NATIONAL ADAPTATION STRATEGY

TO ADDRESS CLIMATE CHANGE IN THE WATER SECTOR IN BELIZE

STRATEGY AND ACTION PLAN

Prepared for the

Caribbean Community Climate Change Centre

Belmopan, Belize

by the
Belize Enterprise for Sustainable Technology (BEST)
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MARCH 2009

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LIST OF ACRONYMS

BAHA	Belize Agricultural Health Authority
BAPPA	Belize Association of Private Protected Areas
BELPO	Belize Environmental Law and Policy Organization
BELTRAIDE	Belize Trade and Investment Development
BEST	Belize Enterprise for Sustainable Technology
BWSL	Belize Water Services Limited
CCCCC	Caribbean Community Climate Change Centre
DOE	Department of the Environment
ENSO	El Nino/Southern Oscillation
FAO	Food and Agricultural Organization
FY	Fiscal/Financial Year
GCM	General Circulation Model
GDP	Gross Domestic Product
GOB	Government of Belize
HEP	Hydro-Electric Power
IWCAM	Integrating Watershed and Coastal Area Management
LSMS	Living Standards and Measurement Survey
MACC	Mainstreaming Adaptation to Climate Change Project
MAF	Ministry of Agriculture and Fisheries
MDG	Millennium Development Goals
NMS	National Meteorological Service
MNRE	Ministry of Natural Resources and the Environment
NAVCO	National Association of Village Councils
NEAC	National Environmental Appraisal Committee
NCEP	National Centre for Environmental Prediction
NAS	National Adaptation Strategy
PAHO	Pan American Health Organization
PRECIS	Providing Regional Climates for Impact Studies
PUC	Public Utilities Commission
RCM	Regional Climate Model
RWS	Rudimentary Water System
SAP	Strategy and Action Plan
SDSM	Statistical Downscaling Model
SIB	Statistical Institute of Belize
SRES	Special Report Emissions Scenarios
SST	Sea Surface Temperature
TOR	Terms of Reference
UB	University of Belize
UNDP	United Nations Development Programme
UN	United Nations

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EXECUTIVE SUMMARY

The Government of Belize, with support from the Mainstreaming Adaptation to Climate Change Project [MACC] executed by the Caribbean Community Climate Change Centre [CCCCC], has undertaken the preparation of a National Adaptation Strategy to Address Climate Change in the Water Sector Belize. This National Adaptation Strategy, (NAS,) was prepared by the Belize Enterprise for Sustainable Technology [BEST] team of consultants.

Primary and secondary research was conducted, the data analyzed and findings reported. Recommendations were distilled from the findings and presented in this paper as the Adaptation Strategy and Action Plan.

Belize's development will be economically impacted by deleterious effects upon the water sector. Temperature rise, changes in precipitation leading to floods and drought, sea level rise causing saline intrusion, biodiversity stress will affect the economy, due to increased water acquisition and processing costs. Reduced availability of freshwater will result in increased procurement and distribution costs.

The demand for water resources in Belize emanates from three (3) broad sources: agricultural, industrial and domestic/residential purposes. In 2005 agriculture, industrial and domestic /residential users required 43.7%, 36.5% and 19.7% of total demand, respectively.

Five key adaptation actions are presented and these include the establishment an agency to execute integrated water resources management; strengthening the existing institutional and human resources capacities in the water sector for improved management practice, formalizing the legal mandate and operations of the National Climate Change Committee, strengthening the trans-boundary relationships to cover the impacts of climate change on the water sector and increasing public awareness and education in water culture and climate change.

Implementation of this Strategy and Action Plan is estimated to cost BZ$ 4.5 over a five year period. The financing is projected to come from a combination of domestic and international resources. The successful implementation of the Action Plan will require effective trans-boundary cooperation between Belize, Mexico and Guatemala.

1. ADAPTATION STRATEGY AND ACTION PLAN

1.1 INTRODUCTION/BACKGROUND

The National Climate Change Committee, in 2008 prepared a "**Government of Belize Policy on Adaptation to Global Climate Change**" in order to address the predicted changes and impact. The National Pro Tempore Water Commission also prepared the Water Resources Management Bill in that year based on initial attempts at drafting water policy. The Caribbean Community Climate Change Center (CCCCC) assisted in a revision and drafting of a National Water Policy to include considerations of Climate Change. This water policy was formalized and accepted by the National Pro Tempore Water Commission[1] and is awaiting Cabinet adoption.

The Government of Belize recognizes that Climate Change poses threats to the water sector that are not being appropriately addressed. As the population grows and the virgin areas are invaded, Belize's water sector becomes more vulnerable. Such vulnerabilities may be exacerbated by the pressures and potential impact of climate change.

Looking at the Caribbean, the percentage of days with minima or maxima warm temperature has been increased since the 1950s, while the percentage of days with cooler temperatures has decreased[2]. Climate change is projected by the mid-century to reduce water resources in the Caribbean to the point where they become insufficient to meet demand during low rainfall periods[3]. Analyses conducted for a pilot study on Water Resources Vulnerability and Capacity Assessment in the North Stann Creek Watershed[4] and this project using climate projections based on A2, B2 Scenarios[5] provided by the Cuban Meteorological Institute indicate that annually there will be a decrease in runoff in the pilot study area and for all hydrological regions in Belize during the time period 2010 -2100.

A recent study of current climatic trends for Belize conducted by Gonguez revealed that the climate of Belize has changed in a way that is consistent with the observed changes globally and in the Caribbean region. The frequency of warm days and nights has also increased and the frequency of cool days and nights have declined. The higher night-time temperature was the largest contributor to the overall increase in average temperature value. The rate of increase of night-time temperatures was larger than those for day-time temperatures.

The reviews and analyses conducted through this study seeks to promulgate a water policy and to determine the nature of existing water legislations, discover overlaps and gaps as well as an examine water management responsibilities. The efficient and effective management of Belize's water resources is the desired objective that may require strengthened policy, integrated legislation, more capacity and better coordination among the institutions that manage water resources. Belize faces changes arising from climate change and the country has to ensure that water resources issues are appropriately recognized and form the basis for strategy development and a good plan of action.

1 The legal term for the National Pro Tempore Water Commission expired in 2007

2 Climate Change and Water-IPCC Technical Paper VI, June 2008

3 Summary for Policymakers - Climate Change 2007:Impacts, Adaptation and Vulnerability Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report

4 Water Resources Vulnerability and Capacity Assessment in the North Stann Creek Watershed was CCCCC/MACC funded project

5 PRECIS

This Strategy and Action Plan is founded on the full understanding of the current and projected threats and the resultant impacts of climate variability and change. The implementation of this National Adaptation Strategy and Action Plan will reduce Belize's water resources vulnerability the adverse impacts of climate change and at the same time meet Belize's obligations under the Millennium Development Goals[6]. This report also includes the draft water policy report as an annex to the Policy and Legislation component.

The report presents strategies for response in the three (3) key focal areas – scientific applications, governance/administration and the economic considerations.

2. METHODOLOGY

The Water Sector for the purposes of this consultancy is defined to be **"all the freshwater resources of Belize"**.

This Strategy and Action Plan (SAP) is guided by the thematic areas of temperature rise leading to sea level rise, increasing variability in intensity of precipitation as well as changing precipitation patterns. As contained in the Terms of Reference, this report closely follows the content and logical order of the deliverables section of the TOR.

The design of this Adaptation Strategy and Action Plan required and involves reviews, analysis, and evaluation leading to preparation of a summary report that is a situational analysis. Historical data leads up to the current position. This baseline was prepared by using the key variables of climate change including temperature and precipitation (See Annex I). Primary and secondary sources assisted in the review of the governance - the policies, legislation and institutions (See Annex II & III). Finally, an economic review of water was conducted and reported upon (See Annex IV).

Baseline climate conditions were established using observed climate conditions for two (2) representative stations in three (3) major hydrological regions of Belize. Projections provided by the Cuban Meteorological Institute were applied to the established baselines to ascertain the future climate conditions. Simulations were then used to determine the topical areas around which the adaptation strategy would be built.

Examination of the Water Sector was conducted to ascertain policy, legislative backing, institutions, legal authorities and relevant responsibilities. An economic study was then applied to a zone for key statistics applicable countrywide.

The Adaptation Strategy and Action Plan based its examination and design on a SWOT model that considers the strengths, weaknesses, opportunities and threats, gap analysis to determine insufficiencies in capacity of the water sector. It is constructed based on Climate Change threats and predicted impacts.

The Adaptation Strategy outlines the direct response to the adverse impacts of climate change. The Action Plan identifies the events and activities for intervention; indicates the responsible parties and spells out the timelines for implementation. This course of action will then prepare Belize for adaptation to climate change during the term horizons from the 2015s through to the 2080's[7].

6 "Millennium Development Goals- First Report BELIZE", Belmopan, July 2005

7 Projections were generated from outputs from the regional climate model providing Regional Climates for Impact Studies (PRECIS) using the ECHAM model and the HadCM3 as the driving global models. The A2 and B2 scenarios were used to describe

3. THE RELATIONSHIP BETWEEN THE ECONOMY AND WATER

Belize used around 579 Million m^3 (15.3 billion gallons) of water in 2007. The demand for fresh water resources in Belize emanates from three (3) broad economic sub-sectors: agricultural, industrial and domestic/residential. In 2005[8] agriculture, industrial and domestic /residential users required 43.7%, 36.5% and 19.7% respectively of the total demand. Belize's use is consistent with those of other countries in the region that show a greater economical demand for water by the agricultural and industrial sectors.

Table 1. Water Demand in Belize[9]

Economic Sub-Sector	Demand	%GDP	Comment
Agriculture/Industrial	>80%	30%	Agriculture is mostly rain-fed
Domestic/Residential including Tourism	<20%	60%	Piped public supply and utility supplied

Belize has 39 identifiable watersheds of which 18 are classified as major watersheds. Swamps cover 13.4 percent of mainland Belize and 29 lagoons (inland water bodies) have been identified. Wetlands and lagoons form the coastal transition/buffer zones between the freshwater supplied by the watersheds and the marine environment. The transition zones provide the environment for abundant mangrove stands that filter the runoff before it enters the marine ecosystems. The mangrove ecosystem provides excellent habitat for fish nurseries. In addition, the filtering functioning of the eco-system reduces the volume of sediments that eventually reaches the barrier reef.

Changes in freshwater inflows into the sea will lead to changes in the physical (turbidity), chemical (salinity, nutrient loads) and biological (flora and fauna) characteristics of water -- all of which affect estuarine and coastal ecosystems and may threaten extinction or migration of species to better habitats.

The coastal and marine ecosystems are very important to Belize's economy. The Belize Barrier Reef is one of the main attractions for tourists visiting Belize. It accounts for 22% of visitations. It is estimated that in a year 13,981 Belizeans[10] are employed in the tourism industry. The marine fishing industry provides employment for more that 6,000[11] fisher folk. In 2006 tourism contributed 16.8 % and the fishing industry 3.1%[12] of Belize's GDP respectively.

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what the world will be in the future. A2 represents a heterogeneous world, with self-reliance and preserved local identities, high population growth, regionally oriented economic growth and fragmented economic and technological development. B2 represents a divergent world with emphasis on local solutions to economic, social and environmental sustainability, moderate population growth, intermediate levels of economic growth and less rapid technological change.

8 Abstract of Statistics, Central Statistical Office of Belize, 2005

9 "Statistics of Belize-2008", Statistics Institute of Belize

10 www.belizetourism.org/belizetourism/tourism-revenues.html

11 Abstract of Statistics, Central Statistical Office of Belize, 2005

12 Statistical Institute of Belize

4. GUIDING PRINCIPLES OF ADAPTATION STRATEGY AND ACTION PLAN

The impacts of Climate Change on the water resources of the country as defined in the scenarios have required the preparation of an National Adaptation Strategy and Action Plan to ensure that Belize has the capacity to conserve and efficiently use this most critical resource. Additionally, the adverse effects of climate change require the following fundamental water resources principles be integrated into the strategy:

- Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment;
- Access to safe drinking water is a fundamental right of all Belizeans;
- Water basins and their linkages to the marine environment are the basic functional units for achieving Integrated Water Resources Management (IWRM);
- Integrated Water Resources Management (IWRM) is paramount to the socio-economic development of Belize;
- Water resources are vested in the state and require stewardship;
- Users and polluters should pay;

Preparation of a strategic document for water means that an underlying philosophical basis must first be delineated. This delineation allowed alignment with internal and external efforts and provided good definition. Water is a major component of food and energy production and directly underpins economic, social and national securities. Belize has a particular water security concern because the potable water supply for more than fifty percent of the population originates in neighboring countries.[13]

5. THE ENABLING ENVIRONMENT

In drafting the Strategy and Action Plan, focus was brought to the various needs in strategic planning for adaptation to Climate Change. Central to the strategy's success are materiality, coherency and comprehensiveness. Integration and completeness are desired outcomes within a time frame and have to be applied, in order to achieve connection between current and future efforts, particularly policy, legislation and institutional will. The responses for adaptation to climate change have to be appropriate and possible as well as incorporate sustainability in the long term.

Water can become a scarce especially in localized areas. Scarcity of this resource will lead to conflict. The nature of conflict will have to be understood and appropriate conflict resolution mechanisms put into place. Communication with stakeholders is required from the outset for those sub-sectors of the economy that are directly affected such as: food producers and processors, manufacturers, the Belizean people and their visitors. Belize is a young nation and

[13] Belize shares five major watersheds with Mexico and Guatemala. Importantly when considering real basins (including Guatemala and Mexico), 31% of the Rio Hondo basin lies in Guatemala and 50.5% lies in south-eastern Mexico. 30.6% of the Belize River lies in Guatemala. The majority (91.2%) of the Sarstoon river watershed lies in Guatemala. The Moho and the Temash rivers have (31.6%) and (24.2%) respectively, of their watersheds in Guatemala. The potable water supply for Benque Viejo Town and Belize City and all the communities along the Belize River originate in Guatemala.

suffers from limited institutional capacity and limited governance, financial and administrative resources.

The body of policies, legislation and institutions of Belize are in varying stages of development. An integrated water policy is in draft form and portions of the required legislation have been enacted. Although there are various water management institutions in existence, the country lacks the complete range and integrated responses required for adaptation to climate change.

6. RECOMMENDATIONS

The initial strategy and action plan (SAP) was presented to a Stakeholders Workshop on December 23rd, 2008. Based on the comments from the stakeholders, the strategy and action plan was revised. The interventions outlined in the SAP are ranked in descending order of importance, given the current situation in Belize. The ranking took into consideration the technical nature of the threats and the current and projected impacts. An indicative costing was then prepared for each action.

The current administration of the Government of Belize is in its first year of a five-year term of office and it is more likely that it can be persuaded to incorporate this SAP into government policy. Also, the country has been able to attract reasonable levels of technical and financial support from bilateral and regional programs for climate change adaptation.

It was with these considerations in mind that the consulting team designed the implementation schedule to take advantage of this reality and ensure that the major commitments for policy change would be done in the next ten (10) years or between 2009 and 2019.

The Government of Belize is a primary player needs to act on each of these recommendations to ensure that the framework for implementation of integrated water management is more effective and efficient. There is scope for the full participation of community and civil society organizations, particularly those key public and private sector organizations charged with the responsibility for policy development and regulation. These actions will ensure that users of this resource can be assured of a sustained quantity and quality of water over the foreseeable future. Commitment will be require ownership and mobilization of all required resources.

These interventions will be executed over a ten [10] year time frame, beginning in 2009 with its completion slated for 2018. This schedule can begin at any point but at the pace at which the commitment needs to be built and the resources need to mobilized, this period seems to be appropriate.

6.1 Actions

The adaptation actions are as follows:

ACTION 1*:*

Establish an agency to execute integrated water resources management.

Given the fractured administration, gaps and the limited coordination among the institutions that manage water resources, the threats to the water sector by climate change are not being appropriately addressed. Belize's water sector is becoming more vulnerable to natural and anthropogenic pressures the potential impacts of climate change will exacerbate such vulnerabilities. The reviews and analyses have established that there is need to overcome fragmentation, overlaps and fill gaps in water legislations and management responsibilities to ensure the coordinated, efficient and effective management of Belize's water resources.

The Government of Belize is fairly advanced in the process required to adopt a national integrated water policy. Cabinet's adoption of this policy and the drafting of enabling legislation will authorize the establishment of a water agency with responsibility to manage water resources in an integrated and comprehensive manner. The Draft Water Policy includes climate change and any legislation passed should adhere and reflect this policy based approach. It is expected that the policy and legislation should be in effect by the end of calendar year 2009.

ACTION 2*:*

Strengthen the existing human resource capabilities and capacities in the water sector for improved management practice.

The National Meteorological Service and other technical agencies supporting water administration and management are operating with human resources levels below the required capacity for normal operations. The technical expertise and level of staffing of these institutions and organizations need upgrading and expansion. As a consequence, the state of meteorological and hydrological information could be described as fragmented and discontinuous. Information on basin characteristics is not current and in some cases, is unavailable. Very little water quality information is available and the reliability of the various laboratories that provide data is questionable with regards to quality assurance and thus results.

The following areas require strengthening to meet strategic imperatives:

- monitoring networks need to be expanded
- water inventory and standards of quality established,
- a national water plan should be prepared and implemented,
- laboratory resources need to be brought together to create a national water quality laboratory.

ACTION 3:

Formalize the legal mandate and operations of the National Climate Change Committee.

The National Climate Change Committee is currently a multi-sectoral committee that deals with climate change issues. This committee functions on an ad-hoc basis and does not address economic and water conservation issues comprehensively.

Re-activating this committee and providing it with a legal mandate will facilitate the mainstreaming of climate change issues, including the water sector, into the national planning and financial processes.

The responsibility for this mainstreaming is identified as one of the functions of the Government of Belize and National Climate Change Committee should be provided with the financial resources to carry out this task.

ACTION 4*:*

Strengthen the trans-boundary relationships to cover the impacts of climate change on the water sector.

Belize shares five (5) watersheds and an unknown quantity of aquifers with Mexico and Guatemala. The two (2) largest watersheds are the Rio Hondo in the north and the Mopan branch of the Belize River. These watersheds supply the majority of potable and agriculture water demands in Belize. There are existing agreements between Mexico and Belize to resolve border issues; however, cooperation in water resources management is only in its formative stages. Belize does not have any water resources agreement with Guatemala concerning the flows in the Mopan Branch of the Belize River, one of the two major co-joining sources of the Belize River.

Available water is not projected to decrease significantly in the northern region (Rio Hondo) but decreases are expected in the western and central regions of the country. Changes in available water will be minor on the eastern slopes of the Maya Mountains. Available potable and irrigation water from groundwater sources is projected to decrease as a result of a projected variability, intense vs. sparse, in rainfall and percolation to the aquifers. Agricultural activities and sewerage disposal have negatively impacted the quality of both surface and groundwater resources on both sides of the borders posing potential water situations between Belize, Guatemala and Mexico.

The strengthening of the linkages between Belize and Mexico and the establishment of similar linkages with Guatemala will identify areas of cooperation that can lead to the reduction in the degradation of the quality of water supplies, thus reducing the water sector vulnerability. Bilateral cooperation in the monitoring of the five watersheds will ensure that common protocols

are observed. This will improve the utility and reliability of the collected information for the preparation of watershed plans that will incorporate current and projected climate change issues.

This action will require the bilateral coordination and cooperation of between the ministries of Foreign Affairs and Natural Resources and the counterpart ministries of the other two countries.

ACTION 5*:*

Increase public awareness and education on water culture and climate change.

Water resources management policies, plans, legislations, and institutions have less meaning if the citizens do not understand their implications. The development of an effective, well managed public awareness and education campaign about water resources and the land should lead to a greater appreciation of the need to protect and conserve Belize's water resources.

Table 2 - ACTION PLAN (2009 – 2018)

ACTION	ACTIVITIES	RESPONSIBLE INSTITUTIONS	TIMELINE (YEAR)									
			09	10	11	12	13	14	15	16	17	18
1. Establish an agency to execute integrated water resources management.	▪ Prepare Cabinet Paper which details the operational framework for the new agency.	MNRE/NMS	X									
	▪ Establish an interim advisory and oversight body for integrated water resources management.	Cabinet/MNRE	X	X								
	▪ Develop procedures, systems and models for Implementation of watershed management including disaster responses.	MNRE/NEMO	X	X								
	▪ Establish a dedicated administrative secretariat with appropriate human and material resources.	MNRE		X	X							
	▪ Maintain appropriate level of operations of new water resources agency.	MNRE/New Water Agency			X	X	X	X	X	X	X	X
	▪ Identify sources of revenue and financing to sustain the agency.	MNRE	X	X	X	X	X	X	X	X	X	X
2. Strengthen the existing human resources capacities in the water sector for improved management practice.	▪ Conduct a detailed assessment of the resource needs of key agencies working in the water sector.	MNRE, MoF and Pub. Service	X	X								
	▪ Campaign for international technical assistance and cooperation support for deployment into the initial national response.	MNRE, MFA and MND	X	X	X	X	X	X	X	X	X	X
	▪ Develop protocols for coordination and cooperation between and among public sector agencies.	MNRE/New Water Agency	X	X	X	X						
	▪ Develop and maintain a focused program for technical and scientific improvements in the water sector.	MNRE/New Water Agency	X	X	X	X						
	▪ Amalgamate public sector laboratory resources for improved water quality determination, monitoring and research.	MNRE/MET-Hydro	X	X	X	X						
	▪ Promote regular public disclosure and sharing of key research findings with national and regional organizations.	Cabinet/MNRE	X	X	X	X	X	X	X	X	X	X

3. Formalize the legal mandate and the operations of the National Climate Change Committee.	▪ Broaden the mandate of the National Climate Change Committee to include economic and financial responses.	MNRE/CCCCC	X	X								
	▪ Report NCCC proceedings to appropriate ministries involved in national planning and programme execution.	MNRE		X	X	X	X	X	X	X	X	X
	▪ Incorporate into national planning processes Climate Change as a cross cutting theme.	MNRE/New Water Agency	X	X	X							
	▪ Institutionalize and nationally socialize water conservation.	New Water Agency		X	X	X	X	X	X	X	X	X
	▪ Periodically review and revise tariff structures to influence more efficient use.	PUC, BWSL , MRD	X		X		X		X		X	
	▪ Improve national water supply and use planning especially for potable water and irrigation. Facilitate efficient use of water.	PUC, BWSL , MRD, MAF		X	X	X	X	X	X	X	X	X
4. Strengthen the trans-boundary relationships to cover the impacts of climate on the water sector.	▪ Review and consolidate the trans-boundary relationships in light of the impact of climate change.	National Climate Change Committee, New Water Agency, MoFA,	X	X								
	▪ Advocate for improvement in capacity for adaptation to climate change in trans-boundary areas and at the official level.	National Met Service, MNRE	X	X	X		X		X	X		
	▪ Sustain trans-boundary collaboration for water issues in the technical and scientific, governance and economic areas.	New Water Agency, MoFA	X	X	X	X	X	X	X	X		
	▪ Establish, review and upgrade the conflict resolution mechanisms.	New Water Agency, MoFA	X	X								

5. Increase public awareness and education on water culture and climate change.	▪ Incorporate integrated water resource management into formal and informal educational systems.	MNRE, MRD, New Water Agency		X	X	X	X	X	X	X		
	▪ Develop popular education models which incorporate water sector and climate change issues.	New Water Agency		X	X	X	X	X	X	X		
	▪ Design and develop a national public awareness and education campaign.	New Water Agency		X	X	X	X	X	X	X		
	▪ Implement the national multi-media public awareness and education campaign.	New Water Agency		X	X	X						
	▪ Build support with community, civil society organizations to broaden the national awareness and education campaign.	MNRE, New Water Agency, CBOs, Civil Society		X	X	X	X					
	▪ Build a framework for sustaining the achievements of the campaign.	Public, Private and Civil Sectors		X	X	X	X					

7. FINANCING THE STRATEGY AND ACTION PLAN

The Government of Belize will be required to provide significant new resources to implement this Strategy and Action Plan. An indicative budget for the first five years has been prepared to a total of BZ$4,516,000.00 (Table 3).

The assumption is that the level of international support that Belize has attracted for projects and programmes in the water sector will be maintained. It is also assumed that over time, these activities will be financed from user fees, royalties and licenses that the new water agency will be able to generate from its regulatory functions.

TABLE 3: Indicative Budget for the Strategy and Action Plan

Action	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
1. Establish an agency to execute integrated water resources management	500,000	325,000	325,000	325,000	325,000
2. **Strengthen the existing Human Resources capacities in the water sector for improved management practice**	572,000	572,000	388,000	312,000	272,000
3. **Formalize the legal mandate and the operations of the National Climate Change Committee**	50,000	25,000	25,000	25,000	25,000
4. **Strengthen the trans-boundary relationships to cover the impacts of climate on the water sector**	28,000	28,000	28,000	28,000	28,000
5. **Increase public awareness and education on water culture and climate change**	70,000	70,000	60,000	60,000	50,000
TOTAL ($BZE)	$1,220,000	$1,020,000	$826,000	$750,000	$700,000

Budget Notes:

1) Hydrology Unit Year 1 budget will include the procurement of furniture and equipment and therefore capital allocations will be the highest of the five years.

2) The capacity strengthening programme includes the training of three hydrologists, two at the Bachelor's level and one at the Master's level. The programme also includes in-country short term training for all staff in areas such as administrations project management and integrated water resource management.

3) The budget provides for the hiring of a legal consultant to formalize the terms of reference of the new agency and legal mandate of the National Climate Change Committee provides for quarterly meetings of the committee per year.

4) The assumption is that there will be two trans-boundary meetings per year with each country.

5) The budget allocation provides for initial investment in public awareness campaign materials and the promotion of the materials widely in local multimedia outlets. Extensive advantage will be taken of publicity.

8. CONCLUSION

The impacts of Climate Change show that there are going to be challenges to Belize's capacity to respond. The technical review has reported that temperature rise and related changes of variation in precipitation regimes, sea level rise are already recorded. The upward trend is for the occurrence of hotter days and warmer nights. Climate Change is here and Belize must be prepared and the lead off comes in the form of development of this Water Sector Adaptation Strategy to Climate Change in the Water Sector of Belize.

The Strategy and Action Plan (SAP) points to critical areas of needing further development and strength. These areas have to be pursued if the country is to sustain its abundant supply and preserve a sufficiently high quality of water for all users.

The technical review has recorded data to show that Belize is already experiencing increased temperatures during the day and warmer nights. The more recent storms have been more intense and the rainfall high leading to floods. Sea level rise has not been documented although anecdotal reports have been noted.

Reviews of policy, legislation and the institutions, has demonstrated the gaps that exist in the management of this critical resource. A single agency for water resources management does not exist and one is strongly proposed along with a re-vitalized Water Commission. The Climate Change Committee needs to be fortified and

The economic review has also pointed out how vulnerable some aspects of the nation's economy to the impacts from Climate Change.

The implementation of the Strategy and Action Plan (SAP) will require a concerted effort by all the stakeholders from both the private and public sectors. It will also require effective trans-boundary cooperation between Belize and Guatemala, to the west and Mexico to the north. Similarly, the financing of the Strategy and Action Plan (SAP) will require the mobilization of national, bilateral and international resources.

Success will only occur if the country is able to establish the mechanisms, align the forces for mitigation of impact and summon the political will required to implement the global commitments which have to be made for the integration of Climate Change into Belize's national development programmes.

NATIONAL ADAPTATION STRATEGY

TO ADDRESS CLIMATE CHANGE IN THE WATER SECTOR IN BELIZE

STRATEGY AND ACTION PLAN

(TECHNICAL REVIEW OF CLIMATE CHANGE ISSUES AND THREATS FACING THE WATER SECTOR)

Prepared for the

Caribbean Community Climate Change Centre

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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 Belize, the Caribbean Community Climate Change Centre or the World Bank.

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EXECUTIVE SUMMARY

The technical review addresses climate change issues and threats related to freshwater resources in Belize. The quality and quantity of water supplies will likely be an important issue in the future, as vulnerability increases due to global warming. The methodology employed in this study focuses on 1) analysis of current and projected trends in temperatures and precipitation 2) analysis of extreme precipitation events 3) statistical analysis of past storms and impacts 4) trends in previous flood and drought events and their impacts 5) impacts on economic sectors such as: agriculture and food security, hydroelectric power generation and tourism.

Analysis of historical and current climatic data for two observing stations in Belize's major watersheds revealed that temperatures have risen by about 1 degree during the past four decades. Projections generated from outputs from the regional climate model Providing Regional Climates for Impact Studies (PRECIS) suggested that temperatures will continue to rise with the greatest warming occurring during September to November for all time horizons selected.

In the case of precipitation, analysis of extreme precipitation indices for six stations indicated small changes in precipitation patterns. These changes also varied among stations analyzed within the watersheds. Projected precipitation for the period 2015s suggested that Libertad and Philip Goldson International Airport in Region 7 and 9, respectively, average rainfall amounts will increase by 4 percent. Melinda has an increase of 17 percent. The other periods indicated a decline in rainfall in mean rainfall. For seasonal rainfall, December to February show an overall decline in rainfall. March to May showed a tendency for increase in rainfall. June to August showed a decrease in precipitation. September to November precipitation suggested that with the exception of 2015s, the tendency was for precipitation to decrease.

Evidence has shown that extreme rainfall events from tropical systems have led to flooding that consequently affect water availability and quality. On the other hand, heat waves and prolonged dry season have resulted in drought which in turn led to changes in surface and groundwater level. These extreme events have affected many livelihoods and economic activities in Belize.

Understanding current risks and impacts will certainly assist policy makers to deal with future risks and impacts of a changing climate. It is important to note that the adaptation policies must take into account the full range of impacts.

Even though a narrow set of economic impacts were considered in this study, other important impacts such as causalities, illness and loss of cultural heritage as well as loss of attractiveness of the towns and cities are also important considerations.

1. TECHNICAL REVIEW OF CLIMATE CHANGE ISSUES AND THREATS

1.1. DEFINING THE PROBLEM

Climate variability is a reality, which is experienced, globally, and results in changes to seasonal weather patterns and extremes. The long term phenomenon of climate change will exacerbate effects of climate variability and is considerably less predictable. Climate change is expected to intensify the global hydrological cycle and will have major impacts on water resources. A change in the volume and distribution of water will have an effect on both the ground and surface water supply used by freshwater ecosystems, irrigation systems, domestic and industrial users.

It is believed that Belize has an abundant supply of fresh and ground water. An increase in population, economic and agricultural activity has increased demand for freshwater and is threatening the quality and availability of freshwater in Belize (First National Communication, 2001).

A critical step in adapting to the adverse effects of climate variability and change is assessing the impacts of climate change on systems. Recently, there have been concerns about possible future climate change and its effects on water resources, future water demands and socio-economic development. This requires detailed impact and adaptation analyses as input to a broader climate change vulnerability and adaptation assessment.

This study represents an initial approach to quantify some of the key factors and give some preliminary recommendations related to the water resource sectors. It is meant to inform policy and decision makers and put a focus on the issues of climate change and management of water resources, as it relates to future development of Belize.

1.2. GOALS OF THE REVIEW

- Identify current climate change issues and threats
- Analyze impacts facing the water sector
- Prioritize climate change impacts and threats to Belize

The following activities will be conducted:

i. An analysis of historic and current climate data to understand current climate change issues and threats.
ii. Construction of climate change scenarios.

iii. Identification and estimation of the possible impacts of climate change on the water resources sector.

