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Drought early warning and risk reduction:

A case study of the Caribbean drought of 2009 -2010

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ABSTRACT

Hydrometeorological disasters are the most frequently occurring disasters in the Caribbean. Many of the Small Island Developing States (SIDS) in the Caribbean, as well as the low-lying coastal regions of South and Central America, are particularly vulnerable to hydrometeorological and climate hazards due to their geology, topography, significant coastal urbanization, small climate sensitive economies and lack of significant economic diversity. As a result, reducing their vulnerability to climate and hydrometeorological hazards is critical if many of these states are to increase or sustain their current level of socio-economic development into the future. Drought represents one of the most frequently occurring climate hazards in the Caribbean with recent droughts resulting in economic losses and national anxiety for many Caribbean SIDS. While droughts are a frequent occurrence in the region, the region's adaptation to such events is quite poor. This paper illustrates the impacts of the most recent drought in the Caribbean through island specific examples. The examples show the sensitivity of key economic sectors (in particular water and agriculture) to drought and the low resilience of the region to drought. This low resilience is due to limited national and regional capacity in key areas, systemic problems within countries that limit information sharing between key stakeholder institutions, inadequate policies, and limited finances to implement and sustain key activities. We conclude that unless more is done to increase the region's resilience to drought, the region will be challenged to sustain and enhance its socio-economic development under range of future climates and increasing climate variability currently being forecast. Areas where more needs to be done include (i) enhancing the quality, delivery and targetting of climate services to national and regional stakeholders, (ii) increasing data sharing, enhancing collaborations between national, regional and international stakeholders, (iii) policy reform with respect to Integrated Water Resources Management (IWRM), and (iv) public education. We conclude that if significant improvements are not made with respect to adaptation to drought, many Caribbean SIDS will find it difficult to adapt to future regional climates which are expected to be marked by on average longer drier conditions than present.

1. INTRODUCTION

The Caribbean consists of a large number of small island developing states (SIDS) that are in most cases completely surrounded by ocean. Haiti and the Dominican Republic represent notable exceptions to this generalization as both countries share a common border on the island of Hispaniola. This is significant as it influences responses to certain types of events and the way some resources such as water are managed. For example, in the area of water, the sharing of borders generally requires a collaborative approach to resource management when the resource straddles the border. In addition to the SIDS of the Caribbean, the countries of Guyana (located in South America) and Belize (located in Central America) are frequently associated with the Caribbean due to their membership in CARICOM, shared history, inter-related economies and common risk factors.

Caribbean SIDS generally have:

- Small land areas with the ratio of the coastal area to the total land area being low;
- Significant amounts of their economic wealth and infrastructure in coastal regions;
- Small climate sensitive interlocking economies (e.g., agricultural and tourism based) that often lack significant diversity at the national level thereby making them particularly vulnerable to economic and shocks.
- Limited or no natural resources, with Trinidad and Tobago (oil and gas), Jamaica (bauxite) and Guyana (bauxite and precious metals) being exceptions.
- Expanding populations that are dominated by youth.

Caribbean SIDS are categorized as Developing Countries with the exception of Haiti which is included in the group of Least Developed Countries (LDCs). Given the characteristics of the region, sustaining growth into the future to reduce socio-economic inequities and meet international objectives such as the Millennium Development Goals represents an important objective of many Caribbean SIDS.

The Caribbean region is often described as being one of the two most at risk in the world when it comes to natural disasters. Events related to these hazards challenge sustainable development activities in the Caribbean as they force regional governments to reallocate funds from national development to disaster recovery. As a result, increasing the region's resilience to natural hazards by reducing vulnerabilities is critical.

Climate related hazards are the most frequently occurring natural hazard in the Caribbean. The region's vulnerability to climate related hazards is manifested in the loss of life, and annual economic and financial losses that result from high winds, flooding and drought. Over the last three decades, the Caribbean region has suffered direct and indirect losses estimated at between US$700 million to US$3.3 billion due to natural disasters associated with weather and climate events (Charvériat 2000). Toba (2009) estimated that the total annual impacts of potential climate change on all CARICOM Member States and Associated Members by ca. 2080 will be US$11.2 billion (referenced to 2007 USD). In addition, the report estimated the total Gross Domestic Product (GDP) in 2007 USD will be approximately US$99.3 billion or about 11.3% of the total annual GDP of all 20 CARICOM Member States and Associate Member States. Of these annual losses, USD 3,800,000 will be attributed to drought.

Droughts in the Caribbean are strongly influenced by El Nino Southern Oscillation (ENSO) events. Since 1990, the Caribbean has experienced several drought events with the most severe in terms of intensity and economic impact occurring in 1997 and 2009 through early 2010. The severity of the 2009 through early 2010 drought lead to significant water shortages across the region which in turn resulted in increased agricultural losses, significant concerns in other key economic sectors that depend on water as a critical input (e.g., tourism) and losses in livelihoods.

The drought event occurred at an untimely juncture as many Caribbean states were experiencing either slowly growing economies or economic decline. The drought event threatened to further reduce their rate of economic growth or increase the rate of economic contraction. Further, the event exacerbated conditions in existing water stressed countries (e.g., Barbados, and Antigua and Barbuda), regions and local communities in the Caribbean. This exacerbation resulted in various interventions by water resources authorities that included various use restrictions aimed at conserving water. In communities in Jamaica, this resulted in brief periods of social unrest. As a result, the drought and its particular impacts on

the water sector were addressed at the July 2010 meeting of the CARICOM Heads of Government and subsequently at a special meeting on water issues held by the CARICOM Council for Trade and Economic Development (COTED) in September 2010. To facilitate the discussion at both meetings, the CARICOM Secretariat commissioned its specialized agencies with responsibility for water issues [the Caribbean Environmental Health Institute (CEHI) and the Caribbean Institute for Meteorology and Hydrology (CIMH)] to prepare a status report on the drought. The report informed the Heads of Government of (i) the current situation regarding the drought, (ii) perceived reasons for the late recognition of the prevailing drought conditions across the Caribbean region, (iii) recommendations for the water sector to mitigate the short and mid-term impacts of the drought and (iv) policy recommendations for mitigating the severity of future droughts on national economies and sustainable socio-economic development.

