STRATEGY AND PLAN OF ACTION

DEVELOPMENT OF A NATIONAL WATER SECTOR ADAPTATION STRATEGY TO ADDRESS CLIMATE CHANGE IN JAMAICA

Prepared for:

Mainstreaming Adaptation to Climate Change Project
c/o Caribbean Community Climate Change Centre (CCCCC)
2nd Floor Lawrence Nicholas Building
Bliss Parade
P.O. Box 536, Belmopan City
Belize

Submitted by:

ESL MANAGEMENT SOLUTIONS LIMITED
20 West Kings House Road
Kingston 10, Jamaica

January 2009

The views and opinions expressed in this report are those of the Authors and do not necessarily represent the views and opinions of the Government of Jamaica, the Caribbean Community Climate Change Centre or the World Bank.

Technical Report 5C/MACC-01-09-1

Published by Caribbean Community Climate Change Centre, Belmopan, Belize

Digital Edition (February 2011)

Caribbean Community Climate Change Centre, Ring Road, P.O. Box 563, Belmopan, Belize

Visit our website at http://www.caribbeanclimate.bz

ISBN-13 978-976-8236-10-4 (pdf)

TABLE OF CONTENTS

List of Acronyms and Abbreviations

AGD	Attorney General's Department
CCCCC	Caribbean community Climate Change Centre
ENSO	El Nino/Southern Oscillation
GCM	General Circulation Model
GDP	Gross Domestic Product
HEP	Hydro-Electric Power
IWCAM	Integrating Watershed and Coastal Area Management
MACC	Mainstreaming Adaptation to Climate Change
NEPA	National Environment and Planning Agency
NIC	National Irrigation Commission
NATL	North Atlantic Ocean
NCEP	National Centres for Environmental Prediction
NWC	National Water Commission
PRECIS	Providing Regional Climates for Impact Studies
Q90	Stream flow that occurs more than 90% of the time
RCM	Regional Climate Model
SIDS	Small Island Developing States
SDSM	Statistical Downscaling Model
SRES	Special Report Emissions Scenarios
SST	Sea Surface Temperature
UNFCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
URCR	Upper Rio Cobre Rainfall
WRA	Water Resources Authority
WMU	Water Management Unit: A single or group of watersheds that have been grouped together for the purposes of management

1 BACKGROUND

Jamaica is in the process of drafting the Second National Communication to the United National Framework Convention on Climate Change (UNFCCC).The Mainstreaming Adaptation to Climate Change (MACC) Project[1] under the Caribbean Community Climate Change Centre (CCCCC) has provided support to Jamaica to prepare a National Adaptation Strategy (NAS) for the water sector to adapt to the adverse effects of climate change. The strategy will be informed by projections; an analysis of the institutional framework within which the sector operates; an assessment of the economic impact of climate change on the sector; and a review of current policies and legal instruments.

Jamaica is taking some initiatives to mainstream climate change into its national development processes and mechanisms. The Government of Jamaica (GOJ) approved a National Water Sector Policy in January 1999; The Water Resources Development Master Plan (Draft 2005) is in its final stage of preparation; and a National Irrigation Development Plan (1997) is in place. Of additional relevance are the Forestry Master Plan and the initiative toward Vision 2030 being spearheaded through the Planning Institute of Jamaica (PIOJ)? Vision 2030, a national development plan to the year 2030, includes task forces focused on the Water Sector, Natural Resources Management and Climate Change and Natural Hazard Reduction, Urban and Regional planning as well as several sector and social themes. These initiatives have been incorporated in the review of information and data to support the preparation of the Strategy.

The report entitled “Development of a National Water Sector Adaptation Strategy to Address Climate Change in Jamaica”, presents four technical areas reviewed as specified in the Terms of Reference for the project. These are climate change modelling; water sector issues and threats; policy, legal and institutional framework; and economic review.

This section of the report presents the strategy and plan of action which includes recommendations on costs, capacity building measures, recommendations on policy, legislation and other interventions and identification of sources of funding among others to support the strategy.

Approach to Strategy Development

Based on findings of the main report and recommendations made in the workshop by the key stakeholders, the team identified the main recommendations along with the responsible agencies, possible amounts and sources of funding and the time frame in which they should be carried out. The recommendations are grouped under four main headings. These include:

- Capacity (Technical)
- Capacity (Institutional)
- Policy
- Legislation

2 MAIN FINDINGS

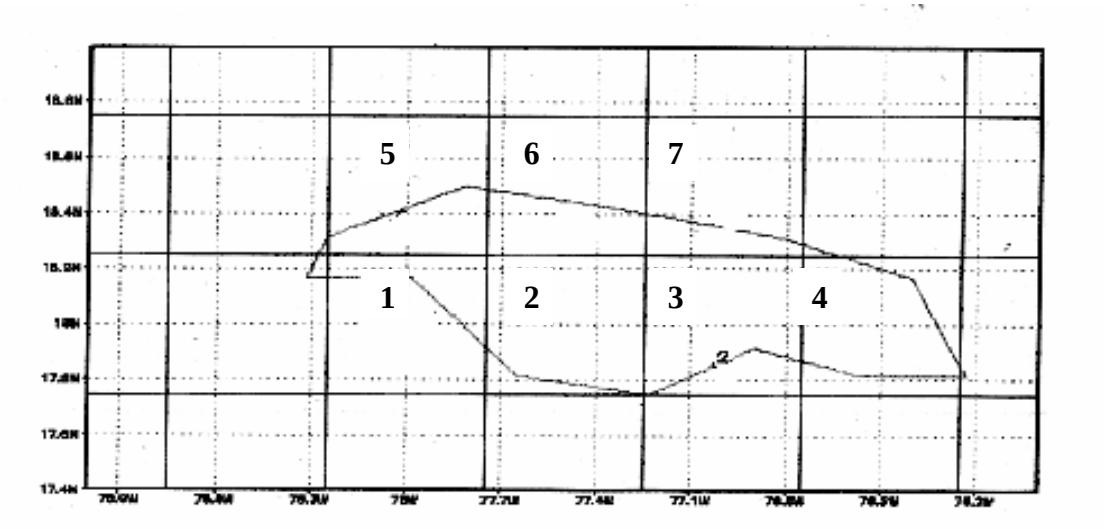
An Analysis of Jamaica's Future Climate for Water Sector Guidance

The findings from the climate assessment and modelling activities includes scenario based forecasts for future climate in Jamaica to the 2080s, with some spatial variability through the use of the PRECIS regional climate model and statistical downscaling at specific locations. The report also presents the findings from the assessment of the issues, vulnerability and threats faced by the water sector as a result of these scenario based forecasts in climate change and climate variability. A number of technical recommendations on how to reduce the sector's vulnerability to climate change and climate variability within an integrated land and water resources management framework are also presented within the report. The future climate scenarios presented in the main document were to be used as a guide for making recommendations about adaptation options for the water sector in coping with climate change.

The IPCC projections are based on low resolution models which simulate changes applicable to a large region as a whole (approximately 300km x 300km. They do not distinguish climate response over smaller regions such as the parishes of Jamaica. It was therefore necessary to downscale the results of these low resolution models to distinguish climate response over the smaller regions of Jamaica. This was done by the use of a dynamic model called PRECIS, which uses physical equations to simulate climate processes, and a statistical model called SDSM, which uses statistical relationships to project future processes.