2. BELIZE WATERSHEDS

Belize is situated on the Caribbean coast of Central America with Mexico to the north and Guatemala to the west and south. It lies between 15º45´ and 18º30´ north latitude and 87º30´ and 89º15´west longitude. Total national territory covers 46,620 square kilometres, which includes 22,960 km^2 (8,867 $miles^2$) of land and 1,060 cays.

Belize has been uniquely endowed with substantial surface and ground water resources and has a total of 18 major river catchments with another 16 sub-catchments, which drain the Maya Mountains and discharge into the Caribbean Sea (Figure 1). Boles (1999) identifies 16 principal watersheds that were grouped into six main watershed regions based on general characteristics of topography, geology, soils, rainfall and land use. He defines a watershed region as a cluster of watersheds that share many structural, climatic and often impact characteristics. The watershed regions include: the Northern Watershed Region, the Northeastern, the Central, the Southeastern, the Southwestern and the Southern Watershed Region. Additionally, numerous freshwater and brackish water lakes or lagoons are scattered in the central and northern coastal and inland low-lying areas (National Meteorological and Hydrological Service).

Belize's water resource is vital for its economy. It provides domestic and industrial users with water supply and is the source of the country's hydropower. The total volume of freshwater available per capita in Belize in 1995 was 80.8 thousand cubic meters, the highest in Latin America (CCAD, 1998; Belize First National Communications COP/UNFCCC, 2000).

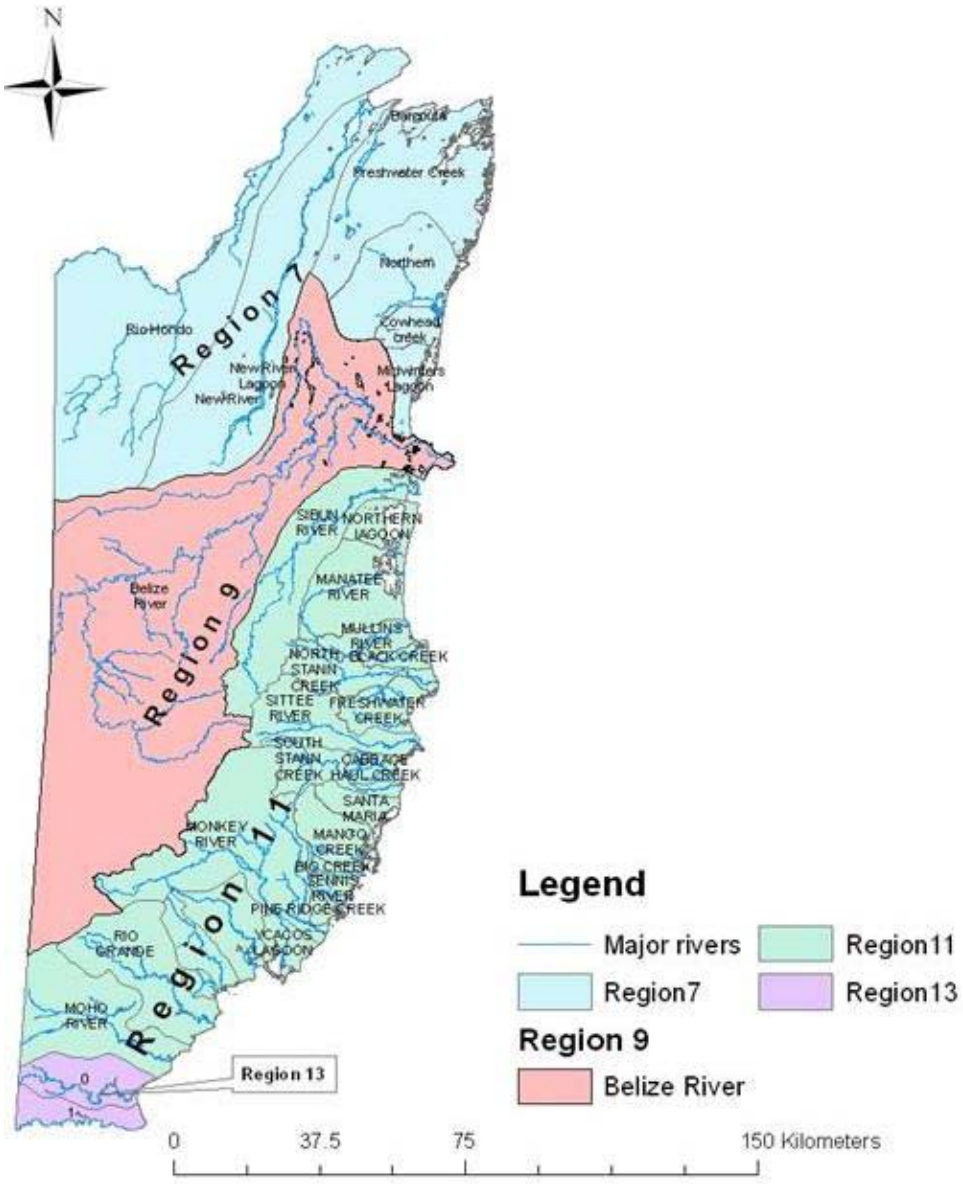


Figure 1 - Belize Hydrological Regions

2.1. DATA METHODS AND SCENARIOS

To identify current climate change issues and threats, analyses of climatic data records were conducted to identify changes in climate parameters pertinent to the water sector. However, adequate stream flow data were unavailable to evaluate impacts (Williams, 2008).

To identify future temperature and precipitation changes, 8 rainfall stations were used that covered the reference or baseline period 1971-2000. These stations represented watersheds in Regions 7, 9 and 11. No data were available for Region 13 watershed (Table 1). For the analyses of temperatures, two stations were used Philip Goldson International Airport station representing coastal areas, and Central Farm representing inland parts of the country.

Stations selected are representative of the main watershed regions and selection is dependent on the following:

- Quality of historical data
- There must be at least 20 years in a record to obtain reliable statistics
- Stations must be permanent and therefore can be updated.

Return periods were calculated for tropical storm and different categories of hurricane that came within 75 nautical miles of Belize. Extreme rainfall events (Table 2) were analyzed using seven extreme rainfall indices for Philip Goldson International Airport and Central Farm.

Climate change impacts require information on how climate is expected to change in the future. This involves the development of scenarios or storylines of the future which involves construction climate change projection for short term, medium term and long term time horizons. These time horizons will be 2015s, 2030s, 2050s and 2080s.

Projections were generated from outputs from the regional climate model Providing Regional Climates for Impact Studies (PRECIS) using the ECHAM model and the HadCM3 as the driving global models. The A2 and B2 scenarios were used to describe what the future world will be.

A2 represents a heterogeneous world, with self-reliance and preserved local identities, high population growth, regionally oriented economic growth and fragmented economic and technological development.

B2 represents a divergent world with emphasis on local solutions to economic, social and environmental sustainability, moderate population growth, intermediate levels of economic growth and less rapid technological change.

The A2 and B2 temperatures and rainfall projections were averaged to calculate changes relative to 1970-2000.

2.1.1. LIMITATIONS

A major issue was the absence of a culture of systematic data collection and archiving among the various agencies. In the case of the National Meteorological and Hydrological Service, long-term meteorological and hydrological records are extremely important to assess climatic and hydrological patterns and trends. It is crucial to have sufficient stations with data on daily timescales that is free from significant gaps. Although the National Meteorological and Hydrological Service has a network of stations countrywide, most of the hydrological data were inadequate because of significant gaps (Williams, 2008). Over the past years, there has been a decline in the number and quality of meteorological and hydrological network stations.

Rainfall and temperature time series with discontinuous data increased the difficulty of identifying climate-change related trends. The fragmented data made it difficult to develop robust statistics that are dependent on consistent multi-decadal to centennial timescales for many of our observing stations.

Station Name	Latitude/Longitude	Altitude	Region	Period
Libertad	18 17 00N 88 28 00W	4.0m	Region 7	1971-2000
Towerhill	18 02 00N 88 34 00W	4.0m	Region 7	1971-2000
St. John's College	17 31 00N 88 12 00W	1.0m	Region 9	1971-2000
Philip Goldson International Airport	17 32 00N 88 18 00W	1.5m	Region 9	1971-2000
Central Farm	17 11 00N 89 00 00W	27.0m	Region9	1971-2000
Spanish Lookout	17 13 00N 88 59 00W	27.7m	Region 9	1971-2000
Pomona	16 59 00N 88 22 00W	12.0m	Region 11	1971-2000
Melinda	16 59 00N 88 22 00W	12.0m	Region 11	1971-2000

Table 1 - Reporting Stations*

3. RECENT DEVELOPMENTS IN CLIMATE CHANGE

Current observations have shown that the climate is changing globally, regionally and locally. The Intergovernmental Panel on Climate change (IPCC) has defined climate change as any change in climate over time, whether due to natural variability or as a result of human activity. There is increasingly strong evidence that suggests changes in greenhouse gases and aerosols concentrations in the atmosphere, solar radiation and land surface properties are changing the energy balance of the climate system.

Greenhouse gases occur naturally in the atmosphere and warm the atmosphere as they prevent some of the energy radiated from the earth escaping into space. Carbon dioxide is the most important of greenhouse gases and is water soluble. Oceans are its largest reservoir. Since pre-industrial times, the global atmospheric concentration of carbon dioxide has increased markedly due to the increase in use of fossil fuel and to a lesser extent land use change. Other gases such as methane and nitrous oxide have also increase from pre-industrial times primarily due to agriculture.

* Source: National Meteorological Service

3.1. CHANGES OBSERVED GLOBALLY

According to the Fourth Assessment Report (AR4), "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level". Global average surface temperatures, global average sea level from tide gauge and Northern Hemisphere snow cover for March-April are illustrated in Figure 3.

Even if greenhouse gas concentrations are kept constant at levels observed in year 2000, warming is expected to increase further by 0.1°C within the next decade and 0.2 °C in the next two decades (Intergovernmental Panel on Climate Change Fourth Assessment Report).

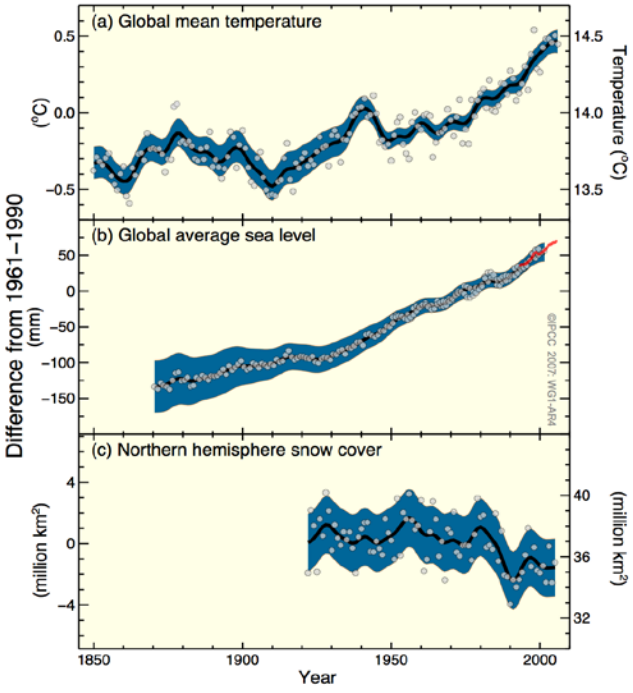


Figure 2 [†]

[†] (Van Aalst, 2007)

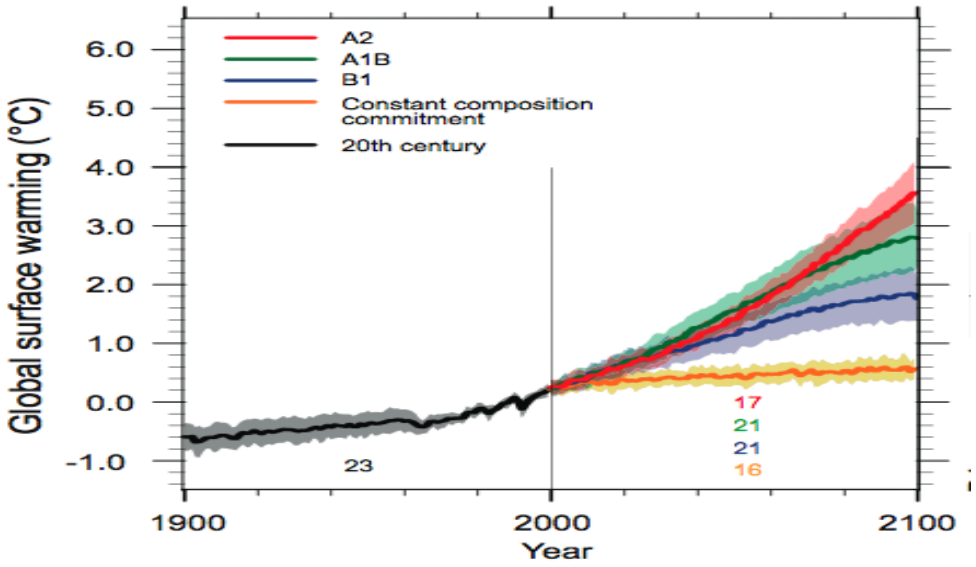


Figure 3[‡]

3.2. CHANGES OBSERVED IN BELIZE

A study of current climatic trends in Belize revealed a change consistent with the changes that are being observed globally and within the Caribbean region. Three stations from the National Meteorological Service network were selected for temperatures analysis. These stations were selected because missing data were minimal.

The results revealed that the frequency of warm days and nights had increased and the frequency of cool days and nights had decreased. The night-time temperatures were the largest contributor to the overall increase in average temperatures. The rate of increase of night-time temperatures was larger than those for day-time temperatures (Gonguez, 2007).

Figure 4 (pages 13 -15) gives a graphical depiction of the average yearly and seasonal temperatures for Philip Goldson International Airport for the period of 1961 to 2005. The study revealed that the 1990's was the warmest decade with 1997 as the warmest year ever. Nine of the ten warmest years occurred between 1991 and 2005. An average increase of 0.9°C was observed during the 45 year period.

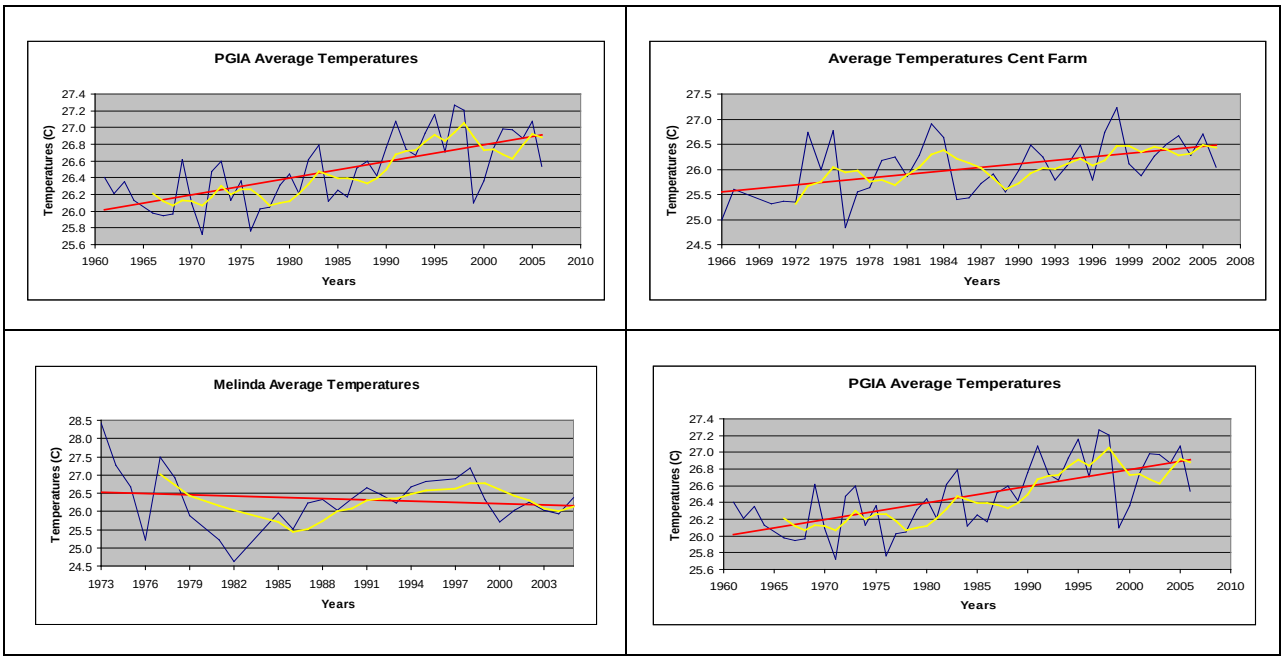
Central Farm's graph (Figure 5, page 16) illustrates an average increase of 1.0°C for Central Farm station for the period 1966-2005. The 1990's was and now the 2000's is becoming the warmest decade for Central Farm. On the contrary, in Melinda, the data trend suggests that

[‡] (Van Aalst, 2007)

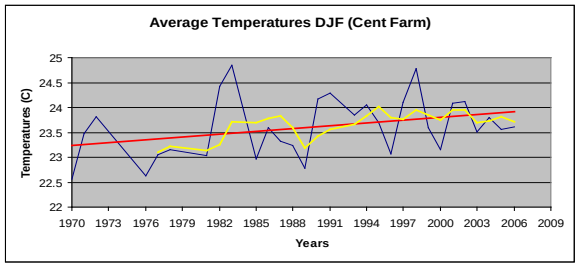
cooling is occurring. Datasets for Melinda were fraught with missing data; therefore, results must be used cautiously.

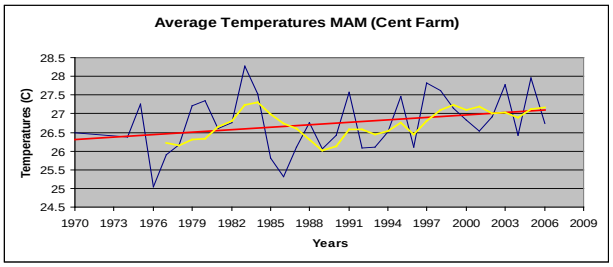
Summary: From the analysis, we can deduce that there has been a warming of about 0.9°C along coastal areas during the 45 year period and a warming of 1.0°C during the 39 year period for inland areas.

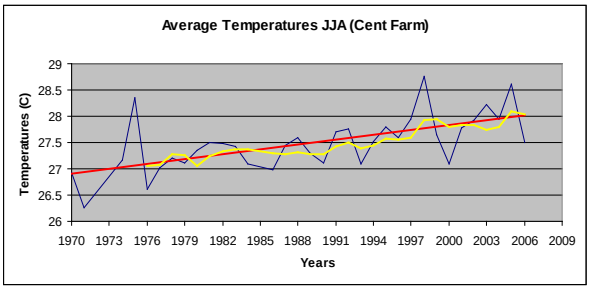
Annual and Seasonal Average Temperatures for Selected Stations in Belize

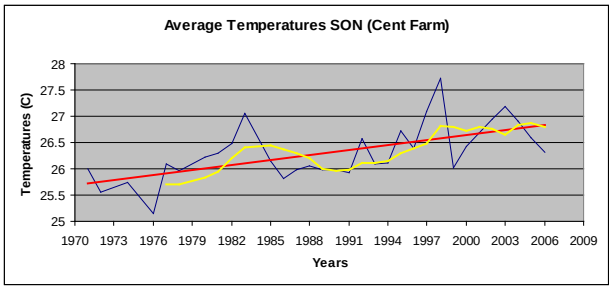


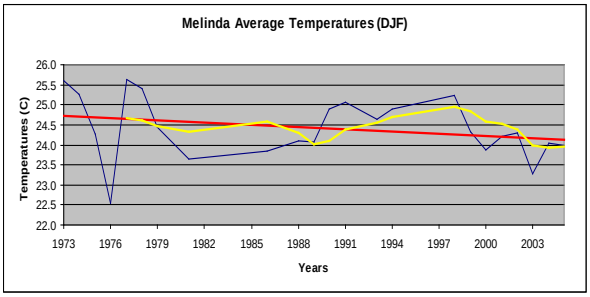
Seasonal Temperature Trends

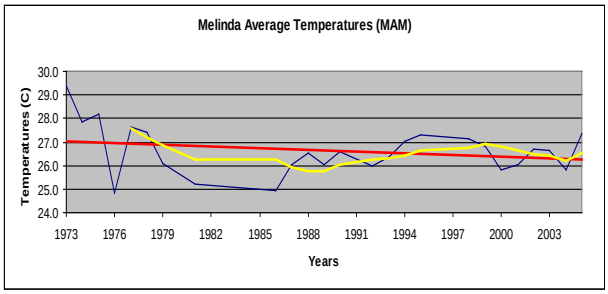


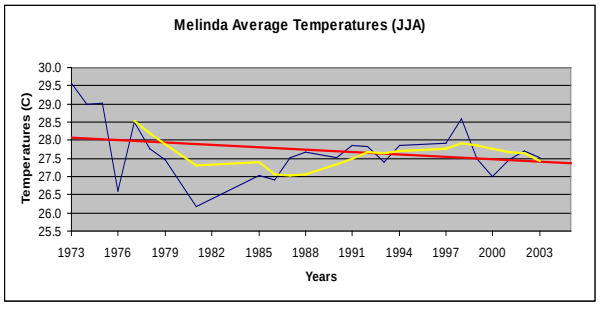


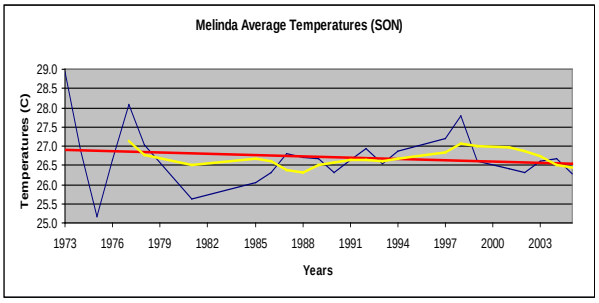












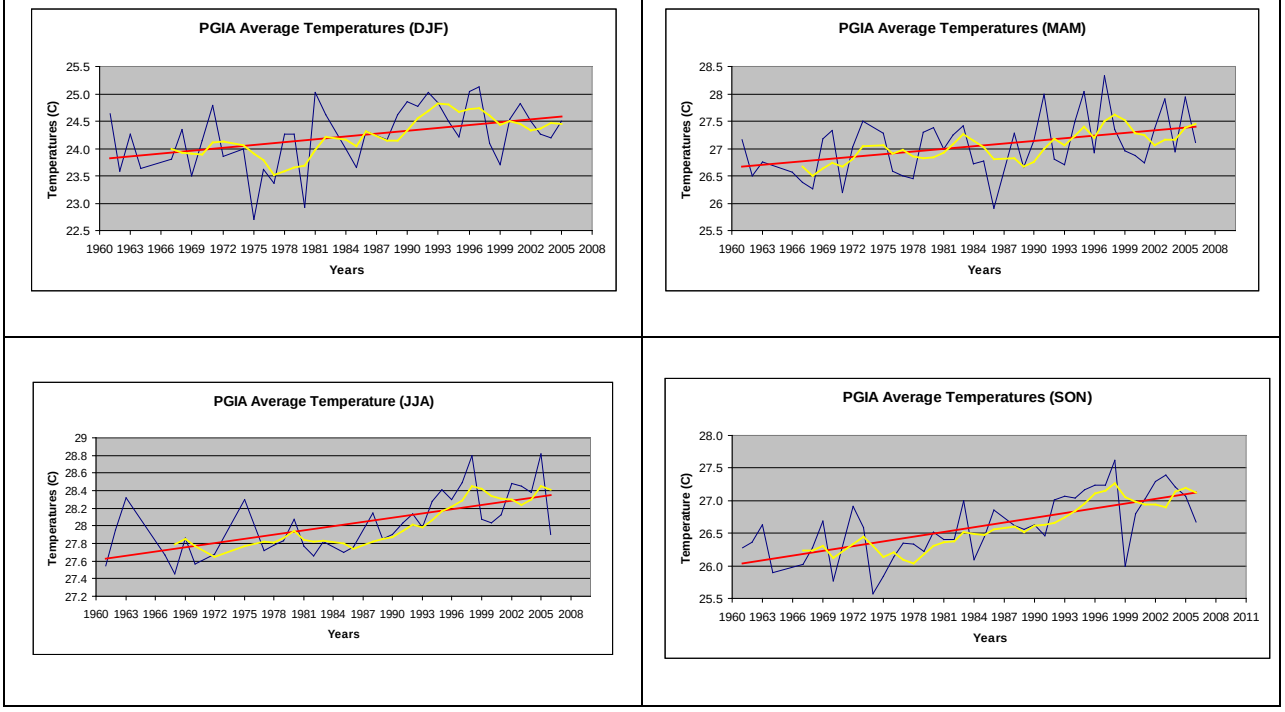
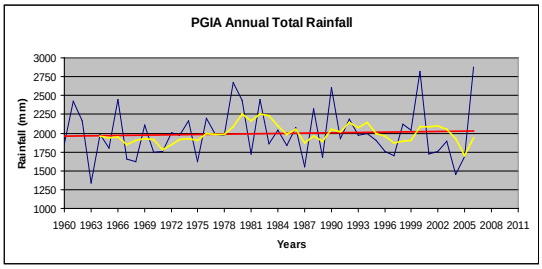
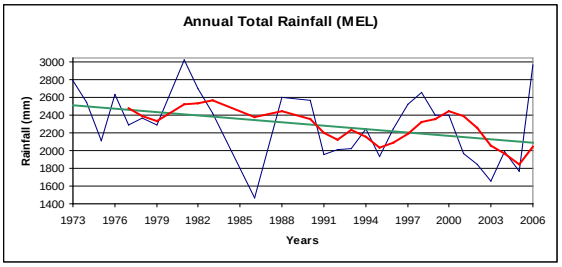
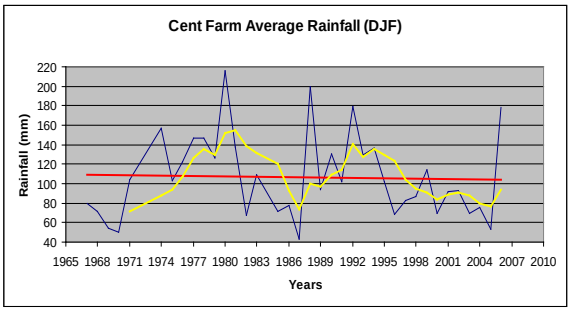

PGIA Average Temperatures (DJF)
Temperatures (C)
25.5
25.0
24.5
24.0
23.5
23.0
22.5
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008
Years
PGIA Average Temperatures (MAM)
Temperatures (C)
28.5
28
27.5
27
26.5
26
25.5
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008
Years
PGIA Average Temperature (JJA)
Temperatures (C)
29
28.8
28.6
28.4
28.2
28
27.8
27.6
27.4
27.2
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008
Years
PGIA Average Temperatures (SON)
Temperature (C)
28.0
27.5
27.0
26.5
26.0
25.5
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011
Years

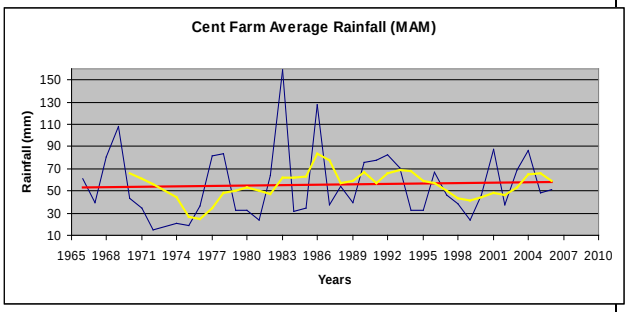
Figure 4

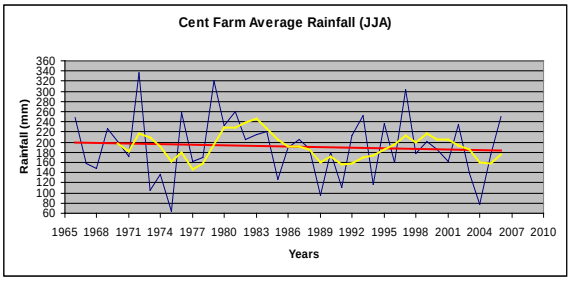
Annual and Seasonal Total Rainfall for Selected Stations in Belize

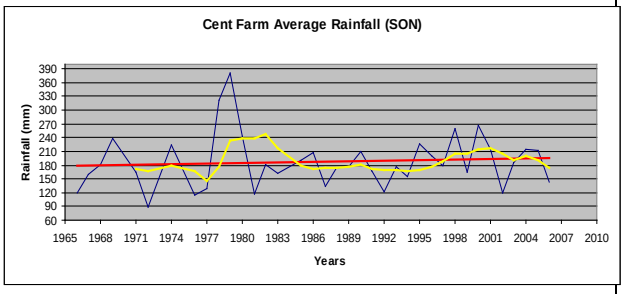


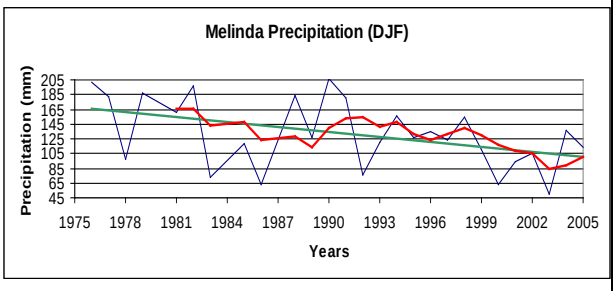


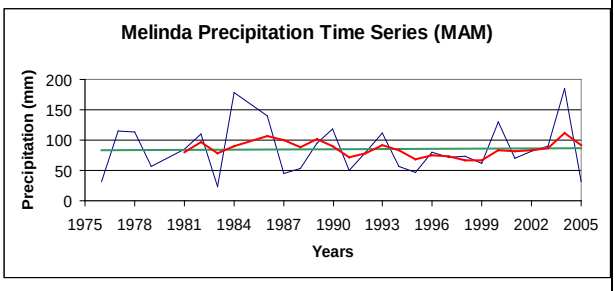


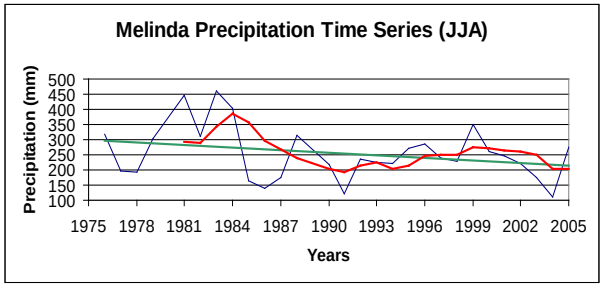


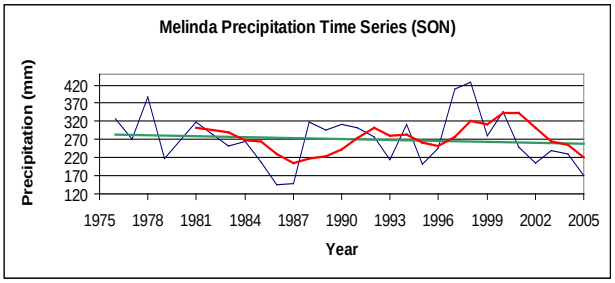


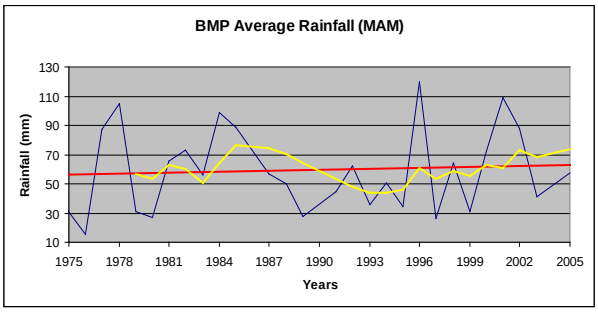


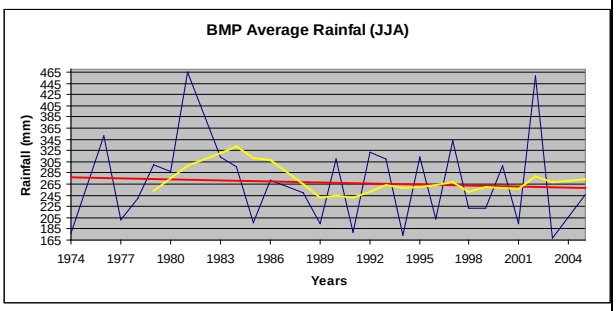


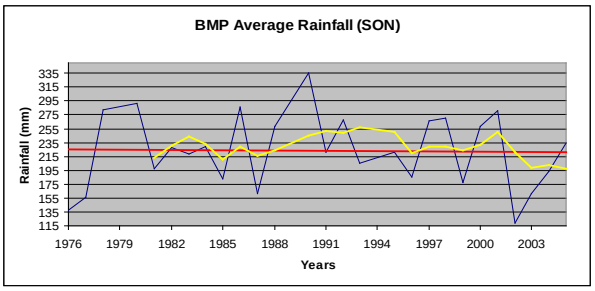


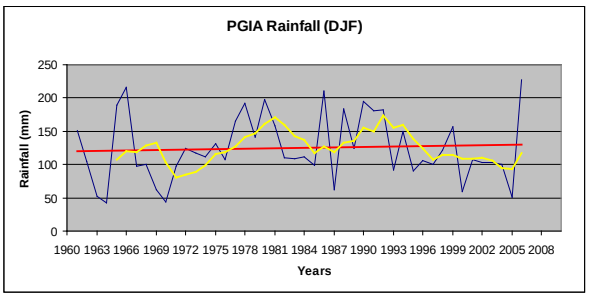

Melinda Precipitation Time Series (JJA)
Precipitation (mm)
500
450
400
350
300
250
200
150
100
1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005
Years