This paper addresses the impacts of drought in the Caribbean by focusing on country and sector specific impacts resulting from the 2009 through 2010 drought which represents one of the most severe events in recorded history in many Caribbean states. Specific attention is given to the impacts of drought on the agricultural and water sectors with less attention applied to other sectors, including the energy sector, due to the limited available data. With respect to the water sector, policy interventions aimed at increasing the resilience of the sector to drought are provided.

2. Overview of the Caribbean Climatic Setting

Rainfall on CARICOM SIDS is characterised by an annual wet season and a dry season. The wet season normally begins in May to June and finishes during the period November through December. In some islands such as Trinidad and Jamaica the wet seasons are disturbed by a period of relatively low rainfall (known as the 'Petit Careme' in Trinidad). On average, at least 70 to over 80 % of the rainfall occurs during the wet season (Enfield and Alfaro, 1999), with October being on average the wettest month in much of the region.

In northern Guyana, the influence of the Inter Tropical Convergence Zone is responsible for two wet (approximately November to January and May to July) and two dry seasons per year. The rainfall of southern Guyana, like the Caribbean islands, is characterised by one wet and one dry season per year. The seasons demonstrate substantial variability in commencement, duration and rainfall quantities. It is not unusual to experience significant dry spells during the wet season or very wet spells in the dry season (Trotman, 1994). Observations indicate the presence of 50 to 60 year cycles of high and low rainfall (Burton, 1995). During the phases of low rainfall, the frequency of water deficits is above normal, whereas flooding potential increases during the phases of high rainfall.

The distribution of rainfall during dry seasons in Caribbean states, and in particular Caribbean SIDS, is of concern for water resources managers, agriculturists and ecosystem managers because the small physical size of most SIDS supports limited understorage. The region's expanding tourist industry is also sensitive to rainfall distributions and quantity, as the dry season, which coincides with the boreal winter season, is the period during which the highest visitor arrivals occur. This situation increases the demand for water due to the increased numbers of persons on the island and the fact that per capita usage of water by tourism industry is higher than in the domestic popular. In the case of Jamaica, Fernandez

and Graham (1999) suggest that the ratio of per capita usage of water between the tourism industry and the domestic population is on the order of 10:1. During 2010 in Barbados, the average guest used 674 litres per day compared to 240 for domestic use (Personal Communication Dr. John Mwansa, Barbados Water Authority). As will be demonstrated later in this paper, drought severely magnifies this lack of water during the dry season and presents significant challenges to the tourism industry. In addition, sub-normal precipitation during wet seasons is common place and can have great impacts on agro-ecosystems and biodiversity.

As noted earlier, the pathway for the future sustainable development of Caribbean and their ability to meet various international obligations such as the UN Millennium Development Goals is in part dependent on the availability of affordable water of sufficient quality to meet the needs of the various socio-economic sectors. In recent years, attempts have been made to quantify future water availability on Caribbean SIDS using precipitation outputs from regional climate models. Using such model outputs, Christensen et al. (2007) predicted that many states in the region will likely experience a decrease in annual precipitation of up to 15 to 20 percent by the end of the century. However, there is significant uncertainty in the rainfall projections from the regional climate models with the greatest uncertainty occurring in the Lesser Antilles.

In the Greater Antilles, the outputs from regional climate models indicate that rainfall is likely to decrease during the months from June to August which coincides with the early part of the rainy season for the region. The frequency of high rainfall intensity events have been increasing (Peterson et. al. 2002) implying that infiltration will be reduced, increasing the potential for run-off. It is therefore anticipated that droughts will become more frequent with more dire impacts in the future. Certainly, with or without a decrease in rainfall due to anthropogenic Climate Change, the seasonal variability in Caribbean rainfall merits a concerted effort to mitigate the impacts of that variability. This comes in light of a statement by the President of Guyana, Bharat Jagdeo[1], that between 1988 and 2006, floods and drought caused Guyana US $35 million per year on average.

3. Drought Early Warning in the Caribbean

Drought can be defined by the user or sector involved; for example meteorological, agricultural, hydrological and socio-economic. The duration and intensity of a meteorological drought, which essentially suggests some deficit in the normal rainfall amounts, will affect the varying sectors to different degrees and at different times.

Chen et al. (2005) noted that monitoring (agricultural) drought in the Caribbean was seen as a case of comparing monthly and annual rainfall totals to their respective averages and monitoring biological indicators in the field. In recent years, the Caribbean Institute for Meteorology and Hydrology (CIMH), with the assistance of a subset of the National Meteorological and Hydrological Services in the Caribbean, has been engaged in a

[1] Kaieteur News Online, 2 November, 2010 http://www.kaieteurnewsonline.com/2010/08/30/regional-body-agrees-to-provide-flood-drought-insurance/

comprehensive effort to establish a more structured, proactive and coordinated approach to monitoring and predicting drought across the Caribbean. This effort is supported by monitoring impacts on the ground, as these impacts demonstrate the true 'severity' of any drought event.

One initiative that supports the increased effort to better monitor and predict droughts in the Caribbean is the Caribbean Drought and Precipitation Monitoring Network (CDPMN) launched under the Caribbean Water Initiative (CARIWN, www.mcgill.ca/cariwin) in January 2009. The goal of this initiative is to provide early warning information on drought by indicating the current and projected future drought severity in the Caribbean. The initiative currently utilises two widely used meteorological drought indices – the Standardised Precipitation Index (McKee et al 1993) and Deciles (Gibbs and Maher, 1967). In light of the future expansion of the CDPMN to provide information on agricultural and hydrological drought, it was clear that in the Caribbean context, meteorological drought indices can be used to warn, inform and advise regional governments paving the way for reduced impacts on the society. The experience gained from the 2009 – 2010 drought in the Caribbean demonstrates that the CDPMN, which utilizes meteorological drought indices, can be used to support hydrological and agricultural drought forecasting and that these aspects of drought should be considered in future updates to the CDPMN.

