NATIONAL ISSUES PAPER

OF JAMAICA

FOR

INTEGRATED ADAPTATION

PLANNING AND MANAGEMENT

Prepared by
Clifford Mahlung
Section Head, Climate Branch
Meteorological Service of Jamaica

TABLE OF CONTENTS

1. Introduction

Jamaica located in the northern Caribbean Sea with a landmass of 10,991 square km is the third largest of the group of islands known as the West Indies. The island is 145 km south of Cuba, 850 km south of Miami and 1,000 kilometres north-northeast of the Panama Canal. Centred on latitude 18^{o}15' N and longitude 77^{o}20' W, it is elongated along a west-northwest to east northeast alignment. It is roughly 230 kilometres long and 80 kilometres wide at its broadest with an exclusive economic zone 25 times its land area.

1.1. Physical Characters

The country's topography consists of interior highlands formed by a series of mountain ranges along the major west, northwest, east-southeast axis of the island. The eastern two thirds of the island's mountains range up to 1,000 metres, with the Blue Mountains reaching a maximum height of 2,256 metres. The mountains, hills and plateaux of the central and western regions are primarily limestone, while the Blue Mountains are volcanic in nature. The Central mountain ranges form the main watersheds for rivers that drain either to the north or south coasts except one the Plantain Garden River, which drains to the east.

Flat coastal plains surround this Central highland ridge. The coastal plains are narrow on the north coast and tend to be wider along the south coast. These include flat alluvial areas such as sections of the parishes of St. Catherine, Clarendon and the Liguanea Plains on which Kingston the capital city is built.

In addition to coastal lowlands there are three major interior valleys. The coastal plains and the interior valleys are the prime areas for agriculture.

The geology of the island consists of three groups of rock types,

- quaternary alluviums,
- tertiary limestone and
- igneous and metamorphic rocks.

The soils of the country are a reflection of its geology. The soils of the upland plateaux for example, were formed mainly from weathered limestone and constitute approximately 64 percent of the island's soil. While, alluvial soils found in flood plains, river terraces, inland valleys and coastal plains constitute approximately 14 percent of island soils.

1.2 Regional/Local Climatology and related Phenomena

Jamaica has a tropical maritime climate. The numerous steep slopes, valleys and plateaux formed by the system of mountains, influence local climate. Spatial distribution of rainfall is a result of the interaction between major rain producing

systems, the influences of the land and sea breezes and the forced or orographic uplifting of moisture due to steep slopes

The most important broad-scale climatic influences are the Northeast trade winds and orthographic features, i.e. the central ridge of mountains and hills. Other influences are the warm waters of the Caribbean Sea as well as synoptic weather systems, primarily high-level pressure centres, troughs, cold fronts, tropical waves, and infrequently the inter-tropical convergence zone. Rainfall is the dominant meteorological variable that influences mesoscale fluctuations of temperature, humidity, sunshine and evaporation.

General statements about the island's climate can be misleading in assessing potential climate change as the elements of climate vary spatially on islands. Therefore, the following general statements are followed below by a more detailed discussion of relevant variation patterns.

- Average temperature is approximately 25^0 C and ranges from 24^0C to 28^0C in the cooler months of January and February and to 30^0C in the warmer months of July and August. Temperatures are generally cooler in the higher elevations.
- Rainfall is marked by monthly, annual, and spatial variation. The average annual rainfall is 1900mm.

Jamaica lies in the global belt of the North East Trade Winds. Predicted by thermal as well as dynamic atmospheric circulation models they emanate from the Azores - Bermuda high-pressure system.

However, because Jamaica is near the Western extremity of the Azores - Bermuda high-pressure centre, the trades in the vicinity of the island is generally between 070 and 090 degrees. This is the result of the centre of the high-pressure system being further north (away from Jamaica) in the summer and closer to the island, or further south in the winter.

Deviations from this constancy occur mainly when landmasses disrupt the basic flow. During winter, a frequent procession of temperate latitude systems moving from the mainland of the United States of America to the Gulf of Mexico and then the southern Atlantic are at a sufficiently low latitude thereby weakening and/or totally displacing the high pressure zone.

Most of the islands of the Caribbean including Jamaica lie within the Atlantic hurricane belt and are vulnerable seasonally to these intense weather patterns. They are occasionally subject to these severe tropical weather systems including tropical waves, tropical depressions, tropical storms and hurricanes.

The official Atlantic hurricane system is June to November, although these tropical systems can occur from April to November. Hurricanes are tropical cyclones that have attained a sustained wind speed of 74 miles per hour or more. More frequent tropical cyclones have been occurring in this region. The season peaks in September with an average of 2.7 tropical cyclones per year. The 1998

Atlantic hurricane season was especially devastating and the impacts of hurricanes George and Mitch will be felt for a long time[1].

The long-term large-scale human induced climate change will interact with natural variability on time scales of days to decades including El Niño the name given to the abnormal warming of the eastern tropical Pacific Ocean.

The 1997/98 El Niño was the most extreme on record. While it is not yet certain whether global warming has led to more frequent or larger warming episodes, its the global effects demonstrate how vulnerable societies are to changes in global climate[2].

The impact of 1997/98 El Niño phenomenon had its strongest on record, on the Caribbean region. ENSO effect is believed to have had an impact on the climate of Jamaica through decreased rainfall, higher temperatures and the effects of the decreased number of hurricanes in the region during 1997/98. Rainfall for the period January – December 1997 was below normal for the entire year with April and May having rainfall reduced by 29 and 31 percent of normal rainfall respectively.

For the period January – December 1998 rainfall amounts were below normal for the months of February, April to June and August to September. The months of April and May received 40 percent and 39 percent respectively of normal rainfall.

These climate changes resulted in millions of dollars of losses to the agricultural sector due to loss of crops, livestock and reduced crop yields. Domestic water supply was also severely affected and the transporting of water to most affected areas was necessary.

El Niño pattern transition to the colder La Nina phase in June 1998 and will have a corresponding influence on the climate of the region in general and Jamaica in particular.

1.3 Important Ecological/Biological Attribute

Species diversity according to the 2000 status report of Jamaica National Environmental Action Plan shows as expected characteristics that are typical of islands as compared to mainland.

Jamaica has a high level of endemism ranking fifth among islands globally in terms of number of endemic species. Approximately 3,304 vascular plants are found on the island, of these 923 are found nowhere else in the world. Of the over 600 species of ferns found, over 14% are found nowhere else in the world. There are 514 species of snails, 133 species of butterflies, 59 species of ants, over 211 species of rotifers and 9 species of *grapsid* crabs.

[1] Caribbean Environment Outlook UNEP 1999
[2] Climate Change and its Impacts DETR November 1998

The Conservation data centre of Jamaica has classified 221 endemic species as "critically imperilled" and as such is especially vulnerable to extinction. The main causes for this are:

- habitat deforestation or conversion and the
- unsustainable harvest of wild life.

This is a consequence of heavy reliance for economic survival by sectors of the population on natural ecosystems such as coral reef, wetlands and the forests.

Public awareness in respect to the vulnerability of these biological systems would contribute to reducing this problem.

