoods, Gender, Poverty and Development; Agriculture and Food security; Energy; Water Quality and Availability; Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements; Comprehensive Disaster Management; Human Health; and Marine and Terrestrial Biodiversity and Fisheries. This work was conducted through the lens of the tourism sector; the most significant socio-economic sector to the livelihoods, national economies and environments of the Caribbean and its people.

SELECTED POLICY POINTS

- Regional Climate Models, downscaled to national level in the Risk Atlas, have provided projections for Caribbean SIDS and coastal states with enough confidence to support decision-making for immediate adaptive action.
- Planned adaptation must be an absolute priority. New science and observations should be incorporated into existing sustainable development efforts.
- Economic investment and livelihoods, particularly those related to tourism, in the coastal zone of Caribbean countries are at risk from sea level rise and storm surge impacts. These risks can encourage innovative alternatives to the way of doing business and mainstreaming of disaster risk reduction across many areas of policy and practice.
- Climate change adaptation will come at a cost but the financial and human costs of inaction will be much greater.
- Tourism is the main economic driver in the Caribbean. Primary and secondary climate change impacts on this sector must both be considered seriously. Climate change is affecting related sectors such as health, agriculture, biodiversity and water resources that in turn impact on tourism resources and revenue in ways that are comparable to direct impacts on tourism alone.
- Continued learning is a necessary part of adaptation and building resilience and capacity. There are many areas in which action can and must be taken immediately.
- Learning from past experiences and applying new knowledge is essential in order to avoid maladaptation and further losses.

Overview of Climate Change Issues in Jamaica

Tourism has been and continues to be a major economic sector in Jamaica. Jamaica is already experiencing some of the effects of climate variability and change through damages from severe weather systems and other extreme events, as well as more subtle changes in temperatures and rainfall patterns. Impacts from climate change will continue to adversely affect the livelihoods based on these sectors.

Detailed climate modelling projections for Jamaica predict:

- an increase in average atmospheric temperature;
- reduced average annual rainfall;
- increased Sea Surface Temperatures (SST); and
- the potential for an increase in the intensity of tropical storms.

And the extent of such changes is expected to be worse than what is being experienced now.

To capture local experiences and observations; and to determine the risks to coastal properties and infrastructure, selected sites were extensively assessed. Primary data were collected and analysed to:

1. assess the vulnerability of the livelihoods of residents in **Port Antonio and surrounding areas (Orange Bay, Buff Bay, Hope Bay, Boundbrook to Drapers and Snow Hill)** to climate change; and
2. project sea level rise and storm surge impacts on the coast of **Portland Parish**.

These sites were selected by national stakeholders to represent areas of the country that are important to the tourism sector and the economy as a whole, and that are already experiencing adverse impacts from climate-related events.

Vulnerable community livelihoods

- At-risk residents in coastal communities make up about 60% of Jamaica's population and while community nuances are different, they are generally vulnerable to storm surges, hurricanes and flooding.
- Male-dominated livelihoods like farming and fishing are very vulnerable to climate change.
- Some livelihood practises are unsustainable and exacerbate vulnerability. However, communities are willing to adapt if resources and training are provided.

Vulnerable coastlines

- Under the smallest SLR scenario (0.5 m), 35% to 68% of the highly valued beach resources in Portland Parish would be lost.
- With a 1 m SLR, 61% of Frenchman's Cove and Winnifred Beach would become inundated and 75% of Hope Bay would be inundated.
- Ports are the most threatened of the coastal infrastructure, with 100% of port lands in Jamaica projected to be inundated with a 1 m SLR.

Climate change effects are evident in the decline of some coastal tourism resources, but also in the socioeconomic sectors which support tourism, such as agriculture, water resources, health and biodiversity.

Climate Change Projections for Jamaica

The projections of *temperature, precipitation, sea surface temperatures;* and *tropical storms and hurricanes* for Jamaica are indicated in Box 1 and have been used in making expert judgements on the impacts on various socio-economic sectors and natural systems, and their further implications for the tourism industry.

Stakeholders consulted in the CCCRA have shared their experiences and understanding about climate-related events, and this was generally consistent with observational data.

Box 1: Climate Modelling Projections for Jamaica

Temperature: Annual mean temperature changes for Jamaica, simulated by Regional Climate Models (RCMs), indicate increases of 2.9 to 3.4˚C by the 2080s under a higher emissions scenario.

Precipitation: Both RCM and General Circulation Model (GCM) ensembles, indicate overall decreases (by 10 - 41%) in annual rainfall for Jamaica as a whole, particularly throughout March, April, May and June, July and August. However, changes in seasonal precipitation simulated by the RCM vary considerably depending on the driving GCM with HadCM3-driven RCM projections indicating large decreases in precipitation.

Sea Surface Temperatures (SSTs): GCMs project annual mean SST increases of 0.9 to 2.7˚C by 2080s relative to the 1970-99 average, in waters surrounding Jamaica across the three scenarios.

Tropical Storms and Hurricanes: North Atlantic hurricanes and tropical storms appear to have increased in intensity over the last 30 years. Observed and projected increases in SSTs indicate potential for continuing increases in hurricane activity and model projections indicate that this may occur through increases in intensity of events but not necessarily through increases in frequency of storms.

Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements

Figure 1: Coastal tourism resort

More than half of the population of Jamaica lives within 1.5 km of the shoreline and approximately 90% of the island’s GDP (through tourism, industry, fisheries, agriculture) is produced within its coastal zone. This high density of development (particularly related to tourism) increases the risk of degradation of coastal and marine biodiversity thereby reducing its resilience to climate change impacts including SLR and storm surge.

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada) and the staff from the National Environment and Planning Agency (NEPA) to complete detailed coastal profile surveying at five beaches in Portland: Frenchman’s Cove, Hope Bay, Long Bay, St. Margaret’s Bay and Winnifred Beach.

Results from the field study sites selected in Portland Parish indicate that a 1 m SLR places 8% of the major tourism properties at risk, with an additional 10% at risk with 2 m SLR. Critical beach assets would be affected much earlier than the SLR-induced erosion damages to tourism infrastructure; indeed, once erosion is damaging tourism infrastructure, it means the beach, a vital tourism asset, has already disappeared! Ports are the most threatened of the coastal infrastructure, with 100% of port lands in Jamaica projected to be inundated with a 1 m SLR, followed by 20% of airports rlands and approximately 30 km, or 2%, of road networks.

Figure 2: High Resolution Coastal Profile Surveying with GPS

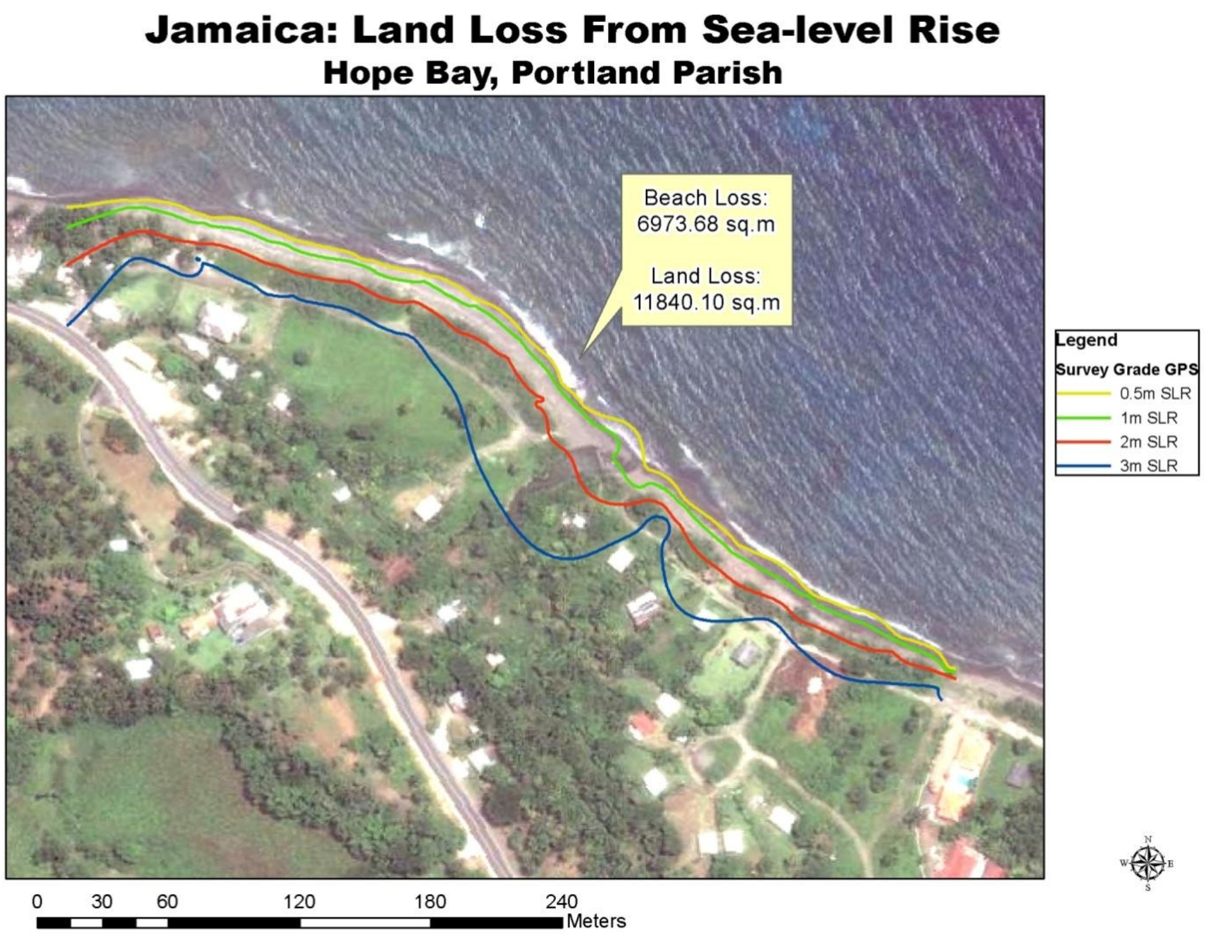


Figure 3: Extent of SLR impact

Even under the smallest SLR scenario (0.5 m), 35% to 68% of the highly valued beach resources in Portland Parish would be lost (Table 1). With a 2 m SLR, 100% of Frenchman's Cove and Winnifred Beach would become inundated and 98% of Hope Bay would be inundated. A 3 m SLR further exacerbates beach loss, four of the five beaches in Portland Parish lost (Frenchman's Cove, Hope Bay, St. Margaret's Bay, Winnifred Beach) and 93% of Long Bay beach becoming inundated.

Table 1: Beach area lost in four sea level rise scenarios across study sites in Portland Parish, Jamaica

	Frenchman's Cove		Hope Bay		Long Bay		St. Margaret's Bay		Winnifred Beach	
SLR Scenario	Beach Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Land Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Land Area Lost To SLR (m²)	Beach Area Lost To SLR (%)
0.5 m	933	36%	3242.76	47%	28771	44%	14113	30%	2181	69%
1.0 m	1609	61%	5198.18	75%	30241	46%	21715	46%	2979	94%
2.0 m	2621	100%	6834.21	98%	58170	88%	43525	92%	3186	100%
3.0 m	2621	100%	6973.68	100%	61289	93%	46926	99%	3186	100%

A map of the severe risk that Long Bay, one of Portland's largest and most widely used beaches, would face under a 3 m SLR is illustrated in Figure 4. The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive these beach areas along with climate to be the island's main tourism products.

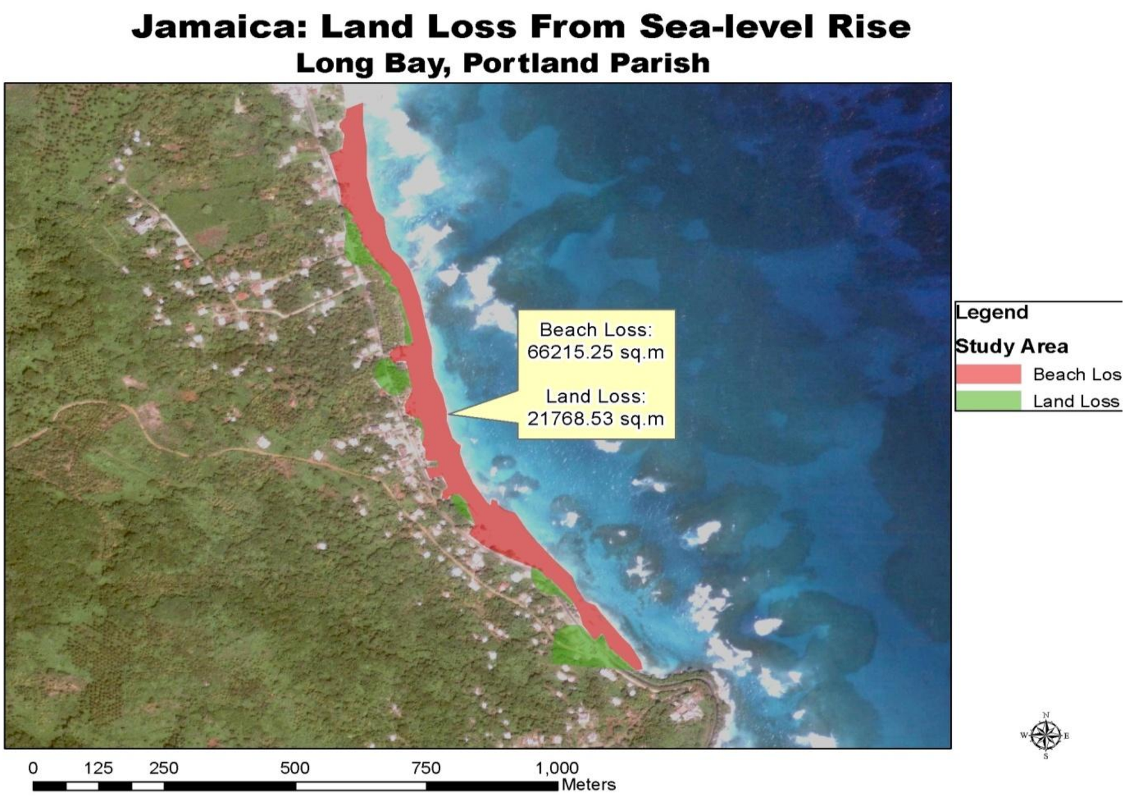


Figure 4: SLR Impacts at Long Bay, Portland Parish by a 3 metre flooding scenario.

This project component generated more coastal topographical data for the National Environment and Planning Agency (NEPA) which has responsibility for the coastal zone in Jamaica and also built capacity in that institution.

An assessment of the costs resulting from SLR and storm surge-induced damage projects that the Jamaican tourism sector could incur annual losses between US $1 billion in 2050 to over US $8.7 billion in 2080.

Capital costs are also high, with rebuild costs for tourist resorts damaged and inundated by SLR amounting to over US $500 million in 2050 up to US $6 billion in 2080.

Given the importance of tourism to the economy, it is conceivable that the Government of Jamaica would employ all measures to rebuild and support this industry. This may of course have implications for other sectors and public services and for the achievement of sustainable development goals as identified in their Vision 2030 National Development Plan (NDP). However, adaptation to minimise Jamaica's vulnerabilities will require full commitment to the implementation of the NDP and considerable revisions to some sectoral plans. It may also require major investment decisions such as 'retreat' or 'protect' policies so climate change and SLR projections should therefore be considered in the early phases of development in coastal areas and be based on the best available information regarding the specific coastal infrastructure and eco-system resources along the coast, in addition to the resulting economic and non-market impacts.

Community Livelihoods, Gender, Poverty and Development

More than 50 residents of Port Antonio and the surrounding communities[i] of Orange Bay, Buff Bay, Hope Bay, Boundbrook to Drapers and Snow Hill, in Portland Parish participated in CARIBSAVE's vulnerability assessment which included a vulnerability mapping exercise, focus-groups and household surveys which were developed according to a sustainable livelihoods framework. This research provided an understanding of: how the main tourism-related activities including fishing, vending, agriculture and other micro- and medium-sized commercial activities located along the coast and have been affected by climate related events; the community's adaptive capacity and the complex factors that influence their livelihood choices; and the differences in the vulnerability of men and women. At-risk residents in coastal communities make up about 60% of Jamaica's population and while community nuances are different, they are generally vulnerable to storm surges, hurricanes and flooding.

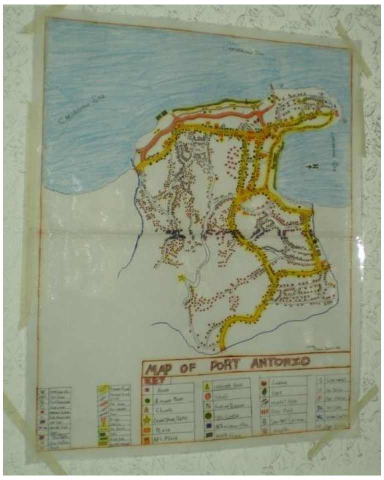


Figure 5: Map of Portland drawn by community members

Community Characteristics and Experiences

Popular nature-based tourism activities in and around Port Antonio include hiking, sightseeing and marine recreational activities, all of which are dependent on stable and reliable weather conditions. Extremes of either heat, rainfall or ocean turbidity will adversely affect visitor experience and even the decision to participate in these activities in the first place. Other activities in the community include farming and fishing.

Tourism provides year-long employment for locals, with peaks occurring during traditional winter months and those community members consulted indicated that tourism-related activities were the sole sources of income. So for a particularly low tourist season, these persons become very vulnerable economically. Further, livelihoods which depend directly on natural resources and climate have been adversely affected by climate change.

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[i] All participating communities are collectively referred to as "the community" in this document.

- Farmers in the area have observed declines in their agricultural production as a result of shifts in seasonal weather patterns, hotter temperatures, longer dry periods and more intense rain and wind events. This has impacted quality and quantity of output, the market price for produce (which will be more expensive when it is scarce or "out-of-season"). If such situations persist, this could likely result in reduced consumption of the local produce by tourism facilities. Local farmers may then suffer loss of markets or business to other producers who can provide a more reliable and consistent service.
- Similarly, fishermen are reporting a decline in the heath of coral reefs and increased sea surface temperatures. This livelihood group is particularly vulnerable to any extreme events that destroy the physical and technical resources that support their livelihood since they are already challenged by the loss of marine biodiversity and unpredictable unfavourable weather conditions.

Men in the community indicated a stronger dependence on the natural resource base than women for their livelihoods – likely due to the larger participation of males in fishing and agriculture over women. This aspect of vulnerability is linked to the climate-sensitivity of their livelihood resources. However, one common coping strategy identified by fishers and farmers is to engage in a variety of activities to earn more income and ensure greater financial stability.

Consistent with global findings, poverty increases the vulnerability of women when there is a disaster owing to the larger proportion of women amongst the poor population (most of the females who participated in the research were unemployed) and the larger number of female-headed households, some of which are single-parents.

It is apparent that local community organisations (including Councils and Clubs) are very active in the community and act as effective mechanisms for social change, empowerment and development, particularly for youth. There is also an existing hierarchy of community based organisations which foster community governance and development.

Community residents are willing to make livelihood and lifestyle changes to reduce their vulnerability to climate change. But they also require assistance in the form of infrastructural improvements to prevent flooding; awareness and capacity building about climate change and alternative livelihoods; and support from other stakeholder groups. Additionally, mainstreaming gender and poverty into climate change and related policies to achieve sustainable and effective responses to climate change is critical. This research has provided the evidence of underlying contributing factors, power relations and gender inequalities to make such mainstreaming possible.

Agriculture and Food Security

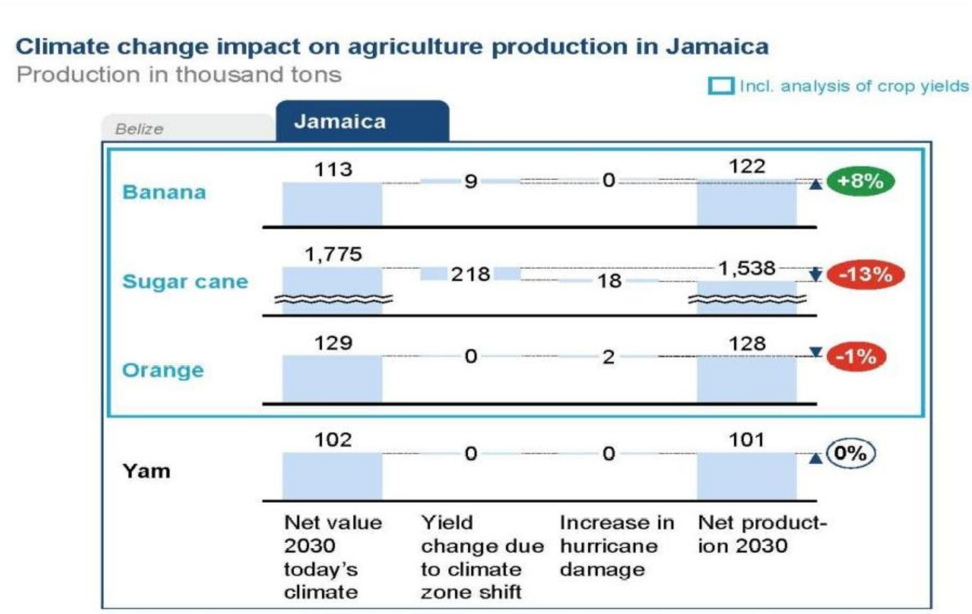

Figure 6: Climate Change Impact on Agricultural Production in Jamaica (000 tonnes)

(Reproduced from CCRIF ECA Study, 2010)

The agriculture sector represents a critical component of Jamaica's national development as an important contributor to GDP, employment, foreign exchange earnings and rural livelihoods. Climate change impacts are already being observed in the Jamaican agricultural sector, resulting in lower yields due to the prevalence of more pests and diseases. Coffee and banana production have faced many extreme weather events during the past years, mainly hurricanes, which have destabilised the agricultural industry and caused declining productivity and crop damage.

A significant contributing factor to vulnerability is land degradation due to the use of unsuitable farming techniques and poor land-use practices, including cultivation and development on unsuitable, unstable slopes, leading to soil erosion, massive flooding incidents and degradation of watersheds. The north-eastern region of the island, particularly the agricultural dependent parishes of St. Ann, Portland and Trelawney are critical zones in need of climate change risk management mechanisms because of the heavy reliance on farming to provide food for the household and as a means of income and these farmers are already experiencing annual recurring drought. The apparently predictability of drought conditions in these areas certainly establishes a basis for assisting farmers through mechanisms to earn a living in at such times. Awareness, capacity and technology in the areas of water storage and recycling; drought tolerant crops, integrated pest management, hydroponics and greenhouse farming would be of sure benefits.

Jamaica has greater resilience and potential for food security than most other Caribbean SIDS, in that local substitutes for imported staples are widely produced. Farmers have also implemented successful coping and adaptation mechanisms at the farm level through damage-reducing strategies such as the protection of nurseries; replanting/transplanting; crop bracing; and early harvesting and storage of produce. Sustainable food production on a national scale needs to be enhanced in the context of a changing climate, particularly with respect to water availability and diseases. Like in most Caribbean countries, there is a shift away from agriculture so to encourage farmers to stay in this sector and to attract more persons there is a need to innovate, build capacity and provide the means for changes in practices and securing markets. Tourism entities should fully support local production and engage in agreements that are mutually beneficial, whereby the farmer has a guaranteed market for produce requested by tourism facilities.

Energy and Tourism

Tourism is an increasingly significant sector in energy use and emissions of greenhouse gases in the Caribbean. Tourism components such as aviation, accommodation facilities and cruise ships are high energy users and are vulnerable to changes in climate that will affect tourist preferences, particularly through international climate policies aimed at mitigating greenhouse gas emissions. This can therefore impact Jamaica's tourism sector resulting in changes in energy demand.

No statistics on energy use in Jamaica could be obtained directly from the national Ministry of Energy and Mining to identify energy flows on a more detailed basis, but the country published its 'National Energy Policy 2009-2030' in October 2009[ii]. As the policy document outlines, the Jamaican economy is characterised by high energy intensity and low efficiency, while being almost entirely dependent on imported oil, which accounts for 95% of energy consumption, the remainder falling on hydropower (4%) and wind (1%). Imported oil is consumed in three main sectors, i.e. bauxite/aluminium production, power generation and transport (See Figure 7). Locally, two of the high-energy sectors, transport and electricity generation are relevant in the context of tourism. However, it is difficult to identify the share of tourism in national energy use, as it is unknown which share of electricity is used by accommodation establishments and other parts of the tourism-related service sector, for which no specific studies have been carried out. Likewise, it is difficult to know which share of energy is used in tourism-related car travel or by cruise ships (bunker fuels).

It should be noted that average emissions per tourist are comparably low, i.e. emissions of 635 kg CO_2 per tourist for air travel. This is largely because the most important market for arrivals, the USA, is comparably close. Keeping their arrival-to-emissions ratio low will demand on-going analysis of markets as climate change continues to impact tourism globally. This information could be used to strategically focus tourism marketing efforts on closer markets.

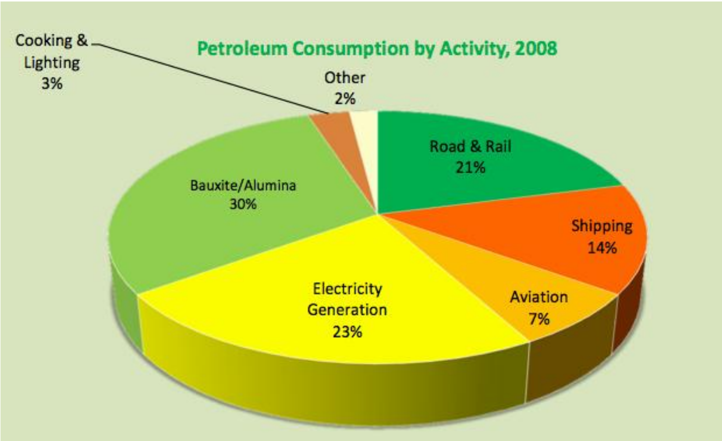

Figure 7: Petroleum consumption by activity, 2008[ii]

Energy generation methods are currently meeting the energy demand in Jamaica, but with increasing atmospheric temperature (this observed trend is projected to continue) this supply is likely to be under

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[ii] MEM (Ministry of Energy and Mining), (2009): Jamaica's National Energy Policy 2009-2030. The Ministry of Energy and Mining, Kingston, Jamaica.

pressure for at least two reasons: the increased use of energy for cooling and the likely reduced volume of river water for hydropower. The added pressure on the energy supply will necessitate the exploration of renewable energy sources to meet both household and tourism demands on the island.

Indirect climate change impacts which are brought on by other sectors through forward or reverse linkages with the energy sector and may include competition for shared resources, trends in demand and supply and pricing are also possible. These impacts are not only limited to traditional (fossil fuel based) energy systems, but renewable systems as well. While direct impacts are more visible, the costs of indirect impacts can be difficult to quantify and often exceed those of direct impacts, given the inter-relationships between energy and other sectors. Energy prices have fluctuated in the past and there is evidence that the cost of oil on world markets will continue to increase. Also, if the international communities' climate objective of stabilising temperatures at 2°C by 2100 is taken seriously, both regulation and market-based instruments will have to be implemented to cut emissions of greenhouse gases. Such measures would affect the cost of mobility, with in particular air transport being a highly energy- and emission-intense sector.

Specific measures to reduce energy consumption and emissions are outlined in Jamaica's 'National Energy Conservation and Efficiency (ECE) Policy 2010-2030[iii]'. Figure 8 shows that by 2030, the share of petroleum in the supply mix is expected to have declined from 95% to 30%, with natural gas accounting for as much as 42% of the mix and renewable energies 20%.

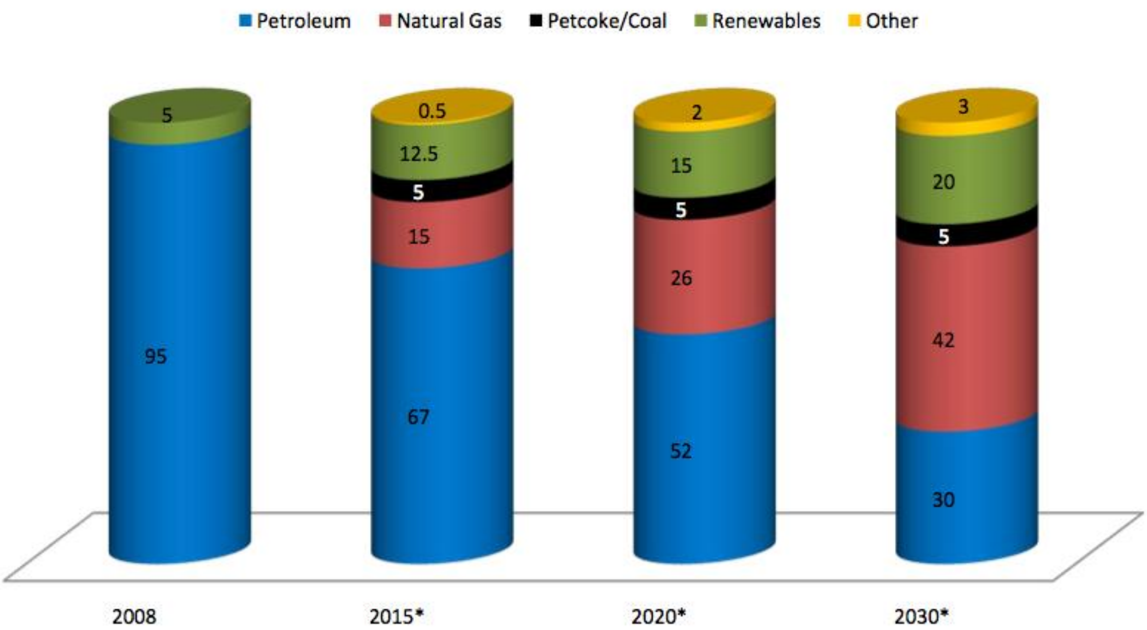

Figure 8: Jamaica's energy consumption by energy source in 2008 and to 2030[ii]

Strategies to reduce energy dependency and emissions include:

1. Security of Energy Supply through diversification of fuels as well as the development of renewables
2. Modernising the country's energy infrastructure
3. Energy conservation and efficiency
4. Development of a comprehensive governance/regulatory framework

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[iii] MEM (Ministry of Energy and Mining), (2010): National Energy Conservation and Efficiency Policy 2010 – 2030 … Securing Jamaica's Energy Future. The Ministry of Energy and Mining, Kingston, Jamaica.

5. Enabling government ministries, departments and agencies to be model/leader for the rest of society in terms of energy management
6. Eco-efficiency in industries

Since traditional tourism management is primarily concerned with revenue management, to facilitate the transformation of tourism towards becoming climatically sustainable will necessitate concerted efforts in mitigation even to the extent of aiming to achieve carbon neutrality. Also, emissions and revenue need to be integrated and energy intensities need to be linked to profits. While this would demand a rather radical change from current business models in tourism, all aspects of a low-carbon tourism system are principally embraced by business organisations. An indicator in this regard can be eco-efficiencies, i.e. the amount of emissions caused by each visitor to generate one unit of revenue and such indicators can serve as a basis for restructuring markets, possibly the most important single measure to reduce the energy dependence of the tourism system. Further analysis is required to distinguish revenue/profit ratios, leakage factors/multipliers (to identify the tourist most beneficial to the regional/national economy). However, this kind of analysis is generally not as yet possible for Caribbean islands due to the lack of data on tourist expenditure by country and tourist type (e.g. families, singles, wealthy-healthy-older-people, visiting friends and relatives, etc.).

While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of greenhouse gases, it also appears clear that energy demand in Jamaica could be substantially reduced at no cost, simply because the tourism sector in particular is wasteful of energy. Furthermore, technological options to develop renewable energy sources exist and can be backed up financially by involving carbon markets as well as voluntary payments by tourists. In order to move the tourism sector forward to make use of these potentials, it is essential that policy frameworks focusing on regulation, market-based instruments and incentives be implemented.

Water Quality and Availability

Jamaica has considerable surface and groundwater resources; however, local demand is met mainly from groundwater supplies. The country is predisposed to seawater intrusion into its coastal groundwater supplies and over-abstraction of this finite resource is already a management challenge, especially because drought is a recurrent problem. The agricultural sector has the greatest water demand and accounts for 75-85% of the water consumed in the country. These trends suggest an inherent vulnerability in this sector.

Jamaica has been found to be vulnerable to climate change as both observed and modelled climate variables indicate some impact on water resource availability. Over the last forty years, temperatures in Jamaica have shown an overall increase and this trend is expected to continue according to both GCM and RCM projections. While there are no observable trends in precipitation in the period between 1961 and 2006 in Jamaica, rainfall extremes (1- and 5- day annual maxima) for the period 1973 – 2008 were found to have decreased. Additionally, there is an overall trend for further decreases in future according to GCM and HadCM3-driven RCM projections. Conditions such as these reflect the experiences that Jamaica has had with droughts, particularly in recent years and will likely increase the occurrence of further dry spells and drought events in the future.

The main stakeholders in the water cycle of Jamaica are the forest managers (government agencies, NGO's and private foresters), upland farmers (legal and illegal), upland settlements, water abstractors (public and private), irrigated farmers, industry and commerce, urban households and tourism. Jamaica will need to enhance the strengths that currently exist within its water sector structure. The institutional networks are quite extensive and have been developed to cope with an already complex water sector that seeks to supply water to 2.6 million people and comprises numerous stakeholders and institutions.

Some individual user groups are already employing methods to address drought problems in particular by increasing water storage in the wet season and using grey-water systems. However, this critical resource necessitates a more coordinated approach to its management and existing institutional frameworks could be revised to address climate change issues and the requirements of specific policies if adequate resources are allocated. Recent adaptation projects have been challenged by the need for co-financing because of the Water Resources Authority's inability to meet their budget contribution requirements. Practical actions such as exploring waste water recycling options and extracting greater volumes of water from areas with more abundant resources can help alleviate pressures on demand.

Comprehensive Natural Disaster Management

Vulnerability to natural hazards is a cross-cutting problem facing many sectors. In recent years, especially since Hurricane Gilbert impacted Jamaica in 1988, natural hazard events have highlighted the physical, social and economic vulnerabilities on the island; and climate change projections pose a concern about the occurrence of natural disasters. Experiences with Hurricane Dean in 2007 (Category 4) and Tropical Storm Nicole in 2010 confirm that infrastructure and property in the housing, agriculture and public utilities sectors of Jamaica are highly vulnerable. Although the tourism industry was not severely impacted in these storms, the sector will become increasingly at risk as climate change causes sea levels to rise, creating the possibility for greater storm surge heights in coastal areas around the island.

Figure 9: Hurricane Dean Impacts on public utilities in Jamaica

As the primary agency working on disaster management in Jamaica, the Office of Disaster Preparedness and Emergency Management (ODPEM) has many programmes and activities that aim to build adaptive capacity at the institutional and local levels. ODPEM has embarked on an assessment of vulnerability in 300 communities across the island in order to rank communities on a variety of vulnerability indicators. Regional programmes led by the Caribbean Disaster Emergency Management Agency (CDEMA) have also been conducted in Jamaica and provide important data about vulnerability. Yet more work must be done to improve awareness and capacity at the community level and provide data, information and tools relevant to decision making and sustainable livelihood strategies.

Some pragmatic strategies recommended to enhance the current system include:

a) The expansion of early warning systems to incorporate new and more technologies (cell phones, media tools etc.) thus making sure that information is widely and equally dispersed;
b) The enhancement of hazard, weather and geographical data collection and management strategies that will generate hazard maps and improve the baseline data available for the whole of Jamaica.

Improvements in data collection must be shared across institutions to ensure risks are considered in all phases of development, from land use zoning and planning to construction; and

c) Build capacity in the ODPEM in the linkages between disaster management and climate change.

Human Health

Health is an important issue in the tourism industry because tourists are susceptible to acquiring diseases as well as potential carriers of vector-borne diseases. The impacts from indirect diseases, such as dengue fever, malaria and leptospirosis, are most extensive and also complex due to the external factors that affect transmission such as mosquito habitat conditions. Other diseases with a climate change signal include communicable (emerging and re-emerging) diseases such as meningococcal infections, acute hemorrhagic conjunctivitis as well as a number of food borne illnesses, namely cholera, salmonellosis, shigellosis, listeriosis and eshericida coli (better known as e-coli). While attention must be paid to diseases themselves, the overall conditions and access to basic amenities such as food, water and sanitation will determine transmission and recovery from all of these health conditions. Following disasters, poor health and sanitation responses generate further vulnerability to vector- and water-borne diseases, especially if there is standing water and high temperatures. Also, droughts affect the food supply and sanitary conditions which weakens people's immunity and exposes them to diseases not normally present. This in turn has consequences for food security, which raises the possibility of an increasing proportion of the population of Jamaica likely to be undernourished. On the contrary, water supplies could also be interrupted by episodes of flooding. Excess flooding can also lead to contamination of potable water supply and impact sanitation, causing an increase in cases of morbidity and possibly mortality from gastroenteritis or Cholera. Remote communities are the most affected as they may be without basic services for an extended period.

Considerable efforts have been made to develop the health care system of Jamaica and the policy context regarding climate change is emerging to address the vulnerabilities that exist. There is extensive institutional capacity to cope and some progress has been made in vector and disease management. However, access to basic amenities such as food, water and sanitation is not clearly linked to policy and practice. Measures proposed by the Government of Jamaica, such as increasing resilience to endemic diseases, adaptation and improvement of the emergency response of the country, show their commitment to increasing the health of the island's natural environment and its people. Awareness amongst tourists and tourism facilities is also important as many conditions are entirely preventable with the proper practices.

Marine and Terrestrial Biodiversity and Fisheries

Jamaica has been rated 5th among the islands of the world with regard to endemic plants, with 923 species found nowhere else[iv]. It is also rich in animal species diversity, with the highest number of bird species (290 recorded – 25 endemic) of any Caribbean island. The environment provides the basis for the tourism industry, which is the most important economic sector in Jamaica and many impoverished rural and coastal communities rely on artisanal fishing and small-scale farming for their livelihoods and nourishment. These two sectors are therefore highly dependent on the natural productivity and integrity of Jamaica's eco-systems.

[iv] NEPA (National Environmental Protection Agency), (2003a): *National Strategy and Action Plan on Biological Diversity in Jamaica.* National Environmental Protection Agency, Kingston, Jamaica.

Jamaica Tourist Board, (2010). Visit Jamaica [Online]. Accessed 11.01.16: http://www.visitjamaica.com/

Figure 10: Blue Lagoon, Jamaica

Source: Jamaica Tourist Board, (2010)

Unfortunately, human settlements, commercial developments (particularly related to coastal tourism) and road networks are encroaching on natural habitats, often creating discontinuities in the environment and often contribute to its degradation. Many coastal roads cut off mangrove swamps from the sea, preventing them from functioning effectively as nurseries for marine fish and shellfish. Coral reefs and seagrass beds have suffered from the impacts of overfishing, sedimentation and agricultural runoff. Furthermore, there is increasing recognition that small changes in climate can trigger major, abrupt responses in eco-systems.

The Government and people of Jamaica are aware of these challenges and there are adequate institutions, laws, policies, regulatory bodies and human/technical expertise for addressing them through natural resources management. However, enforcement has been described as difficult and time-consuming due mainly to insufficient human and financial resources to provide comprehensive protection of biodiversity; a lack of knowledge on the part of the persons given the task of enforcing the relevant legislation; and inadequate penalties provided by Acts and Regulations.

Planning for the management of specific critical eco-systems must consider the linkages between eco-systems such as coral reefs, sea grass beds and terrestrial and mangrove forests and their relationships to the stakeholders who use them. An important tool in environmental management is the Environmental Impact Assessment (EIA), which enables environmental factors to be given due weight, along with economic or social factors, when planning applications are being considered.

Such a process involves wide stakeholder involvement which includes the private sector and non-governmental organisations which have already demonstrated their awareness and stewardship for Jamaica's biodiversity by playing a vital role in research, financing, management and public awareness and education. Participatory governance (Co-management) arrangements are also beneficial and the newly designated fish sanctuaries (in Bluefield's Bay, Treasure Beach, Portland Bight, Oracabessa, Boscobel, Discovery Bay) are to be managed in conjunction with local non-governmental organisations (NGOs) and private sector stakeholders, insofar as possible. A co-management strategy for fish sanctuaries across Jamaica will:

- establish a more effective fish sanctuary management and enforcement system for coastal communities;
- enhance the capacity of resource managers and users to be more resilient to climate change; and
- establish a sustainable finance mechanism for supporting fish sanctuary management.

The strategy should increase the involvement of the tourism sector in supporting community-based MPAs, as well as provide opportunities for alternative livelihoods and technologies for public education.

Conclusion

Jamaica has a strong dependence on the tourism industry which is supported by a diversity of natural assets which enable it to be successful and many local livelihoods are also very dependent on these resources. Coastal eco-systems and water resources in particular, are already facing serious pressures from increasing (and sometimes poorly planned) development and poor land management practices thereby decreasing the resilience of plant and animal species. The natural resource base is also affected by climate-related events. Jamaica also has a history of damages and losses from natural disasters which not only interrupt development progress at the national level, but also result in the investment of much time and resources into rebuilding homes and livelihoods after an impact. Since there is high confidence that climate change will result in more intense hurricanes and extreme events, posing even greater threats to eco-systems and the population, preparedness for disasters and climate change adaptation become common goals.

The CCCRA explored recent and future changes in climate in Jamaica using a combination of observations and climate model projections. Despite the limitations that exist with regards to climate modelling and the attribution of present conditions to climate change, this information provides very useful indications of the changes in the characteristics of climate and impacts on socio-economic sectors. Consequently, decision makers should adopt a precautionary approach and ensure that measures are taken now to increase the resilience of economies, businesses and communities to climate-related hazards.

It is clear that the Government of Jamaica is committed to adapting to climate change, as evidenced by some policy responses, current practices and planned actions; as well as the recognition of the importance of Jamaica's natural resources to livelihoods and economies. However, serious financial resource constraints along with limited technical capacities hinder enforcement of laws to protect natural resources, as well as successful adaptation efforts across most government ministries and other stakeholder groups. One result s that some resource users with little or no awareness of alternative courses of action continue to degrade or over-extract from marine and terrestrial eco-systems in an effort to sustain themselves or even for recreation, thereby exacerbating vulnerability to climate change.

It will therefore become increasingly important that individuals have the capacity and evidence-based tools to make decisions and adapt to the changing climate. As such, many of the sectors have recommended education and awareness-building campaigns that would provide the necessary information about vulnerability and risks in specific regions of Jamaica so as to empower communities to build their own resilience. Considerations for gender, economic security and livelihood activities must be considered in any adaptation intervention as not all persons are affected equally and would therefore need to respond differently. Implementing the specific recommendations proposed for each sector can ensure a balanced approach to Jamaica achieving its vision for 2030 to attain 'developed-country' status.

1. GLOBAL AND REGIONAL CONTEXT

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), published in 2007, provides undisputable evidence that human activities are the major reason for the rise in greenhouse gas emissions and changes in the global climate system (IPCC, 2007a). Climate change will affect ecosystem services in ways that increase vulnerabilities with regard to food security, water supply, natural disasters, as well as human health. Notably, climate change is ongoing, with “observational evidence from all continents and oceans … that many natural systems are being affected by regional climate changes, particularly temperature increases” (IPCC, 2007b: 8). Observed and projected climate change will in turn affect socio-economic development (Global Humanitarian Forum, 2009; Stern, 2006), with some 300,000 deaths per year currently being attributed to climate change (Global Humanitarian Forum, 2009). Mitigation to reduce the speed at which the global climate changes, as well as adaptation to cope with changes that are inevitable, are thus of great importance (Parry *et al.,* 2009).

The IPCC (2007a: 5) notes that “warming of the climate system is unequivocal, as it is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level”. Climate change has started to affect many natural systems, including hydrological systems (increased runoff and earlier spring peak discharge, warming of lakes and rivers affecting thermal structure and water quality), terrestrial ecosystems (earlier spring events including leaf-unfolding, bird migration and egg-laying, biodiversity decline, and pole ward and upward shifts in the ranges of plants and animal species), as well as marine systems (rising water temperatures, changes in ice cover, salinity, acidification, oxygen levels and circulation, affecting shifts in the ranges and changes of algae, plankton and fish abundance).

The IPCC (2007b) also notes that small islands are particularly vulnerable to the effects of climate change, including sea level rise (SLR) and extreme events. Deterioration in coastal conditions is expected to affect fisheries and tourism, with SLR being “expected to exacerbate inundation, storm surge, erosion and other coastal hazards, threatening vital infrastructure, settlements and facilities that support the livelihood of island communities” (IPCC, 2007b: 15). Climate change is projected to reduce water resources in the Caribbean to a point where these become insufficient to meet demand, at least in periods with low rainfalls (IPCC, 2007b). Together, these changes are projected to severely affect socio-economic development and well-being in the world (Stern, 2006), with the number of climate change related deaths expected to rise to 500,000 per year globally by 2020 (Global Humanitarian Forum, 2009). However, not all regions are equally vulnerable to climate change. The Caribbean needs to be seen as one of the most vulnerable regions, due to their relative affectedness by climate change, but also in terms of their capacity to adapt (Bueno *et al.,* 2008). This should be seen in the light of Dulal *et al.*’s (2009: 371) conclusion that:

> *If the Caribbean countries fail to adapt, they are likely to take direct and substantial economic hits to their most important industry sectors such as tourism, which depends on the attractiveness of their natural coastal environments, and agriculture (including fisheries), which are highly climate sensitive sectors. By no incidence, these two sectors are the highest contributors to employment in the majority of these countries and significant losses or economic downturn attendant to inability to adapt to climate change will not increase unemployment but have potentially debilitating social and cultural consequences to communities.*

Climate change has, since the publication of the Intergovernmental Panel on Climate Change’s 4th Assessment Report (IPCC, 2007b), been high on the global political agenda. The most recent UN Conference of Parties (COP) in Mexico in December 2010 agreed that increases in temperature should be stabilised at a maximum of 2°C by 2100. Notably, the 39 member states of the Alliance of Small Island Developing States (AOSIS) have called in a recent Declaration to the United Nations for a new climate change agreement that would ensure global warming to be kept at a maximum of 1.5°C; (AOSIS, 2009).

So far, the European Union is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. Some individual countries are taking action, such as the Australian Government's comprehensive long-term plan for tackling climate change and securing a clean energy future. The plan outlines the existing policies already underway to address climate change and cut carbon pollution and introduces several critical new initiatives and has four pillars: a carbon price; renewable energy; energy efficiency; and action on land. The nations of the Caribbean Community (CARICOM)[1] contribute less than 1% to global greenhouse gas (GHG) emissions (approximately. 0.33%[2]) (World Resource Institute, 2008), yet these countries are expected to be among the earliest and most severely impacted by climate change in the coming decades, and are least able to adapt to climate change impacts (Nurse *et al.*, 2009).

An analysis of the vulnerability of CARICOM nations to sea SLR and associated storm surge by The CARIBSAVE Partnership in 2010 found that large areas of the Caribbean coast are highly susceptible to erosion, and beaches have experienced accelerated erosion in recent decades. It is estimated that with a 1 m SLR and a conservative estimate of associated erosion, 49% of the major tourism resorts in CARICOM countries would be damaged or destroyed. Erosion associated with a 2 m SLR (or a high estimate for a 1 m SLR), would result in an additional 106 resorts (or 60% of the region's coastal resorts) being at risk. Importantly, the beach assets so critical to tourism would be affected much earlier than the erosion damages to tourism infrastructure, affecting property values and the competitiveness of many destinations. Beach nesting sites for sea turtles were also at significant risk to beach erosion associated with SLR, with 51% significantly affected by erosion from 1m SLR and 62% by erosion associated with 2 m SLR (Simpson *et al.,* 2010).

In real terms, the threats posed to the region's development prospects are severe and it is now accepted that adaptation will require a sizeable and sustained investment of resources. Over the last decade alone, damages from intense climatic conditions have cost the region in excess of half a trillion US dollars (CCCCC, 2005).

1.1. *Climate Change Impacts on Tourism*

Direct and indirect climatic impacts. The Caribbean's tourism resources, the primary one being the climate itself, are all climate sensitive. When beaches and other natural resources undergo negatives changes as a result of climate and meteorological events, this can affect the appeal of a destination – particularly if these systems are slow to recover. Further, studies indicate that a shift of attractive climatic conditions for tourism towards higher latitudes and altitudes is very likely as a result of climate change. Projected increases in the frequency or magnitude of certain weather and climate extremes (e.g. heat waves, droughts, floods, tropical cyclones) as a result of projected climate change will affect the tourism industry through increased infrastructure damage, additional emergency preparedness requirements, higher

[1] Members of CARICOM: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago.

[2] The Caribbean Islands contribute about 6% of the total emissions from the Latin America and Caribbean Region grouping and the Latin America and Caribbean Region is estimated to generate 5.5% of global CO_2 emissions in 2001 (UNEP, 2003).

operating expenses (e.g. insurance, backup water and power systems, and evacuations), and business interruptions (Simpson *et al.*, 2008).

In contrast to the varied impacts of a changed climate on tourism, the indirect effects of climate-induced environmental change are likely to be largely negative.

Impacts of mitigation policies on tourist mobility. Scientifically, there is general consensus that 'serious' climate policy will be paramount in the transformation of tourism towards becoming climatically sustainable, as significant technological innovation and behavioural change demand strong regulatory environments (e.g. Barr *et al.,* 2010; Bows *et al.,* 2009; Hickman and Banister 2007; see also Giddens, 2009). As outlined by Scott *et al.* (2010), "serious" would include the endorsement of national and international mitigation policies by tourism stakeholders, a global closed emission trading scheme for aviation and shipping, the introduction of significant and constantly rising carbon taxes on fossil fuels, incentives for low-carbon technologies and transport infrastructure, and, ultimately, the development of a vision for a fundamentally different global tourism economy. The Caribbean is likely to be a casualty of international mitigation policies that discourage long-haul travel.

Pentelow and Scott (2010) concluded that a combination of low carbon price and low oil price would have very little impact on arrivals growth to the Caribbean region through to 2020, with arrivals 1.28% to 1.84% lower than in the BAU scenario (the range attributed to the price elasticities chosen). The impact of a high carbon price and high oil price scenario was more substantive, with arrivals 2.97% to 4.29% lower than the 2020 BAU scenario depending on the price elasticity value used. The study concluded:

> *It is important to emphas*ise *that the number of arrivals to the region would still be projected to grow from between 19.7 million to 19.9 million in 2010 to a range of 30.1 million to 31.0 million in 2020 (Pentelow and Scott 2010).*

Indirect societal change impacts. Climate change is believed to pose a risk to future economic growth of some nations, particularly for those where losses and damages are comparable to a country's GDP. This could reduce the means and incentive for long-haul travel and have negative implications for anticipated future growth in this sector in the Caribbean. Climate change associated security risks have been identified in a number of regions where tourism is highly important to local-national economies (e.g. Stern, 2006; Barnett and Adger, 2007; German Advisory Council, 2007; Simpson *et al.*, 2008). International tourists are averse to political instability and social unrest, and negative tourism-demand repercussions for climate change security hotspots, many of which are believed to be in developing nations, are already evident (Hall *et al.*, 2004).

2. NATIONAL CIRCUMSTANCES

2.1. *Geography and climate*

Jamaica is the largest Anglophone island in the Caribbean Basin, with an approximate total land area of 4,442 square miles (10,991 square kilometres). The island is 146 miles long with widths varying between 22 and 51 miles and is comprised of 14 administrative districts or parishes within three counties – Middlesex, Cornwall and Surrey. The capital city, Kingston, is located to the south of the island. The island's interior is mountainous especially in the eastern and central regions, with the highest peak (Blue Mountain Peak) reaching 7,402 feet (2,256 metres). Approximately 120 rivers flow from this mountainous central interior to the narrow, somewhat discontinuous northern and southern coastlines where multi-character beaches are present. Rich, fertile soils occupy the river-dissected valleys and numerous interior plains where small and large-scale agriculture operations are located. Other natural resources present and extracted include limestone, gypsum and bauxite – the latter being the major resource foundation for the island's mining industry.

Jamaica's climate is predominantly a tropical marine climate with an average annual temperature of 27° Celsius, and average annual rainfall of 78 inches (198 centimetres). Most of the island's rainfall is recorded during the "wet season", corresponding with the Tropical Atlantic Hurricane Season, where Caribbean countries are affected by a range of low-pressure and hurricane events roughly between June and November each year. Other natural hazards that affect the island include floods, landslides and earthquakes. Several regions within Jamaica are affected by microclimates which diverge from national weather trends, specifically areas of high altitude which have more rainfall and lower ranges of temperatures than other lower altitude areas.

2.2. *Socio-economic profile*

Jamaica is defined by a mixed free-market economy with tourism and mining being the two most important economic sectors, with major contributions also coming from the manufacturing and agricultural sectors. The economy is heavily dependent on services which contribute approximately 60% to the island's Gross Domestic Product (GDP). Table 2.2.1 shows that the country's GDP growth rate, both in real terms and purchasing power parity, fluctuated throughout the last decade with a continuous decline from 2006.

Table 2.2.1: Gross Domestic Product for Jamaica, 2000 - 2009

YEAR	Real GDP (J$ billion)	GDP (Real) Growth Rate (%)	GDP (PPP) Growth Rate (%)
2000	17.49	0.88	0.02
2001	18.13	1.34	0.03
2002	18.60	0.97	0.02
2003	19.67	3.50	0.05
2004	20.51	1.44	0.04
2005	21.60	1.00	0.05
2006	22.91	2.72	0.06
2007	23.92	1.50	0.04
2008	24.20	(0.95)	0.01
2009	23.80	(2.82)	(0.02)

(Source: Economy Watch, 2010)

The Jamaican economy has experienced relative instability over the last three to four decades, and faces long-term challenges which include a large merchandise trade deficit, high unemployment and underemployment, a debt-to-GDP ratio of more than 130% and an unstable dollar. The United States to Jamaican dollar exchange rate has increased from approximately 1:62 in 2005 to 1:88 in 2009 (CIA, 2010). Approximately 79% of Jamaica's national budget is consumed by civil servant salaries and debt servicing (DFID, 2010). (Could also talk about economic setbacks resulting from disasters)

Jamaica's population stood at approximately 2,698,800 at the end of 2009 with a population growth rate of 0.74%. Females comprise a slightly larger percentage (approximately 51%) of the population (STATIN-JA, 2010). Net migration in Jamaica has also indicated a larger exodus of the population compared to the numbers immigrating. Figures fluctuated between -16,000 and -21,000 persons since 2004.

Jamaica's history of economic instability stemming from inflation, dollar devaluation and a large national debt burden has resulted in various hardships for citizens, which in turn has contributed to social depression and crime. Information and statistics on various socio-economic indicators are widely published and available and provide an overview of Jamaica's situation.

2.3. *Importance of tourism to the national economy*

Caribbean tourism is based on the natural environment, and the region's countries are known primarily as beach destinations. The tourism product therefore depends on favourable weather conditions as well as on an attractive and healthy natural environment, particularly in the coastal zone. Both of these are threatened by climate change. The Caribbean is the most tourism-dependent region in the world with few options to develop alternative economic sectors and is one of the most vulnerable regions in the world to the impacts of climate change including SLR, coastal erosion, flooding, biodiversity loss and impacts on human health.

Tourism has been and continues to be a major economic sector in Jamaica. There was a 47% increase in stopover arrivals from 1999 to 2009, and during this same period, gross foreign exchange earnings from tourism increased by 50% (see Table 2.3.1 and Table 2.3.2).

Table 2.3.1: Visitor Arrivals to Jamaica 1999 - 2009

Year	Stopovers	Cruise Ship Passengers	Total
1999	1,248,397	764,341	2,012,738
2000	1,322,690	907,611	2,230,301
2001	1,276,516	840,337	2,116,853
2002	1,266,366	865,419	2,131,785
2003	1,350,285	1,132,596	2,482,881
2004	1,414,786	1,099,773	2,514,559
2005	1,478,663	1,135,843	2,614,506
2006	1,678,905	1,336,994	3,015,899
2007	1,700,785	1,179,504	2,880,289
2008	1,767,271	1,092,263	2,859,534
2009	1,831,097	922,349	2,753,446

(Source: Jamaica Tourist Board Annual Travel Statistics 2009 www.jtbonline.org)

Table 2.3.2: Estimated Gross Foreign Exchange Earnings

Year	J$,000	**US $,000
1999	50,323,994	1,279,532
2000	57,728,110	1,332,597
2001	56,950,407	1,232,960
2002	58,938,155	1,209,484
2003	78,366,236	1,351,142
2004	88,191,462	1,436,577
2005	99,269,770	1,545,055
2006	123,232,473	1,870,560
2007	131,911,828	1,910,105
2008	144,054,881	1,975,519
2009	155,959,234	1,925,423

* Figures for 1998 - 2008 include estimated expenditure of non-resident Jamaicans
** Exchange Rate used is taken from the Bank of Jamaica's published Average Annual Exchange Rate
(Source: Jamaica Tourist Board Annual Travel Statistics 2009. www.jtbonline.org)

Tourism is currently Jamaica's second largest foreign exchange earner after remittance inflows. In 2008, net foreign exchange earnings from tourism totalled US $1,707.4 million or 12.2% of GDP (BOJ, 2008).

Additionally, tourism is one of the principal sources of foreign direct investment (FDI) inflows into Jamaica. In 2008, it accounted for 13% of FDI, after Information and Communication Technology (Bank of Jamaica, 2008). Tourism investment is estimated at 28.7% of total investment in 2010, or at a dollar value of J$92,000 million. However, the World Travel and Tourism Council's (WTTC) ten-year projection indicates a decline to 28.1% of total investment (WTTC, 2010).

3. CLIMATE MODELLING: OBSERVED AND PROJECTED CHANGES

3.1. *Introduction to Climate Modelling Results*

This summary of climate change information for Jamaica is derived from a combination of recently observed climate data sources, and climate model projections of future scenarios using both a General Circulation Model (GCM) ensemble of 15 models and the Regional Climate Model (RCM), *PRECIS*.

General Circulation Models (GCMs) provide global simulations of future climate under prescribed greenhouse gas scenarios. These models are proficient in simulating the large scale circulation patterns and seasonal cycles of the world's climate, but operate at coarse spatial resolution (grid boxes are typically around 2.5 degrees latitude and longitude). This limited resolution hinders the ability for the model to represent the finer scale characteristics of a region's topography, and many of the key climatic processes which determine its weather and climate characteristics. Over the Caribbean, this presents significant problems as most of the small islands are too small to feature as a land mass at GCM resolution.

Regional Climate Models (RCMS) are often nested in GCMs to simulate the climate at a finer spatial scale over a small region of the world, acting to 'downscale' the GCM projections and provide a better physical representation of the local climate of that region. RCMs enable the investigation of climate changes at a sub-GCM-grid scale, as such changes in the dynamic climate processes at a community scale or tourist destination can be projected.

For each of a number of climate variables (average temperature, average rainfall, average wind speed, relative humidity, sea-surface temperature, sunshine hours, extreme temperatures, and extreme rainfalls) the results of GCM multi-model projections under three emissions scenarios at the country scale, and RCM simulations from single model driven by two different GCMs for a single emissions scenario at the destination scale, are examined. Where available, observational data sources are drawn upon to identify changes that are already occurring in the climates at both the country and destination scale.

In this study, RCM simulations from PRECIS, driven by two different GCMs (ECHAM4 and HadCM3) are used to look at projected climate for each country and at the community level. Combining the results of GCM and RCM experiments allows the use of high-resolution RCM projections in the context of the uncertainty margins that the 15-model GCM ensemble provides.

The following projections are based on the IPCC standard 'marker' scenarios – A2 (a 'high' emissions scenario), A1B (a medium high scenario, where emissions increase rapidly in the earlier part of the century but then plateau in the second half) and B1 (a 'low' emissions scenario). Climate projections are examined under all three scenarios from the multi-model GCM ensemble, but at present, results from the regional models are only available for scenario A2. Table 3.1.1 outlines the time line on which various temperature thresholds are projected to be reached under the various scenarios according to the IPCC.

Table 3.1.1: Earliest and latest years respectively at which the threshold temperatures are exceeded in the 41 projections*

SRES Scenario	1.5°C Threshold		2.0°C Threshold		2.5°C Threshold	
	Earliest	Latest	Earliest	Latest	Earliest	Latest
A1B	2023	2050	2038	2070	2053	Later than 2100
A2	2024	2043	2043	2060	2056	2077
B1	2027	2073	2049	Later than 2100	2068	Later than 2100

*NB: In some cases the threshold is not reached prior to 2100, the latest date for which the projections are available.

The potential changes in hurricane and tropical storm frequency and intensity, sea-level rise (SLR), and storm surge incidence are also examined for the Caribbean region. For these variables, existing material in the literature is examined in order to assess the potential changes affecting the tourist destinations.

3.2. *Temperature*

Observed mean annual temperatures over Jamaica in gridded temperature observations have increased at an average rate of 0.27˚C per decade over the period 1960-2006. The observed increases have been most rapid in the seasons JJA at a rate of 0.31˚C per decade.

General Circulation Model (GCM) projected mean annual temperatures across the 15 GCM ensemble increase by 0.7 to 1.8˚C by the 2050s and 1.0-3.0˚C by the 2080s, considering their different emissions scenarios. The range of projections across the 15 models for any one emission scenarios spans around 1-2˚C. Projected mean temperatures increase most rapidly in JJA.

Regional Climate Model (RCM) projections indicate much more rapid increases in temperature over Jamaica than any of the models in the GCM ensemble when the projections are compared for the A2 scenario. RCM projections indicate increases of 2.9˚C and 3.4˚C, when driven by ECHAM4 and HadCM3, respectively, compared with GCM ensemble projections of 2.0-3.0˚C. The increased rate of warming over Jamaica in the RCM projections arises because the improved spatial resolution allows the land mass of the island of Jamaica to be represented, whilst the region is represented only by 'ocean' grid boxes at GCM resolution. Land surfaces warm more rapidly than ocean due to their lower capacity to absorb heat energy.

Table 3.2.1: Observed and GCM projected changes in temperature for Jamaica.

Jamaica: Country Scale Changes in Temperature												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
	(˚C)	*(change in ˚C per decade)*		*Change in ˚C*			*Change in ˚C*			*Change in ˚C*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
			A2	0.4	**0.7**	0.9	1.0	**1.6**	1.7	2.0	**2.7**	3.0
Annual	23.7	0.27*	*A1B*	0.3	**0.8**	1.1	1.0	**1.6**	1.8	1.3	**2.3**	2.9
			B1	0.4	**0.8**	0.9	0.7	**1.1**	1.4	1.0	**1.5**	2.0
			A2	0.4	**0.7**	0.9	0.8	**1.5**	1.8	1.8	**2.5**	3.0
DJF	23.7	0.20*	*A1B*	0.3	**0.7**	1.0	0.9	**1.4**	1.9	1.2	**2.2**	2.8
			B1	0.4	**0.7**	0.9	0.5	**1.1**	1.4	0.9	**1.4**	2.0
			A2	0.4	**0.7**	0.9	0.9	**1.5**	1.7	1.8	**2.7**	2.9
MAM	24.3	0.27*	*A1B*	0.2	**0.7**	1.1	0.9	**1.5**	1.8	1.2	**2.3**	2.7
			B1	0.3	**0.7**	0.9	0.6	**1.1**	1.4	0.8	**1.5**	1.9
			A2	0.4	**0.8**	1.0	0.9	**1.7**	1.8	2.1	**2.9**	3.1
JJA	23.7	0.31*	*A1B*	0.4	**0.8**	1.1	1.1	**1.7**	1.9	1.4	**2.3**	2.9
			B1	0.3	**0.7**	0.9	0.8	**1.2**	1.4	1.0	**1.6**	2.0
			A2	0.5	**0.8**	1.0	1.0	**1.6**	1.8	2.2	**2.8**	3.1
SON	23.2	0.28*	*A1B*	0.3	**0.8**	1.1	1.1	**1.7**	2.0	1.5	**2.4**	3.1
			B1	0.4	**0.8**	1.0	0.7	**1.2**	1.4	1.1	**1.5**	2.0

Table 3.2.2: GCM and RCM projected changes in temperature for Jamaica under the A2 scenario

		Projected Changes by 2080s A2		
		Change in ˚C		
	GCM Ensemble Range	*2.0*	**2.7**	*3.0*
Annual	RCM (Echam4)		**3.4**	
	RCM (HadCM3)		**2.9**	
	GCM Ensemble Range	*1.8*	**2.5**	*3.0*
DJF	RCM (Echam4)		**3.0**	
	RCM (HadCM3)		**2.8**	
	GCM Ensemble Range	*1.8*	**2.7**	*2.9*
MAM	RCM (Echam4)		**3.2**	
	RCM (HadCM3)		**3**	
	GCM Ensemble Range	*2.1*	**2.9**	*3.1*
JJA	RCM (Echam4)		**3.6**	
	RCM (HadCM3)		**3.1**	
	GCM Ensemble Range	*2.2*	**2.8**	*3.1*
SON	RCM (Echam4)		**3.6**	
	RCM (HadCM3)		**2.8**	

3.3. *Precipitation*

There are no significant trends in observed rainfall over Jamaica from gridded datasets over the period 1960-2006 – long term trends are difficult to identify due to the large inter-annual variability.

GCM projections of future rainfall for Jamaica span both overall increases and decreases, but most models project decreases. Projected rainfall changes range from -44% to +18% by the 2050s and -55% to +18% by the 2080s. The overall decreases in annual rainfall projected by GCMs occur largely through decreased

MAM and JJA (early wet season) rainfall. Changes to rainfall in the wettest season (SON) are less consistent between models.

RCM projections of rainfall for Jamaica are strongly influenced by which driving GCM provides boundary conditions. Driven by ECHAM4, RCM projections indicate moderate decreases in MAM and JJA rainfall, but very little change in total annual rainfall. Driven by HadCM3, the projections indicate dramatic decreases in rainfall, particularly in JJA and SON. These HadCM3-driven projections correspond with those that are at the most extreme end of the range of GCM projections.

Table 3.3.1: Observed and GCM projected changes in precipitation for Jamaica

Jamaica: Country Scale Changes in Precipitation												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
	(mm per month)	*(change in mm per decade)*		*Change in mm per month*			*Change in mm per month*			*Change in mm per month*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
			A2	-10	**-2**	0	-27	**-4**	7	-40	**-8**	1
Annual	155.2	-2.4	*A1B*	-20	**0**	11	-29	**-3**	4	-27	**-8**	11
			B1	-13	**-3**	11	-16	**-3**	7	-23	**-6**	8
			A2	-9	**-4**	5	-13	**0**	20	-18	**-1**	17
DJF	107.2	0.2	*A1B*	-7	**-2**	19	-16	**0**	8	-14	**-3**	21
			B1	-11	**-1**	11	-8	**-2**	6	-15	**0**	4
			A2	-7	**-2**	12	-13	**-5**	8	-26	**-7**	0
MAM	142.4	1.8	*A1B*	-13	**0**	14	-17	**-1**	4	-12	**-6**	5
			B1	-12	**-2**	7	-13	**0**	17	-13	**-3**	15
			A2	-21	**-6**	3	-46	**-15**	23	-64	**-32**	-5
JJA	141	-6.2	*A1B*	-34	**-7**	36	-47	**-13**	5	-54	**-24**	0
			B1	-24	**-10**	3	-20	**-5**	7	-34	**-14**	6
			A2	-19	**0**	8	-38	**-1**	21	-53	**-2**	26
SON	227.6	-4.5	*A1B*	-32	**1**	32	-43	**0**	18	-49	**-2**	49
			B1	-28	**-5**	43	-31	**-4**	19	-37	**-9**	25

Table 3.3.2: GCM and RCM projected changes in precipitation for Jamaica under the A2 scenario

		Projected Changes by *2080s* *A2*		
		Change in mm		
	GCM Ensemble	*-40*	**-8**	*1*
Annual	RCM (Echam4)		**-4**	
	RCM (HadCM3)		**-36**	
	GCM Ensemble	*-18*	**-1**	*17*
DJF	RCM (Echam4)		**0**	
	RCM (HadCM3)		**-17**	
	GCM Ensemble	*-26*	**-7**	*0*
MAM	RCM (Echam4)		**-7**	
	RCM (HadCM3)		**-26**	
	GCM Ensemble	*-64*	**-32**	*-5*
JJA	RCM (Echam4)		**-8**	
	RCM (HadCM3)		**-35**	
	GCM Ensemble	*-53*	**-2**	*26*
SON	RCM (Echam4)		**-2**	
	RCM (HadCM3)		**-64**	

Table 3.3.3: Observed and GCM projected changes in precipitation (%) for Jamaica

Jamaica: Country Scale Changes in Precipitation												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
	(mm per month)	*(change in % per decade)*		*% Change* Min	Median	Max	*% Change* Min	Median	Max	*% Change* Min	Median	Max
			A2	-31	**-2**	0	-41	**-6**	18	-55	**-10**	2
Annual	155.2	-1.6	*A1B*	-30	**-1**	18	-44	**-6**	8	-40	**-10**	18
			B1	-20	**-4**	11	-29	**-4**	10	-35	**-7**	13
			A2	-30	**-6**	7	-34	**2**	24	-51	**-1**	25
DJF	107.2	0.2	*A1B*	-26	**-4**	34	-46	**-1**	35	-35	**-4**	26
			B1	-32	**-3**	23	-22	**-4**	15	-42	**0**	9
			A2	-20	**-4**	43	-45	**-16**	49	-52	**-20**	1
MAM	142.4	1.3	*A1B*	-24	**2**	32	-48	**-9**	9	-51	**-12**	7
			B1	-37	**-5**	11	-29	**-1**	41	-44	**-12**	37
			A2	-38	**-10**	2	-53	**-15**	14	-65	**-31**	-13
JJA	141	-4.4	*A1B*	-33	**-8**	22	-45	**-18**	9	-62	**-19**	-1
			B1	-40	**-11**	3	-52	**-8**	5	-57	**-13**	10
			A2	-42	**0**	6	-39	**-1**	25	-55	**-2**	22
SON	227.6	-2	*A1B*	-33	**1**	39	-44	**0**	12	-51	**-1**	41
			B1	-28	**-3**	35	-36	**-3**	19	-38	**-8**	23

Table 3.3.4: GCM & RCM projected changes in precipitation (%) for Jamaica under the A2 scenario

		Projected Changes by *2080s* *A2*		
			Change in %	
	GCM Ensemble	*-55*	**-10**	*2*
Annual	RCM (Echam4)		**-14**	
	RCM (HadCM3)		**-41**	
	GCM Ensemble	*-51*	**-1**	*25*
DJF	RCM (Echam4)		**9**	
	RCM (HadCM3)		**-42**	
	GCM Ensemble	*-52*	**-20**	*1*
MAM	RCM (Echam4)		**-23**	
	RCM (HadCM3)		**-36**	
	GCM Ensemble	*-65*	**-31**	*-13*
JJA	RCM (Echam4)		**-35**	
	RCM (HadCM3)		**-31**	
	GCM Ensemble	*-55*	**-2**	*22*
SON	RCM (Echam4)		**-6**	
	RCM (HadCM3)		**-53**	

3.4. *Wind Speed*

Observed mean wind speeds from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) mean monthly marine surface wind dataset demonstrate significantly increasing trends around Jamaica in all seasons over the period 1960-2006. The increasing trend in mean annual marine wind speed is 0.26 ms^{-1} per decade.