CIMH generates SPI and Decile information over 1-, 3-, 6- and 12- months time scales (http://www.cimh.edu.bb/cdpmn/cdpmn.html). The different time scales take into account the fact that the different types of drought are manifested at different times after the onset of the event (e.g. agricultural drought is expressed much sooner than hydrological drought). Information on the indices will also be provided at two spatial scales – *(i)* the Caribbean Basin scale and *(ii)* the national scale. The latter provides higher resolution information from which national governments can identify potential areas of vulnerability which may be based on the degree to which these areas heave been exposed to drought.

When the CDPMN is fully operational, the final rainfall status of the region as well as the specific status of any country in the region will be determined through the consensus of a network of persons from different sectors, institutions, communities and backgrounds embracing the diversity in definitions and impacts of drought and by utilising the spectrum of indices and indicators. In addition, at the national scale, indices and indicators utilising data other than precipitation can also be engaged. It remains to be determined what other indices and indicators are feasible for inclusion in monitoring drought at the country scale and whether the set of indices will vary from country to country. Possible data sets that are currently being considered include soil moisture, soil available water capacity, evapotranspiration, vegetation indicators, streamflow and reservoir levels. The potential application of the Palmer Drought Severity Index (PDSI)(Palmer, 1965) and the Crop Moisture Index (CMI)(Palmer 1968) have already been investigated in Barbados. In Jamaica, soil moisture estimates are being related to the SPI and the Normalised Difference Vegetation Index which is derived from satellite data.

CIMH currently produces a precipitation outlook (http://www.cimh.edu.bb/curprecip.htm) for the Caribbean which extends from Guyana in the south, across the island archipelago to Belize in the west. The information is in the form of probabilities of normal, above normal and below normal rainfall with a lead time of three months. The outlooks are used in

combination with the rainfall information to provide projections of precipitation index values. Using the CIMH tercile probability outlook, a simple procedure was used to provide an outlook of SPI values for land stations in the Caribbean (Table 1).

Table 1 SPI Outlook for CIMH for the period March to May 2010 produced at the start of March 2010.

Month	1 month	3 month	6 month	12 month	Outlook %
May	0.41 - 2.66	0.36 - 3.13	-1.22 - 2.34	-1.21 - 0.85	30
	-0.43 - 0.41	-0.95 - 0.36	-2.39 - -1.22	-1.65 - -1.21	45
	-2.04 - -0.43	-3.06 - -0.95	-3.46 - -2.39	-1.97 - -1.65	25
April	0.39 - 1.72	-0.34 - 1.98	-1.64 - -0.13	-1.10 - -0.28	30
	-0.44 - 0.39	-1.59 - -0.34	-2.17 - -1.64	-1.35 - 1.10	45
	-2.04 - -0.44	-3.54 - -1.59	-2.65 - -2.17	-1.55 - -1.35	25
March	0.41 - 2.15	-1.33 - 0.48	-2.16 - -1.44	-0.90 - -0.52	30
	-0.45 - 0.41	-1.98 - -1.33	-2.35 - -2.16	-1.00 - -0.90	45
	-2.06 - -0.45	-2.71 - -1.98	-2.53 - -2.35	-1.09 - -1.00	25

4. The Caribbean Drought of 2009-2010

During 2009 into 2010, most of the Caribbean experienced a severe to extreme drought. In the eastern Caribbean, it started in the south in the month of October during the wet season of 2009 and spread northward. The impacts of the drought were particularly harsh on the region's farming community. Severe impacts were also experienced in the water resources sector with many Caribbean countries being forced to implement water use restrictions. The drought came at an untimely juncture as many Caribbean States are currently experiencing either slowly growing economics or economic decline. Although economic information on the impacts of the drought is not available, it is likely that in some countries decreases in agricultural productivity, increased costs associated with the delivery of water using tanker trucks and limited availability of water for some industrial process associated with the drought resulted in negative economic impacts.

The drought impacted countries in the Caribbean to different degrees with the magnitude of the impact being influenced by the duration of the experience, the level of rainfall reduction, sources of water (groundwater dependent versus surface water dependent), water demand versus water availability, hydrological environment, and social and cultural setting. Specific impacts of the drought on the water resources and agricultural sectors will be discussed later in this report.

4.1 Rainfall during 2009-2010

Significant declines in rainfall were experienced across the Caribbean from the wet season of 2009 to April/May in 2010. The most significant declines in rainfall reported in the Caribbean during the 2009-2010 drought were experienced in Grenada at the Point Saline

International Airport, where the decreasing rainfall totals began earlier in the rainy season than at other regional stations. Although there is only 25 years of data available for Point Saline International Airport, it is noteworthy to mention that the rainfall in 2009 was the lowest in those years of record. Areas in the interior of the island that usually experience above 4000 mm of rainfall in the rainy season, with no dry months, experienced 1-2 dry months in 2009. For the periods (i) March – September 2009 recorded rainfall was 50 percent of normal; (ii) October, 2009 – January 2010 recorded rainfall ranged between 37 – 19 percent of normal; and (iii) February 2010 rainfall was 0.03 percent of normal.

Guyana and Dominica are known for abundant rainfall. However, they were impacted by the 2009-10 drought. Stations in both countries exhibited significant declines in rainfall (Table 2). These impacts on rainfall were mirrored across the majority of the Caribbean, in particular the eastern Caribbean, where rainfall totals were in the lowest 10 % (some as record lows) of recorded total for February, 2010 (Figure 1).