Jamaica has acceded to or ratified several international treaties and conventions related to the conservation of biological resources and their sustainable use. Additionally, amendment of the Wild Life Protection Act will go a far way in supporting a framework for development and implementation of programs for sustainable use of these important resources[3].

Jamaica possess a varied and irregular coastline that gives rise to a unique ecosystem formed by the integration of coastal features that include harbours, bays, beaches, rocky shores, estuaries, mangrove swamps, cays and coral reefs. Most of its population lives in the coastal plains, therefore the majority of the economic activities within the country occur here, making the management of this is zone a necessity.

Numerous sandy beaches around the coastline and on several inshore cays are invaluable to the tourism industry and local recreation. This resource is under threat from pollution, erosion and illegal sand mining. Beaches have been fouled by pile up refuses, debris and fish offal as well as the occasional oil spill.

The area of wetland (i.e. mangrove forests and salt marshes) has been steadily decreasing, with a corresponding decrease in fish and wild life and an increase in coastal erosion. Mangrove and herbaceous wetlands in 1992 covered approximately thirty percent[4] of the coastline. The two largest and most significant are the Lower and Upper Morass of the Black River. Others of important environmental qualities are Portland Bight and Morant Point.[5]. These wwetlands are ecologically sensitive, as they are important breeding areas for many species of wild life including various fish, birds and the American crocodile. In addition some areas mainly in the western section of the island are peat repositories.

1.4 Brief Socio-Economic Profile of Jamaica

The population of Jamaica at the end of 1998 was estimated at approximately 2,576,200. The rate of natural increase was 16.9 percent while the actual growth

[3] JANEP 1999-2000 Ministry of Environment & Housing
[4] Jamaican National Report on the Environment and Development UNCED June 1992
[5] Coastal Zone Resource Atlas – National Resource Conservation Authority

rate was 0.9 percent highlighting the effects of out migration. Jamaica continues to have a young population due to the effects of high fertility of previous years. Over 60 percent of the population is in the age group 0 –29 years, with 11.4 percent in the 0 – 4 years age group.

Data from the Statistical Institute of Jamaica indicate that 49.6 percent of the population resided in urban areas (Census, 1991). The rapid growth of urban areas reflects a shift of population and number of urban centers. The rapid growth experienced in areas such as the Kingston Metropolitan Area and Montego Bay in recent times is also occurring in newer urban centers such as Ocho Rios and Spanish Town. It appears these towns may have reached saturation point as evidenced by the "ghettos" or inner city areas with substandard social and infrastructure facilities that adjoin these urban centres. These areas are considered to be poor. It has been reported that approximately 26.1 percent of Jamaica's total population live in poverty.

Since the early 1980s, the Government of Jamaica (GOJ) has initiated fundamental reforms of economic policy aimed at fostering private sector activity, increasing the role of market forces in resource allocation and improving the efficiency of product and factor markets. The reforms entailed an overhaul of the trade policy and tax regimes as well as broader reforms of the financial and public sectors.

Over the period 1990 to 1994, the economy experienced positive growth. However, the rate of growth declined over the time period from 5.5 per cent to 0.8 per cent. In the Goods Producing sector, Agriculture had the highest rate of growth while performances in the sectors Manufacturing and Construction showed declined for some years. Performance in the Services sector was more robust over the period, led by the Financial Services sector and Distributive Trade. Sectors such as Electricity and Water performed well over the period

Climate change is an on-going process, which has already impacted on the environment of Jamaica. Added to this, is the growing pace of change in the social and economic sectors. To understand fully the impacts that may occur as a result of climate change and sea level rise it is important to address the issue of people. In the medium term the focus has been on growth and stability, whilst the long-term economic program has a central objective of achieving a high level of growth in order to generate employment and improve living standards.

The emphasis has been on improved export performance, and targeting the export sector to transfer efficient technologies and develop internationally competitive industries. Measures to maintain macro-economic stability and stimulate investment and growth were introduced after collaboration between public and private sector stakeholders.

Government is committed to taking a holistic and comprehensive approach to policy with full recognition that there are inter-dependencies among different components of policy. Hence, the need for establishing consistency, integration, and co-ordination among the different policy areas.

Jamaica was classified at the intermediate stage in its transition to low birth and death rates. The rate of natural increase was 16.9 percent while the actual population growth rate was 0.9 percent. This highlights the effects of international migration especially to the United States of America.

The population at the end of 1998 was estimated at approximately 2,576,200.

Economic changes in Jamaica during the past two decades have had their social cost in terms of their impact on the standard of living of a significant part of the population. This has also aggravated the problems of poverty and of income disparities. Coupled with this the Government has not been able to provide services in the manner and to the extent required to deal with these problems.

Recent estimates indicate that 28 percent of the Jamaican population fall below the poverty line. The majority of the poor live in rural areas where poverty is associated with land ownership patterns, low productivity of small farms, low levels of education and deficiencies in physical and social infrastructure[6].

1.5 Other Factors/Phenomena

Jamaica lies in the region's earthquake belt.

2. KEY ISSUES WITH RESPECT TO CLIMATE CHANGE

2.1 Impacts of Potential Climate Changes in Sea-Level, Hurricane Characteristics, Storm Surge, Rainfall Patterns and Temperature

Beach and shoreline stability

Irrespective of the magnitude of changes in temperatures or sea-level rise, it is anticipated that climate change will have some likely adverse impact on Jamaica's beach and shoreline stability. The potential impacts are anticipated as follows:

Delta – Deltas are particularly vulnerable to erosion enhanced by sea level rise because sediments are unconsolidated mud and other fine grained material. Jamaica's shoreline can therefore be expected to retreat up to several metres horizontally for each centimetre rise sea level.

Coastal Plains- The primary effect on our coastal plains will be increased flooding during storms and changes in the coastline depending on the

[6] National Industrial Policy – Growth & Prosperity. The Way F

substrate. For example, it is anticipated that the numerous sandy beaches will be more affected than rocky coasts and many could become inundated.

Jamaica's coastal zone is particularly important because it contains the majority of our population, a significant portion of our infra-structural investment and is a key contributor to the economy.

An intensive study of the South Coast was conducted by Halcrow Group Limited of the United Kingdom and some of its findings are included in this chapter. The oceanographic studies conducted included an assessment of existing information together with the collection of new data on water quality, currents, waves, tides and areas of coastal erosion in the study area.

From the models of wave climates and the effects of hurricanes and storms it showed that the most severe wave conditions would be experienced between Treasure Beach in the parish of St. Elizabeth and Savanna-la-Mar in Westmoreland. The most exposed parts in general of the areas studied are the Hellshire frontage and the southeast of Portland Ridge. Portland Ridge acts as a wave breaker for much of the western end of the study area.

Existing information reviewed for this study includes meteorology, bathymetry, waves, tides, currents, water quality, sediments, coastal structures and shoreline features. Field surveys were conducted to fill gaps in the information.

The tides were found to be mixed, consisting of between one and two periods of low and high waters each day. Tide gauge measurements made throughout the wider Caribbean were used to predict sea level rise taking into account estimates of global rise and were found to be extremely small. Predicted storm events over the next 50 to 100 years indicate that Savanna-la-Mar is the most vulnerable part of the study area to storm surge effects.