Precipitation changes for 2015's, 2030's, 2050's and 2080's were simulated over 7 regions of Jamaica by use of the PRECIS model (see figure below). For the same periods, precipitation changes for 3 stations (Manley, Sangster and Upper Rio Cobre River) and streamflow changes for 3 stations (Great River at Lethe, Rio Grande River at Fellowship and Hope River at Gordon Town) were downscaled by SDSM. Changes in wet spell and dry spell lengths were also produced by SDSM.

The SDSM results for precipitation were compared with the PRECIS results for consistency and the degree of confidence in the results was increased when all three gave some form of agreement. The streamflow results were used mainly for confirmation, while the PRECIS and SDSM results were used to obtain best estimate of changes in precipitation. These estimates are given in the main report. Most stations begin to show decreases in precipitation by 2050s and by 2080s. The drying effect is noted all over Jamaica. The degree of uncertainty is also discussed and the results indicate that the results are all significant by 2080s.



PRECIS grid boxes surrounding Jamaica. Grid boxes are labelled between 1 and 7 for ease of reference in the text.

Temperatures

The comparison of results from the GCMs, PRECIS and SDSM provides a means of assessing the confidence in results. The general agreement among GCMs that temperatures will increase, gives a high probability that increases will occur in the Caribbean, especially since the temperature signal to noise ratio is high for the GCMs. The probability is increased because of agreement with other regional and statistical downscaling research (Taylor et al., 2007 and Chen et al., 2006), and because the science of global warming is well understood and almost universally accepted. The temperature increase will depend on the future emissions. Under the A1B scenario temperatures in the Caribbean are expected to rise by about 1.5ºC by 2050s and be just under the global average of 2.8ºC by the end of the 21st century.

Precipitation

Most GCM simulations of future Caribbean precipitation show a decrease in annual values, especially in JJA, by the end of the century under the A1B scenario. However, the signal to noise ratio is low and the precipitation signal does not become significant until the latter half of the century. The PRECIS and SDSM results for A2 and B2 scenarios given in Section 2.4 of the report support the general trend and the probability is therefore high that decreases in precipitation will occur, especially by the 2080s. The magnitude of the decrease however is uncertain.

To help to reduce the uncertainty, we compare the PRECIS and SDSM results, i.e. we compare the station projections from SDSM with the projections for the grid box in which it falls from PRECIS. In doing so, it is noted that the uncertainty in rainfall decreases in the 2050s based on projections by PRECIS will also be compounded by the fact that the precipitation signal to noise ratio for GCMs do not become significant until late in the century and the same may be true for PRECIS.

For the Great River streamflow there is good agreement between PRECIS and SDSM with respect to rainfall, with projected decreases being 40% and 55% respectively by the 2080s. The corresponding decrease in streamflow is over 10%. The streamflow here is not used as an estimate of precipitation, but merely to support the projection of a decrease. A conservative estimate of 40% decrease in rainfall, i.e., the decrease projected by PRECIS is therefore recommended for use in estimating water resources in 2080s. For the 2050s the decreases given by PRECIS and SDSM are 4% and 36%. Since the change at Sangster is much greater, a conservative recommendation for decrease in precipitation in region 5 by 2050s is 10%.

Decrease in precipitation is projected by the 2030s, and the 2080s PRECIS shows a precipitation deficit of over 30%. Taking into consideration the smaller deficit projected for the Upper Rio Cobre River basin, a conservative estimate of reduction in rainfall by 2080s is 20%. The deficit in streamflow at Hope River and rainfall at Manley support this estimate of reduction. Again based on the precipitation deficits in Region 3 and in the Upper Rio Cobre River region, the estimate of reduction in rainfall in the 2050s is 10%.

PRECIS simulated a decrease in precipitation in the 2050s.The downscaling of streamflow in the Rio Grande projected decreases in streamflow of 60% i.e. a severe reduction of rainfall. By the 2080s streamflow is reduced to nil using SDSM downscaling, yet reduction in rainfall was only simulated to decrease by about 25% by PRECIS.

The rainfall process in the region should be considered in interpreting the data. The highest peaks in Jamaica, some over 2000 m, are situated in the parishes of Portland and St. Thomas, which comprise the region occupied by box 4. The rainfall is orographic driven by winds pushing moisture up the mountains on the windward side in Portland (no empirical study of orographic clouds has been done for Blue Mountains in the vicinity of Portland and St. Thomas, but the process is well known (See e.g., Wallace and Hobbs, Atmospheric Science, Academic Press, 1997), and the rainfall pattern there conforms to this process). The windward side is consequently wetter (annual rainfall of 367 cm) and the leeward side in St. Thomas drier (annual rainfall of 229 cm). The major predictor for streamflow in Portland is the surface airflow strength, which forces the wind up the mountains. Future global warming will cause the surface airflow strength to decrease, leading to reduced orographic rainfall, and consequently a decrease of rainfall in Portland, affecting rainfall more in Portland than in St. Thomas. The decrease simulated in region 4 by PRECIS would likely be comprised of a greater decrease in Portland and a lesser decrease in St. Thomas.

The decrease in streamflow in the Rio Grande valley downscaled by SDSM is too severe to be accepted, since it is produced by only one simulation. Another SDSM simulation which did not use surface airflow strength gives less reduction in streamflow. As a compromise, then, it is suggested that the rainfall in box 4 be considered in 2 parts - that in Portland and that in St. Thomas - and that the estimate of reduction in Portland be 40% and in St. Thomas be 20% by 2080s. Because of the problem of possible low precipitation signal to noise ratio in the 2050s, no estimate is made for box 4 despite the projected increase in rainfall.

Wet Spells and Dry Spells

Based on SDSM analysis of precipitation, wet-day % and wet spell lengths will decrease while dry spell lengths will increase. For Sangster, the decreases in wet-day% and wet spell are 24% and 7% respectively for the 2050s and 44% and 10% for the 2080s. Dry spells will increase by 32% and 80% by the 2050s and 2080s respectively. Based on an average of values for Manley and URCR, the decreases in wet-day% and wet spell lengths are 2% and 3% respectively by the 2050s and 7% and 6% respectively by the 2080s. Dry

spell lengths will increase by 1% and 4% in the 2050s and 2080s respectively. There are no data with which to make estimates for the other regions. The major difference between Sangster, on the one hand, and Manley and URCR on the other seems to be that Sangster rainfall is controlled by a high pressure system (geopotential height) as well as relative humidity, whereas the others are controlled primarily by relative humidity.

Best Estimates

Based on the results presented, then, the best estimates for temperature and precipitation changes are summarised in the following table.

Best estimates of (a) absolute change in temperature for Jamaica and (b) percentage change in rainfall for 7 regions.