Table 2 First Quarter Rainfall Data for Selected Caribbean Countries for 2005 to 2010

	Guyana			Dominica					
	Georgetown,			Canefield Airport			Melville Hall Airport		
Year	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
2005	1108.2	203.7	78.5	97.5	62.9	5.5	168.3	196.5	31.2
2006	573.3	73.2	43.8	170.8	65.3	38.7	94.3	51.6	94.8
2007	156.5	26.3	121.8	45.4	27.9	32.5	174	53.6	79.9
2008	203.6	365.0	210.2	67.5	85.1	59.2	129.8	134.9	108.6
2009	474.7	151.5	66.0	145.3	46.8	7.7	152.2	85.8	49
2010	20.6	24.7	41.0	32.8	0.4	22.4	76.1	4.2	61
AVG 05 -10	422.8	140.7	93.6	93.2	48.1	27.7	132.5	87.8	70.8
2010 % of 6-yr Avg	4.9	17.6	43.8	35.2	0.8	81.0	57.5	4.8	86.2

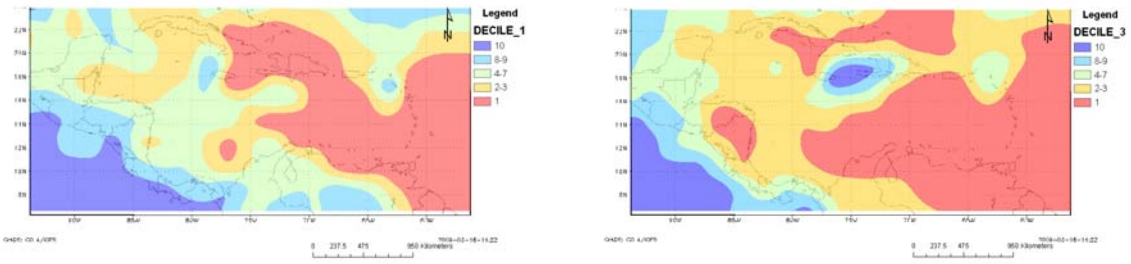

Figure 1 1- and 3- month decile maps for February 2010.

5. Impacts of the 2009-2010 Drought

5.1 Agriculture and Food prices

Agriculture makes a significant contribution to the Gross Domestic Product (GDP) of several Caribbean countries (Table 3). Despite its declining contribution to most national economies in the region, the agricultural sector plays a critical role in food and livelihood provision and the servicing of other economic sectors such as tourism and manufacturing (Trotman et al, 2009). Agricultural employment accounts for at least 20 percent of total employment in some countries and is close to 30 percent in Belize, Dominica and Guyana (Table 3). This profile suggests that many households across the region are at significant risk if agriculture systems are stressed by events such as prolonged drought. The majority of the region's agriculture is rainfed (Table 3) and production and profitability are strongly influenced by variations in rainfall and in particular rainfall extremes. Meteorological drought is, therefore, often a fair reflection of agricultural drought. Irrigated agriculture is a fairer reflection of alternative available water resources that mitigate the impacts of meteorological drought.

Table 3 Contribution of agriculture to GDP and Employment, and proportion of irrigated land

	GDP (%)	Employment (%)	Agricultural Land ('000 ha)	Irrigated Land (% of cropland)
Antigua & Barbuda	3.77	NA	14	N/A[2]
Barbados	4.47	4.6	19	29
Belize	16.65	27.5	152	3
Dominica	18.28	27.3	23	N/A
Grenada	9.77	13.8	13	NA
Guyana	31.44	27.8	1740	29
Jamaica	5.49	20.4	513	9
St Kitts & Nevis	3.03		10	N/A
St Lucia	5.27	11.4	20	17
St Vincent/ Grenadines	8.76	15.4	16	7
Trinidad & Tobago	1.1	6.9	133	3

Source: Compiled from World Development Indicators Online, World Bank (2007)

Decisions made by farmers and government were crucial in mitigating the impacts of the recent drought in Caribbean countries. In Guyana, widely recognised as the largest food producer in the Caribbean Community (CARICOM), the President allocated US $ 1.3 million to bring relief to farmers of Region 2[3] in February, 2010. Relief included planting materials, fertilizers for cash crop and portable water tanks to service communities in desperate need. In some cases in this Region, the desperation for water by some rice farmers resulted in them pumping saline water to about 150 acres of rice lands even though they knew the potentially grave long term consequences of such actions[4]. In Region 5, it cost the government US

[2] Data not available

[3] Guyana is divided into 10 administrative Regions, each with its own administrative or local government unit

[4] Stabroek News, 22 Feb, 2010, http://www.stabroeknews.com/2010/news/stories/02/22/gov%e2%80%99t-commits-258m-for-el-nino-relief/

$16,000 per day to operate pumps and conduct other works essential for the delivery of water (e.g., excavating and re-routing canals)[5].

Significant impacts caused by the drought were also experienced on Caribbean islands. For example, the banana industry on Dominica was severely affected with production approximately 43% lower in 2010 compared to the previous year. This resulted in a significant reduction in banana exports to the UK (Table 4) and a reduction in earned foreign exchange. In St. Vincent and the Grenadines, agricultural production was 20% lower than average. Planting was restricted to vegetables (including cucumber and pumpkin) and sweet potatoes. The resilient farms were the ones that utilised greenhouse facilities and irrigation systems (Personal Communication, Chief Agricultural Officer, Ministry of Agriculture, St Vincent and the Grenadines). In Antigua and Barbuda, the 2010 onion crop was expected to be about 500,000 kg. Unfortunately, 25 percent of it was lost due to the drought. In addition, approximately 30 percent of the Tomato crop, estimated to total 250,000kg, was lost as a result of the water stressed conditions (Personal Communication, Deputy Permanent Secretary, Ministry of Agriculture, Antigua and Barbuda).

Table 4 Comparison of UK Banana exports for weeks 1-11 2009 vs. 2010

Production 2009 weeks 1-11			Production 2010 weeks 1-11		
Wk #	Total MT 2009	Total Boxes	Week #	Total MT 2010	Total Boxes
1	176.01	10607	1	79.75	4367
2	119.98	7389	2	97.36	6047
3	157.83	9736	3	94.56	5896
4	120.04	7483	4	78.97	4975
5	177.89	10995	5	84.28	5340
6	127.44	7921	6	68.7	4341
7	127.55	7941	7	78.71	4996
8	166.32	10454	8	75.73	4803
9	137.2	8210	9	74.63	4729
10	132.69	8299	10	59.86	3843
11	107.12	6679	11	76.07	4880
Total	1550.07	95714	Total	868.62	54217

Source: Dominica National Fair Trade Organization

The impacts of the drought on agricultural production were also reflected in the prices of commodities. In St. Vincent and the Grenadines, prices of tomatoes were $2.35 per pound in February 2010. During March 2010, the prices rose to $6.00 per pound. In April, 2010, the Central Bank of Trinidad and Tobago expressed concerns over rising inflation rates with a significant food prices component. Food prices increased 6.9 % in March 2010 compared with 6.3 % in February and 2.7 % in January. The Central Bank of Trinidad and Tobago specifically mentioned an increase in the price of fruit in March 2010 by 60.8 per cent, up

[5] http://guyaneseonline.wordpress.com/2010/02/19/drought-threatening-guyana-agriculture/ (Guyanese on line

from 40.7 per cent in February, partly related to the severe drought[6]. These rates continued to increase to May 2010[7].