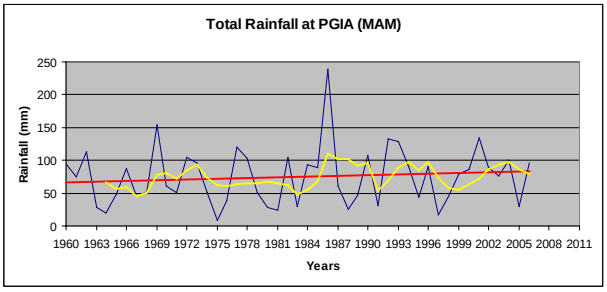

Melinda Precipitation Time Series (SON)
Precipitation (mm)
420
370
320
270
220
170
120
1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005
Year

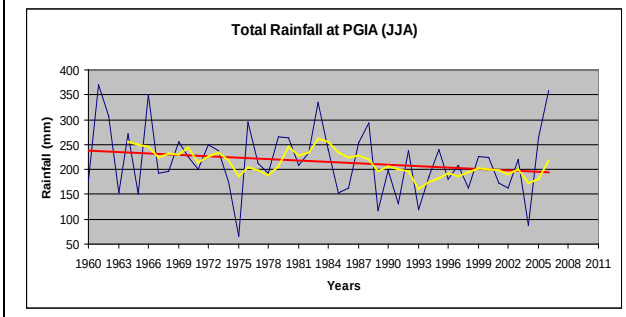

BMP Average Rainfall (MAM)
Rainfall (mm)
130
110
90
70
50
30
10
1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005
Years


BMP Average Rainfal (JJA)
Rainfall (mm)
465
445
425
405
385
365
345
325
305
285
265
245
225
205
185
165
1974 1977 1980 1983 1986 1989 1992 1995 1998 2001 2004
Years


BMP Average Rainfall (SON)
Rainfall (mm)
335
315
295
275
255
235
215
195
175
155
135
115
1976 1979 1982 1985 1988 1991 1994 1997 2000 2003
Years


PGIA Rainfall (DJF)
Rainfall (mm)
250
200
150
100
50
0
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008
Years


Total Rainfall at PGIA (MAM)
Rainfall (mm)
250
200
150
100
50
0
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011
Years



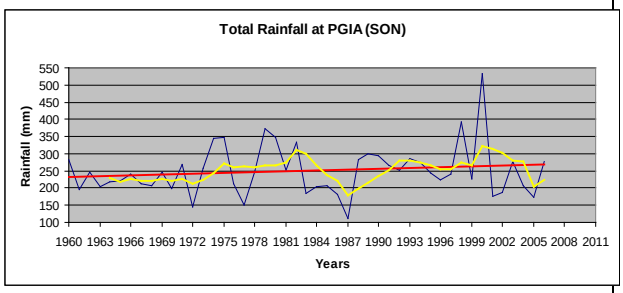


Figure 5[§]

[§] Time series of yearly and seasonal average temperatures for climatological stations in Belize along with linear trend (red) and 5-year moving average (yellow)

Data are from the National Meteorological Service, analysis done by Dennis Gonguez

3.3. EXTREME EVENTS

Sudden or extreme events pose a significant threat to the water sector. The most significant threat is the change in precipitation patterns leading to flash floods or droughts. Changes in the overall amount of precipitation are directly related to changes in the frequency and intensity of precipitation of events. An analysis of selected extreme precipitation indices shown in Figure 5 was conducted on selected stations for Belize. These extreme indices are based on those defined by World Meteorological Organization Expert Team on Climate Change Detection Monitoring and Indices.

Analysis showed that there is a small decrease in maximum 1-day precipitation for both Central Farm (CF) and Philip SW Goldson International Airport (PSWGIA) Stations. A minimal trend increase in maximum 5-day precipitation was observed at PSWGIA whilst Central Farm had a decrease. There were no obvious trends for the number of wet days, heavy precipitation days and very heavy precipitation days at both stations. An increasing trend of very wet precipitation days (above 95th percentile) was observed for both Central Farm and Philip SW Goldson International Airport. Central Farm displayed increasing trend for consecutive dry days and a decreasing trend for consecutive wet days. A significant amount of the dry days occurred between March and May suggesting intense drying in inland areas. It must be stated that an increase in frequency of dry days does not necessarily mean a decrease in the frequency of heavy precipitation event. Meanwhile, data from Philip SW Goldson International Airport indicated a decreasing trend for consecutive dry days and an increasing trend for consecutive wet days.

Analysis of Tower Hill data (1983-1985, 1992-2005) showed an increasing trend in monthly maximum 1-day precipitation and number of wet days but showed a decreasing trend for very wet precipitation day, maximum 5 day total rainfall, consecutive wet days, heavy precipitation days, very heavy precipitation days and consecutive dry days.

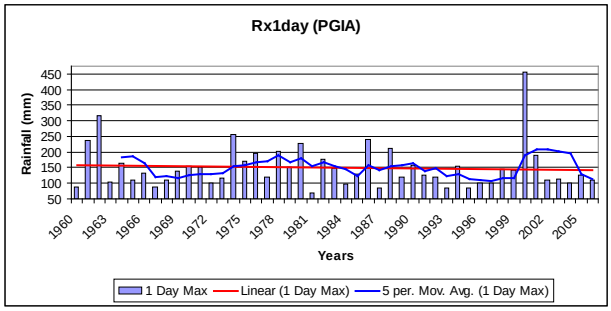
Extreme Precipitation Indices	Definition
Wet Days	Annual count of days with daily precipitation >= 1mm
Heavy precipitation days	Annual count of days with daily precipitation >= 10mm
Very heavy precipitation days	Annual count of days with daily precipitation >= 30mm
Maximum 1-day precipitation	Annual maximum 1-day precipitation total
Maximum 5-day precipitation	Annual maximum consecutive 5-day precipitation total

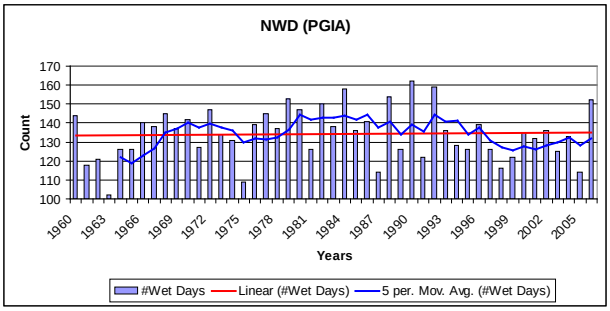
Very wet day precipitation	Annual total precipitation when daily precipitation > 95th percentile
Consecutive dry days	Maximum number of consecutive days with daily precipitation < 1mm
Consecutive wet days	Maximum number of consecutive days with daily precipitation >= 1mm

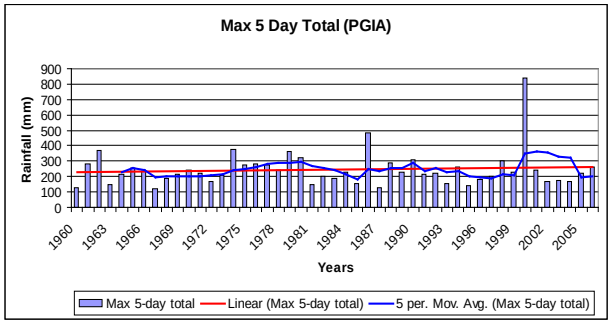
Term	Definition
Rx1day	Monthly maximum 1-day precipitation
NWD (Number of wet days)	Count of the number of days where: $RR_{ij} \geq 1mm$
R95pTOT	Annual total precipitation when daily precipitation > 95th percentile
Mx5day	Monthly maximum consecutive 5-day precipitation
CDD	Maximum length of dry spell, maximum number of consecutive days with RR < 1mm
CWD	Maximum length of wet spell, maximum number of consecutive days with RR ≥ 1mm
HPD (Heavy Precipitation Days)	Annual count of days when PRCP ≥ 10mm
VHPD (Very Heavy Precipitation Days)	Annual count of days when PRCP ≥ 30mm.

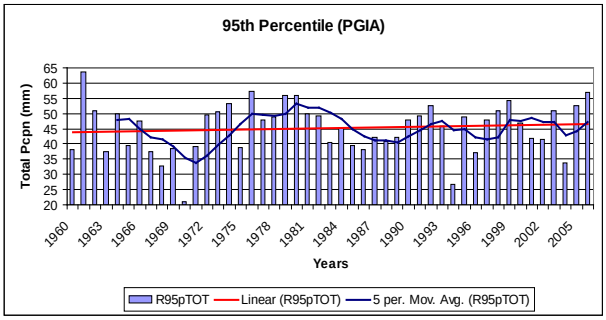
Table 2

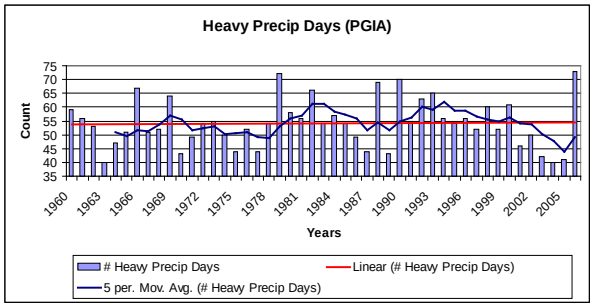
Extreme Precipitation Indices – Phillip S.W. Goldson International Airport

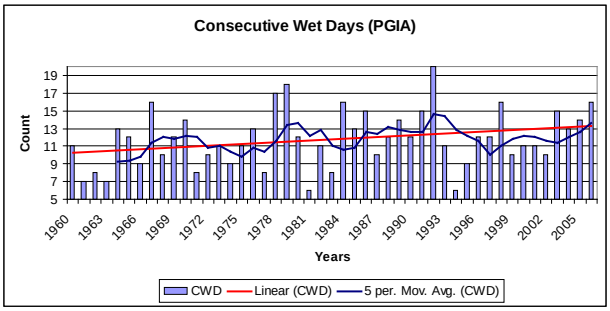


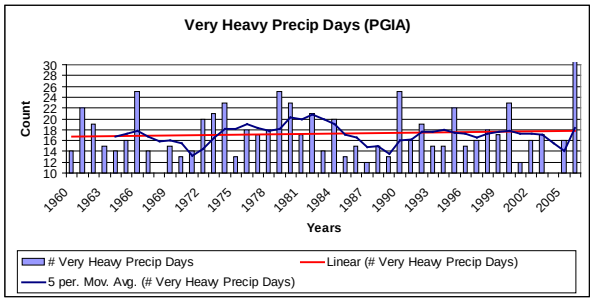


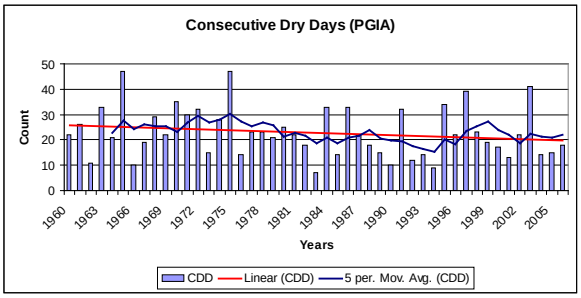




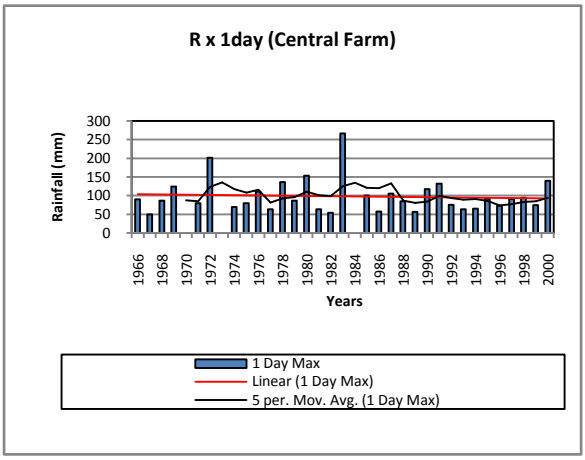


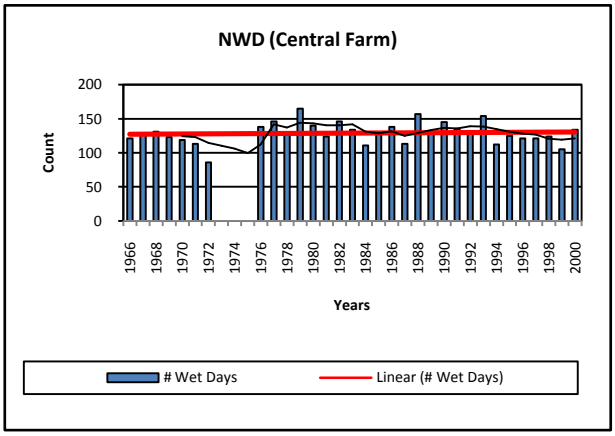


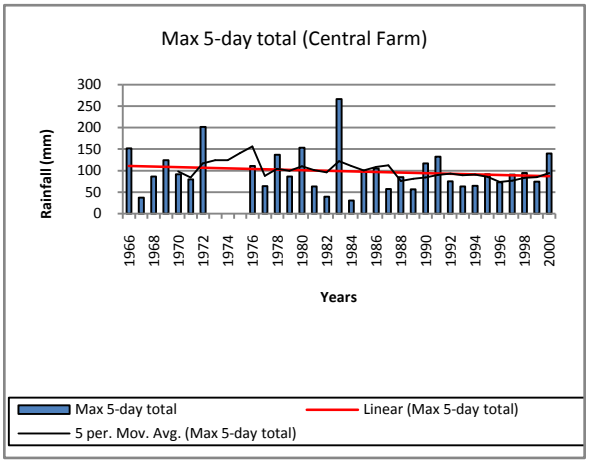


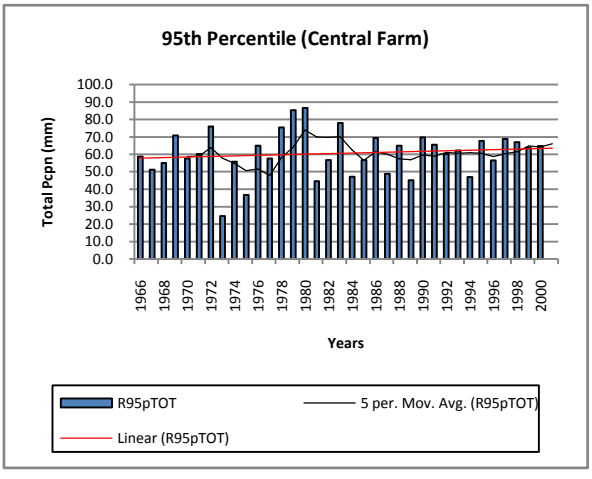


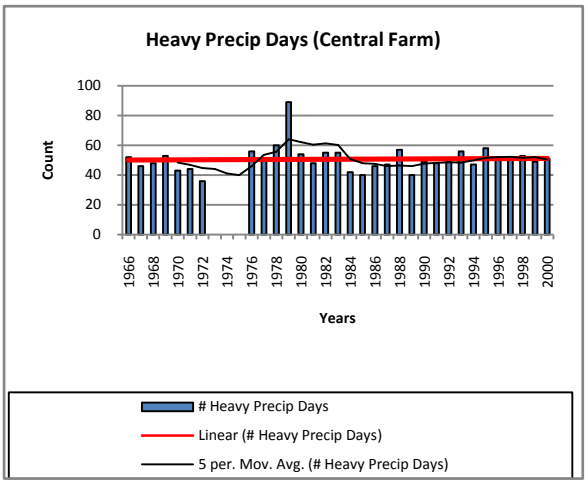
Central Farm

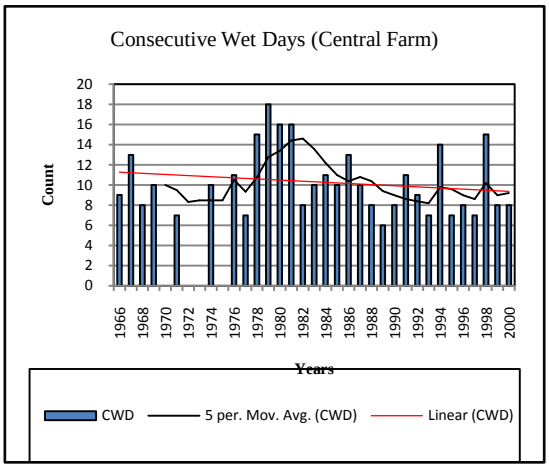


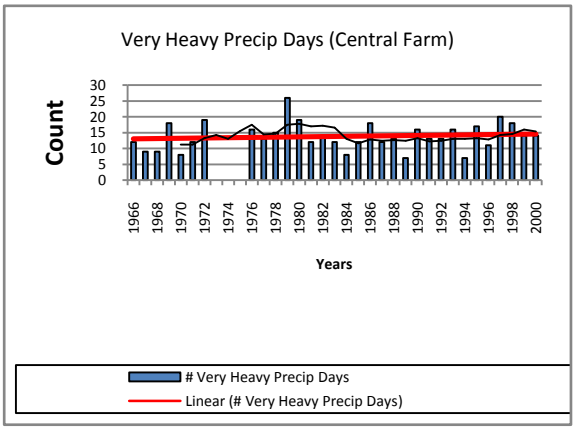


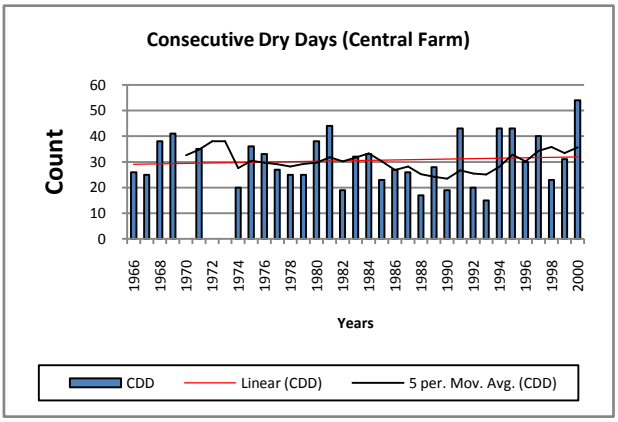




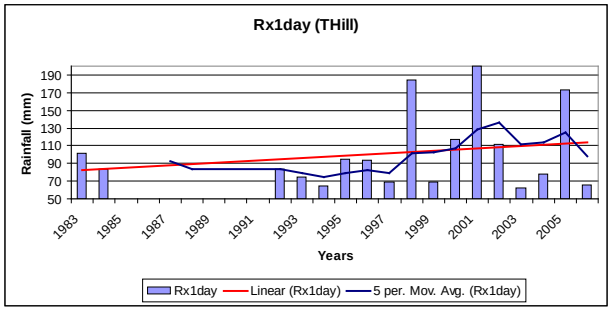

Heavy Precip Days (Central Farm)
Count
Years
Heavy Precip Days
Linear (# Heavy Precip Days)
5 per. Mov. Avg. (# Heavy Precip Days)

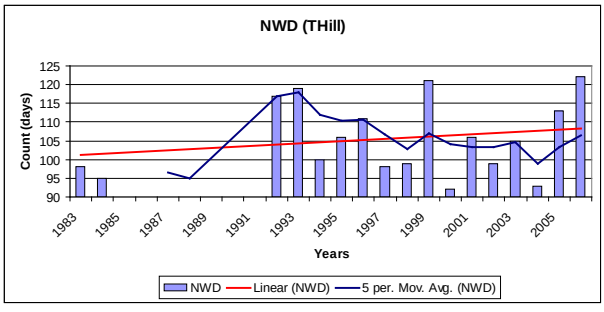

Consecutive Wet Days (Central Farm)
Count
Years
CWD
5 per. Mov. Avg. (CWD)
Linear (CWD)


Very Heavy Precip Days (Central Farm)
Count
Years
Very Heavy Precip Days
Linear (# Very Heavy Precip Days)


Consecutive Dry Days (Central Farm)
Count
Years
CDD
Linear (CDD)
5 per. Mov. Avg. (CDD)

Tower Hill


Rx1day (THill)
Rainfall (mm)
Years
Rx1day
Linear (Rx1day)
5 per. Mov. Avg. (Rx1day)


NWD (THill)
Count (days)
Years
NWD
Linear (NWD)
5 per. Mov. Avg. (NWD)

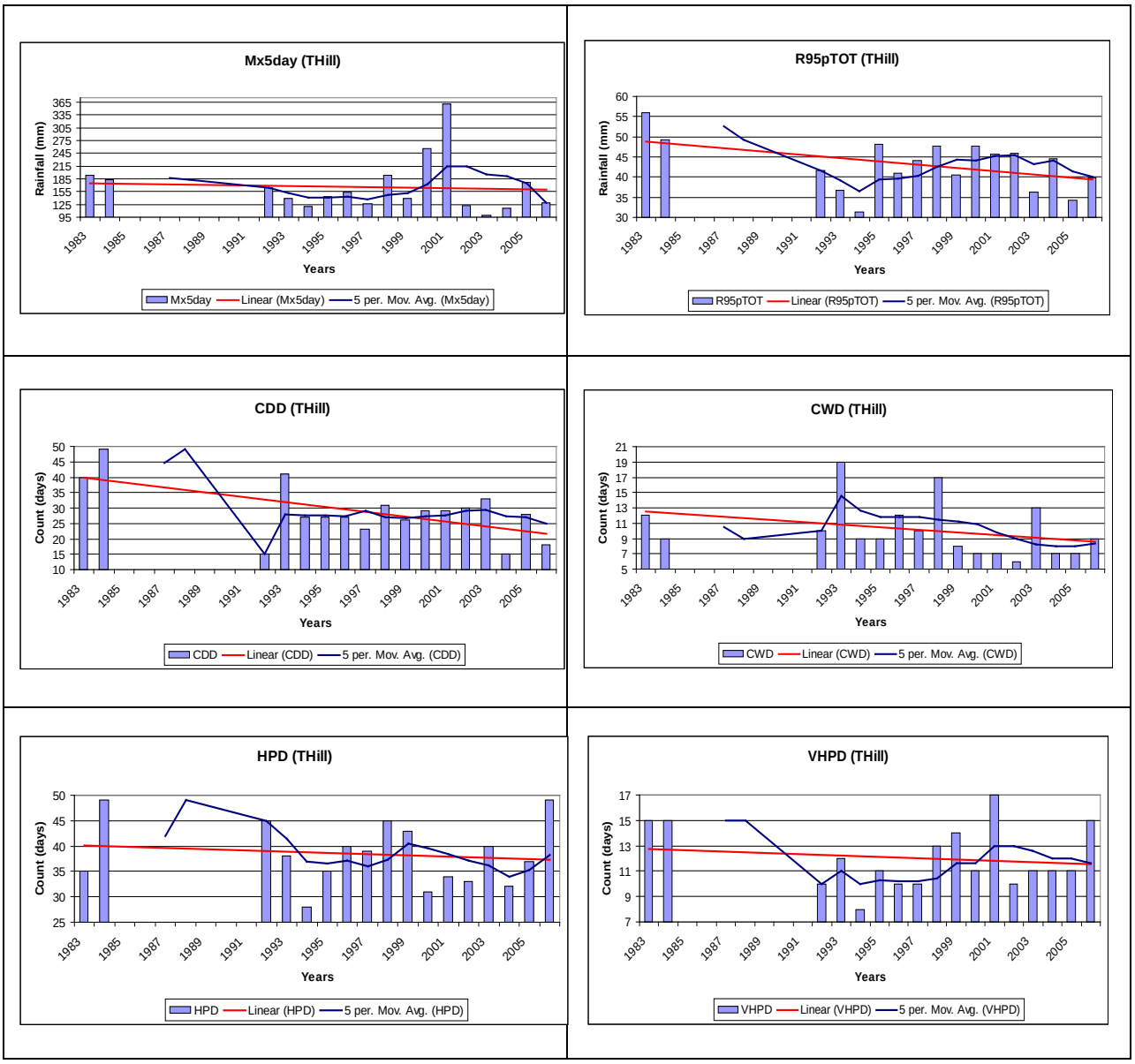


Figure 6[**]

[**] Time series of extreme precipitation indices for Philip Goldson International Airport, Central Farm and Tower Hill along with linear trend (red) and 5-year moving average (black)

Data are from the National Meteorological Service, analysis done by Dennis Gonguez and Ann Gordon

3.3.1. TROPICAL CYCLONES

Belize is inherently vulnerable to tropical cyclone because of its geographical location. The meteorological definition of a tropical cyclone is: a type of low-pressure system which generally forms in the tropics. The system is accompanied by thunderstorms and counterclockwise wind circulation. Tropical cyclones are classified into three main groups: tropical depressions, tropical storms and hurricanes.

Over the past century, Belize has experienced a variety of natural hazards, such as hurricanes and floods that resulted in the loss of both life and property. During this decade, Belize has been affected by four tropical cyclones and associated storm surge. These included: Hurricanes Keith, Iris and Dean which were of categories 3, 4 and 5, respectively. According to the IPCC report, since 1970 the number of category 4 and 5 hurricanes has increased, significantly, by about 75%. Intense tropical cyclone activity is projected to increase which will likely result in power outages causing disruption of public water supply.

Studies for the wider Caribbean region suggested that there has also been an increase in the severity of tropical cyclones. There has been eleven category 4 and 5 hurricanes in the Caribbean since 1988 compared to only three Category 4 and 5 hurricanes during the period 1978 to 1988 (CDERA, 2007).

As the climate system changes it is expected that the intensity of severe hurricanes will increase. As a result, Belize is likely to be exposed to stronger hurricanes with greater risks of flooding events. However, it is uncertain whether frequency will increase.

Table 4 below shows that frequency of tropical storm or the various categories of hurricanes have varied over the past 118 years. Three Category 3 hurricanes, 2 Category 4 hurricanes, 2 Category 5 hurricanes affected Belize during the period (1889-2008). Since June, 2000, five tropical cyclones have affected Belize. Notably 1 of the category 3 (Keith), 1 of the category 4 (Iris) and 1 of the category 5 (Dean) hurricanes that have affected us were in this decade.

- Total Storms: 53
- Total Years with Storms: 40
- Total Years with Multiple Storms: 11
- Total Years with Multiple Hurricanes: 2

Intensity	Events	Greater Interval Analysis
Tropical Storm	32	1 in 4.42 years
Category 1	7	1 in 12 years
Category 2	6	1 in 15.5 years
Category 3	3	1 in 34.5 years
Category 4	2	1 in 40 years
Category 5	2	1 in 52 years

Table 3

Impacts of Some Hurricanes that directly hit Belize

YEAR	NAME OF HURRICANE	CATEGORY	IMPACTS
1931	Unnamed	Category 3	– 2,500 people died
1961	Hattie	Category 4	– At least 307 dead – More than 15,000 homeless – 40% homes in Belize City totally destroyed – Communities destroyed – Main power plant in city down – 1 of 2 main water pipes to the city inoperable – $60M in property damages – Loss of $2M in citrus products and unknown millions in timber, banana and cocoa
2000	Keith	Category 3	– Damage estimated to be $560M – Damage to critical infrastructure – Destruction of homes – Power Outages – Loss of crops, livestock and agriculture – Floods
2001	Chantal	Tropical storm	
YEAR	**NAME OF HURRICANE**	**CATEGORY**	**IMPACTS**
2001 (October 7th – 9th)	Iris	Category 4	– 20 people died – 12,000 residents homeless – Devastating damages to villages – Destruction of agricultural crops – Loss of jobs
2007	Dean	Category 5	– $53M estimated cost of damage – 2,000 people homeless in Northern

			districts – 1,070 houses destroyed – $20M losses to papaya crops – $1.2M damage to sugar crops
2008	Arthur	Tropical Storm	– Suffered damages along delivery lines – Shortages and contamination of surface and ground water systems – Significant flooding – Losses to agriculture crops

Table 4

3.3.2. FLOODING

The country has experienced recurrent flooding. Most flood events happen during the wet season as a result of tropical disturbances moving across the Belize. Annual floods have affected many communities and threatened rich farmlands. The most recent flood occurred in October 2008 and has resulted in significant losses to agricultural crops and transportation infrastructure and is estimated to be in the tens of millions.

Table 5 below is an indication of trend in flooding events during this decade.

Images 1 to 4 show impacts of flooding on communities and farmlands.