Details of the depth and profile of the seabed in the near-shore areas of Treasure Beach and Whitehouse were collected using a depth sounder and global positioning system to record precise locations of each depth reading. The currents, salinity and seawater temperature were measured using four current meters placed at Portland Bight, Alligator Reef, Black River and Savanna-la-Mar. Two tide gauges were also placed at Rocky Point and Savanna-la-Mar and scheduled to record water level every ten minutes for two months.

Measurements of temperature and salinity in surface waters indicated half of all the sites investigated, Black River exhibits the greatest potential for mixing and Savanna-la-Mar the least.

Wind data from the National Meteorological Centre at the Norman Manley International Airport and wave climate information were analysed, using

mathematical modeling techniques, which allowed predictions to be made about wave height and frequencies, based on meteorological conditions and currents. Modeling was also used to determine the movement of sediment along the shoreline at Treasure Beach and Savanna-la-Mar in order to detect whether the shoreline is being eroded or built up. Wave and sediment transport models were used to identify areas, which may be flooded by storm waves and took into account predictions of sea level rise.

The beach sediment analysis showed that the rivers in the study area carry significant amounts of material to the coast. The beach sediments appear to drift in a westerly direction along the shore and Portland Bight, Black River Bay and Savanna-la-Mar are areas where sediment is accumulating.

Other areas that were determined by modeling to be eroding and which contain appreciable numbers of population include:

- Mohoe Bay to Meriman's Point
- John Rock to Parotee Point
- Whitehouse Bay
- Crab Pond Point to Belmont Point
- East and west sections for the Savanna-La-Mar coastline

Models of the effects of a 1 – 50 year tropical cyclone return period showed that erosion was likely to result at Jackson Bay, Long Bay and Treasure Beach. The reef offshore of the Whitehouse was shown to provide protection of the coastline from erosion.

No such study has been done of the north coast.

Marine ecosystems

Wetlands/Mangrove Forests – The mangrove forests are unique feature in the coastal lowlands. Their prop roots stabilize the soil, dampen wave energy, provide habitat shelter for organisms and form the base of the marine food web. Different species of mangrove will react differently to an increase in sea level. There is some evidence that red mangrove will replace black mangrove when mean water elevation increase. In general however, those mangroves that are not juxtaposed to a steep coastline are expected to be able to tolerate the anticipated rise in sea level.

Hydrological characteristics and water resources

Water constitutes the most critical factor associated with climate change impacts and adaptability. It is critical to the life, health and economic well being of a nation and has real value as a commodity. Inadequate supplies can and do have adverse social and economic consequences. There is growing awareness and concern for the issues and problems in the water sector that threatens the

nation's health, agricultural production as well as other key economic sectors such as tourism. Water resources are also an absolutely necessary consideration to environmental sustainability and biodiversity.

Extensive data has been reviewed during the preparation of this National Statement which has allowed an initial qualitative assessment of the areas above and provides a sound foundation for further quantitative evaluation of impacts and refinement of recommended adaptation measures. As such this assessment has been completed through a combination of analogue and expert judgement methods.

WATER RESOURCES BASELINE CONDITIONS

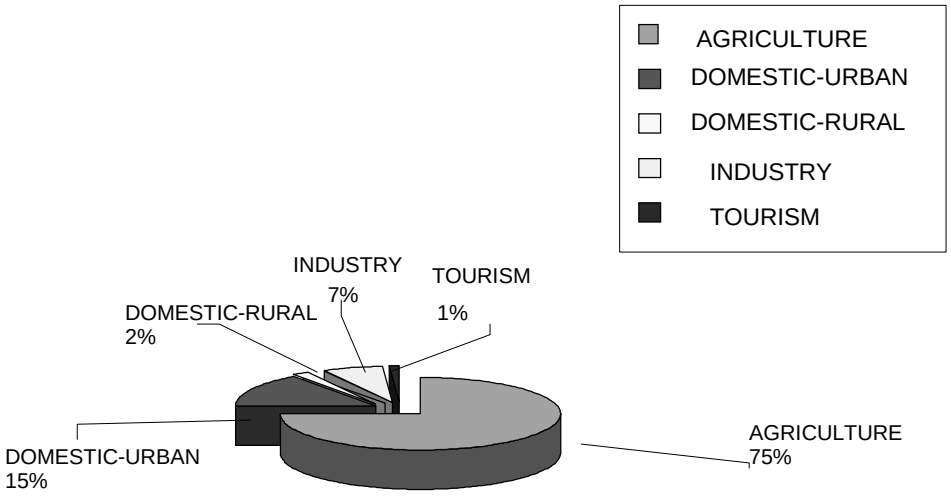
Baseline conditions include the current status of water resources as well as current projections of future water resource conditions based on anticipated population growth, economic conditions, and land uses without consideration of potential climate change impacts.

a. Water Demand

Two main water demand sectors are recognised: the agricultural sector and the non-agricultural sector. The agricultural sector represents approximately 75% of the water demand. The non-agricultural sector is further divided into sub-sectors of domestic-urban (15%), domestic-rural (2%), industry (7%) and tourism (1%).

Water demand distribution in Jamaica is based on the location of irrigated lands, population concentrations, tourism development and other water consuming industries. The demand in the south of the island is greater due to the extensive agriculture in areas of little rainfall. Demand in the north tends to be less because there is greater rainfall and less cultivable land. Bauxite –alumina and sugar cane processing industries, which are concentrated in the south, consume large quantities of water. The concentration of agriculture and industry in the south has also created an increased demand for labour, which in turn has created higher population densities and higher water demands for the domestic sector.

Figure 1: Demand for Water[7]



b. Water Quality

Water quality is of critical importance in assessing water supply. Water present in vast quantities but of poor or marginal water quality for intended uses must be subtracted from the safe available yield. Degradation of water quality has resulted in the loss of some 104.3 cubic meters per year, or 10% of exploitable of groundwater as the result of pollution or saline intrusion[8]. An additional 241.2 million cubic gallons have been affected but continues to be used for restricted purposes. Other factors includes:

- Overpumping of older wells
- Below sea level pumping
- Wells installed in acquifers of high natural salinity[9]

However the current permitting system of wells allows for better management and control to prevent overpumping. Once saline intrusion occurs the cost of recovery may be prohibitive.

c. Watershed Conditions

Watersheds are integral to sustaining the quality and quantity of water. Watersheds serve a number of important functions to water resources, protection of the coastal zone, and as habitat for diverse species. Upper watersheds are of particular importance to water resources since they serve as recharge areas for

[7] State of the Environment The 1997 Report Natural Resources Conservation Authority
[8] Water Supply Master Plan and updated by 1993 Status of Water Supply – B Fernandez(WRA)
[9] In this discussion, wells installed in groundwater aquifer's with higher natural salinity are "associated" with saline intrusion because it has been found that in some cases the assumption has been made that saline intrusion exists when the water had always naturally been more saline.