5.2 Bush Fires

Bush fires represent one category with major consequences resulting from drought in the Caribbean. Because of the intensified dry season that followed a below normal wet season, bush fires and their destruction, to natural habitats, agriculture and even domestic houses and other buildings was significant. In Dominica, the fire department attended to 160 fires (mainly bush fires) during the 1st quarter of 2010; this was more than for the entire year 2009, which was about 103 (Personal Communication, Dominica Fire Department). In St. Vincent and the Grenadines, seven different farms reported the destruction of at least two acres of crops. In Grenada, there was a 150% increase in the amount of bush fires reported and attended to by the fire services that also had an impact on agriculture production and cultivation with a number of farms being affected. The irony of these situations is that the same scarce commodity – water – has then to be used to reduce the risks to the human population and property.

As a result of the bush fires that destroyed large areas of citrus farms, it is reported that imports of citrus increased from TT $38 million in 2008 to more than $50 million by the end of the 2010 drought[8].

When bush fires result in denuded slopes during drought, they provide a catalyst for flooding and land slippage. One such event occurred in Dominica, killing three persons on 24 May 2010 on a day when 68.6mm fell in the area. Under these circumstances, bush fires contribute to land degradation and protracted under productivity of land.

[6] Trinidad and Tobago Guardian, 23 April, 2010 http://guardian.co.tt/news/general/2010/04/23/drought-causes-ri se-food-prices

[7] The West Indian News, June 26, 2010, http://www.thewestindiannews.com/trinidad-food-prices-puch-headline-inflation-rate-to-9-6-repo-rate-remains-at-5-0/

[8] http://www.trinidadexpress.com/business-magazine/98387299.html

Figure 2 A landslide in Dominica after the return of the rains

5.3 Water Resources Sector

All CARICOM Member States rely primarily on either groundwater, surface water or rainwater (harvesting) or various combinations of all three for their potable, industrial, sewerage and agricultural water supply. These sources of water are recharged during the wetter seasons of the year. The onset and duration of wet seasons vary spatially across CARICOM Member States.

Several islands in the Caribbean are defined as water scarce with respect to natural freshwater resources according the United Nations, which defines this condition as having an annual freshwater availability of below 1000 m^3 per person. CARICOM Member States falling into this category include, but are not limited to, Barbados, Antigua and Barbuda, St. Kitts and Nevis and the Bahamas. In larger islands where water scarcity does not exist at the national level, regional disparities with respect to rainfall and physical conditions can result in water scarcity at the local level. Such water scarce countries and regions are particularly susceptible to drought given the competition for water by various sectors.

As noted earlier, sources of potable water vary across CARICOM Member States with some states such as Barbados relying almost exclusively on groundwater resources for their potable water supply. Other countries such as Dominica rely exclusively on surface water sources for their potable water supply. Others like Jamaica and Guyana utilize both surface water and groundwater sources for their potable water supply. Member States such as Antigua and Barbuda, the Bahamas and the Cayman Islands obtain significant portions of their potable water supplies from reverse osmosis plants, and although impacted by drought, are in a better position to adapt. In some localities in some countries, rainwater harvesting is used to augment water supplies. The timing and magnitude of the impacts on these various sources of water will vary. Surface water resources generally show the earliest impacts as such systems are often fed primarily by rainfall run-off with contributions from groundwater occurring in

the lower portions of watersheds. Surface water impoundments are particularly vulnerable to high rates of evaporation during ENSO events due to elevated temperatures and drier than normal air masses. And water is continuously lost via (I) evaporation processes which may accelerate under drier than normal conditions and (ii) discharges to the sea..

From mid-2009 through the first quarter of 2010, several Caribbean countries including Jamaica, Dominica and St. Lucia reported significantly lower than normal flows in many of their streams. In Antigua and Barbuda, the Potswork Reservoir, which is the largest surface water impoundment on the island ($4.1x10^6$ m^3) and which supplies most of the 22 percent of annual water supply derived from surface water sources on the island, was nearly dry during March 2010[9]. The situation in Guyana was particular interesting as water levels in conservancies were at extremely low levels during the drought resulting in water shortages for agricultural farmers. Government of Guyana officials noted that hundreds of millions of Guyana dollars were being spent to reduce the affects of the drought on severely impacted communities[10]. In the case of Barbados, water levels in aquifers reached extremely low levels during the drought prompting the Barbados Water Authority to implement Stage 1 of its Drought Management Plan on March 8, 2010. At this stage in the management plan, customers of the BWA were encouraged to practice good water use habits and to employ voluntary conservation measures.

The impacts of drought on groundwater systems tend in most cases to be delayed relative to surface water systems due to the slow nature of the infiltration/recharge process. As a result, many groundwater managers may misinterpret this initial lack of a decline in water levels as a lack impact. As a result, the full magnitude of the prevailing drought may not be fully reflected in the groundwater system in Barbados which has not applied restrictive water management practices to date. Significant short to mid-term risks for Small Island Developing States (SIDS) such as Barbados in managing drought conditions include (I) groundwater mining, that is pumping more than the volume of recharging volume, (ii) aquifer salinisation due to seawater intrusion which may result for the combination of reduced groundwater recharge and excessive pumping and (iii) increasing pollutant concentrations due to reduced groundwater mixing volumes. These processes could result in a further reduction in potable groundwater.