Temperature	**1.5 degree C (2050's)**	**2.8 degrees C (2080's)**
	% change	
Precipitation:		
Region 1	0	-30
Region 2	-10	-30
Region 3	-10	-20
Region 4:		
Portland	No estimate	-40
St. Thomas	No estimate	-20
Region 5	-10	-40
Region 6	-10	-30
Region 7	-10	-30
Region 5:		
Wet-day%	-24	-44
Wet spell length	-7	-10
Dry spell length	32	80
Region 3:		
Wet-day%	-2	-7
Wet spell length	-3	-6
Dry spell length	1	4

By the end of the century sea levels are also expected to rise by 0.21 to 0.48 meters under an A1B scenario, but the models exclude future rapid dynamical changes in ice flow. A recent study suggests that the rate of rise may actually double (Science Daily, Feb. 12, 2008). Evaporation is also projected to increase by approximately 0.3 mm/day over the sea. As noted before, the changes over land may be less. One model has projected more hurricanes and more intense hurricanes in the Atlantic.

Mitigation to Reduce Dangerous Climate Change

Many scientists and international organizations are now advocating significant cutbacks in greenhouse gases in order to limit temperature rises to less than 2ºC during this century (UNDP, 2007). Several countries of the European Union have given commitments to these drastic reductions. The Governments of France and the United Kingdom, for example, have stated their intention to cut emissions by approximately 80% by 2050.

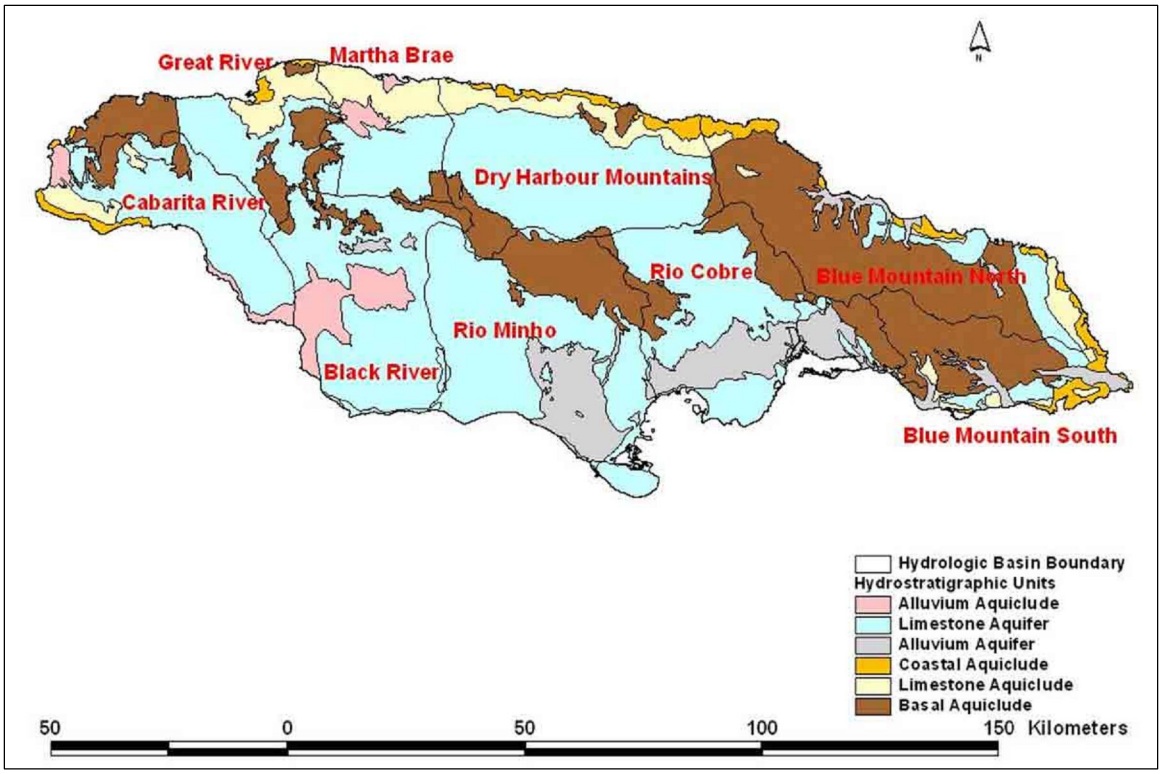
However, this does not mean that we should stop planning adaptation strategies. In the first place, the chances of limiting temperature rise to less than 2ºC are slim because of economic and political hurdles. Energy Information Administration (Washington, DC), in its International Energy Outlook 2008 report released in June, predicts that world energy demand and carbon dioxide emissions will grow by about 50 percent over the next two decades. In the second place, the adaptation measures recommended herein are still applicable, regardless of climate change, and should be considered as 'no regrets' strategies.

Water Sector Vulnerability Issues & Threats

The water sector includes quantity and quality of surface and ground water resources, as well as the water supply and wastewater systems and associated infrastructure. The role of land use and watershed management and protection, is critical to maintaining resilience of the sector as mentioned above in Section 1.

The sector is vulnerable to a range of natural hazards as a consequence of a number of factors, which include:

- Location of Jamaica with respect to a) the paths of tropical storms / hurricanes, and the impacts of related storm surges along the coastline; and b) the Caribbean tectonic plate and its implications for earthquakes and tsunami.
- Geology and topography of Jamaica, which influence rainfall runoff, stream and karstic basin flooding, and landslides.
- Hydrostratigraphy of Jamaica, which influences the location and extent of aquifers and aquicludes. With the spatial and temporal distribution of rainfall, these determine the spatial availability of water during drought periods.



Jamaica Hydrostratigraphic Units and Basins

(Source: http://www.geocities.com/watercaribbean/23.html#TNC, accessed 21 June 2008)

Water Quality

Human activities compromise the ability of the water sector to withstand the impacts of these natural hazards. For example, poor agricultural practices and land management techniques leads to degraded watershed conditions. Such conditions have a negative impact on both water resources and water quality through rapid runoff and flashiness of stream flow, increased flooding intensity and increased sediment loads.

Both surface water quality and groundwater quality have been negatively affected by poor waste management practices including inadequate wastewater treatment and disposal from domestic waste as well as industrial and commercial activities. Examples include nitrate pollution of the Liguanea Plain aquifer by excessive density of soak-away pits and poorly built and/or maintained septic tanks; and leaching and occasional flood washout from pit latrines in many flood prone areas of the island. Other threats to the resource result from effluents of bauxite processing, rum production, and other industrial enterprise as well as over pumping of coastal aquifers, leading to declining groundwater elevations and increasing saline intrusion.

Water Supply

Water supply in Jamaica is characterised by inefficiency. For example, non-revenue water accounts for some 67% of the water produced by the NWC. Similarly within the irrigated water sector, the largest consumptive user of water in Jamaica, losses in irrigation water are of the order of 40%.

Water supplies within the Kingston Metropolitan Area are maintained by flows from the Hope and Wagwater River, Rio Cobre, and the Yallahs and Negro Rivers. (The Hope River is in the Kingston Basin and the Wagwater River is in the Blue Mountain North basin.) Under drought conditions, these basins experience water shortages. The severity of these events may be exacerbated by poorly maintained and operated infrastructure, which may not allow the full potential of these sources to the used even under drought conditions. This situation is unfortunately repeated in other parts of Jamaica, where sources are associated with low drought yields and also low levels of infrastructure maintenance and replacement. In addition, extreme flood events have dislocated supply lines from the Yallahs systems, and high turbidity levels from the Rio Cobre have reduced water availability to the Spanish Town Treatment plant. Recent work on the KMA Water Supply project has remedied this problem.