Mean wind speeds over Jamaica generally increase in GCM projections, but not as dramatically as in the gridded observations of the last few decades from the surrounding marine area. Projected changes in annual average wind speeds range between -0.1 and +0.5 ms^{-1} by the 2080s across the three emissions scenarios. The greatest increases occur in MAM and JJA, ranging between -0.5 and +1.3ms^{-1}, and -0.2 to 1.2ms^{-1} by the 2080s, respectively. Both increases and decreases are seen in DJF and SON across the 15 model ensemble.

RCM projections based on two driving GCMs lie in the lower end of the range of changes indicated by the GCM ensemble, indicating small decreases in mean wind speed over Jamaica by the 2080s under the A2 scenario. The largest decreases in wind speeds in these models occur in SON (the peak of the hurricane season) at -0.3 to -0.5 ms^{-1}. The RCM simulates larger decreases in wind speed in SON and DJF when driven by the GCM HadCM3 than by ECHAM4.

Table 3.4.1: Observed and GCM projected changes in wind speed for Jamaica

Jamaica: Country Scale Changes in Wind Speed												
	Observed Mean 1970-99 *(ms^{-1})*	**Observed Trend 1960-2006** *(change in ms^{-1} per decade)*		***Projected changes by the 2020s*** *Change in ms^{-1}*			***Projected changes by the 2050s*** *Change in ms^{-1}*			***Projected changes by the 2080s*** *Change in ms^{-1}*		
				Min	Median	Max	Min	Median	Max	Min	Median	Max
			A2	-0.2	**0.0**	0.1	-0.1	**0.0**	0.1	-0.1	**0.2**	0.5
Annual	6.6	0.26*	*A1B*	-0.2	**0.0**	0.1	-0.1	**0.0**	0.2	-0.2	**0.1**	0.3
			B1	-0.2	**0.0**	0.1	-0.1	**0.0**	0.2	-0.1	**0.0**	0.1
			A2	-0.5	**0.0**	0.4	-0.7	**-0.1**	0.3	-0.6	**0.0**	0.3
DJF	7.0	0.27*	*A1B*	-0.4	**0.1**	0.3	-0.1	**0.0**	0.5	-0.7	**-0.1**	0.3
			B1	-0.4	**0.0**	0.2	-0.2	**0.0**	0.1	-0.4	**0.0**	0.2
			A2	-0.2	**0.0**	0.4	-0.4	**0.2**	0.5	-0.1	**0.2**	1.3
MAM	6.4	0.25*	*A1B*	-0.4	**0.2**	0.4	-0.3	**0.0**	0.6	-0.5	**0.2**	0.7
			B1	-0.2	**0.2**	0.5	-0.2	**0.2**	0.4	-0.4	**0.1**	0.4
			A2	-0.4	**-0.1**	0.2	-0.2	**-0.1**	0.3	-0.2	**0.1**	1.2
JJA	7.3	0.27*	*A1B*	-0.2	**-0.1**	0.0	-0.1	**0.0**	0.3	-0.2	**0.2**	1.0
			B1	-0.3	**0.0**	0.1	-0.2	**0.1**	0.5	-0.1	**0.0**	0.5
			A2	-0.3	**-0.1**	0.1	-0.4	**-0.1**	0.0	-0.5	**0.0**	0.4
SON	5.9	0.25*	*A1B*	-0.5	**0.0**	0.2	-0.4	**-0.1**	0.0	-0.5	**0.0**	0.2
			B1	-0.3	**0.0**	0.1	-0.6	**0.0**	0.2	-0.4	**0.0**	0.2

Table 3.4.2: GCM and RCM projected changes in wind speed for Jamaica under the A2 scenario

		Projected Changes by *2080s* *A2*		
			Change in ms^{-1}	
	GCM Ensemble	*-0.1*	**0.2**	*0.5*
Annual	RCM (Echam4)		**-0.1**	
	RCM (HadCM3)		**-0.2**	
	GCM Ensemble	*-0.6*	**0.0**	*0.3*
DJF	RCM (Echam4)		**-0.1**	
	RCM (HadCM3)		**-0.5**	
	GCM Ensemble	*-0.1*	**0.2**	*1.3*
MAM	RCM (Echam4)		**0.0**	
	RCM (HadCM3)		**0.0**	
	GCM Ensemble	*-0.2*	**0.1**	*1.2*
JJA	RCM (Echam4)		**-0.1**	
	RCM (HadCM3)		**0.2**	
	GCM Ensemble	*-0.5*	**0.0**	*0.4*
SON	RCM (Echam4)		**-0.3**	
	RCM (HadCM3)		**-0.5**	

3.5. *Relative Humidity*

There is no significant trend in Relative Humidity (RH) over Jamaica in observations from the HadCRUH dataset (1973-2003).

Relative humidity data has not been made available for all models in the 15-model ensemble. Projections from those models that are available tend towards small increases in RH, particularly in DJF and MAM. However the ensemble sub-sample range does span both increases and decreases in RH in all seasons.

Due to the coarse spatial resolution of the GCMs, the land mass of the relatively small island of Jamaica is not represented in the model, and this exerts a strong influence on RH. Ocean and land surfaces respond differently to increases in temperature due to the availability of water. Over oceanic surfaces, temperature increases result in increased evaporation of water from the surface. This not only distributes some of the excess heat, but also results in a higher volume of atmospheric water vapour, causing higher specific humidity (although not necessarily higher RH). Over the land surface, only a limited amount of water is available, and therefore increased temperatures will result in an increased *potential* for evaporation, and this potential increase will only be partially met by available surface moisture. This will result in a small increase in specific humidity, but a likely decrease in RH as the air temperature increases. The representation of the land surface in climate models therefore becomes very important when considering changes in RH under a warmer climate, and we see a substantial disparity between the changes projected for the small Caribbean islands in RCM simulations, where the land surface is represented, compared with coarse scale GCM simulations, where the land surface is not represented.

RCM simulations indicate decreases in RH over Jamaica in all seasons, with changes in annual average RH of -1.1 to -1.7% by the 2080s under the A2 scenario. The largest decreases in RH occur in JJA.

Table 3.5.1: Observed and GCM projected changes in relative humidity for Jamaica

Jamaica: Country Scale Changes in Relative Humidity												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
	(%)	*(change in % per decade)*		*Change in %*			*Change in %*			*Change in %*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
			A2									
Annual	79.3	0.03	*A1B*	-0.1	**0.5**	1.4	-0.7	**0.4**	1.5	-1.2	**0.9**	1.0
			B1	-0.6	**-0.2**	1.4	-0.3	**0.3**	2.4	-0.8	**0.5**	1.5
			A2									
DJF	78.3	0.19	*A1B*	-0.4	**0.5**	1.6	-0.3	**0.7**	1.5	-1.1	**1.0**	1.7
			B1	-0.7	**-0.1**	1.2	-0.6	**0.1**	2.3	-0.7	**-0.2**	1.8
			A2									
MAM	79.2	-0.06	*A1B*	-0.1	**0.8**	2.0	-0.1	**0.7**	2.1	0.4	**1.0**	2.1
			B1	-0.3	**0.2**	1.7	0.4	**0.6**	4.0	-0.1	**0.4**	2.3
			A2									
JJA	79.9	0.09	*A1B*	-0.1	**0.1**	1.0	-1.7	**0.4**	1.1	-2.7	**0.3**	1.1
			B1	-1.6	**-0.4**	1.5	-0.7	**0.1**	2.0	-1.6	**0.4**	0.8
			A2									
SON	79.9	-0.11	*A1B*	0.1	**1.0**	1.6	-0.8	**0.5**	1.3	-2.0	**0.5**	0.8
			B1	-0.5	**-0.3**	1.1	-0.6	**0.0**	1.5	-1.3	**0.3**	1.9

Table 3.5.2: GCM, RCM projected changes in relative humidity for Jamaica under the A2 scenario

		Projected changes by the 2080s SRES A2 Min	Median	Max
			Change in %	
	GCM Ensemble Range		**0.8**	
Annual	RCM (ECHAM4)		**-1.1**	
	RCM (HadCM3)		**-1.7**	
	GCM Ensemble Range		**0.4**	
DJF	RCM (ECHAM4)		**-1.1**	
	RCM (HadCM3)		**-0.7**	
	GCM Ensemble Range		**1.0**	
MAM	RCM (ECHAM4)		**-0.7**	
	RCM (HadCM3)		**-1.3**	
	GCM Ensemble Range		**1.2**	
JJA	RCM (ECHAM4)		**-1.6**	
	RCM (HadCM3)		**-2.6**	
	GCM Ensemble Range		**0.4**	
SON	RCM (ECHAM4)		**-0.9**	
	RCM (HadCM3)		**-2.2**	

3.6. *Sunshine Hours*

The number of 'sunshine hours' per day are calculated by applying the average clear-sky fraction from cloud observations to the number of daylight hours for the latitude of the location and the time of year. The observed number of sunshine hours, based on the International Satellite Cloud Climatology Project (ISCCP) satellite observations of cloud coverage, indicates statistically significant increases in sunshine hours in MAM and JJA for Jamaica over recent years (1983-2001).

The number of sunshine hours implied by most models increases into the 21st Century in Jamaica, reflecting reductions in average cloud cover fractions, although the GCM model ensemble spans both increases and decreases in all seasons and emissions scenarios. The changes in annual average sunshine hours span -0.2 to +0.9 hours per day by the 2080s under scenario A2. The increases are largest in JJA, with changes of -0.9 to +1.9 hours per day by the 2080s.

Comparison between GCM and RCM projections of sunshine hours for Jamaica shows that the HadCM3 driven RCM projections indicate particularly large increases (+1.4 hours per day by 2080s under A2) in mean annual sunshine hours, and that these increases lie beyond the envelope of changes indicated by GCMs. This RCM simulation reflects the particularly dry characteristics of the HadCM3 model. Driven by ECHAM4, the RCM indicates changes that lie towards the centre of the GCM ensemble envelope.

Table 3.6.1: Observed and GCM projected changes in sunshine hours for Jamaica.

Jamaica: Country Scale Changes in Sunshine Hours												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
	(hrs)	*(change in hrs per decade)*		*Change in hrs*			*Change in hrs*			*Change in hrs*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
			A2	-0.2	**0.2**	0.5	-0.3	**0.2**	0.6	-0.2	**0.4**	0.9
Annual	6.4	0.28	*A1B*	-0.3	**0.0**	0.4	-0.2	**0.2**	0.4	-0.3	**0.3**	0.8
			B1	-0.4	**0.2**	0.3	-0.1	**0.2**	0.5	-0.2	**0.3**	0.6
			A2	0.0	**0.2**	0.5	-0.3	**0.2**	0.4	-0.5	**0.3**	0.6
DJF	7.5	0.19	*A1B*	-0.2	**0.0**	0.3	-0.4	**0.2**	0.5	-0.5	**0.2**	0.7
			B1	-0.1	**0.0**	0.3	-0.4	**0.1**	0.3	-0.1	**0.0**	0.6
			A2	-0.4	**0.1**	0.4	-0.4	**0.2**	0.6	-1.1	**0.3**	0.8
MAM	6.6	0.78*	*A1B*	-0.6	**0.1**	0.3	-0.8	**0.2**	0.5	-0.8	**-0.1**	0.7
			B1	-0.8	**0.2**	0.5	-0.6	**0.0**	0.4	-0.5	**0.1**	0.7
			A2	-0.5	**0.2**	1.0	-0.8	**0.5**	1.2	-0.9	**0.8**	1.9
JJA	5.7	0.40*	*A1B*	-0.7	**0.2**	0.7	-0.3	**0.6**	0.9	-0.7	**0.8**	1.6
			B1	-0.4	**0.3**	0.6	-0.5	**0.5**	0.8	-0.4	**0.6**	1.2
			A2	-0.1	**0.1**	0.6	-0.6	**0.2**	0.7	-0.4	**0.4**	1.0
SON	5.8	-0.26	*A1B*	-0.5	**0.0**	0.4	-0.2	**0.0**	0.7	-0.5	**0.3**	1.1
			B1	-0.5	**0.1**	0.6	-0.4	**0.1**	0.9	-0.6	**0.1**	0.6

Table 3.6.2: GCM and RCM projected changes in sunshine hours for Jamaica under the A2 scenario

		Projected Changes by *2080s (A2 Scenario)*		
		Change in hrs		
	GCM Ensemble	*-0.2*	**0.4**	*0.9*
Annual	RCM (Echam4)		**0.8**	
	RCM (HadCM3)		**1.4**	
	GCM Ensemble	*-0.5*	**0.3**	*0.6*
DJF	RCM (Echam4)		**1.0**	
	RCM (HadCM3)		**1.0**	
	GCM Ensemble	*-1.1*	**0.3**	*0.8*
MAM	RCM (Echam4)		**0.5**	
	RCM (HadCM3)		**0.6**	
	GCM Ensemble	*-0.9*	**0.8**	*1.9*
JJA	RCM (Echam4)		**0.8**	
	RCM (HadCM3)		**1.9**	
	GCM Ensemble	*-0.4*	**0.4**	*1.0*
SON	RCM (Echam4)		**0.7**	
	RCM (HadCM3)		**2.0**	

3.7. *Sea Surface Temperatures*

Sea-surface temperatures from the HadSST2 gridded dataset indicate statistically significant increasing trends in JJA and SON of +0.7˚C per decade in the waters surrounding Jamaica.

GCM projections indicate continuing increases in sea-surface temperatures throughout the year. Projected increases range between +0.9˚C and +2.7˚C by the 2080s, across all three emissions scenarios. Increases tend to be fractionally higher in SON than in other seasons (1.0˚ to 2.9˚C by 2080). The range of projections under and single emissions scenario spans around 1.0˚ to 1.5˚C.

Table 3.7.1: Observed and GCM projected changes in sea surface temperature for Jamaica

Jamaica: Country Scale Changes in Sea-Surface Temperature												
	Observed Mean 1970-99	**Observed Trend 1960-2006**		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
	(˚C)	*(change in ˚C per decade)*		*Change in ˚C*			*Change in ˚C*			*Change in ˚C*		
				Min	*Median*	*Max*	*Min*	*Median*	*Max*	*Min*	*Median*	*Max*
			A2	0.5	**0.7**	0.9	1.0	**1.3**	1.6	1.9	**2.3**	2.7
Annual	27.8	0.04	*A1B*	0.3	**0.7**	0.8	0.9	**1.5**	1.6	1.3	**2.2**	2.6
			B1	0.3	**0.6**	0.8	0.6	**1.0**	1.2	0.9	**1.4**	1.8
			A2	0.3	**0.7**	0.9	0.8	**1.3**	1.7	1.8	**2.2**	2.8
DJF	26.9	0.01	*A1B*	0.3	**0.7**	0.8	0.9	**1.4**	1.7	1.3	**2.1**	2.6
			B1	0.3	**0.6**	0.8	0.4	**1.0**	1.3	0.9	**1.3**	1.9
			A2	0.5	**0.7**	0.8	0.9	**1.3**	1.6	1.7	**2.3**	2.7
MAM	27.1	0.02	*A1B*	0.2	**0.6**	0.8	0.8	**1.4**	1.5	1.1	**2.1**	2.5
			B1	0.2	**0.6**	0.8	0.5	**0.9**	1.3	0.7	**1.3**	1.8
			A2	0.5	**0.7**	0.8	1.2	**1.3**	1.7	2.0	**2.4**	2.7
JJA	28.5	0.07*	*A1B*	0.3	**0.7**	0.9	1.0	**1.5**	1.7	1.3	**2.2**	2.5
			B1	0.2	**0.6**	0.8	0.7	**1.1**	1.2	0.9	**1.4**	1.7
			A2	0.5	**0.7**	0.9	1.0	**1.4**	1.7	2.0	**2.5**	2.9
SON	28.7	0.07*	*A1B*	0.4	**0.7**	0.9	1.0	**1.5**	1.8	1.5	**2.3**	2.9
			B1	0.3	**0.7**	0.8	0.7	**1.1**	1.3	1.0	**1.4**	1.8

3.8. *Temperature Extremes*

'Extreme' hot or cold values are defined by the temperatures that are exceeded on 10% of days in the 'current' climate or reference period. This allows us to define 'hot' or 'cold' relative to the particular climate of a specific region or season, and determine changes in extreme events relative to that location.

In Jamaica, the frequency of days and nights that are classed as 'hot' for their season according to recent climate standards have increased in frequency at a statistically significant rate over the period 1973-2008. The annual average frequency of 'hot' days and nights has increased by an additional 6% (an additional 22 days per year) every decade. The frequency of hot nights has increased particularly rapidly in JJA when their frequency has increased by 9.8% (an additional 3 hot nights per month in JJA) per decade. The frequency of 'cold' nights has decreased at a rate of 4% fewer 'cold' nights (14 fewer cold nights in every year) per decade.

GCM projections indicate continued increases in the frequency of 'hot' days and nights, with their occurrence reaching 30-98% of days annually by the 2080s. The rate of increase varies substantially between models for each scenario, such that under A2 the most conservative increases result in frequency of 49% by the 2080s, with other models indicating frequencies as high as 98%.

Those days/nights that are considered 'hot' for their season are projected to increase most rapidly in JJA and SON, occurring on 60 to 100% of days/nights in JJA and SON by the 2080s.

'Cold' days/nights diminish in frequency, occurring on a maximum of 2% of days/nights by the 2080s, and do not occur at all in projections from some models by the 2050s. Cold days/nights decrease in frequency most rapidly in JJA.

Table 3.8.1: Observed and GCM projected changes in temperature extremes for Jamaica

	Observed Mean 1970-99	Observed Trend 1960-2006		***Projected changes by the 2020s***			***Projected changes by the 2050s***			***Projected changes by the 2080s***		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
	% Frequency	*Change in frequency per decade*					*Future % frequency*			*Future % frequency*		
Frequency of Hot Days (TX90p)												
			A2				32	**53**	73	49	**78**	98
Annual	10.7	6.03*	*A1B*				36	**53**	68	41	**71**	96
			B1				27	**39**	53	30	**49**	66
			A2				52	**78**	92	84	**98**	99
DJF	11.3	6.26*	*A1B*				56	**82**	89	73	**96**	99
			B1				34	**62**	70	58	**75**	89
			A2				39	**78**	97	70	**96**	99
MAM	12.8	5.63*	*A1B*				46	**81**	93	61	**94**	99
			B1				32	**55**	84	37	**75**	91
			A2				67	**87**	95	89	**99**	100
JJA	10.9	6.19*	*A1B*				72	**86**	94	79	**98**	99
			B1				43	**67**	79	59	**83**	96
			A2				30	**86**	99	58	**99**	100
SON	13.0	7.87*	*A1B*				33	**79**	99	42	**97**	99
			B1				22	**61**	94	32	**73**	98
Frequency of Hot Nights (TN90p)												
			A2				45	**55**	71	65	**80**	97
Annual	11.5	5.89*	*A1B*				41	**56**	67	54	**72**	94
			B1				29	**42**	52	40	**52**	64
			A2				51	**73**	90	87	**96**	99
DJF	13.7	1.48	*A1B*				49	**78**	86	79	**93**	98
			B1				29	**59**	65	54	**72**	85
			A2				54	**73**	95	90	**95**	99
MAM	10.3	3.63*	*A1B*				45	**77**	90	78	**93**	99
			B1				27	**58**	79	49	**74**	88
			A2				78	**90**	95	96	**99**	100
JJA	12.1	9.76*	*A1B*				68	**92**	93	91	**99**	99
			B1				40	**76**	85	68	**88**	97
			A2				74	**85**	98	93	**99**	100
SON	12.2	4.59*	*A1B*				75	**88**	98	86	**97**	99
			B1				51	**64**	90	70	**86**	96
Frequency of Cold Days (TX10p)												
			A2				0	**1**	3	0	**0**	0
Annual			*A1B*				0	**0**	2	0	**0**	1
			B1				0	**1**	3	0	**1**	2
			A2				0	**1**	3	0	**0**	0
DJF			*A1B*				0	**0**	1	0	**0**	1
			B1				0	**1**	2	0	**1**	2
			A2				0	**0**	3	0	**0**	0
MAM			*A1B*				0	**0**	3	0	**0**	1
			B1				0	**1**	4	0	**0**	2
			A2				0	**0**	1	0	**0**	0
JJA			*A1B*				0	**0**	0	0	**0**	2
			B1				0	**0**	2	0	**0**	3
			A2				0	**0**	1	0	**0**	0
SON			*A1B*				0	**0**	1	0	**0**	0
			B1				0	**0**	4	0	**0**	2
Frequency of Cold Nights (TN10p)												
			A2				0	**1**	2	0	**0**	0

	Observed Mean 1970-99	Observed Trend 1960-2006		Projected changes by the 2020s			Projected changes by the 2050s			Projected changes by the 2080s		
				Min	**Median**	**Max**	**Min**	**Median**	**Max**	**Min**	**Median**	**Max**
	% Frequency	*Change in frequency per decade*					*Future % frequency*			*Future % frequency*		
Annual	10.8	-4.03*	*A1B*				0	**1**	2	0	**0**	1
			B1				0	**2**	3	0	**1**	2
			A2				0	**1**	3	0	**0**	0
DJF	11.1	-3.76*	*A1B*				0	**0**	2	0	**0**	1
			B1				0	**1**	4	0	**1**	2
			A2				0	**0**	2	0	**0**	0
MAM	12.0	-2.81*	*A1B*				0	**0**	2	0	**0**	0
			B1				0	**1**	3	0	**0**	2
			A2				0	**0**	0	0	**0**	0
JJA	11.9	-5.31*	*A1B*				0	**0**	0	0	**0**	0
			B1				0	**0**	3	0	**0**	0
			A2				0	**0**	1	0	**0**	0
SON	14.0	-7.58*	*A1B*				0	**0**	2	0	**0**	0
			B1				0	**0**	2	0	**0**	1

3.9. *Rainfall Extremes*

Changes in rainfall extremes based on peak 1- and 5-day rainfall totals, as well as exceedance of a relative threshold for 'heavy' rain, were examined. 'Heavy' rain is determined by the daily rainfall totals that are exceeded on 5% of wet days in the 'current' climate or reference period, relative to the particular climate of a specific region or season.

Observations indicate statistically significant decreases in the proportion of total rainfall that occurs in 'heavy' events at a rate of -8.3% per decade over the observed period 1973-2008 (where the threshold value for a 'heavy' events is determined according to the values exceeded on 5% of wet days in the reference period). The peak 1- and 5-day rainfalls have also decreased over this period. Decreases in 5-day maxima in DJF and MAM have decreased significantly at a rate of -33 and -18 mm per decade, respectively. These 'trends' should all be interpreted cautiously given the relatively short period over which they are calculated, and the large inter-annual variability in rainfall and its extremes.

GCM projections of rainfall extremes are mixed across the ensemble, ranging across both decreases and increases in all measures of extreme rainfall. However, the model projections do tend towards decreases in rainfall extremes particularly in MAM. The range of changes in the proportion of rainfall during heavy events is -19 to +9% by the 2080s across all emissions scenarios and the range of changes in 5-day maxima spans -29 mm to +25 mm by the 2080s. Even the largest decreases simulated by models in the ensemble do not indicate long-term trends of the magnitudes that have appeared in recent years on the observed record.

Table 3.9.1: Observed and GCM projected changes in rainfall extremes for Jamaica

	Observed Mean 1970-99	Observed Trend 1960-2006		*Projected changes by the 2020s*			*Projected changes by the 2050s*			*Projected changes by the 2080s*		
				Min	***Median***	***Max***	***Min***	***Median***	***Max***	***Min***	***Median***	***Max***
% total rainfall falling in Heavy Events (R95pct)												
	%	*% Change / decade*					*Change in %*			*Change in %*		
			A2				-11	**0**	6	-19	**-1**	7
Annual	35.3	-8.32*	*A1B*				-13	**0**	4	-13	**-1**	5
			B1				-14	**0**	6	-8	**-2**	9
			A2				-14	**-1**	12	-16	**-3**	13
DJF			*A1B*				-13	**0**	11	-14	**-5**	11
			B1				-12	**-2**	7	-15	**2**	8
			A2				-16	**-4**	2	-25	**-10**	4
MAM			*A1B*				-24	**-5**	3	-18	**-8**	2
			B1				-13	**-6**	8	-15	**-1**	11
			A2				-19	**-1**	5	-25	**-8**	8
JJA			*A1B*				-13	**-4**	4	-20	**-6**	8
			B1				-18	**0**	6	-19	**-4**	12
			A2				-11	**-1**	6	-17	**0**	8
SON			*A1B*				-12	**-1**	6	-13	**0**	8
			B1				-10	**0**	8	-15	**0**	4
Maximum 1-day rainfall (RX1day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2				-9	**0**	9	-10	**0**	11
Annual	214.5	-23.58	*A1B*				-4	**0**	6	-5	**0**	14
			B1				-6	**1**	7	-9	**0**	6
			A2				-5	**0**	6	-4	**0**	4
DJF	88.0	-28.70*	*A1B*				-4	**0**	8	-3	**-1**	6
			B1				-2	**-1**	3	-4	**0**	2
			A2				-5	**0**	2	-8	**-2**	5
MAM	117.4	-13.3	*A1B*				-4	**-1**	3	-5	**-1**	5
			B1				-6	**0**	2	-7	**0**	4
			A2				-7	**-1**	4	-7	**-2**	5
JJA	109.2	-0.03	*A1B*				-5	**-2**	7	-6	**-1**	6
			B1				-7	**0**	5	-11	**-1**	2
			A2				-7	**0**	8	-8	**0**	12
SON	131.2	-2.92	*A1B*				-9	**0**	7	-7	**0**	8
			B1				-4	**0**	5	-3	**0**	4
Maximum 5-day Rainfall (RX5day)												
	mm	*Change in mm per decade*					*Change in mm*			*Change in mm*		
			A2				-18	**-1**	18	-29	**-3**	23
Annual	189.4	-48.56*	*A1B*				-22	**-3**	11	-19	**-4**	19
			B1				-15	**0**	21	-25	**-1**	25
			A2				-10	**0**	16	-12	**-1**	9
DJF	90.0	-32.94*	*A1B*				-10	**0**	27	-10	**-3**	14
			B1				-7	**-2**	4	-11	**0**	5
			A2				-11	**-4**	10	-16	**-7**	18
MAM	79.2	-18.26*	*A1B*				-9	**-4**	11	-10	**-4**	9
			B1				-15	**-2**	11	-13	**0**	13
			A2				-16	**-3**	9	-23	**-9**	7
JJA	104.0	-32.64	*A1B*				-16	**-8**	10	-21	**-7**	4
			B1				-16	**-3**	19	-25	**-7**	5
			A2				-20	**-1**	14	-32	**-2**	27
SON	109.9	-24.88	*A1B*				-25	**0**	15	-26	**-1**	16
			B1				-12	**0**	18	-17	**-1**	20

3.10. *Hurricanes and Tropical Storms*

Historical and future changes in tropical storm and hurricane activity have been a topic of heated debate in the climate science community. Drawing robust conclusions with regards to changes in climate extremes is continually hampered by issues of data quality in our observations, the difficulties in separating natural variability from long-term trends and the limitations imposed by spatial resolution of climate models.

Tropical storms and hurricanes form from pre-existing weather disturbances where sea surface temperatures (SSTs) exceed 26˚C. Whilst SSTs are a key factor in determining the formation, development and intensity of tropical storms, a number of other factors are also critical, such as subsidence, wind shear and static stability. This means that whilst observed and projected increases in SSTs under a warmer climate potentially expand the regions and periods of time when tropical storms may form, the critical conditions for storm formation may not necessarily be met (e.g. Vecchi and Soden, 2007; Trenberth *et al.,* 2007), and increasing SSTs may not necessarily be accompanied by an increase in the frequency of tropical storm incidences.

Several analyses of global (e.g. Webster *et al.*, 2005) and more specifically North Atlantic (e.g. Holland and Webster, 2007; Kossin *et al.,* 2007; Elsner *et al.,* 2008) hurricanes have indicated increases in the observed record of tropical storms over the last 30 years. It is not yet certain to what degree this trend arises as part of a long-term climate change signal or shorter-term inter-decadal variability. The available longer term records are riddled with in homogeneities (inconsistencies in recording methods through time) - most significantly, the advent of satellite observations, before which storms were only recorded when making landfall or observed by ships (Kossin *et al.,* 2007). Recently, a longer-term study of variations in hurricane frequency in the last 1500 years based on proxy reconstructions from regional sedimentary evidence indicate recent levels of Atlantic hurricane activity are anomalously high relative to those of the last one-and -a -half millennia (Mann *et al.,* 2009).

Climate models are still relatively primitive with respect to representing tropical storms, and this restricts our ability to determine future changes in frequency or intensity. We can analyse the changes in background conditions that are conducive to storm formation (boundary conditions) (e.g. Tapiador, 2008), or apply them to embedded high-resolution models which can credibly simulate tropical storms (e.g. Knutson and Tuleya, 2004; Emanuel *et al.*, 2008). Regional Climate Models are able to simulate weak 'cyclone-like' storm systems that are broadly representative of a storm or hurricane system but are still considered coarse in scale with respect to modelling hurricanes.

The IPCC AR4 (Meehl *et al.,* 2007) concludes that models are broadly consistent in indicating increases in precipitation intensity associated with tropical storms (e.g. Knutson and Tuleya, 2004; Knutson *et al.,* 2008; Chauvin *et al.,* 2006; Hasegawa and Emori, 2005; Tsutsui, 2002). The higher resolution models that simulate storms more credibly are also broadly consistent in indicating increases in associated peak wind intensities and mean rainfall (Knutson and Tuleya, 2004; Oouchi *et al.,* 2006). We summarise the projected changes in wind and precipitation intensities from a selection of these modelling experiments in Table 3.10.1 to give an indication of the magnitude of these changes.

With regards to the ***frequency*** of tropical storms in future climate, models are strongly divergent. Several recent studies (e.g. Vecchi and Sodon, 2007; Bengtssen *et al.,* 2007; Emanuel *et al.,* 2008, Knutson *et al.,* 2008) have indicated that the frequency of storms may decrease due to decreases in vertical wind shear in a warmer climate. In several of these studies, intensity of hurricanes still increases despite decreases in frequency (Emanuel *et al.,* 2008; Knutson *et al.,* 2008). In a recent study of the PRECIS regional climate model simulations for Central America and the Caribbean, Bezanilla *et al.,* (2009) found that the frequency of ‘Tropical -Cyclone-Like –Vortices’ increases on the Pacific coast of Central America, but decreases on the Atlantic coast and in the Caribbean.

When interpreting the modelling experiments we should remember that our models remain relatively primitive with respect to the complex atmospheric processes that are involved in hurricane formation and development. Hurricanes are particularly sensitive to some of the elements of climate physics that these models are weakest at representing, and are often only included by statistical parameterisations. Comparison studies have demonstrated that the choice of parameterisation scheme can exert a strong influence on the results of the study (e.g. Yoshimura *et al.,* 2006). We should also recognise that the El Niño Southern Oscillation (ENSO) is a strong and well established influence on Tropical Storm frequency in the North Atlantic, and explains a large proportion of inter-annual variability in hurricane frequency. This means that the future frequency of hurricanes in the North Atlantic is likely to be strongly dependent on whether the climate state becomes more ‘El-Niño-Like’, or more ‘La-Niña-like’ – an issue upon which models are still strongly divided and suffer from significant deficiencies in simulating the fundamental features of ENSO variability (e.g. Collins *et al.,* 2005).

Table 3.10.1: Changes in Near-storm rainfall and wind intensity associated with Tropical storms in under global warming scenarios.

Reference	GHG scenario	Type of Model	Domain	Change in near-storm rainfall intensity	Change in peak wind intensity
Knutson *et al.,* (2008)	A1B	Regional Climate Model	Atlantic	(+37, 23, 10)% when averaged within 50, 100 and 400 km of the storm centre	+2.9%
Knutson and Tuleya (2004)	1% per year CO_2 increase	9 GCMs + nested regional model with 4 different moist convection schemes.	Global	+12-33%	+5-7%
Oouchi *et al.,* (2006)	A1B	High Resolution GCM	Global	N/A	+14%
			North Atlantic		+20%

3.11. *Sea Level Rise*

Observed records of sea level from tidal gauges and satellite altimeter readings indicate a global mean SLR of 1.8 (+/- 0.5) mm yr^{-1} over the period 1961-2003 (Bindoff *et al.,* 2007). Acceleration in this rate of increase over the course of the 20th Century has been detected in most regions (Woodworth *et al.,* 2009; Church and White, 2006).

There are large regional variations superimposed on the mean global SLR rate. Observations from tidal gauges surrounding the Caribbean basin (Table 3.11.1) indicate that SLR in the Caribbean is broadly consistent with the global trend (Table 3.11.2).

Table 3.11.1: Sea level rise rates at observation stations surrounding the Caribbean Basin

Tidal Gauge Station	Observed trend (mm yr^{-1})	Observation period
Bermuda	2.04 (+/- 0.47)	1932-2006
San Juan, Puerto Rico	1.65 (+/- 0.52)	1962-2006
Guantanamo Bay, Cuba	1.64 (+/- 0.80)	1973-1971
Miami Beach, Florida	2.39 (+/1 0.43)	1931-1981
Vaca Key, Florida	2.78 (+/- 0.60)	1971-2006

(Source: NOAA, 2009)

Projections of future SLR associated with climate change have recently become a topic of heated debate in scientific research. The IPCC's AR4 report summarised a range of SLR projections under each of its standard scenarios, for which the combined range spans 0.18-0.59 m by 2100 relative to 1980-1999 levels (see ranges for each scenario in Table 3.11.2). These estimates have since been challenged for being too conservative and a number of studies (e.g. Rahmstorf, 2007; Rignot and Kanargaratnam, 2006; Horton *et al.,* 2008) have provided evidence to suggest that their uncertainty range should include a much larger upper limit.

Total sea level rises associated with atmospheric warming appear largely through the combined effects of two main mechanisms: (a) thermal expansion (the physical response of the water mass of the oceans to atmospheric warming) and (b) ice-sheet, ice-cap and glacier melt. Whilst the rate of thermal expansion of the oceans in response to a given rate of temperature increase is projected relatively consistently between GCMs, the rate of ice melt is much more difficult to predict due to our incomplete understanding of ice-sheet dynamics. The IPCC total SLR projections comprise of 70-75% (Meehl *et al.,* 2007a) contribution from thermal expansion, with only a conservative estimate of the contribution from ice sheet melt (Rahmstorf, 2007).

Recent studies that observed acceleration in ice discharge (e.g. Rignot and Kanargaratnam, 2006) and observed rates of SLR in response to global warming (Rahmstorf, 2007), suggest that ice sheets respond highly-non linearly to atmospheric warming. It might therefore be expected that there will be continued acceleration of the large ice sheets resulting in considerably more rapid rates of SLR. Rahmstorf (2007) is perhaps the most well cited example of such a study and suggests that future SLR might be in the order of twice the maximum level that the IPCC, indicating up to 1.4m by 2100.

Table 3.11.2: Projected increases in sea level rise from the IPCC AR4

Scenario	Global Mean Sea Level Rise by 2100 relative to 1980-1999.	Caribbean Mean Sea Level Rise by 2100 relative to 1980-1999 (+/ 0.05m relative to global mean)
IPCC B1	0.18-0.38	0.13-0.43
IPCC A1B	0.21-0.48	0.16-0.53
IPCC A2	0.23-0.51	0.18- 0.56
Rahmstorf, 2007	Up to 1.4m	Up to 1.45m

(Source: Meehl *et al.,* 2007 contrasted with those of Rahmstorf, 2007).

3.12. *Storm Surge*

Changes to the frequency or magnitude of storm surge experienced at coastal locations in Jamaica are likely to occur as a result of the combined effects of:

(a) Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed

(b) Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms

(c) Physical characteristics of the region (bathymetry and topography) which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm.

Sections 3.10 and 3.11 discuss the potential changes in sea level and hurricane intensity that might be experienced in the region under (global) warming scenarios. The high degree of uncertainty in both of these contributing factors creates difficulties in estimating future changes in storm surge height or frequency.

Robinson and Khan (2008) make some estimates of future storm surge flood return periods at Jamaica's Sangster Airport based on projected changes in sea level, assuming that the storm magnitude and frequency remains constant under a warmer climate (Table 3.12.1). Further impacts on storm surge flood return period may include:

- Potential changes in storm frequency: some model simulations indicate a future reduction in storm frequency, either globally or at the regional level. If such decreases occur they may offset these increases in flood frequency at a given elevation.

- Potential increases in storm intensity: evidence suggests overall increases in the intensity of storms (lower pressure, higher near storm rainfall and wind speeds) which would cause increases in the storm surges associated with such events, and contribute further to increases in flood frequency at a given elevation.

Table 3.12.1: Approximate future return periods for storm surge static water levels that would flood current elevations above sea level at Sangster International Airport.

		Approximate Return periods (years) for flooding the current elevation.		
	Current Elevations	Present day Return Period SWIL 1999	2050 Projection (based on IPCC , 2007 SLR Projections)	2050 Projection (based on Rahmstorf, 2007 SLR Projections)
Sangster Airport	0.5	3.5 - 4	about 2	1.5
	1.0	7	about 5.5	5
	1.5	15	11.5	9
	2.0	100	56	33

***NB*: Data based on empirical examination of modelled return periods by Smith Warner International Ltd. for most likely static water elevations at Sangster (SWIL 1999). Wave run-up not included. Source: Robinson and Khan (2008).**

4. VULNERABILITY AND IMPACTS PROFILE FOR JAMAICA

Vulnerability is defined as the "inherent characteristics or qualities of social systems that create the potential for harm. Vulnerability is a function of exposure… and sensitivity of [the] system" (Adger, 2006; Cutter, 1996 cited in Cutter et al. 2008, p. 599). Climate change is projected to be a progressive process and therefore vulnerability will arise at different time and spatial scales affecting communities and sectors in distinct ways. Participatory approaches to data collection were implemented in Portland parish to provide additional community-level data and enable the creation of sea level rise impact data and maps. To help in the identification and analysis of vulnerability, the following sections discuss the implications and impacts of climate change on key sectors as they relate to tourism in Jamaica.

4.1. *Water Quality and Availability*

4.1.1. Background

Freshwater resources in Jamaica come from either surface sources such as rivers and streams or from underground sources, such as wells and springs (GOJ, 2006). Groundwater resources are of significant importance in Jamaica and the country has a large dependence on this water source which supplies between 84% and 92% of water demand. Jamaica is divided into 10 hydrologic (Figure 4.1.1). The Kingston, Rio Cobre and Rio Minho hydrological units, where the largest centres of population exist, each have water demands that exceed available resources (Blake, 2009). The Rio Minho hydrological unit in the south of the island has the greatest water output potential, utilised predominately by the agricultural sector (USACE, 2001; Karanjac, 2002). Water is also sourced from rainwater harvesting, where as much as 100,000 people have been estimated to obtain their main water supply from rainfall (OAS, 1997).

The water use distribution in Jamaica in 1993 was as follows: 75% in agriculture, 17% domestic water supply, 7% industrial and 1% in tourism, for an annual estimated 928 million m^3 of water (AQUASTAT, 1997). This supply is rain water dependant as most of the water recharging of limestone aquifers and alluvial ground water systems comes from precipitation (USACE, 2001). Overall, 93% of the population has access to water and 80% to sanitation and the per capita domestic water consumption in 2009 was 0.034 megalitres (GOJ, 2009d). In the 2007 Annual Water Report for Jamaica, it was noted that,

> *Up to the end of the period 74% of all Jamaican households were supplied directly with piped, potable water via house-to house connections. A further 11% of households is supplied with potable water delivered at standpipes and by other means, amounting to 85% of households with easy access to centra*lised water supply service.

The main stakeholders in the water cycle of Jamaica, identified by Geoghegan and Bass (2002) are the forest managers (government agencies, NGO's and private foresters), upland farmers (legal and illegal) upland settlements, water abstractors (public and private), irrigated farmers, industry and commerce, urban domestic and tourism as shown in Figure 4.1.2. They create a complex structure that is critical to the adaptation of the water sector to the impacts of climate change (See 5.1 of the Adaptive Capacity Profile For Jamaica). In 2010, $546,272,000.00 (approximately US $6,367,000.00) was allocated to the Ministry of Water and Housing or approximately 0.15% of the recurrent national budget and 1.19% of the capital budget (GOJ, 2010a; A. Haiduk, personal communication, November, 16th, 2010). In the Social Review of

Jamaica, in 2009, there was a reported 2.2% economic growth in the Electricity and Water Supply Utility Sectors compared to the previous year due to greater output of both (GOJ, 2009e).

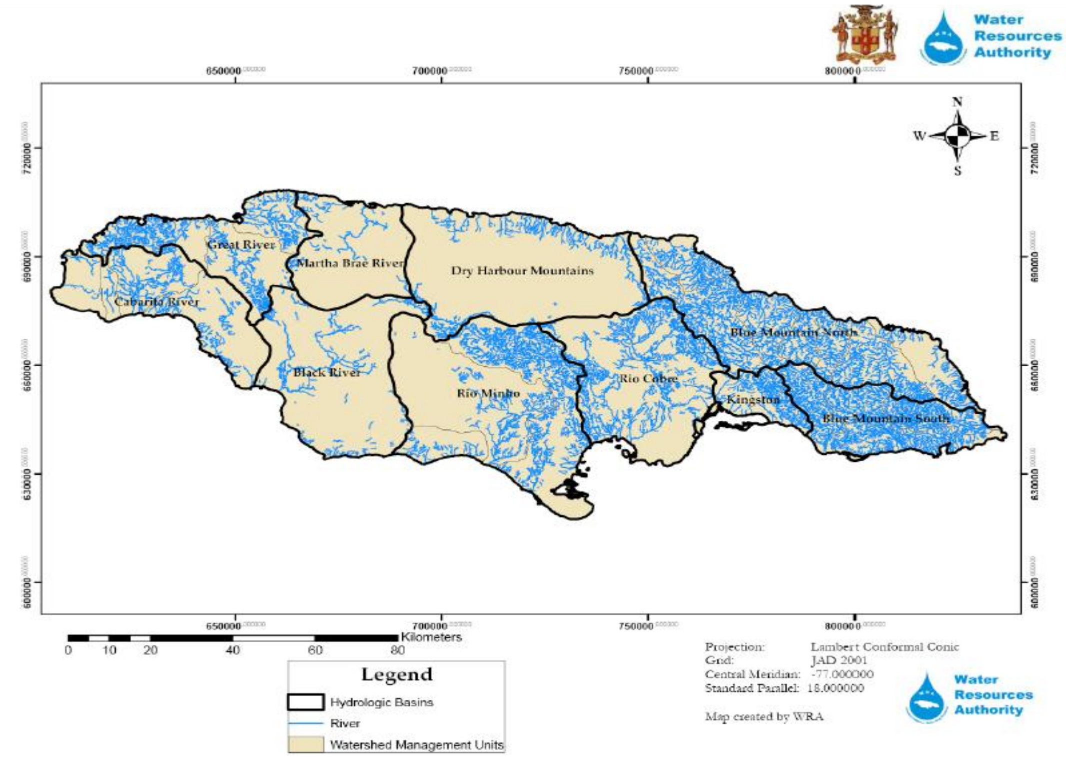


Figure 4.1.1: Rivers and the 10 Hydrological Units in Jamaica

(Source: Marshall, 2010)

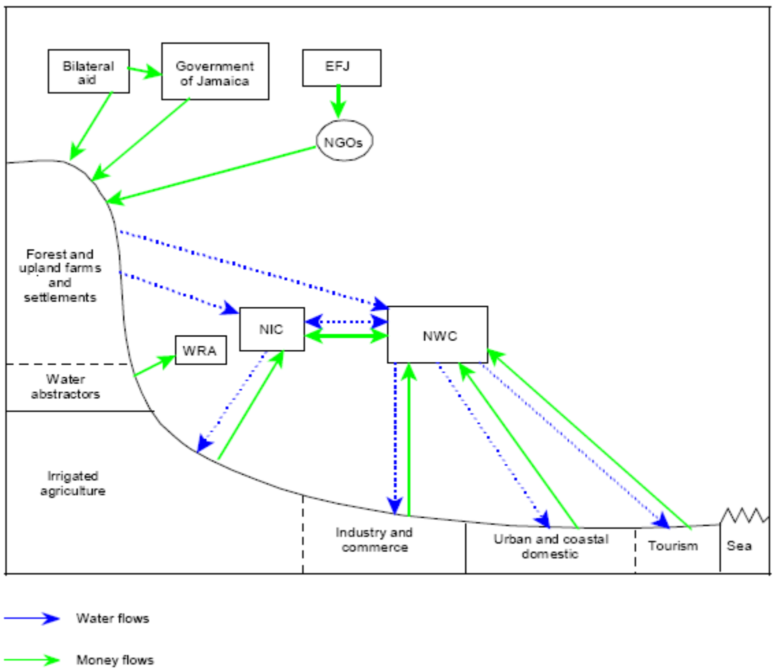


Figure 4.1.2: Simplified diagram of water sector structure in Jamaica

(Source: Geoghegan and Bass, 2002)

The cost of water is determined independently from the body responsible for producing. In addition to the cost of water, the levels of performance of the service as well as the approval of tariffs are determined by the Office of Utilities (OUR) of Jamaica. According to the National Water Commission which is responsible for determining the rate of water for different types of consumers there are three water rates for the Residential, Commercial and Condominium customer. The cost incurred includes a service charge which varies depending on the size of the meter, price adjustment mechanisms and a sewerage charge. The actual water charge, fixed according to the property type, is as follows below and in Table 4.1.1 (GOJ, 2010b – in Jamaican dollars):

- Commercial Properties - $549.19 per 1,000 gallons or $120.76 per 1,000 litres, and a sewer rate of 100% of water bills.
- Domestic Properties - $146.46 per 1,000 gallons or $32.20 per 1,000 litres and thereafter the scale is applied (see back of a bill). Sewerage Rate is 100% of the water bill.
- Condominiums - $272.43 per thousand gallons and sewer rate of 100% of water bill

Table 4.1.1: Water Rates for Jamaica by Type of Customer implemented April 1, 2009

Customer Type	Usage	New rate(s) per 1,000 Litres $ (US $)	
Residential	For up to 14,000 litres (L)	$49.63	(0.58)
	For the next 13,000 L	$87.51	(1.02)
	For the next 14,000 L	$94.50	(1.10)
	For the next 14,000 L	$120.61	(1.41)
	For the next 36,000 L	$150.20	(1.75)
	Over 91,000 L	$193.35	(2.25)
Commercial	All quantities	$186.13	(2.17)
Condominium	All quantities	$92.32	(1.08)
Primary School	All quantities	$74.47	(0.87)

(Source: GOJ, 2010c)

The average Jamaican spends 2.1% of his income on water services, but for the poorest 20% 3.2% of the income is spent on water whereas for the richest 20% only 1.8% (GOJ, 2004). The Government of Jamaica has recognised the inequity that has existed in the last decade with regards to social services. Insufficient financial investment in infrastructure that is required for the development of the water resource sector has been among the main contributors to this problem (GOJ, 2009f).

While water is metered in Jamaica, in March 2003, functioning metering was 71% of all accounts, however, the ideal target was set at 87% of all accounts (OUR, 2004). Office of Utilities Regulation (2003) stipulated that ideally, 'meters should be read at least every other month and that 97% of meters be read in each billing cycle. Illegal connections and meter bypassing are some additional considerations regarding individual water checks and balances. Observation of the cost of water showed that it has doubled between 2004 and 2008 (OUR, 2003; McGregor *et al.*, 2008; GOJ, 2010c). However, still the cost of water has been found to be highly undercharged when the costs of production are weighted up against the revenues generated (Collinder, 2010). While efforts to increase efficiency of water resources have been undertaken, the resource is still undervalued in Jamaica.

4.1.2. Vulnerability of water availability and quality to climate change

In the Initial National Communication on Climate Change to the UNFCCC (http://unfccc.int/resource/docs/natc/jamnc1.pdf), the water resource sector was identified as being vulnerable to climate change. Whether or not rainfall patterns are expected to increase or decrease or become altered seasonally, of immediate concern is the appropriate distribution of the country's water resources (GOJ, 2000), with rainfall distributed predominantly in the north of the island, with the primary centres of population in the south. As a result, water resources in the south of the island are over utilised, leading to a vulnerability to drought and seawater intrusion in some aquifers.

Drought in Jamaica

Over the last forty years, temperatures in Jamaica have shown an overall increase, particularly during the months of June, July and August, where increases are highest at 0.31°C. In addition, rainfall for the period 1973 – 2008 was found to have decreased significantly over all recent years. Extreme rainfall events (1- and 5- day annual maxima) during this period have also decreased and there is an overall trend for such decreases in future according to GCM modelling data (See Section 3). In the case of the observations of past data, all reflect the experiences that Jamaica has had with droughts, particularly in recent years.

The Meteorological Service of Jamaica defines meteorological drought conditions as 'when rainfall amounts are 60% or less of normal over a period of eight consecutive weeks. Extreme drought, if the amounts are 21 – 40% of normal, and severe drought if rainfall is 20% or less of the "normal".' Extreme drought was experienced December 1996 to January 1997 and March to May 1997 and normal drought in May and June 1997 and April 1998 (GOJ, 2002). Jamaica has been identified as a country that suffers from periods of drought by the United Nations Convention to Combat Desertification (UNCCD), where human activities have been found to be the main causative agent in increasing the country's vulnerability to drought, although it is a water rich country. Drought can be classified as agricultural, hydrological, socio-economic or meteorological (spanning an extended period of time), all types affect Jamaica periodically from February to March and July to August (GOJ, not given) and have been a problem for the agriculture and water sectors. Further, Campbell *et al.* (2010) observed that droughts have impacted Jamaican farmers consistently in recent years and Barnett (2010) has highlighted climate change as a cause for concern in the future of managing drought in Jamaica due to expected changes in rainfall frequencies and intensities.

USACE (2001) estimated that Jamaica experiences episodes of drought once in every 15 years, affecting mainly the southern part of the island. Gamble *et al.* (2010) found that between 1980 and 2007 there were 31 drought events, and 13 dry month periods indicating that this phenomenon is not an unusual event. Periods of water deficits are also related to the geography of the island, where the rainfall in the southern coastal plains can be as low as one-fifth of that in the north eastern mountainous regions (GOJ, 2000). El Niño conditions also affect Jamaica and result in drought conditions (GOJ, 2002). Clarendon, Manchester, St. Andrews and St. Catherine parishes, all located on the southern coast of Jamaica, with the coastal borders between Manchester and St. Elizabeth Parishes considered to be most extremely affected (GOJ, 2002).

Periods of drought have been quite common in the last decade, occurring in early part of 2000 (EM DAT, 2011). Particularly in the agricultural sector there have also been droughts affecting Jamaica in the first half of 2004, in the first four months of 2005 and first 3 months of 2008 (McGregor *et al.*, 2008; Campbell *et al.*, 2010). Intense bush fires have also been experienced in southern St. Elizabeth which has been locally termed the 'break basket' parish of Jamaica (Gamble *et al.*, 2010). Fire and its effects on water catchment increases Jamaica's vulnerability. For instance, in 2009 over 14 000 genuine fire calls were reported across the island (GOJ, 2009a) indicating that this is also a serious threat.

In Jamaica, drought management has been more reactive than proactive where crisis management supersedes water management. Most recently drought conditions were experienced throughout 2009 and the beginning of 2010 in south eastern portion of the island such as St. Catherine, St. Thomas and Clarendon, but especially St. Andrews and Kingston. The latter two were experiencing extreme conditions that were the worse in 25 years. These drought conditions were attributed to El Niño events.

The National Water Commission (NWC) is the main supplier of water. However, in drought conditions prioritising demands from customers becomes a challenge for instance essential services such as hospitals are prioritised over commercial premium payers who themselves have to seek water resources by alternative means than the National Water Commission. This situation leads to substantial financial loss to the commission. Further to this, operational costs which are standard, even during dry periods and combined with the transportation costs of distributing water by trucks, incurs greater revenue losses for the NWC. For St. Andrews and Kingston, because of the high population densities and limited water resources, water was imported from St. Thomas and Negroes Rivers and a relatively smaller amount from St. Catherine (Barnett, 2010). Finally drought and its implications for the tourism sector are explored in detail in the Health Sector.

Seawater Intrusion of Ground Water Resources

Currently there are approximately 23,000 drilled and dug wells including boreholes, coreholes and pumping wells in Jamaica which account for approximately 86% of Jamaica's water available water (A. Haiduk, personal communication, January, 26th, 2010). From Figure 4.1.3, it can be seen that there is considerable aquifer activity throughout the island with some trend on the coastal limits. There is also a concentration of wells in the southern hydrological units, which overlap with Rio Minho and Rio Cobre that have historically been affected by this problem (Marshall, 2010) and perhaps worsened by the close proximity of well placement (Karanjac, 2005).

Groundwater use and the vulnerability of Jamaica's coastal aquifers to salt water intrusion is important because about 65% of Jamaica's total population lives within 5 km of the coast (AQUASTAT, 1997) and population density and therefore water demand is higher along the coast, most notably on the south eastern part of the island. In the Initial National Communication on Climate Change to the UNFCCC, the Meteorological Services Jamaica articulated the possibility of groundwater sources being compromised if rainfall patterns were to decrease (GOJ, 2000). Most GCM models have predicted decreases in precipitation in Jamaica in the future, with changes expected to be between -44% to +18% by the 2050's and -55% to +18% by the 2080's. RCM's also predict decreases but the extent differs depending on the specific GCM's output (See Climate Modelling). Additionally, episodes of extreme rainfall are likely to contribute to recharge of groundwater resources. However, it was found that observed rainfall extremes (1- and 5- day annual maxima) showed decreases for the period 1973 to 2008 in Jamaica. The proportion of rainfall measured during 'heavy' rainfall events has also been observed to have decreased. While GCM modelling results have shown both increases and decreases in rainfall extremes, there is a trend towards an overall decrease in rainfall (See Climate Modelling section under Precipitation).

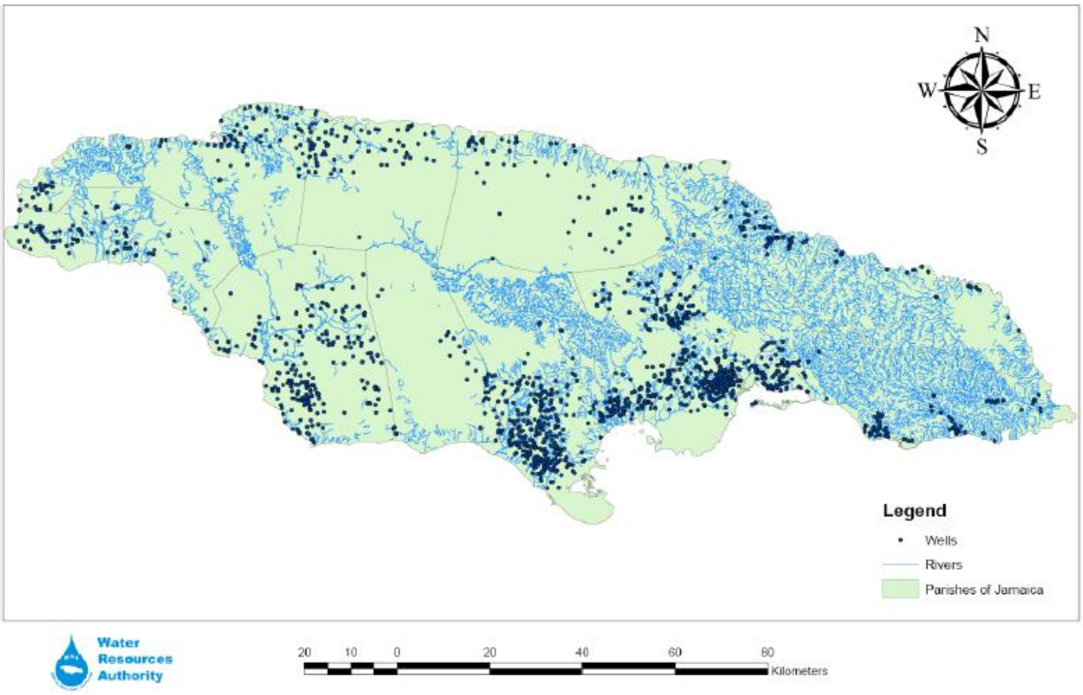


Figure 4.1.3: Wells and River Distribution in Jamaica

(Source: WRA, from Marshall, 2010)

An increase in the incidence of salt-water intrusion as a result of climate change induced SLR was also identified as a major issue for Jamaica in the Johannesburg Summit 2002 (UN, 2002). Aside from a history of saline intrusion in Jamaica due to over-abstraction, sea level is likely to compound the problem (G. Marshall, February 2nd, 2011). In the Caribbean, sea levels have been observed to have risen between 1.5 and 3 mm per year as observed from tidal gauge data (See Section 3, Climate Modelling). As Karanjac (2004) has stated ''WRA has calculated that the degradation of water quality has resulted in the loss of some 10 million cubic meters annually, that is, about 10% of all exploitable ground water, primarily as a result of over-abstraction that produced seawater intrusion.''

Factors that make aquifers vulnerable to saline intrusion are increasing population, agriculture and industry, the proximity of these aquifers to the sea and karstic nature of the limestone aquifer (Karanjac *et al.*, 2000). The hydrological units of Rio Minho (Clarendon Parish) and Rio Cobre (St. Catherine Parish) both have been historical affected by seawater intrusion dating back to periods before 1961. The saline intrusion was so serious it extended up to 10 km inland (Karanjac, 2005). It was observed that parishes which have a high concentration of coastal aquifers also have some of the highest population densities; this results in a high water demand and leads to the problem of over-abstraction. For instance, St. Andrew parish in the Kingston basin, has the highest population density of any parish (Figure 4.1.4); Manchester and Clarendon parishes in the Rio Minho basin have a very high density of wells and the fourth highest population density. In these parishes, Jamaica is therefore vulnerable to continued saline intrusion, which SLR is likely to exacerbate.

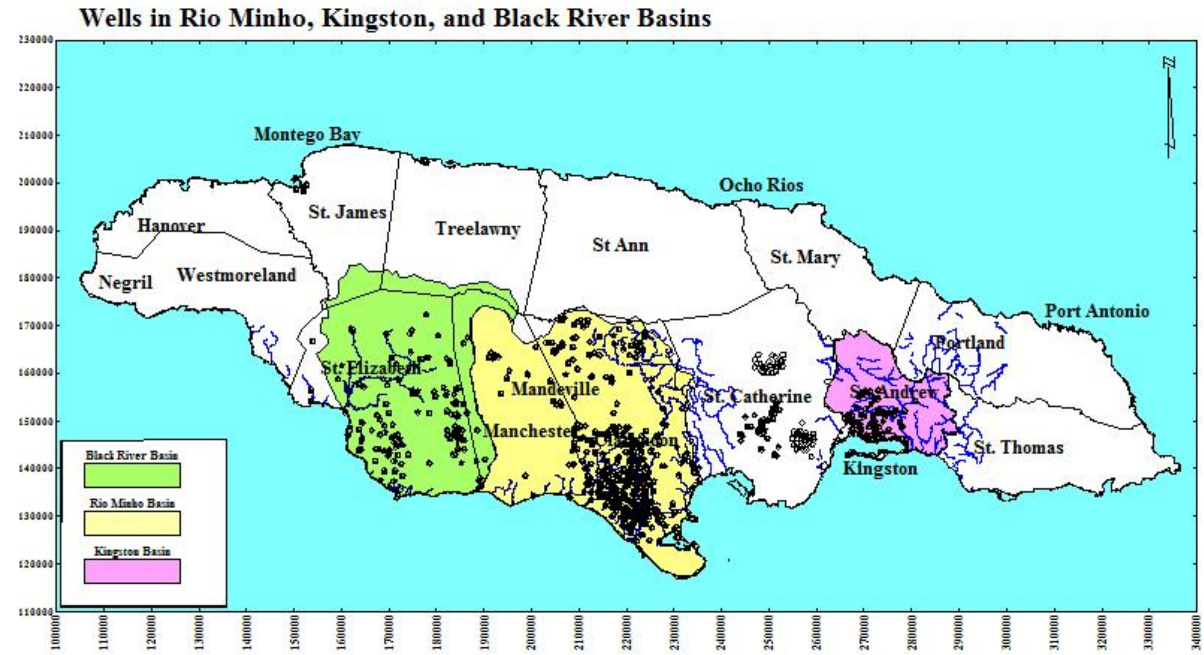


Figure 4.1.4: Wells in Rio Minho, Kingston and Black River Basins

(Source: Karanjac, 2002)

Irrigation Efficiency in the Agriculture Sector

Although agricultural accounts for 75% of total water demand, it may be as high as 85% of the total water usage for Jamaica (ESL, 2008). Since rainfall distribution on the island is uneven, irrigation is important to the Agricultural Sector. Water demands for irrigation are greater in the south of the island due to lower average rainfall (USACE, 2001). In the past, irrigation has been affected by water quality issues. Saline intrusion can result in the need to transport water from water-rich to water-poor parishes (USACE, 2001, ESL, 2008). This compounds the issue of water distribution and its impact on other sectors. Additionally, agricultural productivity will be an important consideration with respect to tourism as foods are grown locally to supply the tourism industry (See Section 4.3 Agriculture and Food Security).

According to the Development of a National Water Sector Adaptation Strategy to Address Climate Change in Jamaica, 2008, water apportioned to irrigation of crops accounts for approximately one third of annual water produced and that water losses from improper irrigation practices in this sector are as high 40% (ESL, 2009). This suggests inefficient water management (USACE, 2001) compared to the contribution of agriculture to the GDP of Jamaica. It is expected that any improvement in irrigation efficiencies and water conservation may subsequently be utilised to expand irrigation schemes in areas to enhance the output of crops (ESL, 2008). ESL (2009) notes that the provision and availability of water is not so much of an issue affecting crop production totals in the agricultural sector as that related to extreme temperature changes anticipated to result from climate change. This is evident from the frequency at which droughts occur on the island and the projected increases.

Flooding

Jamaica experiences tropical storms and hurricanes between July to November, which typically consists of flood-producing rainfall of high intensity and magnitude (AQUASTAT, 1997). Serious flash flooding occurs on average once in every four years (Douglas, 2003). Floods are a particular problem for the water sector because aside from the loss of life and property, they can affect water quality and have implications for sanitation and cause serious soil erosion due to the island's topography of high and mountainous interior lands (GOJ, 2002). Flooding erodes topsoil along with animal waste, faeces, pesticides, fertilisers, sewage and garbage, which may contaminate groundwater sources as well as marine areas (Jackson, 2005). The health implications related to water quality and sanitation as well those associated with tourism are addressed in the Human Health Sector of this report. The island has had significant problems with flooding in the past, to the extent that the Flood Control Act was passed in 1958 which has now been replaced by through the implementation of a Flood Control Policy (Haiduk, 2004). While GCM modelling projections indicate an overall tendency for decreases in overall precipitation in Jamaica, particularly for the period of March - August (early wet season) (See Section 3, Climate Modelling), excluded from these projections is the potential of an increase in the frequency and intensity of storm events with associated heavy rainfall (Frei *et al.*, 1998).

There are a number of causes of flooding depending on the geography and topography of a given part of the island of Jamaica, including groundwater induced flooding, depression related flooding, riverine flooding, storm surge induced flooding and urban runoff (Haiduk, 2004). USACE (2001) lists flash flooding, riverine flooding and tidal flooding as the most likely causes of flooding in Jamaica. Half of the all parishes of Jamaica contain flood prone areas, namely Clarendon, Hanover, Manchester, Manchester, St. Elizabeth, St. James, Trelawny and Westmoreland (ODPEM, 2011). The vulnerability of certain areas resulted in the implementation of flood warning systems between 1991 and 1999 at Rio Cobre (St. Catherine Parish), Cave River (St. Ann Parish) and Rio Grande (Douglas, 2003).

Case Study: Water Management Development in Cedar Valley, St. Thomas Parish

The Environmental Health Foundation (EHF) is undertaking one of the most current climate change adaptation projects in Jamaica with an expected three year duration period. Among its focus areas is the issue of water management, assessed in consultation with the National Water Commission of Jamaica. The target areas are a farming community in Cedar Valley and adjoining communities in St. Thomas, one of the most water resource availability vulnerable parishes (Lowe, 2010). The justification of the project is based on the fact that agriculture accounts for 20% of the labour force and increasing the potential of this industry will contribute to the agricultural output of the country while providing jobs and income for a number of persons in a number of vulnerable communities. While agriculture is a strong focus, first among the expected outcomes is the potential for a sound example of water regulation which will inform climate change adaptation strategies that can be developed further the involvement of the Water Resource Authority. Such research can aid in forming a template for future climate change adaptation strategies in Jamaica and perhaps elsewhere in the region. It is also expected that guidelines for water collection, storage and use will be developed and better irrigation practices will be utilised.

4.2. *Energy Supply and Distribution*

4.2.1. Background

A global perspective

Tourism is a significant user of energy and a concomitant contributor to emissions of greenhouse gases. In various national comparisons, tourism has been identified as one of the most energy-intense sectors, which moreover is largely dependent on fossil fuels (e.g. Gössling *et al.,* 2005; Patterson, 2003). Likewise, the growing energy intensity of economies in the Caribbean has caused concern among researchers (e.g. Francis *et al.,* 2010).

Globally, tourism causes 4.95% of emissions of CO_2, the most relevant greenhouse gas. Considering the radiative forcing[3] of all greenhouse gases, tourism's contribution to global warming increases to 5.2-12.5% (Scott *et al.,* 2010). The higher share is a result of emissions of nitrous oxides (NOx) as well as water leading to the formation of aviation-induced clouds (AIC), which cause additional radiative forcing. The range in the estimate is primarily attributed to uncertainties regarding the role of AIC in trapping heat (Lee *et al.,* 2009). Aviation is consequently the most important tourism-subsector in terms of its impact on climate change, accounting for at least 40% (CO_2) of the contribution made by tourism to climate change. The sector is followed by cars (32% of CO_2), accommodation (21%), activities (4%), and other transport (3%), notably cruise ships (1.5%).

In the future to 2050, emissions from tourism are expected to grow considerably. Based on a business-as-usual scenario for 2035, which considers changes in travel frequency, length of stay, travel distance, and technological efficiency gains, UNWTO-UNEP-WMO (2008) estimate that emissions will increase by about 135% compared to 2005. Similar figures have been presented by the World Economic Forum (WEF, 2009). Aviation will remain the most important emissions sub-sector of the tourism system, with expected emission growth by a factor of 2 or 3. As global climate policy will seek to achieve considerable emission reductions in the order of 50% of 1990 emission levels by 2050, aviation, and tourism more generally, will be in stark conflict with achieving global climate goals, possibly accounting for a large share of the sustainable emissions budget (Figure 4.2.1).

[3] Radiative forcing is defined by the IPCC (2007) as the net (down minus up) irradiance (solar plus longwave energy) at the tropopause after allowing for stratospheric temperatures to readjust to radiative equilibrium, but surface and tropospheric temperatures remain fixed.

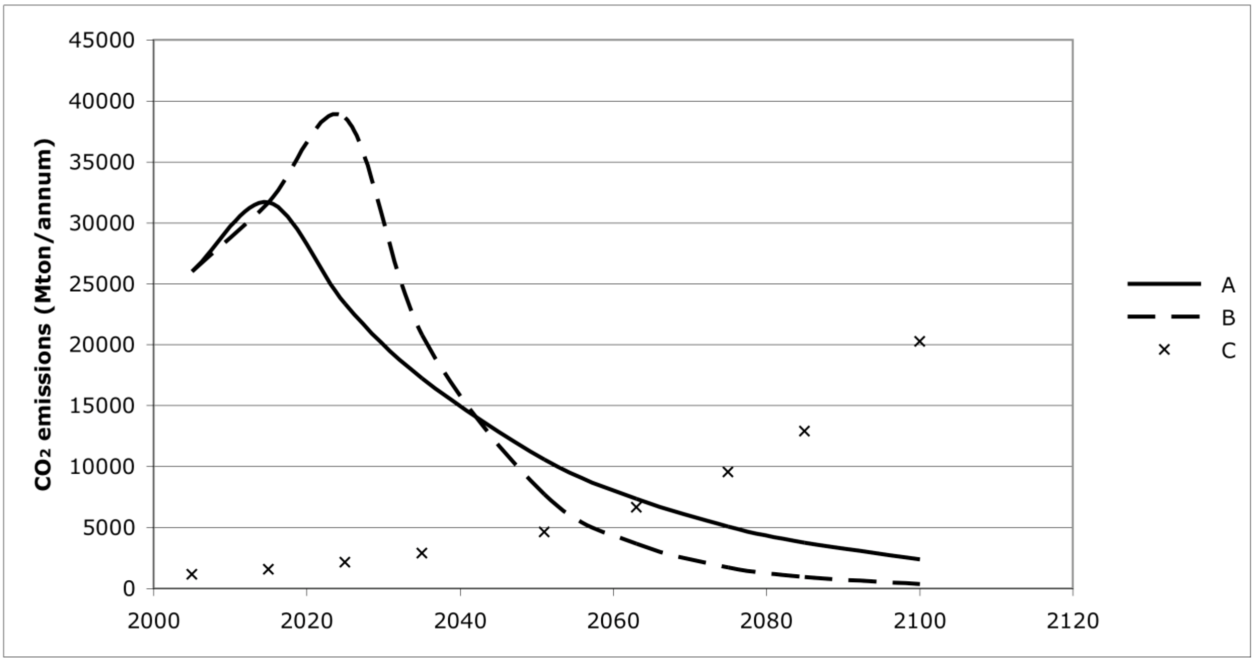


Figure 4.2.1: Global CO_2 emission pathways versus unrestricted tourism emissions growth

(Source: Scott *et al.*, 2010)

Lines A and B in figure 4.2.1 represent emission pathways for the global economy under a -3% per year (A) and -6% per year (B) emission reduction scenario, with emissions peaking in 2015 (A) and 2025 (B) respectively. Both scenarios are based on the objective of avoiding a +2°C warming threshold by 2100 (for details see Scott *et al.,* 2010). As indicated, a business-as-usual scenario in tourism, considering current trends in energy efficiency gains, would lead to rapid growth in emissions from the sector (line C). By 2060, the tourism sector would account for emissions exceeding the emissions budget for the entire global economy (intersection of line C with line A or B).