In the Caribbean, rainwater harvesting is commonly used to augment a primary water supply and is not a mainstream source of water. Because of the limited size limitations of the systems, stored volumes can be highly variable under prolonged drought conditions (to be revised or deleted).

Water resources in all Caribbean countries were impacted by the drought. In water-rich Guyana, the water level at the East Demerara Water Conservancy (EDWC) was 51.65 GD by February 2010. This is significantly below the designated safe level for irrigation – 53.50GD (known as the dead storage level). When the conservancies in Guyana reach their dead storage, water can only be obtained from them through the use of pumps and not by gravity. Actions to activate pumps in several regions to move water into the conservancies were at times terminated, as saltwater had intruded into inland waterways.

[9] Antigua Observer, http://www.antiguaobserver.com/?p=26736
[10] Guyana Information Agency (GINA) http://gina.gov.gy, March 1, 2010

Other Caribbean countries experienced similar reductions in water resources. Grenada is one of those island states that generally does not have a large water storage capacity because of its steep slopes and short distance from mountain to coast (less than 6 miles in most cases, Thompson 2010). This is a reflection of other islands with similar terrain. However, orographic circumstances permit significant rainfall inland with plenty surface flow. Yet during 2009 production was well below normal (Table 5), and grew disastrously worse during the below normal dry season that followed. Despite the dire conditions on the mainland, by 19 February, 90 000 gallons of water was shipped from mainland Grenada to Carriacou, one of the islands making up Grenada[11]..

Table 5 Shows average wet season production of water verses production during the 2009 wet season.

PLANT	AVG. WET PRODUCTION (Gals./day (gpd)	AVG. PRODUCTION, 2009 Gals./day (gpd)	% REDUCTION
Annandale	2,000,000	1,600,000	20.0
Mardigras	167,000	100,000	40.1
Les Avocats	430,000	282,300	34.3
Mamma Cannes	310,000	240,000	23.0
Concord	300,000	298,000	-0.7
Vendomme	450,000	240,000	46.7
Mt. Horne	210,000	210,000	0.0
Mirabeau	700,000	280,000	60.0

6. Some Lessons learnt from the 2009-2010 drought

The outputs from climate change modelling efforts performed by regional institutions including the Caribbean Community Climate Change Centre (CCCCC), the University of the West Indies (UWI) Mona Climate Studies Group and more recently CIMH indicate the frequency of drought conditions across the region will likely increase in the future. This is reinforced by the fact that the outputs from the models also indicate that across most of the Caribbean annual rainfall will decline. In addition, the model outputs indicate that the frequency of intense rainfalls will likely increase in the future. These predictions, coupled with projected increases in day and night time temperatures, are expected to negatively impact available water resources in the future. Hence, the region will have to improve its

[11] International Federation of the Red Cross, http://www.reliefweb.int/rw/RWFiles2010.nsf/FilesByRWDocUnidFilename/MUMA-82U3B7-full_report.pdf/$File/full_report.pdf)

ability to forecast drought the onset, duration and severity of drought as well as its ability to manage its water resources. The current drought conditions provide an opportunity to evaluate its position with respect to these two issues and where necessary to initiate adaptation and mitigation efforts in these areas and dependent downstream sectors to overcome shortcomings. Given likely future realities, it is imperative that CARICOM Member States mainstream their forecasting and alerting systems for drought and to develop and implement cost effective policies for adapting to and mitigating impacts of drought on their planned socio-economic development.

Drought forecasting and alerting at national and regional scales requires a coordinated effort between multiple stakeholders to develop an effective alerting system. Key features of such systems include (i) understanding stakeholder needs and capacities, (ii) timely data collection and dissemination by multiple stakeholders across multiple sectors, (iii) human capacity to process and interpret data in a timely manner, (iv) collaborative non-competitive environment between stakeholders, (v) regular and effective communications between technical personnel and decision-makers and (vi) an effective system of protocols for issuing and communicating alerts to various stakeholders across multiple sectors. Unfortunately, all of these features are not present or are not functioning effectively at national and regional levels in the Caribbean.

In January 2010, the prevailing drier than normal conditions resulted in the Caribbean Institute for Meteorology and Hydrology (CIMH), in consultation with National Meteorological Services, issuing Drought Alerts for Barbados and Grenada. CIMH staff also expressed their concerns about the drier than normal conditions to its counterparts in Antigua and Barbuda, Trinidad and Tobago, Jamaica and Dominica. Those counterparts subsequently made appropriate decisions based on their perceived national situations. CIMH staff also contacted counterparts in the Dominican Republic as the Institute periodically receives their data and the outputs from the Institute's Caribbean Drought and Precipitation Monitoring Network (CDPMN) and Precipitation Outlook models cover the island of Hispaniola. The Institute's concerns were also raised to counterparts working on disaster relief in Haiti because of concerns regarding food production and food security on the island. The Precipitation Outlook (http://www.cimh.edu.bb/precipoutlook.html) has been providing 3-month rainfall forecasts for the Caribbean region since 2004. The CDPMN (http://www.cimh.edu.bb/cdpmn/cdpmn.html) developed by CIMH and launched in January 2009 under the Caribbean Water Initiative (CARIWIN, www.mcgill.ca/cariwin) is a joint initiative with McGill University and is funded by the Canadian International Development Agency (CIDA) through the Association of Universities and Colleges of Canada (AUCC).