most aquifers and as source areas for rivers that supply water for industrial, domestic, and agricultural purposes. The island is divided into 26 watershed management units comprising all of the land from the mountains to the sea and containing over 100 rivers and streams. The land in the upper watersheds is characterised by steep slopes with limestone-derived soils covering approximately 65% of the watersheds and volcanic soils covering the remaining areas. Other contributing factors are:

- Unsuitable agricultural practices
- Deforestation
- Illegal settlements on hillside lands
- Improper construction and maintenance of roads
- Anthropogenic fires
- Unapproved mining and quarrying

The deteriorating condition of the watersheds has resulted in a number of adverse effects to the water resources and overall environmental quality:

- Extensive soil losses through soil erosion results in siltation of drains, streams and rivers and decreased water quality
- Reduced tree and vegetative cover results in decreased percolation thus reducing water availability and acquifer recharge
- Increased and more severe downstream flooding;
- Loss of habitat for important flora and fauna; and,
- Increased marine and coastal degradation due to siltation of rivers and pollutants transported downstream

As it is based in land use and land management it is a cross-sectoral concern. Socio-cultural and economic considerations influence the selection and implementation of management options. An integrated approach to watershed management is necessary. Various aspects of watershed management is now undertaken by several agencies including the National Water Commission (NWC), Forestry Department, and the National Resources Conservation Authority (NRCA). The need for integrated watershed management has been addressed by the creation of a Watershed Management Commission in the Office of the Prime Minister

d. Aquatic Ecosystems

There are many complex interactions among the elements of an aquatic ecosystem. Changes to water quality and climate variables can upset the sensitive balance of the key elements of the ecosystem. These include:

- increased turgidity and sedimentation
- changes in salinity as the result of saline intrusion or increased freshwater flows,
- microbial and chemical contamination
- loss of habitat for both flora and fauna.

e. Economic Relevance

Water resources are directly relevant to a number of key economic sectors. An understanding of the cost and the importance of water to the productivity, and/or yield, of these key sectors are essential to assessing their vulnerability and sensitivity.

f. Water Services

The overarching goal of the National Water Commission (NWC) is to expand the supply of water to all sectors of Jamaica and improve the quality of life in support of economic growth through the provision of urban water supply. Safe piped potable water is available to the majority of urban residents. Metropolitan Kingston Area (MKA) has the only two water reservoirs in the country that supplies 97 percent of households with piped water. In other towns 79 percent have piped water. Although 85 percent of the population receives treated water the quality of piped water is not always acceptable. Those households without piped water rely predominantly on standpipes and on average would travel 50 yards or less to fetch water. Water supply outside Kingston is provided through exploitable groundwater wells and surface water runoff. Households are being encouraged to provide their own water tanks.

Approximately one fifth of the average household income is spent on water services representing half or less of what the average household spends on electricity or communication services. The poorest 20 percent of the population spend proportionately more on water services than those better off.

It appears that Jamaica has sufficient water to meet all demands however the water resources are unevenly distributed in both time and location. Assessment of total exploitable water indicates an estimated shortfall of 126 million cubic meters per year based on existing infrastructure.[10] WRA has the responsibility for regulation and control of the nations raw water resources and ensures there is an integrated planning and management of the resource. Monitoring of the resource is critical to the ability to manage and protect these resources. The Authority is undertaking continuous research to determine acquifer safe yield. As part of its monitoring role the Authority is responsible for issuing and enforcing permits for well drilling and water abstraction

The National Irrigation Commission undertakes water supply to rural agriculture, which is an important contribution to agricultural production in Jamaica. Water is therefore a key element in rural development. The Commission operates only in seven districts, which suggests that some parts of the country that could benefit from irrigation currently do not have access to this service. Lack of funding and low cost recovery has limited the Authorities ability to respond to farmers' needs as desired. An Irrigation Investment Project is currently being reviewed for future implementation.

[10] Jamaica Water Sector Policy Paper- Ministry of Water 28 January 1999

g. Economic Cost of Water

Under the provisions of the National Water Authority Act 1980 the NWC is responsible for providing and operating water supply services in the urban and rural parishes. The Commission in 1985 was mandated to take over all distribution aspects of water operation and in July started billing households for domestic water. The most recent Jamaica Water Sector Policy Paper, January 1999 advances the need for cost recovery mechanisms to ensure that the direct beneficiary pays and that the supply of water services can be maintained. Total water resource assets of the Commission include raw water reservoirs, intakes, wells, mains and pumps water treatment plants, clear water reservoirs meters and pumps including sewage plants are estimated as at March 1999 $130 million.[11] Due to recent macro-economic constraints the Government is prevented from adequately fulfilling the needs of the Commission. Subsequently new avenues of income must be identified to finance operations and capital investment. If the service is to continue to be efficient and provide the essential services required then all cost of operations must be recovered or at minimum paid in full. The financial implications of providing potable water is further developed in the Water Resources Development Master Plan. An initial assessment indicates that water production costs to the urban centers like Kingston is more expensive than the cost of producing water for irrigation. It can be assumed that the extra cost is storage as well as filtration and chlorination required to meet safe drinking water standards.

Productive Sectors

Productive sectors of the economy of Jamaica most directly dependent on water resources include agriculture, tourism and related services.

a. Agriculture

Agriculture is a significant contributor to Gross Domestic Product representing 7.3 percent. Foreign exchange earnings for selected Traditional exports declined by 16.6 percent to US$156.5 million compared with 1997 US$187.6 comprising sugar, banana, coffee, cocoa, citrus (fresh fruit) and pimento[12]. The decline in earnings was reflected in a drop in the volume of exports as a result of poor production in the sub-sector during 1998 as well as a general decline in international prices for some of the major commodities. Commercialisation and more liberalised marketing of produce has put prices closer to free market equilibrium. This on the one hand has created a more conducive economic environment for the farmer to increase output for some crops but has also resulted in increased international competition associated with global supply with a consequent drop in prices.

[11] National Water Commission Annual Report 1998-99

[12] Economic and Social Survey Jamaica 1998 Prepared by the Planning Institute of Jamaica (provisional figures only)

The agriculture sector employs approximately 25 percent of the labour force cultivating nearly 270,000 hectares of the total land area of 1.1 million hectares. The main crops under cultivation are estimated at 80,000 hectares of plantation sugar, banana, citrus, coffee, cocoa and coconut, 53,000 hectares of food crops; 120,000 hectares of improved pasture and 17,000 hectares of other crops.[13] Essential to maintaining export earnings and domestic food supply is water supplied to agricultural areas. The past two years agricultural production figures show that there is a direct correlation between climate and production taking into account other variables such as development schemes and roaming cattle. Irrigation of agricultural crops is essential due to the uneven geographic and seasonal distribution of rainfall over Jamaica. The cost of water is a sensitive component in the evaluation of the cost of agricultural production therefore attempts for full cost recovery in this sector may be unachievable. The national and indirect benefits of agriculture like employment, self-sufficiency in food supply and others gives Government the incentive to supply irrigation water at less than full recovery cost.

b. Industrial

Water use for industry is estimated to be 27 percent of water demand. The major water consuming industries are sugar and bauxite industries. Generally the cost of water usually accounts for a smaller proportion of the total input cost therefore pricing the water at its full cost does not materially affect the profitability of the enterprise.

c. Energy

As of 1996 hydropower-generating capacity remained at eight generating facilities producing 23 megawatts. Since this sector generally uses only the water head and not water volume it does not compete directly with other users of water downstream. However, it does compete with other users of water in that sufficient flow must remain in the stream to provide the necessary head to produce the same quantity of electricity.