The Rio Cobre and Rio Minho provide substantial resources for irrigation and both these basins are under stress from demand.

Threats to the Sector

From the analysis undertaken of the likely performance of the water sector under climate change, these existing vulnerabilities are likely to increase. For example, under changing annual average climate, the supply–demand balance in the already stressed Kingston, Rio Cobre and Rio Minho basins is projected to worsen, especially after 2050, principally due to reduced potential water resources availability.

The climate modelling results are also projecting increased climate variability. This is likely to have a number of impacts on water sector:

1. Water Supply: Increasing length of dry season will increase the vulnerability of those communities who are supplied by single spring or river sources. In contrast, the increased frequency of intense rains are likely to result in high sediment loads, and increased requirements for treatment to meet the standard before entering supply. This also depends on the state of the watershed.

2. Flooding Regimes: For example, within Eastern Jamaica (Blue Mountains), the likely increase in frequency of high intensity rainfall events will increase frequency of occurrence of landslides and floods. High turbidity levels and broken distribution mains are likely under existing conditions.

3. Watershed Protection: Increased frequency of more intense rainfall events will accelerate sediment erosion, movement and transport within basin river systems. Poor land use and agricultural practices have already increased the vulnerability of watershed slopes to soil erosion and sediment transport. It is therefore important to intensify efforts at disseminating best practices and replicating the efforts of pilot programs which are currently underway in selected watersheds.

4. Non-irrigated Agriculture: Irrigated agriculture, although important for the Jamaican economy, accounts for only 9.3% of cultivated lands. Non-irrigated crops are important for the wider rural community in Jamaica and in the provision of locally grown crops and foodstuffs for the local

Jamaican market. This is an important sector with respect to food security, but it remains vulnerable to existing climate and climatic variability. Given the likely increase in climatic variability, the vulnerability of this sector is likely to increase unless measures are adopted to improve its resilience and adaptive capacity to these climatic driven hazards.

5. Sea Level Rise and Coastal Flooding: Sea level is projected to increase by between 0.18m and 0.59m by the 2090s across the SRES scenarios against 1990 elevations (IPCC, 2007). Other projections have estimated up to 1.4m over the same period. This increase, with the likely increase in the severity of hurricanes and tropical storms, will lead to an increase in potential storm surge elevations, thus putting a greater area and population at risk from coastal flooding. Given the coastal location of many of Jamaica's wells, for agriculture, public water supply and industrial use, such increases in sea level increase the vulnerability of these wells to of saline intrusion and reduced water quality.

Although the impacts of climate change on the water sector are wide ranging and significant, there are a number of positive measures that can be taken to increase the adaptive capacity of the sector. These include the following:

a. Investment in hydrological and water quality monitoring and dissemination of data to the stakeholder community. This is in place and is being upgraded.

b. Development of appropriate hydrological and water resources modeling tools in parallel with capacity building within key stakeholder organizations. This is underway with training programmes in progress.

c. More integration and stricter enforcement of physical planning laws and regulations to reduce risks to life and property from extreme rainfall, and coastal flooding events. This will be addressed under the proposed regulation of floodwater control.

d. Identify and replicate best practice programs in local community and stakeholder engagement such as the IWCAM project as a vehicle for watershed management and protection.

e. Support the update of National Forest Management and Conservation Plan, to assist watershed protection.

f. Continue programmes to increase efficiency in water storage and delivery systems.

Institutional/ Policy and Legislative Review

Agency Responsibility

A wide range of agencies are involved in the water sector. The Water Resources Authority has the responsibility for the regulation, control and management of the nation's water resources. The Water Resources Act (1995) established the Water Resources authority (WRA) as the sole agency with responsibility for the regulation of water resources availability, including inter alia, the collection of water resources data (except rainfall), assessment, allocation, planning and management. Its main instrument of control is the issue of well drilling permits and abstraction licenses for both surface and ground water sources.

The National Water Commission (NWC) is the main provider of potable water supply and sewage treatment. The NWC operates within the policy context of the Government of Jamaica's goal of universal access to potable water by the year 2010 and the establishment of sewerage systems in all major towns by 2020. The National Irrigation Commission (NIC) has responsibility for the supply of water for agricultural and irrigation uses while the Rural Water Supply Company has the responsibility for the execution of small rural projects.

The liberalisation of Water Services Sub-sector to include the participation of Private Enterprises as set out in the National Water Policy (1999) has resulted in housing developers who develop their own water supply system to support their respective housing developments opting to operate private water systems rather than handing over to the NWC, as was previously required.

The National Irrigation Commission (NIC) is authorized to provide irrigation water nationally. Across the island it operates the Rio Cobre, St. Dorothy, Mid-Clarendon, Hounslow, Pedro Plains, Braco, Sevens River and the Yallahs Irrigation systems. The NIC is presently promoting the handover of these systems to Water Users Associations (i.e. the farmers themselves).

The National Water Commission Act (1980) gave the NWC authority over the water supply districts prescribed by the Minister under the National Water Authority Act (1963) and those of the Kingston and St. Andrew Water Commission.

Finally, the National Environmental and Planning Agency (NEPA), implements environmental protection laws and regulations and monitors water and wastewater quality. The institutional structure is relatively recent and the actors in the sector are evolving. They are also cognizant of areas of overlap in responsibilities and seek to coordinate in these areas.

Water Sector Policy

In 1999 the Cabinet approved the Water Sector Policy to enable the provision of adequate water and sewerage services. The main objectives of the Policy are universal access to water by 2010, improvement in the efficiency of the NWC, and expansion of central sewerage facilities.

Adapting to the impacts of climate change poses a difficult challenge for developing countries such as Jamaica. It is important that the government provides a clear policy framework to guide adaptation in the following key areas:

(a) high-quality climate change information, including improved regional climate predictions, particularly for rainfall and storm patterns;

(b) land use planning and performance standards to encourage private and public investments in buildings, capital, and infrastructure that are resilient to the effects of climate change, as well as protection of vulnerable utilities and facilities;

(c) long-term climate-sensitive policies such as natural resource and coastal protection, disaster and emergency preparedness, and relocation of vulnerable human settlements.

Proposed Enhancement of Policy and Legislation

It is considered that both the policy and the legislative framework are inadequate for purposes of adapting to climate change. The key changes proposed or recommended are as follows: -

1. Significant and urgent strengthening of the Meteorological Office is an urgent necessity;
2. Institutional strengthening of the WRA, NEPA to deal with the implications of climate change;
3. Upgrading the Water Policy and the Watershed Policy
4. Preparation and approval of a Climate Change Policy
5. Enactment of a Disaster Management Act
6. Enactment of a Meteorological Act
7. Effective enforcement of planning and environmental legislation.

Economic Review and Analysis

Economic Planning and Climate Change Scenarios

The effective planning horizon for economic change is generally not much longer than 20 years. Therefore the interface between climate change scenarios 2030-2080 and the economy is not a comfortable one and challenges the meaningful extrapolation of the economy into those time periods. The approach taken was to examine the current relationship between water consumption and the economy as a basis for suggesting how this relationship might change given expected climate change scenarios.