Image 1[††]

[††] Flooding due to tropical wave that passed on August 29th, 2007 – Courtesy of National Meteorological Service

Image 2[‡‡]

Image 3[§§]

[‡‡] Flooding due to tropical wave that passed on August 29th, 2007 – Courtesy of National Meteorological Service

[§§] Flooding in Southern Belize – Tropical Storm Arthur, June 2008

Image 4[***]

[***] Flooding in Cayo District – Tropical Depression 11

Trends in Previous Flood Events

Date	Location	Precipitation (inches)	Conditional Factors	Effects/Damages
November 1st, 1995	Western Belize	–	–	$20M Damage to agriculture
October 2nd – 4th, 2000	Localized flooding across Belize	Belmopan: 7.33 ins Central Farm: 5.5 ins Chaa Creek: 4 ins Hershey Hummingbird: 5.48 ins Hershey La Democracia: 4.09 ins Philip Goldson International: 18.02 ins Rio Bravo: 17.6 ins Spanish Lookout: 4.73 ins	Hurricane Keith	Flooded streets Destruction of agricultural crops
August 17th 2001				

June 18th – 20th, 2002	Belmopan area	La Democracia 22.83 ins Blue Creek: 13.59 ins Belmopan: 13.15 ins	Tropical wave	
January 25th, 2006	Localized flooding across Belize	Baldy Beacon 5.02 ins Barton Creek: 3.7 ins Hershey Hummingbird: 8.16 ins	Heavy rainfall	
August 29th, 2007 **(2-day total)**	Northern half of the country	Tower Hill: 5.9 ins Philip Goldson International: 11.5 ins La Democracia: 10 ins Pomona : 10.5 ins	Tropical wave	
May 28th – June 2nd, 2008	Flooding across Belize	Libertad: 11.88 ins Tower Hill: 19.13 ins Philip Goldson International: 13.39 ins La Democracia: 13.95 ins	Tropical storm Arthur	7 deaths Agricultural lands inundated Complete destruction of critical bridge in Southern Belize Significant damage to sections of

		Central Farm:9.09 ins Spanish Lookout: 8.30 ins Pomona: 13.75 ins Melinda: 10.61 ins		critical highway infrastructure Power outage in rural areas 10,000 people are affected
13th Oct- 20th Oct 2008	Flooding across Belize, especially the West.	Libertad: 6.42 ins Tower Hill: 6.89 ins Philip Goldson International: 11.59 ins Belmopan 9.82 ins Spanish Lookout: 8.29 ins Central Farm: 9.04 ins Hershey Hummingbird: 16.08 ins Pomona: 11.30 ins Melinda: 10.48 ins Savannah: 18.22 ins Punta Gorda Agstat: 10.96 ins	Tropical Depression No 16	Agricultural lands inundated Significant damage to sections of critical highway infrastructure Flooded streets and impassable roads

Table 5

3.3.3. DROUGHTS

Belize is vulnerable to droughts. There have been periods of prolonged droughts and heat waves which have negatively affected agriculture, cattle ranching and the availability of potable water. Belize experienced a major drought episode in 1975 that intake pipes in rivers had come dangerously close to being exposed. The availability of potable water has become an annual concern for several communities in the dry season as aquifers run low and there is serious threat of saltwater intrusion (First National Communications to the Conference of the Parties of the United Nations Framework Convention on Climate Change, 2000).

Recently Belize experienced a drought in 2004-2005 where rainfall was 20 to 30% below average in the northern regions. Notable was the decrease in rainfall for almost the entire period during January 2004 to May 2005. At Central Farm which is located in the Central-Western Belize, there was a significant decrease in rainfall from January 2004 to May 2005. Analysis indicated that the number of wet days recorded at the Philip Goldson Airport for the wet season of 2004 was significantly lower than the average wet days during the corresponding months. There were nine wet days in June and August 2004 but the norm is an average of eighteen for both months. At Central farm, even though the year 2004 was drier than normal, the number of wet days for the month of May 2004 was fourteen, which was significantly above its normal.

A number of the stations (not shown) indicated that the number of wet days had actually decreased during the wet season of 2004 and 2005.

According to the Report by the Workshop on Damage and Loss Assessment and the Impact of Disasters in Belize, deficits in rainfall during the period January 2004 to May 2005 resulted in water deficits for many economic activities. An evaluation of the economic losses due to the 2004 to 2005 drought revealed that agricultural season rainfall was insufficient to meet crop water demands. Consequently, some crops wilted and there was a lower unit yield of other crops and plantations. Sugarcane yield declined by 15%. A significant number of cattle heads and broiler chickens as well as layers perished. The Cattle and Poultry Association reported about $5,366,091 in losses (Report on the Workshop on Damage and Loss Assessment and the Impact of Disasters in Belize, October 2006).

The report noted that the 2004-2005 drought episode had two effects: an **increase in consumption** by users with a **corresponding higher cost**, as well as an increased cost of operation at Belize Water Services Limited. Percent increases of electricity used for water production during that period were 15.6 percent in Belize City, 19.2 for Hattieville, 23 for Corozal, 24.4 for Orange Walk and 22.5 percent for Belmopan.

The 2004-2005 drought period also resulted in a reduction in electricity generation at the Mollejon Hydropower Plant as water availability was significantly reduced. The shortage of hydropower generation at the thermal plant, along with the significant increase in international

oil prices, led to an increase in the production costs of electricity (Report on the Workshop on Damage and Loss Assessment and the Impact of Disasters in Belize - October 2006).

SOME EXTREME PRECIPITATION INDICES FOR 1975 AND 2004-2005 DROUGHT YEARS		
YEAR	RAINFALL (mm)	IMPACTS
1975	PSWGIA; 66 days in April/May where rainfall is less than or equal 1mm (rr<=1mm). 6 consecutive wet days (rr >= 1mm).	– Loss in Agriculture – Loss of cattle – Reduced availability of potable water
2004-2005	2004: For Central Farm 7 consecutive wet days (rr >= 1mm), 18 consecutive dry days (rr<=1mm). Libertad: 35 consecutive dry days, 3 consecutive wet days. PSWGIA: 13 consecutive dry days, 6 consecutive wet days (rr >= 1mm). Melinda: 12 consecutive dry days, 7 consecutive wet days. Tower Hill: 28 consecutive dry days, 5 consecutive wet days. Spanish Lookout: 20 consecutive dry days, 9 consecutive wet days. 2005: Central Farm: 24 consecutive dry days, 4 consecutive wet days. PSWGIA: 22 consecutive dry days, 8 consecutive rain days.	– Rainfall and river levels low – Increased water demand and sales – Increased in electricity use for water production – Decrease in Hydropower generation result in increase thermal generation – Increased cost to consumers due to higher consumption of water during drought. – Higher operational costs to Utility due to increased electricity cost of pumping – Increased Pumping cost

Table 6

3.3.4. ENSO AND PRECIPITATION IN BELIZE

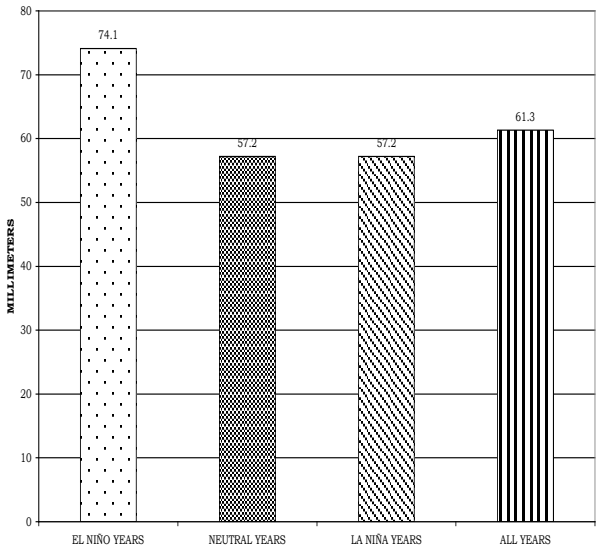
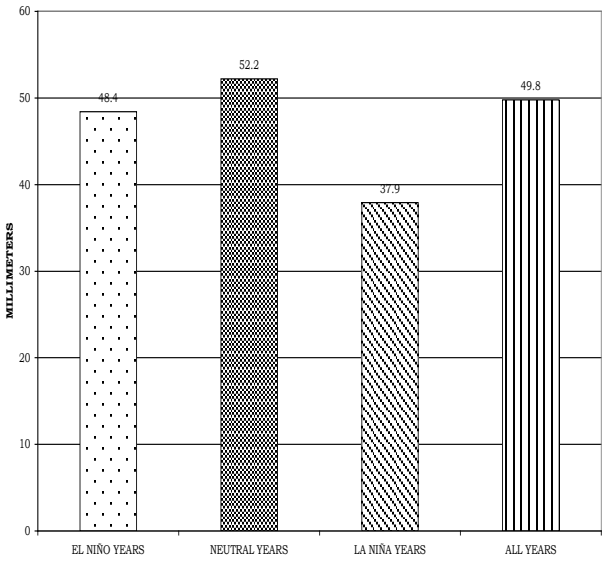
The El Niño/Southern Oscillation (ENSO) is recognized as the strongest natural variability of climate on inter-annual timescales. ENSO has its origins in the tropical Pacific and is known to affect climate conditions over many parts of the world. ENSO has three phases - El Niño which is the warm phase; La Niña - the cold phase; and the neutral phase (non-El Niño or non-La Niña. An ENSO event typically occurs every 2 to 7 years and is used as planning tools for water resources and agriculture in some countries.

According to IPCC Fourth Assessment Report the distribution and timing of floods and droughts is most strongly affected by the cycle of El Niño events, especially in the tropics and over much of the mid-latitudes of Pacific-rim countries. It is the extreme events in water conditions that cause most problems in water management. Some researchers for the Caribbean and Central America suggested that changes in rainfall patterns in the region are associated with ENSO events (Pulwarty 2001, Taylor et al 2002, Magaña et al. 1999). In this regard, local study was done to investigate the effects of ENSO on Belize's rainfall pattern (Gordon, 2004).

Figure 6 shows graphs of seasonal rainfall during El Niño/ Southern Oscillation events. The results of this study suggest that ENSO tends to have an effect on Belize's rainfall. During the winter months, cold fronts tend to move further south into the Gulf of Mexico and the Caribbean. Belize tends to get more cold fronts during an El Niño event. The Northern region receives about 30 percent more rainfall during an El Niño event (Gordon, 2004).

During a La Niña event, for the period March to May (low flow season) the Northern, Central inland and Southern regions corresponding to Region 7, 9, and 11 of the major watersheds tend to get below normal rainfall during a La Niña event. Classification of between 50 – 75 percent was used to identify below normal rainfall amounts. Northern region gets 27 percent less, Central inland 41 percent less and Southern region 33 percent less rainfall relative to the rainfall amounts in a neutral year (Gordon 2004).

It is possible that water catchments in the Northern, Central and Southern regions (Region 7, 9, and 11) would be impacted due to rainfall deficits during March to May (low flow season) La Niña event.

Average Rainfall for Northern Region for the Period December to February (1966 – 1999)	Average Rainfall for Northern Region for the Period March to May (1966-1999)
	

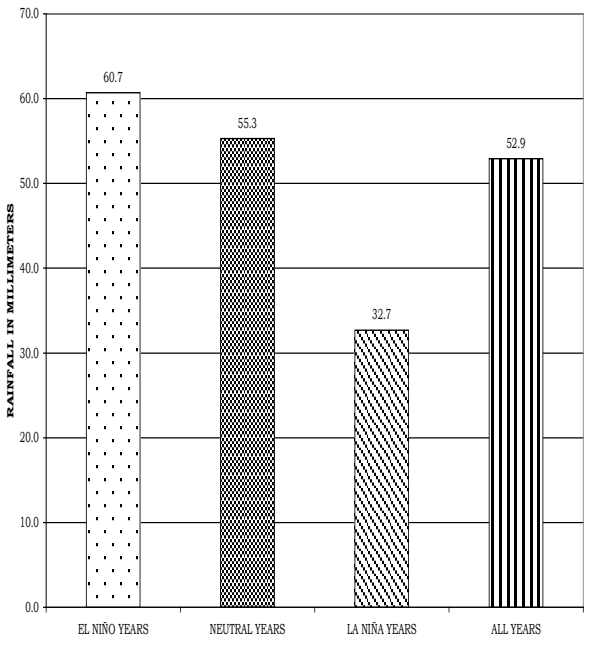
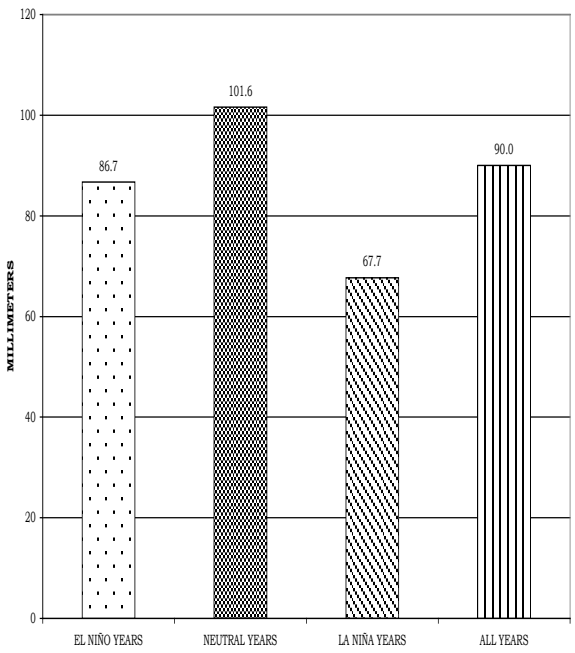
Average Monthly Rainfall for Central Inland Region for the Period March to May (1960 – 1999)	Average Rainfall for Southern Region for the Period March to May (1963 – 1999)
	

Figure 7[†††]

[†††] Graphs of Seasonal Rainfall during El Niño and La Niña events

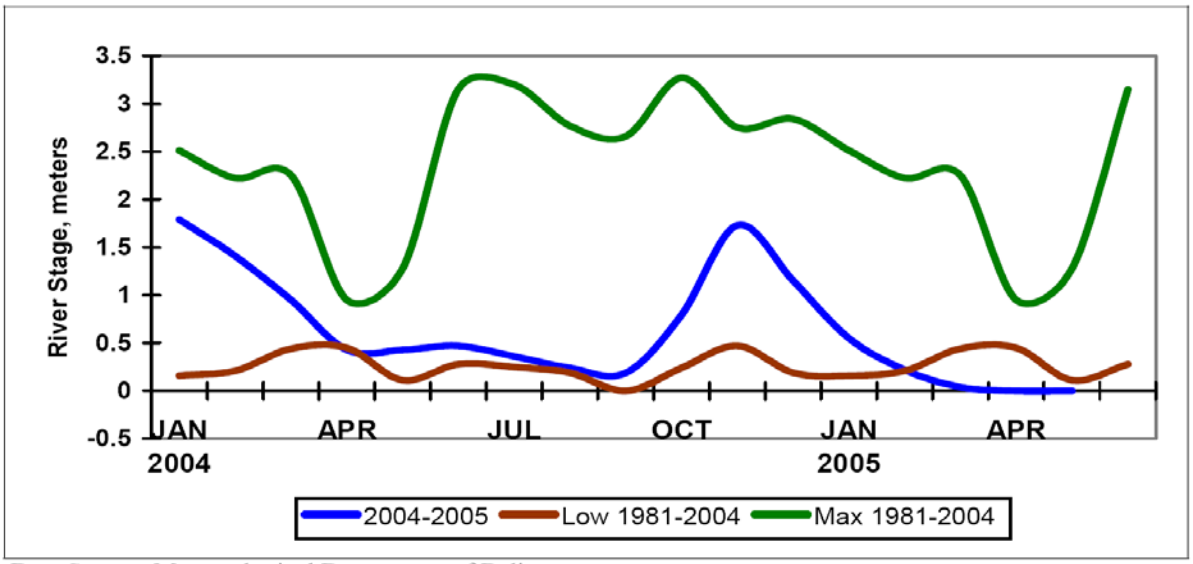
Source: The Effects of El Niño/Southern Oscillation on the Rainfall and Temperatures of Belize and its impacts on sugar cane production (Gordon, 2004)

3.3.5. THE IMPACTS OF 2004-2005 DROUGHT ON SURFACE AND GROUND WATER

Changes in precipitation and temperatures lead to changes in surface water and ground water levels. In 2004 and 2005, average temperatures were above normal and below normal rainfall resulted in additional stress to the Belize's water resources. The effects of the 2004-2005 drought episode on both surface and ground water was obtained from a report done by National Emergency Management Organization and the Economic Commission for Latin America and the Caribbean. The National Meteorological Service provided the information on rainfall. According to the report, the surface water features followed a pattern that resembles the rainfall trend. The report noted that the actual water-stage for the Crooked Tree Lagoon for the period April 2004, coincided with the 25 year minimum (Figure 7). Values continued to be closely related until October when a heavy rainfall event caused levels to rise. There was considerable fall in water levels in November 2004 onwards until February 2005 when it fell below the recorded lows and dried up the following month.

It was also reported that groundwater level had also declined for the period and that pumping cost has risen, accordingly, (Report on the Workshop on Damage and Loss Assessment and the Impact of Disasters in Belize, October 2006).

MONTHLY WATER LEVEL AT CROOKED TREE LAGOON



Data Source: Meteorological Department of Belize.

Figure 8‡‡‡

‡‡‡ Source of Analysis: Roberto Jovel, 2005: Report on the Workshop on Damage and Loss Assessment and the Impact of Disasters on Belize

3.4. CURRENT CLIMATE CHANGE ISSUES AND THREATS TO THE WATER SECTOR

Water supplies are currently sufficient for the present population. When drought or prolonged dry seasons occur there are indications that water deficits affected activities in the economic sector resulting in losses to agriculture, cattle and poultry industries and electricity production potential at existing hydropower stations.

Flooding associated with high run-off with heavy rainfall events associated with tropical systems is a problem for many settlements. Water catchments suffering from poor land use practices have exacerbated this problem for some rural areas. In addition, flooding results in degradation of water quality.

As temperature warms, there is also an increase in water demand and operating costs.

Tropical cyclones will lead to power outages resulting in the disruption of water supply.

3.5. GLOBAL VERSUS REGIONAL CLIMATE MODELS

Global Climate Models (GCM) are a mathematical representation of the physical processes in the atmosphere, ocean, cryosphere and land surface. The GCMs are the only tools capable of providing estimates of future greenhouse gas-induced changes in regional climate. These models can run continuously and can provide time series outputs to be used by Regional Climate Models. One significant disadvantage of using GCMs is that the resolution is too coarse for impact assessments for many Small Island States and Belize. As a result, regional climate change information is sparse for these areas (National Communication Support Programme, 2006).

Regional Climate Models (RCM) use the “outputs from the GCM simulations as initial conditions and time dependent, lateral, meteorological boundary conditions and make higher resolution of the climate system” (National Communication Support Programme, 2006). The horizontal resolutions of RCMs are 50km by 50km. For this study, the regional model “Providing Regional Climates for Impact Studies” (PRECIS) RCM model will be used. This model is an atmosphere and land surface model of limited area which is locatable over any part of the globe and will be used to derive high-resolution climate change projections. Climate parameters such as rainfall and temperatures, which are key variables to the hydrologic cycle, will be used in this study.

3.6. THE SRES EMISSIONS SCENARIOS AND UNCERTAINTIES

The IPCC developed Special Report on Emission Scenarios (SRES), based on the assumptions about the drivers of greenhouse gas and aerosol emissions, without considering the effects of climate change and climate policies on society and economy. IPCC SRES are based on four storylines labeled A1, A2, B1 and B2 of what the future world could be (Figure 9). It describes the relationships between key driving forces of greenhouse gas and aerosol and how they evolve during the 21st century and beyond. Each storyline is based on diverse demographic, social, economic, technological and environmental developments that diverge in increasingly irreversible ways. The four storylines depict four distinct future worlds and are shown in Figure 9.

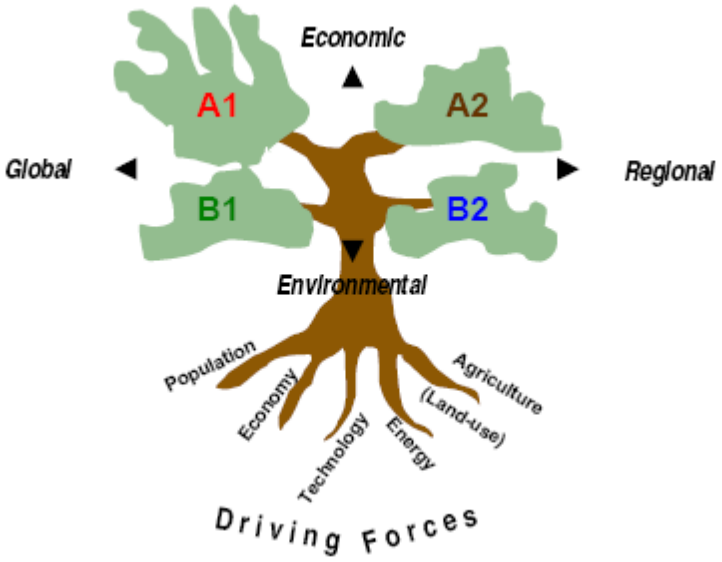


Figure 9[§§§]

The storylines brought together two sets of divergent tendencies: one set varying between strong economic values and strong environmental values, the other set between strong globalization and strong regionalization (IPCC-TGIA, 2007).

[§§§] The four IPCC SRES storylines (after Nakicenovic *et al.*, 2000).

Source: IPCC-TGICA, 2007: General Guidelines on the Use of Scenario Data for Climate Impact and Adaptation Assessment.

In summary, A1 reflects a world with rapid economic growth, low population growth, rapid adoption of new technologies, convergence of regions, capacity building, and increased social interaction as well as reduced regional differences in per capita income.

A2 represents a heterogeneous world, self-reliance and local identities preserved, high population growth, regionally oriented economic growth, fragmented economic and technological development.

B1 storyline reflects a convergent world with low population growth, transition to service and information economy, resource productivity improvements, clean technology towards global solutions.

B2 represents a divergent world with emphasis on local solutions to economic, social and environmental sustainability, moderate population growth, intermediate levels of economic growth, less rapid technological change. Six groups of scenarios were drawn from the four families.

3.7. PROJECTIONS BASED ON CLIMATE CHANGE IMPACTS ON BELIZE

3.7.1. CLIMATE CHANGE SCENARIOS

Human activities will continue to affect the global climate. Because of the long lifetime of some of the greenhouse gases, further warming will continue even if GHG emissions were reduced today. A climate change scenario describes a future climate and is informed by the IPCC Special Report Emissions scenarios. A climate change scenario represents the difference between some possible future world and the current climate. It can be viewed as an interim step toward constructing a climate scenario and is very important for any vulnerability and impact assessment study. Climate change scenarios will be constructed for short, medium and long term time horizons. These time horizons will be 2015, 2030's, 2050's and 2080's.

For this study, outputs from RCMs will be used to construct scenarios that provide insight to the response of water resource to future climate change.

PROJECTED TEMPERATURES AND PRECIPITATION

Figure 10 and Table 8 to 14 are displays of temperature and precipitation changes using two scenarios (A2 and B2). ECHAM and HadCM3 climate models were used. The time periods of data generated from are 1991-2100 for ECHAM A2, 1991-2050, 2081-2095 for ECHAM B2, for HadCM3 A2 and B2 2071-2100. Temperature projections are consistent with what is expected with greater warming at Central Farm an inland station than PSWGIA a coastal station.

Rainfall stations were selected for the major watersheds. While there is generally a decrease in average annual rainfall relative to 1971-2000 for most stations, the magnitude of rainfall deficit for Central Farm is significant compared to others.

Projected Average Temperatures for PSWGIA and Central Farm

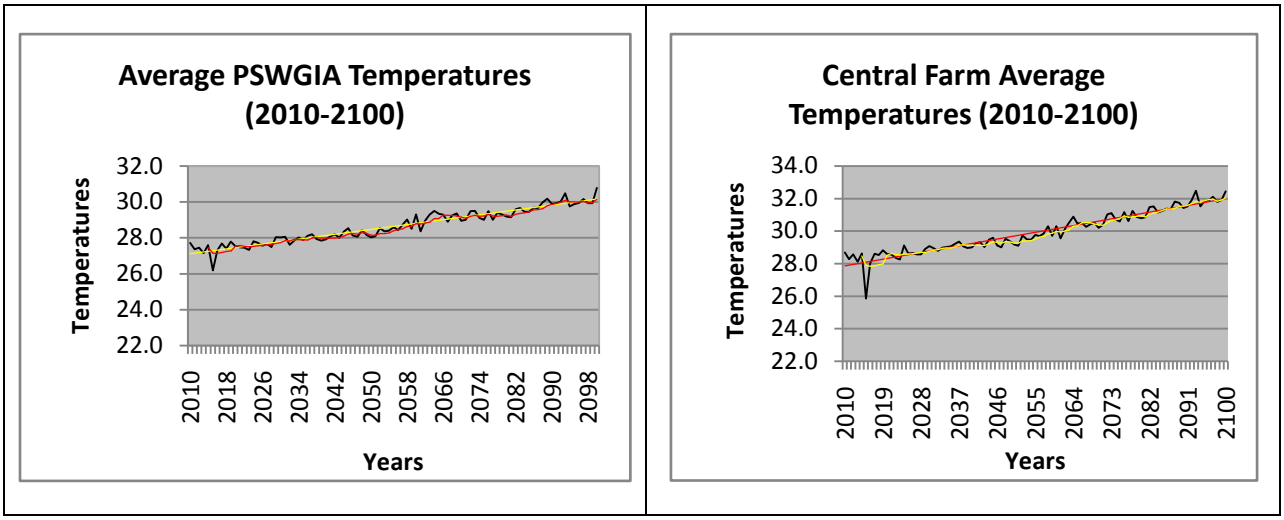


Figure 10[****]

Climate Change Temperature Projections for selected stations relative to 1971-2000

CLIMATE CHANGE TEMPERATURE PROJECTIONS RELATIVE TO 1971-2000				
Stations	**2015s**	**2030s**	**2050s**	**2080s**
PSWGIA	0.8°C	1.5°C	2.0°C	3.1°C
Central Farm	1.7°C	2.7°C	3.3°C	5.0°C

Table 7[††††]

[****] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 temperature changes in relative to 1971-2000 for different time periods

[††††] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 temperature changes in relative to 1971-2000 for different time periods.

Climate Change Seasonal Temperature Projections for Philip Goldson International Airport and Central Farm relative to 1971-2000

Climate Change December to February Average Temperature Projections relative to 1971-2000 for December to February				
Stations	**2015's**	**2030's**	**2050's**	**2080's**
PSWGIA	0.3°C	1.2°C	1.6°C	2.2°C
Central Farm	2.2°C	3.0°C	3.6°C	4.8°C

Climate Change March to May Average Temperature Projections relative to 1971-2000				
Stations	**2015s**	**2030s**	**2050s**	**2080s**
PSWGIA	0.8°C	1.6°C	1.8°C	3.5°C
Central Farm	1.0°C	2.3°C	2.6°C	5.3°C

Climate Change Average June to August Average Temperature Projections relative to 1971-2000				
Stations	**2015's**	**2030's**	**2050's**	**2080's**
PSWGIA	0.8°C	1.7°C	2.2°C	3.6°C
Central Farm	1.4°C	2.5°C	3.1°C	5.3°C

Climate Change September to November Average Temperature Projections relative to 1971-2000				
Stations	**2015s**	**2030s**	**2050s**	**2080s**
PSWGIA	1.3°C	1.9°C	2.4°C	3.6°C
Central Farm	3.6°C	4.3°C	4.9°C	7.1°C

Table 8[‡‡‡‡]

Climate Change Rainfall Projections in percent for selected stations in Belize's watersheds relative to 1971-2000

Climate Change Average Total Rainfall Projections in percent relative 1971-2000

	Stations	2015's	2030's	2050's	2080's
Region 7	Libertad	3.75	1	1.3	-1
	Tower Hill				
Region 9	St John's College	-3.1	-8.1	-8.1	-18.3
	Philip Goldson International Airport	3.8	-5.2	-5.3	-12.3
Region 9	Central Farm	-3.0	-3.4	-5.2	-23.1
	Spanish Lookout				
Region 11	Melinda Forest Station	16.9	-8.2	0.9	-1.5
	Pomona	0.75	-7.1	-5.9	-18.3

Table 9[§§§§]

[‡‡‡‡] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 average rainfall changes in percent relative to 1971-2000 for different time periods.

[§§§§] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 average rainfall changes in percent relative to 1971-2000 for different time periods.

Climate Change Seasonal Rainfall Projections in percent relative 1971-2000					
December to February					
	Stations	**2015's**	**2030's**	**2050's**	**2080's**
Region 7	Libertad	-8.8	-9.5	-10.0	-17.2
	Tower Hill				
Region 9	St John's College	-4.9	-12.1	-11.8	-12.5
	Philip Goldson International Airport	-3.7	-8.9	-8.7	-16.0
Region 9	Central Farm	-4.5	-6.6	-4.6	-35.8
	Spanish Lookout				
Region 11	Melinda Forest Station	-7.5	0	-6.7	-20.7
	Pomona	-5.2	-10.2	-11.5	-42.7

Table 10*****

***** Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 December to February averaged rainfall changes in percent relative to 1971-2000 for different time periods.

Climate Change Seasonal Rainfall Projections in percent relative 1971-2000					
March to May					
	Stations	**2015's**	**2030's**	**2050's**	**2080's**
Region 7	Libertad	26.5	17.5	19.8	16.9
	Tower Hill	–	–	–	–
Region 9	St John's College	29.9	-11.3	-10.3	-31.7
	Philip Goldson International Airport	28.8	-3.5	-2.2	-17.3
Region 9	Central Farm	18.0	-1.3	-12.9	-36.3
	Spanish Lookout	–	–	–	–
Region 11	Melinda Forest Station	195.3	77.7	132.3	44
	Pomona	61	22	39.5	-12.6

Table 11[†††††]

[†††††] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 March to May averaged rainfall changes in percent relative to 1971-2000 for different time periods.

Climate Change Seasonal Rainfall Projections in percent relative 1971-2000					
June to August					
	Stations	**2015's**	**2030's**	**2050's**	**2080's**
Region 7	Libertad	-3.4	-4.9	-4.0	-4.7
	Tower Hill	–	–	–	–
Region 9	St John's College	-10.3	-10.9	-10.7	-4.0
	Philip Goldson International Airport	11.8	-14.4	-14.0	-6.8
Region 9	Central Farm	-2.1	-6.0	-6.1	-20.0
	Spanish Lookout	–	–	–	–
Region 11	Melinda Forest Station	-15.8	-40.4	-14.1	25.1
	Pomona	-1.2	-6.9	-2.7	-3.3

Table 12[ǂǂǂǂǂ]

[ǂǂǂǂǂ] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 June to November averaged rainfall changes in percent relative to 1971-2000 for different time periods.

Climate Change Seasonal Rainfall Projections in percent relative 1971-2000					
September to November					
	Stations	**2015's**	**2030's**	**2050's**	**2080's**
Region 7	Libertad	6.7	4.3	3.1	1.4
	Tower Hill				
Region 9	St John's College	2.6	-3.5	-4.2	-18.1
	Philip Goldson International Airport	1.8	-4.1	-5.4	-18.4
Region 9	Central Farm	7.8	-0.6	-3.8	-15
	Spanish Lookout				
Region 11	Melinda Forest Station	8.1	-4.6	-21.4	-27.3
	Pomona	-0.6	-2.5	-6.4	-20.2

Table 13[§§§§§]

[§§§§§] Averaged modeled ECHAM A2, B2 and HadCM3 A2, B2 June to November averaged rainfall changes in percent relative to 1971-2000 for different time periods.