The product value of hydroelectricity can be estimated by assuming that the source is unreliable due to the depletion of the water sources or due to interruptions of supply in dry months or dry years. The value of the hydroelectricity will then be equal to the power produced from an alternative source.

d. Socio – Economic

The amenities which poor households posses are also important to examine from an environmental perspective because one of the main causes of environmental pollution and biodiversity loss described in the sectoral reports is contamination of ground water caused by seepage from pit latrines. The type of toilet facilities

[13] Preparation of National Irrigation Development Plan and Preparation of an Irrigation Investment Project Executive Summary February 1998

and the main sources of drinking water provide some indication of the environmental risks to which poor households are exposed.
Rural communities continue to be the most disadvantaged in terms of access to water supply during 1997 and 1998. In fact the data JSLC 1990 – 1998 show that the percentage households with piped water in rural areas fell from 23.3 percent to 10.8 percent over 1997 and rose only slightly to 1998. For the poorest quintile standpipes continue to be the most important source of water with 29.1 percent of the households depending on this source of water. Poorest households continue to be the most dependent on untreated water (rivers, ponds, wells and springs). In summary the rural poor are the most reliant on river streams and ponds for their household water supply therefore this population sector is most at risk in the event of any negative affects to water quality and/or water quantity, including climate conditions.

The Government of Jamaica water policy paper provides that water should be available to all citizens irrespective of the citizen's ability to pay. It further advances the need for minimum standards of water and sanitation services for sustenance of life and good health and shall be made available to all at a price, which they can afford.

Water supply and water quality are known critical factors for public health. The distribution of the incidence and prevalence of water-related diseases ascribed to the poor have not been specifically defined. However, gastro-enteritis remains the third leading cause of hospitalisation for children under four years of age. Gastro-enteritis and skin diseases represent 11.4 percent[14] of health centre visits for the total population. Gastro-enteritis and skin diseases are commonly associated with water-related diseases.

The costs of providing health services to the poor are important social costs for the government. Also, health status of the population is closely related to the productivity of the population and as public health declines so may the productivity of the population and the resultant economic output.

[14] E*conomic and Social Survey of Jamaica, 1998. Planning Institute of Jamaica, Government of Jamaica*

2.1 EFFECTS OF CLIMATE CHANGE AND SEA-LEVEL RISE ON WATER RESOURCES

The effects of climate change and sea level rise are assessed and the most vulnerable areas identified based on sensitivity to probable events due to anticipated climate change scenarios. Probable events may include floods, droughts, higher temperatures and/or increased frequency of tropical storms and hurricanes.

The scenarios used for these studies are not predictions but rather provide a picture of future climatic conditions. Quantitative studies will be required as regards the effects of climate change in Jamaica as the statements in this assessment regarding potential effects are qualitative.

Existing and known influences on water resources are as important or more important than climate change alone. Influences on water resources such as the increased demand land use, economic priorities, weather patterns and shorter-term climatic changes, waste management, and population/settlement patterns will remain of critical importance and will also be influenced by climate change and sea level rise.

Effects of climate change and sea level rise will directly affect the natural environment and water resources sub-sectors of water supply, dependent economic sectors, and socio-economic conditions. The potential effects are discussed below.

The scenarios suggest that changes in climate such as rising temperature and changes to rainfall will modify hydrologic cycle. Rising temperatures will also necessarily affect other climate parameters of importance to water resources, including evaporation, humidity, cloudiness, and changes to wind patterns. Increased frequency and severity of severe weather events such as droughts, hurricanes and other tropical storms may also occur, which will result in high intensity rainfall and winds.

A. Water Sources and Water Supply

Raw water supplies are directly affected by changes in climatic conditions. Changes in the amount of rainfall as well as its frequency and intensity determine the amount of water that will be available for exploitation. The changes to the amount of total rainfall that Jamaica may receive under the climate change scenarios are uncertain; however, even changes in rainfall patterns within Jamaica may have significant impacts on water resources. Severe weather events have well-documented effects in Jamaica that serve as examples of the potential effects of climate changes. In evaluating all potential effects of climate change and sea level rise, it is important to remember that the required water will increase with population growth and desired increased economic activity.

Changes in rainfall patterns may further exacerbate the discrepancy in the spatial distribution of water sources and water demands. Rainfall patterns affect the selection of agricultural areas and crops. Changes to rainfall patterns may result in changes in agricultural practices (e.g. crop selection and planting seasons). Population shifts may follow changes in the agricultural economy as well as other water consuming sectors. Infrastructure development must address the need for water in areas far from safe exploitable supplies.

Changes in rainfall patterns while still receiving the same total rainfall may still result in decreased surface and groundwater supplies. When rainfall is received in short intense events, high runoff and low percolation generally occurs. This results in little recharge of groundwater aquifers and lower quality surface waters. The lower quality surface may also have to be diverted to avoid siltation of reservoirs and reduced water storage capacity. With this type of rainfall pattern the ability to maintain adequate storage reservoirs is necessary to maintain a reliable supply. Also, treatment costs for domestic supplies will increase.

Intense rainfalls followed by long dry periods also results in soil moisture deficiencies that result in decreased crop yields and/or increased irrigation demands.

Reductions in rainfall will have a number of effects on water sources and supply, most obviously reduced availability supply. The supply will be reduced directly through insufficient recharge and streamflows. It may also be reduced indirectly through potential degradation of water quality through saline intrusion from over pumping and improper waste management activities. Also, as groundwater storage is reduced so is the head over saline waters, which increases the potential for saline intrusion.

Decreasing rainfall will also mean an increase in irrigation requirements for rain-fed agriculture. If water management in these areas is inadequate then soil degradation could result from a build-up of mineral salts in the upper soils.

Reduced rainfall may also result in the necessity to use brackish water for agriculture. Continued use of high saline water will degrade soil conditions. If more saline water is used for irrigation on lands over aquifers of better quality, the aquifer will also become more brackish, thereby creating a cycle of increasing degradation of more and more water supplies.

Changing temperatures may result in changing wind patterns. If surface winds increase, soil erosion will increase. Increased soil erosion reduces the potential soil moisture reserves, which increases crop vulnerability to short-term dry spells. Increased winds also cause physical damage to crops and other vegetation, and increased evaporation, and increased transpiration.

Severe weather events in recent years, particularly the drought conditions of the 1997/1998 El Niño event, demonstrate the potential effects of climate change on Jamaica's water sources and water supply. The El Niño event resulted in severe drought conditions for much of the country. The effects of the drought included the following:[15]

- Millions of dollars of agricultural losses as a result of decreased productivity, loss of livestock, and reduced yields
- Severe effects to domestic water supply resulting in "lock-offs" and the need to transport water by trucks to the worst effected areas at added costs.
- Reduction in streamflows – in some cases decline in available water to water systems was as much as 50%

Though no data were available to this assessment, it is possible that public health was negatively affected. An insufficient quantity of water, particularly potable water, is related to increases in water-related diseases. This is particularly true when populations seek alternative sources, which may be of poor quality. Increases in the incidence of heat-related illnesses also occur during periods of drought and elevated temperatures.