Currently this relationship is one in which four main economic sectors, contributing 94% of GDP consume about 7% of exploited water resources. Three major consumers of water, the environment, irrigated agriculture and residential water consume about 93% of total water production but directly contribute only 7% of measurable GDP.

With respect to irrigated agriculture, which accounts for about one third of annual water use, three crops account for 90% of the land under irrigation. Also four parishes, accounting for 82% of all land under irrigation are significant producers of the three main irrigated crops: St. Thomas and St. Mary (bananas) St Catherine (sugar cane and pasture land) Clarendon (sugar cane). The projected water balances in the four basins mainly supporting these crops, reflects a sufficiency of exploitable water through year 2025 and 2030, although in two basins The Rio Cobre and The Rio Minho serious challenges already arise in balancing competing demands for usable water. With the exceptions noted however, whereas irrigation water is indispensible to increasing agricultural production, the overall loss of water resources arising from

climate change up to 2030 and closer to 2050, should not significantly impact crop production dependent on irrigation. A more serious threat to agricultural production and food security is likely to arise from projected increasingly intense and hostile weather conditions.

Residences accounted for 21% of total water consumption in 2005, the next largest category after environmental flows and irrigated agriculture. No convenient link between the consumption of residential water and the GDP can be made. Over the 20 year period 2005 to 2025 it will grow on average by 1.2 % per annum. Climate change will challenge the objective of ensuring clean water supply to population dense areas where aquifers are threatened by saline intrusion and where reduced stream flow threatens the source of supply. Based on water balance modelling in three highly stressed WMU's residential demand in 2080 will only be satisfied if other areas of water demand are re-ordered.

Sector Demand

Irrigation water is a major annual user of extracted water. For the main crops consuming irrigation water, (cane, banana and pasture) adaptation strategies due to likely climate change impact on water supplies include the application of increased irrigation through efficiency, the reintroduction of water harvesting, and drought resistant crop modification. The reuse /recycling of treated sewage effluent must be incorporated to meet irrigation and environmental demand. Increased weather threats will require better watershed management, improved drainage systems including river training and flood control, as well as more rapid response systems in which recovery assistance and its distribution could be affected, particularly where smaller and more vulnerable farm units are impacted. Non irrigated crops such as coffee, cocoa and pimento are also important to the economy:

Some adaptation strategies directed at crop production efficiency must include:

- investigation of important pests and plant diseases, including weeds, to climatic changes. Since these have an important bearing on crop productivity.
- investigation of genetic diversity within crop types that might be better suited and called upon to compensate for climatic variability.
- engagement of main stakeholders in areas such as plant breeding, agrochemicals and fertilizers, irrigation and agricultural equipment etc on the implications of climate change

Additionally, sea level rise and resulting saltwater intrusion into the aquifers of important agricultural growing areas such as on the Clarendon plains is a significant threat. It is recommended that water extraction should be curtailed, while encouraging the recharging of these aquifers.

Adequate water resources underpin the current adaptation strategies proposed to address food security. Required strategies include:

- reduction in the level of poverty to reduce undernourishment.
- priority focus on increasing agricultural output and productivity so as to reduce prices and reduce the net of food insecure persons.
- macro economic policies should support the production of food for export but also domestic production.

Although the hotel sector contributes significantly to GDP (24%) it consumes a relatively insignificant proportion of total water demand, less than 0.3%. Based on projections by WRA for the hotel sector's demand for water it is possible that the economic threat of climate change for the hotel/tourism sector will arise more from sea level rise and land inundation. This is due mainly to saline intrusion of coastal aquifers and/or diminishing stream flows. Spatial demand is however a consideration in terms of the concentration of the hotel infrastructure on the north coast of the island. Water treatment combined with re-distribution strategies may in all probability be less expensive to the economy than loss of beach resources due to sea level rise. This however remains to be confirmed by further research.

The manufacturing mining and construction sectors while contributing 29% to GDP in 2005 accounted for only 6% to the total demand for water. Within this grouping the significant user of water is the bauxite industry which currently consumes 81% of the sector's demand. Future water availability to bauxite in two basins/ WMU's which support about half of bauxite production (Rio Cobre and Rio Minho) becomes a serious challenge in the 2050 and 2080 periods, and could significantly impact productivity unless adaptation strategies are put in place. To a lesser extent these challenges could face the rest of the industry. All the bauxite alumina companies now reuse caustic enriched water thereby reducing the use of freshwater.

The diversion of water from near basins with positive balances may be the preferred cost benefit solution for the economy. Technological improvements that might reduce the use of water in bauxite production could offer some hope. Alternatively, the conversion/adaptation of sea water for industrial use may by then be economically feasible. These are all areas that the bauxite industry would need to give some consideration.

With respect to environmental water which accounts for a significant proportion (39%) of consumed water resources, it can be inferred that serious ecosystem loss will occur or radical modification will be required further towards 2080. Though its economic impact cannot be quantified, the ramifications of this cannot be overstated. Sustainable development initiatives need to be continued and strengthened as an urgent priority.

Financial Resources and Research Needs

Adequate financial resources for adaptation strategies are likely to be challenging to secure. Currently Government allocates about 0.1% of its total budget to water resources. Water sector agencies can only 'pay their way' by increasing user fees or by attracting technical assistance flows. Both options present challenges.

This review can only confirm the need for future research. A worse case climate change scenario has the potential for being economically socially and physically catastrophic for Jamaica. In 2008, we just do not know enough to put conclusive measures on this. That being the case two imperatives are non debatable. First is the need for continuing serious ongoing research and introducing investigations into areas related to food security, and sector specific supplies. Secondly, the 'no regrets' approach to planning for climate change should be adopted by all sectors and within the GOJ.

2.1 The SWOT Analysis

The SWOT Analysis highlights the main strengths, weaknesses, opportunities and threats within the water sector.

STRENGTHS- INTERNAL	WEAKNESSES- INTERNAL
• Generally adequate and surplus water resources • High access to potable water (>71%) • Recognition of the link between sanitation and water supply • Demand Side Management Awareness • Established institutional framework for administration of elements of the water sector • Established water resources monitoring programme (quantity and quality) • Existing institutional framework • Water Sector Policy exists • Sector Policy and Framework focusing on all aspects of water (WRMP/NIDP/RWMP/WSP) • Institutional Framework exists • Water Resources Master Plan (Draft 2005) • Water Resources Act (1995) • Forestry Plan/ Forestry • Established communication links between main actors in water sector (Some common membership of boards). • Mechanism exists for enhancement of links between water resources management and environment management. MoU between NEPA, ODPEM, WRA and Ministry of Health. • Jamaica signatory/ party to several international conventions (Montreal Protocol, Kyoto Protocol) • Climate Studies Group at UWI- internationally recognized • Trained cache of meteorologists • Trained cache of hydrologists • Water consumed by main economic drivers – small percentage of total demand. • Most agriculture appears tolerant to predicted climatic variability (temperature and precipitation)	• Fragmented legislation in drainage sector • Poor enforcement of regulatory framework • Inadequate or no enforcement of planning and environmental legislation • Lack of strong focus/ centre on climate change within GoJ • No climate change policy • No National development policies do not now existing policies incorporate climate change considerations. • Lack of incorporation of the pivotal role of water in planning and development • Several pieces of legislation dealing with Water Sector • Overlapping legislation. Especially important regarding enforcement. • Communication between the two tiers of government not always in sync. Note responsibilities and ownership of "fees" generated. • "Conflict" between upstream and downstream users of water and pollution of sources. Blurb on "polluter pay principle". • Inconsistency in supporting water monitoring programmes. Link to funding and funding mechanisms. • Flood control legislation not adequately mainstreamed into sector. • Lack of coordination of water and sanitation programmes, human settlements development and urban and regional planning • "Timidity" re response to social pressure. Relate to Land use and tariff collection. • Use of local professional staff vs dictates of funders and international protocol. Difference in rates paid etc. • Dominance of "Supply Drive" in mind set of polical bosses. • Targeting of technologies to reflect physical/geological differences not sufficiently appreciated. Discuss re rainwater harvesting and selection of appropriate faecal waste disposal mechanism. • Draft Water Plan in existence since 1990. Not considered by parliament as mandated in the Water Resources Act of 1995. • Poorly maintained parish council water systems • Fragmentation of water supplies especially for the rural population • Lack of consistent water quality monitoring programme to detect changes over time • Lack of proper maintenance and monitoring of water sector infrastructure