Achieving emission reductions in tourism in line with global climate policy will consequently demand considerable changes in the tourism system, with a reduction in overall energy use, and a switch to renewable energy sources. Such efforts will have to be supported through technology change, carbon management, climate policy, behavioural change, education and research (Gössling, 2010). Carbon taxes and emission trading are generally seen as key mechanisms to achieve emission reductions. Destinations and tourism stakeholders consequently need to engage in planning for a low-carbon future.

4.2.2. The Caribbean Perspective

It is widely acknowledged that the Caribbean accounts for only 0.2% of global emissions of CO_2, with a population of 40 million or 0.6% of the world's population (Dulal *et al.,* 2009). Within the region, emissions are, however, highly unequally distributed between countries (Figure 4.2.2). For instance, Trinidad & Tobago, as an oil-producing country, has annual per capita emissions reaching those of high emitters such as the USA (25 t CO_2). The Cayman Islands (7 t CO_2 per capita per year) are emitting in the same order as countries such as Sweden. Jamaica is emitting slightly less on a per capita basis than the world average of 4.3 t CO_2. In the future, global emissions have to decline considerably below 4.3 t CO_2 per year – the Intergovernmental Panel on Climate Change (IPCC) suggests a decline in emissions by 20% by 2020 (IPCC 2007), corresponding to about 3 t CO_2 per capita per year, a figure that also considers global population growth. While there is consequently room for many countries in the region to increase per capita emissions, including in particular Haiti, many of the more developed countries in the Caribbean will need to adjust per capita emission budgets downwards (i.e. reduce national emissions in the medium-term future).

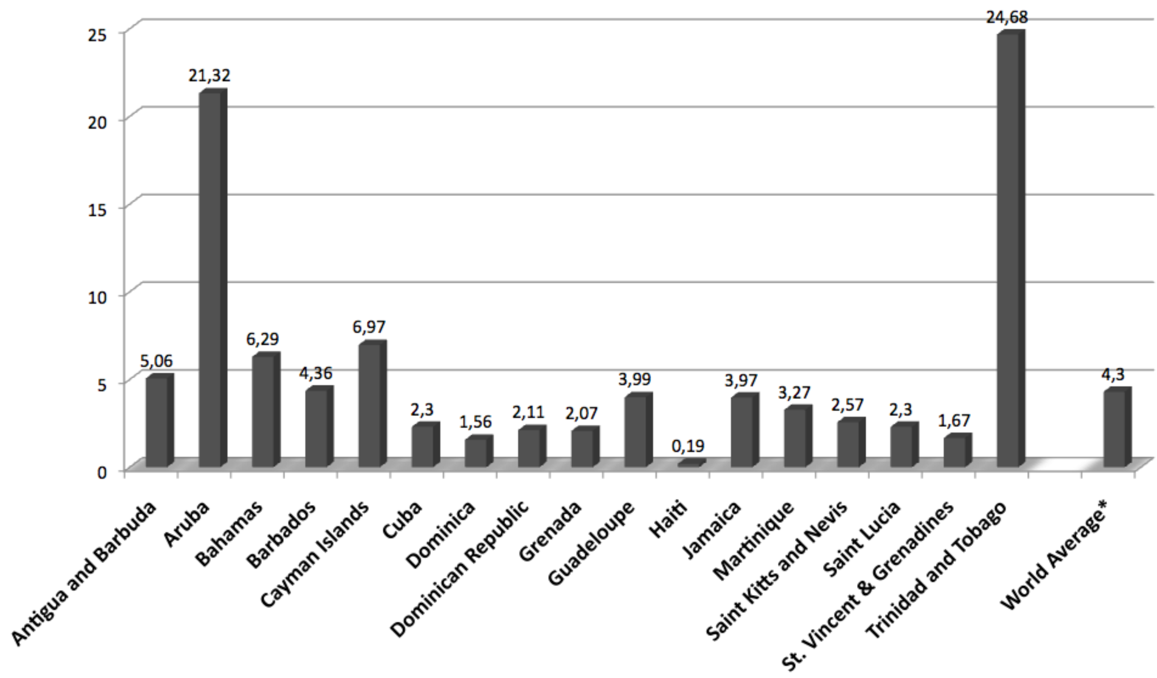


Figure 4.2.2: Per capita emissions of CO_2 in selected countries in the Caribbean, 2005

(Source: Hall *et al.,* 2009 based on UNSD 2009)

There is evidence that in many Caribbean countries, tourism is a major contributor to emissions of greenhouse gases (Simpson *et al.,* 2008). The purpose of this assessment is thus to look in greater detail into energy use by sector.

4.2.3. Jamaica's energy outlook

No statistics on energy use in Jamaica could be obtained directly from the national Ministry of Energy and Mining to identify energy flows on a more detailed basis, but the country published its 'National Energy Policy 2009-2030' in October 2009 (MEM, 2009). As the policy document outlines, the Jamaican economy is characterised by high energy intensity and low efficiency, while being almost entirely dependent on imported oil, which accounts for 95% of energy consumption, the remainder falling on hydropower (4%) and wind (1%). Imported oil is consumed in particular in three sectors, i.e. bauxite/aluminium production, power generation and transport (Figure 4.2.3: Petroleum consumption by activity, 2008Figure 4.2.5; note that in the text, the National Energy Policy 2009-2030 suggests that energy consumption is 34.5% for bauxite/alumina, 23.1% for power/electricity production, and 21.5% for transport).

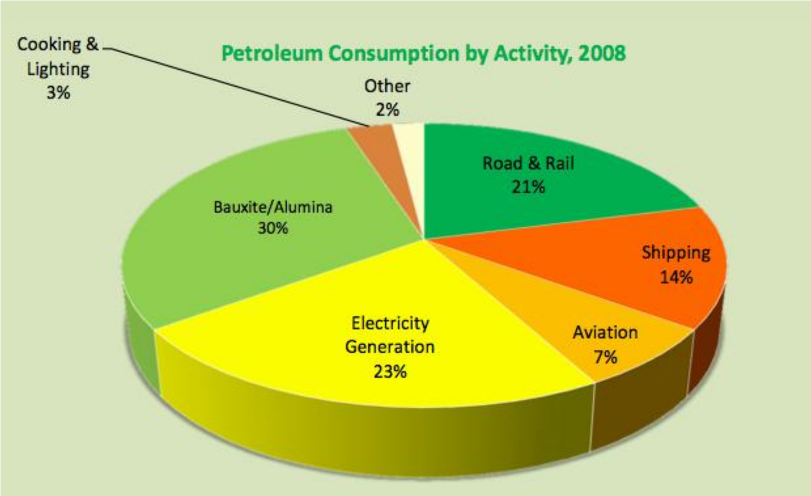


Figure 4.2.3: Petroleum consumption by activity, 2008

(Source: MEM, 2009)

Two of the high-energy sectors, transports and electricity generation, are relevant in the context of tourism. More specifically, in 2008, road and rail transport accounted for 5.8 million barrels of petroleum consumption, followed by shipping (2.8 million barrels), and aviation (1.6 million barrels). Electricity consumption accounted for 6.3 million barrels of oil imports. Combined, the sectors thus consumed about 16.5 million barrels of oil. Further details on energy consumption are provided in Table 4.2.1 (MEM, 2009).

Table 4.2.1: Key energy statistics 2004-2008, barrels

Petroleum Consumption by Activity					
Road and Rail Transportation	6,075,623	6,247,835	6,373,380	6,079,884	5,835,304
Shipping	368,356	1,636,028	3,239,911	3,972,826	2,805,615
Cement Manufacture	104,791	37,066	14,228	28,477	26,004
Aviation	1,792,975	1,577,438	1,983,596	1,931,222	1,598,706
Electricity Generation	6,225,912	6,555,261	6,390,163	6,654,238	6,274,571
Bauxite/Alumina Processing	9,444,053	9,799,121	9,551,792	8,807,899	9,392,039
Sugar Manufacturing	75,993	40,283	50,055	61,491	43,764
Cooking and Lighting	902,939	924,730	963,531	912,116	931,853
Petroleum Refinery	223,266	164,247	331,788	362,947	355,076

(Source*:* MEM, 2009)

It is more difficult to identify the share of tourism in national energy use, as it is unknown which share of electricity is used by e.g. accommodation establishments and other parts of the tourism-related service sector, for which no specific studies have been carried out. Likewise, it is difficult to know which share of energy is used in tourism-related car travel or by cruise ships (bunker fuels). Aviation is the only sector that to a large extent can be considered “tourism”, as most of the sector’s energy consumption will be related to long-distance passenger transport. Vice versa, the share of non-tourism international and domestic freight transports, as well as non-tourism international and domestic passenger flights (same-day return trips) can be assumed to be minor.

Table 4.2.2: Assessment of CO_2-emissions from tourism in Jamaica, 2008

Tourism sub-sector	Energy use	Emissions	%	Assumptions
Aviation[1)]	1,598,706 bls	0.629 Mt CO_2	43	15% non-tourism related freight & same-day trips deducted from total
Road transport[2)]	0.018 Mt fuel	0.057 Mt CO_2	4	Including tourists and cruise ship passengers on day visits
Cruise ships[3)]	0.057 Mt fuel	0.184 Mt CO_2	13	Includes a one-day per tourist estimate
Accommodation[4)]	361 MWh	0.362 Mt CO_2	25	Based on energy statistics from Barbados
Activities[5)]	-	0.048 Mt CO_2	3	Global average
Sub-total		1.280 Mt CO_2	-	
Indirect energy use (factor 1.15)		0.192 Mt CO_2	13	To account for life-cycle emissions
Total		1.472 Mt CO_2	100	

1) Aviation fuels: 1,598,706 barrels equal 254,194,254 litres, which equal 200,813,461 kg of fuel. At 3.13 kg CO_2 per kg of fuel (DEFRA 2010), this results in 0.629 Mt CO_2.
2) Road Transport: 2,859,000 international tourist arrivals in 2008 (out of which 1,767,000 by air, and 1,092,000 by sea), with each tourist travelling an assumed 150 pkm on the island during the stay. At an assumed average of 0.133 kg CO_2 per pkm (50% occupancy rate; UNWTO-UNEP-WMO 2008), emissions are in the order of 20 kg CO_2 (corresponding to about 8 l of diesel) per tourist, totalling 57,180,000 kg CO_2, or 0.057 Mt CO_2.
3) It is unknown whether cruise ships bunker any fuels in Jamaica. To include a rough estimate for the 1,092,000 day visits, daily average global per capita cruise ship emissions of 169 kg CO_2 (Eijgelaar *et al.,* 2010) are included for one day. This corresponds to 1,092,000 x 169 kg CO_2 or 184,548,000 kg CO_2 = 0.185 Mt CO_2, corresponding to about 57,360 t fuel oil (at a conversion factor of 3.206 kg CO_2 per kg of fuel oil, DEFRA 2010). Note that in case of bunkering in Jamaica, this value might be considerably higher.
4) According to a study carried out in Barbados in 2010, hotels (n=22) used on average 22 kWh of energy per guest night. This value is used for Jamaica. 1,767,000 tourists at an average length of stay of 9.3 nights would result in 16,433,100 nights, and a corresponding energy use of 361,528,200 kWh. As outlined by MEM (2009), electricity production is highly inefficient in Jamaica, and a value of 1 kg CO_2 per kWh is assumed here, resulting in emissions of 0.362 Mt CO_2.
5) Activities are included with the global assumption of 27 kg CO_2 per tourist, as provided in UNWTO-UNEP-WMO 2008. Given the energy-intense character of many activities in tropical environments, including boat trips, this value may be conservative. The 1.767 million tourists would thus have caused emissions from activities corresponding to 47,709,000 kg CO_2 or about 0.048 Mt CO_2. As energy use for activities will be partially fossil fuel, and partly electricity based, it is difficult to translate these values into energy use.

(Source: Chenact, 2010; DEFRA, 2010; Eijgelaar *et al.,* 2010; MEM, 2009; UNWTO-UNEP-WMO, 2008; UNWTO, 2010)

Table 4.2.2 outlines the distribution of energy use by tourism sub-sector. This is a conservative estimate based on available data in the general literature, as there is no specific data available for Jamaica. According to this estimate, emissions from tourism accounted for 1.472 Mt CO_2 in 2008, which would correspond to about 29% of national emissions of 5 Mt CO_2, as presented in MEM (2009). However, the national estimate presented in MEM (2009) seems low, even if one considers that emission reductions through forest sinks had been included, which is unclear. In Jamaica's communication to the United Nations Framework Convention on Climate Change (UNFCCC), the island's emissions from fuel combustion were specified as being 8.585 Mt CO_2 in 1994 (Ministry of Water & Housing and National Meteorological Service 2000). According to MEM (2009), the island's total energy demand is 27.8 million barrel of oil equivalent (boe), i.e. including energy not derived from fossil fuels. Petroleum use corresponds to 3.424 Mt of oil products, which, conservatively (at an emission factor of 3.2), resulted in 10.959 Mt CO_2. This appears to more properly reflect growth in emissions since 1994 (cf. Ministry of Water & Housing and National Meteorological Service 2000), but is more than twice the amount of emissions as given in MEM (2009). If this latter estimate is correct, tourism's share in national CO_2-emissions would have been in the order of 13% in 2008, which compares favourably with other national studies (cf. Gössling, 2010).

Trends in energy use in Jamaica

In the future to 2030, growth in energy consumption in Jamaica can be expected. To this end, three growth scenarios were developed by the Ministry of Energy and Mining (MEM 2009; see also Francis *et al.,* 2007 for an alternative assessment), even though they are represented only in terms of costs and shares, not absolute values:

7. Business as usual,
8. Implementing efficiency improvement and conservation programs
9. Efficiency improvement plus fuel diversification

As outlined, 2008 energy demand was in the order of 27.8 million boe, a value that declined to 22 million boe in 2009 and 2010, possibly as a result of the global financial crisis. Nevertheless, energy demand is projected to increase to at least 70.7 million boe under the Efficiency improvement plus fuel diversification scenario, and 126 million boe under the business as usual scenario (MEM, 2009; see also Francis *et al.,* 2007).

Under the business-as-usual scenario, which assumes oil prices of US $100 / barrel (in 2008 dollars), the cost of imported energy is projected to increase from US $2.7 billion in 2008 to US $4.6 billion by 2020. Jamaica thus considers energy-efficiency measures primarily as a cost-saving issue. To this end, an efficiency-improvement and conservation programme has been projected to reduce energy demand by 2 million barrels of oil equivalent in 2015, and 6 million barrels in 2020. This would annually save US $129 million in 2015 and US $555 million by 2020, even though it only represents a less than 6% reduction from business-as-usual growth in energy use (base year 2010). Furthermore, the introduction of a national energy diversification programme (see Figure 4.2.4) is projected to lead to annual savings of US $711 million in 2015 and US $1.7 billion by 2020, compared to the business-as-usual scenario. All investments in these programs are considered cost-efficient.

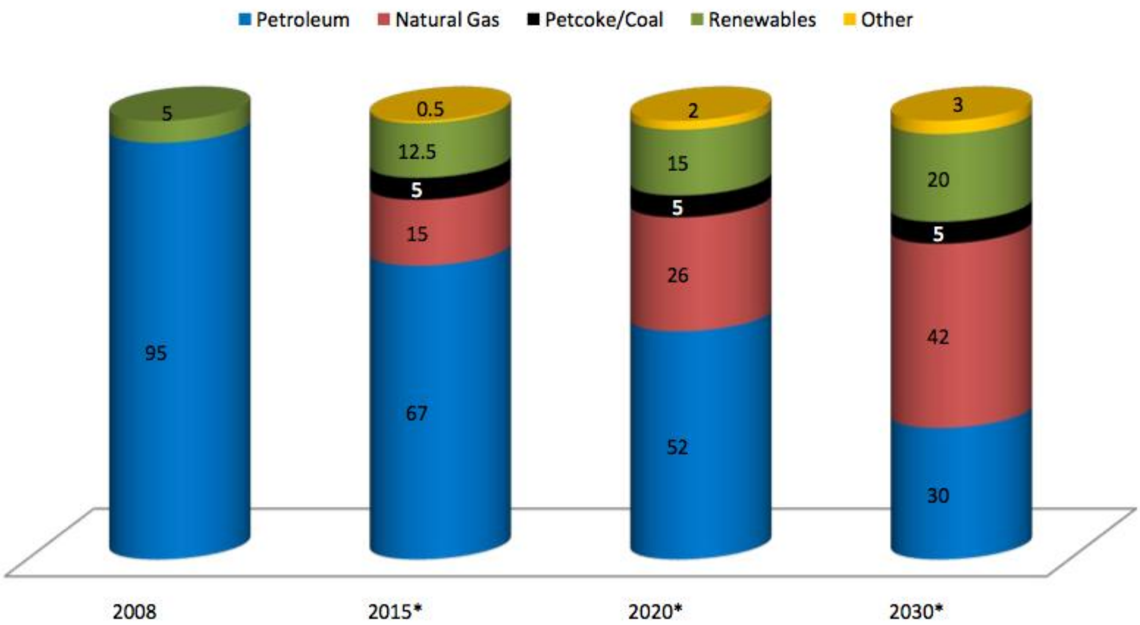


Figure 4.2.4: Jamaica's energy consumption by energy source in 2008 and to 2030

(Source: MEM, 2009)

By 2030, the share of petroleum in the supply mix is expected to have declined from 95% to 30%, with natural gas accounting for as much as 42% of the mix and renewable energies 20%. Figure 4.2.4 does not show that overall energy use will increase to unspecified levels, while overall emissions are expected to decline from about 5 Mt CO_2 in 2008 to 3.5 Mt CO_2 in 2030. Note that it is unclear how these values were calculated, as emissions from fossil fuels from transports and electricity generation alone (16.5 million barrels) should have resulted in emissions >6.5 Mt CO_2 in 2008 (see also previous section). Even in the lowest energy demand growth scenario (70.7 million boe) with the most optimistic assumptions regarding the share of renewable energies introduced (20%) and including a share of 42% natural gas, the use of petroleum alone (30%) would still represent 21 million boe, i.e. as much as consumed in 2009. Given that even natural gas is a fossil fuel, as well as a share of petcoke/coal assumed to account for 5% of energy use by 2030 (see Figure 4.2.4), it is difficult to see how Jamaica could decline in its emissions to 3.5 Mt CO_2.

The same is likely to be true for the tourism system. In the period from 1990 to 2009, international arrivals by air almost doubled from 990,000 to 1.8 million (Jamaica Tourism Board, 2010). Assuming similar continued growth in arrivals over the coming two decades, tourist numbers would double again to 2030, representing some 3.5 million tourists arriving by air and about 2 million arrivals by sea. Even if emissions from tourism could be reduced by as much as 2% per year, a scenario demanding considerable political ambitions to implement regulation and to create incentives for low-carbon technology, overall emissions from the sector are likely to increase by at least 50% over those in 2008. Potentially, growth in emissions will even be higher, because the average length of stay of international tourists in Jamaica has been declining, from more than 11 days in 1996 to 9.2 days in 2009. Over the next decade, in a trend scenario, the island may thus lose as much as another day in average length of stay. Consequently, each arrival in the future would be more energy intense than one at present, because transport to the destination is the most emission-intense part of the trip. The development of tourism consequently indicates an urgent need to establish and implement management plans to reduce emissions from tourism, if a national decline in emissions is to be achieved.

Reducing emissions: Jamaica's National ECE Policy 2010-2030

Specific measures to reduce energy consumption and emissions are outlined in Jamaica's 'National Energy Conservation and Efficiency (ECE) Policy 2010-2030', which was presented in October 2010 (MEM, 2010).

Strategies to reduce energy dependency and emissions include:

10. Security of Energy Supply through diversification of fuels as well as development of renewables
11. Modernising the country's energy infrastructure
12. Development of renewable energy sources such as solar and hydro
13. Energy conservation and efficiency
14. Development of a comprehensive governance/regulatory framework
15. Enabling government ministries, departments and agencies to be model/leader for the rest of society in terms of energy management
16. Eco-efficiency in industries

4.2.4. Vulnerability of the energy sector to climate change

Two impacts related to energy and emissions are of relevance for the tourism sector and the wider economy. First of all, energy prices have fluctuated in the past, and there is evidence that the cost of oil on world markets will continue to increase. Secondly, if the international communities' climate objective of stabilising temperatures at 2°C by 2100 is taken seriously, both regulation and market-based instruments will have to be implemented to cut emissions of greenhouse gases. Such measures would affect the cost of mobility, with in particular air transport being a highly energy- and emission-intense sector. The following sections will discuss past and future energy costs, as well as the challenges of global climate policy.

Energy costs

High and rising energy costs should self-evidently lead to interest in more efficient operations, but this does not appear to be the case in tourism more generally. Since the turn of the 19th Century, world oil prices only once exceeded those of the energy crisis in 1979 after the Iranian revolution. Even though oil prices declined because of the global financial crisis in 2008 (Figure 4.2.5) – for the first time since 1981 (IEA, 2009) - world oil prices have already begun to climb again in 2009, and are projected to rise further. The International Energy Agency (IEA, 2010) projects for instance, that oil prices will almost double between 2009 and 2035 (in 2009 prices). Notably, Figure 4.2.5 shows the decline in oil prices in 2009; at the time of writing, in January 2011, Bloomberg reported Brent spot prices exceeding US $97/barrel.

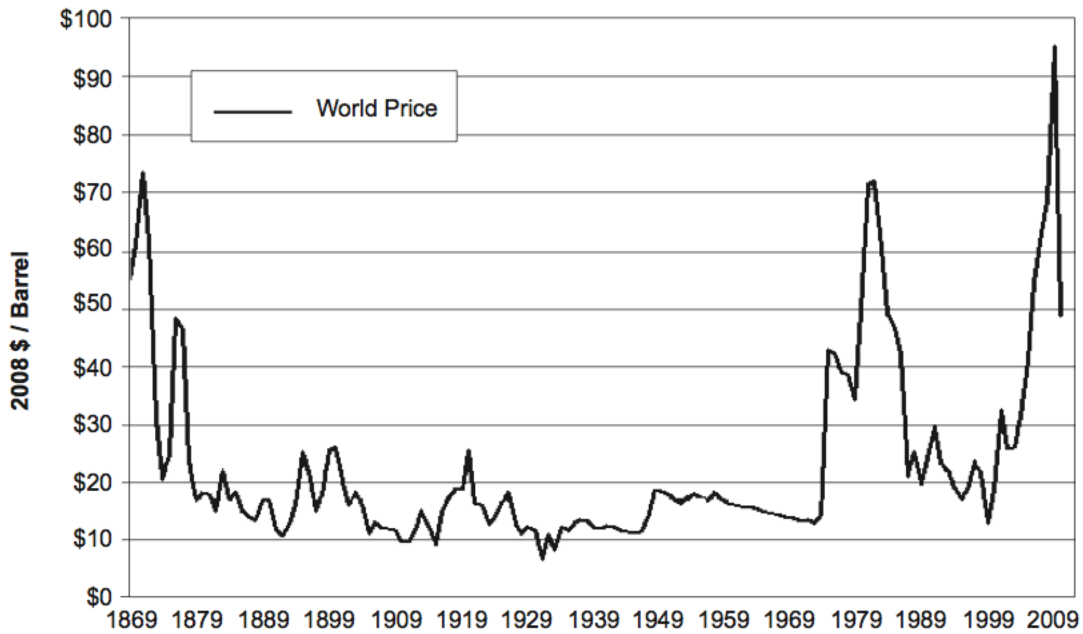


Figure 4.2.5: Crude oil prices 1869-2009

(Source: after WTRG Economics, 2010)

The International Energy Agency (IEA, 2010) anticipates that even under its New Policies Scenario, which favours energy efficiency and renewable energies, energy demand will be 36% higher in 2035 than in 2008, with fossil fuels continuing to dominate demand. At the same time there is reason to believe that 'peak oil', i.e. the maximum capacity to produce oil, may be passed in the near future. The UK Energy Research Centre (2009), for instance, concludes in a review of studies that a global peak in oil production is likely before 2030, with a significant risk of a peak before 2020. Note that while there are options to develop alternative fuels, considerable uncertainties are associated with these options, for instance with regard to costs, safety, biodiversity loss, or competition with food production (e.g. Harvey and Pilgrim, 2011). Rising costs for conventional fuels will therefore become increasingly relevant, particularly for transport, the sector most dependent on fossil fuels with the least options to substitute energy sources. Within the transport sector, aviation will be most affected due to limited options to use alternative fuels, which have to meet specific demands regarding safety and energy-density (cf. Nygren *et al.,* 2009; Upham *et al.,* 2009). Likewise, while there are huge unconventional oil resources, including natural gas, heavy oil and tar sands, oil shales and coal, there are long lead times in development, necessitating significant investments. The development of these oil sources is also likely to lead to considerably greater environmental impacts than the development of conventional oil resources (IEA, 2009).

These findings are relevant for the tourism system as a whole because mobility is a precondition for tourism. Rising oil prices will usually be passed on to the customer, a situation evident in 2008, when many airlines added a fuel surcharge to plane tickets in order to compensate for the spike in oil prices (Sorensen 2008). Increased travel costs can lead to a shift from long haul- to shorter-haul destinations. The cost of energy is one of the most important determinants in the way people travel, and the price of oil will influence travel patterns, with some evidence that in particular low-fare and long-haul flights are susceptible to changes in prices (e.g. Mayor and Tol, 2008). Moreover, it deserves mention that oil prices are not a simple function of supply and demand, rather than involving different parameters such as long-term contracts and hedging strategies, social and political stability in oil producing countries as well as the global security situation more generally. This is well illustrated in the volatility of oil prices in the five-year period 2002-2009, when the world market price of aviation fuel oscillated between a low of US $25 in 2002 (Doganis, 2006) and US $147 in mid-2008 (Gössling and Upham, 2009).

The huge rise in oil prices, which was not expected by most actors in tourism, had a severe impact particularly on aviation. As late as December 2007, International Air Transport Association (IATA) (2007) projected the average 2008-price of a barrel of oil at US $87, up 6% from the average price level in 2007. In early 2008, IATA corrected its projection of fuel prices to an average of US $106 per barrel for 2008, an increase of 22% over its previous estimate. However, in July 2008, oil prices reached US $147 per barrel, and IATA corrected its forecast for average oil prices in 2008 to almost US $142 per barrel, a price 75% higher than a year ago (IATA, 2008a). In autumn 2008, again seemingly unexpected by the overwhelming majority of actors in tourism, the global financial system collapsed due to speculation of financial institutions with various forms of investment. As a result, the global economy went into recession, and by the end of 2008, oil prices had reached a low of US $40 per barrel.

Fuel price volatility, in late 2008 exceeding 30% of operational costs (IATA 2009a, see Figure 4.2.6), had a range of negative impacts for airlines. Before the financial crisis, it appeared as if low-fare carriers would be severely affected by high fuel prices, with even profitable airlines reporting falling profits, grounded aircraft and cancelled routes: high fuel prices had clearly affected the perception of travellers to fly at quasi-zero costs (cf. Gössling and Upham, 2009). However, when fuel costs declined because of the financial crisis, low cost carriers were apparently seen by many travellers as the only airlines still offering flights at reasonable prices, reversing passenger choices to the disadvantage of the flag carriers. These examples show that high and rising oil prices, as well as price volatility can significantly affect tourism and in particular airlines, increasing destination vulnerability.

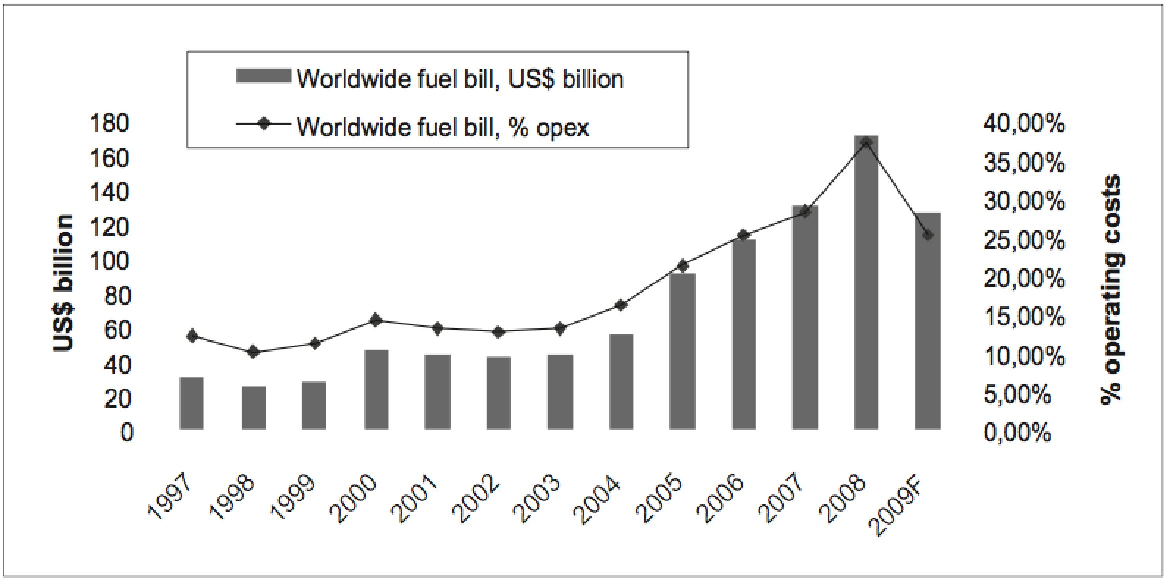


Figure 4.2.6: Fuel costs as part of worldwide operating cost

(Source: IATA, 2009a)

4.2.5. Climate policy

Climate change has, since the publication of the Intergovernmental Panel on Climate Change's 4th Assessment Report (IPCC, 2007), been high on the global political agenda. The most recent UN Conference of Parties (COP) in Mexico in December 2010 agreed that increases in temperature should be stabilised at a maximum of 2°C by 2100. Notably, the 39 member states of the Alliance of Small Island Developing States have called in a recent Declaration to the United Nations for a new climate change agreement that would ensure global warming to be kept at a maximum of 1.5°C (AOSIS, 2009).

So far, the European Union is the only region in the world with a legally binding target for emission reductions, imposed on the largest polluters. While it is likely that the European Union Emissions Trading System (EU ETS) will not seriously affect aviation, the only tourism sub-sector to be directly integrated in the scheme by 2012 (e.g. Mayor and Tol, 2009; see also Gössling *et al.,* 2008), discussions are ongoing of how to control emissions from consumption not covered by the EU ETS. This is likely to lead to the introduction of significant carbon taxes in the EU in the near future (Euractiv, 2009). Moreover, the EU ETS will set a tighter cap on emissions year-on-year, and in the medium-term future, i.e. around 2015-2025, it can be assumed that the consumption of energy-intense products and services will become perceivably more expensive. There is also evidence of greater consumer pressure to implement pro-climate policies. While climate policy is only emerging in other regions, it can be assumed that in the next years, further legislation to reduce emissions will be introduced – the new air passenger duty in the UK is a recent example.

As of 1 November 2010, the UK introduced a new air passenger duty (APD) for aviation, which replaced its earlier, two-tiered ADP. The new ADP distinguishes four geographical bands, representing one-way distances from London to the capital city of the destination country/territory, and based on two rates, one for standard class of travel, and one for other classes of travel (Table 4.2.3).

Table 4.2.3: UK air passenger duty as of November 1, 2011

Band, and appropriate distance in miles from	In the lowest class of travel (reduced rate)		In other than the lowest class of travel * (standard rate)	
	2009-10	2010-11	2009-10	2010-11
Band A (0-2000)	**£11**	**£12**	£22	£24
Band B (2001-4000)	£45	£60	£90	£120
Band C (4001-6000)	£50	£75	£100	£150
Band D (over 6000)	£55	£85	£110	£170

(Source: HM Revenue & Customs 2008)

Scientifically, there is general consensus that a 'serious' climate policy approach will be paramount in the transformation of tourism towards becoming climatically sustainable, as significant technological innovation and behavioural change will demand strong regulatory environments (e.g. Barr *et al.,* 2010; Bows *et al.,* 2009; Hickman and Banister 2007; see also Giddens, 2009). As outlined by Scott *et al.* (2010), "serious" would include the endorsement of national and international mitigation policies by tourism stakeholders, a global closed emission trading scheme for aviation and shipping, the introduction of significant and constantly rising carbon taxes on fossil fuels, incentives for low-carbon technologies and transport infrastructure, and, ultimately, the development of a vision for a fundamentally different global tourism economy.

While this would demand a rather radical change from current business models in tourism, all of these aspects of a low-carbon tourism system are principally embraced by business organisations. For instance, the World Economic Forum (2009) suggests as mechanisms to achieve emission reductions i) a carbon tax on non-renewable fuels, ii) economic incentives for low-carbon technologies, iii) a cap-and-trade system for developing and developed countries, and iv) the further development of carbon trading markets. Furthermore, evidence from countries seeking to implement low-carbon policies suggests that the tourism businesses themselves also call for the implementation of legislation to curb emissions, a result of the wish for "rules for all", with in particular pro-climate oriented businesses demanding regulation and the introduction of market-based instruments to reduce emissions (cf. Ernst & Young 2010; PricewaterhouseCoopers, 2010).

There is consequently growing consensus among business leaders and policy makers that emissions of greenhouse gases represent a market failure. The absence of a price on pollution encourages pollution, prevents innovation, and creates a market situation where there is little incentive to innovate (OECD, 2010b). While governments have a wide range of environmental policy tools at their disposal to address this problem, including regulatory instruments, market-based instruments, agreements, subsidies, or information campaigns, the fairest and most efficient way of reducing emissions is increasingly seen in higher fuel prices, i.e. the introduction of a tax on fuel or emissions (e.g. Sterner, 2007; Mayor and Tol, 2007; 2008; 2009; 2010a,b; Johansson, 2000; see also OECD, 2009; 2010b; WEF 2009; PricewaterhouseCoopers, 2010). As outlined by OECD (2010b: 2):

> *Compared to other environmental instruments, such as regulations concerning emission intensities or technology prescriptions, environmentally related taxation encourages both the lowest cost abatement across polluters and provides incentives for abatement at each unit of pollution. These taxes can also be a highly transparent policy approach, allowing citizens to clearly see if individual sectors or pollution sources are being favoured over others.*

The overall conclusion is thus that emerging climate policy may become more felt that in the future, and tourism stakeholders should seek to prepare for this.

4.2.6. Tourism-related vulnerabilities

Generally, a destination could be understood as vulnerable when it is highly dependent on tourism, and when its tourism system is energy intense with only a limited share of revenues staying in the national economy. Figure 4.2.7 shows this for various islands, expressed as a climate policy risk assessment. In the case of Jamaica, vulnerability is lower than in other countries, because the share of tourism in national GDP is still comparably low, while the energy intensity of the island's tourism system is also low.

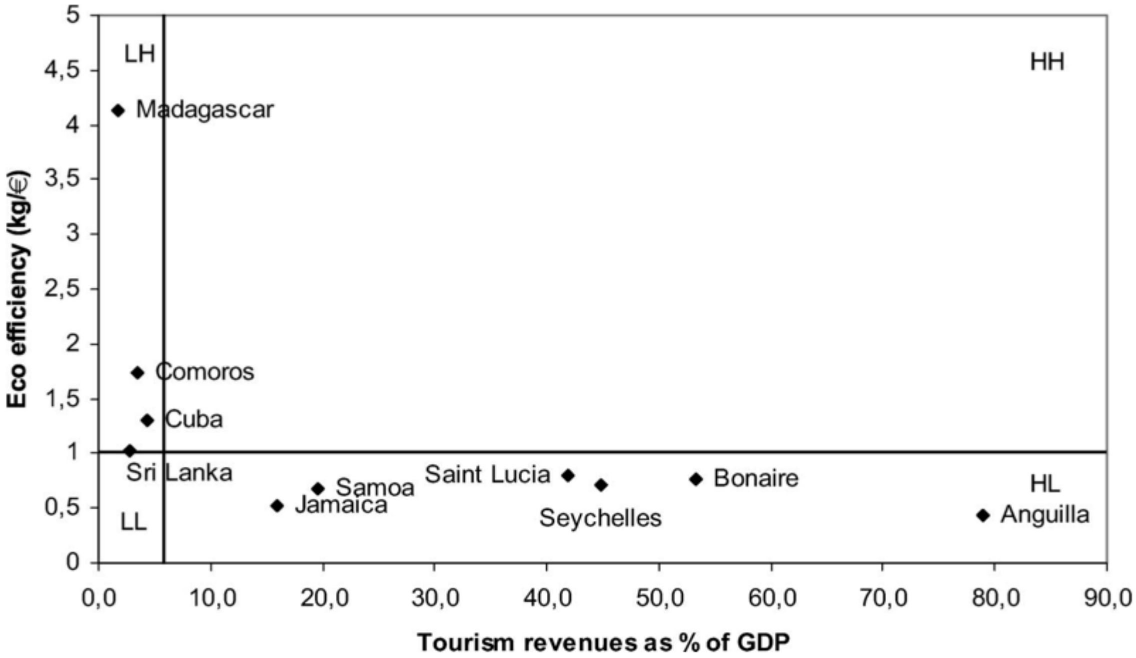


Figure 4.2.7: Vulnerability of selected islands, measured as eco-efficiency and revenue share

(Source: Gössling *et al.,* 2008)

Destination climate policy risk assessment: eco-efficiency. *Notes:* Lines represent the weighted average values of all 10 islands; H is either High (unfavourable) eco-efficiency or high dependency on tourism, L is either low (favourable) eco-efficiency or low dependency on tourism, eco-efficiency = local spending compared to total emissions, i.e. not considering air fares.

While global climate policy affecting in particular transports is currently only emerging, there are already a number of publications seeking to analyse the consequences of climate policy for in particular tourism-dependent islands. There is general consensus that current climate policy is not likely to affect mobility because international aviation is exempted from value-added tax (VAT), a situation not likely to change in the near future due to the existence of a large number of bilateral agreements. Furthermore, emission trading as currently envisaged by the EU would, upon implementation in 2012, increase the cost of flying by just about €3 per 1,000 passenger-kilometres (pkm) at permit prices of €25 per tonne of CO_2 (Scott *et al.,* 2010). Similar findings are presented by Mayor and Tol (2010), who model that a price of €23/t CO_2 per permit will have a negligible effect on emissions developments. Other considerable increases in transport costs due to taxation are not as currently apparent in any of the 45 countries studied by OECD & UNEP (2011), though such taxes may be implemented in the future. Germany, for instance, introduced a departure tax of €8, €25 and €45 for flights <2000 km, 2000-4000 km and >4,000 km as of 1 January 2011.

The implications of the EU ETS for tourism in island states were modelled by Gössling *et al.,* (2008). The study examined the implications of the EU ETS for European outbound travel costs and tourism demand for ten tourism-dependent less developed island states with diverse geographic and tourism market characteristics. It confirmed that the EU ETS would only marginally affect demand to these countries, i.e.

causing a slight delay in growth in arrival numbers from Europe through to 2020, when growth in arrivals would be 0.2% to 5.8% lower than in the baseline scenario (Gössling *et al.,* 2008).

As the Gössling *et al.,* (2008) study only looked at climate policy, but omitted oil prices, Pentelow and Scott (2010) modelled the consequences of a combination of climate policy and rising oil prices. A tourist arrivals model was constructed to understand how North American and European tourist demand to the Caribbean region would be affected. A sensitivity analysis that included 18 scenarios with different combinations of three GHG mitigation policy scenarios for aviation (represented by varied carbon prices), two oil price projections, and three price elasticity estimates was conducted to examine the impact on air travel arrivals from eight outbound market nations to the Caribbean region. Pentelow and Scott (2010) concluded that a combination of low carbon price and low oil price would have very little impact on arrivals growth to the Caribbean region through to 2020, with arrivals 1.28% to 1.84% lower than in the BAU scenario (the range attributed to the price elasticities chosen). The impact of a high carbon price and high oil price scenario was more substantive, with arrivals 2.97% to 4.29% lower than the 2020 BAU scenario depending on the price elasticity value used. The study concluded:

> *It is important to* emphasise *that the number of arrivals to the region would still be projected to grow from between 19.7 million to 19.9 million in 2010 to a range of 30.1 million to 31.0 million in 2020 (Pentelow and Scott 2010).*

A detailed case study of Jamaica further revealed the different sensitivity of market segments (package vacations) to climate policy and oil price related rises in air travel costs (Pentelow and Scott, 2010; see also Schiff and Becker, 2010 for a New Zealand study of price elasticities). Pentelow and Scott (2010) concluded that further research is required to understand the implications of oil price volatility and climate policy for tourist mobility, tour operator routing and the longer- term risks to tourism development in the Caribbean. Overall, current frameworks to mitigate GHG emissions from aviation do not seem to represent a substantial threat to tourism development (Mayor and Tol 2007; Gössling *et al.,* 2008; Rothengatter, 2009), but new regulatory regimes and market-based instruments to reduce emissions in line with global policy objectives would cause changes in the global tourism system that could affect in particular SIDS. To anticipate these changes and to prepare the fragile tourism economies in the Caribbean to these changes should thus be a key management goal for tourism stakeholders.

4.3. *Agriculture and Food Security*

4.3.1. Background

Climate change related impacts on agriculture have in recent times been the focus of discussion and research on an international level. It is anticipated that climatic change will diminish agricultural potentials in some regions thereby affecting the global food system. The IAASTD Global Report (International Assessment of Agricultural Knowledge, Science and Technology for Development, 2009) stresses the need to adopt a more practical approach to agricultural research that requires participation from farmers who hold the traditional knowledge in food production.

This research examines the relationship between agriculture and tourism within the framework of climate change, and seeks to develop adaptations options to support national food security based on experience and knowledge gained from local small-scale farmers and agricultural technicians. The study is exploratory in nature and the findings will be assimilated to develop national and regional projects that promote climate conscious farms and sustainable food production in the Caribbean.

4.3.2. The importance of agriculture to national development

The agriculture sector represents a critical component of Jamaica's national development as an important contributor to GDP, employment, foreign exchange earnings and rural life. In 2009, a year that was challenged by a global economic recession, reduced flows of direct investment and a reduction in demand for Jamaica's exports, Jamaican farmers created approximately $1.2 m USD of value, an increase of 12% over 2008, producing 489,671.5 tonnes of food, the highest figure since 2003. The Table below reveals that during the period 2004-2008 Agriculture represented on average 5.0% of Jamaica's Gross Domestic Product (GDP). According to the Ministerial Report on the Recovery of the Agricultural Sector (2010), the sector recorded an increase from 4.8% to 5.6% in 2009.

Table 4.3.1: Contribution of Agriculture to Gross Domestic Product at Constant Prices (2004-2008)

Year	Agriculture GDP ($JAM)	Growth Rate %	Total GDP ($JAM)	Agricultural Contribution % to Total GDP
2004	25,196.5	-11.2	483, 385.8	5.2
2005	23,487.4	-6.8	488, 362.9	4.8
2006	27, 293.8	16.2	501, 599.2	5.4
2007	25,655.7	-6.0	508, 765.8	5.0
2008	24, 357.6	-5.1	505, 824.0	4.8

(Source: Planning Institute of Jamaica, 2009)

Dr. Christopher Tufton, Minister of Agriculture and Fisheries in Jamaica asserts that traditional measurements of GDP contribution do not give the true value of the agricultural sector to the Jamaican economy as it ignores the value of agriculture in forward and backward linkages (Ministry of Agriculture & Fisheries Sectoral Debate, 2010) . Traditionally, agricultural contribution is based on determining the value of the amount of fresh produce or crops harvested, livestock slaughtered and fish landed. Dr. Tufton argues that the real contribution to GDP should include the expanded value created by agriculture such as demand for input suppliers and agro-processors from using local agricultural raw material. For example, the additional value created by using Jamaican hot peppers to create hot pepper sauce.

The Agriculture Sector Plan for Vision 2030 Jamaica, launched in 2009, is programmed for the dynamic transformation of the Jamaican agricultural sector to revitalise rural communities, create strong linkages with other sectors and reposition the sector in the national economy to focus on production of high-value commodities and contribute to national food security. The Agriculture Sector Plan therefore has implications for other areas of national development including transport, distribution, tourism, urban and regional planning, environmental management, and mining and quarrying.

Notably, strong investment in the tourism sector in Jamaica over the last decade has not translated into the demand-driven transformation of the agricultural sector. In his feature address at an agrotourism workshop hosted by the Inter-American Institute for Cooperation on Agriculture (IICA, 2007), Minister Tufton noted a concern for the kind of relationships that exist between stakeholders in the agriculture and tourism sectors. He acknowledged that there are complex issues to be resolved for supplying agricultural produce to tourism including the ability to guarantee a cost-effective, adequate and predictable supply.

However, to address the supply leakage of tourism income, some all-inclusive hotels in Jamaica have developed linkages with local agricultural producers. The ECLAC (2005) report on Caribbean Tourism and Agriculture refers to an arrangement between The Sandals Group of hotels and local farmers in Jamaica since 1996 to supply quality produce at competitive prices with agricultural support from the Rural Agricultural Development Agency (RADA). A similar scheme was implemented with the Super Clubs resort chain based in Jamaica in February 2004 and the Jamaica Agricultural Society (JAS) under which the JAS would supply the hotel with at least US $1 million worth of agricultural produce annually.

4.3.3. An analysis of the agricultural sector in Jamaica

The Agricultural Policy Framework for Jamaica directs the development of the agricultural sector in the areas of:

- Agricultural Trade Policy
- Export Trade Policy
- Rural Development Policy
- Forestry
- Agricultural Support Services Policies (Research and Extension, Agricultural Incentives and Domestic Marketing)

The Jamaica Ministry of Agriculture has also crafted policies to support critical sub-sectors including sugar, bananas, citrus, coffee, cocoa, domestic food crops. The sector is comprised mainly of small and medium sized farmers with 5 hectares or less, who account for 85.6% of total agricultural holdings. Presently, there is no clear policy on arable land usage for Jamaica. As a result arable lands have remained fallow and in other cases they have been transformed into permanent non agricultural uses. The Minister of Agriculture in his 2010 budget speech estimated that 25% of Jamaica's agricultural land has been lost to other forms of development.

The Jamaica agricultural production index (API) reports that in 2009, production of export crops and post-harvest activities were 63.8% and 70.8% of their levels in 2003. Other agricultural crops used largely for domestic consumption had declined and subsequently recovered in 2009 to 98.6% of the 2003 value. The following Table 4.3.2 shows Jamaica's API for the period 2003 – 2008.

Table 4.3.2: Agricultural Production Index (2003-2008)

Year	Export Crops	Other Agricultural Crops	Animal Farming	Fishing	Total
2003	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
2004	**107.1**	**84.4**	**100.4**	**113.8**	**93.0**
2005	**74.7**	**81.4**	**103.2**	**112.4**	**85.1**
2006	**95.0**	**94.0**	**108.5**	**170.4**	**101.2**
2007	**104.7**	**86.4**	**107.9**	**136.8**	**95.9**
2008	**87.7**	**80.9**	**108.4**	**124.0**	**88.9**

(Source: Planning Institute of Jamaica, 2009)

The agricultural sector significantly contributes to the foreign exchange earnings for the Jamaican economy. The main traditional export crops produced in Jamaica are sugar cane, bananas, coffee, citrus, cocoa and pimento with sugar cane contributing approximately 45% of the export earnings for all export crops (Ministry of Agriculture and Fisheries, 2010). These crops are very important as they provide employment in rural areas of the country. Agricultural workers comprised approximately 20% of the total workforce in 2009. This figure represents an increase of about 9% over the five-year period 2005 – 2009 and does not include those individuals involved in marijuana (ganja) cultivation - another significant and lucrative crop for, even though its cultivation is illegal. Agriculture Minister Dr. Christopher Tufton has acknowledged that it is the mainstay of the livelihood of many communities and, without marijuana; they would not be able to survive. However marijuana cultivation has negative effects on legitimate farming activities. It reduces farmers' access and availability to arable land critical to boosting the country's food supply, and the illegal crop production employs many women and children as ganja pickers to ensure maximum monetary gains.

4.3.4. Women and youth in Jamaican agriculture

Arguably, the real contribution of women in agriculture in Jamaica is grossly underestimated. There is little or no statistical measurement of their involvement even though there is overwhelming evidence of their agricultural outputs. They are the unpaid labour in rural farming households, the vendors that work in the community markets or on roadsides selling produce and the processors of food for rural households. As such, women in Jamaica play a key role in contributing to food security.

The Statistical Institute of Jamaica reports that in 2009 there were 48,000 women working in agriculture; this figure represents only 20% of the agricultural workforce. Jamaican women in agriculture face a unique set of issues including balancing domestic work with farming activities, dealing with the physically laborious task of preparing the land and acquiring ownership of agricultural properties. However female farmers have been reaping the benefits of farming for themselves and their families through community based organisations and local associations such as the Women's Resource and Outreach Centre (WROC) and The Jamaica Network of Rural Women Producers (JNRWP). These groups help women to acquire funding for labour intensive farming activities, provide training in new agricultural practices and technologies and enhance their entrepreneurial activities such as agro-processing, services and retail.

It is difficult to ascertain the number of young people that are involved in agriculture in Jamaica. So far they are not accounted for in national statistical data. However, the Jamaica Ministry of Agriculture and Fisheries' has established a major programme aimed at attracting youths aged 18-35 in rural communities to work in the agricultural sector. The Young Farmers' Entrepreneurship Programme (YFEP) provides interested youth with support in the form of land, access to markets, links to credit agencies and infrastructure (farm roads, office space and fencing). Already several young farmers have benefitted from this initiative which seeks to address the sustainability of the industry with its ageing farmers and the threat of food security in Jamaica.

4.3.5. Climate change related issues and agricultural vulnerability in Jamaica

Climate change impacts are already being observed in the Jamaican agricultural sector, resulting in lower yields, more diseases and serious problems for farmers throughout Jamaica. Coffee and banana production have faced many extreme weather events during the past years, mainly hurricanes, which have destabilised the agricultural industry and caused declining productivity and crop damage. The Planning Institute of Jamaica reports that in the 30 year period 1973-2003 the sector suffered losses amounting to $27.8 million USD. Additionally, the agricultural sector suffered more than $71,000 USD in damage from Hurricane Ivan in 2004 and a further $2.3 million USD in 2005 from Hurricanes Dennis and Emily.

Hurricane Dean in August of 2007 caused approximately one billion Jamaican dollars in damage to domestic crops, inclusive of the then fledgling protected agriculture segment. Production was further disrupted by damages caused by Tropical Storm Gustav in August of 2008. These hurricanes caused crop damage to vegetables, fruits, ground provisions, bananas and plantains. Livestock damage was to poultry, goats and dairy cattle. In addition to crops, significant damage occurred to farm buildings and equipment, roads and irrigation equipment. The Economic Commission for Latin America and the Caribbean (ECLAC, 2004) reports that the distribution of communities most severely impacted by Hurricane Ivan consisted of rural farming communities illustrated in the map below (Figure 4.3.1).

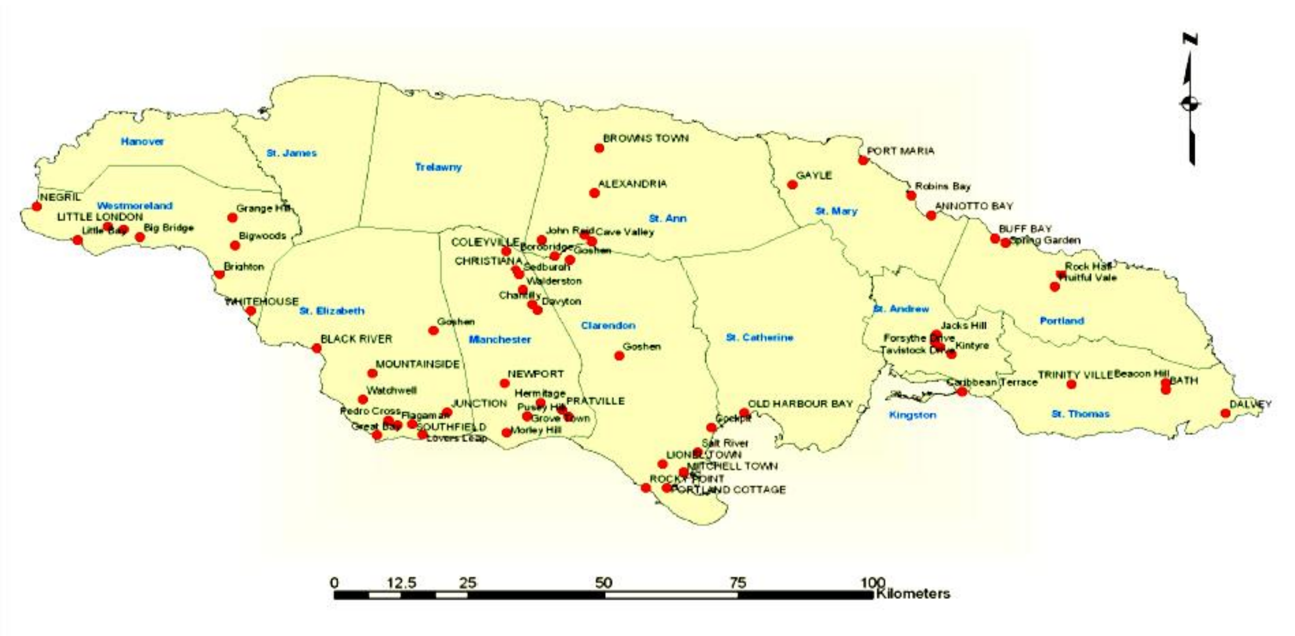


Figure 4.3.1: Rural Farming Communities Impacted by Hurricane Ivan

(Source: Planning Institute of Jamaica, 2004)

Jamaican farmers also experience drought as an annual recurring event. Since February 2010 hot, dry conditions have persisted creating many challenges for farmers especially across the southern belt where the majority of the nation's food is cultivated. Crop-production figures for the second quarter of 2010 reflect the lag effect of the recent drought on the agricultural sector. In the 2010 Ministerial Debate Agriculture and Fisheries Minister, Dr. Tufton revealed that there was a 1.4% decline in cash crop production and 5% in the overall figures for produce, against the corresponding period for 2009. Further tangible evidence of the impact of climate change on Jamaican farms and rural communities is demonstrated with the increase incidents of annual flooding and landslides in areas not prone to flooding and changes in insect's behaviour (Issues and Challenges of Climate Change for Women Farmers in the Caribbean: The potential of ICTs. Tandon, 2009). The key climate change-related issues and risks related to agriculture sector in Jamaica in terms of food security are presented in Table 4.3.3.

Table 4.3.3: Climate Change Issues & Food Security in Jamaica

	Risk Assessment: Food Availability (Imports to Jamaica)	Risk Assessment: Food Accessibility (Local Demand & Supply)
Sea Level Rise	Flooded agricultural areas in the US and other import countries can disrupt food supply	Changes in the level of production in flood prone areas in Jamaica will affect local supply of cash crops
Rainfall Variability	Food supply and prices will tend to be unstable depending on the import product	Supply of some domestic crops will be reduced resulting in shortages
Drought & Increasing Temperatures	Jamaica can expect higher market prices from imports as drought conditions result in reduced production of food crops and livestock	Imported foods used in the hotel sector may become unavailable or too costly Local farmers will experience higher production costs & lower yields resulting in an increase in local food prices

4.3.6. Vulnerability enhancing factors in the agricultural sector: land use and soil degradation in Jamaica

Jamaica has approximately 2.7 million acres of land mass with 17%, or just over 440,000 acres, of flat and arable. The last national land use inventory (1996) indicated that agriculture, forestry, and human settlements were the main land use categories on the island with forests accounting for 24%; shrubs and woodlands 20%; agriculture, including pasture lands 46%; and urban and rural settlements, including industrial and commercial uses, accounting for approximately 4%. Mining, water and wetlands accounted for the remainder of the land uses.

However, this scenario is being modified with the present trends in the Jamaican agriculture sector. The Statistical Institute of Jamaica (STATIN) reports that in 2007 there were 202,727 hectares (ha) of farm lands in Jamaica of which 154,524 hectares were under crop cultivation and 48,203 hectares used for pasture. The parishes with the largest proportion (60%) of farming area are located in districts that share the southern plains and valley region: Westmoreland (44,000 ha), St. Elizabeth (30,000 ha), Clarendon (44,000 ha) and St. Catherine (38,000 ha). These figures represent a decline when compared to the agriculture census report in 1996; crop land areas declined by 23,000 ha (20%) and pasture land experienced a 50% decline over the same period. STATIN (2007) also reported that the highest decline was (15,982 ha) in the parish of St. Ann on the northern plain; Clarendon (13,419 ha) and St. Mary (11,342 ha).

A principal vulnerability feature regarding land use in Jamaica is the insecure tenure and the unequal distribution of agricultural land amongst rural people. The high-quality arable farmland along the coasts is controlled by a few farmers while the small farms, which are in the majority, are left with marginal hillside land. STATIN (2007) estimates that small farms represent 75% of the total number farms in Jamaica and only occupy 15% of total farm land. Approximately 60% of all farming lands are located on in the south western half, the leeward side of the island which experiences semiarid climate. These farms are thus located on slopes with fragile soil which reduces the capacity for sustainable agriculture.

A second vulnerability factor for land degradation is the use of unsuitable farming techniques. Poor land-use practices, including cultivation and development on unsuitable slopes, have led to soil erosion, massive flooding incidents, and degradation of watersheds (World Bank, 2009). Added to this, there are a large number of squatter settlements in these fragile areas; very few rural landholders actually own or have documentation of their rights to land. The added pressure on the natural resources, especially in the squatter lands not suited for residential development, significantly contributes to environmental degradation and makes these areas more susceptible to the impacts of climate change.

An article in the Jamaica Gleaner (5, Jan 2011) reported that Minister of Agriculture in Jamaica, Dr Christopher Tufton, expressed that for too long most of the country's arable lands have been unaccounted for and subject to inactivity. He noted that the system of leasing arable lands tended to be ad hoc and left much to the discretion of the lessee. He also stated that too much of Jamaica's arable lands had been transformed into permanent non-agricultural areas. According to Dr. Tufton's reckoning, as of 2007, only 50% of the 87,000 acres of land with irrigation infrastructure were used for agriculture. The implication here is that agricultural land use systems and policies in Jamaica have the potential to seriously contravene national food security goals.

4.3.7. Social vulnerability of agricultural communities in Jamaica

Out of Jamaica's total population of about 2.6 million people, 47% of them live in rural areas. Of the 445,000 (16.5% of pop.) living below the poverty line (US $2/day) in 2009, the majority were women. Men own 80% and women 20% of agricultural land, with the females holding the smaller plots. Female-headed homes accounts for two-thirds of all poor households in Jamaica (UN 2009; World Bank 2009).

A study conducted by The Planning Institute of Jamaica (2007) reveals that the North-eastern region of the island has the highest incidence of poverty, with the agricultural dependent parishes of St. Ann, Portland and Trelawney having more than 30% of their population in poverty. Clarendon and Manchester have the highest poverty rates in the South. The study asserts that agricultural dependent parishes have the highest incidence of poverty in Jamaica. The heavy reliance on farming to provide food for the household and to make a living is a serious element of social vulnerability in these rural communities.

Vassell (2010), of the Women's Resource and Outreach Centre Jamaica, observed that the social impacts of climate change in rural communities are related to the vulnerability of human security, individual survival, of livelihoods and of dignity. A prime example of this occurred in September 2010 when a six-month drought was followed by three days of persistent rain and flooding. This extreme weather event left 14 people dead and caused US $245,000 in damage to infrastructure and agriculture. Vassell further explained that the damage to infrastructure adversely affected men and women quite differently: For example, with farm roads destroyed, male farmers in the Somerset community in Portland faced high risks from crossing flooded rivers. The men also risked injury from landslides as they travelled to tend their animals and to the risk of their health, they often have to carry the loads to rehabilitate the paths and farms high in the mountains.

Women's safety is compromised from the destruction of roads and bridges; they then have to walk long distances and in darkness, especially if their farm is outside the community. Additionally, female farmers have to pay high labour costs to rehabilitate their farms; hence their ability to recover quickly is low. Since these farmers mostly live in informal settlements, climate related incidents habitually results in destruction of toilet facilities, increase in diseases and increases on work-load of households; drought and floods make provision of water a major pre-occupation for women in particular.

Farmers with small holdings in most parishes irrigate crops using their domestic water supply or from local surface sources or springs or stored precipitation. The demand for irrigation water is greatest in the south, due to lower rainfall. A water resources assessment conducted in 2001 disclosed that about 36,090 hectares of agricultural land in Jamaica is irrigated, representing only one-half of the potential irrigable land in the island. Less than 30% of agricultural land is currently irrigated in each of St. Thomas, St. Elizabeth, Trelawny, and Westmoreland.

The water resources assessment declared that irrigation in Jamaica is characterised by low efficiencies and significant wastage of water. Conveyance of water from source to farmland is hindered by the poor condition of many of the existing waterworks. An estimated 20% of water is lost in irrigation water supply systems. Further losses occur due to the 'continuous flow' method of delivering water to farmland. Farmers experience a lack of control in the application of irrigation water, and runoff losses from farmland are consequently large. Clarendon has the most acute irrigation water shortage. The irrigation inefficiencies outlined here make it more difficult for the vulnerable agricultural populations in Jamaica to adapt to climatic variability and climatic change. Proper irrigation systems can facilitate year-round intensive production and potentially enable farmers to gain access to competitive commercial markets.

4.3.8. Economic vulnerability: climate change & agricultural outputs in Jamaica

An understanding of the economic vulnerability of agriculture requires firstly, a level of knowledge on production change risks for key types of crops; and secondly, an assessment of climate change impacts on three types of agriculture:

1. Export crops that are crucial to livelihoods
2. Crops that are specially produced for use in the tourism (hotel & restaurant) sector
3. Crops for domestic consumption that significantly affect national food security

The Caribbean Catastrophe Risk Insurance Facility (CCRIF, 2010) carried out a study to assess the Economics of Climate Adaptation in Jamaica with specific focus on crop suitability. The impact assessment of climate change focused on 2 drivers of agriculture production:

- Gradual change in climatic conditions (climate zone shift)
- Impact of climate change on crop damage potential with extreme events such as hurricanes and earthquakes.

For each of the selected crops, banana, sugarcane, and orange, the climate change team used International Centre for Tropical Agriculture (CIAT) crop suitability maps to determine climate zone shift impact on crop yields. Current crop yields were used with different climate scenarios as key inputs to calculate the yield changes in each production location. The analysis showed that change in yields as a result of climate zone shift is the main driver of the change in production volume. The results of this study also revealed that potential changes in net production volume 2030 vs. 2009 range from -13% (sugar cane) to +8% (banana) in Jamaica.

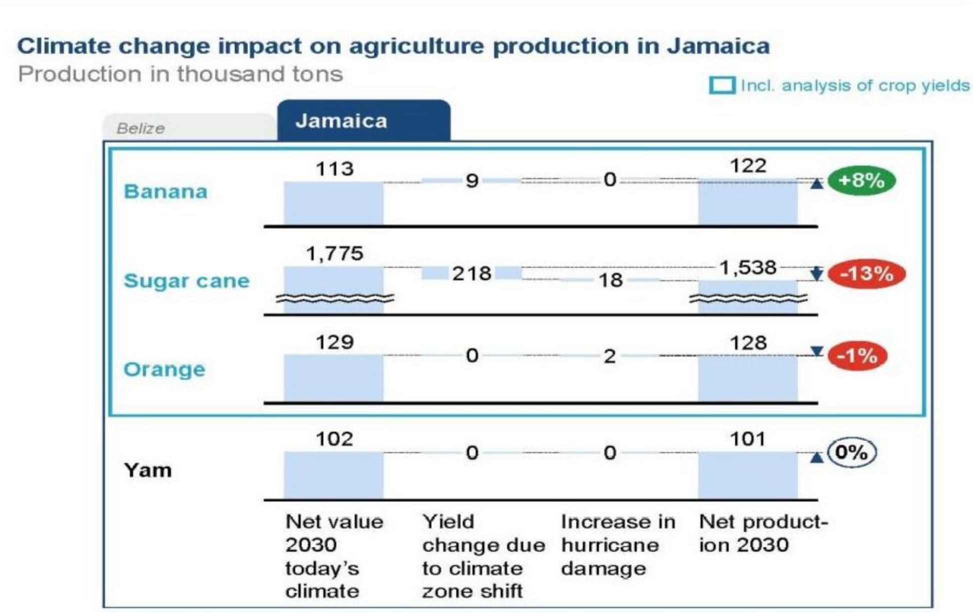


Figure 4.3.2: Climate Change Impact on Agriculture Production in Jamaica (000 tonnes)

(Reproduced from CCRIF ECA Study, 2010)

Comparative analysis showed that although hurricanes damaging yield production ratios are a threat, the comparative effect of 'shifting climate zones' on production has been forecasted as significantly more dangerous.

The next issues for consideration are the state of food security and import/export trends in Jamaica. The major crops for food security are the staples; carbohydrate sources. The major staples eaten in Jamaica are wheat (bread) and rice which are imported. Currently, Jamaica imports all of the 100,000 tonnes of rice consumed annually. The reason for this is that bread and rice are the cheapest carbohydrates available and their availability prevents malnutrition for those that cannot afford to buy the other types of staple foods. Cereals and cereal products make up 75% of the total food imports to the island. Although Jamaica is reliant in many ways on wheat (bread) and rice, in the face of changing climate and more extreme weather events, rice can be successfully grown on the island. Additionally, the percentage use of other staples such as breadfruit, yams, coco (a type of yam), dasheen, Irish potato, sweet potato and cassava can be increased.

According to a report in the Jamaica Gleaner (June, 2010), the Agriculture Minister, Dr. Christopher Tufton, revealed that the country's food-import bill dropped by US $64 million (J$5.5 billion) in 2009 when compared with the previous year. Minister Tufton also acknowledged that not all imported foods can be produced locally but a 2009 study conducted by the Ministry to determine the categories of food and their value that could be replaced, revealed that in 2009 approximately J$23.5 billion (US $261 million) of imported foods could be substituted. This figure equates to a little more than 33% of Jamaica's imports for 2009.

The only times that Jamaica has encountered food shortages is after devastating hurricanes; 40% of the US $4 billion in damage caused by Hurricane Gilbert in 1988 was attributed to agricultural loss. As a result of Hurricanes Charley and Ivan in 2004, 190,000 tonnes of sugar cane were lost and 100% of the banana crop, causing damage amounting to US $85 million. In 2005 Hurricanes Emily and Dennis exacerbated the damage, while in 2007 Hurricane Dean resulted in further damage amounting to US $3.7 million. Even with the fallout from hurricanes, Jamaica has not experienced serious food shortages because agricultural production takes an average of three months for restoration. The implication here is that there is some resilience in terms of national food security on account of Jamaica's propensity to produce local substitutes for imported staples and the public interest and investment in agriculture as a vital sector of the economy.

With regard to the state of diversity and importance of major crops, the Jamaica Report on the State of Plant Genetic Resources for Food and Agriculture (2008), includes some key data for understanding the level of economic vulnerability. Based on this resource, plus information acquired from the Rural Agricultural Development Authority (RADA), the crop specifications for the three types of agriculture that are most relevant to climate change are presented in the diagram below.

Figure 4.3.3: Crop Specifications for the 3 main crops in Jamaica

Evidently, the most vulnerable food item in this schema is sugarcane; it is by far the most important in terms of employment and foreign exchange earnings. Based on the results of the CCRIF (2010) study it is most susceptible to yield changes due to shifts in climate change, it has historically sustained the most losses during extreme weather events, and it is the one crop that can significantly affect the level of poverty in Jamaica. The sugar industry is the second-largest single employer in the country.

The Country Report on the State of Plant Genetic Resources for Food and Agriculture (2008) also gives some indication as to the general vulnerability of the agriculture sector in Jamaica based on the trends recorded for the period 1996 to 2006 which include:

- A decrease in traditional export crops and increase in non-traditional crops
- A decrease in earnings from sugar for the period from US $113.8 million to US $66.8 million
- An increasing in demand for competitively priced value added products such as jerk seasoning.

As far as vulnerability is concerned, the trends described in the country report can actually be translated into opportunities for economic growth in Jamaica; by increasing employment within the agriculture sector, increasing foreign exchange returns from the sector and improving food security. Undoubtedly, Jamaican farmers can find ways to grow food to feed Jamaica. However, it appears that the majority of food utilised in the Jamaican tourism industry is imported. The economic opportunities lie in Jamaica's ability to form viable backward linkages between tourism and agriculture which in turn will decrease the level of vulnerability for both sectors.

4.4. *Human Health*

4.4.1. Background

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) defines health as including ‘physical, social and psychological wellbeing’ (Confalonieri *et al.*, 2007). An understanding of the impacts of climate change on human health is important because of the implications of the above as well as to livelihoods on a local scale and to the economy on a national level. Where health epidemics already have been known to exist or environmental and social conditions make particular populations vulnerable, climate change has the potential to impact on the quality of the environment and the resilience of the ecosystems which they are made up of thereby intensifying disease incidences in a given population.

Health is an important issue in the tourism industry because tourists are susceptible to acquiring diseases as well as being vectors of diseases. Further due to air travel, a large number of diseases are carried from tourist destinations to Europe (Gössling, 2005) and elsewhere in the world. This is highly relevant when one considers that approximately 75% of travellers become ill abroad from infectious diseases; morbidity is most often due to diarrhoea or respiratory infections (Sanford, 2006). It is also important because it can have consequences for tourism destination demand which is a significant contributor to the economies of Small Island Developing States (SIDS).