3.7.2. PROJECTIONS

3.7.2.1. TROPICAL CYCLONE FREQUENCY PROJECTION

The trend in number of tropical storms and hurricanes is uncertain. While evidence suggests that future tropical cyclones would likely be more severe with greater wind speed and more intense precipitation because of global warming, it is uncertain of how frequency and storm tracks will change. Also uncertain is there interactions with other features of variability such as El Nino Southern Oscillation (Christiansen et.al, 2007).

This uncertainty in potential changes in tropical cyclone contributes to uncertainties in future wet seasons for the region. Potential increases in wet season rainfall associated with tropical cyclone activity may counteract projected decreases in rainfall (Christiansen et.al., 2007).

3.7.2.2. ENSO EVENTS

Model simulations show wide disagreements in projected changes in the amplitude and frequency of future El Nino events. ENSO influence on the rainfall pattern in Belize is therefore uncertain.

3.7.2.3. SEA LEVEL RISE

Sea level rise in this region is projected by climate models to rise by the following levels by 2090s, relative to 1980-1999 sea levels:

- 0.18 to 0.43m under SRES B1
- 0.21 to 0.53m under SRES A1B
- 0.23 to 0.56m under SRES A2

(National Communication Support Programme, 2008)

4. WATER SOURCE IMPACTS AND VULNERABILITIES

The climate evidence above indicates that Belize is vulnerable to climate change. Recent and projected trends suggest an increase in surface temperatures, changes in precipitation pattern and more extreme weather. Threats to water, however, were not quantified due to unavailability of good quality hydrological data (Williams, 2008). Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible and unable to cope with adverse impacts of climate change (Impacts, Adaptation and Vulnerability 2007). Based on the criteria used in Impacts, Adaptation and Vulnerability 2007, some of these vulnerabilities are identified as 'key'. The prime criteria used for key vulnerability is magnitude and timing.

Belize is at risk from extreme events such as tropical cyclones, flooding and drought or prolonged dry season. Return periods analyses have shown that a tropical storm is a 1 in 4.4 year event, Category 1 hurricane is a 1 in 12; Category 2 is a 1 in 15.5 years; Category 3, a 1 in 34.5 years, Category 4, a 1 in 40 years and Category 5 in 1 in 52 year event. However, during this decade, Belize has been affected by four strong tropical cyclones and associated storm surge. These included hurricanes Keith, Iris and Dean which were of categories 3, 4 and 5. It must also be noted that for tropical cyclones, wind speeds do not tell the entire story. Slow moving storms can dump significant amount of rainfall thereby increasing risk of flooding in low lying areas. The most recent is Arthur of 2008 and tropical depression #16 of 2008 which resulted in millions of dollars agricultural losses and death.

Therefore, key impacts and resultant vulnerability from tropical cyclone will have implications on the water sector and economic sectors. The potential key impacts from these storms can be used to provide guidance to decision-makers.

Because of the frequency of flooding, during this decade, and the magnitude of the 2008 flood event resulting in the loss of life, this extreme event would be classified in the key vulnerability range. However, the magnitude of this event could have been exacerbated by other environmental stressors such as land use change. Most of these flooding events have been as a result of tropical systems.

How these events impacted water quality is unknown since there is no comprehensive water-quality monitoring program in Belize.

Droughts are recurrent events in any climate systems. El Niño-Southern Oscillation, North Atlantic Oscillation and Tropical Atlantic Oscillation are examples of climate variability that influence atmospheric patterns and cause shifts in weather patterns worldwide. Although information on drought episodes and its causes are sparse in Belize, the country remains highly vulnerable. Reports indicated that the droughts coupled with the heat waves of 1975 and 2003-2005 affected the economic sectors. In 1975, river levels decreased and, therefore, affected agriculture, cattle ranching and availability of potable water (First National Communications to

the Conference of the Parties of the United Nations Framework Convention on Climate Change, 2000). According to the First Communication, availability of potable water has become an almost annual concern for several communities.

Report on the 2004 to 2005 drought episode indicated that event resulted in lower water levels. Rainfall levels for the stations in the Region 7 watershed were between 20 to 30% below normal. For Region 9 watershed area, total rainfall amounts for stations within the watershed were also significantly below normal.

Crooked Tree Lagoon was used as a case study and the report showed that the actual water stage for Crooked Tree lagoon for April 2004 coincided with 25 year minimum for the period (1984-2004). This drought episode resulted in increased in water demand and sales as indicated by higher consumption of water by consumers (Report on the Workshop on Damage and Loss Assessment and the Impact of Disasters in Belize, October 2006). The operational cost to water utility also increased as a result of increased pumping cost. The reduction in water levels led to a decrease in hydropower generation resulting in increase thermal generation. According to the report, the drought of 2004 to 2005 was a 1 in 25 year period event. The Livestock and Poultry Association indicated over $5 million dollars in losses.

Even though Belize is vulnerable to drought, because of insufficient information and the slow onset of this event, drought is not identified as key vulnerability.

In the case of temperatures, it is very likely that Belize will become warmer during the 2015s, 2030s, 2050s and 2080s. However, the rate of warming projected might be too high for Belize.

Projected precipitation is less consistent. For the period 2015s, Libertad and Philip Goldson International Airport mean rainfall is projected to increase by 4 percent. Melinda has an increase of 17 percent. The other periods show a decline in rainfall in mean rainfall.

Changes for December to February show an overall decline in rainfall. On the other hand, March to May showed a tendency for increase in rainfall. June to August showed a decrease in precipitation. September to November precipitation shows that with the exception of 2015s, the tendency is for precipitation to decrease.

The analyses of projected precipitation extreme indices are still in progress.

Temperature Range relative to 1971-2000				
	2015s	**2030s**	**2050s**	**2080s**
Annual	0.8 to 1.7°C	1.5 to 2.7°C	2.0 to 3.3°C	3.1 to 5.0°C
December to February	0.3 to 2.2°C	1.2 to 3.0°C	1.6 to 3.6°C	2.2 to 4.8°C
March to May	0.8 to 1.0°C	1.6 to 2.3°C	1.8 to 2.6°C	3.5 to 5.3°C
June to August	0.8 to 1.4°C	1.7 to 2.5°C	2.2 to 3.1°C	3.6 to 5.3°C
September to November	1.3 to 3.6°C	1.9 to 4.3°C	2.4 to 4.9°C	3.6 to 7.1°C

Table 14

Precipitation Range in percent relative to 1971-2000				
	2015s	**2030s**	**2050s**	**2080s**
Annual	-3.1 to 16.9	-8.2 to 1	-8.1 to 1.3	-23.1 to -1
December to February	-3.7 to -8.8	-12.1 to 0	-11.8 to -4.6	-42.7 to -17.2
March to May	18 to 195.3	-11.3 to 77.7	-12.9 to 132.3	-36.3 to 44
June to August	-15.8 to 11.8	-40.4 to -4.9	-4 to -14.1	-4 to 25.1
September to November	1.8 to 8.1	-4.6 to 4.3	-21.4 to 3.1	-27.3 to 1.4

Table 15

4.1.GENERAL ANALYSIS OF POSSIBLE CLIMATE CHANGE IMPACTS

Projected hydrological data was unavailable (Williams, 2008); hence, it was not possible to quantify projected risks to water. Past and current situation, as well as the pilot study on the "Water Resources Vulnerability to Climate Change in the North Stann Creek Watershed", will be used as a basis for projected climate impacts for the country. The projections of climatic variables that would affect the water sector will serve as a guide.

The mean annual temperature is projected to rise by 0.8 to 2.7 between 2015s and 2030s, and 3.1 to 5 by 2080s. The projected rate of warming is more rapid during the wet season - September to November - and in inland areas. The range used was temperature rise for PSWGIA representing coastal areas and Central Farm representing the interior. Both of these stations are in Region 9.

Projections of mean rainfall suggested that the patterns of change are less consistent between seasons. The projections for 2015s indicated that stations in the Region 7, 9 and 11 watersheds will get between 18 and 195.3 percent more rainfall relative to 1971 to 2000 amounts. March to May show the strongest increasing trend with the most increase occurring in the Melinda sub-catchment area in the North Stann Creek watershed area.

March to May is considered the dry season or low flow season; however, projections show an increasing trend for all periods for all stations analyzed. An increase during this season suggests an increase of rainfall in the water catchment area would increase the dry season available water. However, the increase in rainfall amounts and seasonal runoff could lead to an increase in flood risks thereby affecting the quality of water supply.

June to August precipitation decreases in all periods for almost of the stations with the greatest decreases of about 40 percent occurring in the 2030's in the Melinda catchment area in Region 11. The precipitation in March to May could probably offset the decline in rainfall that is projected to occur during the June to August period.

September to November precipitation shows that, with the exception of 2015s, the tendency is for precipitation to decrease. This may have implications for water availability. Libertad has an increasing trend for all periods.

December to February season shows the strongest decreasing signal at - 42.7 percent by 2080s. The decreasing trend shows up for the selected stations in Regions 7, 9 and 11 for all periods. If precipitation continues to decrease into December to February then lower precipitation could affect water availability in the watersheds and consequently its vulnerability. Prolonged low flows along with warmer temperatures would increase water demand and may aggravate water pollution.

In summary, the quality and quantity of water supplies will likely be an important issue in the future, as vulnerability increases due to extreme events. Historical and current data have shown that high intensity rainfall from tropical cyclones have lead to flooding that consequently affect water availability and quality.

As noted in the report on the 2004 to 2005 drought period, a similar incident could increase water demand as consumption increase, decrease hydropower generation, and affect the agriculture industry.

5. ECONOMIC IMPACTS

The economic effects of climate variability and extremes are noticeable as seen in recent incidents. It is expected that climate change will affect all sectors and will limit each sector's ability to contribute to the economic development of Belize. These impacts will vary across the economic sectors. There are only a few studies directed to evaluate the economic impact of climate change on the important economic sectors of Belize. Negative climate impacts will outweigh benefits. Therefore, it is important to improve our understanding of climate impacts and the cost and benefits of these impacts. Sections 5.1 – 5.3 provide a general analysis on the likely impacts of climate change on the major economic sectors of Belize.

5.1. AGRICULTURAL SECTOR AND FOOD SECURITY

Belize has a small open economy which is dependent on agricultural production, forestry and fisheries. Contribution from these sectors together equate to 35% of GDP ((BZ $338 million) and 41% of total employment. Economic performance in the agriculture sector is primarily dependent on traditional export crops such as sugar, citrus and banana which currently account for at least 60% of the earnings with citrus exports being the principal source of income followed by sugar and banana. Rice, corn and beans are the main domestic food crops.

In 1995, an assessment of the effects of climate change on the main domestic food crops: dry beans, rice and maize using a crop simulation model "Decision Support System for Agrotechnology Transfer" (DSSAT 3) suggested that for a 1 and 2° C rise in temperatures with a +/- 20 % in precipitation there would be a reduction in yield of beans, of 10% to 14% reduction for rice, and a 17 to 22% reduction for maize (First National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change, January 2000).

In 2008 an assessment of sugar cane and citrus to climate change using CROPWAT and DSSAT4, respectively, suggested that the yield of these export crops would be affected. Future climate scenarios of 1° and 1.5° Celsius warmer accompanied by a ±12% for the year 2028 and

±20% for the year 2050 change in precipitation were selected. The overall results suggested that there would be an 11.9% reduction in yield for sugarcane for 2028 with 12mm less rainfall and 17.4% reduction for 2050 with 20mm less rainfall. Using the 2028 scenario with an increase of 12mm rainfall suggested that yields would still fall by 4.5%.

Estimated yield reduction of citrus during the base year is 1.4%. The study revealed that for the year 2028, with a 12mm less rainfall the predicted reduction was 3.4% in yields and 5% reduction for 2050 with 20mm less rainfall. Using the 2028 scenario with an additional 12 mm rainfall yields remained the same.

The changes in rainfall did not affect the growing season. However, it did affect the yield in periods of low or high rainfall. The rise in temperature shortened the growing period for crops, which lowered yields (Draft Report of Climate Change Vulnerability and Adaptation Assessment for Sugar cane and Citrus, 2008). It is expected that if surface water becomes scarce, more groundwater will be used for irrigation purposes resulting in an increase cost of production for agriculture.

In the case where there will be excess water in the soil, due to higher precipitation values, production costs will also likely increase because new drainage infrastructure will be necessary.

Rainfed agriculture production system will also be affected by the adverse impacts of changing climate on the rainfall pattern. This would place a high demand on management techniques for agricultural production and extra input into agriculture also resulting in an increase in cost of production. Irrigation costs would rise in places where soil moisture would decrease. At the same time, soil erosion caused by flooding would increase input in fertilizer and pesticide to offset losses in organic material in soil, reduced soil fertility, plant diseases, pest occurrence and weed control.

5.2. HYDROELECTRIC POWER GENERATION

Belize has three hydropower sites: Mollejon, Chalillo (Image 5) and Hydro Maya which supply the nation with 25 MW, 7 MW and 0.50 MW of hydroelectricity, respectively. There is also a small scale power plant at Blue Creek on the Rio Hondo which provides 15KW of power to the Mennonite community. Belize Electricity Limited generates the remainder of electricity for the country from diesel-burning thermal plants. Higher temperatures will increase the demand for electricity as demand for air conditioning, pumping water for irrigation, refrigerating food resulting in higher costs to consumers.

Hydropower generation utilizes high volume of water. Therefore, any significant change in the hydrological cycle will affect hydropower facilities. A decrease in the river levels during the dry season would have significant adverse effects to the power generating plants and will, therefore,

threaten the reliability and security of Belize's electric supply. Falling rivers affect water intake and availability of water in the reservoirs. River flow would be further reduced if agriculture and potable water demands were given higher priority. Consequently, water replenishment rates may not keep up with rates of desired usage. This will cause hydroelectric dams to be less efficient leading to higher costs of electricity as the country becomes increasingly reliant on fossil fuels. Operational cost for electric generation would likely increase due to higher maintenance needs associated with thermal plants.

However, increases in precipitation amounts would lead to increases in runoff. This would increase the volume of water available for energy generation. The volume of silt and other materials from the runoff will adversely affect the efficiency of power generating stations.

5.3. TOURISM

Belize's tourism industry is the largest contributor to the gross domestic product and the largest source of foreign exchange. Tourism was the largest income earner in 2005 and 2006, accounting for nearly BZ $350 and 400 million in earnings, respectively. This is equates to 16% and 17% of the GDP, respectively.

A changing climate, along with sea level rise, would result in loss of beaches, properties and public infrastructure and will make Belize less attractive as a tourist destination. The loss of beaches and coastline due to erosion, inundation and coastal flooding and loss of tourism infrastructure, natural and cultural heritage would reduce the amenity value for coastal users (IPCC AR4, 2007).

One meter rise in sea level would impact 30% of Belize's wetlands (Image 11) (The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis, February 2007) and none of the remnant cayes in Belize will have a source of potable water (First National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change, January 2000). Additionally, some coastal areas in Belize will experience high levels of saltwater intrusion and rising water tables, thereby reducing water quality. Decline in water quality due to salinization of aquifers would lead to higher costs of water because cayes and other coastal areas would need to invest in desalinization plant.

The overall effect of changing climate on Belize's tourism industry would be a loss of employment and higher insurance costs for properties in vulnerable area.

With 5 meters sea level rise as shown in Figure 10, almost all of Belize's wetlands would be affected (The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis, February 2007).

In 2007, Richardson's assessment of the economic vulnerability of Belize's tourism industry to climate change mentioned that reef-based activities attract more than 80 percent of foreign tourists. Coral mortality from climate change and other human-induced impacts may reduce the appeal of visitors that would like to participate in underwater recreational activities. Richardson suggested that perceptions of reef quality may be an important factor in the assessment of the vulnerability of tourism demand to climate change in Belize.

Image 5******

****** Chalillo Hydroelectric Power Plant

Source: The Island Newspaper Ambergris Caye, Belize Vol. 16 No. 4 January 26 2006

Latin America & Caribbean region: Exposed population (5m SLR)

Figure 11[††††††]

[††††††] Source: Impact of Sea Level Rise on Latin America and Caribbean Countries

*www.temasactuales.com/temasblog/environmental-protection/impact-of-**sea-level-rise**-on-lac/ -*

6. RECOMMENDATIONS

6.1. WATER CONSERVANCY MANAGEMENT SYSTEMS AND PROTECTION OF WATERSHEDS

- Enhance the protection and restoration of ecosystems.
- Adopt forest management plans to prevent and control soil erosion.
- Encourage water harvesting.
- Protection of the water environment, preventing and controlling water pollution.
- Raising awareness to promote the effective and efficient use of water.

6.2. AGRICULTURE

To minimize costs and to conserve water, farmers should:

- Develop drip and sprinkle irrigation practices to increase water efficiency.
- Improve management practices.
- Select and cultivate stress-resistant varieties.

6.3. WATER SATURATED SOIL

To reduce excess soil water under increased precipitation, the following options can be implemented:

- Improve drainage infrastructure as well as improved harvesting practices to maintain quality of crop.
- New cultivars with higher resistance to soil anaerbiosis would be suitable.
- Enhance national capacity to test new cultivars and to conduct genetic improvement.
- Change management practices such as planting dates to compensate for crop cycle modifications.
- Use of technology to enhance management practices to improve crop yield.
- Research pest/disease resistant crop varieties.

6.4. HYDROELECTRICITY

- Improve hydrology and meteorology observation network and data collection.
- Improve flood and drought forecasting.
- Promote energy efficiency.
- Promote alternative sources of energy.

6.5. TOURISM

- Promote inland tourism as alternative to coastal tourism.
- Design standard for minimum floor level heights and other flood resistant measures for buildings in coastal and flood plain areas.
- Incorporate climate change issues into tourism management plans.
- Environmentally friendly resort construction.

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NATIONAL ADAPTATION STRATEGY
TO ADDRESS CLIMATE CHANGE IN THE WATER SECTOR IN BELIZE

STRATEGY AND ACTION PLAN

Annex II - POLICY AND LEGISLATION REVIEW)

Prepared for the

Caribbean Community Climate Change Centre

Belmopan, Belize

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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 Belize, the Caribbean Community Climate Change Centre or the World Bank.

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EXECUTIVE SUMMARY

This review addresses the entire body of policy and legislation relating to the water sector of Belize. This report follows the development of water policy in Belize that is included in this report as an annex to this section. This separate report is entitled: “National Integrated Water Resources Management Policy”. This report also has Climate Change consideration for any of the individual sub-policies proposed.

Belize is still without a comprehensive water policy and the accompanying legislation to give weight to that policy. There have been several attempts at drafting a water policy which previous attempts have all died on the vine. A new draft water policy is now ready for acceptance and consequential action and is a revised and expanded policy. Critical to the implementation of unified management of water resources is an agency charged with administration which does not now exist. The principal proposal is for the formation of that agency.

Water however is managed in several ways operating from several points of view. Water is managed within the broad range of all national resources management and is treated as a step-child if not neglected. There are several agencies charged through various pieces of legislation relating to specific functions. The key guidelines used in the formulation of policy is the IWRM approach that incorporates a social dimension and has clear goals that are in accord with an international/regional approach and minimal standards.

Belize needs to develop a water culture with many facets not only use and utilization that has to be actively promoted. The individual components of the water policy points to the thematic areas of the impact of Climate Change and expands on each one.

METHODOLOGY

Primary and secondary research was used to compile all of the policy attempts and stakeholder interviews were conducted. The methodology employed limited analysis of the attempts at policy formation and legislation.

POLICY AND LEGISLATION REVIEW

Water in Belize is an abundant natural resource and is an externality. We have too much to water to husband and our standard of care is derived from the perception or misperception of never ending “abundance”. Climate change is predicted to upset our attitudes and behavior toward our water resources.

Our available water resources – collection, management, control, conservation and distribution practices of those water resources will be severely challenged. A situation analysis of the current administrative setup affords the opportunity for improvement and meeting the challenges of Climate Change. There are many policies, legislation and institutions relating to water and water resources management. Our water resources do not have a coordinating mechanism and coordinated focus. The institutional map takes account of all agencies in the public sector, NGO and private sector, including private citizens and activist stakeholders that have roles and functions in the water sector. There are two overbearing considerations in the water sector – quantity and quality with both requiring strategy and action planning, due to the threatening scenarios predicted to occur under climate change.

❖ Planning of Water Resources

There is no still overall Master Plan for Water Resources and without a single body with responsibility for producing such a plan.[1] The management of water resources is a complex undertaking addressing topics as Development of Water Resources; Building Inventory; Gathering Grounds and Watersheds; Monitoring and Control of Water Rights; Licences for Water Abstraction; Provision of Water Supplies; Protection of Water Supplies in situ; Use of Water for Irrigation; Use of Water for Hydropower.

❖ Operational Management of Water Resources

There is no authority with the responsibility for the operational management of Water Resources. Water management is not organized into a system of basins from source to reservoir. The holding back or supplementing of river flows, aquifer recharge, or conjunctive use of surface water and underground sources are neglected topics. No mechanisms exist for flood control prevention although NEMO plays a coordinating role is disaster management.

There is limited regulation for conservation and control of water gathering grounds or on land overlying aquifers within the Environment and the Geology departments. These departments have requirements for filing plans and refer to the discharge of effluents/wastes that cover operations including: mining, deforestation, land use, oil exploration. Other facets such as recreational or sporting activities have no focus with the general responsibility falling under the Ministry of Tourism.

POLICY

❖ Water Policy

A draft water policy exists and whilst Climate Change is addressed in some topics of that draft policy and is one thematic area itself, the treatment is incomplete. *Please see the draft Water Policy contained as an annex)*.

❖ Climate Change

An independent Climate Change policy does not exist and has not been drafted. Climate Change Policy is not intended for just the water sector but for the entire range of resources in Belize.

LEGISLATION

There are policies and legislation that address cradle-to-grave issues in water resources that pertain to different administrative functions and responsibilities. Acts set out the creation of

[1] Harrison

institutions, re-form institutions or strengthen the powers of institutions. Belize is also a member of networks of regional/global scope and moves in accord with international perspectives of integrated water resources management. The Convention on Climate Change is one such movement and but our legislated responses have yet to be in synchrony with our obligations. Legislation currently active, that deals with Climate Change and the water sector, does not exist and is in draft stage for presentation, concurrent with an antecedent water policy.

WATER RESOURCES MANAGEMENT FRAMEWORK

❖ Water Related Legislations in Belize

In Belize, there are many legislations pertaining to legal management of water resources. These laws tend to cover, whether directly or indirectly, sub-sector or functional aspects of water resources management and provides for separate implementing institutions[i]. Consequently, several government departments and agencies are legally responsible for the management of water resources within their respective sectors. This arrangement results in the uncoordinated and overlapping management of the nation's water resources and result also in unattended issues such as groundwater exploration and exploitation.

Belize Land Development Authority Act Chapter 146
This Act establishes the Belize Land Development Authority and authorizes the Minister of Agriculture to make regulations to enforce soil and water conservation.

Environmental Protection Act – Chapter 328 – 1992
This act establishes the Department of the Environment and prohibits the dumping of hazardous wastes and fouling of the aqueous environment.

Effluent Limitation

These regulations set limits on the discharge of sewage and industrial waste into inland or marine water bodies.

Environmental Impact Assessment Regulations

These regulations establish builder and developer requirements for the preparation of documentation addressing all issues of the environment including the social component. These regulations also set out the terms of submission and approval by the Department of Environment by an advisory body.

Fisheries Act - Chapter -174 1948 amended by Acts 1 of 1983 & 10 and 22 of 1987
Fisheries Regulations S. I. 66 of 1977, 71 of 1978, 24 of 1980, 83 of 1982, 44 of 1985,139 of 1990, 168 of 1991, 169 of 1991

These regulations are authorized by the parent Fisheries Act and the abovementioned amendments. The Minister of Agriculture and Fisheries is authorized by the these regulations to apply the Fisheries Act to coastal waters, rivers, streams, watercourses, lakes, lagoons and other inland waters of Belize.

Forest Act

The Minister of Natural Resources, on recommendations of the Minister for the Water Industry, protects recharge areas or gathering grounds by designating such areas as protected areas.

Harbours and Shipping Act – Chapter 191

The Minister responsible for harbours is authorized under this Act to make regulations for the control, improvement, preservation and maintenance of all ports, harbours, rivers and public wharves.

Land Utilization Act – Chapter 158A

This Act requires the submission of the subdivisions specifications including the dimensions, boundaries and locations of drainage swamps, streams and rivers.

Mines and Minerals Act – Chapter 183

Mines and Mineral (Safety, Health and Environmental Regulations) S.I. 33 of 1994

Under the parent Act, the Minister may require an EIA for the prevention, limitation or treatment of pollution and minimizing the effects of mining on the surface and ground waters. Under the regulations, the Inspector of Mines is empowered to take steps to alleviate the danger and abate pollution of water courses due to mining activities.

National Lands Act – Chapter 191 (12) – 1992

This Act stipulates the 66 feet vegetation reserve above the high water mark along all water frontages in rural lands unless otherwise authorized by the Minister.

National Parks System Act – Chapter 215 - 2000

Allow for the Water Industry Minister to recommend the designation of recharge areas or gathering grounds as protected areas.

Petroleum Act – Chapter 191(2) – (no. 6 of 1992)

This Act permits the abstraction of water for domestic and operational use and assigns responsibility for the avoidance of water pollution and contamination due to petroleum exploration, oil field development and petroleum extraction.

Private Works Construction Act – Chapter 264

Require that licenses be obtained for construction activities along river banks.

Public Health Act – Chapter 31 and 40 – 1943

This Act empowers the Minister of Health to regulate for the prevention, control of reduction of pollution and contamination of water. Health officers are empowered to inspect water and sewage works. The Chief Medical Officer may authorize or prohibit the construction and or operation of toilet facilities over sea, river or canals.

Public Utilities Commission Act – Chapter 223 – 1999

This Act establishes the Commission to assign responsibilities for water conservation and safe and reliable water supply.

Summary Jurisdiction Procedure (Offences) Act – Chapter 99 – 1953

Sets out a legal mechanism for control of the disposal of rubbish in any street, watercourse, pond, reservoir, thoroughfare, or seashore.

Belize City Council Act – Chapter 85 – 1999

Under this act, the Councils are responsible for proper storm water drainage and provision and safe operation of public lavatories.

Village Council Act – Chapter 85 – 1999

Village Water Boards are established under this act, with the responsibilities for the provision, operation and maintenance of local water service and supplies.

Water Industry Act – 2000

This act provides for the supply and control of water and sewerage services in the urban and rural communities. It also regulates waste discharges to water bodies and provides for recommendation of recharge areas or gathering grounds as protected areas.

Solid Waste Management Authority – Chapter 224 – 1991

Addresses the need for comprehensive treatment of solid wastes, establishment of landfills and an authority to manage solid wastes in Belize.

Public Works Act

Provides a legal framework for the maintenance of canals and river banks.

❖ Regional and International Convention that include Water Resources

The Government of Belize is a party to several regional and International treaties and conventions that have water resources management obligations. These obligations provide a framework for bilateral, regional and or multilateral collaboration in water resources management and development projects.

❖ Conventions with Water Resources Obligations

In 1992, the Government of Belize ratified the *Convention on Conserving Biodiversity and Protecting Priority Wilderness* areas in Central America. The objective of this convention is to preserve the land and costal zone for the benefit of the present and future generations, through the establishment of protected areas. Protected areas which include recharge areas can increase overland travel time in watersheds and allow for greater water infiltration and replenishment of groundwater stocks.

The Government of Belize ratified the *United Nations Convention on Climate Change* in 1994. As a Signatory to this convention, Belize is obligated to gather and share information on green house gas emissions, national policies and best practices; launch national strategies for addressing greenhouse gas emissions and adaptation to the expected impacts and to cooperate on preparing for adaptation strategies to the impacts of Climate Change.

The *Convention to Combat Desertification, Land Degradation and Droughts* was ratified by the Government of Belize in 1998. This convention was formally launched in 2000. Under this convention, Belize is obligated to address issues that may lead to the degradation of the land ecosystems and are required to focus on trans-boundary rivers, lakes and other natural resources. The expected result of this convention's activities is to halt or reverse land degradation and to address poverty alleviation.

The Ministry of Energy, Science, Technology and Transport (Belize) and the Secretariat of the Environment, Natural Resources and Fisheries (Mexico) signed a bilateral agreement in January 1998 for the hydro-meteorological monitoring of Rio Hondo Trans-boundary watershed. This agreement was for the establishment of hydro-climatological monitoring sites on both sides of the International Belize-Mexico boundary. Belize installed the monitoring stations at Blue Creek and Douglas Villages and Mexico installed two stations near La Union and one near Juan Sarabia.

In June of 2003, Belize and Mexico signed the Agreement No.2 of the International Commission of Boundaries and Water between Mexico and Belize for the diagnostic study for the sustainable management of the Mexico-Belize Rio Hondo trans-boundary watershed. This Act required Belize to participate in a study to determine the current state of the watershed and to propose plans for its sustainable management through 2025.

❖ Water Resources Organizational Framework

Harrison identified twenty-eight (28) areas of legal responsibilities and Boles et al identified fifteen (15). The Cardona report adopted the following four Cardona[ii] areas of focus:

1) Supply of Water and Sewerage Services;
2) Water Safety for Human Consumption and Health;
3) Protection and Conservation of Water Sources; and
4) Water Abstraction.

Institutions with legal responsibilities within the four (4) Cardona[iii] focus areas are:

1) Supply of Water and Sewerage Services:
    a. Belize Water Services Limited
    b. Village Councils' Water Boards
    c. Public Utilities Commission
    d. Ministry of Health – Public Health Bureau

2) Water Safety for Human Consumption and Health:
    a. Ministry of Health – Public Health Bureau

3) Protection and Conservation of Water Sources:
    a. Coastal Zone Management Authority and Institute
    b. Department of the Environment
    c. Forest Department
    d. City Councils and Town Boards
    e. Land Utilization Authority
    f. Ministry of Works
    g. Ministry of Agriculture

4) Water Abstraction:

    a. Public Utilities Commission
    b. Geology and Petroleum Department

TABLE 1

Institutions with Legal Responsibilities (L) or Operating (o) in Water Resources Sector					
AGENCY	Supply of Water	Supply of Sewage Services	Water Safety for Human Cosumption and Health	Protection of Conservation of Water Sources	Water Abstractions
Belize Water Services Limited	**L**	**L**			
Village Councils	**L**	**L**			
Public Utilities Commission	**L**	**L**			**L**
Public Health Bureau (MOH)	**L**	**L**	**L**		
Coastal Zone Management Authority				**L**	
Department of the Environment				**L**	
Forest Department				**L**	
Land Utilization Authority				**L**	
Town and City Councils				**L**	
Ministry of Works				**L**	
Ministry of Agriculture				**L**	**L**
Geology and Petroleum Department					**L**
Solid Waste Management Authority			**L**	**L**	
National Meteorological Service	**O**		**O**	**O**	
Bottled Water Compnies	**O**		**O**		**O**
Well Drilling operators					**O**
Aquaculture Companies					**O**
Farmers	**O**				**O**
Hotels	**O**		**O**		**O**
Ministry of Local Government and Rural Development	**O**	**O**	**O**		**O**
Social Investment Fund		**O**	**O**		**O**
Citrus Products of Belize					**O**
Belize Sugar Industries					**O**
Fruta Bomba					**O**
Banana Growers Association					**O**

❖ Water Resources Regulatory Framework

Analyses of the regulatory framework informed by Harrison[iv], Cardona (ibid), Boles[v] and confirmed by surveys conducted under this project, identified the regulatory responsibilities of the key organizations and Institutions involved in water resources.