	• Inadequate design and maintenance of drainage systems in urban drainage and even less in rural communities • Lack of coordination of water and sanitation programmes, human settlements development and urban and regional planning • Limited reservoir capacity • Lack of rainwater harvesting • Aged Infrastructure causing leaks • Siting of waterworks • Washout of pipelines from landslides and flooding • Water resource availability does not coincide with major demand centers • Inadequate distribution network • Inoperable sewage treatment plants • Attrition of professional staff • Non- tariff water/ unaccounted for water • Data gathering related to water is inadequate for several socio-economic parameters • High energy consumption in works • Lack of public awareness of potential impacts of climate change • Financial resources for adaptation strategies a challenge • Lack of adequate funding
OPPORTUNITIES - EXTERNAL	**THREATS- EXTERNAL**
• Development of new climate change policy • Improved ODPEM • New Disaster Management Act • A water policy exists which needs to be updated, improved and expanded • Implementation of draft Met. Act • Strengthening of the capacity of Met. Office to deal with climate change matters. • National Drainage Policy • Improved enforcement of planning and environmental legislation • Inclusion of IWRM in national development plans • Co-ordinate national efforts in watershed management, forestry development programmes and climate change • Establish links between UWI Mona Climate Studies Group and stakeholders • Inclusion of climate change considerations in national development plans • Water Resources Plan now being revised and updated. Opportunity to be used to implement it in accordance with the Water Resources Act (e.g. Consideration and approval by Parliament). • Water Resources acts calls for annual update to parliament. Use opportunity to mainstream climate change aspects. • Use can be made of climate forecasts to plan water management • Lack of integrated planning • International funding to deal with adaptation to climate change for water resources and water supplies	• Overlapping institutional mandates • Enforcement lacking • Lack of political consensus on policy and implementation • Deforestation and increased runoff and erosion • Watershed Degradation • Expanding urbanization into upper watershed areas • Informal Settlements and poor waste practices • Poor agricultural practices • Contamination of water from agricultural practices, etc. • Contamination of resources from sanitation washout during flood events • Climate Change - impacts on natural hazards (flood, drought, hurricanes) and coastal aquifers • Projected increased variability in rainfall • Coastal location of sources and infrastructure at increasing risk from sea level rise • Agriculture vulnerable to predicted extreme weather events • Hotel sector particularly vulnerable to coastal zone inundation • Rising energy costs • Criminality and theft of infrastructure and water

• High Global attention to water and sanitation • Stated commitment of local government to improving water quality • Increased private sector participation in water and sanitation services • New modalities for rural water management involving communities • Implement demand management • Increased conservation of water (reuse, recycle) • Development of economic analysis (Cost Budget Analysis) to support access to funding for adaptation programmes	

3 RECOMMENDATIONS

An Analysis of Jamaica's Future Climate for Water Sector Guidance

Many scientists and international organisations are now advocating significant cutbacks in greenhouse gases in order to limit temperature rises to less that 2^{o}C during this century (UNDP, 2007). Several countries of the European Union have given commitments to these drastic reductions. The Governments of France and the United Kingdom, for example, have stated their intention to cut emissions by approximately 80% by 2050. This does not however mean that we should stop planning adaptation strategies. In the first place, the chances of limiting temperature rise to less than 2^{o}C are slim because of economic and political hurdles. Energy Information Administration (Washington, DC), in its International Energy Outlook 2008 report released in June, predicts that world energy demand and carbon dioxide emissions will grow by about 50 percent over the next two decades. In the second place, the adaptation measures recommended herein are still applicable, regardless of climate change, and should be considered as 'no regrets' strategies.

Water Sector Vulnerability Issues and Threats

The water sector in Jamaica is vulnerable to the existing climate and climatic variability. This can be seen with the impact of: a) flooding events, either localised or across large parts of the country linked with tropical storm events / hurricanes, b) droughts related to global / regional climatic phenomena such as El Nino/Southern Oscillation (ENSO).

Projected changes in Jamaican climate by the end of the century will result in the increased frequency and severity of dry spells / droughts, the increased intensity of tropical storm events / hurricanes, as well as a change in annual average climatic conditions with decreased annual average precipitation, increased evaporation and likely increased wind speeds.

To reduce the vulnerability of the water sector to these likely changes in climate requires the adoption of a pro-active approach to both integrated watershed and water resources management. There are already a number of initiatives and plans / programmes in place that can form the core of this adaptation to climate change. These include the IWCAM project as well as the continuing work that is being undertaken by the Forestry Department through the implementation and continuing development of the National Forestry Plan.

Although flood hazard maps do exist for a number of watersheds, further modelling and mapping exercises are required to increase the coverage of these maps and the promotion of their existence to the relevant national and parish planning agencies and bodies. This is especially important with respect to the planning and location of key national assets given the likely range of sea level rise during this century coupled with tidal surges associated with tropical storms / hurricanes.

This enforcement, set within a wider planning context, must be based on the development of a National Physical Plan for Jamaica.

There is also a need to regularly review engineering design procedures to ensure that both existing and future structures such as bridge crossing and culverts have been designed and built with enough capacity to pass flood waters at agreed magnitudes, as well as debris flows.

Within the area of water supply planning and delivery, an integrated approach has been proposed that looks at water resources availability as well as demand. However, further work is needed to bring within the approach the engineering aspects and constraints related to delivery of water from source to customer at this planning level. The practice of looking solely at annual average conditions, should be expanded to include analysis of system performance under agreed drought conditions for a range of climate change scenarios. Under such an approach, it would then be possible to focus on a range of potential measures / programmes that may be required to address supply-demand deficits projected for these scenarios.

This proposed direction is conditional on the availability of hydrological / groundwater models that can be used to provide estimates of source yields under existing climate. Climate change impacts on yield estimates can then be assessed by perturbing inputs using results from the climate modelling studies. There is therefore a need for investment in the development of these models, which is conditional on the availability of the technical capacity within the relevant organisations and institutions. This is likely to require the pooling of available resources, both technical and financial, but does offer the opportunity of an agreed set of modelling approaches and tools across the key water sector stakeholders. These models can be used in both a planning as well as operational mode, using the outputs from climate models looking to the 2030s and beyond, and also shorter term predictions of likely climate in the next 1-2 years respectively.