The potential effects of climate change on public health can be direct or indirect (Patz, J.A. *et al.,* 2000; Ebi *et al.*, 2006; Confalonieri *et al.*, 2007). Direct effects include those associated with extreme weather events such as thermal stress, changes in precipitation, SLR and natural disasters or more frequent extreme weather events. Both direct and indirect effects include the impact of climate change on the natural environment which can affect food security and the agriculture sector and increase the susceptibility of populations to respiratory diseases and food- and water-borne related diseases (Patz, J.A. *et al.* 2000; Githeko and Woodward, 2003; Confalonieri *et al.*, 2007; Taylor *et al.*, 2009). In this section the vulnerability in the health sector in Jamaica to different climate changes and the associated epidemiology on various diseases will be described.

A significant number of diseases have been linked with climate change on a global scale, with varying levels of confidence. For Jamaica, a subset of these diseases has been identified.

Table 4.4.1 identifies five such diseases that have been found to be sensitive to climate change across the possible range. Malaria and dengue fever will be discussed in detail and meningococcal meningitis and influenza are highlighted because of the relevance in epidemiological data for the island of Jamaica in the recent years. Table 4.4.2 shows selected statistics relevant to the Health Sector of Jamaica.

Table 4.4.1: Communicable diseases in Jamaica which show varying sensitivity to climate change

Very Weak	Some Sensitivity	Moderate	Strong	Very Strong
Intestinal nematodes	Influenza	Meningococcal meningitis	Dengue	Malaria

(Reproduced from WHO, 2000a. Taken from MSJ/UNDP, 2009)

Table 4.4.2: Selected statistics relevant to the Health Sector of Jamaica

[1]Population	2,698,800
[2]Human Development Index (HDI) ranking	80th
[1]Unemployment rate	12.4%
[3]Percentage of population living below the poverty line	9.9%
[4]Expenditure on Public Health	2.4% of GDP
[5]Ministry of Health budget (2010)	$31,809,602 (9% of budget)
[1]Life Expectancy at Birth	74.13 years
[1]Crude Birth Rate	16.3 per 1000
[1]Crude Death Rate	6.5 per 1000 persons
[1]Bed Occupancy rate	67.5%

(Sources: [1]GOJ,2009d; [2]UNDP, 2008; [3]STATIN, 2010; [4]PAHO, 2007 and [4]UNDP, 2010a; [5]GOJ, 2010a)

In Jamaica, with respect to climate change and public health, health was named as an area that was carded to be incorporated in national planning, by the Mainstreaming Adaptation to Climate Change Project (MACCC), according to the Jamaica National Assessment Report of the Barbados Programme of Action (BPOA) (GOJ, 2003). In the Review of the Economics of Climate Change (RECC) in the Caribbean, health along with tourism and agriculture were identified as sector areas in Jamaica that were considered most vulnerable to the effects of climate change (ECLAC, 2010).

4.4.2. Direct impacts

Weather-related mortality and morbidity

Mortality and morbidity due to injuries sustained in natural diseases is an important consideration when assessing the vulnerability of a country to climate change. Jamaica's susceptibility to hurricanes and floods is very high, having a considerable impact on human welfare in the country (GOJ, 2009c). From observed data North Atlantic hurricanes and tropical storms appear to have increased in intensity during the last 30 years and modelling projections indicate that the trend is expected to continue in the future, specifically due to intensification of weather phenomenon rather than increases in frequencies (See Section 3).

Table 4.4.3: Lives lost from five of the major hurricanes to hit Jamaica between 1988 and 2008

Hurricane	Year	No. of Lives Lost
Gilbert	1988	45
Ivan	2004	15
Dennis	2005	1
Dean	2007	3
Gustav	2008	15

(Source: Gordon-Strachan Personal Comm., 6th, December, 2010)

In Jamaica, on average 1,477 persons per million are affected by Natural Disasters according to the International Disaster Database (UNDP, 2010). In real terms, 116 persons have died as a result of tropical storms and hurricanes in Jamaica according to The Director General of the Jamaica Institute of Planning (GOJ, 2010c). Between the years 1980 to 2008, 8 major storms and hurricanes have affected Jamaica (Chen *et al.*, 2008). Table 4.4.3 shows some major hurricanes and the number of lives lost.

Increased temperature and heat illness

Jamaica's Initial National Communication to the UNFCCC to the highlighted the possible implications for temperature on the public health sector, as well as, noting the agriculture sector, water resources sector and other economic activities (GOJ, 2000). The implications for rising temperatures could result in increases in morbidity and mortality (Hajat *et al.*, 2010) for instance from heat exhaustion, heat stroke, dehydration and even death (Sanford, 2006). The elderly (11.01% of the population aged 60 yrs and over GOJ, (2009b)) and young (27.53% of the population 14 years and under (GOJ, 2009b)) are more susceptible than other groups as well as persons chronically sick and those socially isolated. Persons who work outdoors for long periods of time (e.g. construction workers) are also at greater risk to these conditions.

Increased temperatures can also have implications for persons prone to, or suffering from, cardiovascular diseases (Worfolk, 2000; Cheng and Su, 2010) and which could be exacerbated by prolonged exposure. This is of special significance in Jamaica, where cardiovascular diseases were the second leading cause of death in 1999, accounting for one third of inpatient deaths (PAHO, 2000). The effects of heat waves are also intensified by increased humidity and urban air pollution (Moreno, 2006). In terms of tourism this will be an important consideration for the elderly travel enthusiasts when choosing destinations.

Over the period from 1960 to 2006 it was observed that for each decade the average temperature in Jamaica increased on average by 0.27°C. These values vary depending on the particular part of the island, where there are increases above this average value in some cases. Temperature change values can be influenced by localised factors associated with particular measuring stations and due to the length of the observation period. However, it is evident that there has been an overall increase in temperature on the island most notably in June, July and August. GCM projections indicate that temperatures may rise anywhere between 1 – 2°C in June, July, August for any of the emission scenarios across 15 GCM models (See Section 3).

Further to this, the number of sunshine hours per day has shown an increase in the months March, April, May and June, July and August for the period 1981 to 2003. In the modelling projections, GCM and RCM both indicated that the number of sunshine hours per day will increase by the 2080's under A2 scenarios (annual average spans -0.2 to +0.9 hrs/day and up to +1.4 hrs/day respectively). This may also contribute to sustained exposure to higher temperatures. Finally, the number of observed 'hot' days and nights has increased during the period 1973 – 2008 by 6% (22 days) and are also expected to increase further according to GCM modelling projections to 10% of days for 30-98% of days per year by the 2080's (See Section 3). Overall these statistics indicate that increases in temperatures constitute cause for concern in the health sector of Jamaica.

In the context of tourism, while temperature may be considered a positive determinant of visitor demands it should be noted that on one hand cooler temperate destinations tend to become more attractive as temperature increases, but warm tropical destinations become less attractive (Hamilton and Tol, 2004). However, the reverse may be also true depending on the destination. It is uncertain at what temperature threshold such hypotheses will affect Caribbean destinations such as Jamaica.

4.4.3. Indirect impacts

Increase in vector-borne diseases

Jamaica's tropical climate makes it suitable for the transmission of a number of vector-borne diseases. For mosquito vectors, Hales *et al.* (2002) summarises 'mosquitoes require standing water to breed, and a warm ambient temperature is critical to adult feeding behaviour and mortality, the rate of larval development, and speed of virus replication.' Of course climate is not the only factor important factor in the successful transmission of disease, other factors include the disease source, the vector and a human population (Hales *et al.*, 2002). Climate change projections indicate the potential for more intense rainfall events, this would increase the rate at which mosquitoes proliferate by providing more numerous sites for breeding (GOJ 2000; GOJ, 2006). In addition, the observed temperature of Jamaica has shown an overall increase in the last four decades and from model projects is expected to increase in future (See Section 3: Climate Modelling) which would create conditions even more favourable for mosquitoes to breed.

Another important consideration for public health is that incurred from the tourism industry. In 2009 there were 2.7 million visitors (total visitor arrivals) to Jamaica (GOJ, 2009d). This influx of people from other areas could generate vulnerability to vector borne disease infections if conditions were to become even more favourable for their transmission.

Malaria – It is also believed to be sensitive to changes in climate (Martens *et al.*, 1997; Githeko and Woodward, 2003). One of the most recent outbreaks of Malaria was in 2009 in the parish of St. Catherine, Jamaica (GOJ, 2009e). There have been no reported cases of indigenous Malaria in recent times, but imported cases are of concern. The continuance of malarial infections in Jamaica has been attributed to imported cases, such as those from Haitian refugees (PAHO 2007b; Chen *et al.*, 2008; GOJ, 2009c). See

Table 4.4.4 below for recent reported cases of malaria from external sources but no deaths were reported in any of these years. Also important is the transmission of malaria as a result of tourism. At least one study has found that malaria is the most common cause of fever of tourism upon returning from travel in infected areas (Wichmann *et al.*, 2003). Overall Jamaica has been noted as the country in the Caribbean with the highest incidence of imported cases in the region, with 38.4% of 897 cases (Rawlins *et al.*, 2008).

Table 4.4.4: Imported cases of Malaria in Jamaica between 2004 and 2008

Year	No. cases of Malaria
2004	141
2005	79
2006	186
2008	191

(Source: PAHO, 2007; GOJ, 2009d)

The continued localised transmission, in recent times, has been attributed to poor sanitation particularly in urban slums and areas with high populations (e.g. Kingston) (GOJ, 2009c). Malaria has also been described as "intimately connected" with poverty because the mosquito vector breeds in standing water pools that tend to form in the streets of informal development zones which lack proper sanitation and waste removal (Gallup and Sachs, 2001). It should be highlighted here that malaria is the most reported cause of hospitalisations in tourists from malaria prone destinations (Widler-Smith and Schwartz, 2005).

Dengue Fever - Dengue fever is caused by a virus of the genus *Flavivirus* and family *Flaviviridae*, of which four stereotypes exist (Gubler, 1998). As defined by Rigau-Pérez *et al.* (1998) dengue is 'an acute mosquito-transmitted viral disease characterised by fever, headache, muscle and joint pains, rash, nausea, and vomiting. Some infections result in dengue haemorrhagic fever, a syndrome that in its most severe form can threaten the patient's life, primarily through increased vascular permeability and shock.' It is the most important arboviral disease of humans, which exists in tropical and subtropical countries worldwide (Rigau-Pérez *et al.*, 1998; Patz *et al.*, 1998; Gubler, 2002). The arthropod vector for dengue is *Aedes aegypti*.

Population growth, urbanisation and modern transportation are believed to have contributed to its resurgence in recent times (Gubler, 2002).

It has been shown that dengue fever transmission is altered by increases in temperature and rainfall (Hales *et al.*, 1996). Both from modelled data and observations, it has also been found that changes in climate determine the geographical boundaries of dengue fever (Martens, 1997; Epstein *et al.*, 1998; Patz *et al.*, 1998; Epstein, 2001; Hales *et al.*, 2002; Hsieh and Chen, 2009). This is in addition to other economical, social and environmental factors that can affect the occurrence and transmission of the disease (Hopp and Foley, 2001).

Dengue fever is a public health concern in the Caribbean both to locals and to tourists (Pinheiro and Corber, 1997; Castle *et al.*, 1999; Wichmann *et al.*, 2003) and Allwinn *et al.* (2009) have found that the risk to travellers has been underestimated. In fact it is the second most reported disease of tourists returning from tropical destinations (Wilder-Smith, 2005) and air travel has been linked with its spread (Jelinek, 2000). This vector borne disease has affected the region at least as early as the 1800's (Pinheiro and Corber, 1997). Jamaica has a significant history of dengue fever; it was noted as the first country in the Caribbean to experience an epidemic of serotype 1 due to a re-emergence of the disease in the year 1977 (Pinheiro and Corber, 1997; Heslop-Thomas *et al.*, 2006). Further dengue haemorrhagic fever has been confirmed since 1981 (Pinheiro and Corber, 1997). Other outbreaks in Jamaica occurred in 1995 with 1884 suspected and reported cases (Castle *et al.*, 1999) and in 1998 with 1509 cases (PAHO, 2000).

All four serotypes exist in Jamaica (Heslop-Thomas *et al.*, 2006) and since infection of one serotype does not offer immunity against another serotype, re-infection complicates the control of the virus' transmission (Gulber, 1998). This also increases the risk of infection from dengue haemorrhagic fever and dengue shock syndrome (Levett *et al.*, 2000). In the future, predicted increases in precipitation and temperature threaten to also complicate the transmission of the disease by providing longer periods throughout the year where breeding and incubation of the larval can take place.

Between the period 1980 -2001, 8% of reported dengue fever cases in the Caribbean (21 countries studied) were from Jamaica (Amarakoon *et al.*, 2006). While this is a flat figure which does not account for the fact that the population of Jamaica is highest among reporting countries, it is still a significant number or people which has associated costs to the Jamaican health sector. Dengue fever's threat is pre-dominantly on urban areas (Pinheiro and Corber, 1997) which makes highly populated areas like Kingston particularly vulnerable. Additionally, because dengue fever is often under reported, the real threat that this disease poses to populations is currently under estimated (Jelinek, 2000).

In one of the most recent studies of the sources of breeding habitats in 120 households, in three parishes of Jamaica (St. Catherine, Portland and St. Ann) that have had significant *A. aegyti* mosquito infestation, Chadee *et al.* (2009) found that large storage drums were the main breeding sites of the vector, accounting for a third of their breeding sites. Traditional targets of source reduction, i.e. small miscellaneous containers, were found to contain negligible numbers of pupae. The dependence on large storage drums may increase if drought conditions, already a problem in Jamaica may intensify or increase in frequency in the future. This indicates that mosquitoes are already adapting to changing urban circumstances and the growth of vector populations may well increase under future climate change scenarios.

Drought, air quality and respiratory illnesses

Certain areas of Jamaica are more prone to meteorological droughts, that is, rainfall 60% less than the 30 year average, because of the variability of rainfall patterns (GOJ, 2000). The north of the island experiences more rainfall due to the geography of this region and the location of the central range. On the other hand, the south eastern coastal region experiences more localised meteorological drought (A. Haiduk, personal communication, November, 16th 2010). Expected drier spells due to climate change, like the drought of 2009 which continued into 2010 particularly in parishes in Kingston, St. Andrew and St. Thomas, and El Niño induced drought of 1997 – 1998 (GOJ, 2000; GOJ, 2009e), can impact on air quality. If wind patterns change or wind speed increases the population of Jamaica could become exposed to increased amounts of particulate matter which can result in respiratory problems.

An increase in particulate matter can also arise due to increased episodes of bush fires, known to be a problem in Jamaica. In 2009 there were 14,425 genuine fire calls reported across the island, with a great majority being as a result of bush fires. The highest percentages of fire calls reported were in 2006, in the highly populated urban areas of Kingston and St. Andrew Parish (GOJ, 2009e).

Drought can also have impacts on health. For example, the influx of dust from the Sahara due to changing air circulation patterns (tropical waves) can cause asthma, respiratory irritation as well as other respiratory illnesses. The potential significance of such illnesses can be illustrated from health statistics within the country. In 1999, 12% of visits to accident and emergency departments were due to respiratory tract infections with just about half due to asthma (PAHO, 2000). If air quality can have implications for the local population to such an extent, it can easily be expected that similar effects may be suffered by travellers (Sanford, 2006) particularly those with respiratory diseases and those with pulmonary and cardiac diseases. Further, these dynamics also occur against a background of normal and expected urbanisation and industrialisation that is occurring on a global scale and no doubt affects Caribbean islands such as Jamaica.

These postulations are all relevant in the context of GCM modelling projections that indicate both increases and decreases in precipitation in the future, but overall decreases are expected, ranging from between -44% to +18% by the 2050's and -55% to +18% by the 2080's. For RCM's, while ECHAM4 projections do not indicate significant decreases, for HadCM3 dramatic decreases are predicted to occur in the future (See Section 3.3).

Another factor contributing to mosquito breeding sites is water storage which increases across the island during drought conditions. As has been the case in the past, this it is expected to increase mosquito breeding and therefore the rate of transmission of vector-borne diseases such as malaria and dengue (Pinheiro and Cuber, 1997; Chen *et al.*, 2008). As mentioned above in the vector borne diseases subsection, the most significant breeding habitat for mosquitoes in the dry season was found to be drums in a study of container productivity profiles (Chadee *et al.*, 2009).

In terms of diseases associated with drier conditions, Meningococcal infections should be mentioned here. Intensive meningococcal disease is influenced by climatic factors (Palmgren, 2009) and the range of the infections could be encouraged by increases in temperature and decreases in precipitation (Githeko and Woodward, 2003). There have been reported cases of Meningococcal infections in Jamaica, with 67 reported cases out of a total of 460 for the reporting Caribbean Epidemiology Centre (CAREC) Member countries between 1981 and 2005 (CAREC, 2008f).

Food security and malnutrition

Changing weather patterns, in a Small Island Developing State (SIDS) such as Jamaica, could have an impact on water supply and agriculture (GOJ, 2003; GOJ, 2006). This can impact on food availability (Moreno, 2006; Confalonieri *et al.*, 2007)) due to conditions of drought, heat stress or floods. Negative health effects then follow, especially in poor and marginalised communities. Malnutrition constitutes under-nutrition, protein energy malnutrition and or micronutrient deficiencies (Confalonieri *et al.*, 2007). Agriculture employs approximately 25% of Jamaica's population (GOJ, 2000) indicating a direct dependence on crop output for income and therefore food as well as other basic amenities. Campbell *et al.,* (2011) noted that 'Domestic food production has declined progressively in Jamaica since the mid-1990s, being 30% less in 2007 than in 1996' and that 'Climate and trade-related factors have significantly disrupted livelihood activities for many small farmers.' In addition to this, the proportion of the population below the minimum level of dietary energy consumption, i.e. 'the food poor' is 2.9% (GOJ, 2009c), which seems insignificant, but amounts to roughly 78,300 Jamaicans.

The fishery production of Jamaica should also be considered here. Fisheries stocks in Jamaica are undergoing a similar decline (FAO, 1994; CARICOM Fisheries Unit, 2000). Further, the greatest fish landings come from coral reefs, where two-thirds of risked were found to be over fished (Burke *et al.*, 2004). The Reefs at Risk in the Caribbean Report states that 'Widespread unemployment, densely populated coastal zones, easy access to the reefs, and narrow shelf areas mean the reef resources have been heavily used to provide livelihoods and sustenance'. The report also links reduction in fisheries stocks with malnutrition due to a decrease in the protein content in the diet.

It should also be noted that 9.9% of the overall population and a startling 22% of children, live below the poverty line, so in cases of extreme events such as natural disasters, this large segment of, society is extremely vulnerable to health and nutritional issues as they cannot afford treatments or health insurance. Nevertheless, such financial limitations may not necessarily be limited to persons living below the poverty line (GOJ, 2009c).

Water supply, sanitation and associated diseases

As previously noted, drought can affect air quality but it also has implications for sanitation with respect to a reduction in domestic water supplies (Moreno, 2006). In 2007, 92% of the country had access to safe drinking water and 98.9% had access to sanitary facilities (GOJ, 2009c). However, in times when water resources are scare persons seek alternative sources of water that may be less reliable in terms of quality and may therefore contain diseases (GOJ, 2000; GOJ, 2003).

Certain areas depend on rainwater harvesting (RWH) to a substantial extent (CEHI, 2006). In fact in the past over 100,000 Jamaicans depended on RHW as the primary source of water (OAS, 1997b). In the south eastern part of the island, notably the capital of Kingston and parish of St. Andrews, high population densities and periods of *lock offs* to conserve water in the dry season or during droughts can add to the problems of water shortages (A. Haiduk, personal communication, November, 16th, 2010). Any shortage of water or restriction on access to water can lead to health problems. Therefore, emphasis on water and sanitation is critical to public health, which may become even more important because of changes in climate and the associated vulnerabilities that will be exacerbated.

An example of a disease is that's spread is related to water supply and sanitation is Acute Haemorrhagic Conjunctivitis (AHC). Known in the region as 'Pink eye' or 'Red eye', AHC 'is a viral infection of the eye that causes symptoms of pain, redness, swelling, and watery or pus-like discharge. Fever and symptoms of an upper respiratory tract infection may occur' (CAREC, 2008b). As was the case in most Caribbean territories, AHC showed marked increase in 2003 over previous years with 13,716 cases, followed by a subsequent decline. It may be important to note that while a number of countries experienced outbreaks of AHC in the 1980's CAREC reports did not identify Jamaica as among those countries and in 1998 Jamaica also only had 2,596 cases of ACH (CAREC, 2008a).

Cholera is another example of a disease that proliferates in unsanitary conditions. Cholera is 'an acute intestinal infection caused by the bacterium *Vibrio cholera* and is spread by contaminated water and food' (CAREC, 2008b). While CAREC data does not have any reported cases of Cholera between 1981 and 2005

(Cholera, 2008b), outbreaks in 2010 in neighbouring Haiti placed Jamaica on high alert. The Jamaican population was advised to avoid any non-essential travel to Haiti to prevent the spread of the disease. Climate change has been found be an important factor in the spatial and temporal distribution of Cholera (Confalonieri *et al.*, 2007) and may result in increased incidence of the disease in instances of extreme events and above normal precipitation that would give rise to more flooding episodes in Jamaica.

The spread of food-borne illness is also associated with unsanitary conditions. It was observed that 8% (3,438) of cases reported in the Caribbean were from Jamaica, according to a review by CAREC between 1981 and 2005 (CAREC, 2008c). Although proportionally the population in Jamaica is larger than any of the reporting CAREC countries, this is still a large number of cases in the region. The report summary noted that under reporting of the numerous diseases, which include Salmonellosis, Shigellosis, Listeriosis and E. coli, may have occurred in previous years. The transmission of these diseases may also be associated with water supply and lack of improper sanitation which is discussed under the subsection of Water Supply.

Flooding

In Jamaica, flooding is a problem that is associated with increasing episodes of storms and hurricanes as these weather systems bring with them higher than normal rainfall patterns. Extreme flooding events are a serious concern because they can result in deaths and injuries but also because of the post-traumatic stress involved during and after such emergencies. Additionally, the expectation of future economic losses can increase the likelihood of reoccurrence in increase in frequency of such extreme weather events can increase the stress placed upon a given population (GOJ, 2000).

Because coastal areas are susceptible to erosion and more than 60% of the population lives within this zone, it is expected that loss of life due to fatal injuries, among other causes, will be an area in which Jamaica is vulnerable in the future. The Director General of the Jamaica Institute of Planning stated that so far, 116 lives have been lost due to tropical storms and hurricanes (GOJ, 2010c). Additionally according to the Global Climate Risk Index, Jamaica was ranked 13th in 2008 out 120 countries at risk (Harmeling, 2010).

Another very important problem created by flood conditions is the spread of diseases (Hales *et al.*, 2003). Some of these diseases that Jamaica already have a history of and may become more severe in altered climate scenario are described below.

Leptospirosis - Gubler *et al.* (2001) define Leptospirosis as 'an acute febrile infection caused by bacterial species of *Leptospira* that affect the liver and kidneys.' While rats are a known reservoir of the leptospirosis (Hales *et al.*, 2003) infection can occur from other wild or domestic animals such as dogs that come into contact with water, damp soil, vegetation or any other contaminated matter (Gubler *et al.*, 2001; Hansen *et al.*, 2005). Flood waters contaminated with faecal matter and urine from infected rats is often associated with and is one of the main causes of leptospirosis outbreaks and spread (Gubler *et al.*, 2001; Hales *et al.*, 2003; Moreno, 2006; Sachan, 2010). Leptospirosis has been found to be one of the diseases of importance contracted by travellers (Jansen, 2005) and could therefore have implications for tourists.

In Jamaica, one of the most recent outbreaks of leptospirosis occurred in 2007 and was reported to have been influenced by weather conditions (GOJ, 2009c). In fact in the 2007 Health Report of Jamaica, Leptospirosis was identified as a re-emerging communicable disease (GOJ, 2009). According to the Caribbean Epidemiology Centre's (CAREC) morbidity report (1980 and 2005), almost half the 12,475 cases of reported leptospirosis, were from Jamaica (CAREC, 2008e). Conditions in urban slum areas of Jamaica have contributed to the rate of spread of diseases such as leptospirosis. This problem is intensified because physical planning occurs at a rate that is slower than that of population growth (GOJ, 2009c), therefore causing an increase in residents in informal, slum settlements surrounding these urban areas.

Gastroenteritis – Children less than 5 years old accounted for 80% of persons inflicted by Gastroenteritis in Jamaica between 1980 and 2005 and 57% between 2001 and 2005 (CAREC, 2008d). The implications of Gastroenteritis to Jamaica's public health care system are tremendous, contributing significantly to infantile diarrhoea cases (Christie *et al.*, 2006; Chen *et al.*, 2008). The elderly and infants are particularly vulnerable to gastroenteritis.

Table 4.4.5: Gastroenteritis morbidity cases in Jamaica by year: 2001-2007

Year	Number of Cases
2001	18,096
2002	22,230
2003	34,026
2004	39,532
2005	21,156
2006	44,878
2007	28,125

(Source: Surveillance Unit, Ministry of Health, 2007)

Outbreaks on the island typically take place during cooler drier months, in such instances water storage is greater and sanitation and hygiene can be more easily compromised (Chen *et al.*, 2008). However, in instances of natural disasters such as flooding due to hurricane rains, transport of faecal matter may occur, thereby contaminating water sources. This is believed to be the cause of a major outbreak in 2003 involving some 4,000 child cases. Overall there were 23 deaths in 2003 and 24 in 2004 (Christie *et al.*, 2006). Table 4.4.5 shows the number of persons affected by gastroenteritis between 2001 and 2007.

4.5. *Marine and Terrestrial Biodiversity and Fisheries*

4.5.1. Importance of Jamaica's biodiversity

Jamaica is rich in biological diversity and has been rated 5th among the islands of the world with regard to endemic plants boasting at least 923 species of plants that can be found only in Jamaica (NEPA, 2003a). It is also rich in animal species diversity, with the highest number of bird species (290 recorded – 25 endemic) of any Caribbean island (Wolde Kristos, personal communication). The island also has over 100 species of butterfly, including the largest in the Western Hemisphere, *Homerus swallowtail*. The variety of plant and animal species found on the island and within the coastal waters surrounding it provide numerous goods to the population and is also important in provide ecological services. The country's natural environment forms the basis for the tourism industry, which is the most important economic sector in Jamaica.

The socio-economic conditions in Jamaica continue to challenge the expanding population and place unsustainable levels of stress on the island's natural living resource. The follow sections examine specific ecosystems and the local factors to which they are vulnerable.

4.5.2. A review of Jamaica's ecosystems and fisheries sector

Forests

Over 30% of Jamaica, approximately 335,900 ha, is classified as forest. Nearly 35% of all forests and over 73% of closed broadleaf forest are designated protected areas and are located in areas of rugged terrain such as the John Crow Mountains, Blue Mountains and Cockpit Country as well as the uplands in the south, west and north-west portions of the country (Forestry Department, 2010).

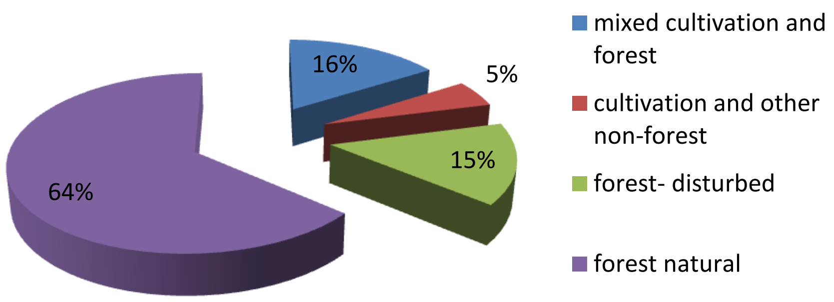
The forests of Jamaica are the main repositories of biodiversity, and provide important ecological services such as air purification, conservation of water supplies, soil formation and climate regulation. Forests play a critical role in preventing flash floods and sedimentation of coastal lowlands and marine ecosystems. Jamaica's forests also offer diverse socio-economic goods and opportunities. Wood extracted from the forest is used for construction, furniture, fish pots, and fuels such as charcoal. In Jamaica the use of charcoal is widespread domestically and commercially in the popular jerk food industry. Other materials extracted from forests, such as wicker reed, are important to Craft and Related Trades workers; a sector which employs approximately 13% of Jamaica's labour force (Ministry of Labour and Social Security, 2009). Furthermore there are still untapped resources within the hundreds of Jamaican plants which have been investigated for medicinal properties. There is ongoing research on extracts from the indigenous plant, *Tillandsia recurvata* (Ball Moss), in prostate cancer treatment.

With these values in mind, the management of Jamaica's forest must be reassessed in order to reduce the factors which threaten to damage this ecosystem and to strengthen its ability to adapt to a rapidly changing climate. The vulnerability of forests is assessed here by considering the negative human impacts on them and the potential climatic impacts (Section 4.5.3) which will further challenge resource sustainability.

Over one-third of all forest reserves and other protected areas in Jamaica have been significantly disturbed by human activity (Figure 4.5.1). Forest cover change in Jamaica is relatively well documented, but the results are highly variable and the estimates of annual deforestation rates range from between 0.03 to 6.7% (Evelyn & Camirand, 2003). One of the main threats to Jamaica's forests has been the conversion of forest to non-forest land. Agricultural development has required the clearing of primary forests and has been ecologically very destructive especially since the slash-and-burn method of farming is still used in these areas. Many farms encroach on forest and other sensitive or important biodiversity areas, leading to habitat loss. Slash-and-burn farming depletes soil nutrients therefore farmers are often forced to rely on chemical fertilisers and pesticides, causing damage to downstream freshwater and coastal ecosystems. Inappropriate farming practices on steep slopes also causes extensive soil erosion and loss of topsoil in many areas of the island.

The need for land to support the growing manufacturing and tourism sectors has also contributed to the destruction of Jamaica's forest biodiversity. Bauxite mining, a major driver of the island's economy, causes deforestation not only in the mining areas, but through the creation of access roads through the forests. A fragmented and weakened ecosystem is less able to adapt to or rebound from climate changes such as temperature rise, intensified hurricanes and altered precipitation levels.

Figure 4.5.1: Present land use within forest reserves in Jamaica



(Source: adapted from Forestry Department, 1999)

Fresh water ecosystems

There are 10 hydrological basins which contain many streams, rivers, springs, ponds, lakes and blueholes (NEPA, 2003). However the distribution and status of Jamaica's freshwater biodiversity are yet to be assessed and mapped on an island-wide basis. Freshwater ecosystems provide habitat to a range of flora and fauna, and are the source of the island's water supply for agricultural, industrial and domestic use. . Rivers are of particular importance to the livelihoods of those involved in commercial freshwater shrimp, fish and snail harvest. These aquatic species are a major source of food for inland rural communities. Freshwater ecosystems are also significant to the cultural heritage of Jamaica. The freshwater snail *Neritina punctulata,* locally referred to as Bussu, is the main feature of the menu at annual Bussu Festival held in Portland parish. The festival is being developed by the Jamaica Tourist Board (JTB) and the Tourism Product Development Company Limited (TPDCo) as a community-based attraction for tourists.

Evaluating the vulnerability of this sector is challenging since it depends on both climatic and non-climatic factors. Fresh water availability and quality are sensitive to changing population demands and distribution, as well as variations in temperature and precipitation.

The main non-climatic threats to Jamaica's freshwater resource come from over-extraction, direct habitat destruction and alien invasive species. About 10 out of the 15 reservoirs in the country are significantly silted because of soil erosion due to the karst topography, deforestation and agricultural practices (US Army Corps of Engineers, 2001). The overuse of agro-chemicals leads to the contamination of freshwater systems as is the case in the eastern parish of St. Thomas where rivers have been polluted by the run-off from coffee farms. These same chemicals are at times deliberately poured into rivers in order to harvest freshwater fish and shellfish (Downer, 2008). The result is not only the degradation of freshwater habitats but also endangerment of human health. Poverty, unemployment and the resulting need for short term gains have been key drivers in these harmful and unsustainable practices.

Plant and animal invasive species present an additional hazard to the health of Jamaica's freshwater biodiversity. The Lower Black River Morass, the largest freshwater ecosystem in Jamaica, is already under threat from the draining of the wetland for agricultural or tourist development and faces the additional pressure of the melaleuca, or Australian paper bark tree. These trees absorb a lot of water and spread rapidly, potentially putting other wetland life at risk if not controlled. Another invasive species in the Lower Black River Morass, the water hyacinth, is a cause for concern for the National Irrigation Commission which has spent hundreds of thousands of dollars unclogging drains and irrigation channels. The plant also blocks sunlight from reaching native aquatic plants, starving the water of oxygen and thus killing fish and other organisms. The population and distribution of another invasive, the invasive suckermouth catfish, is currently being assessed. This freshwater fish may potentially out-compete tilapia, an important fish food to artisan and subsistence fishers who harvest from the Black River.

Coastal wetlands

Jamaica's coastal wetlands occupy nearly one third of the coastline, mainly in the low lying areas on the south of the island (UNFCCC, 2000). There are two main classifications for wetlands in Jamaica: swamps and marshes. Swamp wetlands are dominated by woody vegetation composed mainly of mangroves, swamp forest or palm swamps. Marsh wetlands include saline marshes and freshwater marshes.

The unique ecosystem found within mangrove forests is valuable for its protection of coastal areas and marine life; services which benefit humans, plants and animals. Coastal wetlands provide habitat for, oysters, birds, reptiles and fish including many commercially important fish species which spend part of their life cycles within mangal root systems. Mangroves also play an especially important role in the physical protection of shorelines by buffering against storm surge and reducing erosion by wave action. The roots of mangroves and marshes also perform valued site-specific functions by trapping sediment landward of the beach, making it available for natural accretion processes during periods of sand deficit. They also protect coastal areas and fringing coral reefs from siltation and pollution by slowing down flood waters and filtering out sediments and land-based pollutants. Their highly productive ecosystems are also capable of exporting energy and materials to adjacent communities such as sea grass beds and mud flats.

With regards to livelihood opportunities, mangrove wetlands – such as the Black River wetlands - can be important in generating ecotourism, offering recreational opportunities such as sight-seeing, boating, swimming, and sport fishing.

Draining and filling-in of wetlands to create agricultural land or land for urban growth and tourism expansion have been major causes of wetland loss in Jamaica. Recent plans for coastal improvement work in the Palisadoes peninsula, which lies within a National Heritage Site and a Ramsar Wetland of International Importance, threatens cays, reefs and two years worth of mangrove replanting efforts (Aiken K. , 2010). The greatest destruction has occurred in the larger estuaries now used for harbour facilities such as along Hunt's Bay and the Kingston waterfront. Consequently these areas have suffered a notable decline in fishery resources demonstrating the connectivity between ecosystems and the need for an integrated approach to natural resource management (NRCA & CZMD, 1995). Limited alternatives for those in poor rural communities has also damaged mangrove stands through overharvesting of the trees for fuel, construction of fishpots and furniture.

Although mangroves are hardy plants and have an innate resilience to cope with harsh environmental conditions (high salt, low oxygen and low nutrient soils) their ability to adapt to climatic changes will be compromised if non-climatic pressures are not reduced.

Beaches

Beaches are the most widely used natural resource in Jamaica's tourism industry. Their aesthetic appeal makes them prime property for hotels and accommodation, as well as an important location for recreation for tourists and locals alike. Beaches also play an important ecological role by providing habitat to a variety of plant and animal life. They are important feeding, breeding and roosting grounds for endangered sea turtles and shorebirds. Critical ecological functions also provided by the vegetation found on beaches and dunes include promoting shoreline stability by reducing the mobility of sand grains thus creating a reservoir of sand for beach nourishment. Beach sand protects coastal lands from erosion due to wave action, especially during extreme events and is a source for construction aggregate.

Destructive activities landwards and seawards of Jamaica's beaches are negatively impacting this valuable resource. On the landward side, impervious walls of buildings constructed with inadequate setbacks from the shoreline reflect wave energy back to the sea and accelerate the erosion of sand thus reducing beach width. Poorly constructed groynes, meant to guard against erosion, have the opposite effect causing sand to be removed from the down-drift side of the structure. Illegal sand mining and the removal of stabilising coastal vegetation have also contributed to the degradation of beaches and dunes in many parts of Jamaica.

Hydrodynamic modelling has shown that in Negril the observed rate of maximum beach erosion from 1968-2008 occurred in areas unshielded by coral reefs and thick sea grass beds, suggesting that these ecosystems provide protection to the beach by absorbing some of the wave energy (UNEP, 2010). Coral reefs are also important sources of beach sand therefore fewer reefs means less material available for sand formation. It is therefore reasonable to assume that the dramatic decline of Jamaica's coral reefs in the past 30 years has been a major factor in the increasing coastal erosion and beach loss seen around the Island.

Coral reefs

Fringing reefs occur along most of the north coast and sporadically on the south coast of the island, extending almost continuously along the edge of the shelf from Negril to Morant Point (See following

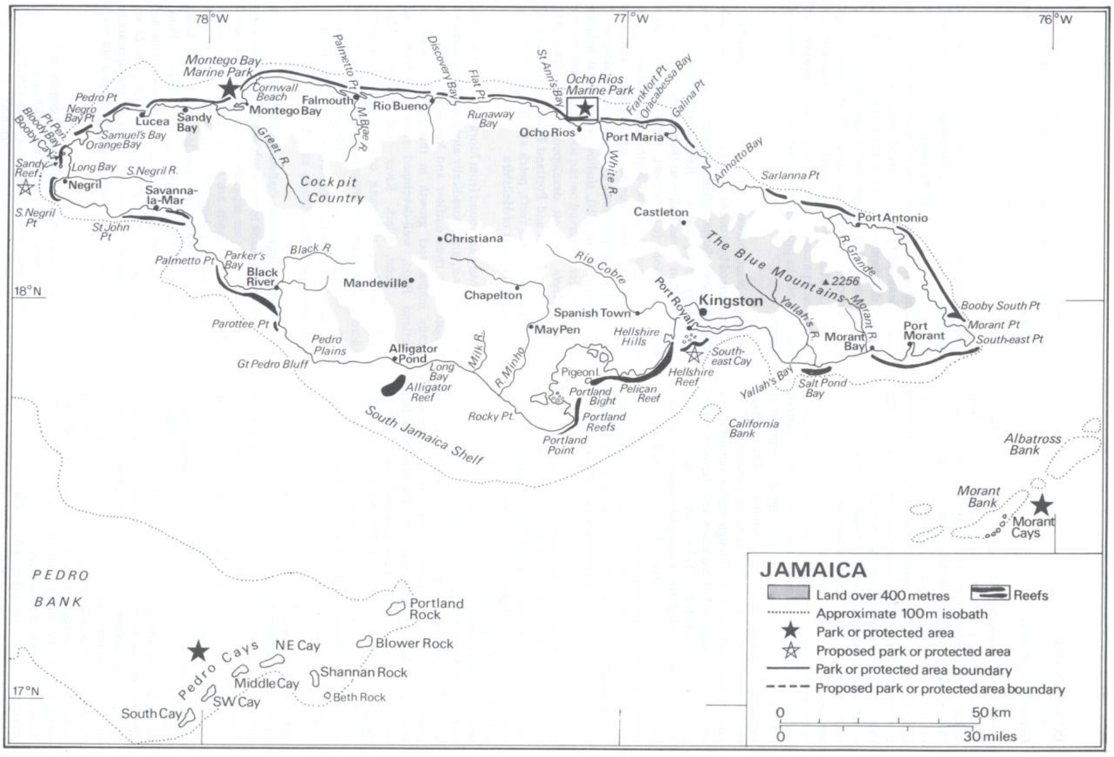


Figure 4.5.2). The greater part of the southern shelf is actually devoid of major coral reefs, except on the eastern portion between Kingston and Portland Bight (Old Harbour Bay) and at Alligator Reef (off Alligator Pond), where larger reefs and numerous coral cays exist. On the western section of the south coast, the reefs tend to be small, patchy and undeveloped, possibly due to the freshwater discharge from several large rivers. Reefs can also be found on the neighbouring banks of the Pedro Cays, 70 km to the south, and the Morant Cays, 50 km to the southwest.

Coral reefs are often called the "rainforests of the sea" for their high primary productivity and astounding richness in biodiversity. Reefs provide a wide array of goods and services both directly and indirectly. They act as physical barriers to storm surge and ocean waves, protecting vital coastal infrastructure. Coral reefs are also of major importance to the island's marine biodiversity serving as nursery grounds for juvenile fish and habitat for commercially important seafood species. The livelihoods of artisanal fishers in Jamaica directly depend on healthy reefs and many other people benefit directly and indirectly from the jobs, income, and tax revenue generated through fisheries and marine tourism. Coral reefs are also valued for their historic, cultural, medicinal and ecological significance (Schuhmann, 2008).

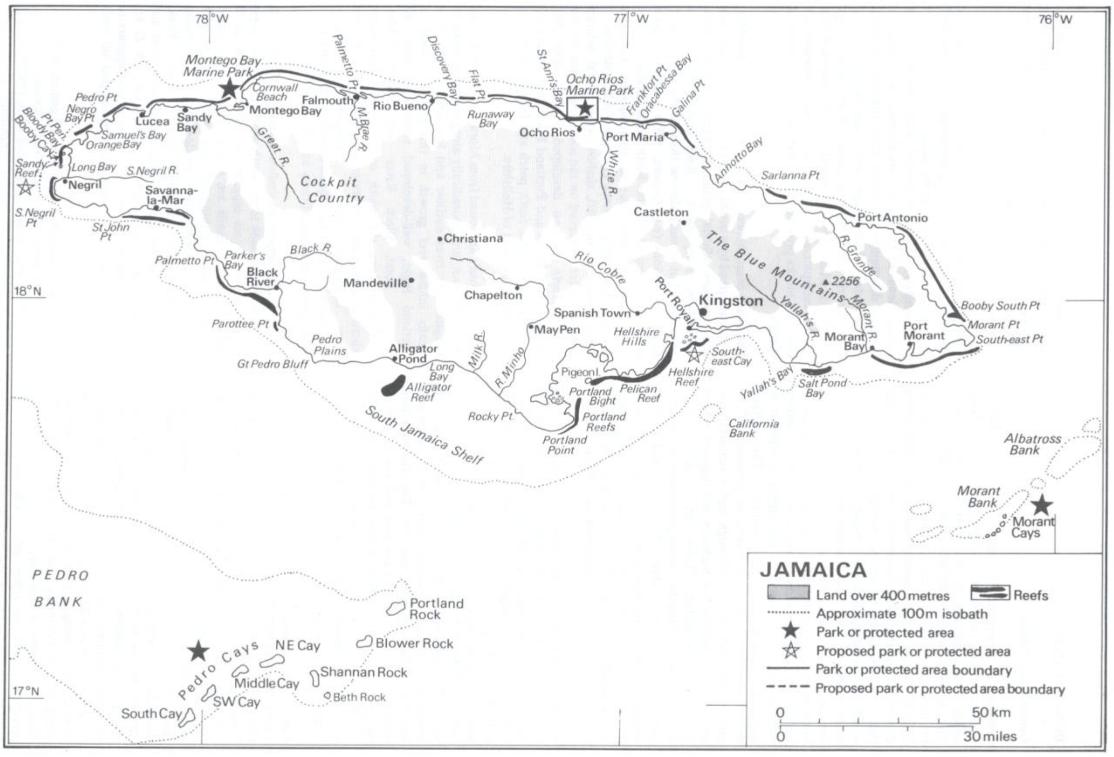


Figure 4.5.2: Location of coral reefs around Jamaica.

(Source: UNEP/IUCN, 1988)

Since the 1950s, coral reefs in Jamaica have deteriorated due to overgrowth by algae and sponges, pollution from sewage and agricultural runoff, over fishing, and poor diving practices and other activities related to the tourism industries (UNEP, 2010). The primary reef builders, elkhorn coral, *Acropora palmata,* and staghorn coral, *Acropora cerviconis,* were once abundant in much of the Caribbean but are now listed as 'endangered' under the US Endangered Species Act. Overfishing can be traced back over 100 years in Jamaica's history, making it the most-overfished island of the Caribbean. Most of the country's reefs have been overfished of all targeted reef fish species, including herbivores such as parrotfish. Removal of these herbivores has allowed corals to be overgrown by macroalgae in approximately two-thirds of Jamaican reefs (Figure 4.5.3) (Burke, *et al.,* 2004).

Over half of Jamaica's reefs are threatened with sedimentation from coastal development and poor agricultural practices. Land based sources of pollution from inadequately treated domestic waste water, fertilisers and industrial discharge are of major concern in Jamaica. Of particular concern is white pox disease which has devastated coral reefs throughout the Caribbean and Florida Keys, and is believed to be responsible for much of the coral reef loss there since 1996 (Sutherland & Ritchie, 2004). White pox disease is caused by a human strain of the common intestinal bacterium *Serratia marcescens*. The most likely source of the pathogen for coral reefs is under-treated human sewage (UGA, 2010).

Figure 4.5.3: Map showing areas of overfishing in Jamaica's coastal waters

(Source: Adapted from IUCN and UNEP, 2009. The World Database on Protected Areas (WDPA). UNEP-WCMC. Cambridge, UK)

Scientists agree that many of the reefs have been reduced to less than 10% live coral cover, and no longer function as vital ecosystems because their biodiversity is so severely degraded (Neufville, 2010). Generally, corals grow slowly and would thus take a long time to recover from physical damage and destruction by disease, especially so as they continuously face environmental degradation. Routine coral reef monitoring in Jamaica began in 2001. Data has shown that in recent times the reefs have rebounded from an average of 5% hard coral cover to an average of approximately 15% (NEPA, 2008). This may be due to the recovery of the long spined sea urchin (*D. antillarum*), a critically important grazer on coral reefs, which almost disappeared in an epidemic in the late 1970s.

Seagrass beds

Three common species of sea grasses found in the shallow coastal waters around Jamaica are: Turtle grass (*Thalassia testudinum*), Manatee grass (*Syringodium filiforme*) and Shoal grass (*Halodule wrightii*). These marine plants are limited to shallow water where sunlight penetration is adequate to facilitate photosynthesis. Seagrass beds are areas of high productivity producing more than 4000 g C/m^2/yr, contributing significantly to tropical reef and other nearshore communities. They play an important role:

- as a primary food source for the green sea turtle
- in fixing nitrogen; a process critical to the growth of all organisms
- in providing habitats – feeding, breeding, recruitment sites and nursery grounds – for juveniles and adults of reef organisms including important commercial fish species such as herring (Clupeidae) and jacks (Carangidae)
- in reducing sediment movement in nearshore waters and removing sediments from the water column
- in decreasing turbidity of the water
- in stabilizing the coastline

Due to their location adjacent to areas of increasing industrialisation sea grasses face threats from sedimentation, dredging activities (including expansion of beaches) and wastewater discharge. Sedimentation run-off from coastal construction and poor agricultural practices can smother the delicate blades of grass and block out essential sunlight. Nutrient overload from fertilisers and untreated sewage are also damaging to this marine ecosystem by encouraging the growth of algae which compete with seagrasses for light and oxygen. Additionally, boating in shallow waters can cause long-term damage to seagrass beds from anchors and propellers.

Fisheries

The fisheries sector provides about 12,287 primary and secondary jobs, and contributes 0.39% to Jamaica's economy (ACP Unit, 2009). Deficiencies in available information on catches and prices, and omission of non-market values such as fisheries biodiversity, make it impossible to provide an accurate appraisal of this sector.

The local fishing industry comprises of five main types of fishing operations:

- Industrial fisheries, for conch, lobster and fish;
- Artisanal fisheries at high sea, banks, inshore and inland;
- Aquaculture, including tilapia, penaeid shrimp, oysters, ornamental fish and others;
- Sport fishing for marlins and fishing trips with tourists and
- Collection of sea weeds, land crabs, etc.

Artisanal fisheries, which generally serve the domestic market, exploit the island shelf and reefs as well as on the offshore banks. Industrial fisheries are mainly involved in the export of conch and lobster, which generate much needed-foreign exchange. Despite severely overfished inshore waters, coral reef finfish still account for the largest catch category in Jamaica fisheries (CRFM, 2010). The catch of coastal pelagics is increasing as more fishers switch to gillnets in nearshore areas in response to declining reef stock. Pelagic fisheries are also targeted by sport fishers. One of Jamaica's popular tourism products making use of this resource is the annual Port Antonio International Marlin tournament; a successful event that has been running for the past 47 years.

In addition to providing livelihood opportunities and ensuring food security, a healthy, diverse fishery is important to coral reef health as herbivorous fish keep algal growth in check. The benefits of coral reefs have been outlined in a previous section.

All major commercially-important fish species and groups of species in the region are reported to be fully-developed or overexploited; Jamaica's fisheries are the worst of these. The shallow reef fishery is considered to be overexploited particularly on the south and west coasts of Jamaica. The top predatory fish such as grouper and snapper have been greatly reduced (Aiken & Kong, 2004) subsequently leading to overfishing of herbivorous reef fish. This disrupts the reef community, alters the food chain and leaves coral reefs susceptible to the overgrowth of algae.

Inshore fisheries also experience the most interaction with other coastal uses and impacts. As was previously stated negative impacts on coral reefs and sea grass beds have serious implications for the populations of commercially important species, conch and lobster.

An additional threat to Jamaica's reefs and fisheries is the voracious predator lionfish. As of 2010 almost every reef of Jamaica has uncounted numbers of this invasive species which could wipe out the already depleted fishing industry (Neufville, 2010).

Other significant species and habitats

Turtles. Abundant populations of sea turtles were once known to nest on the Jamaica's beaches. Habitat loss, environmental degradation and overexploitation have decimated all four species- Green, Hawksbill, Leatherback, and Loggerhead turtles. Only the Hawksbill turtle is seen with any regularity in Jamaica and despite its International Union for Conservation of Nature (IUCN) listing as "Critically Endangered" poaching of both turtle eggs and meat continues across the island. Only one turtle nesting beach being actively monitored in Jamaica.

Impending SLR and loss of beach front will further reduce available habitat (Fish, Gill, Jones, Renshoff., & Watkinson, 2005). A 0.5 m rise in sea level in the Caribbean is projected to cause a decrease in turtle nesting habitat by up to 35% (Fish, Gill, Jones, Renshoff., & Watkinson, 2005). Negative climatic impacts on coral reefs and sea grass beds could also reduce sea turtle populations. Global warming may alter breeding patterns of marine turtles as their gender depends on sand temperatures. Warmer temperatures result in a greater proportion of females. Increased atmospheric temperature increase associated with climate change will alter the sex ratio of hatchlings and the reproductive capacity of turtle populations.

Queen Conch and Spiny Lobster. The queen conch (*Strombus gigas*) and spiny lobster (*Panulirus guttatus* and *Panulirus argus)* fisheries are the most valuable foreign exchange fisheries in Jamaica (CRFM 2006). The agriculture industry projected total sales of US $8.3 million or J$728 million for the conch fisheries sub-sector for the 2010 season (Collinder, 2010). The lobster export market earns an average of US $4-6 million per year (CRFM, 2010). The Fisheries Division of Jamaica manages these fisheries through closed seasons and size restrictions (lobster). Conch is also protected under the Convention on International Trade in Endangered Species (CITES), to which Jamaica is a signatory.

As with other marine species, conch and lobsters are impacted by anthropogenic stressors such as over-exploitation, land based pollution and destruction of the marine environment. Additional threats may result from negative impacts of SLR, SST increases and other climate change impacts on sea grass habitat.

Marine mammals. Whale watching is a valuable industry that has been growing in the region with the potential to generate millions of dollars through direct and indirect expenditure. Jamaica has a new industry with one operator testing the opportunities to see sperm whales and other marine mammals (O'Connor, Campbel, Cortez, & Knowles, 2009). Whale watching has the potential to create substantial earnings for Jamaica but it is dependent on the continued presence of marine mammals in a certain area. Current evidence suggests that the distribution and/or abundance of cetaceans are likely to alter in response to continued changes in sea surface temperature with global climate change (Lamberta, Hunterb, Pierceac, & MacLeoda, 2010).

4.5.3. Vulnerability of biodiversity and fisheries to climate change

Climate change driven impacts will pose even greater threats to ecosystems and livelihoods in Jamaica in additional to the non-climate stressors with which species contend (Table 4.5.1). The small, isolated land mass makes the island inherently susceptible to the projected impacts of climate change, such as SLR, increased intensity of extreme weather events, oceanic and atmospheric temperature increases and altered patterns of precipitation which could cause increased droughts and floods. The expected changes in climate will exacerbate the degradation of the delicate organisms that comprise Jamaica's terrestrial and marine ecosystems which are already stressed by human activity. There is increasing recognition that small changes in climate can trigger major, abrupt responses in ecosystems when a threshold is crossed. The loss of biodiversity will have severe impacts on some of Jamaica's key economic sectors: tourism, agriculture and fisheries. Destruction of ecosystems will also impact livelihoods and threaten the physical security of the population. Biodiversity loss will reduce the nation's adaptation options and will hinder Jamaicans from achieving their goals of sustainable development if appropriate and immediate action towards climate change adaptation is not taken.

Table 4.5.1: Summary table of biodiversity in Jamaica and related anthropogenic and climate change threats

Ecosystem/species	Goods/Services Rendered	Threats	
		Anthropogenic	Climate change
Forests	Lumber, wood for fuel, fish pots, crafts; agricultural land, climate regulation, flood defence, medicinal	Poor farming practices, land clearing for agriculture and development, unsustainable harvesting of forest products	Altered precipitation patterns, warmer temperatures, intense storms
Freshwater Ecosystems	Habitat for plants and animals, food source, livelihood opportunities, cultural importance	Agro-chemical run-off, sedimentation, harmful fishing practices, invasive species	Heavier rains can increase sedimentation, longer dry seasons may limit available water
Coastal wetlands	Soil stability, sediment deposit, nursery for marine species, natural water filter, storm defence, nesting and roosting grounds for birds, medicinal, tannins	Removal of mangroves for construction, dredging, nearshore pollution	Sea level rise, changes in precipitation
Beaches and sand dunes	Tourist attractions, shoreline defence, nesting grounds for turtles	Coastal erosion from construction, poorly sited groins, near shore pollution, illegal sand mining	Sea level rise, increased wave action from extreme events
Corals Reefs	Primary productivity, habitat for marine species, beach protection and stability, sand source, fisheries resource, medicinal significance, tourist attraction	Sedimentation from construction, overfishing, destructive fishing methods, land based pollution including raw sewage, physical damage from anchors and divers,	Sea temperature rise, sea level rise, ocean acidification, intensified storms
Seagrass beds	Primary productivity, nursery for marine species (supports fisheries and dive tourism), nitrogen fixation, shoreline stability, reducing turbidity of water, food source for green turtles, recycle nutrients	Deteriorating water quality (sedimentation, eutrophication), anchor damage, dredging	Sea level rise, intensified storms,
Fisheries	Important source of protein, provides livelihood for fishers, fish processors and vendors,	Overfishing of near shore reefs, degradation of nurseries and habitats (mangroves, sea grass beds, coral reefs),	Sea level rise, sea surface temperature increases may damage threaten reef fisheries, SST may change migration and reproductive patterns; may make species more susceptible to disease

Climate change impacts on forests

While small changes in temperature and precipitation are known to have significant effects on forest ecosystems, there has been little research focused on the projected impacts of climate change on terrestrial biodiversity in the region. The Blue Mountains (2,256 m) and John Crow Mountains (1,140 m), which host over 1,000 species of plants and animals, are a type of tropical montane mist forest known as cloud forest. Some climate models suggest that with increased atmospheric temperatures the optimum climate for many cloud forest habitats will increase in altitude (Bubb, May, Miles, & Sayer, 2004). Assuming a cooling rate of 1°C per 150 m of altitude, a projected increase of 1.7 °C would require vegetative zones to migrate vertically by 260 m, and up to 530 m in a 3.5°C scenario (Day, 2009). The result could be a displacement of cloud forests into progressively smaller regions at the tops of mountains – possibly causing the loss of entire cloud forests if vertical migration is not possible. Projected changes in humidity may also result in forests becoming much drier, potentially causing the wilting and death of epiphytes, which provide important habitat for birds, insects and reptiles (Foster, 2001).

Caribbean forests have always suffered physical damage from storms, but there is evidence that the increasing intensity of hurricanes is causing more severe damage, with potentially longer term consequences for the integrity of the forest structure and canopy. Before Hurricane Gilbert, 1988, the area of forest plantations established with Caribbean Pine was about 11,250 ha. An inventory carried out in 1990 revealed that the area of Caribbean Pine had been reduced to about 5,200 ha (Forestry Department, 2002). There has since been a shift to more robust species that can withstand higher winds.

Climate change can thus alter the composition and functioning of forests, as well as the critical services they provide to people and surrounding ecosystems. The forest management plan does not currently address the projected impacts of climate change, but the Forestry Department of Jamaica is aware that it is an area that needs to be examined.

Climate change impacts on freshwater ecosystems

Climate change adds an element of uncertainty to the future sustainability of Jamaica's freshwater ecosystems. Large variations in observed rainfall patterns make it difficult to identify long term future trends for Jamaica. GCM project both increases and decreases in rainfall, ranging from -44% to +18% by the 2050s and -55% to +18% by the 2080s (Simpson, *et al*., 2010). An increase in precipitation may mean more intense periods of rainfall during the wet/rainy season. Unusually heavy rainfall will increase the amount of sediment and agrochemicals that are deposited downstream damaging coral reefs and other marine life. Silt deposition is hazardous in yet another way. Waterways that are clogged by sediment increase the chances of flooding of surrounding areas causing damage to wildlife habitat and presenting risk to human life.

However, most climate model projections for Jamaica project a decrease in average annual rainfall for the country in general (Simpson, *et al*., 2010). longer dry seasons and warmer temperatures could mean increased evaporation and reduced water levels of ponds, rivers and streams threatening the survival of freshwater biota and the livelihoods of those who dependent on it.

Climate change impacts on coastal wetlands

Global climate change, in particular variations in CO_2, temperature, precipitation and storms will threaten the survival of wetlands. Of these, SLR may be the greatest climate change threat to mangroves (Gilman, 2008). If mangroves are not able to migrate inland and if the rate of SLR exceeds the rate at which mangroves trap sediment for their own stability, then mangrove systems will not survive. The combined effects of SLR and stronger storm surges could also have damaging effects on coastal wetlands by eroding the island's shores, increasing the salinity of estuaries, altering tidal ranges, changing sediment and nutrient transport and increasing the frequency and severity of coastal flooding (Bergkamp & Orlando, 1999). Such environmental changes could adversely alter the conditions that wetlands need for survival. Degraded wetlands have a reduced capability to serve as natural filters and buffering systems for shorelines and coral reefs (UNFCCC, 2000).

Increased intensity of tropical storms has the potential to increase damage to mangroves through defoliation and tree mortality. As a result of Hurricane Gilbert in 1988 mangroves in Jamaica were severely damaged, with losses of up to 60% of trees in some areas (UNEP/CEP, 1989). The passage of Hurricane Ivan, 2004, also caused severe damage to mangroves in Portland Bight, removing foliage, snapping branches and uprooting trees (See Figure 4.5.4; ECLAC, UNDP and PIOJ; 2005). Mangroves reach maturity in 20-25 years so full development had not been attained between these two extreme events.

Figure 4.5.4: Damaged mangrove in Portland Bight following Hurricane Ivan

Changes in precipitation patterns are also expected to impact on mangrove growth and spatial distribution. Intense tropical storms and rainier wet-seasons can alter mangrove sediment elevation either through soil erosion and soil deposition (Smith III, Robblee, Wanless, & Doyle, 1994; Gilman, 2008). The more likely scenario expected for Jamaica is that of decreased rainfall and increased evaporation which will increase the salinity of water available to mangroves thus decreasing their net primary productivity, growth and seedling survival. The long-term effect would be a reduction in the diversity of mangrove zones (Duke, Ball, & Ellison, 1998). The social and ecological value of wetlands cannot be overstated and it is vital that strategies are adopted to minimise damage to this ecosystem.

Climate change impacts on beaches

In the Caribbean basin increased SST, SLR and extreme events are projected to accelerate in the coming decades and compound the existing threats to natural systems and society. The Caribbean is projected to experience greater SLR than most areas of the world due to its location closer to the equator and related gravitational and geophysical factors (Simpson, *et al*., 2010). Climate change models suggest that typically beaches will retreat landwards by approximately 100 times the rate of SLR. If beaches are unable to retreat inland, either because of the natural geology or because of man-made structures (seawalls, buildings, roads) then they will gradually disappear in a phenomenon known as "coastal squeeze".

Severe storms such as hurricanes can do much damage to a beach even changing the entire shape and area of the beach. Erosion of over 50% of beaches in Jamaica occurred during Hurricane Gilbert (UNEP/CEP, 1989). Like other natural systems, beaches are likely to recover from hurricane damage given sufficient time. Climate change projections suggest that hurricanes will likely increase in intensity; this may mean more severe damage to beaches with each extreme event and likely a longer recovery period. Without the presence of dunes, storm surges can cause extensive damage to roads, houses and other key infrastructure along the densely populated coastline of Jamaica.

The combination of non-climate stressors and climate change impacts is having a major effect on the rate of beach erosion along the Jamaican coast. The rate the erosion is very site specific, with some beaches having retreated by 100 metres or more over the past 60 years, while others have had no significant erosion (Robinson, Rowe, & Khan, 2006). While routine monitoring has only been carried out in Jamaica over the past 30 years, concerns about beach erosion are increasing rapidly (Robinson, Rowe, & Khan, 2006).

Climate change impacts on corals

Global warming poses a threat to coral reefs through increased bleaching events and subsequently a reduced resilience to climatic and other stressors. Corals are vulnerable to thermal stress and have low adaptive capacity. In response to an anomalous SST (about 1°C above average seasonal temperature) and increased solar radiation corals bleach, i.e. expel the symbiotic algae which are critical to the life of the coral, in response (Mimura, *et al*., 2007). SSTs in the waters surrounding Jamaica in JJA and SON have increased at an average rate of 0.7°C per decade between 1960 and 2006. GCM projections indicate increases of 0.9 to 1.8°C in annual mean sea surface temperature, relative to the 1970-99 average, in waters surrounding Jamaica by the 2080s across the three scenarios. Increases in SST of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals (Nicholls, 2007). Coral mortality has already been noted in Jamaica, as the death of a large number of corals in 1988 and 1990 was attributed to increases in the temperature of coastal waters (Anderson, 2000). The Regional bleaching event during 2005 affected a significant percentage of Jamaica's reefs and hard coral cover was significantly reduced after the bleaching event (Kane, 2005). Coral bleaching could become more frequent in the next 30 to 50 years or sooner without an increase in coral's thermal tolerance of 0.2 to 1.0°C (Sheppard, 2003; Donner, 2005). Climate model results imply that thermal thresholds will be exceeded more frequently with the consequence that bleaching will recur more often than reefs can sustain (Donner, 2005). Bleaching further weakens reef systems whose health has already been compromised by human activities and damages their ability to withstand the impact of other climate change impacts.

Warmer oceanic waters will facilitate the uptake of anthropogenic CO_2. In turn increased CO_2 fertilisation will change seawater pH having negative impact on coral and other calcifying organisms since more acidic waters will dissolve and this weaken the skeletal structure of such organisms. Coral reefs are also vulnerable to heavy damage from hurricanes as they may be broken, uprooted and destroyed during high wave or storm surge events. Recovery of coral reefs that were damaged by Hurricane Allen in 1980 was set back 8 years later when the island was again impacted by Hurricane Gilbert (UNEP/CEP, 1989).

The ability of coral reef ecosystems to withstand the impacts of climate change will depend on the extent of degradation from other anthropogenic pressures and the frequency of future bleaching events (Donner, 2005). The loss of corals would mean great economic losses to fisheries and tourism sectors, and increase the likelihood of coastal erosion (Anderson, 2000).

Climate change impacts on seagrasses

There has been little study on climate change impacts on sea grass beds. The proximity of seagrass beds to coral reefs exposes them to similar climatic change impacts. As with corals, SLR may reduce the available sunlight to sea grass beds and hence reduce their productivity. While there is no consensus amongst the models as to whether the frequencies and intensities of rainfall on the heaviest rainfall days will increase or decrease in the region (Simpson, *et al.*, 2010), increased rainfall could mean localised decreased salinity and thus decreased productivity of sea grass habitats.

On the other hand, CO_2 enrichment of the ocean may have a positive effect on photosynthesis and growth. The photosynthetic activity of dense sea grass stands have been shown to increase local pH potentially balancing a decreased pH from projected ocean acidification (Bjork & Beer, 2009). Sea grasses are sensitive to thermal discharges and can only accept temperatures up to 2-3°C above summer temperatures (Anderson, 2000). However, the impact of increased SST on sea grass beds in the Caribbean is uncertain, since studies have suggested that the photosynthetic mechanism of tropical sea grasses becomes damaged at temperatures as high as 40-45°C indicating that they may be able to tolerate temperature increases above some climate change model projections (S.J.Campbell, McKenzie, & Kerville, 2006).

Increased storm events, flooding or high intensity rainfall attributed to climate change, will exacerbate existing stressors by increasing the volume of polluted runoff from upstream sources. Sea grass beds are also vulnerable to extreme weather events; often after a hurricane beaches are strewn with mats of dead seagrass. Visible effects of Hurricane Gilbert on the north coast of Jamaica were seen in the increased size of Thalassia "blow-outs" (eroded edges of large seagrass beds) (UNEP/CEP, 1989). Such storms may also cause massive sedimentation increasing the turbidity of waters surrounding sea grass beds.

Climate change impacts on fisheries

Little is known about the long-term effects of climate change in the Caribbean Sea and in turn on fisheries population. As previously discussed, climate change will generally have negative and possibly debilitating impact on coral cover and thus further reduce the abundance and diversity of already depleted stocks of reef fish. Pelagic fisheries are considered to hold the greatest potential for fisheries development in the Region. Warmer waters may drive pelagic species away from the tropics in search of cooler temperatures. An additional concern is that SST increases can increase algal bloom as well ciguatoxins (BBC, 2010).

More intense extreme events will mean severe damage to nursery grounds. After Hurricane Gilbert in 1988 observers in Rocky Point, St. Thomas, Discovery Bay, Ocho Rios and Falmouth reported significantly reduced abundance of juvenile fish in those areas which suffered damage to seagrass beds and coral reefs (UNEP/CEP, 1989). Official estimates of the economic cost of that Hurricane amounted to approximately J$25m in damage to fishing beaches and Fisheries Division infrastructure, fishing gear and boats. Of particular note was the severe damage done to beaches at Manchioneal and Buff Bay. These traditional fishing villages lie only 20m from the shoreline and are located almost at sea level (UNEP/CEP, 1989).

4.6. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

4.6.1. Background

Small islands have the majority of their infrastructure and settlements located at or near the coast, including government, health, commercial and transportation facilities. In the Caribbean more than half of the population live within 1.5 km of the shoreline. Jamaica is no exception to this, as approximately 90% of the island's GDP is produced within its coastal zone (tourism, industry, fisheries, agriculture) and in particular, on continuous corridors of development along the north coast (UNFCCC, 2000; Mimura *et al.,* 2007). Tourism, the largest and most important sector of the Jamaican economy, is the key activity in the island's coastal areas. For example, the World Travel and Tourism Council (WTTC) estimate that in 2002, tourism represented 27% of Jamaica's GDP (WTTC, 2008). With its high-density development along the coast and reliance on coastal transportation networks, the tourism sector is particularly vulnerable to climate change and SLR. This section of the report will focus on the coastal vulnerabilities associated with 'slow-onset' impacts of climate change, particularly inundation from SLR and SLR induced beach erosion, as they relate to tourism infrastructure (e.g. resort properties), tourism attractions (e.g. sea turtle nesting sites) and related supporting tourism infrastructure (e.g. transportation networks). These vulnerabilities will be assessed at both the national (Jamaica) and local (Portland Parish) scale, with adaptation and protection infrastructure options discussed. Please refer to the following section for climate change vulnerabilities and adaptation measures associated with event driven or 'fast-onset' impacts such as disasters and hazards (e.g. hurricanes, storm surges, storms).

Coastal areas already face pressure from natural forces such as wind, waves, tides and currents, and human activities, such as beach sand removal and inappropriate construction of shoreline structures. Some coastal areas are highly susceptible to erosion, and beaches in Jamaica have experienced accelerated erosion in recent decades. Scientific evidence from a 2010 study in the western end of Jamaica (e.g. Negril) by the United Nations Environment Programme (UNEP) Division of Early Warning and Assessment warn that several beaches will disappear within the next five to ten years as a result of current severe and irreversible shoreline erosion and retreat (Matthews, 2010). The report further stresses that other coastal areas in the country are also experiencing similar threats, requiring immediate action. The impacts of climate change, in particular SLR, will magnify these vulnerabilities and accelerate coastal erosion within Jamaica due to increased wave attack. The estimated coastline retreat due to SLR would have serious consequences for land uses along the coast (UNFCCC, 2000; Mimura *et al.,* 2007; Simpson *et al.*, 2010), including tourism development and infrastructure that is concentrated along the coastlines (Figure 4.6.1). A primary design goal of coastal tourism resorts is to maintain coastal aesthetics of undisrupted sea views and access to beach areas. As a result, tourism resort infrastructure is highly vulnerable to SLR inundation and related beach erosion. Moreover, beaches are critical assets for tourism in Jamaica with a much greater proportion of beaches being lost to inundation and accelerated erosion long before resort infrastructure will be damaged.

Figure 4.6.1: Coastal Tourism Development Vulnerable to Storm Surge and Sea Level Rise

4.6.2. Vulnerability of Jamaica's coastline to sea level rise and storm surge

There is overwhelming scientific evidence that SLR associated with climate change is projected to occur in the 21st Century and beyond, representing a chronic threat to the coastal zones in Jamaica. The sea level has risen in the Caribbean at about 3.1mm/year from 1950 to 2000 (Church *et al.*, 2004). Global SLR is anticipated to increase as much as 1.5m to 2m above present levels in the 21st Century (Rahmstorf, 2007; Vermeer and Rahmstorf, 2009; Grinsted *et al.*, 2009; Jevrejeva *et al*., nd; Horton *et al.*, 2008). It is also important to note that recent studies of the relative magnitude of regional SLR also suggest that because of the Caribbean's proximity to the equator, SLR will be more pronounced than in some other regions (Bamber *et al.,* 2009; Hu *et al.,* 2009).

Based on the SLR projections for the Caribbean (see section 3.11 and 3.12), and consistent with other assessments of the potential impacts of SLR (e.g. Dasgupta *et al.,* 2007 for the World Bank), SLR scenarios of 1.0 m and 2.0 m and beach erosion scenarios of 50 m and 100 m were calculated to assess the potential vulnerability of major tourism resources across Jamaica.