SUPPLY OF WATER AND SEWERAGE SERVICES

❖ Water Supply

The main legislation pertaining to the supply of water and sewerage services are the Water Industry Act, CAP. 222 and the Village Councils Act, CAP 88.

The Water Industry Act pertains to a principal utility to cover all urban areas of Belize. However, Belize Water Services Limited, the nationally owned and exclusive water purveyor and sewage company in Belize, only provides such services to urban and suburban areas and a few rural communities associated with these urban areas.

The Water Industry Act provides for the supply and control of urban and rural water and sewerage services in Belize. Section 15 of the Act provides for the licensing of persons to provide water and sewerage services to the public. According to section 30, a licensee is to supply potable water for domestic purposes and a potable or otherwise satisfactory supply for agricultural, industrial or commercial purposes. The legislation imposes numerous obligations on a licensee, most importantly, to provide safe, adequate and reliable supply of water and sewerage services and maintaining, improving or extending such services to ensure that its obligation to continuously provide safe, adequate and reliable supply is met.

Section 26 of the Act imposes a duty on licensees to carry out certain technical obligations, in consultation with relevant government agencies. One of the obligations is to prepare plans for the purpose of securing the more efficient management of water in Belize, including meeting of *future demands for water and use of water*.

Although urban water supplies are the exclusive responsibility of Belize Water Services Limited, under Public Health Act, CAP 40 every town council may, and when required by the Minister shall, construct and maintain tanks and reservoirs for the storage of rain or freshwater and the council may make by-laws for regulating the issue of water from any tank or reservoir under its charge (section 54). In sections 60 - 64 of the Public Health Act, the Minister responsible for health, from time to time, may empower town councils to use the roofs of buildings (other than dwelling houses) to serve as collection surface for rain water, e.g. by fixing gutters and erecting tanks to such premises. Also under the Public Health Act, owners of private dwellings are required to maintain tanks capable of storing not less than five (5) gallons of water per square foot of space contained in such house. This act was appropriate before reliable utility supplies became available.

Under Section 43:05 of the Village Council Act, Village Water Boards are responsible for all operations and maintenance activities necessary for adequate water service and supply, including expansion. For any defined village area.

There are fifteen (15) water purifying companies providing potable bottled water to the Belizean public. The industry/companies do not have any legislation that regulates this water sub-sector. It appears that this sub-sector is regulated by the forces of supply and demand with the market only exercising pocket power. Utility water operates under inelastic demand but bottled water operates in an elastic market.

❖ Sewage Services

In Section 2 of the Water Industry Act, sewerage services relate to the disposal of all sewage - human, agricultural and industrial. Under Section 120, certain sewage could be classified as prohibited from being flushed into the sewerage system if can cause damage to or malfunction of the system.

The Belize City, Belmopan City and Town Councils under Act, CAP. 85, CAP. 86 and Act, CAP 87 are responsible for establishing and controlling the use of public lavatories, the collection of garbage and for ensuring public drains and canals are kept in good and clean condition (Sections 29 – 30 and 49).

Under Section 23 of the Village Councils Act, Village Councils are responsible for the sanitation of their villages, in general, and for the drainage and sewage.

Note that the supply of potable water for and the sanitation of the villages are legislated under the Water Industry Act and the Village Councils Act. These Acts are administered by the Ministry of Public Utilities and the Ministry Local Government.

❖ Public Utilities Commission – Water Industry Regulator

Public Utilities Commission, under the Public Utilities Commission Act, CAP 223, has the responsibility of regulating and monitoring the activities and operations of a licensee. Under Section 8, the Commission is also charged with, among other things, the responsibility for ensuring that demands for water and sewerage services, in general, are satisfied and that such supply is safe and adequate.

Under The Village Council Act, the Public Utilities Commission or other body is appointed as the authority responsible for approving standards and plans in respect of laying of water pipes; design and construction of water systems and provision of services related to water supply by Village Water Boards.

❖ Water Safety for Human Consumption and Health

The Ministry of Health - Public Health Bureau is the vanguard and primary regulator of safe potable water supplies. The Public Utilities commission is legally required to ensure that its licensees provide safe potable water to their supply areas.

The primary legislation that deals with this topic is the Public Health Act, CAP. 40. The administration of this Act is the responsibility of the Director of Health Services in the Ministry responsible for health.

This Act (e.g. Section 7) provides for inspection and monitoring by the Director of Health Services of water and sewerage works under the control of a town council or other person providing a public service. It is clear from its context that the Act is focused on ensuring the safety of water for human consumption and human health and the safety of sewerage works, likewise for human health purposes.

Sections 9 - 25 and 52 - 53, in particular, provides for the director to regulate and monitor construction of sewage facilities and to regulate the provision of drainage in towns and for private and public buildings. Section 132 also provides for the making of regulations for the sanitation of sewage facilities. Under Section 57, the director has the power to determine whether well water is polluted and to regulate the use of such polluted well water for consumption. Under Section 58, the director has the power to regulate the manufacturing of ice. By virtue of Section 122, a health officer is empowered to apply oil to stagnant water (including water for drinking) for the prevention of mosquito breeding; and Sections 147 - 148 empower a Public Health Officer to require the owner of swampy land to clean or fill such land.

In keeping with the jurisdiction of the Ministry responsible for health, over water safety for human consumption and health, Sections 35 and 55, for instance, of the Water Industry Act, provides, respectively, that the monitoring and control of the quality of water supplied by a licensed supplier of water and sewerage services shall be the responsibility of the Ministry charged with the subject of health and that that Ministry may require fluoridation of water supplied by a licensee.

❖ Protection and Conservation of Water Sources

The protection and conservation of water sources is often considered an environmental issue. Up until this point, the responses have been to human that impacts on the availability and the quality of water for potable supplies and health as well as ecosystems. Legislations pertaining to this topic are the Water Industry Act, CAP 222; the Environmental Protection Act, CAP. 328; the Forests Act, CAP 213; the National Parks System Act, CAP 215 and the Land Utilization Act, CAP. 188.

The Water Industry Act, CAP 222 Sections 27 – 29, provides for gathering grounds or recharge areas to be retained as forest reserves, national parks and under Section 58 the Minister responsible for forests may declare such areas as controlled areas to protect the sources of potable water supplies. The Forests Act, CAP. 213 and the National Parks System Act, CAP. 215 provide for the regulation of the use of the land and other resources, including water located in any area designated as gathering areas or water catchment areas. The Land Utilization Authority, Regulation 19, provides for the Minister responsible for lands to make regulations for the better utilization of land, including the demarcation of water catchment areas or watersheds and prohibiting the clearing of any vegetation within those areas. Under the Environmental Protection Act, CAP 328 Section 10, it states that it is the duty of natural resources including water, exploiters to ensure the protection of the environment against unnecessary damage or from pollution by harmful substances.

The Water Industry Act, in Section 70, regulates discharge wastes or pollutants into or onto any water or watercourses, likewise, the Environmental Protection Act, Section 11 and Part IV prohibits the discharge of waste that might directly or indirectly pollute water resources. The Environmental Protection (Effluent Limitations) Regulations, CAP 328, apply to discharges of sewage or industrial effluent into any inland waters; and Regulation 7 requires all sewers and sewerage systems to be maintained in a good working order and sanitary manner to the satisfaction of the Department.

The coastal zone is the end user of all the discharges from the terrestrial water resources related activities. Coastal Zone Management Authority, under the Coastal Zone Management

Act, CAP 329, has a mostly advisory role with respect to the formation of policies in regard to the coastal zone for the development and utilization of the resources of the coastal zone, in an orderly and sustainable fashion. The CZMA is in the process of being re-vitalized.

❖ Water Abstraction

The following legislation provides for the abstraction of water in one way or the other: the Water Industry Act, the Petroleum Act and the Mines and Minerals Act.

❖ Water Industry Act

This Act makes provision for the regulation of water abstraction and use in any area of Belize (Section 58) designated for such regulation in the interest of the public. In any area designated as a controlled area or controlled use area or controlled class of uses, the abstraction or use of water in such areas is subject to the grant of a license. However, occupiers of land in such areas, may use water for domestic purposes including: watering live-stock and irrigation of subsistence garden without the need for obtaining a license. This right and such provisions as contained in Sections 62 (2) (a) and 68 recognizes the long recognized right of landowners to access and use water adjacent to or on their property (riparian rights).

❖ Petroleum Act and Mines And Minerals Act

Under the Mines and Minerals Act, CAP 226, according to the definition of 'mineral' in Section 2, water is not classified as mineral and, therefore, that Act does not regulate abstraction of water in general. Only the abstraction of water taken for the extraction of a substance of commercial value such as minerals is regulated.

Under the Petroleum Act, CAP 225, persons conducting petroleum operations have the right to abstract and use water found in the contract area for domestic use and for the purpose of petroleum operations.

CONCLUSION AND ANALYSIS OF EXISTING LEGISLATIONS WITH WATER RESOURCES MANAGEMENT OBLIGATIONS

With the exception of the Water Industry Act and the Public Utilities Act, that have specific references to water resources, all other legislations include water resources as an add on obligation secondary to the primary intent of such legislations. Consequently, this leads to fragmented and, in some cases, ineffective legislation to deal with water resources issues.

The Integrated Water Resources Management is universally accepted as the best model for the management of water resources. Due to the sub-sectoral nature of Belize's legislations, generally, do not include integrated water resources management principles and, consequently,

water resources activities are uncoordinated with different sets of sub-sectoral guiding principles. Their primary focus is on the supply of water and sewerage services and the protection of water, for present day human consumption and environmental health and to a better defined extent for the benefit of the current ecosystem.

The legal responsibilities in these independent legislations provide overlapping authority over many water resources issues. Such overlaps do not ensure that the relevant bodies will apply the same standards or guiding principles. Successful applications of standards and guiding principles are the results of inter-agency cooperation and coordination.

The Land Utilization Act obligates the Land Utilization Authority with the demarcation of the water catchment areas, while the Water Industry Act provides for the protection of water catchment (recharge) areas and the regulation of abstraction of water. Furthermore, the Forest Act and the National Parks Act also make provisions for the protection of recharge areas through the designations as protected Area.

The Water Industry makes provisions for Belize Water Services Limited to provide water supplies and sewage services. However, the Village Councils Act also makes provisions, through the water boards, for the supply of water. Belize Water Services Limited has the exclusive responsibility to provide urban and some rural Belize with water and sewage services while under the Public Health Act the Town Councils have a measure of responsibility for water quality which was standing water and vector control. While the Town Council's responsibilities were relevant during the drafting of the Public Health Act, the current situation deems this obligation as outdated.

The supply of water in the urban areas is subject to both the Water Industry and the Public Utilities Commission Acts, whilst in the rural areas the supply of water is subject to the Public Utilities Act, only.

The Petroleum Act provides for the right to the abstraction of water from groundwater stocks for domestic purposes for petroleum operations and the Water Industry Act provides for the licensing of water abstraction from surface and groundwater stocks in varying classes of controlled areas. The Minerals Act does not include water as a mineral; however, it does make provisions for the abstraction of water for use during the extraction of minerals. Water abstracted during petroleum and mineral operations are regulated. The Ministry of Agriculture promotes and supports irrigated crops to address food supplies and security issues; however, there is no legal provision for the allocation of rights for the abstraction of water for irrigation purposes.

TABLE 2

CURRENT AND PROPOSED KEY LEGISLATION INCLUDING CLIMATE CHANGE

LEGISLATION	STATUS	THEMES	INSTITUTIONS	ADEQUACY*
Public Health Ordinance, 1943	active	Potable water distribution, protection and quality	Department of Public Health	Somewhat adequate for Climate Change
Water & Sewerage Ordinance, 1971	defunct	Establishment of Utility for Water and Sewerage	WASA - ended with creation of BWSL	Served its time Inadequate
Water & Sewerage Sanitary Instrument, #29 of 1982	Active	Upgrading the original Act of 1971	WASA	Somewhat adequate for Climate Change
Environmental Protection Act, #22 of 1992	Active	Environmental protection and conservation	Department of the Environment	Somewhat adequate for Climate Change
Pesticides Control Act of 1995	Active	Control of hazardous agro-chemicals	Pesticides Control Board	Inadequate
National Lands Act #83 of 1992	Active	Sets out conditions and procedures of land tenure	Ministry of Natural Resources	Inadequate
Land Utilization Act, 1993	Active	Ditto	Ministry of Natural Resources	
Mines and Minerals Act of 1994	Active	Sets up administration and control of mineral resources	Geology Department	Inadequate
Solid Waste Act of 1991	Active	Management & control of solid waste	Solid Waste Authority	Inadequate
National Parks Systems Act of 2000	Active	Statutory organization to conserve protected areas created	Protected Areas Conservation Trust	Inadequate
National Emergency Management Organization Act	Active	Emergency /Disaster planning, management and control	NEMO	Inadequate. Needs upgrading for Climate Change
Water Resources Management Act, 2006	Active	Administration and management of water resources	Pro-Tem Water Commission	Inadequate
National Village Council Act of 1999	Active	Organization and administration of village councils	Water Boards	Needs upgrading
National Integrated Water Resources Management Act	In draft	Administration and management of water resources	New entity	Good for policy social slant
Watershed Protection Act	Not initiated	Comprehensive management of the nations' watersheds. Could be included in Water Resources Act.	New Entity or Forest Department	Unknown
Water Industry Act, 2001	Active	Sets out responsibilities of DOH	Public Health Bureau	Nearly adequate

***** Adequate refers to addressing Climate Change. Particular water sector issues already addressed

NATIONAL AND INTERNATIONAL TREATIES AND CONVENTIONS WITH RESPECT TO CLIMATE CHANGE

❖ Climate Change Convention

This Convention is to stabilize the level of greenhouse gases in the atmosphere, to avoid triggering rapid climate change. Signatories pledge to work for the reduction of greenhouse gas emissions, the protection of greenhouse gas sinks and reservoirs and the mitigation of any effects of climate change. [2]

❖ Kyoto Protocol

The Kyoto Protocol represents the first binding agreement for cause reduction and sets targets under the United Nations Framework Convention on Climate Change (UNFCC). Developed countries agreed to reduce their emissions of greenhouse gases (GHGs).[3]

❖ Millennium Development Goals

The Millennium Development agenda sets out key tasks and targets which relate to the rights and obligations of states with respect to human needs for water.[4]

INTEGRATED WATER RESOURCES MANAGEMENT

The guidance document of the International Water Resources Management (Global Water Partnership) sets out the definitions and parameters for good water stewardship-policy, aims, objectives and practice.[5] Belize is loosely connected to the regional grouping.

[i] Report on legislation
[ii] Cardona, Jose A., Report on Draft Policy on Integrated Water Resources Management (IWRM) and Draft Legislation on Integrated Water Resources Management
[iii] Cardona, Jose A.,Report on Draft Policy on Integrated Water Resources Management (IWRM) and Draft Legislation on Integrated Water Resources Management, 2005
[iv] Harrison: Report on Belize's Integrated Water Resource Management Policy,1994 FAO
[v] Boles, Ed, Buck David, Esselman Peter C.,: Synthesis of Water Resource Conservation, Management and Research Activities in watersheds of Belize: The Nature Conservancy 2008

[2] "Climate Change Convention",
[3] Kyoto Protocol
[4] Millennium Development
[5] IWRM

NATIONAL ADAPTATION STRATEGY
TO ADDRESS CLIMATE CHANGE IN THE WATER SECTOR IN BELIZE

STRATEGY AND ACTION PLAN

(Annex III - INSTITUTIONAL CAPACITY ANALYSIS)

Prepared for the

Caribbean Community Climate Change Centre

Belmopan, Belize

by the
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MARCH 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 Belize, the Caribbean Community Climate Change Centre or the World Bank.

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Executive Summary

This review addresses the institutions that are currently charged with the current functional responsibilities for water as product or water resources sector management.

The listing of the agencies is organized according to descending order in terms of importance. The Ministry of Natural Resources executes most current and future functions since it has the largest number of related technical departments. Thus, it is identified as the key player in future strategy and actions.

A capacity rating is assigned to each functional administrative stakeholder and a particular analysis is paid to the monitoring mechanisms and analytical capabilities of laboratories. Limited monitoring was found to be occurring but the quantity was insufficient to build of databases and baselines so important for factual decision making in light of Climate Change. Laboratories' capacity and capability were found to be significantly sub-par and need to be upgraded. The singular recommendation which has been made is for the establishment of a single water quality laboratory. This laboratory should be a technical support unit of the new water agency already proposed elsewhere.

There is currently an operating Hydrology Unit under the National Meteorological Service. It is under-sized, understaffed and under financed in view of the importance of making climatological observations to compile and build baselines and databases. The major gap in the data for the country shows that in view of Climate Change and the water resources - the real time inventory of all waters particular sub-surface and aquifers needs to be put into place immediately.

The technical support and services were found to be in need of significant upgrading and the SWOT's analysis of the entire water resources sector substantiates this finding

INSTITUTIONAL ASSESSMENT

This capacity review of the institutions identifies the organizations and evaluates their critical roles, responsibilities and roles as they relate to the water sector and climate change.

INSTITUTIONS AND RESPONSIBILITIES

GOVERNANCE

The bi-cameral National Assembly is comprised of a House of Representatives and Senate. Portfolio responsibilities are assigned to members of both houses when they are appointed as Ministers. The Cabinet is the executive body which decides and approves measures coming to the National Assembly. National or central government's role for water resources is an overarching one and covers the areas of vestment, governance, leadership, administration, protection, infrastructure and external affairs as in the case of

trans-boundary issues. Municipal and local governments have a very limited role, although water resources governance and services has local definitions.

Responses to the need for national management of water resources can be described as having come about incrementally and then only as needed. These responses have come in a parochial, rather than a strategic fashion, as is evidenced by the various pieces of legislation. The strategic design and implementation of a focused water resources management plan has not occurred, due to absence of an integrated and holistic approach to water management. The governance and administrative structures for the management of water resources are fragmented among several ministries, departments and units and is relatively uncoordinated.

A fully operating central administration for water resources management with coordinated and hierarchical focus is not in place. The current structure can currently be defined as a flat structure in practice. Financial resource allocations for water resources have been minimal from a national integrated management perspective. Historically, outlays have been only on the delivery end for residential/domestic use. However, lack of proper allocations cannot be exclusively blamed for the lack of strategic design but, equally at fault, has been the absence of national mobilization including the lack of appropriate threats and ownership. Global Climate Change is the supra threat and strategic imperative, but the coordinated response and treatment including full administrative infrastructure for national interests is only prepared.

❖ CABINET

The Constitution establishes a Cabinet for Belize as the executive authority. The Cabinet consists of the Prime Minister and other Ministers. The current administration has a Cabinet composed of a Prime Minister and fifteen (15) other full Ministers and five (5) Ministers of State (junior ministers). Ministers, including the Prime Minister, are assigned portfolios of responsibilities. Ministers head these ministries that are organized as the uppermost administrative units and are responsible for executing decisions from Cabinet in relation to their assigned portfolios. Functional administrative units such as departments and statutory bodies are charged with the direct execution.

Cabinet determines the general direction and control of government. Cabinet has the key responsibility for policy consideration and approval of those policies, relevant to its political definitions of governance. Arising out of the functional apportionments are accountability for results and spending. The government backs up by supplying budgetary financial resources that are voted in the national budget, in order to provide the requisite financial support for planning and execution of policy. The Cabinet also approves any policy and accompanying proposed legislation for presentation to the National Assembly.

❖ MINISTRIES

A number of government ministries are directly and indirectly involved in water resources management. These are listed, in the tabular form, with their accompanying responsibilities and lines of authority including the departments and statutory bodies.

The Ministry of Natural Resources has a generalized charge but the charge is not unified nor coherently spelt out with respect to water. This absence is accompanied by an over-arching water policy and related legislation, although there have been several attempts at drafting of comprehensive policies and legislation relating to the gathering, collection, standing, environmental protection and terms of use especially for large water bodies such as rivers, lagoons, aquifers and territorial seas.

Other ministries have separate functional charges but are confined to one (1) or two (2) aspects of water, rather than an entire treatment of water resources. The Ministry of Natural Resources is considered primus inter pares in water resources issues since water resources are a natural resource. This ministry also has the largest number of departments involved with water. Inter-disciplinary and inter-ministerial interactions and participation takes place through various committees requiring multi-disciplinary representation.

A number of other government ministries are involved as key but minor players in water resources management. These are listed, in the table below, with their accompanying responsibilities and lines of authority including the departments and statutory bodies.

Table 1. GOVERNANCE CHART – KEY PLAYERS FOR WATER RESOURCES AND CLIMATE CHANGE

National Assembly – Parliament Sub-committee
Cabinet - Cabinet Advisory Committees

MINISTRIES	DEPARTMENTS	WATER RESOURCES RESPONSIBILITY	CLIMATE CHANGE RESPONSIBILITY	STATUTORY, COMMISSIONS & RELATED BODIES	CAPACITY RATING (1-5)*
Natural Resources	Environment	EIA's, Compliance Conservation, Pollution	Loosely Defined	NEAC	2
	Lands	Permitting	Loosely Defined	None	3
	Geology	Allocations of land containing water bodies	Loosely Defined	None	2
	Forest	Minerals, Petroleum	Watershed Management	None	4
	Meteorology		Focal point for Climate Change	Pro-Tem Water	1
	Land Information Center	Watersheds Climate, Hydrology, Climate Change Cartography	Technical Support	Commission None	4
Health	Public Health Bureau	Potable and Domestic water supplies	Same	None	3
Agriculture	Agriculture	Food Security	Loosely defined	BAHA	4

Works	Works	Inland water bodies-navigation	Loosely Defined	Port Authority	3
NEMO & Transport	NEMO Transport	Disaster Management Logistics	Integrated Response	None	5 3
Public Utilities	None	Service providers	None		
Foreign Affairs	Foreign Affairs	Mutual interests, Conservation, Border Issues, Utilization and Boundary Waters	Technical issues	Bi-Lateral Commissions Guatemala, Mexico	4
Finance	Office of Budget	Allocations of money	Funding	None	3
Economic Development	Economic Development	National Planning	All aspects	None	3

*** Score is 1-5, 5 being best but is subjective and are guesstimates of capacity to respond to climate change**

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- **MINISTRY OF NATURAL RESOURCES**

This ministry is the lead ministry with respect to water resources and has the full responsibility for the administration of all our natural resources. The active departments listed are directly derived from key functions with respect to water resources administration. This ministry also has technical units and supporting staff such as the Lands and Survey Departments as well as the cartographic Land Information Center. Unlike minerals, lands or other natural resources, water resources has never been considered to be of such importance as to deserve its own department or sub-administration unit.

The economic value of water has never been fully recognized and, thus, has not been afforded the importance it deserves. Despite some changes in the picture of water abundance, the view of water in the political eye has not been focused enough to bring criticality to water resources management or its nature as a finite resource. Belize is blessed with very high inventories of freshwaters and other natural waters and a huge internal sea behind the barrier reef. Water is still strongly viewed as a free public good, an annually replenished externality put there for everyone's indiscriminate and unregulated use, except for some regulation.

The most focus with respect to water resources and the effects of Climate Change in this ministry are centered in the Departments of Meteorology including the Hydrological Unit and less so in the Ministry. Despite several attempts over many years, the ministry has yet to promulgate a water policy. The Caribbean Community Climate Change Centre/Mainstreaming Adaptation to Climate Change (CCCCC/MACC) project has brought the scenarios under climate change to bear. They have taken up the effort at getting a water policy formulated, legislation drafted, strategy identified and an action plan drawn up for water, as a natural resource. These actions will bring the attention that Global Climate Change deserves.

DEPARTMENT OF METEOROLOGY

This department provides climatology and hydrology services. It is the principal focal point for current efforts relating to water resources and is a key player for the efforts, directed under the regional Caribbean Community Climate Change Project. It maintains current database of the climate of Belize and utilizes this data for predicting and informing all sectors of the national community. Aside from daily and period weather forecasting, it also provides information on atmospheric conditions and events useful in the management of climactic hazards especially storms and, particularly, hurricanes. The Meteorological Department is expected to provide technical guidance to public sector agencies on the use of meteorological information and the application of meteorological information, and has a hydrology unit that focuses on water resource assessment, agriculture meteorology as well as cooperates with all relevant scientific institutions. This department is understaffed and heavily engaged in regional and international participation.

HYDROLOGY UNIT

The Hydrology Unit of the National Meteorological Service, which prior had departmental status, is now composed of a hydrologist and two (2) technicians and is responsible for implementing the Ministry of Natural Resource programs relating to collection and analysis of data on quantity, quality and variability of the nation's water resources; conduct hydrological investigations for engineering and water resources projects and publish and disseminate hydrology information. The unit advises the government on watershed and environmental management and natural disasters such as droughts, floods and water pollution. Water resources are contained in rivers, lagoons, streams on the surface and underground and are typically organized for management purposes in watersheds/basins. Given the predicted scenarios under Climate Change, the unit is understaffed, under-funded and has too much ground to cover.

DEPARTMENT OF THE ENVIRONMENT (DOE)

Under the legislation of 1992, the department is charged with Assessment of Natural Resources, Development Control, Land Use Planning, Control of Waste Discharges, Pollution Control, Pollution Monitoring, Enforcement, Use of Natural Resources, Policy Formulation, Cooperation and Publicity. This department is loosely connected to Climate Change efforts but is a major player in terms of its actions related to the strategies for adaptation.

FOREST DEPARTMENT

The Forest Department was established to exercise overall responsibility and to directly manage national owned forest lands and forest resources including the bio-diversity, to advise and assist private landowners on the management of private forest lands. The Forest Department is also charged with responsibility for watershed management for the purpose of minimizing erosion. The effects of erosion are becoming more pronounced and, particularly, intensive during floods. A specific objective in the management of the Forest Reserves ought to be the maximization of water retention and reduction of flood peaks. The department is mandated to conserve and enhance watersheds - forests, water, soil and other related natural resources on a sustainable basis.

The Forest Department has prepared and published the National Forest Strategic Plan that involves management and conservation but the treatment of Global Climate Change is inadequate.

GEOLOGY DEPARTMENT

The Geology Department is charged with all the physical natural resources, some of which are contained in water bodies but does not actively administer the water resource itself. Historically they have concentrated on building or road metals and mineral exploration. More recently they have elevated functions to deal with gold mining and petroleum extraction activities that are coming into production phases and there will be effects on both the surface and subsurface water assets. Treatment and positions on Climate Change are not comprehensive.

LANDS DEPARTMENT

The Lands Department is directly concerned with terrestrial affairs pertaining to ownership and land development terms, land sales and issuance from the national inventory. There are many bodies of water which are involved in land transactions and legacies. Lagoon fronts, river fronts and sea fronts are all important in considerations of the effects Climate Change and current rules of granting and occupancy, land reservation and de-reservation, land class classification and definition will need revisiting to reflect impacts of Climate Change such as declarations of flood zones and prohibition of issuing lands in these flood zones. Any effort should be in concert with master planning for land utilization and land utilization policy.

- **MINISTRY OF HEALTH**

The ministry has long been involved with the procurement and quality of public supplies of potable water. The ministry has operated a well drilling program for the various rural water supplies programs. The ministry, through its Public Health Bureau, is currently actively engaged in monitoring of potable water quality for public and domestic consumption. Their capacity is just below adequate but can be boosted, incrementally and easily, in the face of Climate Change. The potable water unit is one of the functions that should be transferred to the new water resources administration agency.

- **MINISTRY OF AGRICULTURE**

AGRICULTURE DEPARTMENT

The Ministry of Agriculture is concerned with the uses of water resources for agriculture and the use of fertilizers, pesticides and other agro-chemicals. These agro-chemicals have a polluting effect.

There is an irrigation unit but it does have nor exercise jurisdiction with respect to water resources. The ministry is integral to any policy-decision affecting water resources, since

irrigation water is becoming a more important topic in agriculture. Permits are not now required from this ministry for the extraction from surface or subterranean sources to be used for irrigation. The ministry does not have programs for on-farm capture and retention, nor is aquifer re-charge considered as important since the majority of arable land is underlain by limestone formations. The ministry does not have any planning document with respect to water resources and Climate Change.

This ministry has two statutory bodies which are indirectly related to water sector issues.

BELIZE AGRICULTURAL HEALTH AUTHORITY (BAHA)

BAHA is directly involved with handling the technical issues of food security. Water is a food item although administratively not treated as such. BAHA deals with a small area of water resources affecting animal health and food contamination. Manufactured/bottled water is unregulated.

PESTICIDES CONTROL BOARD (PCB)

The Pesticides Control Board licenses and authorizes agro-chemical products and certifies users of those products. The outlier objective is the prevention of indiscriminate threats to our land and water resources due to the polluting nature of these substances used in fertilization, insect and weed control.

FISHERIES DEPARTMENT

The Fisheries Department exercises limited administrative jurisdiction over the water resources that are contained in the sea, coastlines, islands, rivers and inland bodies. An important and substantial aquaculture industry has arisen in highly vulnerable areas. This industry and the sister marine industry will be significantly impacted by Global Climate Change in many dimensions such as sea level rise, reduced or intense rainfall and storms. Our seas are the ultimate repository of our terrestrial water resources. Global Climate Change is expected to cause temperature rise and loss of feral populations as well as submergence of islands.

➢ MINISTRY OF NEMO AND TRANSPORT

NATIONAL EMERGENCY MANAGEMENT ORGANIZATION (NEMO)

The National Emergency Management Organization is directly charged with the management of disasters and their after effects. Climate Change is expected to aggravate catastrophic outcomes especially with regard to water resources. The availability is expected to be affected due to deleterious effects such as contamination by natural or anthropogenic agents. NEMO is required to be engaged in planning for national and other local response to threatening issues pertaining to water resources, especially potable water resources during catastrophic events.

➢ MINISTRY OF WORKS

This ministry is, in principle, responsible for the public infrastructure for water control and planning.

The physical infrastructure for water control is weak and the topic of water resources does not elicit great excitement except when road design and damage has occurred. National plans for dealing with Global Climate Change, especially district or large area control, do not exists although there have been flood mitigation and drainage works in the Belize City and the Belize District. Water control is limited only to works related to drainage and water mitigation.

➢ MINISTRY OF PUBLIC UTILITIES

This ministry has a singular commission engaged in any aspect of the water sector – the Public Utilities Commission (PUC). Its participation is limited to the regulation of the utilities concerned with supply and demand of water through the Public Utilities Commission. The dams in Belize and their status as reservoirs, role in flood control does not fall under this ministry or any single ministry. This control has been surrendered under the various Master Agreements governing dam construction but the flood control aspects as a by-product than an inherent part of dam design.[1]

➢ PUBLIC UTILITIES COMMISSION

The Public Utilities Commission (PUC) was established by the Public Utilities Commission Act. Currently, the PUC has full responsibility for regulating the utilities in Belize. This regulation is confined to regulating the utility company Belize Water Services Limited, with regard to the provision of water for the public consumption. Potable water supplies and sewerage fall directly under its purview. They are required to work with other related agencies in the promotion of sustainable environment.

➢ MINISTRY OF FINANCE

The Ministry of Finance is the principal authority for the budget and national spending. Insufficient financial recognition has been given for a national water resources unit but, rather, money is provided under the main budget of the Ministry of Natural Resources or other ministries. Line items do not appear in that budget dedicated to water resources.

[1] "Third Master Agreement"...

➢ MINISTRY OF FOREIGN AFFAIRS

The Ministry of Foreign affairs is concerned with the water resources from two (2) areas of responsibility.