At present, even without the modelling approaches suggested above, support for measures to increase water use efficiency must continue. This is both for the agricultural sector as well as for public water supply.

Monitoring is a key aspect to understanding what is happening within the watershed. Therefore, investment in the meteorological / hydrological / hydrogeological monitoring networks must be a priority. This includes quantity as well as quality. It is important that a co-ordinated approach across agencies is adopted to maximise return on this investment and avoid duplication of effort. It is also important that the collected data, once it has been through the necessary Quality Assurance/Quality Control checks is made available to all stakeholders. The WRA has a GIS web-based database system that can be accessed through its website that provides an existing platform for stakeholders to view and download these kinds of data. The continued investment and growth of this service must be supported, with, for example, incorporation of data held by other government bodies such as the Met. Service, (precipitation and evapotranspiration) into this platform.

Unless and until the main water sector government institutions and agencies (WRA, NIC, Met. Office, Forestry Dept., relevant functions of NEPA) are brought together within a single Ministerial responsibility, there is a need for these agencies, in partnership with others such as the NWC, to present a unified approach / coalition on key water sector strategic issues to their respective ministers. This is to assist with the development of co-ordinated GoJ policy with respect to the water sector and the development of adaptation policies, plans and programmes to manage the impacts of climate change.

There may be an implied assumption that the adoption of the measures to increase the adaptive capacity of the water sector outlined above will assist directly and / or indirectly with a similar increase in the adaptive capacity of the aquatic environment / flora and fauna. This may not be the case, and therefore it is important that those bodies and organisations with such specialist knowledge are included within the key stakeholder group in the development of the water sector adaption policy to ensure that the role and importance of the aquatic environment is explicitly considered.

Much of what has been presented so far will involve the investment of significant funds by the Government of Jamaica, or the accessing of funds as low interest loans or grants from bi-lateral or multi-lateral lending agencies. Such applications for funding will require supporting economic evidence on the benefits that such investments will bring to Jamaica. Therefore, it is crucial that mechanisms are developed and put into place to provide the necessary socio-economic tools on which to assess such potential benefits that would form the adaptation strategy.

Institutional Review

- Strengthen the Meteorology Office by providing additional staff and where necessary technical expertise to discharge its functions in climate change adaptation.
- Establish a climate change desk in the OPM.
- Strengthen the ODPEM to deal with new issues emerging from climate change.
- Strengthen the Water Resources Authority to deal with new issues emerging from climate change.
- Clarify agency responsible for planning for coastal works (including beach and shoreline erosion).

Policy and Legislative Review

- A climate change policy should be developed by the Government and be presented to Cabinet for approval.
- There needs to be a link between the climate change policy and the water policy.
- Revise the Watershed Policy and the Water Policy to take into account climate change considerations
- The draft Disaster Management Act should be enacted by Parliament at an early date.
- The proposals for the enactment of a Meteorological Act should be implemented.
- Stricter enforcement of physical planning laws and regulations is necessary to ensure that life and property are not placed at risk from pluvial, fluvial and coastal flood events.

Economic Review

Irrigation water is a major annual user of extracted water. For the main crops consuming irrigation water, (cane, banana and pasture) adaptation strategies due to likely climate change impact on water supplies include the application of increased irrigation efficiency, the reintroduction of water harvesting, use of alternative water sources such as treated sewage effluent and drought resistant crop modification. Also increased weather threats will require better watershed management, improved drainage systems including river training and flood control, as well as more rapid response systems in which recovery assistance and its distribution could be effected particularly where smaller and more vulnerable farm units are impacted.

Other non irrigated crops such as coffee, cocoa and pimento are also important to the economy: Some adaptation strategies directed at crop production efficiency must include:

- investigation of important pests and plant diseases including weeds to climatic changes. Since these have an important bearing on crop productivity.
- investigation of genetic diversity within crop types that might be better suited and called upon to compensate for climatic variability.
- engagement of main stakeholders in areas such as plant breeding, agrochemicals and fertilizers, irrigation and agricultural equipment etc on the implications of climate change

Sea level rise and the resulting potential saltwater intrusion into the aquifers of important agricultural growing areas such as on the Clarendon plains is a significant threat. Further research into the development of specific adaptation measures is required, but they are likely to include the need to reduce / redistribute abstractions, investigation of the use of alternative surface water sources (including use of surface water storage), and assessment of the use of aquifer recharge to act as barrier to saline intrusion amongst others. Climate change will challenge the objective of ensuring clean water supply mainly in relation to the resource commitment required to improve water quality in : 1) population dense areas whose aquifers are threatened by saline intrusion and 2) in diminished supply in populated areas where reduced stream flow on important sources threatens this supply.

Adequate water resources underpin the current adaptation strategies proposed to address food security. Required strategies include:

- reduction in the level of poverty to reduce undernourishment.
- priority focus on increasing agricultural output and productivity so as to reduce prices and reduce the number of food insecure persons.
- macro economic policies should support the production of food for export but also domestic production.
- need to improve coordination of planning and policies for activities that impact the food sector.

Future water availability to the bauxite industry could become a serious overall challenge leading up to the period 2050 through 2080 , but is a much nearer problem particularly in two important basins, the Rio Cobre and the Rio Minho that support this production. Adaptation strategies to be considered would need to address the following considerations: the diversion of water from nearby basins with positive balances may be the preferred cost benefit solution for the economy. Technological improvements that might reduce the use of water in bauxite production could offer some hope. Alternatively the treatment of sea water for industrial use may by then be economically feasible. These are all areas that the bauxite industry would need to give some consideration.

With respect to environmental water which accounts for a significant proportion of potentially available water resources, it can be inferred that serious ecosystem loss will occur or radical modification will be required approaching 2080. Sustainable development initiatives need to be continued and strengthened.

Research into the likely impact of climate change on the economy should be commissioned through the PIOJ. It could be guided by the Stern Report undertaken for the UK Government in 2006.

4 STRATEGY AND PLAN OF ACTION

RECOMMENDATIONS	TIMEFRAME	FUNDING		RESPONSIBLE AGENCIES
		Amount (USD)	Suggested	
Capacity (*Technical)*				
• Island wide implementation of best practices learnt from the IWCAM pilot project in Drivers River WMU.	Long Term (post IWCAM)	T.B.D. (Note: IWCAM budget is $1.2M over 3 years)	G.E.F. / UNDP / UNEP	NEPA / WRA / PCs
• Resumption of island wide WQ monitoring (SW & GW)	Immediate & On-going	T.B.D	GoJ through increase in WRA recurrent expenditure.	WRA
• Support for WRA GIS based publicly accessible database (including MoU on data sharing and transfer)	Immediate & ongoing	T.B.D	GoJ with increase in WRA recurrent expenditure	WRA, Met. Service, NWC, NEPA
• Regular review of engineering design procedures	Immediate & ongoing	Minimal	GoJ through NWA, private sector through JIE	NWA, JIE, NWC
• Develop water modelling capacity within Water Sector	Immediate & ongoing	T.B.D.	G.E.F. / UNDP / UNEP	WRA, Met Service, NWC, NIC, FD, UWI
• Introduce environmental economics to assist with climate change adaptation programme and policy development	Short-term	T.B.D	CCCCC / G.E.F / UNDP/ UNEP	PIOJ/ UWI
• Complete WRDMP within revised schedule agreed with funder.	Immediate	Minimal	N/A	WRA
• Commission a comprehensive study on the likely impact of climate change on the economy. It could be informed by the Stern Review on The Economics of Climate Change report done for the British Government by Lord Stern in 2006.	Short term	US$929,300. Based on 30 professional person months @US$17,600/pm and associated direct costs at 60% plus 10% contracting costs.	Bilateral or Multilateral sourcing	PIOJ
• Models should consider forest cover and other land-atmosphere interactions	Long term	T.B.D	CCCCC	Climate Studies Group, Mona
• Tide gauges should be maintained to monitor sea level and other parameters	Ongoing	T.B.D	MACC/ CCCCC	Met Office
• More regional and statistical downscaling models need	Ongoing	T.B.D	MACC/ CCCCC	Climate Studies Group, Mona