Flooding can result in loss of life, property, and economic productivity. A review of the impacts of the floods of 1979 provides some examples of the potential effects of flooding:

- Emergency measures for feeding and housing were implemented.
- At least 33 deaths were confirmed
- Infrastructure damage was estimated at $JA70 Million Three bridges collapsed and 10 bridges/culverts were damaged
- Over 1,000 houses were destroyed or badly damaged and some 1,250 towns and villages suffered some loss
- Agriculture losses were estimated at $JA 10.5 million

While this flooding event represents an extreme event, similar types of losses will occur with floods of lesser intensity.

Flooding also results in downstream pollution from sediment and pollutant laden runoff. Flooding may bring increase siltation and sedimentation of rivers, streams, and reservoirs. In addition, it has been reported that there is an increase in reported cases of gastroenteritis after heavy rainfalls.

Hurricanes represent the most dramatic severe storm event and their effects on the resources of the country are obvious. As evidenced by Hurricane Gilbert that made a direct hit on Jamaica on September 12, 1988, where billions of dollars of damage resulted from high winds, storm surge and flooding.

[15] Spooner, Jeffrey, "Summary of the Impact of the 1997/1998 El Niño on Jamaica", undated.

Substantial damage is caused not only by direct hits of hurricanes, hence increases in frequency and/or intensity of hurricanes in the region will have substantial consequences for Jamaica.

B. WATER QUALITY

Water quality will be affected by climate changes in four key areas:

- Higher runoff with greater erosion and transport of pollutants to downstream areas, including coastal waters,
- Reducing the available volume of surface and groundwater to safely absorb waste discharges, additionally lower volume of water may require the mixing of low quality water with good quality water
- The need to use lower quality water over aquifers of good quality
- Reduction of streamflows to keep saline water out of riverbeds below sea-level

Increased rainfall or rainfall of greater intensity will lead to increase runoff and sedimentation of streams and rivers. This increased runoff will also carry pollutants, such as

- agricultural chemicals (nutrients, pesticides),
- sanitary wastes (overflowing individual wastewater systems and animal wastes), and
- pollutants from urban non-point sources (petroleum products, cleaning chemicals, solid waste)

If streamflows are reduced there may not be a sufficient volume of water to dilute inflows from wastewater discharges and pollution from non-point sources.

Groundwater resources would also be more susceptible to pollution and any loss of groundwater resources due to contamination would be more severe since the demand on the remaining sources would be greater increasing competition for the available supply.

Sea level rise most directly impacts water resources by causing increased saline intrusion of coastal aquifers. Intrusion into alluvium aquifers may be moderate and higher in limestone aquifers. The effect of sea level rise will be exacerbated by lower rainfall that reduced the groundwater head (potential).

C. Watersheds

The above-described effects of climate change on water sources, water supply, and water quality primarily reflect changes to watersheds. Thus, the maintenance of watersheds will become increasingly difficult yet increasingly essential under all climate change scenarios.

D. Aquatic Ecosystems

Climate is a direct input to many of the variables and interactions among the elements of the aquatic ecosystem. Climate changes may easily affect the chemical, biological, and physical structure of the ecosystem. Climate change

may affect nearly all the elements of the ecosystem though changes in water flow, sedimentation, and introduction of pollutants with increased upstream surface runoff.

Saline intrusion into rivers and streams as a result of sea level rise is likely under anticipated scenarios. The effect of the saline intrusion is uncertain, as the balance among the critical ecosystem elements will vary from ecosystem to ecosystem. However, it is reasonable to assume that some degree of change to flora and fauna will occur.

E. Economic Relevance

Water is an essential element to economic growth and productivity. Climate change and the resulting effects on water will have impacts on both the micro-economic and non-traditional sectors and the macro-economic, traditional sectors and industry. Some climatic changes will benefit certain sectors of an economy. Rising sea level may benefit the construction industry while being detrimental to others as beach erosion may cause a loss in the tourism industry.

It is not totally misleading to suggest that certain positive benefits may accrue from what may be considered a negative impact. A further example: a change in rainfall associated with temperature rise may allow the introduction of different crops but perhaps at the sacrifice of others. It should be noted that a benefit accrued as a result of climate change to a sector reflects a transfer of benefits and costs rather that the creation of new benefits and costs. The net sum of costs and benefits should be assessed because it is only the true cost due to climate change that should be of interest[16].

F. Water Services

Increased temperature and sea level rise will require more consideration being given to the provision of water to domestic, rural and productive sectors of the country. The increased population and demand for more basic services will place extra stress on the water related infrastructure. Cost recovery for these services need to be improved to meet these growing demands. For large urban centers like the Kingston Metropolitan Area larger water storage facilities will have to be considered.

2.2 Food and nutrition: Agriculture

a. Agriculture

[16] Implications of Climatic Changes in the Wider Caribbean Region Preliminary Conclusions of the Task Team of experts prepared by: George Maul Wider Caribbean Task Team Chairman, CEP Technical Report No 3 1989

Current information with regard to traditional export crops indicate that during 1997/98 the relatively poor performance was due partly to the lingering effects of the drought which began in the last quarter of 1996 and persisted until the third quarter of 1998. This negatively affected production systems of the various traditional export crops in late flowering in coffee and cocoa, a shift in the regular cropping pattern for sugar cane and stunted fruit development for most crops.

The drought or dry spell had less of an impact on non-traditional crops and domestic crop production due in part to the shorter crop cycle and improved weather conditions in the last half of 1998.

There is no indication whether subsistence-farming crops were affected except that productivity generally was considered to be lower and therefore suggests that less farm products were available to supplement family incomes.

Further periods of dry weather would continue to have a major impact on productivity levels of coffee, sugar and bananas the major export earners for Jamaica with the consequent effect on the Balance of Payments.

Within the coastal zone of Jamaica are a number of coastal aquifers and sea level rise will impact water quality in aquifers that have hydrological continuity with the sea.

Loss of agricultural land would not be significant however agricultural activity will be reduced in those areas where saline intrusion affects the water supply.

2.3 Settlement and infrastructure

a. Socio-Economic Considerations

By the year 2025 the population is expected to be 3,245,000 (median estimate). Given the current trends population distribution will continue along the same trends with migration to urban centres in search of employment.

Climate change and sea level rise impacts on domestic agriculture in the rural areas may drive this shift in population settlement.
Demand for water services by the population will place further pressure on already stretched resources of the urban centres and further increase the number of those less able and below the poverty line. Climate change and reduced water supply will have immediate impacts on the poor as the percentage of households sharing “standpipes” in inner city ghettos will increase. Fewer poor households will have access to safe water and pit latrines will be on the increase further impacting groundwater resources.