To examine the SLR exposure risk of Jamaica, research grade Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) data sets that were recently publically released by the National Aeronautics and Space Administration (NASA) and the Japanese Ministry of Economy, Trade and Industry, were integrated into a Geographic Information System (GIS). The ASTER GDEM was downloaded from Japan's Earth Remote Sensing Data Analysis Centre using a rough outline of the Caribbean to select the needed tiles, which were then loaded into an ArcMap document. The next step was to mosaic the tiles into a larger analysis area, followed by the creation of the SLR scenarios as binary raster layers to analyse whether an area is affected by SLR through the reclassification of the GDEM mosaics (see Simpson *et al.*, 2010 for a more detailed discussion of the methodology). These assessments were used to calculate the impacts of sea level rise on the whole island.

To examine SLR-induced coastal erosion, a simplified approximation of the Bruun Rule (shore recession = SLR x 100) that has been used in other studies on the implications of SLR for coastal erosion was adopted for this analysis. The prediction of how SLR will reshape coastlines is influenced by a range of coastal morphological factors (coastal geology, bathymetry, waves, tidal currents, human interventions). The most widely used method of quantifying the response of sandy coastlines to rising sea levels is the Bruun Rule, which is appropriate for assessing shoreline retreat caused by the reestablishment of equilibrium beach profile inland by the erosion of beach material from the higher part of the beach and deposition it in the lower beach zone (Zhang *et al.,* 2004).

Table 4.6.1: Impacts associated with 1m and 2m SLR and 50m and 100m beach erosion in Jamaica

		Major Tourism Resorts	Sea Turtle Nesting Sites	Transportation Infrastructure		
				Airport Lands	Road Networks	Seaport Lands
SLR	1.0m	8%	25%	20%	2%	100%
	2.0m	18%	32%	60%	2%	100%
Erosion	50m	32%	43%	-	-	-
	100m	50%	57%	-	-	-

A summary of results for SLR and erosion impacts in Jamaica are noted in Table 4.6.1. These results highlight that some tourism infrastructure is more vulnerable than others. A 1 m SLR places 8% of the major tourism properties at risk, with an additional 10% at risk with a 2 m SLR. It is important to note that the critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure. Indeed if erosion is damaging tourism infrastructure, it means the beach has essentially disappeared. With projected 100m of erosion, half of the resorts in Jamaica would be at risk. Such impacts would transform coastal tourism in Jamaica, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and economic well-being of thousands of employees. Sea turtle nesting sites, a tourist attraction, are also at risk to SLR and erosion, with nearly one-third affected by a 2m rise in sea level and over a half at risk with 100m of beach erosion. Transportation infrastructure, also of key importance to tourism, is highly at risk. Ports are the most threatened, with 100% of port lands in the country projected to be inundated with a 1m SLR, followed by 20% of airports lands and approximately 30 km or 2% of road networks (Figure 4.6.2).

Figure 4.6.2: Coastal Road Networks Vulnerable to Erosion and Sea Level Rise

Given Jamaica's tourism dependent economy, the country will be particularly affected with annual costs as a direct result of SLR. For example, the Jamaican tourism sector could incur annual losses between US $1 billion in 2050 to over US $8.7 billion in 2080. Capital costs are also high, with rebuild costs for tourist resorts damaged and inundated by SLR amounting to over US $500 million in 2050 up to US $6 billion in 2080. Infrastructure critical to the tourism sector will also be heavily impacted by SLR resulting in capital cost to rebuild airports estimated to be between US $43 million in 2050 to US $761 million in 2080. The capital costs to rebuild port infrastructure is estimated to be between US $1.2 billion in 2050 to US $18 billion in 2080, particularly significant due to the impacts on the major trans-shipment terminal at Kingston. The capital costs to repair and rebuild roads impacted by SLR are also high, ranging between US $8 million in 2050 to US $58 million in 2080.

A particularly vulnerable coastline in Jamaica is the Portland Parish (Figure 4.6.3). In addition to the national assessment the CARIBSAVE field team conducted survey transects (perpendicular to the shoreline) at 5 locations around Portland Parish where tourism infrastructure was located. Four SLR scenarios (0.5 m, 1.0 m, 2.0 m, 3.0 m) were then applied to the region with the results mapped below (Figure 4.6.4 and 4.6.5).

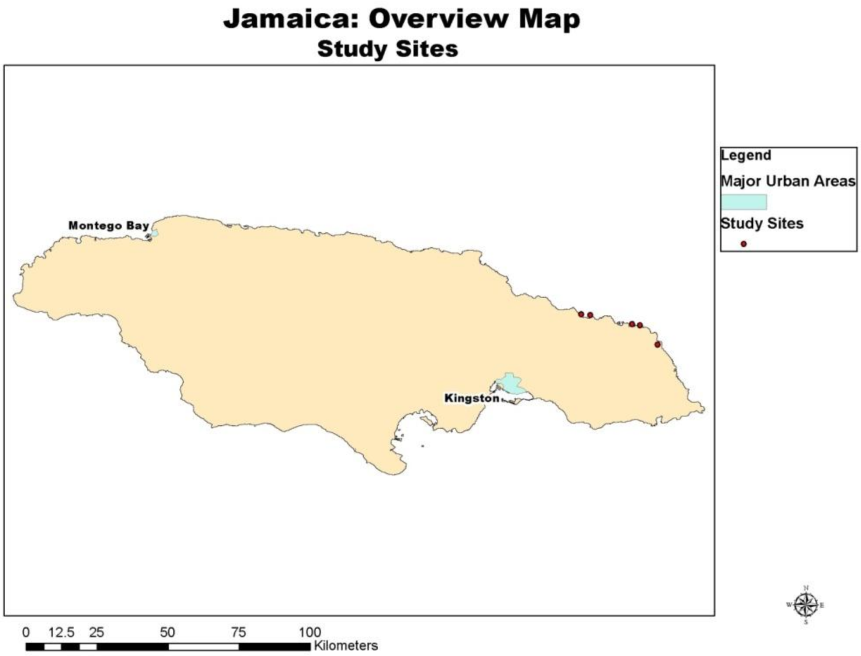


Figure 4.6.3: SLR Study Areas in Portland Parish, Jamaica

Following the field collection, all of the GPS points were downloaded on to a Windows PC, and converted into several GIS formats. Most notably, the GPS points were converted into ESRI Shapefile format to be used with ESRI ArcGIS suite. Aerial Imagery was obtained from Google Earth, and was geo-referenced using the Ground Control Points collected. The data was then inspected for errors and incorporated with other GIS data collected while in the field. Absolute mean sea level was determined by comparing the first GPS point (water's edge) to tide tables to determine the high tide mark. Three dimensional topographic models of each of the study sites were then produced from a raster topographic surface using the GPS elevation points as base height information. A Triangular Irregular Network (TIN) model was created to represent the beach profiles in three dimensions. Contour lines were delineated from both the TIN and raster topographic surface model. For the purpose of this study, contour lines were represented for every metre of elevation change above sea level. Using the topographic elevation data, flood lines were delineated in one metre intervals. In an effort to share the data with a wider audience, all GIS data will be compatible with several software applications, including Google Earth.

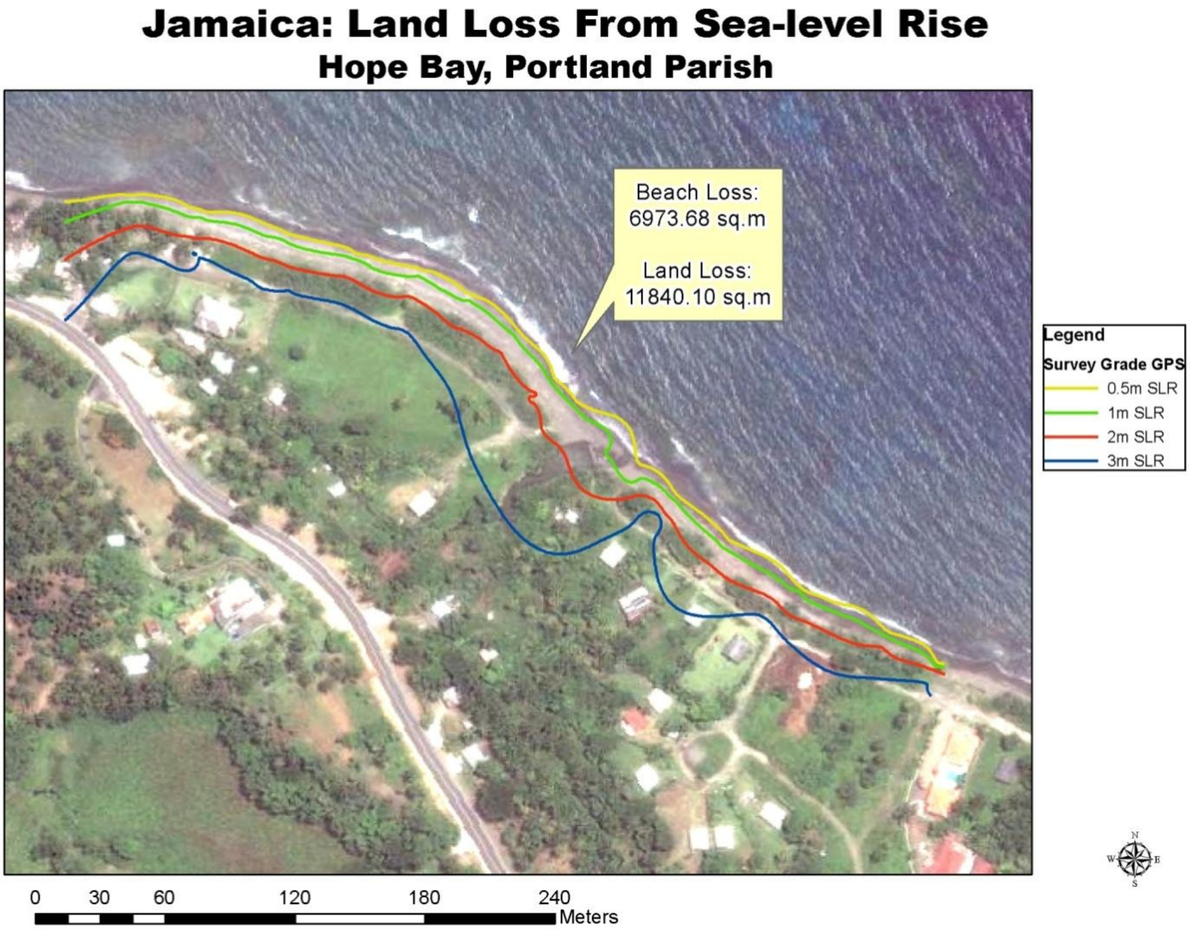


Figure 4.6.4: SLR Impacts at Hope Bay, Portland Parish

Even under the smallest SLR scenario (0.5 m, yellow contour), 35% to 68% of the highly valued beach resources in Portland Parish would be lost (Table 4.6.2). With a 2 m SLR (red contour), 100% of Frenchman's Cove and Winnifred Beach would become inundated and 98% of Hope Bay would be inundated. A 3 m SLR further exacerbates beach loss, four of the five beaches in Portland Parish lost (Frenchman's Cove, Hope Bay, St. Margaret's Bay, Winnifred Beach) and 93% of Long Bay beach becoming inundated.

Table 4.6.2: Beach area lost in four sea level rise scenarios across study sites in Portland Parish, Jamaica

	Frenchman's Cove		Hope Bay		Long Bay		St. Margaret's Bay		Winnifred Beach	
SLR Scenario	Beach Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Land Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Beach Area Lost To SLR (m²)	Beach Area Lost To SLR (%)	Land Area Lost To SLR (m²)	Beach Area Lost To SLR (%)
0.5 m	933	36%	3242.76	47%	28771	44%	14113	30%	2181	69%
1.0 m	1609	61%	5198.18	75%	30241	46%	21715	46%	2979	94%
2.0 m	2621	100%	6834.21	98%	58170	88%	43525	92%	3186	100%
3.0 m	2621	100%	6973.68	100%	61289	93%	46926	99%	3186	100%

A map of the severe risk that Long Bay, one of Portland's largest and most widely used beaches would face under a 3 m SLR is illustrated in

Figure 4.6.5. The response of tourists to such a diminished beach area remains an important question for future research; however local tourism operators perceive these beach areas along with climate to be the island's main tourism products.

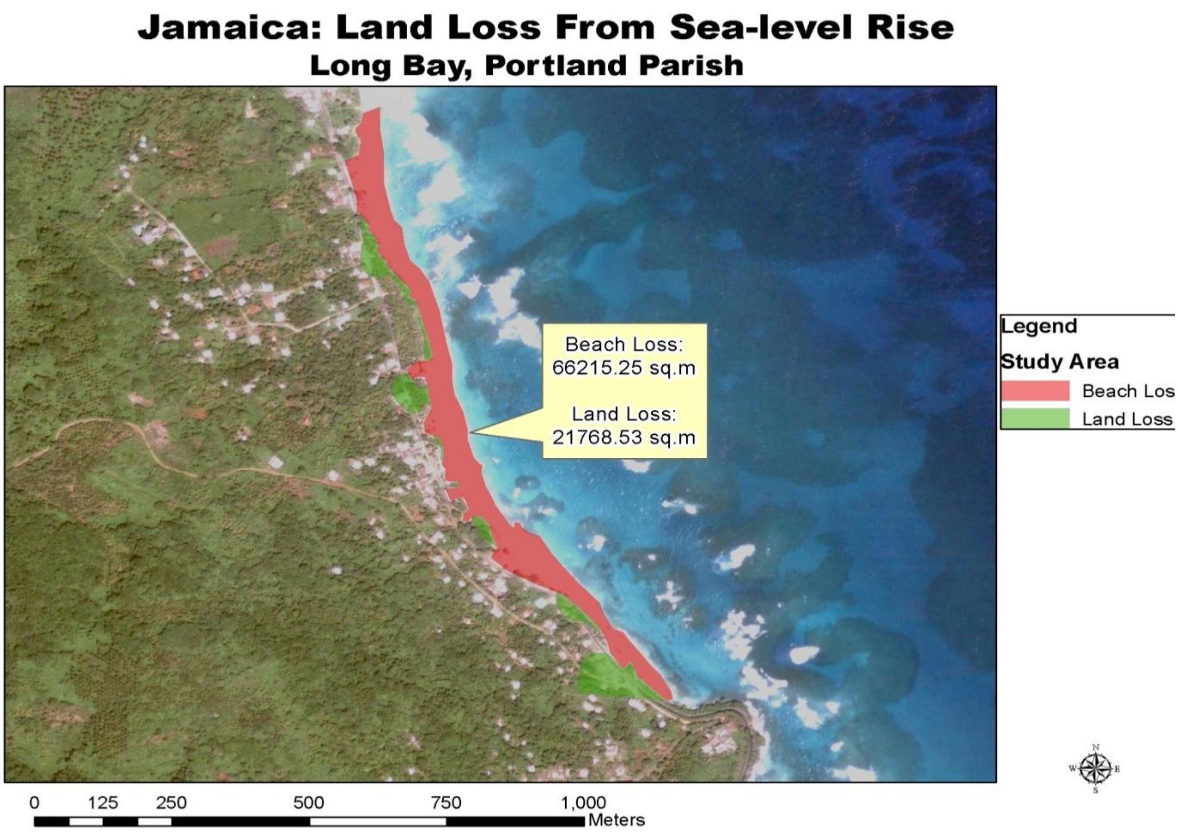


Figure 4.6.5: SLR Impacts at Long Bay, Portland Parish by a 3 metre flooding scenario.

4.7. *Comprehensive Natural Disaster Management*

4.7.1. History of disaster management globally

Though natural hazards have been affecting populations and interrupting both natural and human processes for millennia, only in the last several decades have concerted efforts to manage and respond to their impacts on human populations and settlements become a priority. Most recently these efforts have been informed by the work of the International Strategy for Disaster Reduction (ISDR), a United Nations agency for disaster reduction created after the 1990s International Decade for Natural Disaster Reduction. After several years of reporting on hazards and impacts, the ISDR created the Hyogo Framework for Action (HFA) in 2005. This strategy aimed at preparing for and responding to disasters was adopted by many countries in order to address a growing concern over the vulnerability of humans and their settlements. The HFA took the challenges identified through disaster management research and practice and created five priorities:

> *Priority #1: Ensure that disaster risk reduction is a national and local priority with a strong institutional basis for implementation*
> *Priority #2: Identify, assess and monitor disaster risks and enhance early warning.*
> *Priority #3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels*
> *Priority #4: Reduce the underlying risk factors.*
> *Priority #5: Strengthen disaster preparedness for effective response at all levels.*
>
> (ISDR, 2005)

Extensive elaboration of each priority is beyond the scope of this report, however, there are some key points that are considered here to inform the national disaster management context in Jamaica. Priority #1 of the HFA can be thought of as the foundation for hazard and disaster management.

> *Given that governance and institutions also play a critical role in reducing disaster risk,…fully engaging environmental managers in national disaster risk management mechanisms, and incorporating risk reduction criteria into environmental regulatory frameworks [are key options for improving how institutions address disaster-related issues] (UNEP, 2007, p. 15).*

The Hyogo Framework suggests strengthening effective and flexible institutions for enforcement and balancing of competing interests (UNEP, 2007).

Priority #2 focuses on spatial planning in order to identify inappropriate development zones, appropriate buffer zones, land uses or building codes and the use of technology to model, forecast and project risks (UNEP, 2007, p. 15). The development of technology for mapping, data analysis, modelling and measurement of hazard information offers decision makers a much better understanding of the interaction hazards have with their economy and society.

Priority #3 encourages the promotion and integration of hazard education within schools to spread awareness of the risks and vulnerability to the individuals of at-risk communities. This relates to climate change awareness as well. The countries of the Caribbean, including Jamaica, not only face annual hazards, but will also be directly affected by changes in sea levels, more extreme temperatures and other predicted climate changes. By educating children, hazard information will be transferred to adults and basic knowledge about threats and proper response to hazards, as well as climate change, can help improve community-level resilience. It is important that hazard and climate change awareness be promoted within the tourism sector as well, since tourists may not be familiar with the hazards in their destination and will thus require direction from their hosts.

Priority #4 demands the synthesis of the previous three priorities: governance, education and awareness, and appropriate technologies. "To develop and implement effective plans aimed at saving lives, protecting the environment and protecting property threatened by disaster, all relevant stakeholders must be engaged: multi-stakeholder dialogue is key to successful emergency response" (UNEP, 2007). Not only is this dialogue encouraged here; Goal 8 of the Millennium Development Goals also advocates for participation and open communication. As climate change threatens the successful achievement of the HFA and the MDGs, simultaneous dialogue about development and risk management will ensure continued resilience in communities and countries across the Caribbean.

The final priority of the Hyogo Framework, Priority #5, is geared toward a more *proactive* plan of action, rather than the reactive disaster management that has failed to save lives on many occasions in the past. It is now commonplace to have this same *proactive* approach to disaster management. However, finding ways to implement and execute these plans has proven more difficult (Clinton, 2006). Managing disaster risks requires an understanding of cross-sectoral relationships and the interdependent pressures that create vulnerability as well as demands cooperation of various sectors.

4.7.2. CDM and vulnerability in Jamaica

Vulnerability depends on exposure to a hazard as well as the capacity to cope with that hazard. The Inter-American Development Bank's (IDB) report on Jamaica's Catastrophe Risk Profile released in August 2010 revealed that the island is at risk of losing approximately US $105 million dollars in hurricane damage on a yearly basis. With an increase in the intensity of hurricane activity now being observed, due - in part - to the effects of climate change, this figure can only be expected to increase. What is also concerning is:

> *[the] vulnerability of the Caribbean countries due to their geographic location is compounded by the absence of economic diversity...Most Caribbean countries are strongly dependent on tourism and small-range of export farm commodities, such as bananas, sugar and coffee. Moreover, the relatively narrow geographical parameter of most Caribbean countries means that a single hurricane or severe flooding event affects the entire national territory, exerting measurable negative impacts on Global [sic] Domestic Product (GDP), through various channels, including dampened fiscal revenues, loss of employment, loss of foreign direct investment* (Shirley, 2005, p. 2).

Jamaica has also fallen victim to these vulnerabilities during recent disasters. For example, the agricultural sector, which is highly dependent on consistent rainfall and temperature ranges, also contributes 5% to Jamaica's GDP thus a disaster impacting the agricultural sector will also have impacts on the greater economy and livelihoods (see Section 4.3 Agriculture and Food Security). Furthermore, the major economic contribution from tourism in Jamaica means that projected changes in climate, specifically SLR, are likely to change the natural environmental features that tourists expect (e.g. coral reefs and beaches), as well as having a damaging effect on the tourism infrastructure located in low lying coastal areas.

There are three broad categories of hazards, and the countries in the Caribbean Basin could face all, or most, of them at any given time.

Types of Hazards in the Caribbean Basin	
1. Hydro-meteorological	Hurricane
	Tropical Storm
	Flooding
	Drought
	Storm Surge
	Landslide/mud-flow
2. Geological	Earthquake
	Volcano
	Tsunami
3. Biological	Epidemic
	Wildfire/Bushfire

Specifically, Jamaica is at risk to all of these hazards, except volcanoes. Jamaica is located on the Caribbean Plate, in an active seismic zone. Although there has not been a major earthquake impact in Jamaica for nearly a century, various moderate earthquakes have occurred near Kingston in recent decades (Smith, Zapata, & Meli, 2007). Additionally, flooding is commonly associated with weather troughs and frontal systems and also often results from tropical storms and hurricanes; with excessive rainfall, landslides in the steeply sloped hills on the island are also regular hazards (Smith, Zapata, & Meli, 2007). Drought and Wildfires are also of concern because of predicted climate changes that will lead to reductions in precipitation (See Section 3 Climate Modelling under Precipitation).

Health epidemics in Jamaica range from vector-borne diseases, like dengue fever, to infectious diseases like influenza. Additionally, an increase in vector-borne diseases has been linked to recent climatic events, and in February of 2010, Health Minister Rudyard Spencer pointed to the lack of rain as a contributing factor to an increase in the incidence of some communicable diseases, citing a marked increase of cases of gastroenteritis, malaria and dengue fever. It was noted that "*…as of the end of January 2010, there were 19 confirmed cases of dengue fever compared to 10 for the same period in 2009. Since the start of this year, we've had four confirmed cases of malaria (and) the total number of gastroenteritis cases up to the end of January was 3,890, a 30 percent increase over the 2,989 cases reported during the same period last year.”* (Caribbean360, 2010) ". Further details on disease outbreaks and their relationship with climate change have been discussed in detail in the Human Health report in this profile.

4.7.3. Vulnerability to natural hazards in Jamaica

In recent years, especially since Hurricane Gilbert impacted Jamaica in 1988, natural hazard events have highlighted the physical, social and economic vulnerabilities on the island.

Figure 4.7.1: Hurricane Dean impacts on Public Utilities in Jamaica

(Source: PAHO, 2007)

Hurricane Dean, a Category 4 hurricane impacted Jamaica in 2007. Post-disaster assessments following Hurricane Dean indicated various areas of vulnerability in Jamaica. Figure 4.7.2 illustrates the vulnerability of various sectors to hurricanes through their respective economic impacts from Hurricane Dean. Interesting to note are the impacts on the agricultural sector, where more than a third of the actual or expected damages and losses from Dean were felt in lost output (Caribbean Policy Research Institute, 2008, p. 27). Greater detail on agricultural sector vulnerability is explored in section 4.3: Agriculture and Food Security.

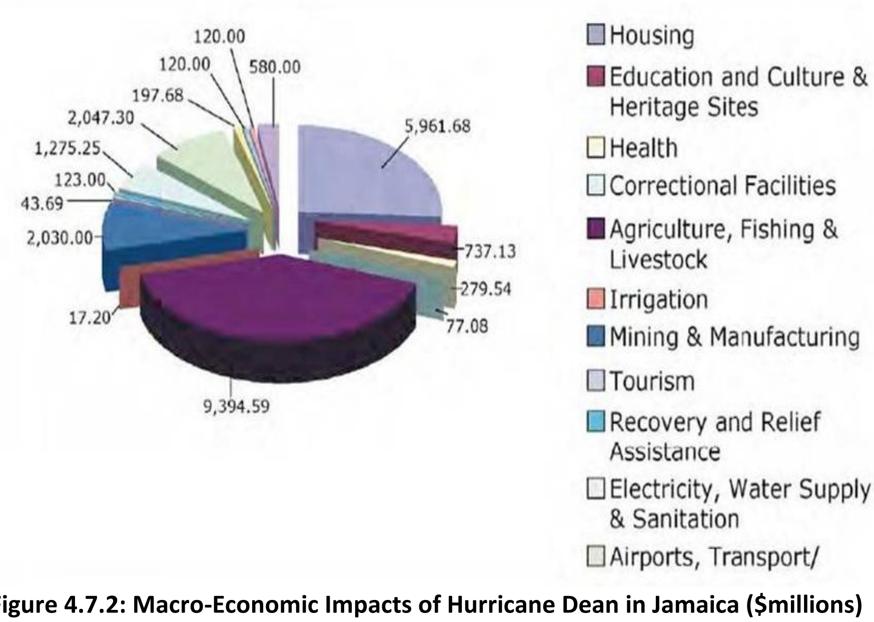


Figure 4.7.2: Macro-Economic Impacts of Hurricane Dean in Jamaica ($millions)

(Source: Caribbean Policy Research Institute, 2008, p. 27)

Additional impacts from the storm include damages to homes and public infrastructure, such as schools and police stations, at a cost of approximately J$23 billion, or US $326.94 million (approx. 10% of GDP) (Caribbean Policy Research Institute, 2008, p. 26). Housing in Jamaica is built with galvanized metal sheeting for the roof and over time rust can weaken the stability of the sheets.

In the general population, the poor were impacted considerably worse than the middle income, as would be expected (see Table 4.7.1). Generally, knowledge and awareness as well as livelihoods resources (financial, human, physical, social and natural capital) – the subsequent discussion in the section on Community Livelihoods, Gender, Poverty and Development: the Case-study of Port Antonio and Surrounding Communities.

Table 4.7.1: Relationship between economic status and level of impact in Jamaica following Hurricane Dean

Impact	Poor	Very Poor	Middle Income
Minor	17.1%	8.1%	40.6%
Severe	31.3%	40.5%	34.4%
Very Severe	51.6%	51.4%	25.0%

(Source: Caribbean Policy Research Institute, 2008, p. 28)

The impacts described above, however, note that housing and buildings, specifically roofing, are not currently built to withstand the high winds that accompany hurricanes. Shelter from a storm is an important aspect of safety and resilience, therefore the loss of roofing on homes and public infrastructure is a major concern that would put more pressure on sheltering relief efforts following a disaster. Furthermore, when residents refuse to take public shelters prior to impacts it is an indication that the system has failed in some way to build the necessary trust between the population and disaster management authorities. Vulnerability cannot be thought of only in terms of the physical characteristics and exposure sensitivities, but is also a function of community cooperation, respect and trust.

The nature of a tropical storm can cause different vulnerabilities to arise based on the trajectory of the storm or simply the category/intensity of the hurricane. In contrast to the impacts from Dean, damage estimates from Tropical Storm Nicole are now over US $13 billion (Golding, 2010). Assessments carried out by the transport and works ministry and the department of local government indicate that it will cost US $10.6 billion to restore the country's road network, while damage to the National Water Commission's systems has been placed at US $270 million. Moreover, though tourist arrivals during the period were not adversely affected, significant damage was done to beaches and buildings in Negril and that cost has been placed at over US $1 million. Further to this it was reported that 211 communities were adversely impacted by the sustained rainfall and flooding which resulted in 13 confirmed deaths (Golding, 2010). Further vulnerability discussions for the water, energy and other public infrastructure are located in the various named sections herein. The point to note is that impacts from natural hazards and extreme weather events serve to help identify how and why various sectors are vulnerable. Jamaica is vulnerable to high winds, flooding and landslides in various parts of the country. While ODPEM have embarked on an extensive community vulnerability assessment, other sectors too must be active in their efforts to reduce vulnerability.

Tropical Storm Nicole highlighted how vulnerabilities develop in some communities as a result of poor enforcement or a complete lack of land-use plans in areas where informal settlements have been constructed by residents themselves without proper approvals under the Town and Country Planning Act. People who live next to gullies are vulnerable to erosion of the sides of the gully walls, especially when their homes are near the gully edge (ODPEM Interview, 2011). Informal settlements are a complex phenomenon that is very difficult to control but it is these communities where many social, economic and environmental processes interact to generate great vulnerability.

The community of Sandy Park, located very near a gully in St. Andrew is a prime example of this in Jamaica. Their vulnerability also relates to knowledge and awareness of the environment in which they live. Persons interviewed for a news programme seemed to feel their community was safe from flooding and erosion in this location until one specific house was built (Jackson-Miller, 2010). Although that 1 home may have made the situation worse, the proximity of many homes in this community to the gully meant that all persons were vulnerable long before the new house was located in the way of the channel. Awareness of environmental processes is a major part of disaster risk reduction activities and Hurricane Nicole has highlighted that work on awareness raising and capacity building within the general public of Jamaica is far from finished.

Tropical Storm (TS) Nicole was a much weaker storm when you consider wind speed, but the greater number of fatalities (13 vs. 4 in Hurricane Dean) highlights the fact that flooding and landslides often pose much greater risk than the storm itself. Additionally, community level responses during TS Nicole identified that vulnerability results, to some extent, from poor understanding of the environments in which they have settled.

4.8. *Community Livelihoods, Gender, Poverty and Development: the Case-study of Port Antonio and Surrounding Communities*

4.8.1. Background[4]

> *Where disasters take place in societies governed by power relations based on gender, age or social class, their impact will also reflect these relations and as a result, people's experience of the disaster will vary.*
>
> *Madhavi Ariyabandu (UNECLAC, UNIFEM[5] and UNDP, 2005)*

Figure 4.8.1: Map of Portland Parish, Jamaica

(Source: GeoAtlas.com, 2004)

The parish of Portland in Jamaica is located in the north-east and borders the parishes of St. Mary and St. Thomas, covering an area of 814 square kilometres. Port Antonio, the parish capital, is about 60 miles from Kingston and is regarded as the cradle of the tourist industry in Jamaica, with residents who are both directly and indirectly involved in tourism. Although it is less popular than other well-known locations, it still represents a key tourism destination with a number of nature and eco-tourism activities, tourist accommodation and recreation facilities. As Port Antonio is located along the north-east coast, residents interact frequently with the sea and its resources for both recreational and livelihood uses. The communities in Portland are representative of coastal and rural communities in Jamaica whose livelihoods have linkages to tourism. Consequently, community assessments would provide a comprehensive overview of the vulnerability profile of these types of communities in Jamaica.

As at April 2008, the population of Portland was 82,025 persons accounting for approximately 3% of the Jamaican population. For that period, 45% of its residents were listed as at least 24 years of age, with slightly more females than males within the parish, as there were 41,130 females and 40,895 males. Approximately 23,000 or 28% of the residents of Portland resided in urban areas, namely Port Antonio and Buff Bay.

Average household size was relatively small, and in fact decreased from 3.72 to 3.35 persons over the period 1991 to 2001. Approximately 52% of the houses were built from concrete and blocks, with 54% of the households relying on water piped into a dwelling or yard and 82% relied on electricity as their main source of energy and lighting.

[4] Extracted and modified from http://lms.heart-nta.org/

[5] UNIFEM has been dissolved and incorporated into the newly established UN Entity for Gender Equality and the Empowerment of Women (UN Women)

For the period under consideration, the main sectors of employment were (i) Agriculture, (ii) Community, Social and Personal Services and (iii) Wholesale and Retail Trade. On the other hand, the main sectors of unemployment were (i) Construction, (ii) Community, Social and Personal Services and (iii) Wholesale and Retail Trade. An examination of employment rates indicated that persons seeking employment within the Mining, Electricity, Gas and Water and Agricultural sectors were most likely to be employed. Conversely, persons seeking employment within the Construction, Manufacturing and Restaurants and Hotels Sectors were least likely to be employed. Overall, the parish carried an employment rate of approximately 80%, 8 percentage points below that of the national average employment rate of 88%.

Labour force participation stood at a rate of 60%, with 35,960 persons participating in the labour force. Of note, males accounted for approximately 59% of the labour force. Of those employed, 50% was self-employed; approximately 79% worked full-time and the main places of employment were on a plantation/farm/garden, in an industry/factory/office and shop or store. Most persons were employed as Mixed Crop Growers, Demonstrators, and Market Salespersons. Conversely, most persons unemployed had last worked as Waiters, Waitresses and Bartenders, Bricklayers and Stonemasons, Domestic Helpers and Cleaners and Building Construction Labourers. The main occupational areas of interest for those unemployed were Demonstrators, Cooks and Housekeepers and Related Workers.

Port Antonio in Portland was selected as the community in which to implement the *Community Vulnerability and Adaptive Capacity Assessment* methodology developed by The CARIBSAVE Partnership. Due to the broad level of interest and existing vulnerabilities, several persons from surrounding communities participated. These communities included: Orange Bay, Buff Bay, Hope Bay, Boundbrook to Drapers and Snow Hill. The methodology uses participatory tools to determine the context of the community's exposure to hazards, and a sustainable livelihoods framework to assess adaptive capacity, and all data are disaggregated by gender. The three main means of data collection are: (i) a vulnerability mapping exercise which is the main activity in a participatory workshop; (ii) three focus groups (two single-sex, and one with persons with tourism-related livelihoods) ; and (iii) household surveys to determine access to five livelihood assets (financial, physical, natural, social and human). Livelihood strategies (combinations of assets) are evaluated to determine the adaptive capacity of households and consequently communities.

4.8.2. Natural resources and community livelihoods

Observed changes to the natural environment

Common understanding and perceptions of climate change in the community are strongly linked with those changes observed in the natural environment, and while some are not the direct result of climate change, the majority of the observations reported are consistent with the observed and predicted impacts published by the IPCC and regional scientific institutions. Multiple consultations with persons from several communities on the north-east coast of Jamaica indicate that community residents are witnessing both spatial and temporal shifts to a number of elements of the natural environment. The observed changes included:

1. rising sea level
2. coastal erosion and beach loss
3. new weather phenomena such as hail and mini-tornadoes
4. changes in agricultural yield and output; and insect species behaviour
5. shifts in the frequency and intensity of low pressure systems that affect the island
6. increasing incidences and severity of flooding events

7. decline in the health of coral reefs and other marine ecosystems

The adverse impacts of human activity were also identified by community residents, indicating some degree of awareness and appreciation of the implications and consequences of human actions. Solid waste management was the most critical of these, as it is a major concern in itself, and contributes to most of the other challenges presented. Such impacts, of course can render natural systems even more susceptible to climate change.

The challenges caused and faced by community residents result from:

1. lack of an effective solid waste management programme which contributes to illegal dumping and burning of waste;
2. chemical and solid waste pollution of rivers and streams for fishing purposes, but also resulting from the aforementioned solid waste issue and lack of due diligence;
3. increases in vector populations and associated health concerns;
4. destruction of wetlands and watershed areas for construction and physical development; and
5. unsustainable fishing and farming practices resulting in short-term high quality yield and high output, but longer term decline in soil quality, soil erosion, deforestation and a loss of marine and terrestrial biodiversity.

Implications for vulnerability of livelihoods

Up until the end of 2009, statistics indicate that nearly one-fifth of Jamaica's employed labour force was engaged in primary economic activities, including agriculture, hunting, forestry and fishing and thus depended on the good health and balance of the natural environment for their livelihood. In Portland specifically, according to 2008 statistics, the main sectors of employment – as highlighted previously – include agriculture; community, social and personal services; and wholesale and retail trade. Further to this, local community consultations suggested that residents of rural areas tend to engage in farming and agriculture, fishing, mining, vending and taxi operations. Community surveys suggested, outside of tourism activities, a high level of involvement in agriculture within the sample group. This is followed by government employment, and retail services. However, recent statistics indicate that tourism potentially has one of the highest unemployment rates by sector, and is also one sector least likely to employ job-seekers.

Industries that are natural resource-intensive and highly climate-sensitive include agriculture, fisheries and tourism (direct and indirect activities). These industries, and persons employed by them, are therefore considered particularly vulnerable to the impacts of climate change. Notwithstanding potential climate change impacts, satisfactory returns from these industries, in existing circumstances, clearly depend on a combination of agreeable climatic and environmental conditions, and human factors (enabling environment, competition, cost of living). Hence, the assessment of livelihood vulnerability focuses on these industries at particularly high risk, and highlights the need for prioritising adaptation strategies which are practical and industry-specific; to protect the livelihoods of the citizens thereby employed. A current coping strategy identified in the community is that some residents engage in a combination of activities to earn more income and to ensure greater financial stability.

Farmers and fishermen

Participants in the community consultations suggested that farmers in Jamaica have observed declines in agricultural production as a result of shifts in seasonal weather patterns. Hotter and longer dry periods and shorter, more intense rain events have caused crop yields to suffer. Banana farmers in particular have been impacted by intense weather events and have borne tremendous losses from hurricane and tropical storm systems that affected the island within recent years. Farmers in the area, and in particular those that rely on agriculture as their sole source of income, are at significant risk.

Fishermen likewise are particularly vulnerable to any further extreme changes. Income earnings by fishermen are relatively unsteady. Additionally, the fishing industry already faces multiple threats of loss of marine biodiversity and lack of infrastructure, mainly stemming from human impacts. Extreme climate and hydrological events have damaged or destroyed physical and technical resources owned by fishermen in the past and subsequently temporarily or permanently halted fishing activity for those individuals.

Unemployment statistics for these economic activities fluctuate during any given year, possibly influenced by the seasonality of some activities, but generally indicate that for every 100 persons employed by this sector, there are 2-3 persons that are unemployed (STATIN-JA, 2010). Therefore, any drastic changes or depletion in resources will likely cause unemployment to increase and exacerbate the poverty situation in Jamaica.

Tourism

Tourism provides year-long employment for locals, with peaks occurring during traditional winter months. Persons who are employed seasonally are already disadvantaged because work is only guaranteed for a portion of any given year and income from alternate sources is required to supplement for the remainder of the year. Additionally, the performance of the sector in terms of arrivals and tourism spending influences wage and the number of employed persons. So for a particularly low tourist season, there may be less work and lower wages for persons both directly and indirectly employed by the industry. Approximately 5-6% of the employed Jamaican labour force[6] fall within the Hotel and Restaurant category which serves as an indicator of the minimal percentage of persons directly employed by the tourism industry (STATIN-JA, 2010). However, this same category also has the second highest level of unemployment compared to other categories of employment by industry, and represented an average of 11% of the labour force that was unemployed between 2008 and 2009. For the same period, statistics showed that for every five persons employed in hotel and restaurant services, there was one unemployed (STATIN-JA, 2010).

Consultations with the community indicate that only a few members were directly involved in tourism, but those persons depended on that sector for their sole income-earning activity. As expected, responses also indicate that these persons have no alternative means of dealing with losses suffered from extreme weather which are often sudden.

Popular nature-based tourism activities in and around Port Antonio include hiking, sightseeing and marine recreational activities, all of which are dependent on stable and reliable weather conditions. Extremes of either heat, rainfall or ocean turbidity will adversely affect visitor experience and even the decision to participate in these activities in the first place. This has clear implications for livelihoods dependent on nature tourism.

Relationships between local agriculture, fisheries and tourism are also affected by adverse weather conditions, in that, farmers and fishers who depend on the tourism market for income encounter difficulties of supplying produce. Additionally, unexpected shifts in growing seasons may have negative impacts on a farmer’s quality and quantity of output, the market price for produce (which will be more expensive when it is scarce or “out-of-season”), and could likely subsequently result in reduced consumption of the local produce by tourism facilities. Local farmers may then suffer loss of markets or business to other producers who can provide a more reliable and consistent service.

[6] Working age population except those persons who are unable to work because of physical and/or mental disabilities.

4.8.3. Implications for gender-specific vulnerability in Port Antonio and surrounding communities

Socio-economic factors

Gender-specific experiences regarding impacts from weather and climate-related events have been researched and recorded, with strong indications of greater vulnerability of women, residing in poorer communities in particular, *during* events and disasters. Examining Jamaica specifically, the Jamaica Country Assessment Report for Enhancing Gender Visibility in Climate Change and Disaster Risk Management notes that poverty increases the vulnerability of women when there is a disaster, owing to the increasing proportion of women amongst the poor population, and the large number of single-parent or single (and therefore poorer) female headed households. The report mentions that "women's higher levels of poverty and increased vulnerability to disasters is related to their unequal participation in the labour force, lower rates of employment, and higher rates of unemployment" (Senior & Dunn, 2009). The average proportion of males in the employed labour force is 57%, mostly within primary and informal economic activity categories where more manual labour is required. More females however, are employed within secondary and tertiary economic activity categories. Between 2008 and 2009, females comprised more than half (up to 66%) of the unemployed labour force, 10% of which are unemployed females in the hotel and restaurant services category - the second highest category of unemployment for females.

These differences were also highlighted during the consultations with residents from rural and coastal communities in Portland, Jamaica. Discussions highlighted that, in addition to higher unemployment, more of the households within the community are female-headed, some as single parent households. The burden therefore rests with more women to provide for surveyed households. However, despite higher unemployment levels, women are generally more qualified than men, and engage in a variety of income-making activities. It was noted that males tended to resort to illegal activities for a faster income, and also experienced greater difficulty in sourcing and maintaining some (legal) forms of employment. Certain roles, within the hotel industry for example, were also disregarded by males who perceive them as too subservient or better suited (and dominated) by females (e.g. ancillary services).

The research conducted in Port Antonio suggested that local community organisations (including Councils and Clubs) were very active and acted as effective mechanisms for social change, empowerment and development. There is also an existing hierarchy of community based organisations which foster community governance and development. Gender participation in these organisations is reported to be balanced, but are mostly led by men. Despite the male-dominated leadership trend, women are not discriminated or ill-favoured for leadership, and assume other executive duties within the organisations.

Natural resources

During the consultations, males indicated a stronger dependence on the natural resource base than women for their livelihoods. They noted that this was due particularly to the larger participation of males in fishing and agriculture over women. Interestingly, male participants suggested that their contribution to the climate change issue was greater than females, because most of the activities or industries with the greatest contribution or influence on weather and climate related events are male-dominated: resource-intensive activities such as mining and factory industries, lumbering, slash-and-burning, burning of debris, inappropriate farming, fishing and general environmental practices. In light of these linkages, it was also concluded that in consequence, males will potentially suffer more from the potential impacts of climate change, since the same male-dominated resource-intensive activities contributing to climate change impacts and effects were also the most sensitive to climate change impacts.

Disaster management

According to Senior, *et al.* (2009), based on an interview with personnel at the Jamaica Bureau of Women's Affairs:

- *Women and men are differently exposed disasters because they have different biological, sexual and reproductive health needs and these factors influence their experience during disasters […the needs of menstruating, pregnant and breast-feeding women…] must be considered in a disaster.*
- *Women and men also face differences in specific health risks such as cancers.*
- *Women's unequal socio-economic status makes them more vulnerable to disasters since they experience higher rates of poverty and unemployment than men.*
- *Female-headed households are likely to be more negatively affected by disasters.*
- *Females are at risk from sexual harassment by men in shelters.*

5. ADAPTIVE CAPACITY PROFILE FOR JAMAICA

Adaptive capacity is the ability of a system to evolve in order to accommodate climate changes or to expand the range of vulnerability to which it can cope (Nicholls *et al.,* 2007). Many small island states have low adaptive capacity and adaptation costs are high relative to GDP (Mimura *et al.,* 2007). Overall the adaptive capacity of small island states is low due to the physical size of nations, limited access to capital and technology, shortage of human resource skills and limited access to resources for construction (IPCC, 2001).

Low adaptive capacity, amongst other things, enhances vulnerability and reduces resilience to climate change (Mimura *et al.,* 2007). While even a high adaptive capacity may not translate into effective adaptation if there is no commitment to sustained action (Luers and Moser, 2006). In addition, Mimura *et al.* (2007) suggest that very little work has been done on adaptive capacity of small island states; therefore this project aims to improve data and knowledge on both vulnerability and adaptive capacity in the Caribbean small island states to improve each country's capacity to respond to climate change.

Information on the following factors was gathered, where possible to reflect adaptive capacity for each socio-economic sector:

- Resource availability (financial, human, knowledge, technical)
- Institutional and governance networks and competence
- Political leadership and commitment
- Social capital and equity
- Information technologies and communication systems
- Health of environment

The information is arranged by sector, under the headings *Policy, Management and Technology* in order to facilitate comparisons across sectors and help decision makers identify areas for potential collaboration and synergy. Some of these synergies have been included in practical Recommendations and Strategies for Action which is the following section of this report.

5.1. *Water Quality and Availability*

5.1.1. Policy

In the Vision 2030 Jamaica National Development Plan the Government of Jamaica seeks 'to ensure adequate and safe water supply and sanitation' under one of their broader objective to create a prosperous society. This will require development of current infrastructure (GOJ, 2009f). The pathway by which this can be achieved has been developed through the integrate water resource planning and development, outlined in the Water Sector Policy, Strategies and Action Plan of Jamaica. Through the Water Resource Authority of Jamaica, the formulation of a Water Resources Development Management Plan and the National Irrigation Development Master Plan both seek to address issues related to water supplies and water demand across the island. Additionally, the National Water Commission is responsible for controlling water resource use on a parish scale (GOJ, 2004). Equity is one of Jamaica's six guiding principles in Vision 2030 Jamaica National Development Plan where the government is cognisant of the need to consider social services such as the provision of water (GOJ, 2009f). However, as a result of rapid urbanisation in Jamaica, social infrastructure has not developed at a similar rate leaving the country with a limited ability to adapt.

Within the Water Resources Authority of Jamaica, there is no specific government budget for climate change initiatives. However, specific externally funded projects are supported where funds can be accessed but only cover these specific projects. Even so, the funding arrangement is often co-financed, where the agency seeking funding has to contribute part of the budget of the given project. This has presented challenges in the completion of projects because of the inability to meet budget requirements for such projects (A. Haiduk, personal communication, January, 26th, 2011).

Mr Haiduk of the Water Resource Authority has stated that 'The recent world trends have shown its impact on Jamaica. Jamaica had to sign up with the International Monetary Fund (IMF) for budgetary support and the IMF conditions are very harsh. The Government needs to save where it can and in the WRA case no funds were allocated for technical budgets. The technical budgets allow us to continue upgrading the hydrologic network to ensure that data collected are of highest quality. While the WRA is able to produce quality assured/controlled data increasing efficiency is critical.' Such constraints will affect Jamaica's ability to adapt to problems that are exacerbated by climate change issues in Jamaica. One example where financial constraints have delayed development of water resource initiatives can be seen from saline intrusion of coastal aquifers: Marshall (personal communication, February 2nd, 2011) explained that there were plans to mitigate saline intrusion occurring in the St. Catherine Parish (See Section 4.1 Water Quality and Availability), however, although these were planned for April 2011, they were postponed to due financial constraints.

The Water Sector Policy Strategies and Action Plan 2004 document has also emphasised the aim of focusing greater on the restoration of existing resources and the enhancement of water quality, as opposed to financial investment in the development of new infrastructure. This results in less financial resources being required for capital investments (GOJ, 2004).

The Watershed Management Policy acknowledges the role of health watersheds in the prevention of flooding and in recharging of aquifer systems. Other policies, such as the Forest policy 2001, also link the overall health of the environment with water security and water quality. In the Social Sector Review 2009 of Jamaica, protection of the island's biodiversity on a whole was done in conjunction with the assessment of the water quality. Overall, the ability to execute environmental protection on a catchment level can translate into the ability to reverse threats to water scarcity, which is particularly of concern in drought prone areas (GOJ, 2009e).

5.1.2. Management

In the context of managing water resources, the institutional capacity in Jamaica can be considered as extensive. The Meteorological Services of Jamaica (MSJ) is the main institution that deals with climate change issues in Jamaica. They collaborate with local and regional institutions such as the UWI Mona Studies Group, the Cuban Institute of Meteorology, CCCCC and CIMH (Spooner, 2007). The MSJ is also the national country representative to a range of climate change related international conferences and institutions such as the COP, IPCC and UNFCCC (ECLAC, 2010) and with regards to the UNFCCC positions previously held have included Member of COP Bureau (Spooner, 2007).

There are a number of other institutions that are responsible for the provision and management of water resources and services in Jamaica. Chief among them are the National Water Commission, the Water Resource Authority, the Rural Water Supply Limited (RWSL) and the Rural Water Project (GOJ, 2007). Other agencies that also have some degree of specialised input into the management of water resources include:

- The Office of Utilities Regulation
- The National Solid Waste Management Authority
- The National Irrigation Commission Limited
- The National Environmental Protection Agency
- The National Environment Planning Agency
- The Natural Resource Conservation Authority

According to Barnett (2010) the following institutions should be considered in instances of drought

- The Statistical Institute of Jamaica
- Planning Institute of Jamaica
- Office of Disaster Preparedness and Emergency Management

This institutional framework could be simply modelled to suit the requirements of specific climate change policies and projects as the overall objectives of water conservation and sustainable water use are complementary in nature. In addition to the numerous Governmental institutions, the private sector has had some role in climate change and water related issues in Jamaica. Rose Hall, a water supplier to the tourism sector held four discussion groups on Climate Change and Alternative Energy in 2008 and 2009 in Kingston engaging various stakeholders in the climate change landscape of Jamaica.

While the institutional capacity in Jamaica is extensive, one of the main constraints to the sustainable development of water resources in the island has been found to be a lack of qualified personnel in the sector to implement current policies (UN, 2002). This has also been highlighted as a problem for drought management and policy making and implementation (GOJ, 2002). However, this is not the case within all organisations that encompass water resource management. For instance in the Water Resources Authority of Jamaica (WRA), the regulatory body of water resources in Jamaica, there are sufficient highly trained persons with masters and bachelor degrees. Mr Haiduk of the WRA has explained that 'the problem is one of how to keep staff when you have other options particularly the richer neighbours in the North are willing takes of experienced person.' Another point Mr Haiduk noted is that working within the public sector of

Jamaica does not have the same level of financial remuneration as the private sector, which in itself has limited opportunities. As a result this limits the number of qualified persons needed to ensure optimum functioning of such institutions. On the other hand Mr McKinney, of Rose Hall, the largest private water supplier on the island has commented that 'recruiting employees is not really an issue as the unemployment rate in Jamaica is so high.' He also raised the issue of finding persons suitably qualified, but because persons at Rose Hall have been employed for many years, this has been less of an issue (R. McKinney, personal communication, January 27th, 2011).

One area that human resources for the adaptation to climate change can be expanded, is through the use of community based organisations and non-governmental organisations. For instance, on 5 November 2007 *Jamaica's Initial Vulnerability and Adaptation Workshop for the Second National Communication to the UNFCCC* was held in Kingston. One of the main objectives of this programme was to underpin the potential contribution of Community-Based Adaptation as a sustainable means of combating climate change on a local and therefore case specific level. The project is currently being funded by the United Nations Development Programme and the Global Environment Fund. Jamaica was a pilot country for this study receiving as much as 20 project 1:1 co-financing in cash grants, of <US $50,000 each for a period of 5 years. The outcome of the projects currently devised within Jamaica can be beneficial on a community level and therefore indirectly on a national level (Rankine, 2007).

It is important to reemphasise that although water resources are available in Jamaica, management and distribution of water is a significant problem. Unaccounted water resource use in Jamaica was 57% of the total collected and processed in 2004 (OUR, 2004). The National Water Commission, through the assistance of the Office of Utilities Regulation, has sought to reduce this to 40% over a 10 year period. Efforts such as this are fundamental in directly tackling water conservation and ensuring water availability in the future. There have been several long term projects already designed that will be important in maintaining the quality and quantity of water available in Jamaica. According to Barnett (2010), these include:

- The Kingston Metropolitan Area Water Supply Rehabilitation Project – rehabilitation of the Spanish Town Water Treatment Plant among other supply strengthening initiatives.
- Kingston Water Supply and Sanitation Project – Mona and Hope Water Treatment Plants targeted
- Jamaica Water Supply Improvement Project – among other activities, this project involves the construction of a new 15 MG Water Treatment Plant and rehabilitation of the Constant and Sea View Water Treatment Plants
- Forestry Planting in Collaboration with the Forestry Department – Hope Valley watershed is the current target area

Rural areas in Jamaica have their own challenges and the Government of Jamaica has addressed them through the use of tank water distribution and delivery of water via water trucks (minimum 200,000 gallons of water delivered per truck per month for the financial yr 2006/2007) (GOJ; 2007).

5.1.3. Technology

In the National Water Policy Strategies and Action Plan, one of the objectives is resource monitoring and assessments which are important for generating statistical data. Such knowledge creation has a bearing on the climate change agenda. The WRA currently monitors water levels in 278 wells and have six groundwater loggers (A. Haiduk, personal communication, January, 26th, 2011). This is very important because the data are collected for the purpose of informing water supply management decisions and planning of infrastructure (WRA, 2011). These data will become even more critical for observing changes in water supply and decision making regarding the provision of water resources across the island in future as a result of climate change related events such as droughts. A recent initiative has been the implementation of a Ground Water Information Systems on all wells and springs across the island, which is vital in understanding the association between abstraction rates and ground water resource status and problems that can arise such as salt water intrusion and pollution from agriculture and industry (Karanjac, 2002).

Three recent projects have been undertaken by the Water Resources Authority of Jamaica which aim to acquire a better understanding of the implications of climate change on water resources in Jamaica. The first involves a water assessment of the Yallahs Basin, which is being funded by United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the Italian Ministry of the Environment and Territory (IMET). The other, funded by the World Bank/GEF was implemented by the CCCCC under the MACC facility and involved a vulnerability and capacity assessment for the Vere Plains in Clarendon (A. Haiduk, personal communication, January, 26th, 2011). Finally, due to concerns about the effects of SLR on coastal aquifers, a Vulnerability and Adaptive Capacity Assessment on the Rio Minho basin was also carried out in the southern Clarendon in 2008 involving modelling the projected impact of SLR on the aquifers water quality (G. Marshall, personal communication, February 2nd, 2011).

5.2. *Energy Supply and Distribution*

5.2.1. Policy

As evident from current energy documents in many countries both in the Caribbean and outside, tourism is not central in the consideration of wider strategies to reduce energy use (Brewster 2005, Haraksingh 2001). Yet, as this document has shown for Jamaica, its share in energy use and emissions is considerable, and likely to grow in the future, leading to growing vulnerabilities in a business-as-usual scenario. At the same time, the sector holds great potential for energy reductions. The sector should thus be one of the focus points of policy considerations to de-carbonise island economies.

It is vital for governments to engage in tourism climate policy, because tourism is largely a private sector activity with close relationships with the public sector at supranational, national, regional and local government levels, and through politics, there is thus an outreach to all tourism actors. Furthermore, governments are involved in creating infrastructure such as airports, roads or railways, and they also stimulate tourism development, as exemplified by marketing campaigns. The choices and preferences of governments thus create the preconditions for tourism development and low-carbon economies. Finally, there is growing consensus that climate policy has a key role to play in the transformation of tourism towards sustainability, not least because technological innovation and behavioural change will demand strong regulatory environments.

As pointed out by the Organisation for Economic Co-Operation and Development (OECD) (2010b), emissions of greenhouse gases essentially represent a market failure. The absence of a price on pollution encourages pollution, and creates a market situation where there is little incentive to innovate. While governments have a wide range of environmental policy tools at their disposal to address this problem, including regulatory instruments, market-based instruments, agreements, subsidies, or information campaigns, the fairest and most efficient way of reducing emissions is to considered to increase fuel prices, i.e. to introduce a tax on fuel or emissions (e.g. Sterner 2007, Mayor and Tol 2007, 2008, 2009, 2010a,b, Johansson 2000, see also OECD 2009, 2010b; WEF 2009; PricewaterhouseCoopers 2010).

Carbon taxes may be feasible for accommodation, car transport and other situations where tourism activities cause environmental problems. Taxation is generally more acceptable if taxes are earmarked for a specific use, which in this case could for instance include incentives for the greening of tourism businesses. Tax burdens would then be cost-neutral for tourism, but help to speed up the greening of the sector. If communicated properly, businesses as well as tourists will accept such instruments, and the economic effect can be considerable. The Maldives charge, for instance, US $10 per bed night spent in hotels, resorts, guesthouses and yachts, which accounts for 60% of government revenue (McAller *et al.,* 2005).

Money collected in various ways could be re-invested in sustainable energy development. Haraksingh (2001), for instance, outlines that there is a huge potential to use solar energy, with insolation of 15-20 MJ per m^2 per day being twice the level found in many industrialised countries. Both economical and non-economical technical solutions to reduce the energy-dependency of islands in the Caribbean could thus be implemented based on regulation, market-based approaches and incentives, as well as through financing derived from voluntary and regulatory carbon markets. Policy intervention is however needed to initiate these processes. Overall, Haraksingh (2001: 654; see also Headley 1998) suggests that:

> *The Caribbean region is a virtual powerhouse of solar and other renewable sources of energy waiting to be exploited. It has the advantage of not having winters when hot water demands can increase from summer by approximately 70% in cold climates. Solar water*

heaters for the tourism industry and domestic and commercial usage have perhaps the greatest potential. There is a general commitment to the development of [Renewable Energy] RE, but matters have not gone very far beyond this. The movement towards greater implementation of RE technologies is gaining strength, but there is a large gap between policy goals and actual achievement. Clearly, much work still needs to be done. Government fiscal incentives, greater infrastructure for policy development as well as joint venture partnerships are needed in the Caribbean region for a smooth transition.

5.2.2. Management

Any action on reducing energy use and emissions of greenhouse gases has to begin with a review of emission intensities, to enable action where this will lead to significant reductions. From a systems perspective, hundreds of minor actions will not yield anywhere near as much as one change in the major energy consuming sub-sectors. Aviation is thus, as outlined earlier, a key sector to focus on, followed by - in smaller to medium-sized islands - hotels, as these are comparably energy-intense, while car-travel is not as relevant. Cruise ships will often be the third most relevant energy sub-sector. This is however dependent on whether fuels are bunkered in the respective island or not.

Tourism management is primarily concerned with revenue management, as the ultimate goal of any economic sector is to generate profits and jobs. A general critique of tourism management in this regard must be that it is too occupied with revenue, rather than profits as well as multiplier effects in the economy. This is an important distinction because profits have been declining in many tourism sub-sectors, such as aviation, where revenues have been increasing through continuously growing tourist volumes, while profits have stagnated. This is equally relevant for average length of stay, which is falling worldwide: to maintain bed-night numbers, destinations have consequently had to permanently increase tourist numbers. Both trends need to be reversed.

In an attempt to look at both profits and emissions of greenhouse gases, a number of concepts have been developed. One of the most important overall objectives can be defined as to reduce the average energy use/emissions per tourist. In the case of Jamaica, average emissions per tourist are already comparably low, i.e. corresponding to emissions of 635 kg CO_2 per tourist for air travel (Gössling *et al.,* 2008). This is largely because the most important market for arrivals, the USA, is comparably close. Table 5.2.1 illustrates this for a number of islands in terms of weighted average emissions per tourist (air travel only) as well as emissions per tourist for the main market. In the case of Jamaica, these are identical, but the table can nevertheless serve as the first and most relevant benchmark, i.e. emissions caused by one tourist arrival.

Table 5.2.1: Average weighted emissions per tourist by country and main market, 2004

Country	Av weighted emissions per tourist, air travel (return flight; kg CO_2)*	International tourist arrivals (2005)	Total emissions air travel (1000 tonne CO_2)	Emissions per tourist, main market (return flight; kg CO_2) and percentage share of total arrivals*
Anguilla	750	62 084	47	672 (USA; 67%)
Bonaire	1302	62 550	81	803 (USA; 41%)
Comoros	1754	17 603**	31	1929 (France; 54%)
Cuba	1344	2 319 334	3 117	556 (Canada; 26%)
Jamaica	635	1 478 663	939	635 (USA; 72%)
Madagascar	1829	277 422	507	2 159 (France; 52%)
Saint Lucia	1076	317 939	342	811 (USA; 35%)
Samoa	658	101 807	67	824 (New Zealand; 36%)
Seychelles	1873	128 654	241	1935 (France; 21%)
Sri Lanka	1327	549 309	729	606 (India; 21%)

Notes:* Calculation of emissions is based on the main national markets only, using a main airport to main airport approach (in the USA: New York; Canada: Toronto; Australia: Brisbane); **Figures for 2004.

Source (tourist arrivals): UNWTO Compendium of Tourism Statistics, Madrid: UNWTO, 2007; and UNWTO, Yearbook of Tourism Statistics Madrid: UNWTO, 2007.

(Source: Gössling *et al.,* 2008)

A strategic approach to reduce per tourist emissions would now focus on further analysis of markets. To this end, an indicator is the arrival-to-emission ratio, based on a comparison of the percentage of arrivals from one market to the emissions caused by this market (

Table 5.2.2). For instance, tourists from the USA account for 67% of arrivals in Anguilla, but cause only 55% of overall emissions. The resultant ratio is 0.82 (55% divided by 67%). The lower the ratio, the better this market is for the destination, with ratios of <1 indicating that the market is causing lower emissions per tourist than the average tourist (and vice versa). Arrivals from source markets with a ratio of <1 should thus be increased in comparison with the overall composition of the market in order to decrease emissions, while arrivals from markets with a ratio of >1 should ideally decline. In the case of Anguilla, the replacement of a tourist with a ratio of >1 in favour of one tourist from the USA (ratio: 0.8) would thus, from a GHG emissions point of view, be beneficial. However, as arrivals from the USA already dominate overall arrivals, it may be relevant to discuss whether the destination becomes more vulnerable by increasing its dependence on this market.

Table 5.2.2: Arrivals to emissions ratios

	Anguilla	Bonaire	Jamaica	Saint Lucia
Primary market Emissions ratio	USA 0.8	USA 0.5	USA 0.8	USA 0.9
Secondary market Emissions ratio	UK 2.5	Netherlands 1.6	-	UK 2.0
Third market Emissions ratio	-	-	-	Barbados 0.1
Fourth market Emissions ratio	-	-	-	Canada 1.0

(Source: Gössling *et al.,* 2008)

To integrate emissions and revenue, energy intensities need to be linked to profits. An indicator in this regard can be eco-efficiencies, i.e. the amount of emissions caused by each visitor to generate one unit of revenue. This kind of analysis is generally not as yet possible for Caribbean islands due to the lack of data on tourist expenditure by country and tourist type (e.g. families, singles, wealthy-healthy-older-people, visiting friends and relatives, etc.), but Figure 5.2.1 illustrates this for the case of Amsterdam. By assigning eco-efficiencies, it is possible to identify the markets that generate a high yield for the destination, while only causing marginal emissions. For instance, in the case of Amsterdam, a German tourist causes emissions of 0.16 kg CO_2 per € of revenue, while a visitor from Australia would emit 3.18 kg CO_2 to create the same revenue.

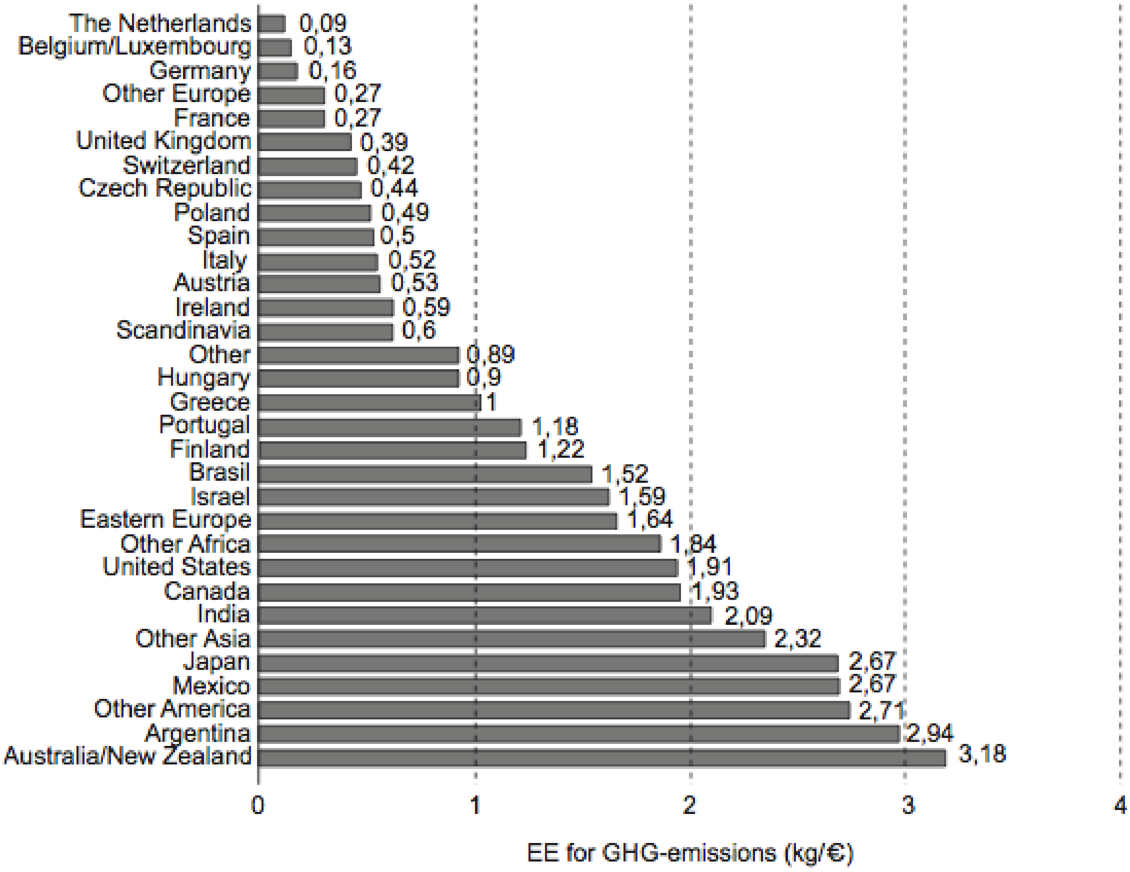


Figure 5.2.1: Eco-efficiencies of different source markets, Amsterdam

(Source: Gössling *et al.,* 2005)

These indicators can serve as a basis for restructuring markets, possibly the most important single measure to reduce the energy dependence of the tourism system. However, further analysis is required to distinguish revenue/profit ratios, leakage factors/multipliers (to identify the tourist most beneficial to the regional/national economy) and to integrate market changes into an elasticity analysis (to focus on stable, price-inelastic markets) (see also Becken 2008, Schiff and Becken 2010). No study that integrates these factors has been carried out so far, but further developing such strategic tools for revenue and energy management would appear useful for the Caribbean.

While these efforts to restructure the tourism system in the islands would be key priorities, there are also various other options for businesses to reduce emissions. For instance, Hilton Worldwide saved energy and water costs in the order of US $16 million in the period 2005-2008, primarily through behavioural change of employees as a result of a training in resource-efficiency. These measures have to be discussed on the business level and are mostly relevant to accommodation and activities managers. As about 15% of a typical Caribbean hotel's operating cost is attributable to energy usage (Pentelow and Scott 2011, based on Caribbean Alliance for Sustainable Tourism, 2001), management-related reductions in energy use of 20%

would correspond to savings of 3% on the overall economic baseline. This should represent a significant incentive to engage in energy management. For further details on energy management see Gössling (2010).

5.2.3. Technology

The potential of saving energy through technological innovation has been documented for a growing number of case studies. For instance, luxury resort chain Evason Phuket & Six Senses Spa, Thailand, reports payback times of between 6 months and ten years for measures saving hundreds of thousands of Euros per year. Often, it is also economically feasible to replace conventional, fossil-fuel based energy systems with renewable ones, with payback times of 3-7 years (e.g. Dalton *et al.,* 2009). It is beyond the scope of this report to list all measures in this regard, and readers are referred to Gössling (2010) for further guidance: case studies provided in this book indicate technology-based energy savings potentials of up to 90% for accommodation.

Examples of the economics of resource-savings from the Caribbean include five case studies in Jamaica (Meade and Pringle, 2001). Properties investigated within the framework of a re-structuring programme include the Sandals Negril (215-rooms), which saved approximately 45,000 m^3 of water (compared to pre-Environmental Management System standards), 444 MWh of electricity, and 100,000 litres of diesel. The total investment for the programme was $68,000[7]. As Meade and Pringle (2001) outline, with estimated savings of $261,000, the programme yielded an annual return on investment (ROI) of 190% over the first 2 years. The payback period for the initial investment was approximately 10 months. A second case, the Couples Ocho Rios (172-rooms) saved approximately 31,000 m^3 of water and 174 MWh of electricity. The total investment for the programme was $50,000: approximately $20,000 in equipment and $30,000 in consulting fees. Based on the estimated savings of $134,000, the programme yielded an annual ROI of 200% over the first 16 months. This represents a payback period of just 6 months. The Swept Away (134-rooms) saved approximately 95,000 m^3 of water, 436 MWh of electricity, 172,000 litres of liquefied petroleum gas and 325,000 litres of diesel. Based on available data, the total investment for the programme was approximately $44,000. Based on the estimated savings of $294,000, the programme yielded an ROI of 675% over the first 19 months. The payback period for the initial investment was approximately 4 months. The fourth establishment, the Negril Cabins (80-rooms) saved approximately 11,400 m^3 of water and 145 MWh of electricity. In addition, the hotel achieved savings of over $5,000 on laundry chemicals since August 1998 through its towel and linen reuse programs and efforts to reduce the use of laundry chemicals. Based on available data, the total investment in the programme was $34,670, and the resulting savings over 2.75 years are estimated to be $46,000, producing an annual ROI of 48%. Finally, Sea Splash (15-rooms) saved approximately 7,600 m^3 of water and 154 MWh of electricity. The cost of the project at this resort was $12,259, and the savings since July 1998 are estimated at $46,000, yielding an annual Return on Investment (ROI) of 151% over the first 2.5 years of the project.

[7] These figures are presumed to be in US dollars, though the currency could not be confirmed.