Sources and repositories of major portions of our freshwater resources are shared with neighboring countries and, thus, there are co-joined interests. Trans-boundary waters and issues are subject to special agreements and treaties and so, in this case, the management and participation in bi-lateral administration are required. There already exist bi-lateral commissions for the Rio-Hondo, Mopan and Sarstoon Rivers. Strategy and action planning have to accommodate bi-lateral concerns. Belize and Guatemala currently do not have any agreements or treaties with respect to water resources.

External agreements and negotiations for programs and projects fall under the aegis of this ministry. Climate Change is not a local phenomenon but is global. The Ministry of Foreign Affairs occupies a central position at the uppermost level, in terms of negotiations of external issues related to our water resources and Global Climate Change.

➢ MINISTRY OF ECONOMIC DEVELOPMENT

The Ministry of Economic Development is responsible for the determination and efficient allocation of resources to meet the needs of economic development according to the social and political agenda and needs of the country. Climate Change is already having effects upon the domestic and international economies. Water resources, being critical to every aspect of human activity, mean that the economic consequences are already needed to be included in national strategic development and action planning.

➢ MINISTRY OF LOCAL GOVERNMENT

There are two (2) municipalities - Belize City, Belmopan City and seven (7) Town Boards - San Pedro Town, Corozal Town, Orange Walk Town, San Ignacio Town, Benque Viejo Town, Stann Creek Town and Punta Gorda Town. They account for the bulk of demand for potable water and are producers of sewerage and wastewater. Climate change will pose risks to the supply of freshwater.

The Department of Local Government has decentralized, in a limited way, the affairs of villages through an Act to organize development through the establishment of National Association of Village Councils. Villages now have water boards that run rudimentary water supply and these supplies are bound to be affected by changes in water regimes-excessive water as well as shortages. Conflicts about sourcing are currently minimal as they are primarily intra-village but do not yet include ‘source, disposal or contamination conflicts’.

INTER-GOVERNMENTAL COMMISSIONS

The Pro-Tem Water Commission was established by "The Water Services Act of 2006". The Authority consisted of nine (9) members. They were required to put forward the general principles for a national water resources management policy The Pro-Tem Commission is now defunct following a few years of activity. One primary activity was the drafting of the original water policy in 1993. Its advisory functions and administrative capacity should have put them in the vanguard for water resources management under the effects of Global Climate Change.

NON-GOVERNMENTAL ORGANIZATIONS (NGOs)

Belize is unique in having a highly diverse natural resource base per capita and successive governments have allowed NGOs to administer natural reserve areas especially national parks and other reserved areas. NGOs play an important role in the management of natural resources in Belize, including water resources. National and international NGOs have been conduits for focusing on several aspects including this focus on Global Climate Change. Privately owned protected areas are managed by individuals or companies.

❖ COASTAL ZONE MANAGEMENT AUTHORITY AND INSTITUTE (CZMAI)

In March 1990, the Coastal Zone Management Authority and Institute (CZMAI) was set up with the particular responsibility for coastal zone planning and the protection of coastal ecosystems. The seas behind the reef are the repository for the water coming off the land. This organization is operating, minimally, pending a full decision to re-invigorate.

❖ MESOAMERICAN BARRIER REEF SYSTEM

The Mesoamerican Barrier Reef System is a consortium of four (4) countries that border the barrier reef system. They have been charged with the research and analysis of the reef system in the first phase of that project. This very important barrier is very fragile and, is itself, subject to significant changes if Climate Change occurs and may not tolerate more than a few inches of sea level rise. The Mesoamerican Barrier Reef System is currently in suspension before progressing to the other phases.

❖ UNITED NATIONS DEVELOPMENT PROGRAM AND THE GLOBAL ENVIRONMENTAL FACILITY

The United Nations Development Program and Global Environmental Facility are foremost in identifying and funding programs/projects aimed at any level of human and country endeavor. They have taken a lead in executing the major initiatives for the adaptation strategies for Climate Change.

- **PAN AMERICAN HEALTH ORGANIZATION**

The Pan American Health Organization has been active in Belize for many years and has executed many projects related to domestic water supplies and sanitation. They play a key role in the determination and maintenance of water quality.

- **THE NATURE CONSERVANCY, WORLD WILDLIFE FUND, CONSERVATION INTERNATIONAL**

These international NGOs have, at one time or another, provided substantial funding for conservation of areas so critical to watersheds, wetlands and ecosystems.

- **PROGRAMME FOR BELIZE**

Currently manages a 265,000 acre reserve that is a contiguous area in a very sensitive watershed. Climate Change can have a very significant impact on this area and the water resources contained and flowing out of there.

- **BELIZE ASSOCIATION OF PRIVATE PROTECTED AREAS**

Belize Association of Private Protected Areas is an association of private landholders who have reserved portions of their holdings, in order to achieve their own conservation aims and objectives but act in accordance with national aims and objectives.

- **BELIZE AUDUBON SOCIETY**

Belize Audubon Society has been a major player in conservation and conservation management. They have been forthcoming in having produced a major environmental report in which Climate Change and Water Resources have been highlighted these important topics and related topics..[2]

- **UNIVERSITY OF BELIZE AND GALEN UNIVERSITY**

Both schools have faculties of environmental/ecology science and they are graduating a cadre of environmental scientists so critical to forming the next generations of environmentalists.

[2] "Water Resources of Belize", Belize Audubon Society, 2008 pp 31-36

INTER-GOVERNMENTAL AND REGIONAL ASSISTANCE ORGANIZATIONS

USAID funded the NARMAP study which was a seminal baseline of water resources. The Inter-American Development Bank and the Caribbean Development Bank continue to make grant contributions and policy-based loans for structural improvements and would be major players in the strategy as they have been in the early phases of the Caribbean Community Climate Change project.

GLOBAL WATER PARTNERSHIP (INTEGRATED WATER RESOURCE MANAGEMENT)

The Integrated Water Resource Management explicitly challenges conventional water resources development and management systems[3]. It provides a unified and regional model for the integrated management of water resources.

- **ACTIVIST**

Belize Environmental Law and Policy Organization (BELPO**)** has been active in bringing attention to the degradation of the Mopan and, especially, the Macal Rivers in the context of conservation of the water resources of the country. Their primary focus has been the dams and the disturbance wrought by their construction.
The Belize Zoo has taken a particular interest in the destruction of the riparian and aquatic habitats due to the construction of the dams.

OTHER

The Corozal Free Zone is an area of interest since it is a major commercial retail and wholesale hub. The Corozal Free Zone is equivalent to a medium-sized Belizean town in terms of demand for water supplies and production of effluent and sewerage. Climate Change could have a significant impact on this important trading area which is located by a river or on a floodplain, not more than a mile from the sea.

GAP ANALYSIS OF THE KNOWLEDGE BASE OF THE WATER SECTOR

The knowledge base of the water resources is severely deficient with respect to quantity and quality. The water resources of Belize have never been completely inventoried but good estimates exist on a real time basis for the majority of rivers. The lagoons and wetlands have only been inventoried on a selective basis. As changes on the land, such as erosion and loss of vegetative cover have occurred, there have been increases in rates of run-off and heightened flood potential. Data of volumes of retention and storage,

[3] "Policy Choices and Challenges", IWRM Toolbox, V2 pg 1

in real time, improve flood forecasting capabilities. Aggravation of flooding has resulted in an even greater need for accurate information.

The major aquifers of Belize have been identified but roles, pathways, capacity and replenishment have not been sufficiently established. This deficiency in knowledge of groundwater stocks is a growing concern as more and more groundwater is being tapped.

The last major study on water quality for the watersheds for the whole country was performed under the NARMAP Project[i4] and has not been updated nor measurements kept up to the degree required. The analytical data for that study was acquired by field test kits and, thus, are very suspect.

- **WATER QUANTITY**

SURFACE BODIES

The water resources of Belize have never been completely inventoried but good estimates exist on a real time basis for a majority of rivers. The lagoons and wetlands have only been inventoried on a selective basis. As changes in the landform (dams) and vegetative cover (agriculture and housing) have occurred, there have been increases in rates of run-off and flood potential. Data of volumes of retention and storage, in real time, will improve flood forecasting capabilities. On the other hand, failure of the institutions to address their respective responsibilities, as it relates to aggravation by flooding, have resulted in an even greater need for accurate information with respect to water inventory.

SUBTERRANEAN

The major aquifers of Belize have been identified and their roles, pathways and capacity have not been sufficiently established and mapped. This deficiency in knowledge of groundwater stocks is a growing concern as more and more groundwater is being tapped.

- **WATER QUALITY**

The last major study for the whole country was performed under the NARMAP Project[5] and has not been updated nor measurements kept up to the degree required. The analytical data contained was acquired by test kits and, thus, are very suspect.

[4] "NARMAP Project", pp xx-xx
[5] "NARMAP Project", pp xx-xx

PUBLICLY OWNED TREATMENT WORKS (POTW) FOR POTABLE WATER

All municipalities have treatment works of varying degrees of basic capability/quality but almost all are using the same process. Water quality varies, tremendously, with waters in the northern areas (Corozal and Orange Walk) showing high salinity (conductivity ranges 800-1200 µ siemens) and southern areas (Stann Creek and Toledo), low salinity (conductivity ranges 100-200 µ siemens).

Villages have established water boards and are responsible for their village(s)' rural water systems for the delivery of potable water for domestic use only. Some of this water is used for irrigation of garden crops. Storage is in elevated tanks and treatment is confined to shot injection of disinfection chemicals – chlorination.

Villages have established water boards for the delivery of potable water primarily for domestic use. Some of this water is used for irrigation of garden crops.

TABLE 2

INDICATORS OF DOMESTIC SUPPLY QUALITY*

REGION	TOTAL DISSOLVED SOLIDS (ppm)	CONDUCTIVITY **(µsiemens)**	PROBLEM/PROCESS USED	PROCESS NEEDED
Northern	500- 700	800-1200	High pH ,High Calcium Hardness/ Alum Flocculation Hypochlorite disinfection	Hardness removal
Central	300-600	500-1000	Moderate to High Calcium-Magnesium-Iron Hardness/ Alum Flocculation Hypochlorite disinfection	OK
Southern	50-200	75- 300	High Iron, Manganese/ Alum Flocculation	Iron/Maganese Reduction (green sand) Hardness added for increased buffering of low pH.
Cayes & Coastal	500-900	800- >1500	High Sodium Salinity, Hardness,Organic Residues-Odor/ Reverse Osmosis, Disinfection	Hypochlorite for de-odorizing of non-potable supplies. Reverse Osmosis

* Source- Unpublished communication -H.Vernon

Except for Belize City, the rest of Belize is producing potable water for direct consumption with partial and incomplete treatment. Dissolved solids in these waters vary, considerably in the smaller systems from the wet season to the dry season. Suspended solids, in the form of fine mineral particles, discolor many municipal and most rural supplies due to inadequate settling and residence time. This occurrence is especially prevalent during high rainfall times when the systems cannot cope.

Water treatment in the largest systems consists of alum flocculation, settling and disinfection using hypochlorite. Town and rural systems are largely raw water treated with chlorination mostly from groundwater well sources or flowing rivers and large streams. Rural supplies are being minimally treated, usually by disinfection only and standards of quality vary considerably.

BOTTLED WATER INDUSTRY

The bottled water industry (18 + suppliers) is growing and splintering to local production. The industry is unregulated and producing all kinds of claims of purity for their products. This industry subjects water to filtration and/or treatment systems culminating in reverse osmosis and ultra-violet exposure at the highest level. Mineral removal is followed by ultra violet exposure for disinfection and is promoted to qualify the product to be labeled ‘purified by reverse osmosis’. Advertising promotes a belief that their water is pure, without proof. Scientific studies of product water quality have not been conducted. Bottled water plays a very important role, in times of significant water contamination, when there is loss of the normal supplies and the loss of public confidence in public supplies. This is especially so when extreme climate events. This private sector capability represents an un-intended strategy to climate change.

SEWERAGE WORKS

There are few post use treatment systems for water in operation in Belize and almost all effluents would fail international discharge standards. Raw and open discharges take place to the rivers. Groundwater contamination is rampant especially in areas of high water tables, the villages and towns. Drains and storm water systems are conduits of wastewater from major polluters of rivers and streams. They contain solid wastes and dissolved pollutants. There is substantial hydrocarbon pollution caused by leaking underground fuel tanks and the practice of washing vehicles in rivers.

MONITORING

➢ HYDROLOGY UNIT

The Hydrology Unit is currently carrying out a series of measurements at established gauging stations and conducts very basic physical and chemical field measurements of water quality.

Monitoring data is only as good as the fixed laboratory behind it. Field kits (HACH) are extensively used in Belize but are only good for mandatory in-situ measurements and should be backed up by fixed laboratory results, to arrive at true values with small relative error. Data generated from field kits are, unfortunately, being used for final action for environmental impact assessments and submitted in court actions.

Belize does not have a high quality analytical chemistry and bacteriology laboratory for water resources, producing consistent results of high quality assurance. None of our current laboratories can stand up to a quality assurance audit required for drinking water analysis for final action.

LABORATORY ASSESSMENT

Numerous past recommendations have been made, with respect to government owned laboratories in Belize. These have come from multi-lateral as well as national sources. The last major investment in laboratories was made by Belize Agricultural Health Authority and these facilities and supplies have been under-utilized and are degrading.

“It would be a grossly inefficient use of limited resources, (financial, human skills and equipment), to attempt to operate four (4) separate water quality laboratories. Instead, it is strongly recommended that Belize should establish a single well-equipped National Laboratory, dealing with all types of analysis (soils, food, water, waste water, etc); and serving all government departments and providing an analytical service to private interests. There is no reason why such a laboratory should not be operated on a self-financing commercial basis. The laboratory should make maximum use of existing available facilities and should, initially, be based upon the PHB laboratory. “

All the required resources are present in the country, if only the government labs were joined together

TABLE 3

WATER QUALITY LABORATORIES – INORGANIC AND ORGANIC CAPACITY*

ANALYTICAL CHEMISTRY AND BACTERIOLOGY LABORATORIES IN BELIZE BY RANKING – 25 BEING IDEAL

NAME	EQUIPMENT	STAFFING	QUALITY ASSURANCE	STANDARDS	SCORE	COMMENT
CPBL	3	4	3	4	1 4/25	Internal use only
BWSL	3	3	2	2	10/25	Lab is process testing lab
BAHA	4	3	2	2	11/25	Start and stop fits, best trained staff
Bowen and Bowen	3	2	1	1	7/25	Selling inferior data
Public Health	2	1	1	1	5/25	Too small for the identified work
UB	2	2	1	1	6/25	Inexperienced
BSI	2	2	1	1	6/25	Confined to process

* Assessed on the basis of capacity to perform the required type of work in 4 (four) criteria.

TABLE 4

MATRIX OF CAUSES OF DEFICIENCIES IN WATER QUALITY LABORATORIES

QUALITY ASSURANCE	EQUIPMENT	PERSONNEL	FACILITIES	EXPERIENCE
Lack of quality control	Wrong equipment	Improperly educated	Poorly designed	Lack of throughput
Expired materials	Defective instruments Low technology	Improperly trained	Poorly lit	Poor Methodology
Low quality reagents	Equipment not maintained	High staff attrition	Insufficient funding	Test kits only experiences
Lack of quality documentation	Inadequate equipment	Poorly motivated	Too many small labs	Lack of training certification
Invariable methods and references	Uncelebrated equipment	Gaps in learning	Lack of segregated areas	Lack of external auditing
Lack of Standard Operating Procedures	Operations beyond capability	Piecemeal training	Dangerous work environments	Lack of round robins
Poor sample handling	Fluctuating power supply	Low management skills	Hazardous work environments	Lack of experience with instrumentation
Independent knowns Unverified	Contaminating containers	Lack of senior personnel	Inadequate space	
Errors unknown	High transcription	Unfilled functions	high humidity	
Performance unknown	Low computerization	Lack of Professionalism		

SUMMARY OF EVALUATION AND ANALYSIS

The summary analysis of the water sector was prepared in a SWOT's format. This analysis is an evaluation and assessment of capacity and capability under the Climate Change scenarios.

TABLE 5

SWOT OF THE WATER SECTOR

STRENGTHS	WEAKNESSES
Very high per capita water resources	Only natural catchments and reservoirs
Low population density	Quantity of water resources unknown especially aquifers
High annual replenishment 130-500 mm per year	Perception that water as a free good
Pristine sources as alternative supplies	Inadequate national, regional flood infrastructure/plans
Fair institutional framework	Lack of dedicated agency coordinating water resources
Inter-agency cooperation	Water policy not accepted – still in draft
Strong body of conservation laws	Fragmented water legislation
Government and private partnerships	Poor maintenance of water bodies
Education level and awareness fairly high	Weak recognition of a water culture -
	Insufficient funding of the Water Sector
	Insufficient trained personnel
	Poor awareness of Climate Change issues
	Inadequate waste-water and solid waste treatment
	Landfills and waste dumps effluent impacting water bodies
	National Climate Change Policy has not been adopted
	Laboratory support infrastructure of poor quality
OPPORTUNITIES	**THREATS**
Time to incorporate Climate Change considerations	High vulnerability, especially on coast and islands
Adaptation strategies can be instituted in time	Water quality degradation from trans-boundary sources
International assistance available	Climate change effects - sea level rise, intense rainfall, etc.
Regional models are available for use	Limited cooperation among neighboring countries
Sufficient case studies exist to determine strategy and action	Seasonable supply shortages - distribution poor
Strong organizational drivers for adaptation efforts	Seasonal decline in quality

SUMMARY

The capacity of the institutions directly involved in the water is less than adequate, given the lack of government policy, legislation and mechanisms for the water sector especially in view of Climate Change.

[i] NARMAP

NATIONAL ADAPTATION STRATEGY

TO ADDRESS CLIMATE CHANGE IN THE WATER SECTOR IN BELIZE

STRATEGY AND ACTION PLAN

(AN ECONOMIC REVIEW AND ANALYSIS OF THE CURRENT STATUS OF THE WATER SECTOR)

Prepared for the

Caribbean Community Climate Change Centre

Belmopan, Belize

by the

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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 Belize, the Caribbean Community Climate Change Centre or the World Bank.

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EXECUTIVE SUMMARY

This economic review and analysis of the current status of Belize's water sector is an integral component of the Mainstreaming Adaptation to Climate Change (MACC) Project under the auspices of the Caribbean Community Climate Change Centre (CCCCC). The specific terms of reference for this economic review required, inter alia, a focus on both demand and supply of water, main bottlenecks and barriers facing the sector, the economic impacts of climate change on this sector and suggested policy options to address these challenges.

The demand for water emanates from three broad sources – residential, industrial and agricultural. Belize used marginally in excess of 15 B gallons of water in 2007, with some 19.7% being used for residential purposes, 36.5% for manufacturing/industrial purposes and 43.7% for agriculture.

Defining a main river as having a permanent water flow, Belize has eighteen such "catchment areas" though it depends on its water supply from only a few main sources. The Macal which subsequently feeds into the Belize River, for example, supplies the major municipalities in the largest district, Cayo, specifically the twin towns of San Ignacio/Santa Elena, Belmopan and then the largest urbanized area in the country, Belize City, the largest village Ladyville, and including all the many villages in between and, finally, is also the primary source of water for all the agricultural and industrial requirements of that major agricultural-producing area known as the Belize River Valley.

Other main district towns source their water from either other rivers or from wells, with the exception of San Pedro Town where potable water is accessed using reverse osmosis. The majority of rural residents are supplied by rudimentary water systems, while about one in every five villages depend on hand pumps only. A thriving bottled water industry has also developed to serve the country's rapidly increasing demand for such a commodity. The country's agriculturalists and industrialists, generally, source their water from nearby rivers and streams, which may also serve as a reservoir for their liquid wastes.

Some of the main challenges facing the water sector include increasing urbanization, the unregulated use of water and issues relating to water quality and pollution. These challenges are likely to be aggravated by climate change which, in Belize, is forecast to result in decreases in precipitation and surface water runoff and a rise in sea levels. These threats to water security will bring commensurate threats to food security and possibly even national security. Therefore, despite the perception that water – a cyclical resource – is readily available in Belize, there is a pressing need to develop a national water culture to emphasize conserving our water resources. Though cognizant of Government's efforts to alleviate poverty and improve health conditions by making potable water readily accessible, it is important that variations in tariff structures be introduced to encourage efficient use and prevent unnecessary wastage of water. Also with broader revenue streams from such a differential tariff structure, the wherewithal for system expansions and provision of potable water to all remote villages could be sourced.

INTRODUCTION

Based on global evaluations of water resources by the UN and various other international agencies, water will increasingly become a temporary and non-renewable resource if current local and global trends persist. It is projected that by 2025, the global population will be 8.3 billion, and will grow to 9.4 billion by 2050 (United States Census Bureau, 2008). Estimates are that Belize's population is projected to reach 397, 171 by 2025 and 499,836 by 2050 (Statistical Institute of Belize). As water demand typically increases at twice the growth rate of the population, the consequent increase in agricultural and industrial activities to meet the needs of expanding populations places pressure on and exacerbates already depleting water stocks. This economic review and analysis of the current status of the water sector in Belize will, initially, focus on the demand for water and then the supply of that commodity. The analysis will, subsequently, shift to the main bottlenecks facing this sector, then a discussion on the projected economic impact of climate change on this sector and will conclude with suggested policy options.

DEMAND ANALYSIS

Pan American Health Organization (2000) notes that the demand for water resources, worldwide, emanates from three broad sources: residential, agricultural and industrial, though not necessarily in that order of magnitude.

❖ Residential Demand

Data on the residential demand for potable water, countrywide, can be gleaned from the last two census studies (1991 & 2000) and also the last two Living Standards Measurement Surveys (LSMS) (1995 & 2002) conducted in Belize. (Table 1)

TABLE 1: MAIN SOURCES OF DRINKING WATER

Main Source of Drinking Water	1991 Census	1995 LSMS	2000 Census	2002 LSMS
Public/Private piped into dwelling	31.3	43.6	29.9	25.5
Public piped into yard	18.0	18.8	17.0	12.6
Private Vat/Drum/Well, Not piped	20.1	20.0	27.3	29.5
Public Standpipe/ Hand Pump	5.6	7.2	4.2	3.2
River/Stream/Creek/Pond/Spring	7.5	2.6	2.2	2.6
Purified Water	NA	NA	16.9	24.3
Other	17.6	7.6	2.2	2.3
Don't Know/ Not Stated	0.0	0.2	0.2	0.1
Total	100	100	100	100

Source: Belize: LSMS 2002: Table 4-1.

From a high of 44% in 1995, the percentage of Belizean households using water piped into their dwelling as their main source of drinking water showed a declining trend to a low of marginally in excess of one-quarter of households by 2002. Simultaneously, there has been a major increase in the use of bottled purified water as a main drinking source.

Given the higher costs of using bottled water versus tap water for drinking purposes, it is likely that the 24% of Belizeans who mainly use purified water also possess water piped into their dwelling. Thus, it can be surmised that in 2002, some 50% of Belizean households had water being piped into their dwelling. This statistic provides a first useful indicator of the extent of demand for water for residential purposes in Belize.

Table 2 below was also gleaned from the census and LSMS data. This table shows a clear upward trend in the use of water closet as the type of toilet used by the household. Compared to the other response options, and using an average of between 3 - 5 gallons per flush, the water closet uses the most water and its use also correlates positively with income.

TABLE 2: MAIN TYPE OF TOILET USED BY HOUSEHOLDS (PERCENTAGES)

Type of Toilet	1991 Census	1995 LSMS	2000 Census	2002 LSMS
Water Closet	34.8	41.0	49.9	54.8
Pit Latrine	51.3	52.3	44.0	39.7
Other	5.7	0.2	1.6	1.7
None	8.2	4.8	4.3	3.5
Don't Know/ Not Stated	0.0	1.6	0.2	0.3
Total	100	100	100	100

Source: Belize: LSMS 2002

It is to be expected that with continued economic development, there will be greater demand for indoor toilet facilities and commensurate less use of pit latrines. The data does show declining use of pit latrines among Belizean households and there is every expectation of these trends to continue.

While it has been difficult to disaggregate the data in the tables by location – either at the district level or the urban/rural level – they do indicate that the demand for water for residential purposes in Belize is expected to increase.

It has been noted that the above data were sourced from the two most recent censuses and the two previous LSMS. As a data set, the census is the most comprehensive since its covers the entire population. The LSMS data set was also found to be useful because even though it was not as comprehensive as the census, it occurred at a different period in time and, as such, it facilitated comparison.

SIB also collects data on sources of drinking water from its labour force surveys. Though not as comprehensive in scope as its censuses or even its LSMS, the labour force surveys do provide data that are more recent (Table 3 refers).

TABLE 3: WHAT IS YOUR MAIN SOURCE OF DRINKING WATER?

Source	2005	2006	2007
	Percentages		
Piped water	29	32	30
Stand Pipe	9	4	1
Handpump	2	2	2
Covered vat/drum/well	12	14	16
Uncovered vat/drum/well	3	2	2
Purified/Bottled water	43	44	47
Rivers/creek/stream/pond	1	1	2
Totals	100	100	100

Source: Labour Force Surveys (various years): SIB

While similar is some respects to Table 1, there is a need for a separate table since the response categories for the labour force surveys differ somewhat from the response categories on the census and LSMS in Table 1.

Regarding the demand for drinking water, there are many positives to note in Table 3. The percentage of households sourcing their water from high quality sources such as purified or bottled water showed a consistently upward trend, as did the percentage sourcing their water from a covered vat/drum or well. While the percentage of households that get their water from pipes fluctuated, that one in three households get water from this source is to be regarded as a positive.

Overall, therefore, the table shows that if sources such as piped water, standpipe, covered vat/drum/well and purified/bottled water are regarded as safe, then a combined percentage of 94% of local households acquire safe water for drinking purposes. Of issue would be the remaining 6%, most of whom source their drinking water supply from river/creek/stream/pond and uncovered vat/drum/well. It is also likely that these households are located in the rural areas.

❖ Agriculture and Water Demand

Water demand for agricultural purposes depends mainly on the size and characteristics of the cultivated soils, climate and the plants under cultivation. Agricultural water demand refers to the amount of water that needs to be supplied to compensate for the loss due to evapotranspiration.

Data sourced from the Ministry of Agriculture indicate that in 2007, there were some 195,000 acres of commercial cultivation of some 57crops. These crops included grains and beans, vegetables, root crops and tree crops and other fruits. All these crops require varying amounts of water at differing stages of the production process. For most farms located near a water source, that source likely provides their water needs. The majority of the farms uses wells and relies on rainfall.

Wells and surface water sources also provide the water requirements for farmers engaged in animal husbandry. Ministry of Agriculture data also indicate a cattle population of some 76,000

heads, some 10,000 sheep and some 12,000 pigs, while 8.5M chickens were slaughtered and processed and 24,000 turkeys were slaughtered in 2007.

Belize's agricultural sector also includes fish farming, notably tilapia. This fish farm subsector of agricultural production requires a more intensive utilization of water resources. And unlike some aspects of traditional agriculture, which still uses potable water or is dependent on rainfall and/or wells or aquifers, the fish farming sector sources its water needs directly from source, whether rivers, lakes or the sea. The subsequent discharge of waste water into these sources is an issue that requires policy action.

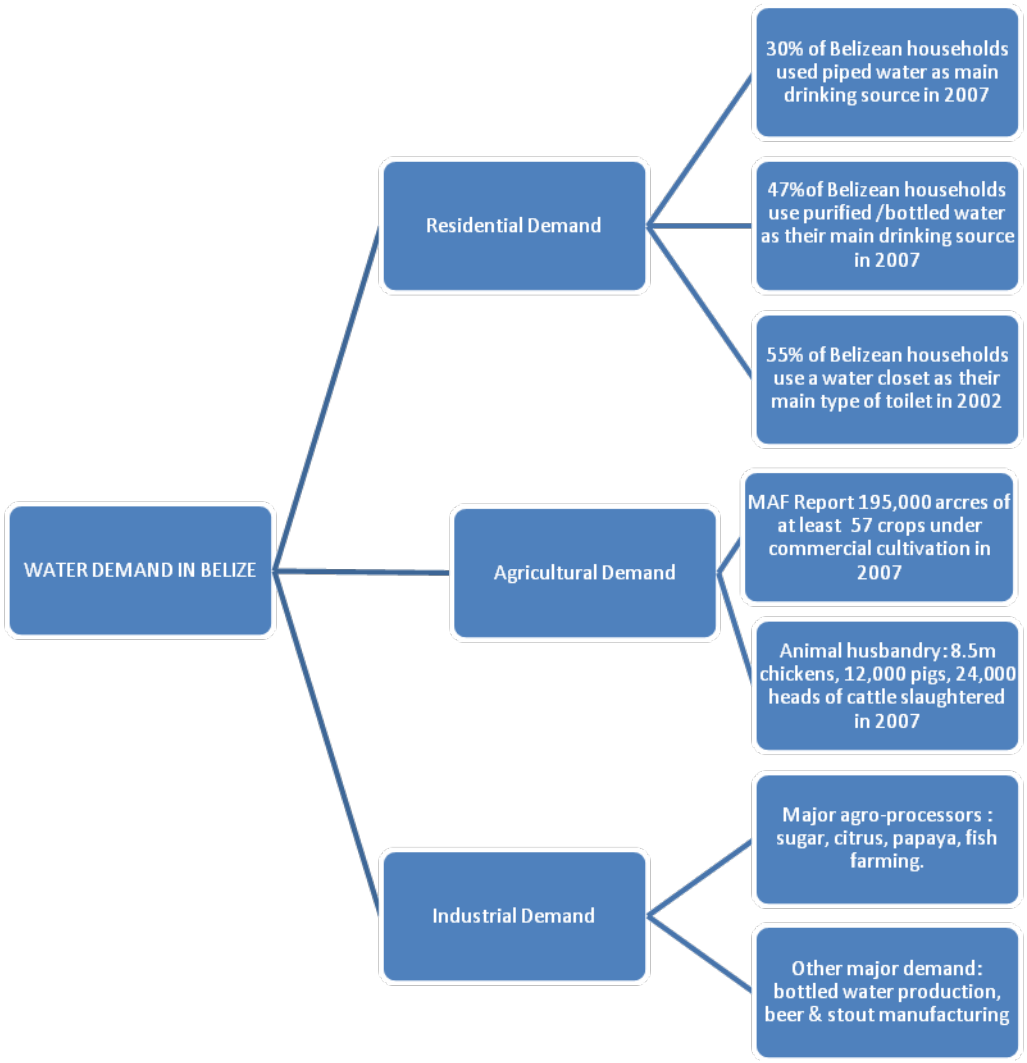
❖ Industrial Demand

Narrowly defined, this sector includes the mining and manufacturing subsectors (ERMA Consultants: 2007). For the purposes of the demand for water, these sectors can be more broadly defined to incorporate the broader range of non-agricultural and non-residential demand for significant quantities of water. As such, included would be bottled water companies that do not source their water from any public supply but rather from their own private intake, and also major tourism enterprises, which are located in far-flung areas and as such need to source their own water.

A major demand for water emanates from the bottled water companies locally. Data provided by BELTRAIDE indicates that there are some twenty such companies. While most of the companies demand potable water from Belize Water Services Limited, two of the largest companies, Bowen and Bowen Ltd. and Zeta, do not demand potable water from Belize Water Services Limited, but have their own independent sources of water intake. Bowen and Bowen Ltd. is also the local manufacturer of beers, soft drinks and other soda beverages.