Outputs from both the Precipitation Outlook and the CDPMN consistently forecasted below average rainfalls for the Caribbean region over the 4-6 month period prior to January 2010. Furthermore, the Precipitation Outlook for the period January-March 2010 forecasted the subsequently recorded below average rainfalls over the period. During February 2010, expert opinion at CIMH along with model outputs successfully forecasted that the below normal rainfall conditions would persist beyond March 2010. Subsequent forecasts regarding the drought and the ensuing above normal rainfalls recorded during the rainy season were found to be qualitatively accurate. Currently, CIMH is planning to expand work on country specific Water Monitors (Figure 3) initiated in collaboration with Institute of Earth Sciences of the University of Applied Sciences of Southern Switzerland (SUPSI) that utilize concepts embedded in the CDPMN to define spatio-temporal drought at the country scale. Once

completed, this initiative will build resilience in the water and agricultural sectors by facilitating their adaptation to drought. Timely access to national climate databases is critical if countries are to maximize the benefits of this initiative.

a) b)

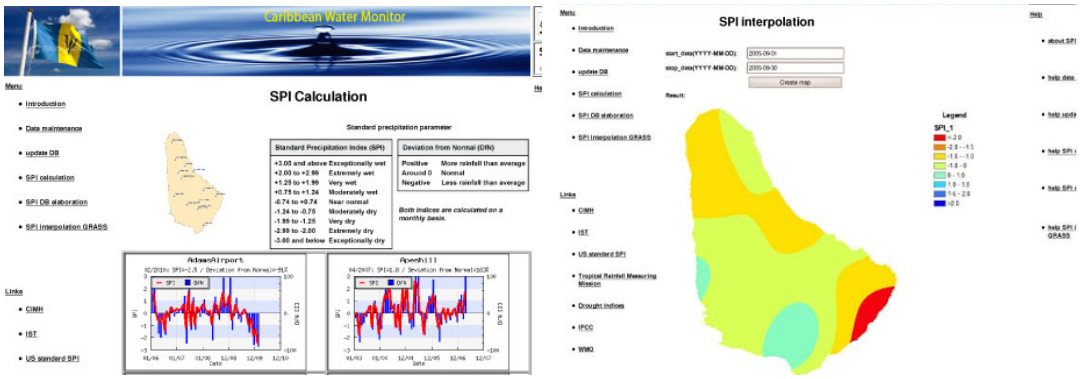

Figure 3 The Caribbean Water Monitor tool displaying a) Calculation and graphical representation of the Standard Precipitation Index (SPI) and the Deviation from Normal (DfN) and b) interpolation of the calculated SPI indices of 14 measuring stations on Barbados

The fact that many agencies and sectors across the region were unaware of the onset of the drought conditions in their respective countries and across the region raises concerns about (i) the capacity of the region to convert observations to information and to effectively communicate that information to stakeholders, (ii) whether all stakeholders are aware of the availability of the products and (iii) the capacity of the downstream users to effectively integrate drought information into their decision making processes. These concerns need to be investigated to develop appropriate actions to ensure that the problems encountered in 2009-2010 drought do not occur in the future.

7. Drought Mitigation Recommendations to Water Resources and Water Supply Managers

All countries impacted by the 2009-2010 drought conditions in the Caribbean implemented various measures in the water sector to address the situation depending on severity of the water deficit, on-the-ground circumstances and their capacity to implement. In the most affected countries, particularly those that lack special water augmentation capabilities such as desalination, water rationing was the front-line response adopted by the water utilities followed by trucking of water to affected communities. Several measures were recommended by CEHI to not only alleviate water scarcity in the short-term, but also to provide some level of security against future occurrences of drought.

Some of the immediate measures recommended by CEHI, represented “no-cost” conservation approaches. However, given the urgent needed to mitigate the situation in many countries, some level of investment was used to activate alternative water supply sources. These investments were not only relevant to the immediate short-term crisis, but also support reducing vulnerability during future crises if properly managed and maintained. In many cases, these investments support longer-term policy measures that revolve around a more

holistic approach to management of water resources under an integrated water resources management or "IWRM" framework. It should be noted that a number of agencies such as CEHI, the GEF-funded Integrating Watershed and Coastal Areas Management (GEF-IWCAM) Project and the Global Water Partnership-Caribbean (GWP-C) are working with Member States to develop IWRM Plans.

7.1 Summary of Actions Proposed to Water Resources Managers to Address the Drought

Several immediate, mid- and long-term actions were recommended to CARICOM's political leaders to provide relief to water resources managers during the drought. These proposed actions are summarized as follows:

Immediate Actions

- Implementation of an aggressive public awareness programme to provide information (on water safety, conservation, demand management, etc.) for dissemination through the media. The core stakeholders in this action include National Meteorological and Hydrological Services (NMHSs), water utilities, water resources managers, ministries of health and national emergency management organizations. Other groups that could support information dissemination include business leaders, community and church leaders and schools.
- Prioritization of critical water users and estimation of their critical demand through the rapid development of a critical users inventory. The critical users inventory may include but is not limited to essential services, health care institutions and diplomatic missions.
- Implementation of water demand management and water restrictions should be initiated in accordance with existing legislation, statutes and rules of operation. It is expected that this would include appropriate measures to restrict all non-potable uses of potable water.
- An assessment of suitable alterative water sources of potable water should be performed. If alternative sources of water can be converted to potable water in a cost-effective and efficient manner provisions should be made to utilize the source and to protect it from potential pollution.
- Increase surveillance of potentially unsafe untreated water sources as it is possible that severely drought impacted persons may attempt to access water of marginal quality for various activities thereby increasing the risk of exposure to water-borne diseases. The quality of such waters should be assessed and relevant usage rules supplied to the public.
- Increase surveillance of unregulated water delivery systems such as trucks and barges whose operations are largely unmonitored in terms of safety of the operation as water rationing may lead to a greater demand for trucked water. Sources of trucked water should be checked, particularly where 'marginal' quality waters are easily accessible. In addition, the health status of the storage containers on such vehicles should be assessed to prevent chemical, bacterial and viral contamination.
- Increase awareness of appropriate household water treatment options when receiving water from unregulated suppliers to prevent chemical, viral and bacterial illnesses.

- Efficient and cost-effective infrastructure to augment the water supply system should be installed. In some islands where water is in surplus at various locations but there is no infrastructure to bring the water to where it is needed this action may be considered especially if financial resources are accessible.
- Acquisition of PVC tanks for storage of rain water in vulnerable communities should be encouraged by Governments, the regional private sector and NGOs. This should be encouraged through various legislative and institutional mechanisms.
- Access surplus water production capacity from private sources by establishing relationships with business such as bottled water suppliers, hotels and other commercial enterprises with excess desalination capacity.
- Transportation of water from countries with surplus capacity to those with water deficits if financially feasible and no other financially affordable options are available that are consistent with national water security objectives.
- Procurement of small-scale package (containerized) desalination plants where the need is extreme and there are very limited financially viable options for access to potable water.