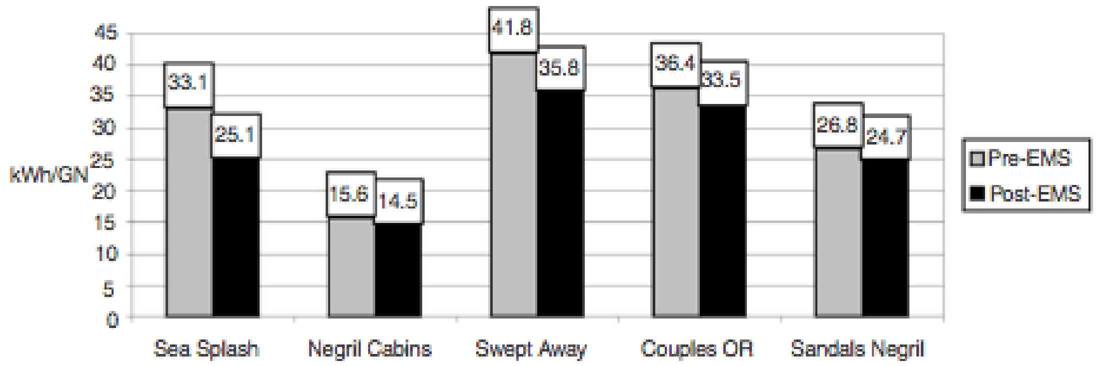


Figure 5.2.2: Change in electricity consumption, pre- and post Environmental Management System

(Source: Meade and Pringle, 2001)

As outlined, managers will usually be interested in any investment that has pay-back times as short as 5-7 years, while longer times are not favourable. While this would support investments into any technology with payback times of up to 7 years, it also opens up opportunities to use the Clean Development Mechanism (CDM) as an instrument to finance emission reductions. The CDM is one of the flexible instruments of the Kyoto Protocol with two objectives: to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the convention of cost-efficient emission reductions; as well as to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments. The CDM is the most important framework for the supply of carbon credits from emission reduction projects, which are approved, validated and exchanged by the UNFCCC secretariat. CDM projects can be implemented in all non-Annex I countries, and are certified by operational entities (OE) designated by UN COP (IPCC 2007). The CDM thus generates credits, typically from electricity generation from biomass, renewable energy projects, or capture of CH_4, which can be sold in the regulatory or the voluntary carbon markets. As such, it is a novel instrument to restructure islands towards low-carbon economies.

In Jamaica, discussions are already ongoing of how to use the CDM in restructuring the energy system. The MEM (2009) states that:

> *Carbon credits are a key component of national and international attempts to reduce the growth in concentrations of greenhouse gases. A Carbon Emissions Trading Policy is now being developed to address Jamaica's participation in the Clean Development Mechanism and its position regarding carbon neutral status in sectors such as the tourism industry.*

It is worth noting, however, that emission reductions achieved through the CDM do not apply to the Jamaican economy, rather than the purchaser's economy. While the CDM is thus an instrument to achieve technological innovation, it is not an instrument to achieve carbon neutral status.

Further funds can be derived through voluntary payments by tourists. For instance, Dalton *et al.* (2008b) found that 49% of Australian tourists were willing to pay extra for renewable energy systems, out of which 92% were willing to pay a premium corresponding to 1–5% above their usual costs. In another study, Gössling and Schumacher (2010) found that 38.5% of a sample of international tourists in the Seychelles expressed positive willingness to pay for carbon-neutrality of their accommodation, out of which 48% stated they would be willing to pay a premium of at least €5 per night. While these values are not representative, they nevertheless indicate that there is considerable potential to involve tourists emotionally and financially in strategies to implement renewable energy schemes. Such options should be further explored.

5.3. *Agriculture and Food Security*

5.3.1. Policy

There is currently no national policy or legislation dealing specifically with climate change in Jamaica. Although Mclymont-Lafayette (2007), while conducting climate change research on the Mocho agricultural district in Jamaica, found that there were seven public sector plans and nine pieces of legislation that mention climate change, there is a dearth in the legislative framework for directing climate change issues especially as they relate to agriculture. Actually Jamaica is still in the process of reviewing or developing several pieces of legislation that are relevant to adapting to climate change issues. At the policy level, several plans have been put in place to mitigate climate change impacts. These are briefly outlined in Figure 5.3.1.

Figure 5.3.1: Existing Mitigation Plans for Climate Change impacts on Agriculture in Jamaica

The Jamaica Ministry of Agriculture and Fisheries has also made some interventions to help farmers deal with climate change issues through special programmes such The A.L.I.G.N initiative (Arable Lands Irrigated and Growing for the Nation) launched by Minister Tufton on February 9, 2010 . The programme is a drive to (a) engage land owners of prime agriculture lands that are either underutilised or unutilised and encourage them to put these lands back into production and (b) 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 now being prepared for productive use.

Additionally, the Ministry is exploring on-farm water management systems to deal with drought. The Food and Agriculture Organization (FAO) is currently funding a J$20m pilot project to implement a rainwater harvesting system in South St. Elizabeth, which is the most productive agricultural territory in Jamaica, but also the area most severely challenged by water deficits.

Some response strategies for climate change are underway. Jamaica participated in Clean Development Mechanism (CDM) activities and established an interim Designated National Authority (DNA) in 2002. A draft CDM Portfolio of projects and draft sustainable development criteria has been crafted. Other initiatives pertaining to climate change and agriculture include the development of storm surge maps and multi-hazard assessment maps for Kingston and the creation of reliable Early Warning Systems for hurricanes and storm surges.

Evidently, Jamaica has initiated the process to include climate change policy into public policies but the focus is on ensuring national food security and environmental sustainability which both indirectly support the cause for climate change adaptation.

5.3.2. Technology

The Vision 2030 document for Agriculture in Jamaica explains that widespread application of modern technology outside the traditional export agriculture has been limited. Current research and development efforts are focused on germplasm development/improvement, agronomy and production systems, plant and animal health, and value added product development.

According to an August 2010 report in The Gleaner, the training manager at the Rural Agricultural Development Authority (RADA) said that her research found that only about 15 to 20% of traditional farmers utilised information and techniques from extension officers. The challenge is to get these farmers to incorporate greater use of technology in farming instead of acquiring information from their peers, or continuing to rely solely on the techniques they had learnt from their fathers and grandfathers.

The research also confirmed that low agricultural productivity on local farms is linked to the resistance of farmers to new technologies. The officer admitted that one of the greatest problems is the perception of some traditional farmers who believe that the younger generation is not equipped to provide or apply sound technical principles for farming. This resistance to technological change inhibits the capacity for the development of climate change strategies that would help extension officers and specialists to improve the level of productivity and reduce risk elements among the traditional farmers.

In 2008, a joint initiative involving the Ministry of Agriculture and Fisheries, Rural Agricultural Development Authority (RADA), HEART Trust/NTA (National Training Agency), and the United States Agency for International Development (USAID) was launched to improve farmers' skills in greenhouse technology in order to boost agricultural production and local food security. Greenhouse technology has been scientifically proven to aid in the mitigation of climate change impacts. The programme is targeted towards the youth in agriculture who learn skills to correctly fabricate greenhouses, as well as use protected horticultural and agricultural practices to respond to the needs of the agricultural sector. Trainees are instructed on plant growing environment, structure and systems; plant nutrition and fertilisation; integrated pest management; and crop culture.

A government project aimed at developing a technologically driven and modern agricultural sector in Jamaica has been allocated JA$66.3 million for the 2010/11 financial year. The objectives are to increase productivity and sustain production and marketing of high quality products; and to support the adaptation of greenhouse technology. Achievements up to March 2010 include the establishment of one greenhouse cluster within 18 greenhouses in St. Elizabeth and anticipated targets for the 2010/11 fiscal year include the installation of 22 commercial greenhouses for one cluster of farmers. The Jamaican Agricultural Sector is poised to take advantage of the technological advances that are used to prepare the industry to deal with climate change impacts. The numerous initiatives indicate that work is in progress. However, the volume and scale of work compared to the potential size of the agriculture sector needs to be upsized to adequately address climate change impacts. Furthermore, given the existence of numerous bodies associated with technology generation, adaptation and transfer for local agriculture (UWI Mona, HEART

Trust/NTA, RADA, CARDI, IICA, FAO, and various national farmers' organisations); coordination presents an issue to avoid duplicating efforts and for sharing information amongst these entities.

5.3.3. Farmers' adaptation - initiatives and actions

A study conducted by Campbell and Beckford (2009) suggests that despite high levels of vulnerability to hurricanes, farmers have achieved successful coping and adaptation at the farm level. Farming households in four communities in southern St. Elizabeth parish, the bread basket of Jamaica, were polled to assess the adaptive capacity and strategy among farmers in that area. The main damage-reducing strategies of farmers during before the impact of Hurricane Dean were the protection of nurseries, (re) transplanting, crop bracing, lowering yam sticks, cutting trenches, spraying crops as well as the harvesting and storage of produce. Post hurricane measures included harvesting and plant restoration, relocation of farm plots and scaled down production.

The Caribbean Agricultural Research and Development Institute (CARDI) has long recognised the 'dry-land' farming system in the parish of St. Elizabeth as one of the most innovative water management systems in Jamaica. Dry-land farming technology developed and perfected over the years has played a major role in addressing issues resulting from climate change, especially drought. The underlying principle of dry-land farming is water conservation, which is achieved principally through grass mulching. In St. Elizabeth, Guinea grass (panicum maximum) is a sacred crop. It is cultivated as a cash crop for mulching purposes. Water application is the other major component of the dry-land farming system. The mulching tradition is coupled with the modern technology of drip irrigation to enhance the efficiency of water usage.

A Hazard Risk Management Study for Agriculture, conducted by The Food and Agriculture Organization of the United Nations (FAO, 2008) concluded that Jamaican small farmers use a variety of good practices for mitigating the impact of hydro-meteorological hazards caused by changing climate. The table below highlights some of the practices that were identified during the field survey component of that project.

Table 5.3.1: Agricultural Practices and Climate Change Mitigation Effects

Agricultural Practice		Application	Climate Change Mitigation Effect
1.	Guinea Grass Mining	Drought/moisture deficit	Reduce wind erosion, soil temperature and run-off
2.	Minimum Tillage	Drought/Rainfall-related soil erosion	Reduced fossil fuel use, reduced soil erosion
3.	Drip Irrigation	Drought	Water conservation
4.	Fire-breaks	Drought-induced bushfires	Extra protection against wind damage for storms
5.	Rainwater Harvesting & storage	Drought	Water conservation
6.	Aquifer recharge	Drought & Flood impact reduction	Drought and flood mitigation, mitigation of saline intrusion
7.	Timing of Crop Establishment	Drought	Drought mitigation
8.	Raised Beds/Network Drains	Floods	Reduction in the depth and of area extent of floods
9.	Planting of drought tolerant crops	Drought impact reduction	Drought mitigation
10.	Contour planning of Matt & King Grass	landslides	Slope stabilization, soil loss and reduction

The evidence here suggests that Jamaican farmers are capable of making appropriate changes to adapt agricultural production to changing climate conditions. The fact that agricultural production is maintained in Jamaica under varied and challenging conditions also suggests that, as climate changes, Jamaican farmers may find it possible to adapt agricultural production in ways that take advantage of these changed conditions.

5.4. *Human Health*

5.4.1. Policy

The most recent development in the climate change landscape in Jamaica is the Jamaica National Climate Change Policy and Action Plan draft (Department of Environment, Office of the Prime Minister of Jamaica). Additionally, in the Government's Vision 2030 ambitions, the 14th out of 15 ambitions is 'Hazard Risk Reduction and Adaptation to Climate Change' which will have important implications for health in the areas of vector borne diseases and the previously described complications that natural disasters such as hurricanes can cause within the public health care system of Jamaica. Therefore, a vision for addressing issues is vital if Jamaica's development is to continue unimpeded over the next 20 years.

The Government of Jamaica's Heath Sector Plan for Vision 2030, outline amongst the Action Plans Under its *Goal 1: Social, Cultural, Physical and Economic Conditions that Support the Health and Wellbeing of Jamaica Society,* which involves the infusion of climate change issues into the National Health Policy and which is one of the strategies under the responsibility of the Ministry of Health and the Environment and other Environmental Organisations (GOJ, 2009a). As with governments throughout the Caribbean region, Jamaica is currently tailoring its responsibilities and focussing on the increasing challenges that climate change will present in the health sector.

To achieve progress in health care at a national level all of society must be taken into consideration and accounted for. The Government of Jamaica attempts to address this. For instance on a policy level, in the Ministry of Health's Strategic Plan 2006 – 2010, it states that one of the roles of the State is to pursue equity as well as equitable access to health services. In the *National Report of Jamaica Millennium Development Goals (MDG) for the UN Economic Council Annual Ministerial Review*, among the MDG targets, progress was achieved in the areas of absolute poverty, malnutrition and hunger. It was also highlighted that the incidence of malaria was being halted and is in the process of transfer. Access to safe drinking water and sanitation has also improved (GOJ, 2009c). The National Water Policy of Jamaica also found that 'the use of pit latrine and other sanitary conveniences has declined commensurately' (GOJ, 2004).

On the other hand, there is a concern that the proportion of persons living in urban areas that are defined as slums or in unacceptable living conditions is increasing (GOJ, 2009c). While one of Jamaica's health care system's goals is to seek 'equity, access and quality in the delivery of services to improve health' (GOJ, 2009), the problems of inequity and poverty have been acknowledged in the Vision 2030 Jamaica National Development Plan which identifies the reduction of inequity as one of its goals (GOJ, 2009f).

Associated with the above is the issue of sanitation, the National Water Commission's has a goal to establish sewerage systems in all major towns by 2020. This is particularly relevant for informal settlements that exist on the island without access to toilet facilities (GOJ, 2005). The National Sanitation Policy of Jamaica (2005) noted that the 'existing institutional setting at the local and national levels is not structured to effectively address the most urgent problems associated with poor sanitation' (GOJ, 2005).

The link between agriculture and poverty will also affect the Jamaican population, because poor people will less likely be able to adapt to climate change. Campbell *et al.*, (2011) states that there is a potential for the rural poor in Jamaica to even increase in number as a result of increasing food insecurity, noting that 9 out of Jamaica's parishes had 70% of rural poor which would have implications for food security and result in malnutrition. These conditions are alarming and a major cause for concern for present and future population trends as it relates to morbidity and mortality data.

Among the eight MDG's, Jamaica has been described as lagging behind in terms of Environmental Sustainability (GOJ, 2009c). The Vision 2030 of the Government of Jamaica emphasises the importance of environmental conditions to public health and by association the impact human-induced changes, or anthropogenic facts on the environment and its potential impacts on public health such as the recent emergence and re-emergence of certain communicable diseases, respiratory diseases and epidemiological events. The document also draws reference to the availability of water and issues such as salt water intrusion which will impact water quality, availability and sanitation and therefore disease transmission. Therefore, having identified the importance of the environment in the context of climate change and health, measures should be proposed to in the policy context to strengthen resilience to natural diseases as well as increase adaptive capacity and improve emergency response of the country. This will demonstrate a sense of commitment by the Government of Jamaica to increasing the health of the environment on the island.

5.4.2. Management

In the Ministry of Health, four Regional Health Authorities are responsible for the provision of health care services in Jamaica. They work separately from the Ministry of Health in Jamaica, providing more of a steering and monitoring role in the system. The Vector Control Division within the Ministry of Health is of particular importance. It is responsible for the vector disease surveillance and education of the population. With the increase in vector borne diseases in 2007 increased focus was placed on surveillance and vector monitoring by the Vector Control Division under the Ministry of Health (GOJ, 2009).

A major concern in terms of human resource capital in Jamaica, as is also the case elsewhere in the Caribbean, is loss of skilled personnel due to out-migration. Primary health care has faced shortages of qualified nurses (53%) and midwives (54%). The attrition rate of these personnel is 15% per year. Nursing staff is currently at 26% of the required staff cadre (GOJ, 2009c). Such deficiencies will affect the ability to adapt in emergency situations as well as an overall deterioration in health standard as a result of susceptible groups in the population being further affected due to the effects of climate change.

During the period 1988 to 2007 Borne and Eldemire-Shearer (2009) observed that Jamaicans prefer private health care over public health care service utilisation. Jamaica has experienced high levels of inflation in the last two decades and turning to the perspective of the actual users of the health care services, this is cause for concern if the risk from diseases as a result of climatic changes increases. Therefore, socioeconomic issues such as increased poverty, increased prices and unemployment and a reduction in health seeking behaviour may have a significant impact on the health of the Jamaican population (Borne, 2009). Borne and Eldemire-Shearer (2009) concluded in their study of the public hospital health care utilisation in Jamaica that "The greater percentage of Jamaicans who access private health care is not owing to plethora of services, higher specialised doctors, more advanced medical equipment, or low [sic], but this is due to social environment– [poor] customer service and social interaction between staffers and clients- and physical milieu – more than one person per bed sometimes, uncleansiless [sic] of the facilities."

The Meteorological Service of Jamaica, a scientific division of the Ministry of Land and Environment in conjunction with the Ministry of Water and Housing, undertook the responsibility to write the first and second National Communications to the UNFCCC. They represent the co-ordinating body with the task of bringing together the range of stakeholders in Jamaica, in this case the health section as well as water, waste and sanitation institutions. These range from the Ministry of Health (MOH), the Ministry of Housing and Water (MHW), the Ministry of Land and the Environment (MLE), the Ministry of Agriculture the National Environment and Planning Agency (NEPA), the National Solid Waste Management Authority

(NSWMA), the National Irrigation Commission (NIC), the Water Resources Authority (WRA) (and other water institutions), the Ministry of Local Government, Community Development and Sport as well as Local Authorities.

Also of relevance here in terms of researching climate change is the University of the West Indies Climate Studies Group of Mona (CSGM) which was formed in 1994. Among its many objectives are two that can have some bearing on and can inform on public health issues, 'To determine how anthropogenic climate change will manifest itself in the Caribbean region' and 'To investigate and promote the advantageous uses of climate prediction in socio-economic sectors'. Regionally important institutions include the Caribbean Environmental and Health Institute (CEHI), the Caribbean Epidemiology Centre (CAREC) and the Caribbean Disaster Emergency Management Agency (CDEMA).

Community Based Organisations (CBO's) may contribute to solutions that mitigate, if not adapt to climate change. For instance, GEF funded projects in Jamaica promote environmental management and therefore have a bearing on public health. In the Ministry of Health of Jamaica Annual report, the importance of CBO's in the prevention of malarial outbreaks was noted. Entities that assisted in the control of the outbreak included international organisations such as PAHO, USAID and locally the National Health Fund and the Jamaica Pest Management Association (GOJ, 2009).

The most researched area of public health sector and the possible implications of climate change in Jamaica are in vector control. Extensive research on dengue fever and some on Malaria have been undertaken on the island, some of which have been mentioned in this report (Castle *et al.*, 1999; Rawlins *et al.*, 2008; Chadee *et al.,* 2009; Brown *et al.*, 2010). There is also a growing body of research that specifically deals with vector borne diseases and climate change issues (Amarakoon *et al.,* 2006; Chen *et al.*, 2006; Heslop-Thomas *et al.*, 2006) not only in Jamaica but that address the region. Gubler (2002) comments that a lack of public health resources for research, surveillance, prevention and control programmes are some areas identified as contributing to the continued prevalence of dengue fever in addition to urbanisation. Notable instruments in Jamaica that may assist in addressing the issues are the National Malaria Control Strategic Plan and a Dengue Early Warning System (2009d). In addition, the WHO (2007) identified a number of key areas for vector management and indicated that an evidence-based approach should be adopted with development and research being key elements.

Pinheiro and Corber (1997) suggested that the inability of vector control programmes to achieve objectives highlights the problem of a reduction in political will which spirals into problems with management and insufficient suitably trained personnel. No evidence was provided so as to assess the applicability to Jamaica. Even so, WHO (2007) has stated that 'significant success in the short-term maybe a weakness because it can lead to premature diversion of resources.' In the case of vector borne diseases and the likelihood of their resurgence, insufficient financial support and the resultant decrease in public health infrastructure are also important considerations (Gubler, 1998b).

5.4.3. Technology

In the Government of Jamaica's *Draft Health Plan, Sector Vision 2030 Jamaica National Development Plan* the strategy - 'Ensure the provision and equitable access to appropriate and cost-effective technology' (GOJ, 2009a) was listed which indicates that in its broadest sense this has not currently been achieved. As such for the Health Sector, technology was interpreted as 'infrastructure' due to the limited reference of the latter in reports and documents from the Jamaica Government and limited research time period to investigate the former. Additionally, in the *Enabling Activities for the Preparation of Jamaica's Second National Communication to the UNFCCC Vulnerability and Adaptation in Human Health*, Chen *et al.* (2008)

have also mentioned that '…while medical technology has a role to play more attention should be paid to community development and the provision of safe water supplies to increase the resilience of this section of the population.'

Also in the *Draft Health Plan, Sector Vision 2030 Jamaica National Development Plan* also mentions the following National Strategy which seeks to 'Provide and maintain an adequate health infrastructure to ensure efficient and cost effective service delivery' (GOJ, 2009a). Complementary to this the National Report of Jamaica on Millennium Development Goals states that "Jamaica ranks high among developing countries in the health status of its population, the result of well developed primary health care (PHC) infrastructure which reaches deep into rural areas…"(GOJ, 2009c). However, Jamaica's economy is prone to inflation and it has low to negative economic growth and a high debt-to GDP ratio (GOJ, 2009c). In the Human Health Section of the Fourth Assessment Report to the IPCC, it notes that such financial constraints limit the ability to carry out health-impact and climate-impact adaption research in low- and middle-income countries such as Jamaica (Confalonieri, *et al.*, 2007).

Infrastructure is an important element to the development of any nation. The National Sanitation has notes that 'A vicious cycle exists as developing nations do not have the necessary infrastructure to provide adequate sanitation while it is recognised that appropriate levels of sanitation would place less stress on these fragile economies' (GOJ, 2005). This problem also affects rural communities in particular where access to water is sourced from 'entombed springs and rain catchments (which) are many decades old' and from wayside tanks filled by water trucks (GOJ, 2005). The Water Sector Policy of Jamaica notes that problems, particularly 'deterioration and malfunction of the municipal supply and sewage treatment infrastructure', within the Jamaica water sector, which place the health of the nation at risk as diseases previously described would be on the increase.

Proximity to health care facilities is important for overall good health of a country and even more so in times of natural disasters and national emergency situations especially given that predicted climate changes are likely to increase the intensity of these storms. In the original healthcare model of Jamaica, there were plans for health care facilities no further apart than 10 km; however, some of the health facilities have been closed. Currently there are about 320 primary health care facilities (Gordon-Strachan, 2010), with 23 public hospitals (GOJ, 2009). Figure 5.4.1 demonstrates that roughly speaking health facilities are fairly well distributed across the island and contributes to its resilience to the impacts of climate change on health.

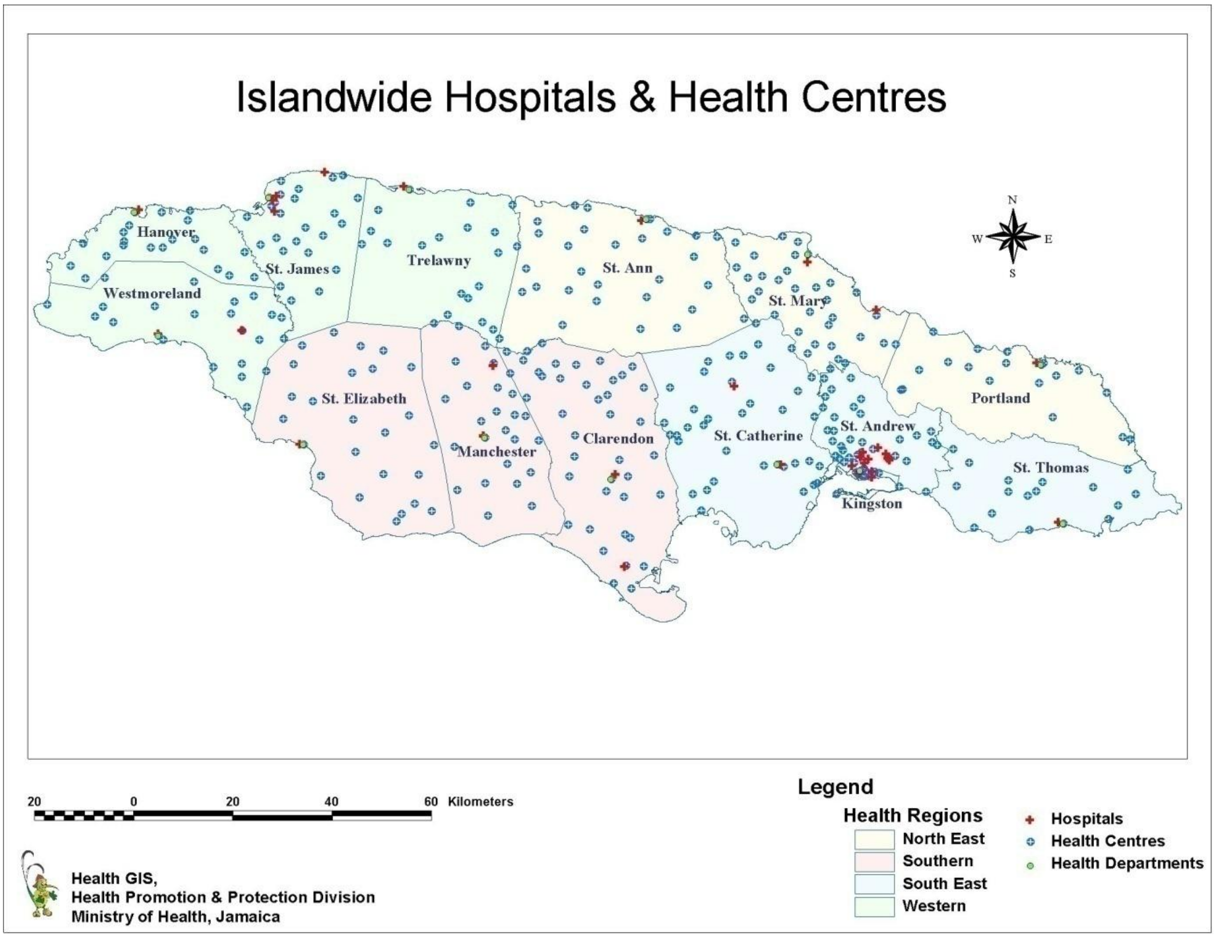


Figure 5.4.1: Island Wide Hospitals and Health Centres in Jamaica

(Source: Gordon-Strachan, 2010)

5.5. *Marine and Terrestrial Biodiversity and Fisheries*

Adaptation requires "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Intergovernmental Panel on Climate Change, 2007). The adaptive capacity of ecosystems then is the property of a system to adjust its characteristics or behaviour, in order to expand its coping range under existing climate variability, or future climate conditions (Brooks & Adger, 2004). Despite global action to reduce greenhouse gases, climate change impacts on biodiversity are unavoidable due to climate inertia. Natural ecosystems have long demonstrated the ability to adapt to changes in their physical environment. The rate at which climatic changes occurs may exceed the rate at which ecosystems can adapt. Furthermore, natural environments which are already stressed by human activities have compromised ability to cope with and to adapt to climate change. This adaptive capacity assessment thus considers the country's ability to manage its biodiversity through managing sustainable resource use and the capacity to implement strategies to protect its natural environment.

Six principles for climate change adaptation have been identified by Natural England the UK government's advisor on the natural environment (Hopkins, Allison, Walmsley, Gaywood, & Thurgate, 2007). Many elements of these principles may be applied within the Caribbean context. The principles are as follows (not in order of priority):

BIODIVERSITY: SIX PRINCIPLES FOR CLIMATE CHANGE ADAPTATION
Conserve existing biodiversity
Reduce sources of harm not linked to climate
Develop ecologically resilient and varied landscapes
Establish ecological networks through habitat protection, restoration and creation
Make sound decisions based on analysis
Integrate adaptation and mitigation measures into conservation management, planning and practice

A number of factors can influence a nation's ability to execute effective and appropriate adaptation strategies, or to react to hazards and stresses so as to reduce the magnitude of harmful outcomes resulting from climate-related hazards. Information on the following factors was gathered to reflect Jamaica's adaptive capacity:

- Political leadership and commitment
- Resource availability
- Institutional and governance networks and competence
- Social capital and equity
- Information technologies and communications
- Health of environment

Many small island states generally have low adaptive capacity for some of the same reasons that they tend to be highly vulnerable to climate change, i.e. small physical size, limited access to capital and technology, shortage of human and financial resources (Mimura, *et al.*, 2007). The ability of ecosystems to adjust to projected climatic changes depends not only on their inherent resilience but also on the ability of resource users to make required adjustments. By addressing shortcomings in the above indicators adaptive capacity can be built. The specific challenges facing Jamaica's biodiversity are not dissimilar from other Caribbean islands, but magnified by the high levels of poverty, resource depletion and population density. The government of Jamaica is aware of the challenges and has relatively good institutions, policies and human/technical capacity for addressing them, but is hindered by a chronic lack of resources and low levels of public awareness.

5.5.1. Policy

A nation's adaptive capacity is greater if the roles and responsibilities for implementation of adaptation strategies are well delineated by central governments and are clearly understood at national, regional, and local levels (Burton, 1996). There is some political support for environmental management in Jamaica, as can be seen by the current environmental legislation that provides a framework for the conservation and sustainable use of biodiversity under the authority of various agencies. A number of Acts and Regulations guide the management of natural resources and physical development in Jamaica; there are at least 52 pieces of legislation which address the management of the environment (see Table 5.5.1). However, the laws are scattered between various sectors and there is no comprehensive statute for the protection, conservation and sustainable use of biodiversity. Jamaica is also a party to several international and regional multilateral environmental agreements (MEAs), which guide the management of the island's natural resources (see Table 5.5.2). The appointment of The National Environment and Planning Agency (NEPA) as the focal point for implementation makes Jamaica one of the more successful examples of MEA compliance in the region (Anderson, 2000). At times however compliance with MEAs is constrained by the absence of supporting national legislation and a lack of human and financial resources.

Table 5.5.1: Legislation on environmental protection in Jamaica

Legislation	Impact on Biodiversity
Natural Resource Conservation Authority Act (1991)	Effectively manage the physical and natural resources of Jamaica, Develop, implement and monitor plans and programmes relating to the management of the environment
Wild Life Protection Act (1945)	Only statute in Jamaica that specifically protects designated species of animals and regulates hunting in Jamaica.
Watershed Protection Act (1965)	Provides a framework for the management of the 26 declared watersheds in Jamaica; makes provisions for the intervention of the Government in regulating uses of private land including the clearing of land and implementing appropriate agricultural practices. No regulations have ever been prepared under this Act
Beach Control Act (1956)	Regulates rights to the foreshore and the floor of the sea in Jamaican waters. Marine protected areas may be declared under the Act; does not appropriately address larger issues of the proper management of the coastal zone and marine resources.
The Forest Act (1996)	The only piece of legislation in Jamaica that uses the word 'biodiversity'. This Act sets out the role and function of the Forestry Department and the Conservator of Forests. Under the Act private lands may be acquired for declaration as forest reserves.
The Fishing Industry Act, 1975	The taking and catching of fish are regulated by the Fishing Industry Act. Provides for the protection of fish through the designation of fish sanctuaries and the declaration of open and closed fishing seasons.
Endangered Species Act, 2000 (Protection, Conservation and Regulation of Trade)	Provides for the conservation, protection and regulation of trade in endangered species.
Town and Country Planning Act, 1948 (amended in 1999)	To ensure the orderly development of land. provides for the making of Tree Preservation Orders (Section 25) whereby a local authority may seek to preserve trees or woodlands
The Mining Act, 1947 (amended in 1988)	Regulates mining activities in Jamaica
The Quarries Control Act, 1983	Provides for the establishment of a Quarries Advisory Committee (Section 6) to designate quarrying zones and to license operators
Water Resources Authority Act, 1995	Regulate and manage the abstraction and allocation of water resources through the establishment of the Water Resources Authority.
The Jamaican Constitution	Protects property rights and establishes the principles on the ownership of property in Jamaica. proprietor owns all flora on his/her property and if he/she catches wildlife on his/her property (subject to the Wild Life Protection Act) then he/she owns these wild animals.
Animals (Disease) and Importation Act, 1969	Allows for controlling the spread and treatment of diseases within the island via importation controls on animals, and the eradication and disposal of infected animals or where such infection is suspected.
Black River (Upper Morass) Reclamation Act, 1941	Empowers the Black River Drainage and Irrigation Board to regulate and maintain water courses and damming structures; keep the Black River clean, clear and navigable to a certain point; and can require landowners to clean canals, trenches, etc. located on their lands.
Clean Air Act, 1964	Makes provision for the prevention of the discharge of noxious or offensive gases into the air including fumes and dust from alumina, cement, lime, petroleum and gypsum works

Legislation	Impact on Biodiversity
Harbours Act, 1874	Regulates activities within harbours through the Marine Board by regulating the movement of boats and vessels in harbours, channels or approach thereto; the placement of buoys and removal of sunken structures from harbours; penalties for depositing refuse and waste matter from vessels; and removal of sand, stone, ballast, etc., from harbours, reefs or shoals
Institute of Jamaica Act, 1978	Promotes Literature, Science and Art, with responsibility for national Museums
Jamaica National Heritage Trust Act, 1985	Establishes a statutory body to protect Jamaica's national heritage, including any place, animal or plant species or object/building
Litter Act, 1985	Defines what constitutes litter on private and public property and prescribes penalties for offences against the Act and the provision of receptacles for proper disposal
Local Improvements Act, 1914	Governs all development of lands within Kingston or other such Ministerial prescribed areas via the requirement for subdivision approval from the relevant local authority.
Morant and Pedro Cays Act, 1907	Affirms the status of the Morant and Pedro Cays and prohibits fishing inside certain limits, slaying or catching of birds on the Cays or the catching of turtles within the territorial limits of the Cays.
Petroleum Act, 1979	Vets all petroleum in the State and makes provisions for the creation of Regulations which prevent pollution and orders remedial action where this takes place, as well as the protection of fishing, navigation, etc.
Plants (Importation) Control Regulation, (1997)	Outlines the role of the National Biosafety Committee in monitoring and regulating the importation of Living Modified Organisms for research only.
Plant Quarantine Act, 1993	Provides protection for Jamaica's flora from imported diseases or pests transported via plants, plant products, and soil or via other means as well as the course of action to be taken when these are discovered within the island.
Public Health Act, 1985	Allows for the establishment of Local Boards to regulate activities carried out in private or public buildings or properties where such activities prove injurious to public health
Urban Development Corporation Act, 1968	Establishes the Urban Development Corporation as a statutory body, which has amongst its functions the duty to carry out construction, maintain public parks, car parks, etc. in such manner to ensure preservation of architectural or historical objects or sites.

(Source: Natural Resources Conservation Authority, 1999)

Table 5.5.2: International/regional multilateral environmental agreements to which Jamaica is a Party

Instrument	Status
International Plant Protection Convention, Rome, 1951	Accession:24 November,1969
United Nations Convention on the Law of the Sea, Montego Bay, 1982	Ratification: 21 March, 1983
Convention Concerning the Protection of the World Cultural and Natural Heritage, Paris, 1983	Acceptance: 14 June, 1983
Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, Cartegena de Indies, 1983	Ratification: 1 May, 1987
Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean Region	Entry into Force: 1 May, 1987
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (as amended), London, Mexico City, Moscow [Washington], 1972	Ratification: 22 March, 1991
International Convention on the Prevention of Pollution from Ships, London, 1973	Ratification: 13 June, 1991
Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, London, 1973	Ratification: 13 June, 1991
London Amendment to the Montreal Protocol on Substances that Deplete the Ozone layer, London	Ratification: 31 March, 1993
Vienna Convention for the Protection of the Ozone Layer, Vienna,1985	Accession: 31 March, 1993 Entry into Force: 29 June,1993
Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 1989	Instrument of Accession Deposited: 6 January, 1995 Effective: 5 April, 1995
United Nations Framework Convention on Climate Change, New York, 1992	Instrument of Accession Deposited: 6 January, 1995 Entry into force: 5 April, 1995
Convention on Biological Diversity, Rio de Janeiro, 1992	Instrument of Accession Deposited: 6 January, 1995 Entry into force: 5 April, 1995
Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	Accession: 23 April, 1997 Entry into Force: 22 July, 1997
The Copenhagen Amendment to the Montreal Protocol on Ozone Depleting Substances	Accession: 7 November, 1977 Entry into Force: 4 February, 1998
Convention on Wetlands of International Importance especially as Waterfowl Habitats (RAMSAR Convention)	Accession: 7 October, 1997 Entry into force: 7 February, 1998
Convention to Combat Desertification Accession: 12 November, 1997	Entry into Force: 16 March, 1998

(Source: Ministry of Land and Environment, 1999)

NEPA is an Executive Agency that was formed from a merger between the Natural Resources Conservation Authority (NRCA), the Town Planning Department (TPD) and the Land Development and Utilization Commission (LDUC). Such a merger integrates environmental, planning and sustainable development policies and programmes and is a step towards achieving another key adaptation principle, that of integrating across all sectors. All sectors of society use natural resources in some way or another, therefore concerted effort is required if ecosystems are to successfully adapt to a changing climate.

Up until 2009, Jamaica had two officially declared fish sanctuaries namely: Bogue Islands Lagoon (to the western end of the island) and Bowden Inner Harbour (to the eastern end). These were declared in 1979 and 1986 respectively to tackle the decline in fish catches. The problem of depleting marine resources has, however, continued due to increased fishing pressure and land-based nonpoint-source pollution, among other stressors. The degradation of habitats makes it critical to establish more marine protection areas (GOJ). The Jamaica Fisheries Division thus gazetted ten new fish sanctuaries between 2009 and 2010. These fish sanctuaries have gained the buy-in of fishers and will be managed by community groups. Supporting legislation for protected areas has been improved and now reflects international recommendations for co-management."

Box 5.5.1: Plans to guide the management of natural resources and physical development in Jamaica:

Jamaica National Environmental Action Plan: highlights the major recognises the increasing threats to Jamaica's biological resources due to habitat degradation, pollution and unsustainable levels of utilisation, as well as establishing the necessary corrective measures to be undertaken by various Government agencies, ministries and non-governmental organisations. Including the development and management of a system of protected areas.

Jamaica National Land Use Policy 1996: establishes the framework for the planning, management and development of Jamaica's resources.

Policy for Jamaica's System of Protected Areas, 1997: policy framework for the establishment of a National System of Protected Areas

National Physical Plan, 1978: focuses on physical planning, settlement, conservation, income generators (i.e. forestry and fisheries, agriculture, mineral industries, tourism and manufacturing) and public utilities through the use of Development Orders.

Forest Policy, 2001 (updated Forest Land Use Policy, 1996): The Forest Policy attempts to ensure the sustainable management of the island's forests and by extension its watershed areas.

National Forest Management and Conservation Plan (NFMCP): similar in some respects to the Forest Policy but seeks to provide a more detailed outline of all facets of forestry in Jamaica.
Ocean and Coastal Zone Policy: aim is to enhance the contribution of economic sectors to the integrated management of coastal areas and to integrate sectoral policy and planning into coastal area management.

Management and Recovery Plans for Endangered Species: These include: the Crocodile Action Plan; the Giant Swallowtail Butterfly Recovery Action Plan; the Jamaican Iguana Conservation Strategy; the Sea Turtle Recovery Action Plan; the Jamaica Coral Reef Action Plan; and the Plan for Managing the Marine Fisheries of Jamaica. In addition, management plans have been developed for other, non-threatened species such as the Sooty Tern and the Brown Noddy.

5.5.2. Management

The existence of environmental laws and regulatory bodies is commendable, however, the enforcement of environmental legislation in Jamaica has been described as difficult and time consuming due mainly to (1) insufficient human and financial resources to provide comprehensive protection, (2) a lack of knowledge on the part of the persons given the task of enforcing the relevant legislation, and (3) inadequate penalties provided by Acts and Regulations (NEPA, 2003). Recently NEPA has come under heavy criticism in a report, which claimed that NEPA had failed to adequately protect Jamaica's natural resources in the best interest of future generations. The current environmental regulatory framework is dysfunctional and has been under review for many years. A number of civil-society groups have also decried the apparent lack of public-involvement in plans for a new NEPA Act and Environmental Regulatory Authority (Hunter, 2010).

An important tool in environmental management is the Environmental impact assessment (EIA) which enables environmental factors to be given due weight, along with economic or social factors, when planning applications are being considered (ODPM, 2000). Like many other small islands, Jamaica does not have an explicit EIA law, however there are laws that make provisions for the authority to request EIA where warranted. A major challenge of the EIA process in Jamaica is the inadequate legislative and regulatory basis. The EIA Authority is granted discretionary power but is not by law obliged to take a particular course of action.

As a result of inadequate planning, inefficient land development has led to increased soil erosion, loss of agricultural productivity, deforestation, and deteriorating freshwater and marine water quality (UNFCCC, 2000). Both mining and processing, which make up to 28% GDP, have placed serious and sustained burdens on the environment. On an annual basis, an average of almost 100 hectares of land are disturbed for bauxite mining while only 76 ha are restored (NEPA, 2003). The loss of biodiversity is not adequately addressed nor monitored through the present EIA process, neither is monitoring of the construction process and subsequent activities on the site comprehensively addressed. NEPA has tried to facilitate transparency in this process but there is no legal requirement to ensure public participation in the EIA process.

Jamaica does not have specific monitoring programmes related to marine biodiversity but assessments of reefs around the island and the creation of a database of marine fauna and flora species are conducted and managed by the National Environment and Planning Agency, Centre for Marine Sciences-University of the West Indies and the Jamaica Coral Reef Monitoring Network (JCRMN).

Despite efforts of the Government to protect species through legislation, illegal harvesting still takes place. Killing or harming marine turtles or eggs is punishable by law through fines or imprisonment, yet, poaching of marine turtles continues throughout the island. Only one turtle nesting beach being actively monitored in Jamaica. In 2009 the Jamaica Environment Trust (JET), with the assistance of NEPA formed the Jamaica Sea Turtle Project that plans to identify additional sea turtle nesting beaches across Jamaica for monitoring. There are also plans to implement an island-wide education and awareness programme aimed at highlighting the threats currently faced by sea turtles and to stop the poaching of eggs and adult turtles (JET, 2001).

Coastal defences (dunes) are being reconstructed and a mangrove replanting project underway in the most vulnerable areas of the Palisadoes Spit, which provides the only access to the Norman Manley International Airport. This project is of strategic importance as coastal erosion along the Palisadoes Spit has caused sporadic flooding and the deposit of sand and debris on the road (water from the southern side comes across to the northern side) rendering it impassable on several occasions.

Stakeholder awareness and involvement

At the private sector level there is evidence of awareness and interest in environmental sustainability. The Private Sector Organization of Jamaica (PSOJ), an umbrella organisation for private sector entities, has established an Environmental sub-committee. A number of environmental NGOs are playing a vital role in research, financing, management, and public awareness and education. These include the Environmental Foundation of Jamaica (EFJ) which offers grant funding; the Jamaica Conservation and Development Trust (JCDT); Jamaica Environment Trust (JET) initiated by a group of concerned citizens, which focuses on environmental education and advocacy; and the Jamaica Protected Areas Trust Limited (JPAT), a public-private initiative that seeks to protect and enhance Jamaica’s natural resources and biodiversity, among others.

Traditionally Jamaica’s fisheries have been managed solely by the Fisheries Division, however the newly-declared sanctuaries are to be managed in conjunction with local non-governmental organisations (NGOs) and private sector stakeholders, insofar as possible. This progress in management approach is in keeping with adaptation principles 2 and 3 i.e. accommodate change, develop knowledge and plan strategically. Meetings with a number of the community groups mandated to manage the new sanctuaries (e.g.

Bluefield's Bay, Treasure Beach, Portland Bight, Oracabessa, Boscobel, Discovery Bay) revealed a good level of local support and involvement in management insofar as resources allow. These groups did however express the need for more education and awareness campaigns in the wider community. Generally speaking, lack of public awareness about the importance of habitat/ecosystem destruction and of conserving biodiversity is one of several factors that contribute to the loss of biodiversity in Jamaica.

Although there have been substantial investments in environmental education awareness of environmental issues in Jamaica remains at a relatively low level (NEPA, 2003). There is a need to increase support for NGO and CBO environmental education and projects; and for coordination of efforts at the national level to avoid duplication of effort thereby promoting greater efficiency in communicating environmental issues (NEPA, 2003).

Planned projects to address constraints and challenges

Attempts to build institutional capacity and to address flaws in policies and practice with regards to environmental management are slow in coming. For the past five years there have been plans to establish a Climate Change Unit in the Meteorological Office. The Unit will among other activities, liaise with the Ministry of Land and Environment and the Office of the Prime Minister in order to have an input in the formulation of climate policy. Consideration is being given to a reformation of NEPA and updating the NEPA Act.

Jamaica's "Vision 2030" is the country's first long-term National Development Plan which aims to achieve "developed country" status for the island in the next two decades. The document acknowledges the value of biodiversity and ecosystem conservation in achieving development goals. Key strategies and actions planned for the period 2009-2012 include:

- ensuring that the activities of the tourism industry support biodiversity conservation objectives through implementation of programmes for awareness
- Developing a comprehensive framework to reverse loss of ecosystems and biological resources
- Establishing institutional mechanisms to foster coordination and collaboration among resource management agencies
- Creation of mechanisms to fully consider the impacts of climate change and 'climate proof' all national policies and plans

Protected areas

The Principles of Adaptation developed by Natural England (listed at the beginning of Section 5.5) emphasise the importance of minimising existing stressors on the environment (2), building resilient ecosystems (3) and creating networks of protected areas (4). Protected Areas (PA) aim to do all of these things and often provide a more practical and cost-effective approach to achieving results when enforcement of environmental laws over the entire national territory is not feasible or practical. PAs are therefore recognised as a key strategy for biodiversity adaptation to climate change in developing countries (UNEP). In the case in Jamaica, the large tourism sector can also help provide income for park mangers and more importantly livelihood opportunities for communities living in or near PAs. There is also increasing scientific evidence that the greater biomass of herbivorous fish inside marine protected areas (MPAs) increases the resilience of corals to climate change. The herbivorous fish keep the corals free of algae and thus make them more able to survive mass coral bleaching events.

The most promising and significant project currently underway to build the resilience of Jamaica's coastal ecosystems and to restore the heavily depleted fish stocks is the new network of fish sanctuaries that was enacted in 2009-2010. This initiative by the Government of Jamaica and the University of the West Indies has benefited from good planning, strong scientific design and most importantly community support and involvement. The central aim of this new network of MPAs was to increase the productivity of coastal fisheries and thus benefit some of the most vulnerable groups in Jamaica that live in small fishing communities. The initiative however suffers from a chronic shortage of financial support and a lack of integration with the tourism sector.

Other activities to protect the island's rich biodiversity continued with work on the Protected Areas Systems Master Plan; mangrove rehabilitation in degraded areas; water and air quality checks; and the monitoring of coral reefs and beach erosion. Forestry management is being enhanced with the establishment of the Dolphin Head Local Forest Management Committees (PIOJ, 2009).

5.5.3. Technology

The lack of appropriate technology may restrain a nation's ability to implement adaptation measures. (Scheraga & Grambsch, 1998). A nation which has a stable and prosperous economy, regardless of biophysical vulnerability to the impacts of climate change, is better prepared to bear the costs of adaptation than countries that lack financial resources (Goklany, 1995; Burton, 1996). The main barrier to the transfer of technology to Jamaica has been identified as capital cost (UNFCCC, 2006). UNDP's technology needs assessment of Jamaica highlighted a number of priority needs to protect the island's coastline. These include beach protection measures such as correctly placed groynes and revetments, the reinstating of the tidal gauge network coupled with improved data collection for the geographic information system, expansion of beach profiling and the regeneration of mangroves. All of these are costly measures in the short-term, but would provide cost savings over the long-term.

The adoption of existing Information and Communication Technologies (ICTs) could substantially improve environmental management, by facilitating monitoring and data sharing, as well as by engaging a much greater base of stakeholders. The penetration of the internet and cell phones in Jamaica's rural and coastal communities have seen a ten-fold increase in the past 10 years (Prof. Hopeton Dunn, personal communication) and this could facilitate a much more effective process of information-sharing and participatory governance.

5.6. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

Based on the Vulnerability evaluation (see Section 4.6), if action is not taken to protect Jamaica's coastline, the current and projected vulnerabilities of the tourism sector to SLR, including coastal inundation and increased beach erosion, will result in the very significant economic losses for the country and its people. Adaptation strategies to minimise Jamaica's vulnerabilities will involve considerable revisions to development plans and major investment decisions and must be based on the best available information regarding the specific coastal infrastructure and ecosystem resources along the coast, in addition to the resulting economic and non-market impacts.

Integrating climate change adaptation strategies into relevant national policies and plans has been limited in Jamaica, although the country's involvement with climate change projects over the past decade suggests this may changing. For example, Jamaica participated in two projects (coral reef monitoring project and SLR/climate monitoring project) as part of the Caribbean Planning for Adaptation to Climate Change (CPACC) Project (1997-2001) which aimed to support Caribbean countries in coping with the adverse effects of climate change, particularly SLR, by building monitoring and mitigation capacity in the region through the development of human resources, databases and equipment. Moreover, in 2006 the National Council on Ocean and Coastal Zone Management (NCOCZM) coordinated a continual island-wide tide gauge network to measure and track SLR. Most recently, as part of an Adaptation to Climate Change and Disaster Risk Reduction Project (2010-2013), NEPA has commenced a project entitled "enhanced natural buffers and increased resilience to climate change impacts through restored and protected coastal ecosystems (e.g. mangrove replanting, installation of artificial reefs, early warning systems for SLR). In terms of shoreline development setbacks in Jamaica, no policies or regulations were found, but there is at least one example of an environmental impact assessment that was completed on the building of the Bahia Principe Resort (Montego Bay), that advised a 50 m setback with room blocks situated at elevations in excess of 2 m.

Despite the identified vulnerabilities, knowledge of coastal response to climate change, SLR and erosion remains limited in Jamaica. Most Caribbean islands lack the high-resolution topographical data required to assess the impacts based on projections of SLR and altered storm intensity, which is a priority for Jamaica, particularly given the popularity of their coast as a tourism destination.

The CARIBSAVE Partnership coordinated a field research team with members from the University of Waterloo (Canada), Oxford University (UK) and the National Environment and Planning Agency (NEPA) of Jamaica to complete detailed coastal profile surveying (Figure 5.6.1). The sites were surveyed using a TOPCON Real Time Kinematic model (RTK) GPS system including a base station, 15 km radius antenna, surveying stick and a hand held data logger. Distance between points along transects were measured using a Lecia Disto laser distancing meter. Transects were spaced at approximately 30-50 m intervals depending on the length of the beach of interest and variability in topography along the beach. The water's edge was fixed to a datum point of 0 for the field measurements, but later adjusted according to tide charts. Generally, satellite connections were very good, receiving up to 10 satellites, resulting in 10 cm accuracy. The mean vertical accuracy for all points was approximately 0.20 cm while the horizontal accuracy had a mean average of 0.10 cm accuracy. An average of 6 measurements was taken for each point along transect lines. At each point, the nature of the ground cover (e.g. sand, vegetation, concrete) was logged to aid in the post-processing analysis. Ground control points were taken to anchor the Global Positioning System (GPS) positions to locations that are identifiable from aerial photographs to improve horizontal accuracy. These were taken where suitable landmarks at each transect location and throughout the island. Ground Control Points (GCP) were measured over 60 readings at 1 second intervals. At each GCP, the physical characteristics of the site were logged to enable the point to be identified from areal images. Photographs were taken from north, south, east and west perspectives to aid this process. The GCP points were also collected as a means of geo-referencing digital satellite imagery for the study sites.

Figure 5.6.1: High Resolution Coastal Profile Surveying with GPS, Long Bay, Jamaica

Sean Green (NEPA), Ryan Sim (University of Waterloo) and Jerome Smith (Office of the Prime Minister)

Following the field collection, all of the GPS points were downloaded on to a Windows PC, and converted into several GIS formats. Most notably, the GPS points were converted into ESRI Shapefile format to be used with ESRI ArcGIS suite. Aerial Imagery was obtained from Google Earth, and was geo-referenced using the 22 GCP collected Portland Parish. The data was then inspected of all errors and incorporated with other GIS data collected while in the field. The first step in the post processing was determining the position of the absolute mean sea level by comparing the first GPS point (water's edge) to tide tables to determine the high tide mark. The second step was to produce three dimensional topographic models of each of the 15 study sites. First a raster topographic surface was created, using the GPS elevation points as base height information. Similarly, a Triangular Irregular Network (TIN) model was created to represent the beach profiles in three dimensions. Contour lines were delineated from both the TIN and raster topographic surface model. For the purpose of this study, contour lines were represented for ever metre of elevation change above sea level. Using the topographic elevation data, flood lines were delineated in one metre intervals. In an effort to share the data to a wider audience, all GIS data will be compatible with several software applications, including Google Earth.

There are three main types of adaptation policies that can be implemented to reduce the vulnerability of the tourism sector in Jamaica to SLR and improve the adaptive capacity of the country: (1) Hard engineering defences and (2) soft engineering defences, which both aim to protect existing infrastructure and the land on which the infrastructure is built, as well as (3) retreat policies, which aims to establish setbacks and thereby move people and/or infrastructure away from risk. A summary of examples for each of the three types of adaptation polices are provided in Table 5.6.1, along with a summary of select advantages and disadvantages of each.

Table 5.6.1: Summary of Adaptation Policies to reduce Jamaica's vulnerability to SLR and SLR-induced beach erosion

Protection Type	Advantages	Disadvantages
	Hard Engineering Defences	
Dikes, levees, embankments[1, 2]	- Prevents inundation	- Aesthetically unpleasing - Can be breeched if improperly designed - Can create vulnerabilities in other locations (e.g. further erosion downward from the dikes) - Expensive - Requires ongoing maintenance
Groynes[3, 4]	- Prevents erosion	- Aesthetically unpleasing - Can increase erosion in other locations (e.g. stops longshore drift and traps sand) - Expensive
Revetments[3, 4]	- Prevents inundation - Less unwanted erosion than seawalls or levees	- Aesthetically unpleasing - Expensive - Requires ongoing maintenance and/or replacement (temporary)
Seawalls[3, 5]	- Prevents inundation - Good for densely developed areas that cannot retreat	- Aesthetically unpleasing - Can be breeched if improperly designed - Can create vulnerabilities in other locations (e.g. further erosion adjacent from seawalls, reflect waves causing turbulence and undercutting) - Expensive - Requires ongoing maintenance - Scouring at the base of the seawall can cause beach loss in front of the wall
Structure Redesign (e.g. elevate buildings, enforce foundations)[6, 7]	- Less environmentally damaging compared to large scale defenses - Can be completed independently of centralised management plans	- May be technologically unfeasible and expensive for larger buildings and resorts - Only protects the individual structure (not surrounding infrastructures such as roads)
	Soft Engineering Defences	
Beach nourishment and replanting of coastal vegetation[2, 3, 8]	- Enhances slope stability - Reduces erosion - Preserves natural beach aesthetics - Provides protection for structures behind beach - Improves biodiversity and ecological health	- Can ruin visitor experience while nourishment is occurring (e.g. restrict beach access) - Can lead to conflict between resorts - Differential grain size causing differing rates of erosion (e.g. new sand vs. natural sand) - Difficult to maintain (e.g. nourishment needs to be repeated/replenished, unsuccessful plantings) - Will not work on open coastlines (i.e. requires locations where vegetation already exists)
Replant, restructure and reshape sand dunes[3, 8]	- Enhances slope stability - Reduces erosion	- Conflict among resort managers (e.g, 'sand wars') - Temporary (waves will continually move sand)
	Retreat Policies	
Relocate settlements and relevant infrastructure[2, 9, 10, 11, 12]	- Guaranteed to reduce SLR vulnerability - Less environmental damage to coastline if no development takes place - Retains aesthetic value	- Economic costs (e.g. relocation, compensation) - Social concerns (e.g. property rights, land use, loss of heritage, displacement) - Coordination of implementation is challenging (e.g. timing of relocation is problematic) - Concerns with abandoned buildings

[1]Silvester and Hsu, 1993; [2]Nicholls and Mimura, 1998; [3]French, 2001; [4]El Raey *et al.*, 1999; [5]Krauss and McDougal, 1996; [6]Boateng, 2008; [7]Lasco *et al.,* 2006; [8]Hamm *et al.*, 2002; [9]Frankhauser, 1995; [10]Orlove, 2005; [11]Patel, 2005; [12]Barnett, 2005

Hard engineering structures are manmade, such as dikes, levees, revetments and sea walls, which are used to protect the land and related infrastructure from the sea. This is done to ensure that existing land uses, such as tourism, continue to operate despite changes in the surface level of the sea. The capital investment needed for engineered protection is expensive. For example, to protect the city of Kingston, US $286.7 million would be required to construct new levees, with an additional US $993.8 million to construct a new 58 km sea wall (Simpson *et al.,* 2010). Unfortunately the effectiveness of this approach may not withstand the test of time nor against extreme events. Protective infrastructure not only requires expensive maintenance which can have long-term implications for sustainability, but adaptations that are successful in one location may create further vulnerabilities in other locations (IPCC, 2007b). For example, sea walls can be an effective form of flood protection from SLR, but scouring at the base of the seawall can cause beach loss, a crucial tourism asset, at the front of the wall (Kraus and McDougall, 2006). Moreover, hard engineering are of particular concern for the tourism sector because even if the structures do not cause beach loss, they are not aesthetically pleasing, diminishing visitor experience. It is important for tourists that sight lines to the beach not only be clear, but that access to the beach is direct and convenient (i.e. to not have to walk over or around a long protective barrier). Smaller scale hard engineering adaptations offer an alternative solution to large scale protection. Options include redesigning structures to elevate buildings and strengthen foundations to minimise the impact of flooding caused by SLR.

Protection can also be implemented through the use of soft engineering methods which require naturally formed materials to control and redirect erosion processes. For example, beaches, wetlands and dunes have natural buffering capacity which can help reduce the adverse impacts of climate change (IPCC, 2007b). Through beach nourishment and wetland renewal programmes, the natural resilience of these areas against SLR impacts can be enhanced. Moreover, these adaptation approaches can simultaneously allow for natural coastal features to migrate inland, thereby minimizing the environmental impacts that can occur with hard engineering protection. Replenishing, restoring, replanting and reshaping sand dunes can also improve both the protection of a coastal area, as well as maintain, and in some cases improve, the aesthetic value of the site. Although less expensive and less environmentally damaging, soft engineering protection is only temporary. For example, the ongoing maintenance required to upkeep sand dunes, such as sand replenishment schemes, will create the periodic presence of sand moving equipment, subsequently hindering visitor experience (e.g. eye and noise pollution, limit beach access). Conflicts can also arise between resort managers resulting in 'sand wars', whereby sand taken to build up the beach at one given resort may lead other resorts to 'steal' sand and place it on their own property.

Managed retreat is another adaptation measure that can be implemented to protect land and infrastructure from SLR. Such an adaptation strategy raises important questions by local stakeholders as to whether existing land uses, such as tourism, should remain or be relocated to adjust to changing shorelines (e.g. inundation from SLR) (IPCC, 2007b). Adaptation through retreat can have the benefit of saving on infrastructure defence costs (hard and soft engineering measures) while retaining the aesthetic value of the coast, particularly in those areas that are uninhabited (i.e. little to no infrastructure or populations along the coast). The availability of land to enable retreat is not always possible, especially in highly developed areas where roads and infrastructures can impede setbacks.

For many tourist destinations in Jamaica, retreat is both difficult in terms of planning (and legally challenging) as well as expensive to implement. Resorts and supporting tourism infrastructure are large capital investments that cannot be easily uprooted to allow the sea to move inland. If the resorts cannot be moved, then the alternative is to leave them damaged and eventually abandoned, degrading the aesthetics of the destination coastline. It is important that the retreat policy be well organised, with plans that clearly outline the land use changes and coordinate the retreat approach for all infrastructures within the affected areas. Additional considerations of adaptation through retreat include loss of property, land, heritage, and high compensation costs that will likely be required for those business and home owners that will need to relocate. Priority should be placed on transferring property rights to lesser developed land, allowing for setback changes to be established in preparation for SLR (IPCC, 2007b).

Decisions regarding where retreat policies should be implemented versus what should be protected needs to be a priority if Jamaica is to help curb development in vulnerable areas and protect vulnerable tourism assets. Continued development and an increasing population will only magnify the vulnerabilities Jamaica faces, placing additional assets and people at risk, while simultaneously raising the damage estimates and the costs to protect the coastline. The National Council on Ocean and Coastal Zone Management (NCOCZM), established in 1998, functions as a multi-disciplinary and an inter-agency advisory body on decisions relating to ocean and coastal zone management. However, NCOCZM does not have the power to implement policy and/or strategies for the management of the coastal zone, with no single agency that oversees responsibility for coastal zone management (CZM) plans. The final decision to implement and/or manage a particular issue rests with National Environment and Planning Agency (NEPA), although several government agencies do have legal mandates which directly relate to CZM, including the Jamaica Tourist Board, which is responsible for recreation areas and cruise ship terminals.

5.7. *Comprehensive Natural Disaster Management*

Adaptive capacity can be measured through examination of policies, plans and practices implemented for the management of disasters, i.e. before, during and after the disaster. Natural disasters cost small island nations dearly in terms of loss of lives as well as economically. Particularly when countries experience disasters repeatedly, this has further effects on national budgets and allocation of funds for various government programmes and operations since the priority becomes that of immediate survival (shelters, medical care, relocation, search and rescue). Hazard impacts also directly affect the foreign exchange earning capacity in Jamaica (Office of Disaster Preparedness and Emergency Management, 2005, p. 1).

> *As a consequence of recurrent hazard-related damages, Jamaica is forced to divert scarce resources earmarked for development projects to relief and reconstruction, resulting in impeded economic growth. For instance, in the immediate aftermath of Hurricane Ivan in September 2004, J$94.9 million was diverted from government institutions to finance relief activities. The total economic impact of this hurricane is estimated at J$35,931 million or the equivalent of 8.0 percent of the country's GDP for 2003 (Planning Institute of Jamaica, 2004).*

5.7.1. Management of natural hazards and disasters

The disaster management system can be thought of as a cycle where preparedness, mitigation[12] and adaptation activities (disaster prevention) are the focus prior to a disaster impact. Following an impact the management focus becomes response, recovery and reconstruction (disaster relief). These two parts of the disaster management system work together and also impact the broader social, economic, ecological and political system (see Figure 5.7.1).

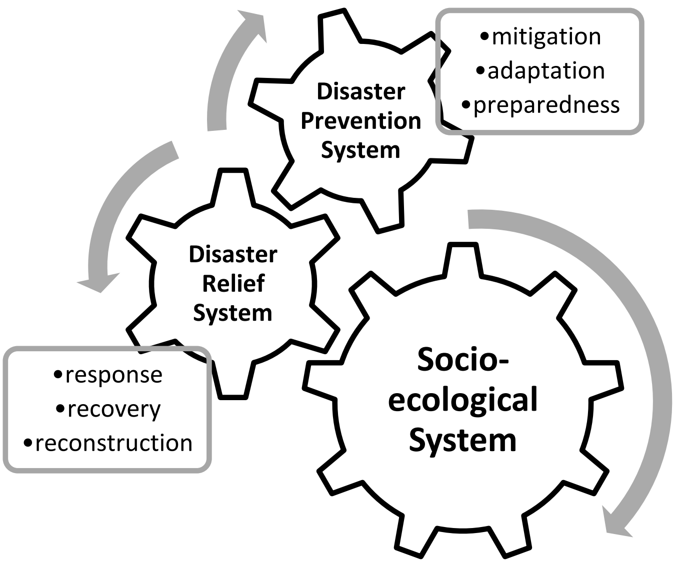


Figure 5.7.1: Relationship of the Disaster Management System and Society

[12] In the disaster management literature, 'Mitigation' refers to strategies that seek to minimise loss and facilitate recovery from disaster. This is contrary to the climate change definition of mitigation, which refers to the reduction of GHG emissions.

Caribbean Disaster Management and Climate Change

As a region, the Caribbean has made coordinated efforts to prepare for and respond to disasters. The Caribbean Disaster Emergency Management Agency, CDEMA, (previously the Caribbean Disaster Emergency Response Agency, CDERA) was created in 1991. CDEMA plays a leadership role in disaster response, mitigation and information transfer within the region, operating the Regional Coordination Centre during major disaster impacts in any of their 18 Participating States, while also generating useful data and reports on hazards and climate change. The primary mechanism through which CDEMA has influenced national and regional risk reduction activities is the Enhanced Comprehensive Disaster Management (CDM) Strategy (CDEMA, 2010). The primary purpose of CDM is *to strengthen regional, national and community level capacity for mitigation, management, and coordinated response to natural and technological hazards, and the effects of climate change*(CDEMA, 2010)(emphasis added).

This regional disaster management framework is designed to inform national level disaster planning and activities but also takes into consideration potential climate change impacts in its resilience building protocols. The four Priority Outcomes of the CDM framework are:

1. Institutional capacity building at national and regional levels;
2. Enhanced knowledge management;
3. Mainstreaming of disaster risk management into national and sector plans; and
4. Building community resilience.

These outcomes have been further broken down into outputs that assist in the measurement of progress towards the full implementation of CDM at the national and community level and within sectors (see Table 5.7.1). The CDM Governance Mechanism is comprised of the CDM Coordination and Harmonization Council and six (6) Sector Sub-Committees. These sectors include – *Education, Health, Civil Society, Agriculture, Tourism and Finance.* These six sectors have been prioritised in the Enhanced CDM Strategy as the focus during the period from 2007 to 2012. CDEMA facilitates the coordination of these committees (CDEMA, 2010).

To address disaster management in the Caribbean tourism sector, CDEMA, with the support of the Inter-American Development Bank (IDB) and in collaboration with the Caribbean Tourism Organization (CTO), CARICOM Regional Organisation for Standards and Quality (CROSQ), and the University of the West Indies (UWI) will be implementing a Regional Disaster Risk Management (DRM) Project for Sustainable Tourism (The Regional Public Good) over the period of January 2007 to June 2010. The project aims to reduce the Caribbean tourism sector's vulnerability to natural hazards through the development of a '*Regional DRM Framework for Tourism'*. Under the Framework, a '*Regional DRM Strategy and Plan of Action'* will be developed, with a fundamental component being the development of standardised methodologies for hazard mapping, vulnerability assessment and economic valuation for risk assessment for the tourism sector (CDERA 2007; CDERA 2009).

The inextricable links between climate change and comprehensive disaster management have not been ignored. In an effort to strengthen, regional, national and community level capacity to mitigate, and respond to the effects of climate change the Austrian Development Agency (ADA) is providing support to the Caribbean Disaster Emergency Management Agency (CDEMA) for the execution of the "Mainstreaming Climate Change into Disaster Risk Management for the Caribbean Region (CCDM) Project". This two year project seeks to achieve three outcomes:

1. Improved coordination and collaboration between community disaster organisations and other research/data partners including climate change entities for undertaking comprehensive disaster risk management;
2. Enhanced community awareness and knowledge on disaster management and climate change procedures ; and
3. Enhanced preparedness and response capacity (technical and managerial) for sub-regional and local level management and response.

Projections for the region suggest that more extreme temperatures and more intense rainfall in certain seasons could lead to a greater number of hydro-meteorological disasters. Many of the hazards facing Caribbean countries already pose threats to lives and livelihoods and climate-related events are regular occurrences. The CCCRA report will not only offer improvements to the existing disaster management framework in the region, but will also offer pragmatic strategies for action which will build resilience in the Caribbean to the predicted impacts from climate change (see herein, the Sections on Climate Modelling, Water Quality and Availability, Marine and Terrestrial Biodiversity and Fisheries, Community Livelihoods, Gender, Poverty and Development, Human Health, Energy Supply and Distribution, and Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements).

Table 5.7.1: Enhanced Comprehensive Disaster Management Programme Framework 2007-2012

GOAL **Regional Sustainable Development enhanced through Comprehensive Disaster Management**			
PURPOSE *'To strengthen regional, national and community level capacity for mitigation, management, and coordinated response to natural and technological hazards, and the effects of climate change.*			
OUTCOME 1: Enhanced institutional support for CDM Program implementation at national and regional levels	**OUTCOME 2:** An effective mechanism and programme for management of comprehensive disaster management knowledge has been established	**OUTCOME 3:** Disaster Risk Management has been mainstreamed at national levels and incorporated into key sectors of national economies (including tourism, health, agriculture and nutrition)	OUTCOME 4: **Enhanced community resilience in CDERA states/ territories to mitigate and respond to the adverse effects of climate change and disasters**
OUTPUTS ***1.1 National Disaster Organizations are strengthened for supporting CDM implementation and a CDM program is developed for implementation at the national level*** ***1.2 CDERA CU is strengthened and restructured for effectively supporting the adoption of CDM in member countries*** ***1.3 Governments of participating states/ territories support CDM and have integrated CDM into national policies and strategies*** ***1.4 Donor programming integrates CDM into related environmental, climate change and disaster management programming in the region.*** ***1.5 Improved coordination at national and regional levels for disaster management*** ***1.6 System for CDM monitoring, evaluation and reporting being built***	OUTPUTS ***2.1 Establishment of a Regional Disaster Risk Reduction Network to include a Disaster Risk Reduction Centre and other centres of excellence for knowledge acquisition sharing and management in the region*** ***2.2 Infrastructure for fact-based policy and decision making is established /strengthened*** ***2.3 Improved under-standing and local /community-based knowledge sharing on priority hazards*** ***2.4 Existing educational and training materials for Comprehensive Disaster Management are standardized in the region.*** ***2.5 A Strategy and curriculum for building a culture of safety is established in the region***	OUTPUTS ***3.1 CDM is recognised as the roadmap for building resilience and Decision-makers in the public and private sectors understand and take action on Disaster Risk Management*** ***3.2 Disaster Risk Management capacity enhanced for lead sector agencies, National and regional insurance entities, and financial institutions*** ***3.3 Hazard information and Disaster Risk Management is integrated into sectoral policies, laws, development planning and operations, and decision-making in tourism, health, agriculture and nutrition, planning and infrastructure*** ***3.4 Prevention, Mitigation, Preparedness, Response, recovery and Rehabilitation Procedures developed and Implemented in tourism, health, agriculture and nutrition, planning and infrastructure***	OUTPUTS ***4.1 Preparedness, response and mitigation capacity (technical and managerial) is enhanced among public, private and civil sector entities for local level management and response*** ***4.2 Improved coordination and collaboration between community disaster organizations and other research/data partners including climate change entities for undertaking comprehensive disaster management*** ***4.3 Communities more aware and knowledgeable on disaster management and related procedures including safer building techniques*** ***4.4 Standardized holistic and gender-sensitive community methodologies for natural and anthropogenic hazard identification and mapping, vulnerability and risk assessments, and recovery and rehabilitation procedures developed and applied in selected communities.*** ***4.5 Early Warning Systems for disaster risk reduction enhanced at the community and national levels***

In Jamaica disaster management is organised with the Office of Disaster Preparedness and Emergency Management (ODPEM) as the leading agency and various other committees and groups below directing local activities. In addition, local non-governmental organisations (NGOs) contribute to disaster management in Jamaica with the Red Cross and Seventh Day Adventist Churches playing important roles in disaster response at the community level (Office of Disaster Preparedness and Emergency Management, 2008).