The main agro-industrialists in the country can be regarded as the sugar, citrus and banana producers. The sugar processing facility, Tower Hill, sources its water from the nearby New River, while the citrus factory, Citrus Products of Belize Limited sources its water from wells near the North Stann Creek River. Banana operations are further south in the Stann Creek District where several rivers, including the South Stann Creek and Monkey rivers are some of the main water sources.

Figure 1 below outlines the major sources of demand for water in Belize.


WATER DEMAND IN BELIZE
Residential Demand
30% of Belizean households used piped water as main drinking source in 2007
47%of Belizean households use purified /bottled water as their main drinking source in 2007
55% of Belizean households use a water closet as their main type of toilet in 2002
Agricultural Demand
MAF Report 195,000 arcres of at least 57 crops under commercial cultivation in 2007
Animal husbandry: 8.5m chickens, 12,000 pigs, 24,000 heads of cattle slaughtered in 2007
Industrial Demand
Major agro-processors : sugar, citrus, papaya, fish farming.
Other major demand: bottled water production, beer & stout manufacturing

SUPPLY ANALYSIS

The Belize Water Services Limited (BWSL) is the water and sewerage utility charged with providing potable water to Belize. According to the company's most recent annual report, it serves approximately 42,000 customers with a total average water demand in excess of 140,000 US gallons on a monthly basis (BWSL: 2006/07 Annual Report). The company has nine water supply systems, countrywide, supplying potable water to all the urban municipalities in Belize. As many as twenty villages feed off these urban systems. Over 60% of the water supplied is produced using conventional water treatment processes with rivers as its sources. The remaining 40% is sourced from water wells. Whereas on the mainland, BWSL distributes water that it produces, on San Pedro, Ambergris Caye, the company purchases water produced via reverse osmosis from a private company for subsequent distribution to the general population. The company categorizes its customer base into five broad categories of residential, commercial, industrial, institutional and government.

BWSL operates sewerage systems in Belize City, Belmopan and San Pedro, only. However, in neither of these municipalities is sewerage coverage complete since the newer areas of all those population centers lack connections to the main sewerage lines. In these new sections, septic tanks remain in use. From its sewerage systems, BWSL treats all wastewater collected but only to a primary level. In Belmopan, a primary treatment plan has been installed but in the other two centers, sewerage lagoons are used for treatment.

Table 4 below details key performance indicators of BWSL over a five-year period ending in 2006/2007 financial year.

TABLE 4: KEY PERFORMANCE INDICATORS

Indicator	2006/07	2005/06	2004/05	2003/04	2002/03
Water Production (Kgal)	2,735,108	2,792,885	2,739,479	2,875,377	3,222,544
Water Sales (Kgal)	1,694,286	1,677,077	1,659,894	1,624,507	1,494,062
Beginning Connections	40,581	39,764	38,971	37,609	37,303
New Connections Added	2,634	2,785	2,764	3,675	3,316
Ending Water Connections	42,130	40,581	39,764	38,971	37,609
Ending Sewer Connections	10,441	10,436	10,333	10,231	10,130
Consumption per Connection Monthly (Gal)	3,434	3,485	3,510	3,506	3,329

Source: BWS Annual Report 2006/2007

❖ Water Supply in rural areas

The overwhelming majority of villages and rural population are supplied with potable water via village rudimentary water systems. There are some eighty-seven village water boards serving one hundred thirty-nine villages and communities. Most village water boards rely on wells as the primary source of water and use electrically-powered pumps to move water to reservoirs. The water is then distributed to households. Whereas some

systems have meters and as such charge volumetric tariffs, most systems merely charge a flat monthly fee. Funds for capital expansion of these village water systems are usually sourced from Government, through the Ministry of National Development and/or the Social Investment Fund.

About three in every ten villages and communities have no piped water service or service providers. In these villages, hand pumps are used to access ground water supplies, while nearby rivers and streams are used for washing and bathing.

Table 5 provides a summary of the number of rural communities with and without piped water services and water service systems.

TABLE 5: VILLAGES/COMMUNITIES WITH/WITHOUT WATER SERVICES

DISTRICT	Total Number of Villages/Communities with water from BWSL/RWS	Total Number of Villages/Communities without water from BWSL/RWS	Total Number of Villages/Communities
Belize	12	21	33
Cayo	32	2	34
Orange Walk	20	4	24
Corozal	24	4	28
Stann Creek	22	4	26
Toledo	29	19	48
Total	139	54	193

Source: Belize: Ministry of Economic Development: 2008

Table 6 below provides an overview of the supply of potable water in Belize.

TABLE 6: SUPPLY OF POTABLE WATER IN BELIZE

Service Area	Service Provider	Services Provided	Population size range of Service Area	Population Served
Belize City, Belmopan, San Pedro	BWSL	Potable Water, Sewage connection & treatment	8,400 – 70,800	92,000
All other district towns	BWSL	Potable Water	6,000 – 18,000	63,000
Villages served by BWS	BWSL	Potable Water	200 – 4,000	28,400
Villages served by Water Boards (139 Villages)	Village Water Boards	Potable Water	60 – 3,000	71,000
Villages without service	None		60 – 1,000	15,000 (population unserved)

Source: Belize Water & Sanitation Strategic Sector Report: 2008

Other sources of water in Belize are the bottled water companies. It has already been noted that there are some twenty such companies currently operating.

Finally, imports of bottled water represent yet another supply source of water available locally. Data sourced from Statistical Institute of Belize indicate that bottled water imports were valued at $585,000 in 2006. One year later in 2007, the value of water imports had more than doubled to $1.27M. These imports are mainly classified under the Belize Customs classifications of ordinary natural waters, mineral waters and aerated waters.

Figure 2 provides an overview of the main sources of water supply in Belize.

FIGURE 2: MAIN SOURCS OF WATER SUPPLY

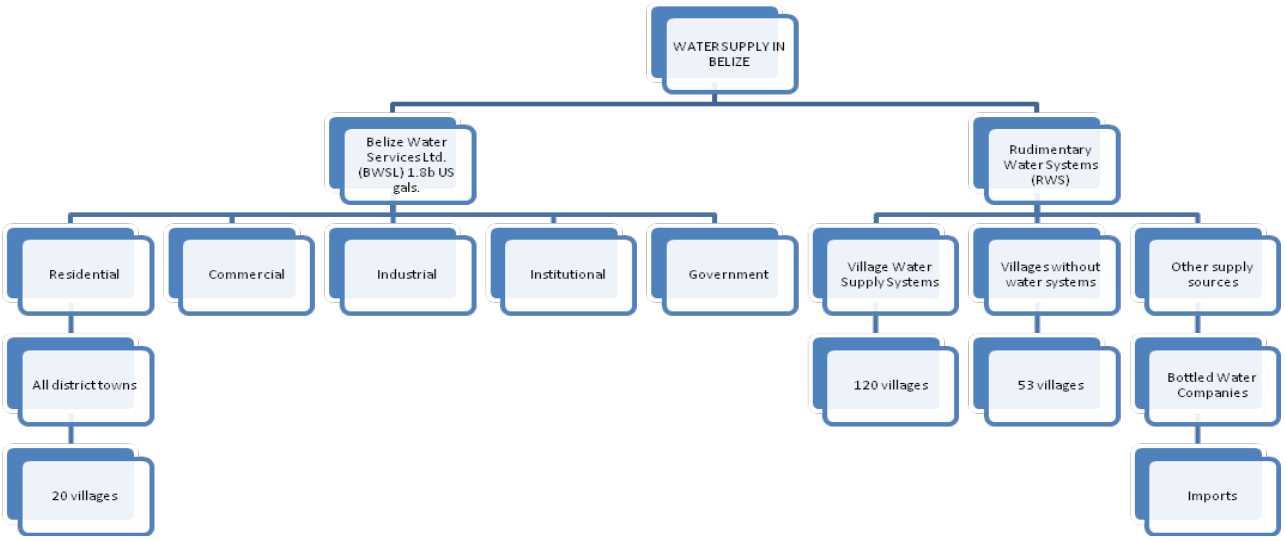


Table 7 seeks to incorporate data on the demand and supply of water in Belize into a single spreadsheet to show, among other things, greater detail on the usage of water by specific sectors.

The table shows that in 2007, Belize used marginally in excess of 15.3 billion gallons of water. Of this amount, some 19.7 percent was used for residential purposes, 36.5 percent for industrial purposes and the remaining 43.7 percent for agricultural purposes. In this regard, Belize's data are consistent with those of other countries that show an overwhelming demand for water for use in the industrial and agricultural sectors.

For several years now, Tourism has been Belize's major source of foreign exchange and also a major employer as one in every four jobs locally is dependent upon that sector. The extreme importance of this sector, in Belize and in several other Caribbean countries, has brought to the fore, issues such as the availability of potable water to ensure its continued viability. In Belize, most of the largest tourism establishments are located in urban areas and, as such, they source their water from BWSL. In the rural areas, several of the hotels source their water from existing village water systems, where

they pay at a higher rate than the villagers. Hence, the water used by these hotels would already be accounted for in water supplied either by BWSL or the rural water systems.

There are tourism establishments that are located in the hinterlands and, as such, need to source their own independent water supply. However, these establishments are comparatively few in number and they are known to be extremely conservative in the use of this resource.

The relationship of the Belizean economy with water is such that the manufacturing and agricultural sectors, which contribute a combined total of 30.3% to GDP (Statistical Institute of Belize - 2007), utilize marginally in excess of 80% of the country's exploitable water resources. The hotel and restaurant sector is a component of the tertiary sector, a sector that contributes over 60% of GDP. Statistical Institute of Belize (2008) cites the specific sectoral contribution of hotels and restaurants to GDP as 4.4%. However, since the overwhelming majority of hotels and restaurants in Belize source their water from BWSL; their water usage would be included in the 19.7% of water used for residential purposes.

TABLE 7: WATER DEMAND AND SUPPLY: BELIZE

PAHO (2000) notes that the demand for water resources worldwide emanates from three broad sources: residential, agricultural and industrial, though not necessarily in that order of magnitude. The following table seeks to provide estimates of current water usage in these three broad areas in Belize as well as the source of the water being used.

Use of Water	Service Provider	Source of Water			Total Annual Usage (Gallons)	Comments
		Surface	Underground	Rain		
Residential[i]: Main Urban Areas	BWS	1,641,064,000	1,094,043,200		2,735,108,000	Data for FY 2006/2007. BWS sources 60% of its water from surface sources.
Village Water Systems[ii]	87 water boards		258,440,000		258,440,000	Assumption of per capita usage of one-half the urban average. 71,000 villagers served.
Other Villages[iii]	Hand Pumps		27,300,000		27,300,000	15,000 villagers served. Assumption of per capita usage of one –quarter of urban usage.
Industrial:						
Bottled Water companies[iv]	Belize River, Wells	15,250,746	14,560,000		29,810,746	Nearly 50% of this amount is unaccounted for water loss.
Belize Sugar Industries[v]	New River	5,417,280,000	83,808,000		5,501,088,000	Water sourced both from surface and underground sources.
Citrus Products of Belize Ltd.[vi]	North Stann Creek River	50,880,000			50,880,000	Estimated usage: 200 gallons per minute per 20 hour day during season.
Belize Natural Energy Ltd[vii].	Underground		9,172,800		9,172,800	Produce water generated due to separation of water from crude oil.
Agricultural:						
Rice[viii]	Mopan River	999,835,200		ND	999,835,200	3 inches or 82,000 gallons per acre. Two farms use only rain water. No data from those farms.
Bananas[ix]	South Stann Creek, Sittee & Monkey Rivers	5,500,111,084			5,500,111,084	70 cubic meters per hectare per day during dry season. Some 2,350 hectares are irrigated during January to May.
Papayas	Wells		3,660,800		3,660,800	286 acres of papayas. Also rain fed.
Other Agric	Varied sources			ND		Belize has 195,000 acres of 57 crops under commercial cultivation. Most are rain fed.
Animal Husbandry[x]	Varied sources				188,315,925	Nearly 100,000 live heads of cattle, sheep and pigs.
Grand Total		**13,624,421,030**	**1,490,984,800**		**15,303,721,755**	

Source: Ministry of Agriculture, BWS, Ministry of National Development, BSI, CPBL, BNE, BGA, Alcamo et. al (1997) and estimates by the Author

[1] BWS is by far the main service provider and since its data are comprehensive; these form the basis of other estimates to be made. A perusal of BWS data over the past years indicates an annual increase of 1.4 percent. BWS data being used are production amounts and not sales, since the latter does not include unaccounted for water.

[II] BWS data indicate a national per capita consumption rate of 20 gallons per person. Per capita for the village water systems is estimated at one-half that amount.

iii Hand pumps are used to access water in villages with no water systems. There are some 20 such villages in Belize and per capita usage is estimated at one-quarter the national level or 5 gallons per person per day.

[IV] Two of the country's nine bottled water companies, Bowen & Bowen and Zeta source their own water supply. Zeta has its own deep wells and Bowen sources its water directly from the Belize River and has no metering system in place to measure water extraction. Bowen also manufactures a variety of beverages. Use of water by Bowen & Bowen was estimated from SIB data on bottled water usage countrywide.

v Estimates provided by BSI

[vi] Estimates provided by CPBL. Though water source is cited as from surface sources, the company has started to use wells.

[vii] Estimates provided by BNE

viiiGrowing season lasts 3.5 months and there are generally two growing seasons annually.

[ix] Data sourced from BGA, conversion estimates from cubic meters to gallons by Author.

xData provided by Alcamo et. al (1997) cites UN sources as estimating the use of water by livestock as follows: Cattle 25 litres per day, pigs 4 litres per day, sheep 2.25 litres per day, goats 2.25 litres per day, chickens 0.028 litres per day and horses 15 litres per day. Data provided by the Ministry of Agriculture indicate that Belize had 12,403 heads of live pigs, 9,645 heads of sheep, and marginally over 75,000 heads of cattle. No data were provided on number of goats and horses.

MAIN BOTTLENECKS & BARRIERS

Its many rivers and waterways and other inland water bodies, excluding mangroves and saline swamps constitute a total of 1.86% of its total land mass (FA0: 2005). Given its most recent population estimate of 314,300 (Statistical Institute of Belize 2008), the country does have one of the lowest population densities in the region. In her address at the workshop to present the Draft Water Sector Adaptation Strategy on December 23rd, 2008, Mrs. Beverly Castillo – Chief Executive Officer of the Ministry of Natural Resources and the Environment noted that, "Belize has the highest water availability throughout Latin America and the Caribbean" and that "none of the country's 18 major watersheds are water stressed." Though Belize has adequate supplies of water, there are issues on the horizon that require attention before becoming a major threat to the country's water supplies.

A first main issue is water quality. At the present time, the Department of the Environment (DOE) monitors water quality in only two rivers - the Macal and the New Rivers. Monitoring of the Macal was stepped up following the construction of dams on the river. DOE reports that dissolved oxygen (D0), a main indicator of water quality continues to steadily improve in this river. A recent Compliance Assessment Site Visit Report noted that "with respect to analysis done on the levels of alkalinity, chlorides, sulphate and nitrate, it can be concluded that these parameters are within the acceptable levels as per baseline data in the Environmental Impact Assessment."

The DOE reports, however, that at some portions of the New River, water quality as measured by DO is not as optimal. This may be due to emissions from the sugar factory, though these emissions undergo at least two levels of treatment, prior to being discharged into the river.

Of greater concern though, is that with respect to water quality, only two rivers are being monitored countrywide; and none are in the south of the country where the higher levels of rainfall allow minimal time for fertilizer absorption and, consequently, there is likely a greater degree of runoff into the nearby streams and rivers, which form part of the water supply network for the neighbouring communities. Ministry of Agriculture officials acknowledge this is occurring though it is not being monitored

Pollution of surface water is also seen as problematic. Some recent notable examples in this regard include spills caused by citrus operations in the North Stann Creek River, which supplies Dangriga, the largest municipality in southern Belize with its water, and aquaculture operations which affected the Sibun River in the Belize District.

Decreases in water quality will make water treatment more expensive. This is likely to impact on supply.

Polluted surface and ground water are also regarded as major causes of degradation of coastal and near-shore marine ecosystems including mangrove, estuary, sea-grass and coral reef systems (Caribbean Environmental Outlook).

Another emerging bottleneck is increasing urbanization. The overwhelming majority of the country's population is concentrated in urban settlements near the coast. The increased urbanization is forcing residents to live in marginal areas such as mangrove

settlements, which proliferate on the fringes of these urbanized areas. Challenges in supplying these residents with water include the costs of extending the water supply network and other increased overheads to supply generally lower end consumers. Furthermore, living in wetlands may also serve to threaten sources of water supply. Further expansion in sewerage cover has not kept pace with urban expansion and, at present, none of the three municipalities countrywide which has sewerage systems has more than 50 percentage coverage.

Expansion of village water systems is also seen as a main bottleneck. It has already been noted that only some twenty or about one in every five villages countrywide is being supplied by potable water from BWSL's urban network. The overwhelming majority of the other villages - some three in every five villages - are being supplied by village water systems. The locational dispersion of these villages largely renders it impossible that they be supplied from BWSL without massive injections of capital funding.

In virtually all of these villages, the existing flat rate tariff structure does not encourage conservation of water, which is a cyclical resource. Modifying the tariff structure to reflect actual usage is likely to yield multiple advantages. The first of which is that conservation will be encouraged. Persons are likely to consume less when they become fully aware that their fees are tied to their consumption levels.

Second, a tariff structure based on actual usage is more equitable. Persons with higher incomes who presently consume more ought to pay more. And finally, varying the tariff structure would likely provide the wherewithal to fund further expansions and capital works projects. At present, system expansions are being funded by the Social Investment Fund and the Ministry of National Development on an ad hoc basis. Water Boards face challenges when major capital expenditures, such as purchasing new pumps, are required. These could be easier funded from any savings generated from tariff rate modification.

To address all the above mentioned bottlenecks in the village water supply system would also likely require changes in how these systems are managed. Professional management and a level of autonomy to such managers would be necessary. This issue will be elaborated upon in the next section focusing on policy options.

For the remaining one in every five villages which has no water boards, the main issue is water quality, when available. For villages with water boards, there is a basic level of chlorine treatment administered to the water. For the villages that only use hand pumps, there is no treatment, except if villagers opt to boil the water as encouraged. In all villages sewerage disposal is mainly via pit latrines which can potentially pollute the water table from which water is sourced.

The above analysis has, thus far, indicated some generalized problems facing rural settlements and communities in Belize. However, the level of mainly tourism expansion and other developments in select areas has aggravated water problems in select locations across the country. For example, the Placencia peninsula is the country's largest tourist destination on the mainland. This peninsula is home to at least four villages and over ninety hotels and guesthouses, most of which are concentrated in a rather narrow area near the tip of the peninsula. This rapid and largely unplanned

commercial expansion and continued developments in this peninsula will likely aggravate water issues as will sewerage disposal problems.

A largely similar situation obtains in Caye Caulker where a thriving tourism destination remains largely dependent on underground water supplies sourced from wells. Again, issues of contamination of ground water supplies from the lack of central sewerage facilities also loom as a possibility.

The Corozal Free Zone is another area where accessing adequate quantities of potable water is also problematic. At the present time, most of the business establishments in the zone use wells for potable water. It has been reported that water runoff from the zone is causing some level of pollution in the Rio Hondo River, which forms Belize's northern border with Mexico.

The existence of the Mollejon Dam on the Macal River and the Challilo Dam on the Macal River and the construction of another dam, Vaca, on the Macal River can present issues to the country's water sector. On the one hand, BWSL reports that the ability of the dams to regulate the flow of water has been helpful, since in the dry season, water levels in the Macal River no longer falls to unusually low levels. On the other hand, environmentalists have raised concerns regarding levels of mercury found in fishes caught in the river since the construction, particularly of Chalillo.

And finally, sand mining emerged as an issue when residents of the North Stann Creek watershed area were sampled to ascertain from their perspective, some causes of climate change in their communities. It emerged that unregulated and illegal sand mining in the upper reaches of the river was cited by several respondents as a main cause of climate change. A study by students of the Department of Forestry and Environment Science of the University of Sri Jayewardenepura in Sri Lanka found that the over mining of sand and gravel from the Kelani River had several negative effects including salination of Colombo's drinking water due to the intrusion of sea water into the river, collapse of river bank, loss of river land (Wijemanna: 2006). From this perspective then, it may be possible that sand mining in the North Stann Creek River could be a causal factor explaining the recent destructive floods that occurred on that river for the first time in living memory.

The Caribbean Environmental Outlook (undated document) also reports that increasing rates of deforestation are thought to be contributing to severe flood and drought cycles in several Caribbean countries during the annual wet and dry seasons. Table 8 summarizes the discussion on main bottlenecks and barriers.

TABLE 8: SUMMARY OF MAIN BOTTLENECKS/BARRIERS

No.	Bottleneck/Barrier	Comments
1	Water quality	One of the main indicators of water quality is Dissolved Oxygen (DO). DO levels are only being monitored in 2 of Belize's 18 rivers or "catchment areas."
2	Increasing urbanization & unregulated use of water	Urban expansion is occurring in mangroves/wetlands and it is costly to extend the water supply network into these wetlands.
3	Expansion of village water systems	One in every five villages has no system.
4	Developing "hotspot" areas	Though well endowed with precipitation, and having a relatively low per capita daily water consumption of about 27gallons per day, "hotspot areas" are developing. These include outlying cayes, Placencia peninsula, and Corozal Freezone border area. All these areas have high tourism potentials.
5	Climate change challenges	Various climate change scenarios including reduced rainfall, severe flooding, and salination of fresh water supplies.
6	Non-climate factors	Illegal sand mining in river beds, increased deforestation, contaminants from upstream areas of watershed, and improper liquid and solid waste disposal

ECONOMIC IMPACTS OF CLIMATE CHANGE ON WATER SECTOR

To undertake the economic impacts of projected changes in climate on the water sector, a review of the relevant findings of the hydrologist/climatologist is required since their findings will feed into the economic analysis. These main findings, which made projections for the short, medium and long term horizons are encapsulated below:

- Global Climate Change is predicted to lead to increased atmospheric temperatures, causing the melting of the polar caps and resulting sea level rise. Projections in the scenarios show reduction in availability of freshwater and degradation of quality. Intensification of the hydrological cycle is expected to increase the frequencies and length of extreme events such as floods and droughts.
- **Temperature:** Trends in Belize will be consistent with the changes being observed - globally - and within the Caribbean. Analysis detected a warming trend over the baseline period from 1960 – 2005. In Region 9, coastal temperatures are projected to increase by 3.1°C by 2080, while inland; it is projected to increase by 5.0°C. In Region 11, a cooling, rather than a warming trend was observed.

- **Precipitation:** In Region 7, rainfall is projected to initially increase by 3.8% in the 2015s and to gradually fall to 1% below the baseline. In Region 9, along the coast rainfall will fall by 18% and inland by 23.1% below the baseline. In Region 11, rainfall will initially fall by 16.9% in the northern portion of the region and then fall by 18.3% by 2080s.
- **Current Trends in Runoff**: In Region 9, during the dry season, there is expected to be above normal water runoff for this entire century. A similar scenario is also expected in Region 11. In Region7, however, during the dry season, there will be above normal water runoff up to the 2070's and, thereafter, a decrease until the end of the century.

For hydrological/climatological purposes, the country was divided into three regions: Region 7 is the northern portion of the country; Region 9 is the central portion of the country and includes the Belize River Valley; and Region 11 is southwards from the Sibun River. Climate change impacts on the water sectors in these regions were not uniform and, as such, each region will be discussed separately.

In the northern region, there is projected to be a decrease in precipitation, which will likely result in a reduced recharge for groundwater in the north. Compared to other regions of the country, the north is less endowed with water resources and its existing water resources are more intensively used with irrigation of rice and papayas and by the sugar agro-industry.

A similar scenario is likely in the central region. There is also intensive use of water in this region and also this region is most densely populated since it includes the Belize and Cayo districts. Given that the southern region is least populated and has the most water resources, decreases in water runoff are not likely to have major negative effects.

An impact of climate change on the water sector is likely to be a continued deterioration in water quality brought about by a combination of decreased water runoff, agricultural pollution and increased urbanization. This will increase treatment costs for potable water as well as result in greater competition for the use of this increasingly scarce resource. This could be the genesis of water conflicts.

Any reduction in availability of water especially for agriculture is likely to have an impact on food security. The northern and central regions of the country are the country's bread basket, where the overwhelming percentage of one of its major staples – rice - is grown. A comparatively smaller percentage of the country's rice is grown in the south via rain fed methods, but it is mainly in the north that intensive use of water for rice growing is done since irrigation is more widespread.

Yet another impact of climate change on the water sector is increased frequency of salt water intrusion. This will occur as sea levels are projected to rise. Salt water intrusion is regarded as the displacement of fresh surface water or groundwater by the advance of saltwater due to its greater density. It usually occurs in coastal or estuarine areas (e.g. either from reduced runoff and associated groundwater recharge or from excessive water withdrawals from aquifers) or increasing marine influence (Bates et al 2008). Monitoring along the Belize River has found evidence of salt water intrusion as far upstream as the Philip Goldson International Airport, which is only a few miles downstream from Double Run, the location of the water intake that BWSL uses to supply Belize City. Saltwater intrusion may also be possible in Dangriga, where BWSL's water

intake is only some two miles from the coast. The economic impact on the water sector arises when potable water supplies are affected by this intrusion resulting in increased treatment costs and decreased water quality.

Climate change is also likely to bring to the fore, issues with national security implications. This is because some of Belize's major rivers originate in neighbouring countries which are likely to experience similarly negative climate change impacts. Actions by these countries could affect the flow of water to Belize. For example, Belize's main waterway, the Belize River, has marginally in excess of 30% of its watershed in Guatemala. There is a substantially higher level of poverty in Guatemala, most notably in its provinces that proximate Belize's border. There are also more intensive agricultural practices that are likely to negatively impact water quantity and quality flowing eastwards to Belize. A largely similar situation obtains in southern Mexico, from where the Rio Hondo is sourced.

Table 9 below summarizes the economic impacts of possible climate change events on the water sector:

TABLE 9: SUMMARY OF ECONOMIC IMPACTS

No.	Climate change event	Economic Impacts on water sector
1	Decreased precipitation & decreases in surface water runoff	Greater impacts in northern region 7, where there is intensive use of water for agricultural and industrial purposes. Great impact in central region 9 overwhelming portion of country's population lives, and likelihood of increased competition for water. Impact on food security as north and central regions are the breadbasket of the country.
2	Rise in sea levels	Salt water intrusion could impact Belize and North Stann Creek rivers, affecting water quality for Belize City/Ladyville and Dangriga, respectively.
3	Intensification of hydrological cycles – droughts & floods	Droughts could lead to water conflicts. Water and national security implications as some of the country major rivers originate in neighbouring countries. Floods lead to quality issues and increased treatment costs.
4	Increased temperatures	Increased evapotranspiration. Possible impact on water availability for agriculture as most of country's agriculture is rain fed.

SUGGESTED POLICY OPTIONS

Given the reality of climate change and the likelihood of its impact on our water resources, a first policy option is necessarily a campaign of sensitivity to water issues. Such a campaign has to be broadly national in scope, low cost to be sustainable and sufficiently long term to alter behaviour in ways that must be measurable. Essentially the campaign must be aimed at creating a water culture in Belize.

An integral component of creating a water culture in Belize would be mitigation and adaption measures to focus specifically on the effects of climate change on the country's water resources.

Pollution of surface water has impacted on the water supply sources for several municipalities. Pollution also occurs due to run off from chemicals used in the agriculture and the fish farming industry. Government can encourage self regulation, and can demand that the companies purchase water testing equipment or institute arrangements whereby water quality is regularly tested. This is already being done with Belize Sugar Industries Limited (BSI) in northern Belize. BSI is mandated by DOE to provide results of tests undertaken on water sampled from the New River. This policy can be extended to all agro-industrial concerns that use substantial amounts of water.

The bottled water industry in Belize is growing and remains unregulated. No reliable estimates exist regarding the quantity of plastic wastes created by these companies. A policy option to address this situation could be setting minimum standards for water quality and then facilitating market competition to foster minimum pricing. Rather than instituting bureaucratic procedures to ensure adherence to these standards, Government could, through its Ministry of Consumer Protection, rate these companies and regularly and publicly update its ratings. These ratings can be disseminated via its website, newspaper advertisements and releases to the press. It is likely that this level of exposure which encourages market oversight will ensure adherences to best practices.

An important goal of government remains poverty reduction. This goal has been mainstreamed in various government activities. Regarding water resources, efforts must be made to provide these services at minimal cost to the poor. Since there are costs involved, which could at times be prohibitive, further discrimination in the pricing structure may be pursued. At this time, while BWSL provides different categorization of its customers, there is no price discrimination, since all categories of consumers pay at the same tariff levels. The recommendation is that wealthy customers, who can be easily identified based on their consumption levels, subsidize poorer customers, who can then face a reduced tariff structure. Price discrimination is likely to enhance revenue streams to water service providers and with the broader revenue streams from such a differential tariff structure, the wherewithal for expansion and provision of potable water to all remote villages could be sourced.

Any enhanced revenue streams, particularly to BWSL, can also fund system improvements for continued reductions in unaccounted for water. The Caribbean Environmental Outlook (undated document) notes that due to a lack of investments particularly in maintenance, "most water utilities in the region are unable to account for up to 50% of total water production."

Table 10 below shows BWSL's unaccounted for water over a six–year period.

TABLE 10: BWSL NON-REVENUE WATER

FY	06/07	05/06	04/05	03/04	02/03	20/02
Non-Revenue Water (%)	38%	40%	39%	44%	54%	52%

Source: BWS Annual Report 2006/2007

The data show that from a high of 54% in 2002/2003, BWSL has brought down its percentage unaccounted for water to a low of 38% in 2006/2007. The Annual Report predicted an additional reduction to 35% in the 2007/2008 FY. This will still be some 15 percentage points above the standard of 20% in some developed countries. The need for further reductions is important since the water has already been produced and was available for sale. At this time, there is absolutely no information on unaccounted for water from the various rudimentary water systems countrywide. Efforts to ensure greater levels of efficiencies from these systems must be regarded as an important policy option towards the conservation of the country's water resources. This will be important in the context of reduced water availability occasioned by climate change.

A final recommendation also seeks to conserve the country's water resources. This study has computed that the agriculture sector is the country's single largest user accounting for marginally in excess of 43% of the over 15 B gallons used in 2007. A sizeable portion of the water used in this sector is used in low efficiency surface irrigation systems that cause high water losses. In virtually all instances, agricultural companies that source their water for irrigation from rivers have no incentive to be efficient in water usage since the water is "free". The recommendation is to provide incentives to encourage the use of more efficient irrigation equipment to minimize water losses and encourage conservation of the resource.

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APPENDIX A – ABBREVIATIONS AND ACRONYMS

BELTRAIDE	Belize Trade and Investment Development
BWS/BWSL	Belize Water Services/Belize Water Services Limited
CCCCC	Caribbean Community Climate Change Centre
CEO	Chief Executive Officer
DOE	Department of the Environment
FAO	Food and Agricultural Organization
FY	Fiscal/Financial Year
LSMS	Living Standards and Measurement Survey
MACC	Mainstreaming Adaptation to Climate Change Project
MAF	Ministry of Agriculture and Fisheries
MDG	Millennium Development Goals
PAHO	Pan American Health Organization
RWS	Rudimentary Water System
SIB	Statistical Institute of Belize
UN	United Nations

APPENDIX B – LIST OF TABLES AND FIGURES