Medium-term actions

- Expansion of storage capacity by placing bulk storage water tanks in locations that can be used to serve communities in times of shortage. Although it will not be possible in all locations, it is preferable that the lands for siting these tanks are elevated so that flow can be via gravity.
- Introduction of temporary import duty waivers on water augmentation systems and equipment including those that support water harvesting and transportation and storage of water. This should be supported by an aggressive national programme to encourage the practice of Rainwater Harvesting (RWH) such as the initiative presently being advanced in the region by CEHI, the Global Water Partnership-Caribbean (GWP-C), and the FAO.
- Improve leak detection and mitigation should be practiced to reduce losses within high priority sections of water distribution networks, particularly those through those communities with large populations.
- Recycle grey water at hotels and other large institutions for irrigation use. This area represents great potential as a water resource, when properly treated.

Long-term actions

- Facilitate investment in major water system infrastructural upgrades as most water utilities in the Caribbean are significantly under-capitalized. This represents a significant concern which complicates development of a coordinated intervention in this area.
- Development and integration of local drought indices and indicators for water allocation into the standard operating procedures of water utilities. This requires the strengthening of national decision support systems through the flow of data and information between key agencies such as the Meteorology Office, Water Utilities, Water Resources Agencies, Ministries of Health, Agriculture, Tourism among others.
- Development of Water Safety Plans (WSPs) by water service providers that seek to reduce hazards (including drought) along all points of the water supply chain. Water

utilities and other water service providers must develop well-articulated plans to address heath concerns within the framework of a WSP.

8. Proposed Policy Interventions to Reduce Risks in the Water Sector Caused by Climate Change and Increasing Climate Variability

The following interventions are recommended to reduce risks in the water sector due to climate change and increasing climate interventions:

- Adoption and implementation of the principles of Integrated Water Resource Management (IWRM) with specific attention to the development of national actions that address drought management plans. Such actions should be broad based and include consideration of all aspects of fresh and coastal waters management. IWRM should be considered within the context of national and global climate change strategies.
- Given the potential for increasing occurrences of drought in the future due to the combined effects of climate change and climate variability, CMO Member States are urged to perform comprehensive reviews of their water resources to ensure that clear regulations and policies related to Action Plans to be implemented under drought conditions are clearly articulated and that the necessary competencies to activate the actions are in place. In this regard, Member States should ensure that water resources management and regulatory agencies are familiar with climate change and climate variability predictions for respective Member States and to ensure that this information is included in planning and design activities.
- Data and integrated analysis and decision making is critical in identifying the onset of droughts. CMO Member States are urged to ensure that data collection networks and associated instrumentation are calibrated and are functioning effectively and efficiently. Member States are also encouraged to ensure that data collected from such networks are made available to national and regional institutions to support a broad range of investigations including drought analysis and the impacts of drought on water resources and sectors sensitive to water availability. Further more, Member States are encouraged to ensure that appropriate technical capacity to support decision making in the water resources sector and related sectors is available in national institutions. Where such capacity is lacking, Member States are urged to utilize appropriate resources in regional Institutions. Regional Institutions are urged to include in their research and development activities the development of early warning systems and appropriate indicators to support Member States in their planning and adaptation strategies. In this regards, Member States are encouraged to renew their various commitments to the activities of regional institutions.
- Given the financial vulnerability of national and regional economies to droughts and the fact that such events may become more frequent, intense and extreme in the future, CARICOM Member States are encouraged to consider requesting the CCRIF to explore the possibility of offering drought insurance to national governments to offset financial losses from drought.
- As indicated by the current drought, decision making in one sector can have significant implications in other sectors. CARICOM Member States are encouraged to implement appropriate multi-sector national working groups to ensure that all sectors

are familiar with the various sensitivities and needs of other sectors to ensure timely and effective decision making. A model for similar working groups currently exists among CARICOM Institutions. Member States are encouraged to draw on the strengths of this model.

- Given the increasing complexity associated with sustainable water resources management, Member States are encouraged to ensure that they have access to skilled professionals with investments in tertiary training and continuous professional development. Where resources are lacking, Member States are encouraged to utilize south-south bilateral relations or other regional cooperation arrangements.

9. Conclusion

The drought of 2009-2010 exposed severe deficiencies in the region's ability to cope with drought. This was evident in several sectors including water, agriculture and energy. The net impact of the drought in some countries was an increase in the cost of living as evident by increases in food prices.

The greatest challenge was the region's inability to recognise the onset of the drought and its severity. Recent advances such as the Caribbean Drought and Precipitation Network and the application of the Caribbean Precipitation Outlook to forecast the drought and its duration have significantly increased the capability of the region to address the deficiencies and better cope with future situations. This was evident during the recent drought in that although not fully operational the CDPMN brought the awareness of the situation and the continued intensification of the drought to the attention of the Caribbean public. This exposed yet another deficiency in the region, where national meteorological services, even though the information is available, lacks the capacity to, in some cases digest or other cases to divulge or adequately communicate information provided. It is critical that the region develops good forecasting capability as an important component of our region's adaptation strategy. Under projected climate change and variability scenarios, such degrees of dryness are likely to be more common-place. This may involve creating a culture where climate services are accepted as important to national development.

For the economic sectors to adapt to drought involves greater integration between stakeholders, including sharing of data, dialogue and collaboration between national, regional and international stakeholders in various activities that inform drought monitoring and forecasting.

Also critical is policy reform to incorporate Integrated Water Resources management (IWRM). IWRM provides a framework for managing water resources under different scenarios including and for water resources planning, imperative for minimising water resources deficits. Policies that encourage i) regular reviews of water resources, ii) guarantees of functioning and well calibrated instrumentation for data collection, iii) the introduction of drought insurance, iv) the implementation of multi-sector national working groups v) access to skilled professionals; should be seriously considered.

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