National level

Jamaica has developed a tiered system in order to decentralise the responsibility of disaster response and preparedness. At the national level there is the National Disaster Committee (NDC) that meets annually to review and monitor the National Disaster Strategy; formulate guidelines for Response Teams; and advise, supervise and monitor annual work programmes of disaster related activities (Office of Disaster Preparedness and Emergency Management, 2008). As part of the NDC there are 6 sub-committees for the following activities:

- Administration/ Finance and Public Service
- Damage Assessment, Recovery and Rehabilitation
- Emergency Operations, Communication, Transportation
- Public Information and Education
- Welfare/Shelter, Relief Clearance
- Health Planning

These sub-committees integrate various public agencies and government ministries to collaborate on issues surrounding disaster management. However, a shortcoming of this kind of the structure used in Jamaica is that it is heavily focused on 'response' and 'recovery'. Meanwhile, following the Asian Tsunami in 2004, one of the primary findings was that generally disaster management must shift its focus to the need for 'building back better' and 'enhancing preparedness to future disasters' (Clinton, 2006). Thus, the only sub-committee focused on that type of effort is possibly Public Information and Education. The Damage Assessment, Recovery and Rehabilitation committee would also be focused on building a 'culture of safety' and avoiding the simple reconstruction of risks that existed prior to the disaster. Although efforts have been made to better incorporate hazard mitigation and capacity building into the disaster management plan for Jamaica, funding restrictions and limited human resource capacity has limited efforts in this area (ODPEM Interview, 2011). In addition, the annual impact from hurricanes has prevented real advancement on mitigation and adaptation, because as noted, disasters demand that monies intended for other purposes be used instead for recovery.

Jamaica has had the privilege of being a pilot for some regional studies on disaster risk management and climate change adaptation initiated by CDEMA. Though ODPEM has played a role in the provision of information to these CDEMA studies, the implementation of recommendations and institutionalisation of changes has been slower to occur (ODPEM Interview, 2011). Although CDEMA conducts many studies and creates reports with valuable information, their ability to ensure the recommendations are implemented within Participating States is restricted by time and resources, not to mention the fact that their mandate is not to legislate but rather to "build capacity" and "coordinate response".

Parish level

National disaster plans are implemented at the parish level by the Parish Disaster Committees (PDC). PDCs are led by the Parish District Coordinator who coordinates activities in conjunction with the Mayor (Office of Disaster Preparedness and Emergency Management, 2008).

In recent disasters the need to better communicate and disseminate post-disaster damage and vulnerability assessment information has been recognised. ODPEM is working to improve their information sharing mechanism through a programme called 'Building Disaster Resilient Communities' that is expected to be completed in 2011 (ODPEM Interview, 2011). This programme started in 2008 and aims to improve communication and planning systems at the national, parish and community level.

Community level

Though national level policies are important for disaster risk reduction, it is the community level practices that will ultimately determine how well a country manages impacts and adapts to change. ODPEM has divided the communities of Jamaica into 'zones' and 'focal points' where a Zone Chairman passes information to the PDC and assesses resources and capacity needs in their communities (Office of Disaster Preparedness and Emergency Management, 2008). The Seventh Day Adventist Church in Jamaica has played a key role in community disaster management. Each zone has its community headquarters in a Seventh Day Adventist Church. In addition, a National Zonal Committee coordinates the National Zonal Programme and implements a Public Education Programme, raising funds and preparing detailed policy and mission statements (Office of Disaster Preparedness and Emergency Management, 2008).

The consistent structure of zones with headquarters in a familiar location helps individuals maintain an awareness of where to go for information and shelter before or during a disaster regardless where they live. This standard indicates that the vulnerability at the community level would be reduced and the effectiveness with which adaptation efforts are made would also be good throughout the country. Nevertheless, the use of a specific religiously affiliated group may pose some challenges in the more diverse communities of Jamaica. Sensitivity to cultural or religious practices must also be incorporated into community level disaster management in order to ensure a consistent level of vulnerability and adaptive capacity across the entire cross-section of individuals in a community.

Jamaica Tourism Board*:* Communication of climate hazards is part of the Jamaica Tourist Board information for tourists (Jamaica Tourist Board, 2010). A simple message to tourists indicating which months hurricanes typically occur is a satisfactory effort at building awareness of the risks and will help tourists to plan their trip. However, use of statements like the rainy season is August to October, "but even then it doesn't rain every day and the showers typically only last a couple of hours" (Fenix Capital Group LLC, 2006) seriously reduces the severity of the threat. This passive warning leaves a large number of the tourists vulnerable in the event of a hurricane impact. "The overwhelming scientific evidence [shows] that people typically are unaware of the hazards they face, underestimate those of which they are aware, overestimate their ability to cope when disaster strikes, often blame others for their losses, underutilise pre-impact hazard strategies, and rely heavily on emergency relief when the need arises" (Mileti, 1999, p. 136-7). If this is the case for people in their normal circumstances, where they are familiar with their surroundings and have a community support network that could help them in case of an emergency, imagine how vulnerable tourists must then be in a foreign place. The guidance provided in a document from the UNEP on disaster risk management for coastal tourism destinations indicates how to develop and implement a disaster preparedness plan; however, the actual use of this information will vary across countries (see Shurland & de Jong, 2008 or Organization of American States (OAS), 1998 for examples).

5.7.2. Policy and legislation

Disaster Management: National level legislation guides disaster and emergency decision making through the Disaster Preparedness and Emergency Management Act of 1993. The primary objectives of this act are to "advance disaster preparedness and emergency management measures in Jamaica by facilitating and co-ordinating the development and implementation of integrated disaster management systems" (Government of Jamaica, 1993). The age of this legislation could be seen as an obstacle to adaptive capacity since the country has definitely changed in the nearly two decades since the last update of this act.

The Jamaica National Hazard Mitigation Policy accedes to Jamaica's vulnerability to multiple natural and human-induced hazards, and notes that the impact of such hazards - including climate and climate-change related events - on the social and economic fabric of the society are challenges to the attainment of sustainable development, which are further compounded by social issues such as poverty, the location of human settlements in high-risk areas, environmental degradation and instances of poorly constructed infrastructure and housing (Spence, 2005). While Jamaica's disaster preparedness and emergency management capacity has made steady progress since the establishment of the Office of Disaster Preparedness and Emergency Relief Coordination (ODIPERC) in 1980, through to the later establishment of the Office of Disaster Preparedness and Emergency Management (ODPEM) in 1993, it is now imperative that Jamaica factors the threats and potential damage of climate and climate related events into its sustainable development framework.

Land Use Planning: ODPEM is part of the approval process for all development and land use management decisions (ODPEM Interview, 2011). This participation is executed through the physical planning mechanism in such legislation as: the Town and Country Planning Act of 1957, the Local Improvements Act of 1914 and the Parish Council's Building Act of 1908 (OAS, 2001). This participation in the planning of land uses and the development of communities adds adaptive capacity to Jamaica however, ODPEM's role as merely a consultant leaves the ultimate decision to allow construction in hazard-prone lands in the hands of the physical planning department. This is not to suggest that ODPEM should have the authority to approve development, but rather the fact that hazard maps and land-use zoning should correspond to reduce risks. Furthermore, hazardous lands are often settled on an informal basis in which case the legislation is not enacted. Monitoring of informal development is a difficult process to manage and therefore it is inevitable that some housing vulnerabilities will continue to persist.

Flood plains are high risk areas and therefore flood plain regulations in Jamaica designate the use of flood plain areas based on their degree of flood risk (Office of Disaster Preparedness and Emergency Management, 2008). Designations serve various purposes including:

- To prevent new development in flood-prone areas, that could result in loss of life and property.
- To inform and protect buyers purchasing lands in flood-prone areas.
- To prevent encroachments that decrease the flood carrying capacity of flood plains, or otherwise aggravate flood problems.
- To reduce public costs for emergency operations such as evacuation, relief and reconstruction.
- To preserve natural flood plain values and characteristics.
- To reduce future expenditure for the operation and maintenance of flood control structures

(Source: ODPEM, 2008a)

Additional legislative considerations for forest cover and slope stability will prevent and mitigate disaster impacts. The National Forestry Action Plan has not been updated since 1989 (Ministry of Agriculture, n.d.). The legislation to control forest removal or reforestation actions is therefore likely inaccurate in its ability to reduce risks. In May 2010 the Forestry Department was created under the Ministry of Agriculture (Ministry of Agriculture, n.d.). This new department is likely to have to update documents in order to ensure they are effective and accurate according to the current situation of the forestry resources in Jamaica. As a result the adaptive capacity of the Forestry Department can be said to be low at the moment. As improvements and changes to current regulations and laws are made, the dedicated forestry management agency will create a great adaptive capacity within both the Ministry of Agriculture and the Forestry Department because each agency will be acting on more specific areas of Jamaica's resource management.

Development and EIA: Commercial and industrial developments, on the other hand, should be monitored and halted if proper environmental impact assessments (EIA) and natural hazard impact assessments (NHIA) procedures have not first been executed. Jamaica has EIA guidelines specific to different sectors and these guidelines could easily be expanded to include considerations for both natural hazards and climate change impacts (Caribbean Development Bank (CDB) and Caribbean Community Secretariat (CARICOM), 2004). The Natural Resources Conservation Authority Act, 1991, governs the EIA process and defines an EIA as "a study of the effects of a proposed action on the environment" (Caribbean Development Bank (CDB) and Caribbean Community Secretariat (CARICOM), 2004, p. 48). To expand this study, considerations for how the changing environment may affect a specific development (i.e. Climate change impacts such as SLR) would also be worth including in the development permit process.

Nevertheless, Jamaica is aware of their risk. Anthony McKenzie, Director of the Coastal Zone Management Branch at the National Environment and Planning Agency (NEPA), at a Lunch to mark Maritime Awareness Week (September 25, 2009) emphasised the cost of climatic changes when he noted that "Jamaica is already paying for the effects of climate change and that NEPA is working assiduously to mitigate the effects of sea level rise, [as] continuous rise in sea levels will compound beach erosion and permanently inundate areas along Jamaica's coast" (JIS, 2009).

Drought and Flooding: Climate change projections (see Section 3 Climate Modelling) indicate that continued decreases in precipitation could lead to a higher incidence of drought. Flooding may become less frequent as a result of heavy rainfall, however, rising sea levels and the likelihood of increased wave heights from storm surge will lead to flooding in coastal areas. In 2003, the Ministry for Water and Housing opened a Drought Management Unit to help manage storage of water during a period of drought (Jamaican Gleaner, 2003). The National Water Commission has the difficult task of managing water supplies during times of heavy precipitation as well as times of very little rainfall (See Section on Water Quality and Availability). Although water management is generally a concern for the agricultural ministry and water commission, there is also the aspect of times when the situation turns to a disaster. In collaboration with the Meteorological Service of Jamaica and the National Water Authority, efforts are made to keep these situations from becoming national disasters.

Tourism: The legal tourism acts referenced on the Jamaica Tourist Board (TIPS) website make no reference to hazards, emergencies or disaster. Despite ODPEM suggesting that they have involved the tourism industry in disaster preparedness and response, there is no indication that it is legislated by any of the acts.

5.7.3. Technology

The maintenance of a strong communication network is a vital part of adaptive capacity because it allows information to reach all audiences and stakeholders in an efficient manner and permits informed decisions. ODPEM, under a programme called 'Building Disaster Resilient Communities' has acknowledged that their communication system could be improved, and is working to build adaptive capacity in this area, as well as improving the management of emergency situations.

Another related communication tool that is vital to disaster relief and response is early warning systems. Typically early warning systems (EWS) are used to indicate pending flood risks in a river basin or low-lying community. A complete EWS consists of monitoring stations that track rainfall and weather conditions (rain gauges, weather radar, human observation etc), and an alarm system that sounds when thresholds are met. In a simple system there are two types of alarms, one which sounds to indicate increasing risk and another that identifies immediate danger and the need for evacuation. There are various means through which to communicate these levels or risk and with increasing technology availability and use, new methods, such as mobile phone applications, have increasing usefulness. In recent years, ODPEM has reviewed these systems and tested their function to ensure they will work effectively in an emergency (ODPEM, 2008a).

Due to the similarity of hazards and impacts from climate change across countries of the Caribbean region, organisations such as the Caribbean Tourism Organization and the Organization of American States have provided guidance documents for tourist establishments to use in developing a disaster preparedness plan (see for example Shurland & de Jong, 2008). Additionally, “tourists tend to see the Caribbean as one marketplace. If one part of the Caribbean is deemed to have been devastated this easily is reflected as a reduction of flow of visitors also in the other parts of the region. [Therefore,] (each) territory will benefit individually and collectively from reduced interruption, losses and dislocation as appropriate risk management procedures are implemented” (CDEMA, 2010). This perspective highlights the importance of cooperation across the region. Sharing lessons learnt during disaster events and dissemination of information on adaptation strategies, successful or otherwise, is a key part of building resilience and reducing vulnerability in the countries of the region.

In Jamaica, the entire island is exposed to hazards from flooding to high winds and storm surge, and there is an island-wide early warning system consisting of satellite (internet) monitoring, weather radar, wind vanes, rain gauges, human reporting, and cable channels (CRID, no date). The information is disseminated via broadcast radio and TV, sirens, bull horns, fax, HF/VHF/UHF radio, email, telephone, cell phones, satellite phones and SMS (text messaging) and can thus be quickly spread across a vast number of the at risk population (CRID, no date).This system has been in place for 14 years and assistance from various international organisations ensures its effective function so as not to cause panic unnecessarily while communicating an accurate level of risk. Resources used to create this EWS came from various agencies and government bodies, except for community organisations (CRID, no date). This omission of community groups from the implementation, operation and maintenance of the EWS could be seen as a weakness of the system because without direct contact with communities, there is the possibility of poor communication and lack of trust in the system by the individuals who must heed the warnings.

Further engineering technologies have been used to develop building standards that reduce flood risks. Buildings, especially housing, require some form of flood proofing in order to withstand heavy rainfall. This can come in the form of site planning where water flows away from the house structure or through the use of sandbags to dam water off during times of high water levels in rivers near a settlement. Generally, flood-proofing activities are best done prior to construction and thus architects and building contractors use their knowledge to create a safe structure. ODPEM also uses their flood risk maps to monitor areas where water levels commonly rise to dangerous levels. These mapping resources build adaptive capacity by allowing emergency supplies to be directed to those who will require them most (i.e. Sandbags, transportation to shelters etc.). ODPEM offers resources for flood proofing in dry and wet conditions on their website (ODPEM, 2008a). Taking proactive measures to flood proof a structure before it gets wet is obviously the best way to mitigate impacts.

These structural flood-proofing measures indicate that there is a good level of awareness across the institutions in Jamaica. It was difficult, however, to find data that would indicate how well these measures are being implemented across the general population. Nevertheless, because of the frequency of flooding events in Jamaica, one can infer that individuals and institutions would have a good adaptive capacity to flooding impacts.

5.8. *Community Livelihoods, Gender, Poverty and Development: the Case-study of Port Antonio and Surrounding Communities*

A total of thirty-one respondents were surveyed, thirteen (42%) of whom were male and eighteen (58%) female.

5.8.1. Demographic profile of respondents

Residency in the Parish

Overwhelmingly, respondents were long-time residents of the Parish, with 70% (N= 22) of the sample indicating that they had lived in the Parish for a minimum of 16 years. Female respondents, however, recorded longer periods of residency, with 83% (N = 15: 83.34%) of all female respondents indicating that they had lived in the community for at least 16 years, compared to just over 50% (N = 7: 53.84%) of male respondents who had lived in the Parish for a for a similar period.

Table 5.8.1: Length of Residency in Parish / Community

Residency	Male		Female		Total	
1 - 5 years	3	23.08%	2	11.11%	5	16.13%
6 - 10 years	2	15.38%	0	0.00%	2	6.45%
11 - 15 years	1	7.69%	1	5.56%	2	6.45%
16 - 20 years	2	15.38%	3	16.67%	5	16.13%
21 - 25 years	5	38.46%	12	66.67%	17	54.84%

Age distribution[13]

The disparity in male and female residency could be explained by the age distribution of the sample, which – while a predominantly youthful sample with only 16% of respondents older than 60 years of age (N=5/ 16.13%) – comprised 22.23% of women over the age of 45, compared with only 7.69% of males in a similar age band.

Table 5.8.2: Age Distribution of Sample

Age	Male		Female		TOTAL	
Under 25	5	38.46%	5	27.78%	10	32.26%
25 – 34	4	30.77%	4	22.22%	8	25.81%
35 – 44	3	23.08%	5	27.78%	8	25.81%
45 – 54	0	0.00%	3	16.67%	3	9.68%
Over 60	1	7.69%	1	5.56%	2	6.45%

Household Form and Structure

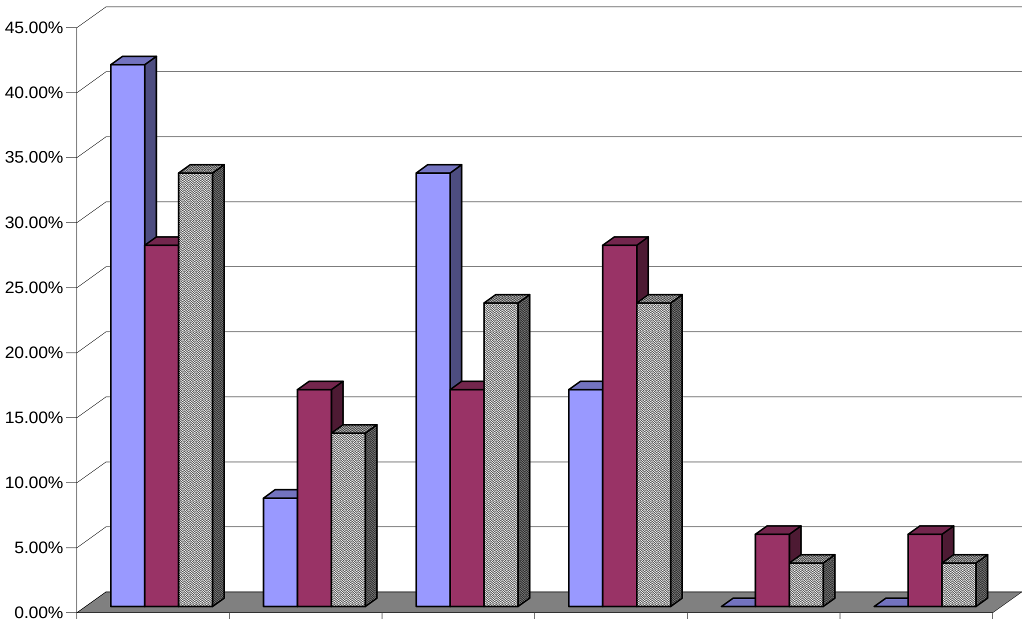
An equal proportion of the respondents sampled were either single (N=14 / 46.67%) or were married (N 14 = / 46.67%).

Table 5.8.3: Relationship Status of Respondents

[13] It bears noting that the sample closely mirrors statistics from the 2008 STATIN Labour Market Force, which indicate an age distribution in the parish of Portland where only 16.9% of persons are 55 and older.

Status	Male		Female		Total	
Single	5	41.67%	5	27.78%	10	33.33%
Single (Visiting Relationship)	1	8.33%	3	16.67%	4	13.33%
Married	4	33.33%	3	16.67%	7	23.33%
Other/Common Law	2	16.67%	5	27.78%	7	23.33%
Divorced	0	0.00%	1	5.56%	1	3.33%
Widowed	0	0.00%	1	5.56%	1	3.33%

When disaggregated on the basis of sex, a larger proportion of male respondents (N=5 / 50%) than female respondents (N=5 / 44.44%) indicated that they were married, suggesting stronger support systems present for men. This was of particular interest when considered against the backdrop that only female respondents were either divorced (N=1 / 5.56%) or widowed (N=1 / 5.56%).



	Single	Single (Visiting Relationship)	Married	Other/Common Law	Divorced	Widowed
Male	41.67%	8.33%	33.33%	16.67%	0.00%	0.00%
Female	27.78%	16.67%	16.67%	27.78%	5.56%	5.56%
Total	33.33%	13.33%	23.33%	23.33%	3.33%	3.33%

Figure 5.8.1: Relationship Status of Respondents

Household headship

More than half of the respondents sampled listed themselves as the heads of their respective households (N=19/63.3%). This was more so the case for female respondents, however, 64.71% of whom indicated that they were considered the head of their households compared to 61.54% of male respondents who indicated that they were considered the head of their household

Table 5.8.4: Perception of Headship of Household

Perceived as Head of Household	Sex of Respondent			
	Male		**Female**	
Yes	8	61.54%	11	64.71%
No	5	38.46%	6	35.29%

With regards to household size, 74.19% of respondents indicated that they lived in households of between 2 and 5 persons. One male and female respondent respectively indicated that they were the only members of their households. Similarly one respondent indicated that she belonged to a household of more than seven (N=9) persons.

Table 5.8.5: Family Size by Sex of Head of Household

Size of Household	Headship of Household					
	Male		**Female**		**Total**	
1	1	8.33%	1	5.26%	2	6.45%
2 – 3	3	25.00%	8	42.11%	11	35.48%
4 – 5	5	41.67%	7	36.84%	12	38.71%
6 – 7	3	25.00%	2	10.53%	5	16.13%
More than 7 persons	0	0.00%	1	5.26%	1	3.23%

Of interest, respondents indicated that males tended to head larger households. Two-thirds of the sample indicated that males headed of four or more persons, compared to only 53% of women heading similarly large households.

However, when measured against the age of household members, female heads seemed to have an increased burden of care as 42% of persons in female-headed households were under the age of 25; and assumedly requiring more care, while 50% of persons in male-headed households were at productive ages (between 25 and 35) and could therefore potentially offer economic support to the home, thereby lessening the burden on the male head.

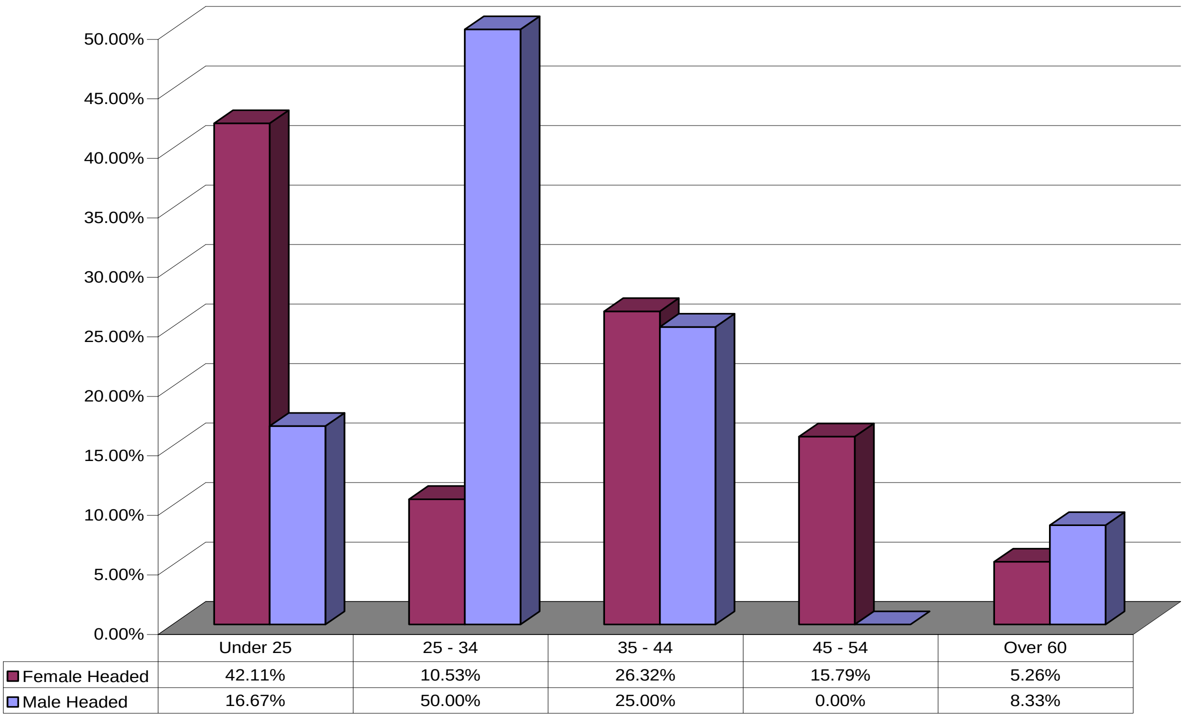


Figure 5.8.2: Age Distribution of Households by Sex of Head of Household

Education and Livelihoods

Similar to findings of the Portland Parish Profile[14] the largest proportion of the sample (N=14 / 45.16%) indicated that they had completed up to a secondary level of education. Of note however, is that while 61.54% of male respondents indicated that they had completed a secondary education, this was the case for only 45.16% of female respondents. Conversely, 25.18% of female respondents indicated that they had completed tertiary education, compared to 7.69% of male respondents who had done the same. Not surprisingly, given the widely accepted perception of technical areas as the purview of males, almost twice the proportion of male respondents (30.77%) indicated that they had completed training at a technical-vocational institute, an than female respondents (16.67%).

Table 5.8.6: Sample Distribution by Education and Training

Highest Level of Education	Male		Female		Total	
Secondary	8	61.54%	6	33.33%	6	45.16%
Community College	0	0.00%	1	5.56%	1	3.23%
Teachers College	0	0.00%	1	5.56%	1	3.23%
Technical-Vocational Institute	4	30.77%	3	16.67%	3	22.58%
Tertiary	1	7.69%	7	38.89%	7	25.81%

Congruent with higher rates of education of females sampled, female respondents indicated higher average incomes than male respondents While 40% of female respondents (N = 6 / 39.99%) recorded earning in excess of US $750 per month; and 13.33% recording earning in excess of US $1,500 per month, no male respondent recorded average monthly earning of more than US $1,000.

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[14] http://lms.heart-nta.org/DesktopModules/DocumentView.aspx?TabId=0&Alias=ppdd.lms.heart-nta&Lang=en-US&ItemId=2083&wversion=Staging

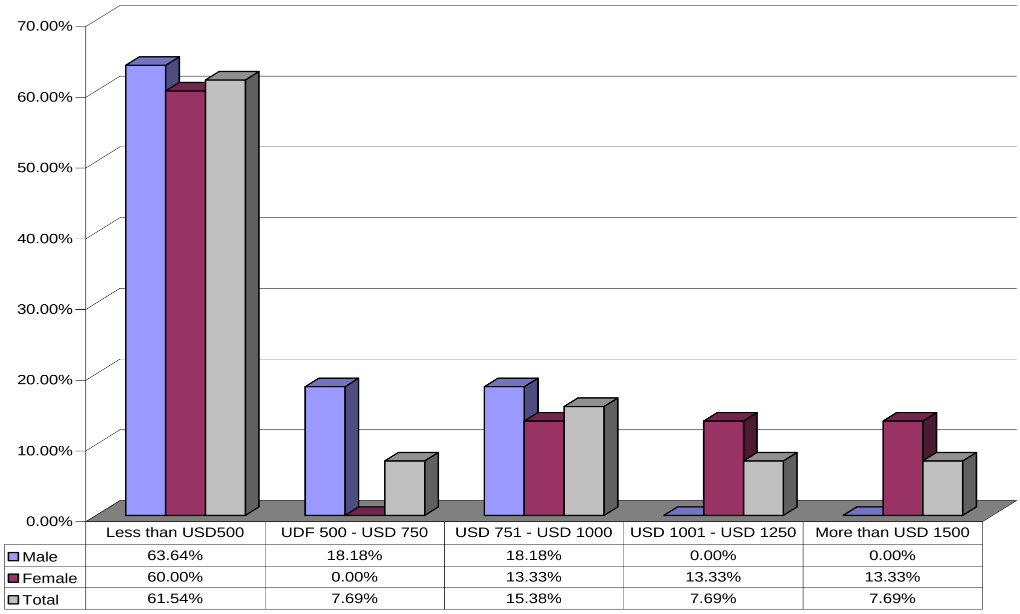


Figure 5.8.3: Sample Distribution by Average Monthly Earnings

Predominantly, respondents acquired their primary income from sources other than tourism.

Of the three female respondents who indicated that their primary income was derived from Tourist activities, one worked as a Tour Operator and the other two, as Hotel Workers.

Table 5.8.7: Labour Market Participation: Involvement in Tourism Sector

Involvement in Tourism	Male		Female		Average	
Yes	0	0.00%	3	20.00%	3	12.50%
No	9	100.00%	12	80.00%	21	87.50%

Reflective of the structure of the Portland Economy, the largest proportion of respondents (N=6/ 28.57%) derived their primary source of income from Agriculture. This was particularly the case for male respondents (N=4 / 50%). Conversely, the largest proportion of female respondents indicated employment with a government agency (N=3 / 23.08%).

Not dissimilar to Parish level and national trends, gender segregation seemed evident with regards to Labour market participation. On the one hand only female respondents indicated involvement in Education or the Health Services, while on the other, only male respondents indicated involvement in Mechanical or Technical areas.

Also of note, only female respondents indicated that they were unemployed. Against the background of higher educational qualifications of females, it is interesting to find that translation to the labour market is not as expected[15].

Table 5.8.8: Labour Market Participation: Involvement in Non-Tourism Sectors

[15] Ricketts & Benfield 2000 Gender and The Jamaican Labour Market: The Decade of the 90s in The Construction of Gender Development Indicators for Jamaica. A joint PIOJ/CIDA publication

Employment Sector	Male		Female		Total	
Administration	1	12.50%	1	7.69%	2	9.52%
Agriculture	4	50.00%	2	15.38%	6	28.57%
Education	0	0.00%	1	7.69%	1	4.76%
Mechanical / Technical	1	12.50%	0	0.00%	1	4.76%
Retail sales and services	1	12.50%	2	15.38%	3	14.29%
Health Services	0	0.00%	1	7.69%	1	4.76%
Government Worker	1	12.50%	3	23.08%	4	19.05%
Transportation	0	0.00%	1	7.69%	1	4.76%
Unemployed	0	0.00%	2	15.38%	2	9.52%

Interestingly, despite female respondents indicating higher levels of unemployment than male respondents, a larger proportion of female respondents indicated involvement in income generating activity than male respondents. While the data does not shed additional light on the apparent discrepancy, it could be indicative of women's involvement in informal work, for which they may receive payment, which falls outside the formal economy.

Table 5.8.9: Sample Distribution by Involvement in Income Generating Activity (IGA)

Involvement in IGA	Male		Female	
Yes	9	69.23%	14	77.78%
No	4	30.77%	4	22.22%

Also noteworthy, is despite disparities in levels of education, income earning and rates of employment and income generation, almost identical proportions of male (N= 8: 61.54%) and female (N = 11: 61.1%) respondents indicated that they were the primary income earner for their households.

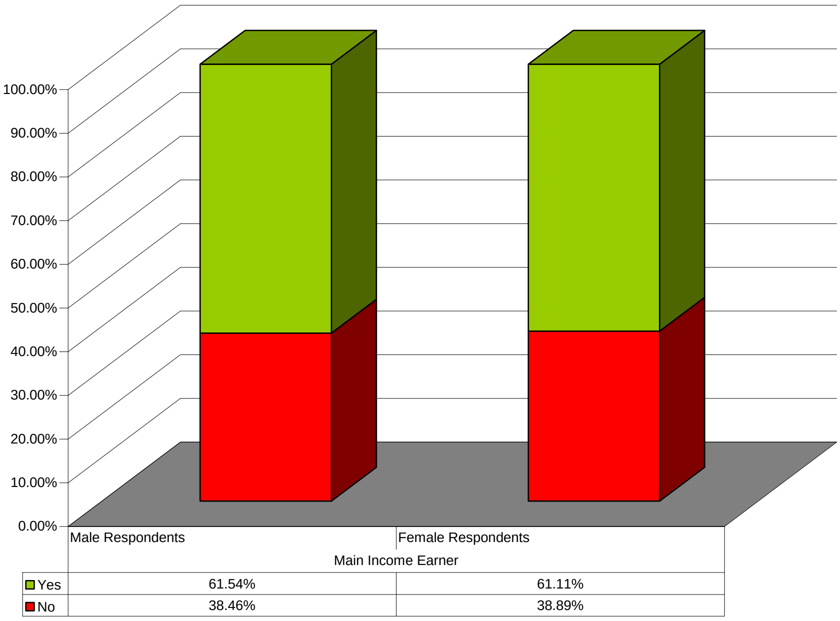


Figure 5.8.4: Sample Distribution by Financial Responsibility for Household

Further, 78.57% of respondents from female headed households indicated that they were in receipt of financial assistance to supplement the monthly household income, in comparison to only 50% of respondents from male headed households.

Conversely, while 70.59% of respondents from female headed households were responsible to offer financial support to other households, this was only the case in 50% of male respondents.

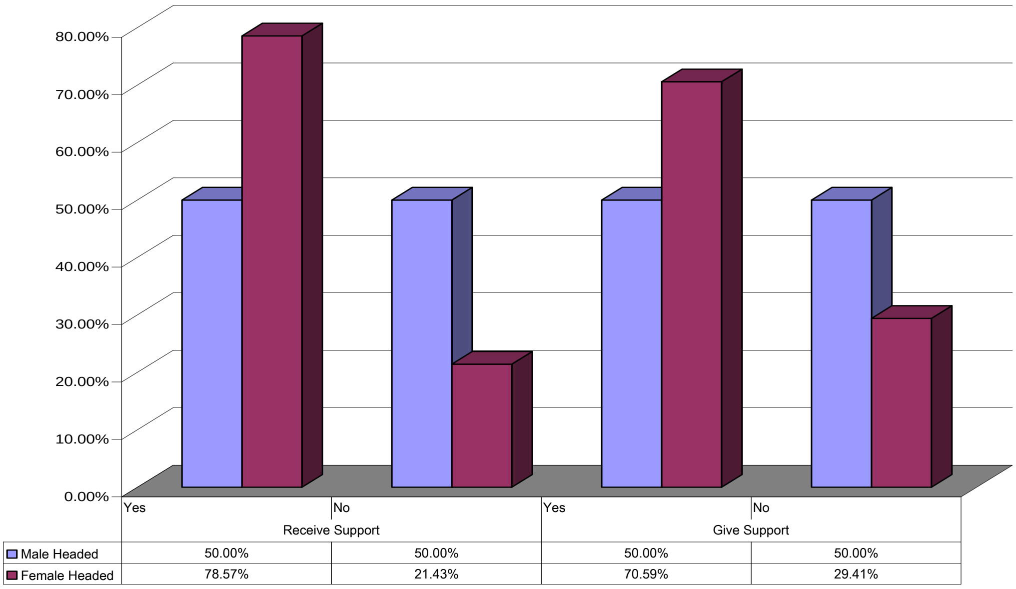


Figure 5.8.5: Sample Distribution by Financial Responsibility for Household

The pattern could suggest better developed support systems and systems of social capital among female headed households. Such systems would be critical in the aftermath of a climate related disaster.

5.8.2. Food security

Overwhelmingly respondents (93.55%) indicated that their food supply was procured from Grocery stores or super markets. Additional sources of food included Community Shops (51.61%) and Traditional Markets (41.94%). Respondents also indicated that food was provided by family plots (38.71%) as well as obtained through barter arrangements (12.9%), though this was the least used method.

Table 5.8.10: Source of Food Supply

Source of Food Supply	Sample	Male Headed			Female Headed		
		Male	**Female**	**Total**	**Male**	**Female**	**Total**
Grown by Family	38.71%	100.00%	0.00%	50.00%	16.67%	83.33%	50.00%
Grocery store / Super market	93.55%	75.00%	25.00%	41.38%	17.65%	82.35%	58.62%
Open air / Traditional market	41.94%	66.67%	33.33%	23.08%	30.00%	70.00%	76.92%
Community	51.61%	62.50%	37.50%	50.00%	12.50%	87.50%	50.00%
Barter	12.90%	50.00%	50.00%	50.00%	50.00%	50.00%	50.00%

Of note, when asked about the adequacy of the household food supply, while approximately three-quarters of the sample (73.33%) indicated an adequate supply throughout the year, when examined on the basis of household structure and headship:

- Female headed households were in a far more secure position with sixteen of the twenty-two respondents indicating adequacy (72.73%) coming from female headed households
- However, despite higher levels of food security than male headed households, only 18.75% of male respondents within female headed households indicated adequacy
- Similarly, no female respondents from male headed households agreed that there was an adequate supply of food throughout the year

The scenario raises important questions as to how adequacy is viewed, as well as to how food is distributed within households.

Table 5.8.11: Adequacy of Food Supply

Adequacy of Food Supply	Sample		Male Headed						Female Headed					
			Male (%)		Female (%)		Total (%)		Male (%)		Female (%)		Total (%)	
Yes	22	73.33	6	100.00	0	0.00	6	27.27	3	18.75	13	81.25	16	72.73
No	8	26.67	3	50.00	3	50.00	6	75.00	1	50.00	1	50.00	2	25.00

Reasons for inadequacy cantered mainly around financial concerns. In the instance of inadequacy, it was noted that "*when supplies are low, children are made a priority…we* [the adults] *will have something small like tea and crackers*"

5.8.3. Financial security and social protection

Evidence of such networks is apparent, based on the ways in which differently-headed households received and offered support:

- 36% of respondents from female headed households received financial support from relatives compared to 33% of respondents from male headed households who receive similar support
- Even a larger proportion of respondents from male headed households gave financial support to relatives, these persons were mainly females.
- Respondents from female headed homes both gave and received more financial support to religious organisations, than respondents from male headed households

Table 5.8.12: Sample Distribution by Financial Responsibility for Household

SUPPORT	RECEIVE FINANCIAL SUPPORT						GIVE FINANCIAL SUPPORT					
	Male Headed			Female Headed			Male Headed			Female Headed		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)
Relative	25.00	50.0	33.33	0.00	47.06	36.36	44.44	66.67	50.00	100.0	40.0	43.75
Family Friend	25.00	50.0	33.33	60.00	17.65	27.27	22.22	0.00	16.67	0.00	26.67	25.0
Religious Organisation	0.00	0.0	0.00	40.00	11.76	18.18	11.11	0.00	8.33	0.00	20.00	18.75
Charitable Organisation							11.11	0.00	8.33	0.00	13.33	12.5
Government	25.00	0.0	16.67	0.00	11.76	9.09						
Other	25.00	0.0	16.67	0.00	11.76	9.09	11.11	33.33	16.67	0.00	0.0	0.0

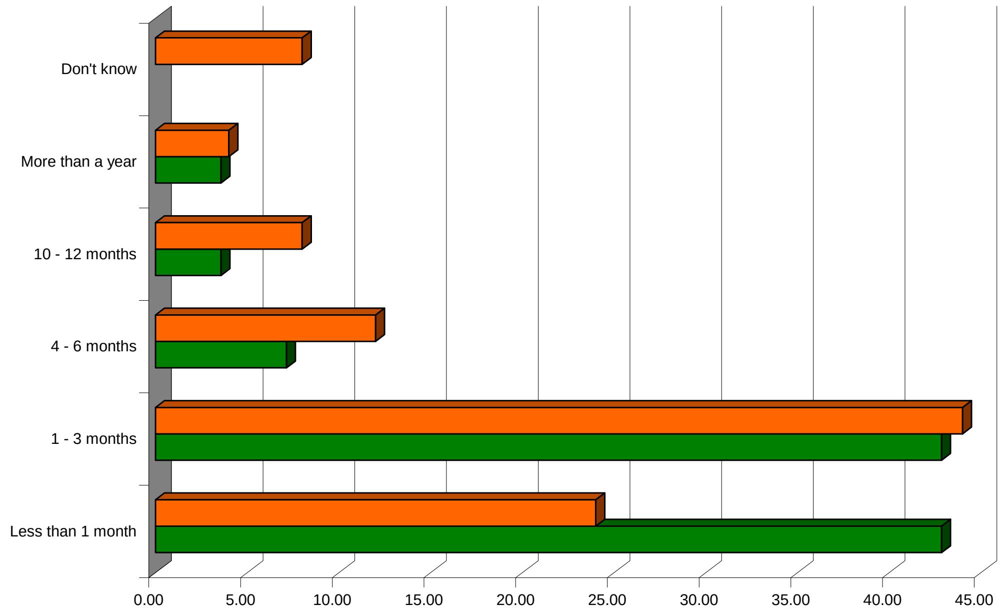
Respondents generally seemed to prefer accessing credit from less formal sources as 81% of all respondents accessing credit within the last year did so through either a Credit Union or a Partner scheme.

This was particularly the case for female respondents. Similar to patterns observed in the Livelihoods, Gender, Poverty Development (LGPD) work completed in Barbados, while the data does not definitively explain why, it could be indicative of a preference for community schemes, which would be less stringent in terms of prerequisites for borrowing.

Table 5.8.13: Sample Distribution by Access to Credit

Credit Facility	Total Sample	Male Headed			Female Headed		
		Male	**Female**	**TOTAL**	**Male**	**Female**	**TOTAL**
Commercial Bank Loan	18.52%	22.22%	0.00%	16.67%	0.00%	21.43%	20.00%
Credit Union Loan	33.33%	55.56%	33.33%	41.67%	0.00%	28.57%	26.67%
Sou Sou / Partner	48.15%	55.56%	66.67%	41.67%	100.00%	50.00%	53.33%

Respondents generally believed that in the instance of job loss or the occurrence of some natural disaster, their financial reserves would last between one and three months.



	Less than 1 month	1 - 3 months	4 - 6 months	10 - 12 months	More than a year	Don't know
Job Loss	24	44	12	8	4	8
Natural Disaster	42.86	42.86	7.14	3.57	3.57	

Figure 5.8.6: Financial Security: Job Loss or Natural Disaster

More specifically: in relation to Job Loss, respondents from female headed households indicated longer periods of financial coverage than respondents in male headed households, though only marginally so. While 70% of respondents from male headed households indicated an ability to survive for less than three months, in the instance of job loss, this was the case for 67% of respondents of female headed households. Of note, is that only female respondents from female headed households indicated that they would be able to support themselves for over a year, in the case of job loss.

Table 5.8.14: Sample Distribution by Financial Security: Job Loss

Financial Reserve	Male Headed						Female Headed					
	Male		**Female**		**Total**		**Male**		**Female**		**Total**	
Less than 1 month	4	50.00%	1	50.00%	5	50.00%	1	50.00%	0	0.00%	1	6.67%
1 - 3 months	2	25.00%	0	0.00%	2	20.00%	1	50.00%	8	61.54%	9	60.00%
4 - 6 months	1	12.50%	0	0.00%	1	10.00%	0	0.00%	2	15.38%	2	13.33%
10 - 12 months	0	0.00%	1	50.00%	1	10.00%	0	0.00%	1	7.69%	1	6.67%
More than a year		0.00%		0.00%	0	0.00%	0	0.00%	1	7.69%	1	6.67%
Don't know	1	12.50%	0	0.00%	1	10.00%	0	0.00%	1	7.69%	1	6.67%

Similarly, respondents from female headed households indicated longer periods of financial coverage than respondents in male headed households, in the instance of a natural disaster.

While no respondent from a male headed household indicated an ability to survive financially for more than three months, in the instance of a natural disaster, 12.5% of respondents in female headed households indicated that they would be able to support themselves for more than 10 months. The perception of ability to support the household is a particularly useful indicator of resilience and would be important in determining the ways in which households adapt in the face of a natural / climate related event.

Table 5.8.15: Sample Distribution by Financial Security: Natural Disaster

Financial Reserve	Male Headed						Female Headed					
	Male		**Female**		**Total**		**Male**		**Female**		**Total**	
Less than 1 month	4	66.67%	1	66.67%	5	66.67%	1	50.00%	0	21.43%	1	25.00%
1 - 3 months	2	33.33%	0	33.33%	2	33.33%	1	50.00%	8	50.00%	9	50.00%
4 - 6 months	1	0.00%	0	0.00%	1	0.00%	0	0.00%	2	14.29%	2	12.50%
10 - 12 months	0	0.00%	1	0.00%	1	0.00%	0	0.00%	1	7.14%	1	6.25%
More than a year		0.00%		0.00%	0	0.00%	0	0.00%	1	7.14%	1	6.25%
Don't know	1	0.00%	0	0.00%	1	0.00%	0	0.00%	1	0.00%	1	0.00%

Respondents generally had little social protection, with less than one half of respondents (N=15 / 48.39%) having health insurance and just over half of respondents (N = 17/54.84%) registered for National Insurance/Government Pension. Home insurance, which covered climate related events, was particularly low given the potential for such events in the area.

When examined on the basis of household structure and sex of respondent, interesting patterns emerged:

- While a larger proportion of female headed households indicated health coverage, female respondents within male headed households had less coverage than males within male headed households
- Similarly, while twelve of the seventeen (71%) respondents registered to receive government pension were from female headed households, only five such persons were from male headed households. However, of these five persons, three were male
- Additionally, while six of the ten (60%) respondents in possession of private pension savings were from female headed households, three of the four respondents (75%) who were from male headed households, were themselves male

Table 5.8.16 provides additional details:

Table 5.8.16: Sample Distribution by Social Protection Provisions

Financial Provision	Sample		Male Headed						Female Headed					
			Male		**Female**		**Total**		**Male**		**Female**		**Total**	
Health Insurance	15	48.39%	4	66.67%	2	33.33%	6	40.0%		0.0%	9	100%	9	60.0%
Private Pension Savings	10	32.26%	3	75.0%	1	25.0%	4	40.0%		0.00%	6	100%	6	60.0%
Government Pension	17	54.84%	3	60.0%	2	40.0%	5	29.41%	2	16.67%	10	83.33%	12	70.59%
Home Insurance - Hurricane Damage	4	12.90%	1	100.0%		0.0%	1	25.0%		0.0%	3	100%	3	75.0%
Home Insurance - Flooding	4	12.90%	1	100.0%		0.0%	1	25.0%		0.0%	3	100%	3	75.0%
Home Insurance - Storm Surge	3	9.68%	1	100.0%		0.0%	1	33.33%		0.0%	2	100%	2	66.67%
Home Insurance - Fire	5	16.13%	2	100.0%		0.0%	2	40.0%		0.0%	3	100%	3	60.0%

Though not conclusive, observed intra-household gendered patterns of social protection and ownership may indicate higher levels of social protection for women, only in the instance they are members of female headed households. This is particularly critical as risks associated with climate change threaten to reinforce gender inequalities[16]. The United Nations Economic Commission for Latin America and the Caribbean suggests that the relationship between gender and the environment requires an examination of existing gender roles and relative socio-economic status in pre-disaster situations[17] In 2009, Deputy Resident Representative of the Jamaica Office of the United Nations' Development Programme (UNDP), Akiko Fujii, asserted that already the lives of women and children in particular are being affected by the growing problem of climate change[18].

It must be noted that women's limited access to resources can make them much more vulnerable than men to the effects of climate change.

5.8.4. Asset base

Ownership of assets, like provision of social protection, was generally low for respondents. The highest proportion of respondents indicated ownership of houses (65%), Land (45%) and Livestock (45%)

Similar patterns emerged in relation to ownership of assets, where females in female headed households fared better than females in male headed households:

- Eleven of the twenty (55%) respondents indicating home ownership were from male headed households, however eight of those respondents (72.73%) were male
- Similarly, nine of the fourteen (71.43%) respondents who owned livestock were from female headed households, however of the five respondents from male headed households who owned livestock, four (80%) were male
- Further, nine of the fourteen (71.43%) respondents in possession of land were from female headed households, however all respondents from male headed households who owned land (100%) were male. This pattern of male dominant ownership was also observed in relation to ownership of Industrial Equipment and Commercial Vehicles.

[16] Resource Guide on Gender and Climate Change: http://content.undp.org/go/cms-service/download/asset/?asset_id=1854911
[17] http://www.eclac.cl/publicaciones/xml/7/23217/L.48.pdf
[18] http://jamaica-gleaner.com/gleaner/20090502/lead/lead4.html

Table 5.8.17: Sample Distribution by Ownership of Assets

Asset	Sample		Male Headed						Female Headed					
			Male		Female		Total		Male		Female		Total	
House	20	64.52%	8	72.73%	3	27.27%	11	55.00%	0	0.00%	9	100.00%	9	45.00%
Land	14	45.16%	4	100.00%	0	0.00%	4	28.57%	0	0.00%	10	100.00%	10	71.43%
Livestock	14	45.16%	4	80.00%	1	20.00%	5	35.71%	0	0.00%	9	100.00%	9	64.29%
Industrial Equipment	3	9.68%	2	100.00%		0.00%	2	66.67%	0	0.00%	1	100.00%	1	33.33%
Commercial vehicles	5	16.13%	1	100.00%		0.00%	1	20.00%	0	0.00%	4	100.00%	4	80.00%
Private Business	6	19.35%	3	75.00%		25.00%	4	66.67%	0	0.00%	2	100.00%	2	33.33%

A further examination of assets revealed that:

- Respondents most often indicated having Television sets (100%), Radios (97%), Cellular Phones (100%) and DVD Players (96.77%) in their homes.
- 38.71% of respondents indicated having a desk top computer, while 48.39% indicated having lap tops. Of interest: eleven of the fifteen respondents indicating ownership of laptops were female respondents from female headed households.
- While all respondents sampled indicated ownership of a cellular telephone, less than one-third of respondents indicated having permanent access to a land line telephone.

This could have serious implications for community based warning systems in the event of a climate related event, and in the creation of any mitigation or adaptation strategy, the cost to communicate with all community members would need to be factored in as a consideration.

This is particularly important given that community members noted that in the instance of a disaster:

> *We have a list before of all the persons who live in the vulnerable areas… we monitor the communities on say a daily basis. We know vulnerable persons… we know the problems, and the problems become our problems. So now they are always in our focus…As a community, we work together.*

Table 5.8.18: Sample Distribution by Ownership of Assets: Appliances / Electronics

Asset / Amenity	Male Headed				Male Headed				Sample	
	Male		Female		Male		Female			
Computer (Desktop)	3	75.00%	1	25.00%	2	25.00%	6	75.00%	12	38.71%
Computer (Laptop)	1	25.00%	3	75.00%		0.00%	11	100.00%	15	48.39%
Internet	3	75.00%	1	25.00%	1	16.67%	5	83.33%	10	32.26%
Television	9	75.00%	3	25.00%	4	21.05%	15	78.95%	31	100.00%
Video Player / Recorder		0.00%	2	100.00%					11	35.48%
DVD Player	8	72.73%	3	27.27%	4	21.05%	15	78.95%	30	96.77%
Radio	8	72.73%	3	27.27%	4	21.05%	15	78.95%	30	96.77%
Telephone (Land line)	2	66.67%	1	33.33%	1	16.67%	5	83.33%	9	29.03%
Telephone (Cellular Phone)	9	75.00%	3	25.00%	4	21.05%	15	78.95%	31	100.00%

The issue of communication in the instance of a climate related event seems more critical when measured against access to transportation. Predominantly the sample most normally had access to public transportation, though members of female headed households had marginally more access to private motorised vehicles. However, only members of male headed households had access to non motorised private vehicles (bicycles etc), which could be useful in the even t that roadways have become blocked in the passage of the climate related event.

Table 5.8.19: Sample Distribution by Ownership of Assets: Transportation

Vehicle Access	Male Headed		Female Headed		Sample	
Private motorised vehicle	4	33.33%	7	36.84%	11	35.48%
Private non-motorised vehicle	2	16.67%		0.00%	2	6.45%
Public transit	9	75.00%	14	73.68%	23	74.19%
Other		0.00%	1	5.26%	1	3.23%

Congruent with findings of the Portland Parish profile, of the 29 respondents answering this question, the largest proportion of respondents (N=20/69%) indicated that their home was made of Blocks and cement. It is worthy of note, that more female headed households were constructed of Blocks and cement.

Table 5.8.20: Sample Distribution by Ownership of Assets: House Material

House Material	Male Headed		Female Headed		Sample	
Blocks and cement	4	36.36%	16	88.89%	20	68.97%
Wood	7	63.64%	2	11.11%	9	31.03%

Respondents indicated that they had reasonably good access to sanitation conveniences, with 83.33% and 96.03% of respondents sampled indicating that they always had access to liquid waste disposal and indoor water-flush toilets, respectively.

Table 5.8.21: Sample Distribution by Ownership of Assets: Access to Sanitation Conveniences

Amenity	Access	Male Headed	Female Headed	Sample
Liquid waste disposal	Always	77.78%	86.67%	83.33%
	Sometimes	0.00%	6.67%	4.17%
	Never	22.22%	6.67%	12.50%
Indoor water-flush toilets	Always	90.00%	100.00%	96.30%
	Sometimes	0.00%	0.00%	0.00%
	Never	10.00%	0.00%	3.70%
	Never	0.00%	10.53%	6.90%

Reflective of Census 2001 data,[19] 61.29% of respondents indicated that they had access to piped water within the home, though a larger proportion of female headed households (68.42%) than male headed households (50%) had such convenience.

Other water supplies used included privately supplied water in the home (usually through the use of wells and pumps) and natural water sources, such as rivers and streams.

[19] According to the 2001 Census survey, approximately 54% in the Parish of Portland reported that their water was either publicly or privately piped in their dwelling or yard, while 17% reported that they relied on standpipes and 13% relied on springs or rivers.

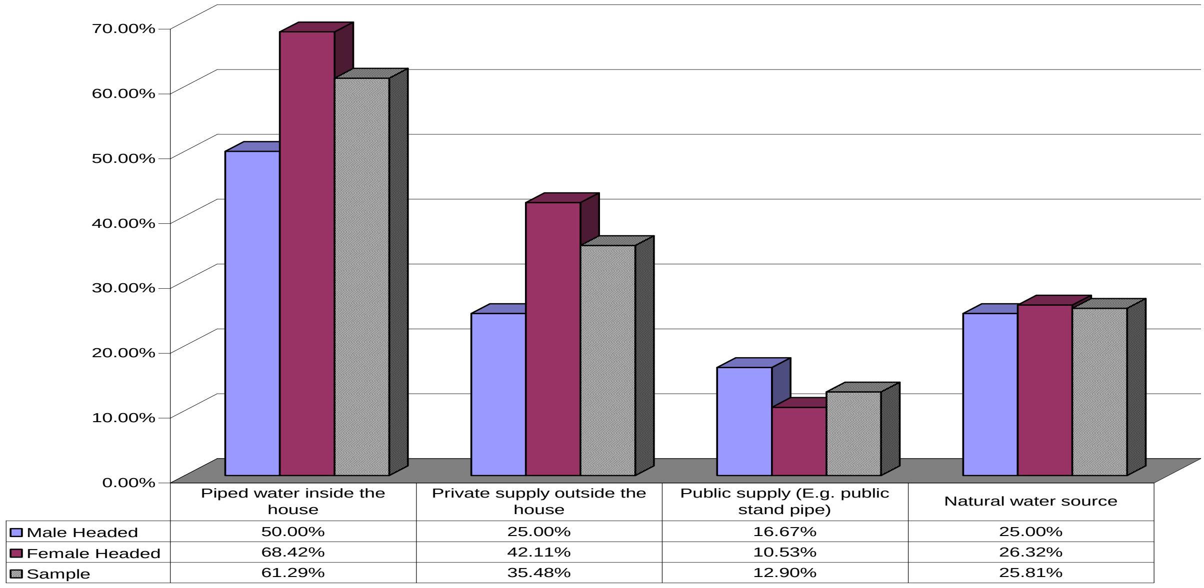


Figure 5.8.7: Sample Distribution by Ownership of Assets: Access to Water

Of some concern, only 7% of the sample indicated that they never had garbage collection done in their community. Findings from the Participatory Workshop revel that in some instances residents were forced to improvise garbage disposal facilities, or to bun their garbage at their homes.

Table 5.8.22: Sample Distribution by Ownership of Assets: Access to Garbage Collection

Amenity	Access	Male Headed	Female Headed	Sample
Garbage collection	Always	40.00%	52.63%	48.28%
	Sometimes	60.00%	36.84%	44.83%
	Never	0.00%	10.53%	6.90%

5.8.5. Power and decision-making

Female respondents indicated higher levels of responsibility for decision making at level of the household and formal community:

Table 5.8.23: Power and Decision Making

Site of Decision Making	Males	Males	Females	Females
Household	10	76.92%	17	94.44%
Informal Community	5	38.46%	4	22.22%
Formal Community	4	30.77%	11	61.11%

When examined on the basis of household headship, however, decision making within the household seem to rest largely with the head of the household, regardless of sex.

Table 5.8.24: Power and Decision Making: Intra Household

Site of Decision Making	Male Headed						Female Headed					
	Male		Female		Total		Male		Female		Total	
Household	9	75.00%	3	25.00%	12	100.00%	1	6.67%	14	93.33%	15	78.95%
Informal Community	4	80.00%	1	20.00%	5	41.67%	1	25.00%	3	75.00%	4	21.05%
Formal Community	3	60.00%	2	40.00%	5	41.67%	1	10.00%	9	90.00%	10	52.63%

5.8.6. Social networks and social capital

Female respondents, however, who were far more actively involved in their respective communities, with 78% of all female respondents belonging to a social group within the community, compared to 38% of male respondents who were similarly involved.

Table 5.8.25: Social Networks: Community Involvement

Membership	Male		Female	
Yes	5	38.46%	14	77.78%
No	8	61.54%	4	22.22%

Moreover, the types of groups in which males and females had membership differed:

- Predominantly, male respondents were members of sporting groups, such as police clubs and training clubs
- Female respondents were primarily involved in parish administrative and service organisations, which may be indicative of deeper ties within the community

Table 5.8.26: Social Networks: Community Involvement – Organisation Membership

Organisation	Male		Female	
Administration		0.00%	7	38.89%
Leisure	1	7.69%	5	27.78%
Savings		0.00%	1	5.56%
Church	0	0.00%	2	11.11%
Service	3	23.08%	5	27.78%
Sports	5	38.46%	3	16.67%
Other		0.00%	1	5.56%

With regards to support systems:

- Male respondents tended to rely on relatives within their households for physical help, personal advice and financial assistance to a far greater degree than female respondents relied on their relatives with whom they lived.
- Conversely, female respondents relied more heavily on relatives outside their respective households than did male respondents. This was particularly the case in the instance of financial assistance.

- Of note, though no male respondents were members of churches, 53.85% of male respondents indicated that they would seek personal advice from a religious organisation, compared to 44.44% of female respondents.
- Also noteworthy, other than for financial assistance, Government Agencies seemed to be a last resort for respondents in need of physical help or personal advice.

Table 5.8.27: Social Networks: Support Systems

Support System	Physical Help		Personal Advice		Financial Assistance	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Relative (within the household)	69.23%	61.11%	84.62%	50.00%	61.54%	50.00%
Relative (outside the household)	61.54%	61.11%	38.46%	61.11%	53.85%	83.33%
Family friend	61.54%	44.44%	23.08%	44.44%	53.85%	38.89%
Religious Organisation	7.69%	16.67%	53.85%	44.44%	0.00%	11.11%
Non-religious Charity	7.69%	5.56%	7.69%	0.00%		
Government Agency	7.69%	5.56%	0.00%	11.11%	23.08%	27.78%

5.8.7. Use of natural resources

Other than in the instance of Rivers/Streams, Agricultural Land, Bush/Forest and Wild Animals respondents generally indicated a low level of use for natural resources, with less than 10% of resources indicating that resources were of particular importance to them for either their subsistence or livelihoods. Not surprisingly, however - given the structure of the Portland economy - the largest proportion of respondents indicated that Agricultural land was very important for their subsistence (N = 14 / 63.65%) or their livelihood (N = 13 / 59.09%).

Table 5.8.28: Use and Importance of Natural Resources

Resource	Importance	Subsistence		Livelihood		Recreation	
River / Stream	Very Important	7	26.92%	5	19.23%	19	67.86%
	Somewhat important	6	23.08%	4	15.38%	8	28.57%
	Not at all important	12	46.15%	16	61.54%	0	0.00%
	None / Do Not Use	1	3.85%	1	3.85%	1	3.57%
Sea	Very Important	2	8.70%	2	8.70%	16	55.17%
	Somewhat important	1	4.35%	2	8.70%	13	44.83%
	Not at all important	20	86.96%	19	82.61%	0	0.00%
	None / Do Not Use	0	0.00%	0	0.00%	0	0.00%
Coral Reefs	Very Important	2	10.53%	2	10.53%	0	0.00%
	Somewhat important	1	5.26%	1	5.26%	3	16.67%
	Not at all important	15	78.95%	15	78.95%	14	77.78%
	None / Do Not Use	1	5.26%	1	5.26%	1	5.56%
Mangrove	Very Important	2	11.76%	2	11.76%	2	11.11%
	Somewhat important	1	5.88%	2	11.76%	3	16.67%
	Not at all important	13	76.47%	12	70.59%	12	66.67%
	None / Do Not Use	1	5.88%	1	5.88%	1	5.56%
Agricultural Land	Very Important	14	63.64%	13	59.09%	2	11.11%
	Somewhat important	2	9.09%	3	13.64%	4	22.22%
	Not at all important	5	22.73%	5	22.73%	11	61.11%
	None / Do Not Use	1	4.55%	1	4.55%	1	5.56%
Bush and Forest	Very Important	5	29.41%	7	41.18%	1	6.25%
	Somewhat important	2	11.76%	1	5.88%	3	18.75%
	Not at all important	9	52.94%	8	47.06%	11	68.75%
	None / Do Not Use	1	5.88%	1	5.88%	1	6.25%
Mountain	Very Important	1	6.25%	3	17.65%	8	44.44%
	Somewhat important	2	12.50%	0	0.00%	6	33.33%
	Not at all important	13	81.25%	14	82.35%	4	22.22%
	None / Do Not Use	0	0.00%	0	0.00%	0	0.00%
Caves	Very Important	0	0.00%	1	6.25%	3	17.65%
	Somewhat important	1	6.25%	1	6.25%	3	17.65%
	Not at all important	14	87.50%	13	81.25%	10	58.82%
	None / Do Not Use	1	6.25%	1	6.25%	1	5.88%
Wild Animals	Very Important	3	17.65%	2	12.50%	1	5.88%
	Somewhat important	5	29.41%	2	12.50%	3	17.65%
	Not at all important	8	47.06%	11	68.75%	12	70.59%
	None / Do Not Use	1	5.88%	1	6.25%	1	5.88%

When further disaggregated on the basis of sex, there was an apparent gender disparity in the use of natural assets, where a much larger proportion of male respondents were dependent on natural resources for livelihood and subsistence.

This was particularly true of use of:

– Rivers / Streams: 38.46% and 30.77% of male respondents indicated that the use of rivers and streams was very important to their subsistence and livelihood respectively, compared to 15.38% and 7.69% of female respondents citing similar importance

- Bush and Forest: 37.5% and 50% of male respondents noted that the use of bush and forests was very important to their subsistence and livelihood respectively, compared to 22.22% and 33.33% of female respondents indicated similar importance
- Wild Animals: 22% of male respondents considered wild animals to be very important to their subsistence, compared with 12.5% of female respondents who considered them equally important

However, with regards to the use of Agricultural land, it was female respondents who indicated the highest level of importance for their subsistence (69.23%) as well their livelihood (61.54%).

With regards to changes observed over the last five years in relation to natural resources, respondents were particularly concerned about rivers, agricultural land and the sea. It was noted that:

River / stream

- The river has taken some of the land
- Discolouration in the water
- In more recent times the river has changed course in the Buff Bay Valley
- The Rio Grande River is currently being mined for sand and gravel

Agricultural land

- It [is] not cultivating as before [one has] to go further inland to plant
- Have to use too much fertilizer, as [one was] not getting as much produced
- Have to be moving from one place to another for more fertile land
- Have to be moving closer to the mountains

Sea

- Coastal erosion is more evident especially in the Orange Bay community
- Decreased catches of fish
- It is not as clean as it used to be

provides additional detail:

Table 5.8.29 provides additional detail:

Table 5.8.29: Use and Importance of Natural Resources, by Sex of Respondent

Resource	Importance	Subsistence		Livelihood		Recreation	
		Male	Female	Male	Female	Male	Female
River / Stream	Very Important	38.46%	15.38%	30.77%	7.69%	76.92%	60.00%
	Somewhat important	23.08%	23.08%	7.69%	23.08%	23.08%	33.33%
	Not at all important	38.46%	53.85%	61.54%	61.54%	0.00%	0.00%
	None / Do Not Use	0.00%	7.69%	0.00%	7.69%	0.00%	6.67%
Sea	Very Important	16.67%	0.00%	16.67%	0.00%	53.85%	56.25%
	Somewhat important	8.33%	0.00%	16.67%	0.00%	46.15%	43.75%
	Not at all important	75.00%	100.00%	66.67%	100.00%	0.00%	0.00%
	None / Do Not Use	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Coral Reefs	Very Important	9.09%	12.50%	9.09%	12.50%	0.00%	0.00%
	Somewhat important	9.09%	0.00%	9.09%	0.00%	30.00%	0.00%
	Not at all important	81.82%	75.00%	81.82%	75.00%	70.00%	87.50%
	None / Do Not Use	0.00%	12.50%	0.00%	12.50%	0.00%	12.50%
Mangrove	Very Important	11.11%	12.50%	11.11%	12.50%	10.00%	12.50%
	Somewhat important	11.11%	0.00%	22.22%	0.00%	30.00%	0.00%
	Not at all important	77.78%	75.00%	66.67%	75.00%	60.00%	75.00%
	None / Do Not Use	0.00%	12.50%	0.00%	12.50%	0.00%	12.50%
Agricultural Land	Very Important	55.56%	69.23%	55.56%	61.54%	22.22%	0.00%
	Somewhat important	22.22%	0.00%	22.22%	7.69%	22.22%	22.22%
	Not at all important	22.22%	23.08%	22.22%	23.08%	55.56%	66.67%
	None / Do Not Use	0.00%	7.69%	0.00%	7.69%	0.00%	11.11%
Bush and Forest	Very Important	37.50%	22.22%	50.00%	33.33%	12.50%	0.00%
	Somewhat important	12.50%	11.11%	12.50%	0.00%	25.00%	12.50%
	Not at all important	50.00%	55.56%	37.50%	55.56%	62.50%	75.00%
	None / Do Not Use	0.00%	11.11%	0.00%	11.11%	0.00%	12.50%
Mountain	Very Important	12.50%	0.00%	12.50%	22.22%	37.50%	50.00%
	Somewhat important	12.50%	12.50%	0.00%	0.00%	37.50%	30.00%
	Not at all important	75.00%	87.50%	87.50%	77.78%	25.00%	20.00%
	None / Do Not Use	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Caves	Very Important	0.00%	0.00%	0.00%	12.50%	0.00%	33.33%
	Somewhat important	0.00%	12.50%	0.00%	12.50%	37.50%	0.00%
	Not at all important	100.00%	75.00%	100.00%	62.50%	62.50%	55.56%
	None / Do Not Use	0.00%	12.50%	0.00%	12.50%	0.00%	11.11%
Wild Animals	Very Important	22.22%	12.50%	12.50%	12.50%	12.50%	0.00%
	Somewhat important	44.44%	12.50%	25.00%	0.00%	25.00%	11.11%
	Not at all important	33.33%	62.50%	62.50%	75.00%	62.50%	77.78%
	None / Do Not Use	0.00%	12.50%	0.00%	12.50%	0.00%	11.11%

Consistent with natural resource usage, predominantly it was respondents from female headed households that indicated that they were involved in Agriculture:

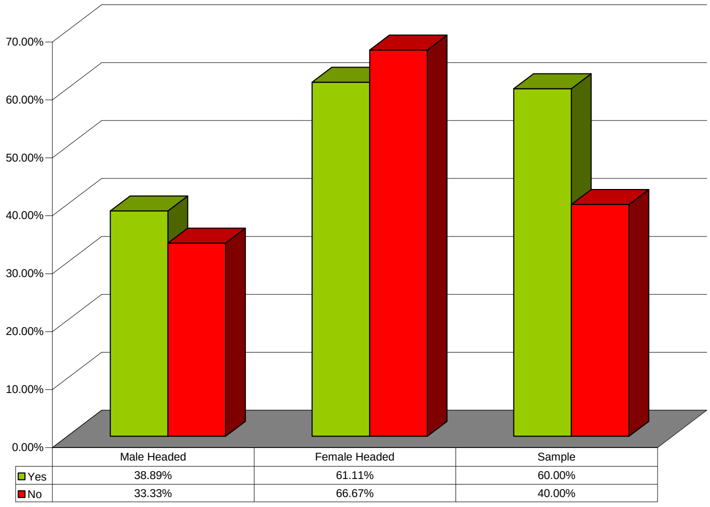


Figure 5.8.8: Involvement in Agriculture

Table 5.8.30: Involvement in Agriculture

Involved in Agriculture	Male Headed		Female Headed		Sample	
Yes	7	38.89%	11	61.11%	18	60.00%
No	4	33.33%	8	66.67%	12	40.00%

Given the structure of households in the sample, particularly in relation to headship and household composition, the importance attached to agricultural land for women, particularly in regards to subsistence, could point to real vulnerability to food security in the instance of a climate related event, such as landslides, flooding or drought.

It was noted in Focus Group Discussion that such vulnerability was already being experienced as respondents expressed a belief that that climate related events were causing crop patterns to change and accounted for significant financial (and emotional) loss. One participant shared that: *Persons are turning away from agriculture, as it is seen as a risky venture, with little benefits. Climate and weather changes have also posed a serious challenge with water sources drying up….*

The point is emphasised when one considers that 80% of respondents involved in Agriculture were dependent on rain water for irrigation and, further no respondents from female headed homes had installed mechanical systems of irrigation, which could be used in the absence of rainfall.

Table 5.8.31 provides additional details:

Table 5.8.31: Involvement in Agriculture: Irrigation Method

Irrigation Method	Male Headed		Female Headed		Sample	
Rain water	5	71.43%	7	87.50%	12	80.00%
Manual Irrigation	1	14.29%	1	12.50%	2	13.33%
Mechanical irrigation	1	14.29%		0.00%	1	6.67%

Further to this, only 53.85% of respondents indicate that they consistently have access to water for land irrigation.