2.4 Tourism [effects both direct and indirect]

a. Direct

The tourism sector in Jamaica is the largest foreign exchange earner with receipts totaling US$1.196 billion in 1998 which was an increase of 4.9 percent relative to 1997. Tourist stopover arrivals in 1998 totaled 1,898,977 down from the 4.6 percent growth recorded in 1997. This decline occurred although Jamaica became the preferred destination in the wake of considerable damage by Hurricane George to neighbouring islands in the region during 1998. Despite this slowdown Jamaica remained a leading Caribbean destination for cruise tourism.

Jamaica as a tourist destination is well known for sun, sea and sand. It more recently has diversified its tourism product by including nature based Eco-tourism adventures. Eco-tourism is one of the fastest growing sectors of the tourism industry globally. For Jamaica this is reflected in a few small pockets of activity such as Port Antonio and South Coast however its contribution to Jamaica's tourism product is difficult to assess.

Growth in the Jamaican tourism sector will hinge directly on appropriate infrastructure development to ensure availability of safe water, greater emphasis on alternate forms of recreation and the continued development of the popular heritage tourism and Eco-tourism. The economic activities of these activities provide further incentives to protect watersheds and natural resources, which in turn will help to provide for sustainable water resources. Though the tourism sector currently uses approximately one percent of total water demand tourism is the largest contributor to the national economy.

b. Indirect

Jamaica's tourism industry is centred on the beaches, inshore waters and real estate development close to the sea.

Climate change with resulting increase in storm surges, beach erosion, coral reef bleaching sea level rise and saline intrusion in coastal aquifers will have major effects on recreational activities and availability of land. Water is already a concern in areas such as Ocho Rios and Montego Bay where the infrastructure is currently insufficient to meet demand. This situation could very well worsen under the selected climate change scenarios.

Emphasis is being placed on the diversification of the tourism product to include Eco-tourism activities and heritage tourism. Protection of the environment will be an important aspect in developing this product and changes to climate in particular sea level rise may have a detrimental impact on the biodiversity and ecology of these areas.

Inland waterways provide a unique environment to observe first hand the natural beauty of the island and more frequent periods of drought or increased severe events will have damaging consequences.

A reduction in tourism earnings will have a consequent impact on employment and related services such as taxi drivers, restaurants and farmers

2.5 Human health and implications

Population growth into areas with marginal water supply poses increased public health concerns such as water related diseases including those borne by parasites and malnutrition.

The Survey of Living Conditions 1998 identifies the level of malnutrition for children under five. The data for low weight for age indicate a steady decline in malnutrition levels from 1978 to 1989, Although for 1990 to 1992 an upturn of 8 – 9 percent is shown. The indications are that there are also under-nutrition pockets in Jamaica. Within Kingston the problem of under-nutrition is one which displays a definite spatial pattern; there are areas which have been consistently identified as having higher malnutrition levels. The hospital has reported an increase in the percentage of children admitted for malnutrition. Overall the children most at risk from malnutrition were identified as those in living in rural areas[17].

Since there is a direct correlation between diet, water and health, adequate water supply is necessary to maintain cost effective food production. If safe and sufficient water supply is not available this may result in increased stresses on the poorest communities to maintain health.

2.6 Other key concerns

a. Industry

Competing demands for reduced supply of water as a result of climate change could increase the costs of production to industries such as the bauxite and sugar industries. This may reduce the competitive advantage they currently enjoy with regard to cost of production

b. Energy

Hydropower in Jamaica is generated from the natural water head that comes from the flow in the river. Any reduction in flow will result in the reduction of energy production. Although this power is only supplementary to the main grid it

[17] Based on data and discussion in "Human Development and Welfare" chapter of *Economic and Social Survey of Jamaica*.1998. PIOJ. Government of Jamaica. ……

still provides for a small contribution to import substitution and reduction and reliance on fossil fuels.

3. Identification of Priorities

The following matrix, (Table 1) provides a summary of the relative effects of climate change and sea level rise on water resources and the dependent sectors. It attempts to demonstrate graphically the interrelationship and dependency of the various sectors on water resources. Generally climate changes and sea level rise are expected to have moderate to high level impacts on water resources.

Table 1: Impacts Of Climate Change on Water Resources And Dependent Sectors

	Temp Increase	Sea Level Rise	Uncertain Rainfall	Severe Events[18]	General Comments
Water Source					
Ground water	H	M	H	M	
Surface water	H	L	H	H	
Water Supply					
Delivery Infrastructure	H	M	M	M	
Urban	H	L	M	M	
Rural	H	M	H	M	
Water Demand					
Water Utilities	H	L	M	L	
24 hour daily service	H	M	M	L	
Water Quality					
Treatment	H	L	M	L	Microbial
Saline Intrusion	L	H	M	L	
Chemical Pollution	M	M	M	H	
Waste Disposal	M	M	M	H	
Watersheds	H	L	H	H	
Forests	H	L	H	H	
Aquatic Ecosystems	M	M	M	M	Fresh water /mixed
Biodiversity	M	H	M	H	High Uncertainty
Morass	M	H	M	H	
Economic Relevance					
Agriculture	H	H	H	H	
Tourism	M	H	M	H	
Industrial	L	L	L	L	
Energy	M	No	M	L	Hydropower
Socio Economic Considerations					
Urban Drift	H	M	M	M	

[18] Severe events include Hurricanes and other tropical storms, storm surge and flooding

Cost of Water	H	M	M	M	
Poverty	H	L	H	H	
Health	H	M	M	H	
Key					
High Impact	H	Significant change			
Medium Impact	M	Medium change			
Low Impact	L	Low change			
No Impact	No	No change			

4. INSTITUTIONAL AND LEGAL ARRANGEMENTS FOR RESPONDING TO ISSUES

4.1 Allocation of responsibilities

The matrix provided below (Table 2) identifies proposed adaptation measures, together with known information gaps, capacity building requirements, and potential implementation institutions.

Table 2 Matrix of Effective Adaptation Measures for Key Sectors

Sub-Sector	Adaptation Measures	Implementing Institution(s)
Ecosystems and Near-shore areas	• Advanced planning to avoid worst impacts • Assessment of need for modification of land use and implementation of identified land use guidelines • Modification of building styles and codes • Protect threatened ecosystems such as the Black Morass • Strict regulation of hazard zones • Hazard insurance to reinforce regulation • Conditional phased out development in high risk areas • Withdrawal of Government subsidies for development in high risk areas • Resettlement packages	NEPA
Coral Reefs ***Jamaica National Environmental Action Plan JANEAP 1998 Action 23***	• More structured coral reef management • Promote research and monitoring • Monitoring of construction that may contribute to coral reef destruction • Support for coral reef mapping and monitoring programme	NEPA
Reef Resources (fisheries)	• Development of fishery management plan • Exercise greater control over fishing activity • Continued support for NGO's with monitoring programs • Pelagic and Reef Species assessment • Biological and Data collection research programs enhanced • Policies and guidelines related to the collection and export of materials • Fishing gear and net limitations • A fishers education publicity campaign	NEPA
Protected Areas	• Continued support for ecosystem protection • Support for research and environmental monitoring	NEPA