RECOMMENDATIONS	TIMEFRAME	FUNDING		RESPONSIBLE AGENCIES
		Amount (USD)	Suggested	
to be run to reduce uncertainty				and Met Office
• A Joint GoJ/Private Sector Rehabilitation and Development Program. Reintroduction of rain water harvesting, use of alternative water sources such as treated sewage effluent and crop production efficiency including drought resistant crop modification.	Short term	US$1.5M per year for first 2 years.	GoJ and private sector	Ministry of Agriculture
• Improvement in response systems for recovery assistance and its distribution to farmers arising from weather threats and mainstreaming risk reduction in the agricultural sector for emphasis on the wet and dry spells.	Immediate and ongoing	T.B.D	GoJ with Bi and Multilateral assistance.	ODPEM & Ministry of Agriculture
• Technical assessment of the use of aquifer recharge to act as barrier to saline intrusion	Short term	$250,000	GoJ	WRA
▪ Engagement of main stakeholders in areas such as plant breeding, agrochemicals and fertilizers, irrigation and agricultural equipment etc on the implications of climate change	Short term	$50,000 To fund a series of sector specific consultations	GoJ	PIOJ
• Continue and strengthen broad range of sustainable development initiatives so as to protect environmental flows.	Immediate and ongoing	T.B.D	PIOJ/ CCCC/ G.E.F /UNDP/UNEP	PIOJ
Capacity (*Institutional)*				
• Stricter enforcement of physical planning laws and regulations is necessary to ensure that life and property is not placed at risk from both pluvial, fluvial and coastal flooding and flood events and identify 'No Build' Zones.	Immediate & ongoing	Minimal	NEPA / PCs/ODPEM	NEPA / PCs
• Establish Water Sector Task Force to develop and promote IWRM in Jamaica.	Immediate	Minimal	Across stakeholders	WRA, NEPA, FD, NIC, NWC, UWI, PCs, Private Sector.
• Promote training and career development for water professionals in Jamaica	Immediate & Ongoing	Minimal	GoJ, UWI, JIE	GoJ, UWI, JIE, WRA, NWC, NIC, FD etc.
• Get Parliamentary approval of WRDMP – as mandated by 1995 Water Resources Act.	Short term	Minimal	N/A	MoW&H

RECOMMENDATIONS	TIMEFRAME	FUNDING		RESPONSIBLE AGENCIES
		Amount (USD)	Suggested	
• Water mangers should take climate change forecasts (1-3 months ahead) into account in planning	Ongoing	T.B.D	Ministry of Water and Housing, NWC, WRA	Climate Studies Group, Mona, Met Office and Carib. Inst. Met & Hydro.
• Set up a mechanism for data sharing and collaboration, including sharing model results for storm surges	Ongoing	T.B.D	Ministry of Environment	Ministry of Environment
• Establish links between UWI Mona Climate Studies Group and stakeholders	Immediate	T.B.D	Stakeholders	Climate Studies Group, Mona and stakeholders
• Strengthen the Meteorology Services by providing additional staff and where necessary technical expertise to deal with climate change matters.	Short term	T.B.D	GEF/ GoJ	Met. Service, ODPEM, OPM
• Establish a climate change desk in the OPM.	Short term	T.B.D	GEF/ GoJ	Met. Service, ODPEM, OPM
• Strengthen the ODPEM to deal with new issues emerging from climate change.	Short term	T.B.D	GEF/ GoJ	Met. Service, ODPEM, OPM
• Strengthen the Water Resources Authority to deal with new issues emerging from climate change.	Short term	T.B.D	GEF/ GoJ	WRA, MoW&H OPM
• Clarify agency responsible for planning for coastal works (including beach and shoreline erosion).	Short term	T.B.D	GEF/ GoJ	NWA, OPM
Policy				
• Develop & publish National Physical Plan for Jamaica	Medium Term	T.B.D.		PIOJ, WRA, NEPA, PCs
• Revise Water Sector Policy to mainstream adaptation mechanisms regarding Climate Change	Immediate	$75,000 (100 person days)	GEF	MoW&H, WRA
• Revise Forestry Policy to mainstream adaptation mechanisms regarding Climate Change				MOA, Forestry Dept.
• Need to get out message of climate change impacts to all sectors, not just the water sector. Similarly other sectors should take scenarios of climate change into consideration when doing adaptation studies, as was done with the ESL Water project. Public awareness and mainstreaming climate change in the formal education system.	Immediate	T.B.D.	UNDP	Ministry of Environment, Lead Government –wide initiative

RECOMMENDATIONS	TIMEFRAME	FUNDING		RESPONSIBLE AGENCIES
		Amount (USD)	Suggested	
• Building incentives for compliance and best practices- e.g. carbon trading (carbon points)				
• There needs to be a link between the climate change policy and the water policy.	Immediate	T.B.D.	GEF	OPM
• Revise the Watershed Policy and the Water Policy to take into account climate change considerations	Immediate	T.B.D.	GEF	OPM
• A climate change policy be developed by the Government and be presented to Cabinet for approval.	Immediate	T.B.D.	GEF	WRA/ FD, ODPEM, Met. Services, OPM
Legislation				
• Ensure "climate change" friendliness in new legislation being prepared regarding Flood Control.	Immediate	T.B.D.	MoW&H	MoW&H, WRA
1. The draft Disaster Management Act to be implemented.	Short term	T.B.D.	GEF	AGD
2. Proposals for the enactment of a Meteorological Act be implemented.	Short term	T.B.D.	GEF	AGD

On-going Immediate Short term= 1-3 yrs Medium= 3-5 yrs Long term= > 5 yrs

Abbreviations

AGD= Attorney General Department
FD = Forestry Division
GEF= Global Environmental Fund
GoJ = Government of Jamaica
JIE = Jamaica Institute of Engineers
Met. Service = Meteorological Service of Jamaica
MoW&H = Ministry of Water & Housing
NEPA = National Environment and Planning Agency
NIC = National Irrigation Commission
NWC = National Water Commission
OPM= Office of the Prime Minister
PCs = Parish Councils
PIOJ = Planning Institute of Jamaica
UWI = University of West Indies
WRA = Water Resources Authority