Table 5.8.32: Involvement in Agriculture: Access to Water

Reliability of Water	Male Headed		Female Headed		Sample	
Always	2	40.00%	5	62.50%	7	53.85%
Sometimes	1	20.00%	3	37.50%	4	30.77%
Never	2	40.00%		0.00%	2	15.38%

Additionally, whereas a larger proportion of the sample with such reliable access was from female headed homes (N=7 / 71.43%), a larger proportion of respondents who were aware of water conflicts in their respective communities, was also from female headed households (N = 10 / 55.56%):

Table 5.8.33: Involvement in Agriculture: Knowledge of Water Conflict

Knowledge of Water Conflict	Male Headed		Female Headed		Sample	
Yes	8	44.44%	10	55.56%	18	72.00%
No	3	42.86%	4	57.14%	7	28.00%

5.8.8. Exposure and experience of climate related events

Not surprising, given recent weather patterns (See Boxes 1 & 2), respondents indicated very good levels of knowledge in relation to Hurricanes (74.19%), Flooding (70.97) and Landslides (61.29%). However, knowledge was not quite as comprehensive in relation to Storm Surge or Drought.

When examined on the basis of household structure and headship:

- respondents from female headed households recorded more comprehensive knowledge in relation to all climate related events, safe Storm Surge
- Despite more comprehensive knowledge of female headed households, female respondents in male headed households were far less knowledgeable than males in male headed households about any of the climate related events:
- In the instance of Hurricanes, while 78% of male respondents in male headed households indicated that their knowledge was very good, 67% of female respondents in male headed households indicated that their knowledge was only average
- Though there was a less glaring knowledge gap in relation to flooding, while 71% of male respondents from male headed households indicated that they had very good knowledge of the phenomenon, 67% of female respondents from male headed households recorded similar levels of knowledge
- While 33%, 22% and 56% of male respondents in male headed households indicated that they had very good knowledge of Storm surge, Drought and Landslides respectively, no female respondents from male headed households indicated such a level of knowledge around any of these climate related events.

Table 5.8.34: Knowledge of Climate Related Events

Event	Knowledge	SAMPLE	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Poor	3.23%	0.00%	33.33%	8.33%	0.00%	0.00%	0.00%
	Average	22.58%	22.22%	66.67%	33.33%	25.00%	13.33%	15.79%
	Very Good	74.19%	77.78%	0.00%	58.33%	75.00%	86.67%	84.21%
Flooding	Poor	3.23%	0.00%	0.00%	0.00%	0.00%	6.67%	5.26%
	Average	25.81%	33.33%	100.00%	50.00%	25.00%	6.67%	10.53%
	Very Good	70.97%	66.67%	0.00%	50.00%	75.00%	86.67%	84.21%
Storm Surge	Poor	51.61%	44.44%	66.67%	50.00%	75.00%	50.00%	55.56%
	Average	29.03%	22.22%	33.33%	25.00%	0.00%	42.86%	33.33%
	Very Good	16.13%	33.33%	0.00%	25.00%	25.00%	7.14%	11.11%
Drought	Poor	32.26%	33.33%	33.33%	33.33%	75.00%	20.00%	31.58%
	Average	45.16%	44.44%	66.67%	50.00%	0.00%	53.33%	42.11%
	Very Good	22.58%	22.22%	0.00%	16.67%	25.00%	26.67%	26.32%
Landslides	Poor	3.23%	0.00%	33.33%	8.33%	0.00%	0.00%	0.00%
	Average	35.48%	44.44%	66.67%	50.00%	25.00%	26.67%	26.32%
	Very Good	61.29%	55.56%	0.00%	41.67%	75.00%	73.33%	73.68%

Box 2: Portland and the Experience of Climatic Variability

Portland Sees Threat As Heavy Rains Begin

http://jamaica-gleaner.com/gleaner/20101105/news/news1.html

TORRENTIAL RAINFALL pounded sections of eastern Portland yesterday afternoon, as Tropical Storm Tomas edged closer to the island, forcing several residents to contemplate evacuation.

A group of informal settlers at Boundbrook in Port Antonio, along with fisherfolk at a nearby fishing village, moved to secure their property. Some persons moved to safer ground yesterday, while some said they were adopting a wait-and-see approach. "This thing look serious," commented Albert Davis, one of the settlers.

He continued: "The storm has not really started, and we are already getting so much rain. I am worried about what it will be like on Friday. I have no relatives to run to, so I have to protect my common-law girlfriend and child, so I might be one of the first to go into a disaster shelter should conditions get worse."

As early as midday yesterday, sections of Long Bay and Manchioneal had begun to feel the effects of the tropical storm, as high winds and rough seas intensified.

Despite knowledge gaps with regards to the technical aspects of the various climate related events, respondents showed various levels of awareness of the appropriate course of action to be taken in the instance such an event occurred:

- In the event of a Hurricane, all respondents were aware of what to do, without having to ask for assistance.
- In the instance of Flooding, a slightly less proportion of respondents sampled (87.1%) were aware of appropriate action to take, without asking for assistance

- In the event of a Landslide, 64.52% of respondents were aware of what should be done.

Of note, respondents from male headed households consistently were more aware of the appropriate response to climate related events, than respondents from female headed households. This could have serious implications for the development of adaptation and mitigation strategies for members of these households.

Table 5.8.35: Knowledge of Appropriate Response to Climate Related Events

Event	Knowledge	SAMPLE	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	Yes	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	No	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Don't Know	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Flooding	Yes	87.10%	100.00%	100.00%	100.00%	25.00%	100.00%	84.21%
	No	9.68%	0.00%	0.00%	0.00%	75.00%	0.00%	15.79%
	Don't Know	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Storm Surge	Yes	16.13%	50.00%	0.00%	36.36%	0.00%	9.09%	6.67%
	No	45.16%	25.00%	66.67%	36.36%	100.00%	54.55%	66.67%
	Don't Know	22.58%	25.00%	33.33%	27.27%	0.00%	36.36%	26.67%
Drought	Yes	51.61%	55.56%	100.00%	66.67%	25.00%	53.85%	47.06%
	No	29.03%	33.33%	0.00%	25.00%	75.00%	23.08%	35.29%
	Don't Know	12.90%	11.11%	0.00%	8.33%	0.00%	23.08%	17.65%
Landslides	Yes	64.52%	100.00%	66.67%	90.00%	25.00%	83.33%	68.75%
	No	12.90%	0.00%	33.33%	10.00%	75.00%	0.00%	18.75%
	Don't Know	6.45%	0.00%	0.00%	0.00%	0.00%	16.67%	12.50%

Appropriate responses to various climate related events are capture in Table 5.8.36:

Table 5.8.36: Appropriate Response to Climate Related Events

Hurricane	Flooding	Landslide	Drought
Batten down house	Evacuate area	Evacuate area	Store Water
Prepare to go to a shelter	Do not attempt to cross flooded area		Reduce water usage
Pull down hurricane shutters	Evacuate to higher ground		Pay close attention to sanitation
Clean Drainage			
Put bedding on blocks			
Store adequate drinking water			

When questioned around the perceived risk of climate related events to their households, respondents most often indicated a High Risk of Hurricanes (51.61%), though this was slightly more so in the case of respondents from male headed households (66.67%) than those from female headed households (42.11%). Similarly, respondents from male headed households reported higher levels of risk for Flooding (16.67%) and Landslides (41.67%) than respondents from female headed households, 15.79% and 21.05% of whom reported high levels of risk of flooding and landslides respectively.

Table 5.8.37: Perceived Level of Risk of Climate Related Events: Household

Event	Knowledge	SAMPLE	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	16.13%	33.33%	0.00%	25.00%	25.00%	6.67%	10.53%
	Low Risk	32.26%	11.11%	0.00%	8.33%	0.00%	60.00%	47.37%
	High Risk	51.61%	55.56%	100.00%	66.67%	75.00%	33.33%	42.11%
Flooding	No Risk	54.84%	33.33%	66.67%	41.67%	100.00%	53.33%	63.16%
	Low Risk	29.03%	55.56%	0.00%	41.67%	0.00%	26.67%	21.05%
	High Risk	16.13%	11.11%	33.33%	16.67%	0.00%	20.00%	15.79%
Storm Surge	No Risk	77.42%	75.00%	100.00%	81.82%	100.00%	73.33%	78.95%
	Low Risk	16.13%	25.00%	0.00%	18.18%	0.00%	20.00%	15.79%
	High Risk	3.23%	0.00%	0.00%	0.00%	0.00%	6.67%	5.26%
Drought	No Risk	22.58%	25.00%	0.00%	18.18%	25.00%	26.67%	26.32%
	Low Risk	58.06%	75.00%	100.00%	81.82%	75.00%	40.00%	47.37%
	High Risk	16.13%	0.00%	0.00%	0.00%	0.00%	33.33%	26.32%
Landslides	No Risk	41.94%	33.33%	33.33%	33.33%	75.00%	40.00%	47.37%
	Low Risk	29.03%	22.22%	33.33%	25.00%	25.00%	33.33%	31.58%
	High Risk	29.03%	44.44%	33.33%	41.67%	0.00%	26.67%	21.05%

Of interest respondents consistently reported higher levels of risk to climate related event for the community than they did for their own households.

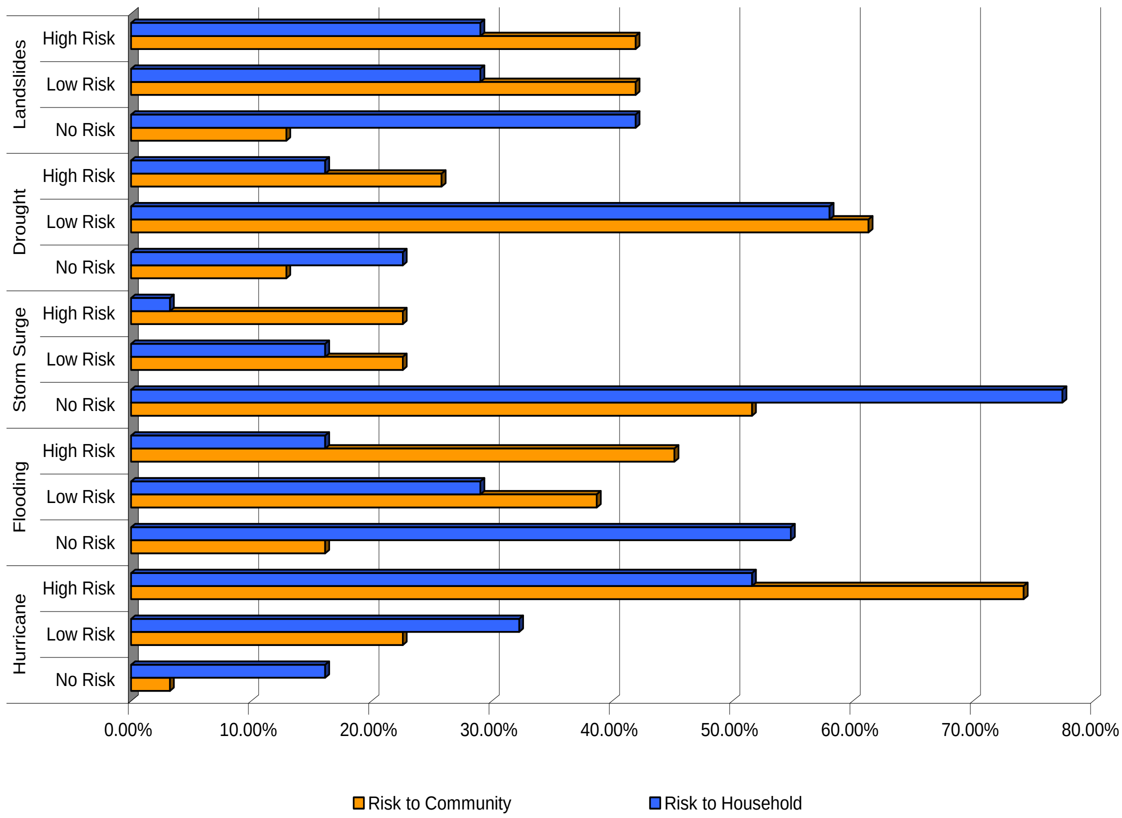


Figure 5.8.9: Perception of Risk for Climate Related Events

The disparity (between perceived risk at the household and community level) was greatest in the instance of Flooding: for which 16.13% of respondents indicated a High Risk for their households, compared to 45.16% of whom indicated a high risk for their respective community.

Similar to patterns observed in relation to perceived risk to respondents' households, respondents from male headed households indicated higher levels of risk to their community in the instance of Hurricane, Storm Surge and Landslides than respondents from female headed households.

Table 5.8.38: Perceived Level of Risk of Climate Related Events: Community

Event	Knowledge	SAMPLE	MALE HEADED			FEMALE HEADED		
			Male	Female	Total	Male	Female	Total
Hurricane	No Risk	3.23%	11.11%	0.00%	8.33%	0.00%	0.00%	0.00%
	Low Risk	22.58%	11.11%	0.00%	8.33%	0.00%	40.00%	31.58%
	High Risk	74.19%	77.78%	100.00%	83.33%	100.00%	60.00%	68.42%
Flooding	No Risk	16.13%	0.00%	0.00%	0.00%	50.00%	20.00%	26.32%
	Low Risk	38.71%	66.67%	33.33%	58.33%	25.00%	26.67%	26.32%
	High Risk	45.16%	33.33%	66.67%	41.67%	25.00%	53.33%	47.37%
Storm Surge	No Risk	51.61%	44.44%	0.00%	33.33%	75.00%	64.29%	66.67%
	Low Risk	22.58%	33.33%	33.33%	33.33%	25.00%	14.29%	16.67%
	High Risk	22.58%	22.22%	66.67%	33.33%	0.00%	21.43%	16.67%
Drought	No Risk	12.90%	11.11%	0.00%	8.33%	0.00%	20.00%	15.79%
	Low Risk	61.29%	88.89%	100.00%	91.67%	50.00%	40.00%	42.11%
	High Risk	25.81%	0.00%	0.00%	0.00%	50.00%	40.00%	42.11%
Landslides	No Risk	12.90%	0.00%	33.33%	8.33%	25.00%	14.29%	16.67%
	Low Risk	41.94%	44.44%	33.33%	41.67%	50.00%	42.86%	44.44%
	High Risk	41.94%	55.56%	33.33%	50.00%	25.00%	42.86%	38.89%

However, when perception of risk is measured against respondents' levels of knowledge (Table 5.8.38) of climate related events, the lower perception of risk by women could be reflective of a lack of knowledge of the real threats posed by the various events.

Similar to perceptions of risk of climate related events, respondents consistently reported higher levels of support received within the community than in their respective households, during climate related events.

The greatest disparity was observed in evacuation assistance received, as well as residence in shelters. The disparity in relief supplies distribution also bears noting as respondents indicated that distribution was affected by political allegiance as well as corruption among local politicians; and that supplies were often diverted away from the persons that most needed them.

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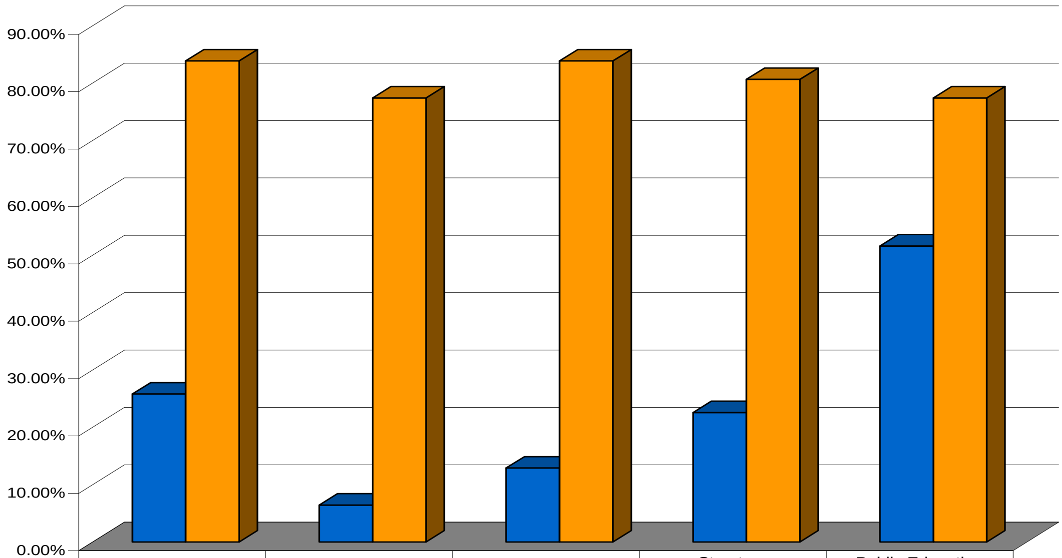


	Relief Supplies	Evacuation assistance	Residence in a shelter	Structure improvements	Public Education material
Household	25.81%	6.45%	12.90%	22.58%	51.61%
Community	83.87%	77.42%	83.87%	80.65%	77.42%

Figure 5.8.10: Support during Climate Related Events

5.8.9. Current coping mechanisms and perceptions of future risks

An almost even number of respondents indicated that preparations to mitigate the possible effects of climate change required financial wherewithal, which they did not possess (N=15 / 48%), others believed that small changes could affect substantial changes (N=16/52%).

Respondents reported being most affected by Hurricanes, Flooding and Landslides within the last five years, with regards to having to take specific measures to adapt to climate related events:

- In the instance of Hurricanes, respondents were most likely to reduce expenses as a strategy of adaptation. This was only the case, however in male headed households
- In the instance of Flooding, respondents were most likely to seek assistance as an adaptation strategy. This was more so the case in female headed households
- Similarly, in the instance of Landslides, respondents were most likely to seek assistance. This occurred irrespective of household headship

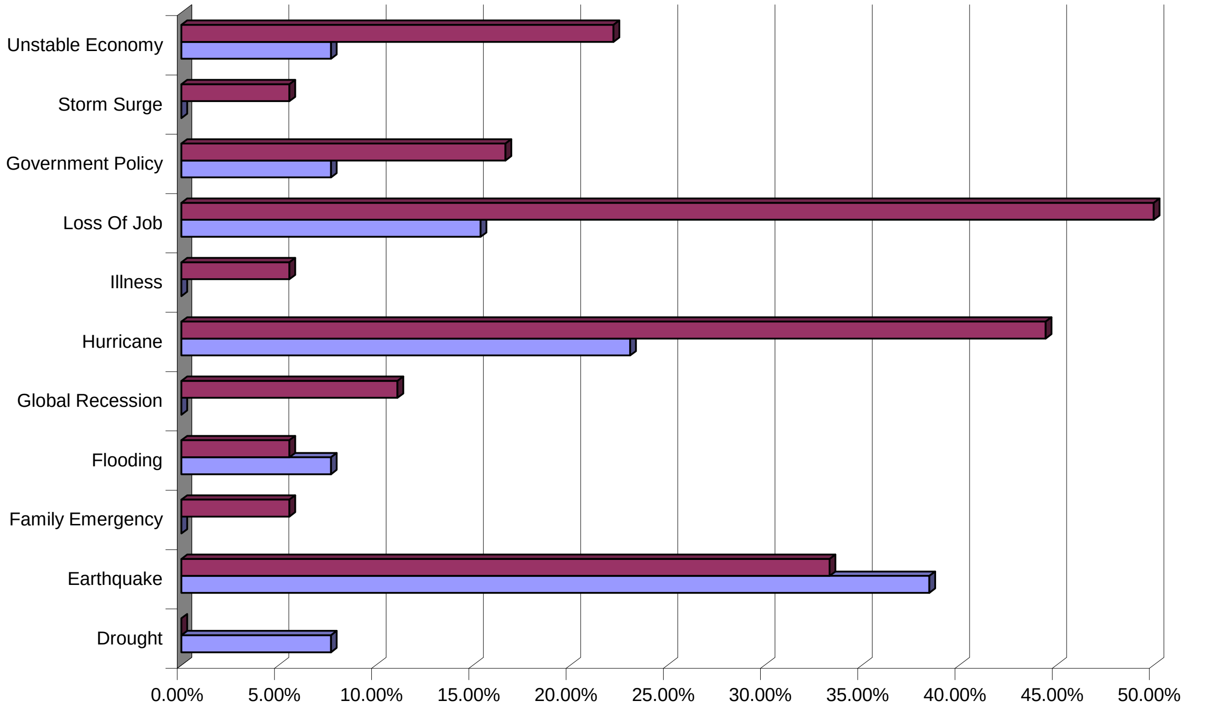
Table 5.8.39: Adaptation Strategies Employed[20]

Event	Adaptation Activity	Male Headed			Female Headed			Sample
		Male	Female	Total	Male	Female	Total	
Hurricane	Selling Assets	1		1				1
	Borrowing Money	2	1	3		1	1	4
	Seeking Assistance	2	2	4				4
	Reducing Expenses	1		1	1	3	4	5
	Starting a New Livelihood Activity				1		1	1
	Decreasing Household Size	1		1				1
Flooding	Selling Assets	1		1				1
	Borrowing Money	1		1				1
	Seeking Assistance	1		1	1	1	2	3
	Reducing Expenses	1		1				1
	Starting a New Livelihood Activity				1		1	1
	Decreasing Household Size							0
Storm Surge	Selling Assets							0
	Borrowing Money							0
	Seeking Assistance							0
	Reducing Expenses	1		1				1
	Starting a New Livelihood Activity				1		1	1
	Decreasing Household Size							0
Drought	Selling Assets							0
	Borrowing Money				1		1	1
	Seeking Assistance	1		1				1
	Reducing Expenses							0
	Starting a New Livelihood Activity							0
	Decreasing Household Size							0
Landslides	Selling Assets							0
	Borrowing Money	1		1				1
	Seeking Assistance	1		1		1	1	2
	Reducing Expenses	1		1				1
	Starting a New Livelihood Activity							0
	Decreasing Household Size							0

When questioned around issues of the potential risk to their livelihoods, female respondents tended to have a less positive outlook for the future than male respondents:

- 50% of female respondents identified the possibility of job loss as the greatest risk to their economic livelihood, compared to 15.38% of male respondents
- While 11% of female respondents identified the impacts of the global recession as a risk to their economic livelihood, no male respondents felt similarly threatened
- Only female respondents identified illness or family emergencies as having a potential impact on their livelihoods.

[20] Values too small to be represented as percentages. Figures appear as *N* values



	Drought	Earthquake	Family Emergency	Flooding	Global Recession	Hurricane	Illness	Loss Of Job	Government Policy	Storm Surge	Unstable Economy
Female	0.00%	33.33%	5.56%	5.56%	11.11%	44.44%	5.56%	50.00%	16.67%	5.56%	22.22%
Male	7.69%	38.46%	0.00%	7.69%	0.00%	23.08%	0.00%	15.38%	7.69%	0.00%	7.69%

Figure 5.8.11: Perceived Future Threats to Livelihood

6. RECOMMENDED STRATEGIES AND INITIAL ACTION PLAN

The following recommendations have been developed in consultation with national and community stakeholders through the use of various participatory tools. They support the main objective of the CCCRA which is to provide a scientific (physical and social) basis to support decision making, policy and planning by governments, communities and the private sector that increase resilience of economies and livelihoods to climate change. The recommendations are also consistent with the strategies and programmes identified in the *Climate Change and the Caribbean: A Regional Framework for Achieving Development Resilient to Climate Change* endorsed by the CARICOM Heads of State and the Jamaica National Development Plan (Vision 2030). They are intended to build on the existing sustainable development goals in order to achieve maximum impact across Jamaica.

Recommendations are presented as an initial plan of action with a brief description of the intervention, the national and/or local stakeholders involved and the expected benefits, and are categorised according to short-, medium- and long-term interventions. All recommendations are considered 'No-regret' or 'Low-regret' strategies. 'No-regret' strategies seek to maximise positive and minimise negative outcomes for communities and societies in climate-sensitive areas such as agriculture, food security, water resources and health. This means taking climate-related decisions or actions that make sense in development terms, whether or not a specific climate threat actually materialises in the future. 'Low-regret' adaptation options are those where moderate levels of investment increase the capacity to cope with future climate risks. Typically, these involve over-specifying components, for example installing larger diameter drains or hurricane shutters at the time of initial construction or refurbishment (World Bank, 2012).

Each one or a group of recommendations can be further developed into a concept note or project proposal with a full action plan, with much of the supporting information found in this document. Earlier sections of this report have provided the rationale for recommended interventions based on the vulnerabilities and adaptive capacity identified for key sectors.

6.1. *Cross-Sectoral Recommendations*

The following activities must be undertaken in the short-term, across a number of sectors, to ensure the success of the more specific and practical recommendations presented in later sections. These cross-cutting actions provide the necessary foundation, in terms of information and data, development policy, awareness raising and cross-sectoral linkages from which wider actions to combat the threat of climate change on future development can be legitimised. With this foundation, future actions and the allocation of resources to adaptation and mitigation activities are more easily justified because decisions can be based on current information, as well as common goals and a widespread understanding of the severity of the threat.

6.1.1. Implementing and Strengthening Data Collection, Measuring and Evaluation Mechanisms

It is evident in a number of sectors that the lack of data and inadequate monitoring and evaluation procedures inhibit the ability of the relevant agencies to plan and manage a number of resources. Monitoring and evaluation is essential if progress is to be demonstrated. By collecting and sharing the information gathered, Section 6.1.3, it is possible to gain even greater support amongst stakeholders.

Specific areas and suggestions for data collection, monitoring and evaluation include:

Hazard, weather and geographical data collection and management: Minimal progress can be made on vulnerability reduction efforts without proper baseline data. ODPEM has recognised this and has started a programme of community vulnerability assessment, however additional priority must be given to funding proper data collection for GIS hazard maps and expansion of vulnerability assessment to ALL communities. This data collection must be a collaborative effort between the Meteorological Service of Jamaica, the Water Resources Authority, ODPEM and community organisations. More robust data collection will allow for the prioritisation of future projects on areas that are least able to adapt to climate change and those most at risk to damage and loss from hazards and disasters.

Furthermore, the CCRIF insurance facility currently determines pay-outs for hurricane damage based on wind speed. The wind speed index is used largely as a result of inaccurate or limited rainfall data. With greater availability of reliable rainfall data for the entire island, the index insurance from the CCRIF may be able to link catastrophe pay-out to a rainfall index as an extension of the current system of wind speed and shake intensity indices. Better data will also improve land use planning and assist in sustainable development efforts across Jamaica.

Energy Audits: National as well as company-specific inventories to assess energy use and related emissions are a precondition for any work to reduce energy use. Companies should thus engage in energy- and carbon audits, while energy- and carbon labelling of a wide range of products and services should be policy goals. Energy audits can range from walk-through audits (which can be conducted in small accommodation units) to detailed energy audits, which are more suitable for large businesses or companies (e.g. hotels, restaurants) with a high energy demand. The Petroleum Corporation of Jamaica (PCJ) and the Jamaica Society of Energy Engineers (a member of the global Association of Energy Engineers) have a list of Certified Energy Auditors and Certified Energy Managers who have been trained for conducting audits and managing efforts to achieve greater energy efficiency in places of work and business. The benefits that can be gained from implementing a regular audit schedule and following up on the subsequent recommendations made to promote energy efficiency are both environmental and financial. Meade and Pringle (2001) have shown, engaging in environmental management systems can have a significant cost-saving impact and be an avenue to engage stakeholders.

Assessments focussing on the links between health, tourism and climate change: Further research should be conducted to link the epidemiology of diseases in Jamaica with climate data. For instance, dengue fever is perhaps under-reported by travellers who experience the generalised symptoms of the disease, but are unfamiliar with them. Similarly, health care professionals also under diagnose the disease (Wilder-Smith and Schwartz, 2005). An Exit Survey can be conducted to assess the veracity of the previous statements, to investigate other potential health concerns, and to determine the perception of tourists on the relationships between travel, health and climate change in Jamaica. These assessments can lead to a better understanding of the implications for tourists entering the region and contracting diseases, particularly communicable diseases; and the likelihood of destination substitution.

Inventory of existing coastal protection defences and their design range and maintenance status: This analysis was hindered by inadequate data on existing coastal structures, their type, design specifications and expected lifetime. Future assessments of the costs and benefits of coastal protection require this information to provide accurate estimates of the resources needed for SLR adaptation.

6.1.2. Mainstreaming Climate Change in Policy, Planning and Practice

More than investing in technology or building a structure, mainstreaming climate change is a critical element of adaptation if adaptation is to be successful. It involves awareness raising, information sharing (Section 6.1.3 and 6.1.4), planning and design, implementation, and perhaps most importantly, evaluation (Linham & Nicholls, 2010). Jamaica is perhaps one of the more advanced territories, having made significant progress in efforts to mainstream climate change across multiple sectors in policy and practice. For example, specific mention of climate change and recommendations for adaptive interventions are highlighted in the National Development Plan ("Vision 2030"; GOJ, 2009f). The following recommendations were tailored to further build on these key action areas:

Integrate SLR considerations in local land use and development planning, with special consideration for vulnerable coastal areas and tourism hot-spots to reduce or avoid impacts: Within the Vision 2030 document (GOJ, 2009f), storm surge hazard mapping has been identified as one of the key actions. Three institutions – ODPEM, SDC and the Jamaica Social Investment Fund (JSIF) – are the lead agencies tasked with implementing this action. Further to storm surge, considerations for SLR also need to be integrated. This will require national-level consultation by the aforementioned agencies with other coastal management and tourism stakeholders, to utilise the broad scale results of this study and higher-resolution local scale studies to guide reviews and updates of official land use and tourism master plans. Measures to be considered include:

- Commence coastal adaptation planning early, by working with local stakeholders on the development of coastal protection systems. The detailed local level planning for coastal protection needs to begin within the next 15 years if the environmental assessments, financing, land acquisition, and construction is to be completed by mid-Century, so that the economic benefits of damage prevention are optimized.
- Assess all projects that involve building, maintaining, or modifying infrastructure in coastal areas at risk from SLR to ensure that the new developments take the most recent estimates of SLR from the scientific community into account. The cost of reconstruction after flood damage is often higher than modifying structures in the design phase.
- Work with insurance companies to develop policies that take into account the unique risks faced by coastal areas which will enable landowners to properly assess coastal protection and retreat options.
- Provide subsidies for appropriate adaptation measures that will result in long term economic benefits for both the tourism sector as well as for the people of the Jamaica.

Use regulation to stimulate changes and adaptation and create incentives for low-carbon technology use: While carbon pricing is the most efficient tool to stimulate behavioural change and changes in production, market failures justify additional policy intervention (see also Francis *et al*., 2007). Regulation can include building codes and other minimum standards to reduce emissions. The introduction of low-carbon technology needs to be supported through incentive structures. An ecological tax reform, for instance, could shift tax burdens from labour to energy and natural resources, and thus "reward" users of low-carbon technology. Other incentives could include financial support, reward mechanisms or awards. There is also a range of examples of bonus-malus[21] systems in tourism and transport, rewarding those choosing to pollute less.

[21] Business arrangements which alternately reward (bonus) or penalise (malus) for specific actions.

6.1.3. Building and Strengthening Information Sharing and Communication Networks

It is essential that a tri-partite approach is taken when developing the full action plans for the recommended strategies given. A number of relevant studies have been undertaken in Jamaica in the past, but the recommendations are frequently not implemented for a number of reasons, lack of resources being commonly cited. By establishing a framework by which government, private sector entities and civil society can work more effectively together, the probability of implementation and widespread 'buy-in' to the numerous initiatives increases. It is not possible for any one group to achieve the changes that are needed alone and government must ensure that national policy goals and challenges faced are shared so that solutions can be discussed and negotiated between groups. Gaining support for initiatives is also facilitated through education and awareness, Section 6.1.4.

The data and information produced through the various initiatives described in Section 6.1.1 must be communicated and made available through networks in each sector and across sectors. This is especially true for the idea of a green economy that will require the restructuring of economic systems towards establishing a low-carbon society, Section 6.3. It is thus important to document and communicate progress to create positive opinion in large parts of society.

National level data should be made available to regional clearing houses where they exist and, where they don't exist, thought should be given to establishing them. One area that could benefit from such a data repository includes the Health sector for information on diseases whose transmission is modified by climate change along with relevant environmental data (Moreno, 2006). This would require input from the health, environment and meteorological departments.

6.1.4. Climate Change Awareness and Education

The previous section on communication and networking relates directly to the sharing of information to assist decision making and planning. However, without education and awareness raising on climate change and the likely impacts of climate change on specific sectors the information shared will be meaningless. The sustainability of natural resources requires that they are used in such a way so as not to hamper their replenishment/survival into the future. As part of their national goals for the year 2030, Jamaica has aimed to increase environmental awareness of the general population to ensure the sustainable use and management of its natural resources. Specific areas that have been identified for additional efforts include:

- Disaster risk reduction and emergency preparedness at the household level;
- Water conservation, rain water harvesting and other collection techniques for households, as well as water treatment;
- The importance of energy and the role of emissions in climate change, specifically knowledge about energy, its generation, and the economic and environmental importance of energy;
- Climate-related diseases and health promotion, particularly malaria and diarrhoea that are entirely avoidable;
- The development of linkages between the health and agricultural sectors to reduce malnutrition and improve food security;
- Impacts and costs of SLR to communities, but also to the public and private sectors, because these damages have implications for livelihoods and sustainable development.

Due to the interrelated nature of some environmental issues and natural processes, collaboration between different sectors can reinforce learning amongst the general public while also providing synergistic benefits for resources. Creative methods for public education and awareness have been developed. For example, the use of mobile phone technology can allow vital information to reach individuals during emergency situations. Research at the community level revealed that not all persons have cell phones, so this technique requires complementary messages to be transmitted through more traditional mediums, radio and television. A creative initiative that could be initiated with the Red Cross is a series of songs about different hazards, or a TV commercial showing community members conducting flooding and hurricanes vulnerability assessments. In this way, popular media can be used to communicate some basic skills and knowledge to the general public. Since music is such an integral part of Jamaican society, it may be possible to get a popular artist to assist in creating suitable songs. The use of film is another effective method of quickly transferring information, increasing knowledge and changing audience attitudes. The CARIBSAVE Partnership has produced a series of films which focus on climate change impacts on tourism and coastal resources. These films will be widely distributed and will help to facilitate a change in the way people view the environment, increase knowledge of climate change impacts and inform the viewers of actions which they can take to preserve their environment and livelihoods. In addition, building awareness can be better embraced when the message is conveyed by a respected figure.

6.2. *Water Quality and Availability*

Short Term Actions

Assess the possibility of broad scale implementation of waste water recycling schemes and legislation, including for agricultural irrigation: Thus far, measures to cope with drought conditions involve mitigating the effects of droughts, most commonly through the use of truck water and the rotation of water distribution. In future, to cater for the water resource demands of Jamaica, waste water will need to be seen as a resource worthy of exploitation (Barnett, 2010), particularly at the national level. The private tourism sector of Jamaica has experimented with waste water recycling (R. McKinney, personal communication, January 27th, 2011), particularly Rose Hall which supplies potable water to tourist resorts in the north-west then collects back wastewater for treatment to produce water suitable for golf course irrigation. Special mention should be made here regarding the use of waste water in irrigation as it is the main water consumer in Jamaica. This both greatly reduces water demand and reduces the nutrient loading on coastal waters. Collaboration between the National Water Commission, National Irrigation Commission and private tourism sector will be needed to ensure all aspects of the water supply system are effectively monitored and necessary legislation is enforced.

Reassess National Water Commission pricing structures in line with those from the private sector: Most data state that the allocation to the tourism sector is 1% of total water demand, the WRA has calculated it to be 0.5% (calculated using the number of hotel rooms, 25929, multiplied by 800 l x 365 days) (A. Haiduk, personal communication, January 28th, 2011). Water resources in the private sector are often provided by private companies, to protect against any unreliability in the supply provided by the National Water Commission. The private water suppliers charge at a rate that ensures greater efficiency of water resource use. Wastage in the private sector is also prevented through legislation where, for instance, irrigation of golf courses with freshwater supplies is prohibited. Public sector water pricing should therefore be set at a level which encourages water conservation, reducing water wastage and demand.

Medium Term Actions

Undertake broad consultation on the Barnett (2010) recommendations, giving particular consideration to (a) urban development in areas with good water resources such as on the north coast and (b) development of pipe infrastructure to transport water from water-rich areas to areas of high demand and low resource such as Kingston: Following the 2009/10 drought, Barnett (2010) assessed its impact on water supplies in Kingston and St. Andrews. The considerations for future drought management included a review of city planning, limiting development to areas with sufficient water resources; the co-ordination of sewage disposal placement with ground water resource locations; update aging infrastructure to reduce water loss; the development of storage capacities to meet current populations; the continued exploration and expansion of water resources infrastructure; distribution of water at lower than normal pressures; legislate to prohibit water wastage for non-essential activities; and increase public education campaigns on water conservation. By encouraging development in areas with additional good water resources, it would be possible to continue economic development without increasing pressure on existing resources. The development of infrastructure should be focussed on increasing the efficiency of existing networks and expanding the network to include resources which are not yet fully utilised. This project would involve many government agencies with the National Water Commission playing an important role.

Undertake broad consultation over the licensing of abstraction and control of land development, developing computer models of groundwater flow to account for the impact of changes in legislation on groundwater levels: Licensed abstraction would allow much closer control over groundwater levels and enable mitigation of potential impacts of drought and SLR. Similarly, the control of land development can protect water quality of aquifers and the rate of recharge. However, in order for this to be effective, detailed information on the impacts of licensed abstraction on groundwater levels would be required. Groundwater modelling will provide this information in conjunction with existing groundwater information networks. The implementation of pumping restriction regulations at aquifer sites is also critical to aquifer management (G. Marshall, personal communication, February 2nd, 2011). Basic restrictions such as no pumping of water below sea level will help to reduce the number of aquifers prone to saline intrusion and ensure more secure water for the people of Jamaica (Marshall, 2010).

Reinstate pilot projects to assess artificial recharge of limestone aquifers in the Kingston basin, and conduct feasibility studies to explore the possibility of additional projects in the Rio Minho and Black River basins: The Water Resource Authority of Jamaica is responsible for monitoring water resources, which includes aquifers. One of the newest strategies being considered by the WRA to combat saline intrusion is the implementation of Managed Aquifer Recharge. A pilot project has been proposed which will involve the use of artificial recharge for one of the major limestone aquifers (Rio Cobre Basin) supplying the Kingston Metropolitan Region. This project was carded for April 2011, but has been postponed due to financial constraints. Previous work was done in the region (Innswood, St. Catherine) in 1982 and included the pumping of about 820 million gallons into three sinkholes in the region. This project generated positive results, which created two groundwater mounds (G. Marshall, personal communication, February 2nd, 2011). The source of water used for artificial recharge should be selected carefully: consideration should be given to pumping water from regions in the north which have plentiful water resources and low population.

6.3. *Energy Supply and Distribution*

Short Term Actions

Stabilise energy pricing to influence energy use and emissions: Taxes, emission trading and other economic instruments are needed to steer energy use and emissions, conveying clear, long-term market signals. It is important for these economic instruments to significantly increase the costs of fossil fuels and emissions. Price levels also need to be stable (not declining below a given level), progressive (increasing at a significant rate per year) and foreseeable (be implemented over longer time periods), to allow companies to integrate energy costs in long-term planning and decision-making.

6.4. *Agriculture and Food Security*

Short Term Actions

Generate a more sustainable, organic and local food supply that can be used for tourism while providing sustainable livelihoods that can adapt to changing agricultural conditions. CARIBSAVE recommends a project to evaluate organic production practices with regard to improving climate resilience for selected vegetables including seeds, soil preparation, nutrition and production, harvesting, and processing to strengthen the links between the agriculture and tourism sectors, advance sustainable food production and national food security adaptation. The project should principally involve farmers from the Jamaica Organic Agriculture Movement (JOAM), agricultural extension officers, and other farmers with a vested interest in organic production. The proposed programme is intended to increase local vegetable production for selected crops, help local organic farmers to understand how organically grown varieties perform under different climatic conditions and increase opportunities for local farmers to supplying niche products to the local hotel sector.

Conduct adaptive research in protected agriculture and develop production modules suitable for local agro-climatic conditions. This initiative should seek to evaluate different protected cultivation technologies and match them to the different categories of farmers based on their crop needs – heat, drought, saline resistance, etc. Training for farmers, agricultural extension officers from the Rural Agricultural Development Authority, and other related NGO staff on technologies for various types of greenhouse installation and management, drip irrigation, crop nutrient/management requirements, and vegetable production methods is another strategy to address the gaps in agro-technologies that help to mitigate climate change impacts.

Medium Term Actions

Develop an Integrated Production and Protection Management (IPPM) protocol for cultivation of high-yielding varieties of fruits and vegetables for supply to the local hotel/restaurant sector. IPPM combines several components: climate management (temperature, ventilation), irrigation, fertilizer, management practices (appropriate cultivars, growth media, nursery, plant density, etc). As such, the project would be a collaborative effort between farmers, nursery operators, and tourism related businesses, including kitchens and hotels. This strategy aims to minimise local supply shortages based on an increased reliability of crop production, and to facilitate linkages between the agriculture and tourism sectors.

6.5. *Human Health*

Short Term Actions

Improve post-disaster prevention measures through collaboration of relevant health sector stakeholders and the Office for Disaster Preparedness and Emergency Management. The reduction of morbidity and mortality as a result of physical injuries during natural disasters can be curbed through strengthening of existing disaster prevention measures. Also of importance is post-disaster sanitation to curb the spread of food- and water-borne diseases when infrastructure is damaged (e.g. water supply) in critical periods when it is most needed. These are relevant in the context of tourism because the perception of visiting a safe country is important to tourists, so attempts at achieving this will not only be valuable to the population but also to the tourism sector. Existing disaster preparedness and response plans must be enhanced to better incorporate health concerns and improve the education level of individuals to reduce vulnerability to such health problems.

Medium Term Actions

Build a supply of public health resources for the surveillance, prevention and control of vector-borne Diseases: Gubler (2002) has stated that the resurgence of diseases, and particularly vector borne diseases has been 'compounded by complacency about infectious diseases in general and vector-borne diseases in particular, and a lack of public health resources for research, surveillance, prevention, and control programs.' While there is considerable action being taken in Jamaica with regard to vector borne disease management and the country is one of the leaders in research in this field, greater involvement of stakeholders is required because of the seriousness of the problem. As such, based on the endemicity of dengue and malaria in Jamaica it is recommended that the Integrated Vector Management (IVM) Programme approach of the WHO be adopted. Diseases that have a climate change signal in Jamaica include malaria and dengue fever. Limited human capacity and attention to evaluation are two major challenges to the utilisation of IVM and need to be addressed under this recommendation.

Long Term Actions

Improve the use of technology in the Health Sector: There are various aspects of technology that can be developed in the health sector.

1. An Early Disease Warning System that considers temperature signatures, however these must be validated (Amarakoon *et al.*, 2006). Other indicators could also be further researched such as the use of pre-seasonal treatment (Chadee, 2008).
2. The use of alternative energy sources such as renewable energy (e.g. wind, tide and solar) to improve the resilience and stability of basic utilities. For instance, if electricity fails, water cannot be pumped or sufficiently distributed. This in turn impacts on the ability of the country to provide sanitary potable water and can affect the level of sanitation and hygiene.
3. Many health issues are directly related to availability and access to clean potable water, thus efforts to conserve groundwater and improve distribution will have a direct benefit to the health of Jamaicans. The means through which to achieve more reliable water storage and distribution as well as ways to protect against saline intrusion have been outlined in the Recommendations under 6.2 Water Quality and Availability.

This will require the combined expertise of researchers, health professionals and meteorological services. The use of alternative sources of energy can be explored by targeting clusters of researchers from the region.

6.6. *Marine and Terrestrial Biodiversity and Fisheries*

An Ecosystem-based Approach to environmental management is an integrated approach to sustaining and building the resilience of ecosystems while allowing for the sustainable use of natural resources by humans. Planning for the management of specific critical ecosystems will involve recognition of the linkages between ecosystems such as the inter-dependence of coral reefs, sea grass beds and mangrove forests.

Ecosystem-based management considers not just the protection of the environment but the need to protect the socio-economic well-being of the humans who interact with it. Considering the human component of biodiversity adaptation to climate change encourages the engagement of various stakeholders through participatory governance; doing so increases the likelihood of successful implementation of strategies and makes room for readjustment as lessons are learned. The following strategies offer solutions to some of the challenges discussed in the Vulnerability and Adaptive Capacity sections of this document and are aimed to build resilience and improve adaptive capacity of two of Jamaica's key sectors, tourism and fisheries, to climate change.

Medium to Long Term Actions

Improve the management and resilience of fish sanctuaries: Create a strategy for:

- establishing a more effective fish sanctuary management and enforcement system for coastal communities;
- enhancing the capacity of resource managers and users to be more resilient to climate change; and
- establishing a sustainable finance mechanism for supporting fish sanctuary management.

The strategy should increase the involvement of the tourism sector in supporting community-based MPAs, as well as provide opportunities for alternative livelihoods and technologies for public education.

Replant mangroves: Growing appreciation for the ecosystem services provided by mangroves has motivated some organisations and communities in Jamaica to undertake mangrove replanting projects, however more work needs to be done. One method of mangrove reforestation which has proven successful in Belize is the Riley Encased Methodology (REM). The method, which uses a small poly-vinyl chloride (PVC) pipe to protect growing saplings, is relatively inexpensive, easily implemented and causes minimal disturbance to the environment. A local Caribbean Coastal Area Management Foundation (C-CAM) representative would like to explore the option of using water-proofed paper tubing that will biodegrade over time. This adaptation from the REM methodology will save a step in the process since the piping will not have to be removed once the saplings have grown to reproductively mature trees.

Reforestation of the mangrove stands will improve the health of fish nurseries and coral reefs thus benefitting the livelihoods of those engaged in marine-based activities. The new fish sanctuaries will also benefit from the presence of mangrove trees which filter pollutants and provide protection to fish and crustaceans allowing them to increase in size and abundance. Healthy mangrove forests will also provide better protection of the coastline and to coastal communities against natural disasters such as storm surge and hurricanes.

6.7. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

Medium Term Actions

Conduct a thorough cost-benefit analysis of coastal protection at a local level: This will be informed by the estimated value of damage to specific infrastructure and properties. The specific location of infrastructure is important for estimating impacts to a high level of fidelity. Similarly, property values are highly dependent on exact location – for example in some areas the most expensive property values may be on the coast, whereas in others they may be located in a hillside. Therefore a detailed analysis of property prices by location is required as part of local level studies. In addition to refining estimates of rebuild costs (particularly in areas with high-density coastal development), there is an important need to investigate the response of international tourists and the private sector to the impacts of coastal erosion, coral reef degradation and market test adaptation strategies in the tourism sector. An additional focus of future economic assessments of the costs of SLR must be to improve methods for incorporating ecosystem services, which are often ignored or undervalued in conventional economic analyses. Structural measures of coastal protection are not the only option to control coastal erosion or reef degradation. Many innovative, natural solutions exist and deserve consideration, see Marine and Terrestrial Biodiversity Recommendation regarding mangrove restoration.

Complete a focused analysis of the vulnerability of the secondary and tertiary economic impacts of damages to the tourism sector due to SLR: Determining the secondary and tertiary economic impacts of damages to the tourism sector and possible adaptation strategies for the tourism sector should be a priority for future research, and will ideally draw input from several institutions, including the National Environment and Planning Agency, the Jamaica Tourist Board and the Jamaica Hotel and Tourism Association, amongst others.

Conduct further and more detailed assessment of the adaptive capacity of the tourism sector to SLR including improved information on the specific impacts tourism infrastructure will experience: More detailed analysis of the impacts of SLR for major tourism resorts, critical beach assets and supporting infrastructure (e.g. transportation) is needed to accurately assess the implications for inundation and erosion protection. A necessary part of this evaluation is to identify the land where tourism infrastructure and future development can retreat to in response to SLR.

Long Term Actions

Review and develop policies and legal framework to support coordinated retreat from high-risk coastal areas: Existing policy and legal frameworks should be reviewed to assess the responsibilities of the state and landowners for the decommissioning of coastal properties damaged by the impacts of SLR. Examine the utilisation of adaptive development permits that allow development based on current understanding of SLR, but stipulate the conditions for longer-term coastal retreat if sea level increases to a specified level. The National Environment and Planning Agency may need to re-assess current coastal set-back regulations in light of the SLR projections.

6.8. *Comprehensive Natural Disaster Management*

The UN-ISDR conducted an assessment of the implementation of the Hyogo Framework for Action goals in selected countries. The following are some of the recommendations that came out of the HFA National Progress report for Jamaica during the period of 2007-2009.

1. Promote and disseminate the Hazard Risk Reduction Policy to the public and other government agencies
2. Update the ODPEM Act
3. Make better use of existing Community based organisations and community networks
4. Improve data management and collection techniques
5. Need to build a “culture of resilience”

Though these are good recommendations, there are a few more practical strategies that came out of this research for the CARIBSAVE Climate Change Risk Atlas.

Medium Term Actions

Expand early warning systems to incorporate more technologies (cell phones, media tools etc) so that information is widely and equally dispersed: Though efforts to work with private companies have been attempted in the past, financial restrictions have provided limited results thus far. Current early warning system uses text messages and internet to disseminate information about hazards. ODPEM can work in conjunction with local cell phone companies to develop a system of text/SMS messages that will reach the majority of citizen quickly and at low cost. This system can be used to convey climate change information as well as communicating emergency information. Care must be taken to not overwhelm people about the severity of the risk (scare-mongering); the goal is not to scare them but rather empower them with vital information. Also use of text messages must not be too frequent as that could cause people to delete them without even reading the information.

Further to the HFA evaluation recommendation of building a 'culture of resilience', attention to how to build this culture in the tourism industry is needed. In creating a 'culture of resilience' the tourists must also be integrated. Care must be taken, however, to generate equality between local people's safety and that of the tourist. A culture of rivalry can easily develop if locals perceive that there is dual exploitation by the tourists – exploitation of resources (beaches, prime coastal property) and then priority treatment of tourists during emergency situations. Rivalry can also occur between local people during emergencies and disasters when stress is high and resources are limited. Encouragement of more sustainable livelihoods through the protection of biodiversity and agriculture help provide individuals/households with the necessary financial resources to prevent rivalry (see recommendations in Section 6.4 and 6.6).

Conduct capacity building and technical training programs for ODPEM employees so that the current technical deficiencies can be remedied and skills gained. The HFA evaluation of the 2007-2009 period indicated that ODPEM is currently without adequate technical skills to manage vulnerability assessments and other important activities. This finding was also supported during an interview with an ODPEM representative. Through their participation in CDEMA, ODPEM should be able to identify a qualified team to conduct a training program for them. Funding for such training can likely be obtained from a regional grant from the Caribbean Development Bank, the Inter-American Development Bank or other agencies who support disaster risk management in the region.

6.9. *Community Livelihoods, Gender, Poverty and Development*

Community members identified strategies which could be implemented to cope with the possible effects of climate change. Some of the recommendations (at the household level) are already in practice but should be more wide-spread and more readily facilitated by either local or national authorities.

Short Term Actions and Lifestyle Changes for Resilience

Reduce the use of electricity and water in households and local organisations: This has immediate cost-saving benefits to consumers, thereby making more money available for other important expenses such as better health care. Investment in electricity and water saving devices in communities could be supported by private and public sector initiatives. This was also highlighted as an important intervention in the relevant sector assessments.

Manage solid waste disposal: Recycling packaging (including bottles); cashing in refundable bottles; composting organic material; and reducing or eliminating the burning of solid waste are sustainable practices that can benefit households, communities and the country. Recycling reduces the use of energy and other resources in manufacturing and when combined with backyard composting minimises the need for waste collection and landfill space. Organic material can be composted in backyards or on a larger scale and can provide a beneficial input for crop and herb farming. Convenient collection points for refundable bottles and recyclable waste is critical for the success of such an initiative and very often this is led by private sector ventures. Both recycling and composting should be seen as possible business opportunities for entrepreneurs. Minimising waste will result in fewer unsightly dumping areas and breeding grounds for vermin, which has its own health benefits.

Use fewer chemicals in farming and in the home: This is particularly important in coastal communities and those located near rivers. As harmful chemicals leach into soils, rivers and the sea, adverse impacts on aquatic life and water quality are inevitable. In many instances, coastal communities are dependent on these same resources for their livelihoods. Education and awareness campaigns to encourage the use of less chemicals must provide an equally effective and safe alternative if success is to be had.

Medium Term Actions

Install water catchment tanks on homes and local organisations and businesses: This is critical where the public water supply may be unreliable because of distribution challenges or scarcity in water supply (for instance, frequent or persistent drought conditions). In the rainy season, water supply may be entirely from the tanks thereby resulting in cost savings to users. Communities using water tanks extensively need to be educated on water treatment at the point of distribution to avoid water-borne illnesses. Part of this education may involve the provision of water treatment devices which could be supported by the government. Safe and clean water means a healthier and more productive population.

Reduce or eliminate the cutting down of trees, particularly on hillsides in and surrounding communities: Communities that have large-scale vegetation removal for firewood and construction materials should benefit from education and awareness campaigns that provide alternatives to ensure that community members' livelihood needs are adequately met. This can be augmented by re-plantation programmes using indigenous food crops, shade trees and vegetation whose roots bind soil to avoid erosion.

Long Term Actions

Infrastructural improvements

Community members indicated that infrastructural improvements to their homes would prevent or minimise impacts and damage in the instance of an extreme climate related event. These included: **Remodel houses from wood to concrete or retrofit where necessary:** This can be done by installing hurricane shutters and straps, and replacing roofs. Government housing assistance programmes can assist in communities (or specific areas within communities) where the need is greatest, i.e. where homes are most exposed or vulnerable to extreme events. Also, concessions on building materials could be granted to homeowners who meet predetermined criteria to qualify for assistance.

Build carefully designed retaining walls to cope with flood events, soil erosion and land slippage: This could be of benefit to an entire community or several households. Such a public works project would generally be the responsibility of the government or at least endorsed by them. Studies that identify priority areas of concern and projected impacts would support the decision making.

Clean drains on a regular basis: Where areas are not frequently serviced by the government, community members should take the initiative to clean drains that when blocked, result in flooding and extensive damage. Businesses can support this initiative by donating and/or providing concessions on the necessary tools and equipment required for carrying out this activity. New drainage systems can also be constructed where necessary, as in instances where natural water courses have been altered.

7. CONCLUSION

7.1. *Climate Modelling*

Recent and future changes in climate in Jamaica have been explored using a combination of observations and climate model projections. Whilst this information can provide us with some very useful indications of the changes to the characteristics of regional climate that we might expect under a warmer global climate, we must interpret this information with due attention to its limitations.

- Limited spatial and temporal coverage restricts the deductions we can make regarding the changes that have already occurred. Those trends that might be inferred from a relatively short observational record may not be representative of a longer term trend, particularly where inter-annual or multi-year variability is high. Gridded datasets, from which we make our estimates of country-scale observed changes, are particularly sparse in their coverage over much of the Caribbean, because spatial averages draw on data from only a very small number of local stations combined with information from more remote stations.
- Whilst climate models have demonstrable skill in reproducing the large-scale characteristics of the global climate dynamics, there remain substantial deficiencies that arise from limitations in resolution imposed by available computing power, and deficiencies in scientific understanding of some processes. Uncertainty margins increase as we move from continental/regional scale to the local scale as we have in these studies. The limitations of climate models have been discussed in the context of tropical storms/hurricanes, and SLR in the earlier sections of this report. Other key deficiencies in climate models that will also have implications for this work include:
    - Difficulties in reproducing the characteristics of the El Niño – Southern Oscillation which exerts an influence of the inter-annual and multi-year variability in climate in the Caribbean, and on the occurrence of tropical storm and hurricanes.
    - Deficiencies in reliably simulating tropical precipitation, particularly the position of the Inter-tropical Convergence Zone (ITCZ) which drives the seasonal rainfalls in the tropics.
    - Limited spatial resolution restricts the representation of many of the smaller Caribbean Islands, even in the relatively high resolution Regional Climate Models.

We use a combination of GCM and RCM projections in the investigations of climate change for a country and at a destination in order to make use of the information about uncertainty that we can gain from a multi-model ensemble together with the higher-resolution simulations that are only currently available from two sets of model simulations. Further information about model uncertainty at the local level might be drawn if additional regional model simulations based on a range of differing GCMs and RCMs were generated for the Caribbean region in the future.

7.2. *Water Quality and Availability*

Jamaica has considerable water resources, including both surface water and groundwater reserves. Groundwater supplies most of the water demand of the island. The distribution of water resources varies in the country's ten hydrological units, where the north-eastern regions are more water secure and the southern coastal plains suffer from low rainfall and frequent periods of droughts. In terms of water use, the agricultural sector has the greatest water demand, accounting for 75% of the water consumed in the country in any given sector, followed by 17% from domestic water, 7% from industrial and 1% from tourism.

The island has been found to be vulnerable to climate change as both observed and modelled climate variables indicate some impact on water resource availability. Drought conditions frequently affect Jamaica, which has been a reoccurring national problem in the last decade, particularly in the southern coastal plains which also have the highest urban population. If temperatures increase and rainfall decreases, as they both have been shown to from observed climate data, episodes of drought may become more severe. Coastal aquifers in the south have already experienced seawater intrusion, largely resulting from over-abstraction. Sea level rise is likely to make this issue more severe. Finally, Jamaica has a history of flooding and changes in climate may result in increased episodes of extreme weather events which can cause erosion of the topsoil and subsequent reduction in water quality in groundwater.

To cope with these problems, Jamaica can develop on strengths that exist within its current water sector structure. Its institutional networks are extensive, but these have been developed to cope with an already complex water sector that seeks to supply water to 2.6 million people and comprises of numerous stakeholders and institutions. Their ability to adapt will also depend on human resources and the human resource potential of the sector. While there may be sufficient qualified persons in the area of water resource management, the challenge will be to sustain such personnel in a continually evolving professional environment, especially regarding climate change issues.

A key problem with management of any resource or management in a general context is the base of sufficient financial resources to execute a given agenda. In the case of Jamaica, given its economic status, financial resources may not currently be sufficient. This economic downturn will have bearing on the kind of technical support available to further develop the infrastructure within the country and also the ability of relevant institutions to conduct research to create a more accurate picture of climate change related issues and the effect they will have on water security in the country's future.

The following strategies are recommended for water management in Jamaica:

1. Assess the possibility of broad scale implementation of waste water recycling schemes and legislation especially in irrigation.
2. Undertake broad consultation on the Barnett (2010) recommendations, giving particular consideration to (a) urban development in areas with good water resources such as on the north coast and (b) development of pipe infrastructure to transport water from water rich areas to areas of high demand and low resource such as Kingston.
3. Reinstate pilot projects to assess artificial recharge of limestone aquifers in the Kingston basin, and conduct feasibility studies explore the possibility of additional projects in the Rio Minho and Black River basins.
4. Undertake broad consultation over the licensing of abstraction and control of land development. Develop computer models of groundwater flow to account for the impact of changes in legislation on groundwater levels.
5. Reassess National Water Commission pricing structures in line with those from the private sector.

7.3. *Energy Supply and Distribution*

There can be little doubt that tourism is an important and growing energy-consuming sector in the Caribbean. If this growth continues, vulnerabilities associated with higher energy prices as well as global climate policy will grow concomitantly. As a reminder, Jamaica's imports of oil surpassed the country's export earnings of USS771.3 million in 2008 and where almost 50% higher than in 2007, i.e. just one year before. This situation is not going to change: Jamaica's automotive fuel consumption alone is growing at a rate of 4.3% per annum, totalling 5.6 million barrels of oil equivalent in 2008 or 21.5% of oil demand and 31% of foreign exchange expenditure (MEM, 2009).

Any Caribbean nation's ambition should thus be to reduce its energy use and to increasingly use renewable energy produced in the region. In practice, this appears to be hampered by the lack of detailed databases on energy use by sub-sectors, which is a precondition for restructuring energy systems. To this end, Francis et al. (2007: 1231) suggest that:

> Finally, given the absence of a more detailed database on energy consumption and GDP in Haiti, Jamaica, and Trinidad and Tobago, further research can be directed at two important issues. First, with wider data on energy consumption and GDP (total and sectoral), a decomposition analysis could be undertaken, which can add value by identifying the main drivers, a useful approach to the formulation of effective policies.

While an energy and emissions database would thus be paramount to the understanding, monitoring and strategic reduction of greenhouse gases, it also appears clear that energy demand in Jamaica could be substantially reduced at no cost, simply because the tourism sector in particular is wasteful of energy. Furthermore, technological options to develop renewable energy sources exist, and can be backed up financially by involving carbon markets as well as voluntary payments by tourists. In order to move the tourism sector forward to make use of these potentials, it appears essential that policy frameworks focusing on regulation, market-based instruments and incentives be implemented.

7.4. *Agriculture and Food Security*

The state of agriculture and food security in Jamaica as they relate to climate change revolves around several key priorities which include:

- filling critical knowledge gaps on how to increase food production and decrease food imports in the face of changing climatic conditions

- managing the linkages between the local agriculture and tourism sectors in terms of sustainable supply of high demand items

- developing adaptation options through scientific research to assist farmers to respond to and quickly recover from the effects of extreme weather events, particularly hurricanes.

Jamaica's main export crops have already begun to experience significantly decrease yields due to the effects of changes in climate, particularly extended drought. On the upside, the sustained investment in agriculture over the past decade has resulted in increased production of locally produced vegetables and roots crops for domestic use. The challenge now is to properly target agricultural investments to mitigate the impacts of climate change and enhance sustainable food security.

Jamaican food crop producers are characterised as having uneconomically small farms with subsistence farming, limited incorporation of new technologies, and a low recruitment and an ageing population group. Despite these conditions, farmers in Jamaica have adopted strategies that so far cope with climate change impacts reasonably well. The issue of climate change in relation to agriculture has spurred recognition at this grass roots level, as well as in the government arena where the discussion is now centred on the value of a joint multi-sector approach to food and nutrition security.

The government has pledged funding and technical support for agricultural innovation that improves food production, activities that develop resiliency to climate change with a focus on adaptation strategies, and early warning systems that can mitigate risks.

7.5. *Human Health*

In an environment where global tourism destination competitiveness is high and with ever changing niche markets and destinations (Hamilton and Tol, 2004) it will be important to address issues related to the tourism sector and climate change. However, in the IPCC Fourth Assessment Report, Human Health Section, it is noted that 'population health is a primary goal of sustainable development' (Confalonieri *et al.*, 2007) and therefore while not prioritizing the Health Sector over the important contribution to sustainable development other sectors have, it is essential that the inherent value of a healthy population not be under-recognised. Further to this, the impact of health on the tourism sector.

Based on the combination of hard data and grey data used to inform the vulnerability and adaptive capacity sections of this report it is very difficult to make definitive statements about the Health Sector of Jamaica. However, the data suggests a number of trends which include that the population is vulnerable in a number of ways, most notably to vector borne diseases, sanitation and potable and accessible water supply and drought related issues and the spread of food- and water- borne illnesses. It is further evident that these factors impact on multiple sectors, such as the tourism, water and agricultural sectors.

With the establishment of a research culture and validation of data from the various components of the Health Sector, these will pave the way for a sound platform from which to inform policy and planning for the future as the climate changes.

7.6. *Marine and Terrestrial Biodiversity and Fisheries*

The policy responses and planned actions described above demonstrate at least some awareness, at the national and community levels, of the importance of Jamaica's natural resources to livelihoods and economies. However impoverished communities continue to over-extract from marine and terrestrial ecosystems in an effort to sustain themselves. Poorly planned land development and population expansion defragments habitats and introduces pollutants into the environment thereby decreasing the resilience of plant and animal species. Climate-change driven impacts will pose even greater threats to ecosystems in Jamaica as SLR, increased intensity of extreme weather events, oceanic and atmospheric temperature increases and altered patterns of precipitation interfere with their functions. Destruction of ecosystems will impact on livelihoods and threaten the physical security of the population.

The government of Jamaica is aware of the challenges and has begun to address these challenges through policies and the establishment of management agencies but is hindered by a chronic lack of resources and low levels of public awareness. Planning for the management of specific critical ecosystems must consider the linkages between ecosystems such as that between coral reefs, sea grass beds and mangrove forests and the relationship between the stakeholders who use these ecosystems. Strategies for adaptation that encourage greater participation of the private sector in natural resource management are required. The engagement of various stakeholders through participatory governance increases the likelihood of successful implementation of strategies and makes room for readjustment as lessons are learned from various management actions. The Jamaica Fish Fund strategy in particular is one which will address the inherent linkages between the coral reef ecosystem, fisheries livelihoods and the tourism industry. This strategy as well as the others described in this document will assist in laying the foundation for achieving Goal 4 of Jamaica's National Development Plan, Vision 2030: "Jamaica has a healthy natural environment."

7.7. *Sea Level Rise and Storm Surge Impacts on Coastal Infrastructure and Settlements*

With its high-density development along the coast and reliance on coastal transportation networks, the tourism sector in Jamaica is particularly vulnerable to climate change and SLR. Given Jamaica's tourism dependent economy, the country will be particularly affected with annual costs as a direct result of SLR. If action is not taken to protect Jamaica's coastline, the current and projected vulnerabilities of the tourism sector to SLR, including coastal inundation and increased beach erosion, will result in the significant economic losses for the country and its people. Adaptations to minimize Jamaica's vulnerabilities will involve considerable revisions to development plans and major investment decisions. These considerations must be based on the best available information regarding the specific coastal infrastructure and ecosystem resources along the coast, in addition to the resulting economic and non-market impacts. Decisions regarding where retreat policies should be implemented versus what should be protected needs to be a priority if Jamaica is to help curb development in vulnerable areas and protect vulnerable tourism assets. Continued development and an increasing population will only magnify the vulnerabilities Jamaica faces, placing additional assets and people at risk, while simultaneously raising the damage estimates and the costs to protect the coastline. It is vital to recognise the vulnerabilities of current SLR and SLR-induced erosion, as well as to anticipate and prepare for future SLR implications. There is an urgent need for serious, comprehensive and urgent action to be taken to address the challenges of adapting to SLR in Jamaica.

7.8. *Comprehensive Disaster Management*

Jamaica is exposed to a variety of hazards that will affect all aspects of the society, including government agencies and the private sector. Recent natural disaster events, such as Hurricane Dean and Tropical Storm Nicole, have drawn attention to the vulnerability in the housing sectors as well as the need to further protect public utilities from the damaging effects of high winds and heavy rains. Additionally, regional projects executed by CDEMA have been piloted in Jamaica including the Sustainable Tourism Project on the 'Regional Public Good'. Together national and regional initiatives, along with smaller community activities, provide some information on vulnerability; however much more data is needed to truly build resilience to natural hazards, especially given the fact that climate change may cause more extreme events. With better data, projects that improve early warning systems and build capacity at the community level can be prioritized and executed using the resources available to the relevant stakeholders.

As the primary agency working on disaster management in Jamaica, ODPEM has many programs and activities that aim to build adaptive capacity at the institutional and local level. ODPEM has embarked on an assessment of 300 community vulnerabilities across the island in order to rank communities on a variety of vulnerability indicators (ODPEM Interview, January 2011). Generation of an up-to-date list of vulnerable groups using a comparable indicator measurement tool will allow funding and programs to be geared towards the communities most in need. With this, the reduction of risks and vulnerabilities will build capacity across the country, one community at a time. Further coordination and communication with land-using planning and environmental management ministries is a positive effort to keep risks from growing out of control or from being created by new development projects. However, enforcement of land use planning and building codes is a necessary part of this process of risk reduction and therefore communication and the development of a shared view will be needed across agencies. Adaptive capacity of government institutions involved in disaster management in Jamaica could benefit from better hazard mapping data and rainfall data could also provide an alternative index through which the CCRIF could provide post-disaster assistance.

The local level activities are also an important part of adaptive capacity. A Parish level program has also been implemented to improve the sharing of lessons documented after disaster impacts under a project entitled “Building Disaster Resilient Communities” (ODPEM Interview, January 2011). Good communication and the clear designation of roles and responsibilities is a common challenge in disaster risk reduction activities, thus, this program is a positive effort in the creation of a better adaptive capacity in Jamaica. More work could be done to build trust between individuals and ODPEM so that storm or hurricane shelters are used, warnings are heeded and people do not expose themselves to unnecessary risks by staying in their homes during storms.

Although efforts to reduce vulnerability and enhance adaptive capacity are being made, limited financial resources and technical capacities within government agencies have stifled progress while the on-going threat from natural hazards has also demanded resources be reallocated to recovery rather than sustainable development efforts. As such, an institutional shift towards ‘building back better’ following disasters could facilitate disaster risk reduction, sustainable development and climate change adaptation goals.

7.9. *Community Livelihoods, Gender, Poverty and Development*

It is well documented, that women and men – in their respective social roles – are differently affected by the effects of climate variability and change. Reasons include the different responsibilities men and women assume in relation to care work, income generating work, as well as their different levels of dependency on natural resources, knowledge and capacities to cope with the effects because of differences in the access to education and information systems.

Findings from the Focus Group Discussions indicated that respondents agreed that men and women were affected differently by weather-induced hazards and disasters, noting that the differences were most obvious before and after the event. Participants noted that men are generally expected to be responsible for preparing households and communities just before slow-onset events such as storms by installing protective structures (hurricane straps, shutters); and responsible for much of the recovery and response efforts after slow and rapid onset events (storms, flooding, landslides) by informal household and community damage evaluations, making repairs and conducting search and rescue or recovery operations. Moreover, it was felt that men often bore these responsibilities because they are more physically able and capable than women to carry out the required tasks. Some of the participants however, did refer to the role of women in preparation and response efforts and specifically mentioned stocking up food items, looking after children and rebuilding[22].

As Ariyabandu notes, "…*where disasters take place in societies governed by power relations based on gender, age or social class, their impact will also reflect these relations and as a result, people's experience of the disaster will vary*[23]"

Social roles and responsibilities of women and men lead to different degrees of dependency on the natural environment. The data show that women are more engaged in household subsistence activities, thus degradation of forests, watersheds and agricultural land can have a severe effect on their ability to perform the daily household maintenance tasks, thereby threatening the livelihood of their households[24] and placing additional burdens on women. The use of a 'gender lens' can help to better understand social processes, thereby ensuring that adaptation projects consider gendered differences and do not inadvertently perpetuate inequality.

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[22] Excerpted and modified from Male Focus Group Report for Port Antonio

[23] Socio-economic impacts of natural disasters: a gender analysis: http://www.eclac.org/publicaciones/xml/3/15433/lcl2128i.pdf

[24] Gender, Climate Change and Adaptation: www.uneca.org/acpc/resources/Gender-and.../Roehr_Gender_climate.pdf

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