Sub-Sector	Adaptation Measures	Implementing Institution(s)
Improved integrated watershed management *See Watershed Policy for Jamaica and proposed institutional mandates*	• Public education and awareness • Implement integrated watershed management • Promote appropriate agricultural practises • Promote improved soil management practices • Improve crop selection and planting/harvesting practices.	NEPA
Coastal Water Quality	• Regular monitoring of water quality • Develop and implement non-point source (pollution) • Improve wastewater discharge regulation and enforcement.	NEPA
Demand-Side Management – Water Resources		
Reduction of Unaccounted for Water	• Establish Leak detection/repair program	NWC
Promote Domestic Water Conservation	• Low-flow toilets and showers • Household leak repair • Re-use of gray water • Enhanced Education and Awareness Programs	NWC NWC MOH, UWI, SRC NWC, MW&H
Promote Industrial Water Conservation	• Promote re-use of acceptable water quality • Industrial Recycling • Develop Environmental Management System requirements, include market/economic instruments	NWC
Promote Agriculture Use Conservation **National Irrigation Development plan provides specific planning recommendations for this area*	• Night time irrigation • Lining of open channel canals • Use of drip irrigation systems where soil conditions allow • Use of closed pipe systems where feasible • Use of treated wastewater effluent • Better control and management of supply network • Develop Environmental Management System requirements, include market/economic instruments	NIC NIC NIC, MOA NWC MOH NWC,NIC, MOA MOW&H
Supply-Side Management – Water Resources		
Reduction of unaccounted for water	• Establish leak detection/repair program • Improve monitoring and metering	NWC NWC
Improved integrated watershed management *See Watershed Policy for Jamaica and proposed institutional mandates*	• Public education and awareness • Implement integrated watershed management • Promote appropriate agricultural practices • Promote improved soil management practices • Improve crop selection and planting/harvesting practices	NEPA NEPA MOA MOA MOA

Sub-Sector	Adaptation Measures	Implementing Institution(s)
Increase Storage Capacity	• Encourage household water catchments • Encourage farm/estate-based water storage facilities	MOW&H MOW&H; MOA
Development of infrastructure	• Upgrade existing infrastructure • Develop new extraction facilities as geographically appropriate • Investigate dual supply systems • Storage facilities to harness wet season flows particularly in the rural areas • Investigate water intake locations • Artificial recharge • Consider expansion of inter basin transfer • Improve flood control structures to handle more frequent and extreme events	NMC, WRA, MOW&H NWC, WRA NWC, NIC NWC, PC NWC WRA WRA NWA
Information Gaps: Research and Planning Measures		
Meteorological data gaps and inconsistencies	• Improve the availability and interpretation of climate data and services • Further research on climate change and variability • Country-specific modelling of potential climatic change impacts	NMS, UWI
Need for more detailed information on within country regional climate patterns and integration of water resources planning	• Integrate climate information into coastal management planning • Hydrological research • Coastline surveys and monitoring	NMS,WRA WRA
Need for more detailed contour data and vertical land movement	• Additional topographic surveys • Complete digital elevation modelling of existing data	ML&E , Survey Department ML&E
Data Coordination Mechanism	Development of Clearinghouse for water resources information – Common GIS	WRA NEPA
	• Communication linkages between Kingston and rural areas	ODPEM
	• Parish planning for vulnerable areas	ODPEM
	• Collation and analyses of relevant data	

Capacity Building Measures	
National Meteorological Service	Research and forecasting
Natural Environment & Planning Agency	Appropriate legislation and environmental plans
Water Resources Authority	Monitor water resources and detect trends
Office of Disaster Preparedness and Emergency Management	Communication linkages between Kingston and rural areas
Parish Councils	Parish planning for vulnerable areas
Ministry of Agriculture	Collation and analyses of relevant data
Integrated Management and Coordination	Establish technical and management coordination systems

4.2 Legislation and statutory Provisions

Table 3: Relevant Natural Resources Conservation Authority Guidelines and Standards

NRCA Guidance/Standard	Focus
Guidelines for the Development of Benthic Structures	Deals with: artificial reefs, casitas, breakwaters and specialized diving attractions
Guidelines for the Development of Marinas	Deals with the environmental aspects of marinas and small craft harbours
Guidelines for the Deployment of Pipelines and Cables	Offers guidance on the permitting process and the engineering aspects of pipelines and cables in the coastal area
Standards for the Provision of Service and Facilities on Fishing Beaches	See also Towards a Beach Policy for Jamaica Natural Resources Conservation Authority 1997
Standards for the Provision of Service and Facilities on Bathing Beaches	See also Towards a Beach Policy for Jamaica Natural Resources Conservation Authority 1997
Guidelines for the Planning, Construction and Maintenance of Facilities for the Enhancement and Protection of Shorelines	Develops a planning process for protective beaches dealing with long shore transport issues, selection of borrow material, beach slopes, transition structures and feeder beaches
Guidelines for the Planning and Execution of Coastal and Estuarine Dredging Works and Disposal of the Dredged Material	Offers guidance on the permitting process and the engineering and environmental aspects of projects involving capital works dredging and maintenance dredging, with reference to relevant World Bank Technical Papers.

4.2 Other Relevant Institutional Considerations (if any)

(Text to be added)

5. TOWARDS AN ADAPTATION POLICY

5.1 Guiding principles

(TEXT TO BE ADDED)

5.2 Specific options

(TEXT TO BE ADDED)

5.3 Opportunities (if any) and constraints

(TEXT TO BE ADDED)

6. SUMMARY AND CONCLUSIONS

Based on review of baseline conditions, existing economic activities, existing institutional arrangements, expected population growth and, economic development proposed adaptation measures have been developed. It is important that all adaptation measures to be adopted must take into account cross-sectoral relationships and the integrated nature of the environment. Adaptation measures also must consider the social and economic implications of marginal communities

Planning and implementation of the adaptation measures for improving water supply and water quality is a necessary component of sustainable economic development and socio-economic well being of Jamaica regardless of the presence or absence of climate change or sea level rise. Adaptation measures for climate change are consistent with those for watershed management, water resources management and overall environmental management. Specifically, current and planned implementation of the following plans and programs will be major steps toward implementation of adaptation measures for potential climate change.

- Jamaica Water Sector Policy Paper – 28 January 1999
- Jamaica National Environmental Action Plan, JANEAP, October 1998
- Toward a Watershed Policy for Jamaica, Green Paper No. 2/1999
- National Irrigation Management Plan
- Draft National Forest Management and Conservation Plan
- DRAFT Handbook for Development in the Coastal Zone of Jamaica
- Existing water conservation under NWC
- Soil management programs for Ministry of Agriculture
- SIRI Research programs for improved sugar cane yield
- UWI Climate Change and Weather Research Programs

7. GLOSSARY

ENSO.....El Niño Southern Oscillation
MOA.....Ministry of Agriculture
MOH.....Ministry of Health
ML&E.....Ministry of Land & Environment
MW&H.....Ministry of Water & Housing
NEPA.....National Environment & Planning Agency
NIC.....National Irrigation Commission
NMS.....National Meteorological Service
NWC.....National Water Commission
ODPEM.....Office of Disaster Preparedness & Emergency Management
SRC.....Scientific Research Council
UWI.....University of the West Indies, Mona Campus
WRA.....Water Resources Authority