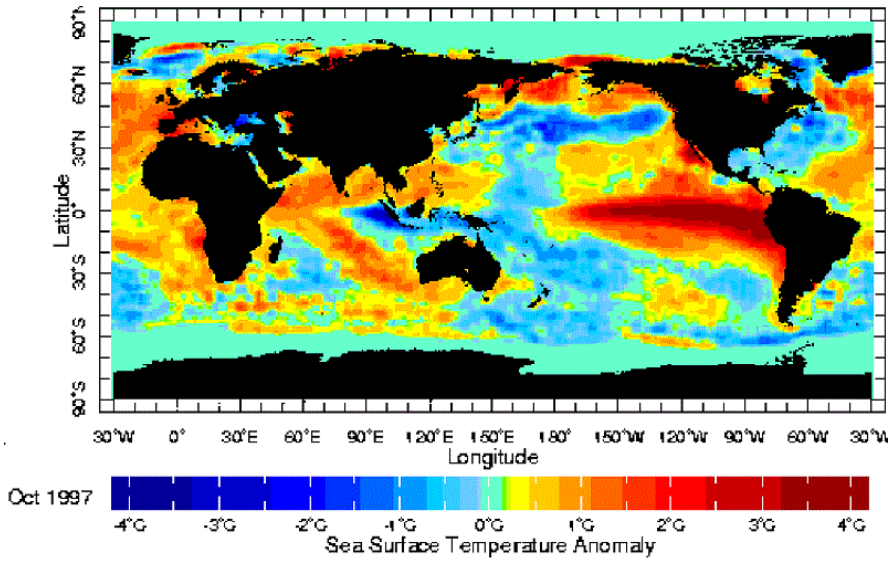
Guyana Lands and Surveys Commission (GLSC)
United Nations Development Programme (UNDP)

GUYANA DROUGHT EARLY WARNING SYSTEM PROTOCOL



October 2015.

GUYANA
DROUGHT EARLY WARNING SYSTEM PROTOCOL

Mario Epstein (D.Sc. , J.D.)
Epstein.mario@gmail.com
October 2015

Table of Contents

Cover: The 1997 El Niño, when Guyana suffered one of its worst drought in the history.

List of Acronyms

CDC	Civil Defence Commission
DEWS	Drought Early Warning System
DMP	Drought Mitigation Plan
EDWC	Guyana East Demerara Water Conservancy
ENSO	El Niño/Southern Oscillation
EWS	Early Warning System
FAO	Food and Agriculture Organization
GINA	Guyana Government Information Agency
GWI	Guyana Water Incorporated
ITCZ	Inter- tropical Convergence Zone
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
PDO	Pacific Decadal Oscillation
RDCs	Regional Democratic Councils
SPI	Standardized Precipitation Index
TAO	Tropical Atmosphere and Ocean
TOGA	Tropical Ocean–Global Atmosphere
TRITON	Triangle Trans Ocean Buoy Network
WMO	World Meteorological Organization

1. INTRODUCTION

1.1. Guyana Geography

1.1.1. The territory controlled by Guyana lies between latitudes 1° and 9°N, and longitudes 56° and 62°W. The country can be divided into five natural regions; a narrow and fertile marshy plain along the Atlantic coast (low coastal plain) where most of the population lives; a white sand belt more inland (hilly sand and clay region), containing most of Guyana's mineral deposits; the dense rain forests (Forested Highland Region) in the southern part of the country; the desert savannah in the southern west; and the smallest interior lowlands (interior savannah) consisting mostly of mountains that gradually rise to the Brazilian border.

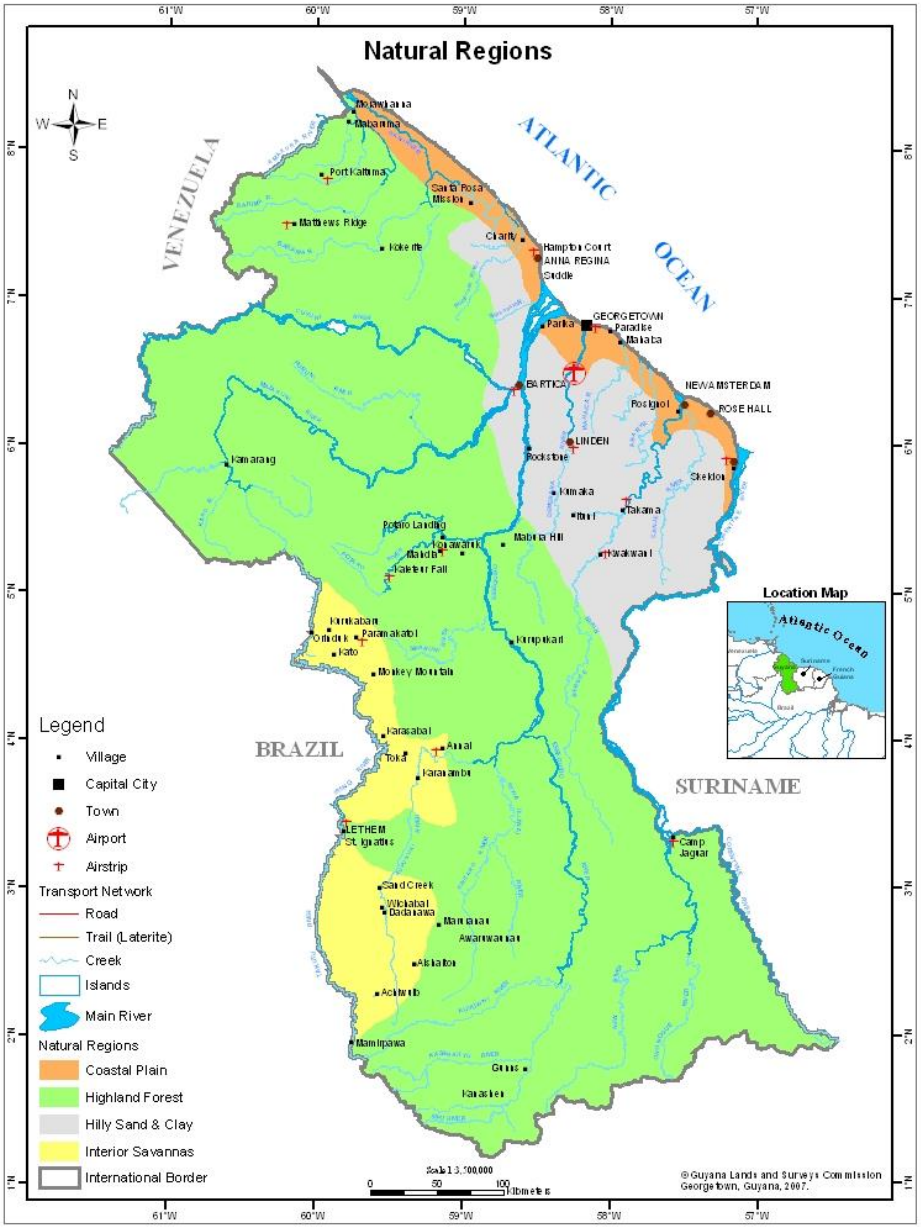


Figure 1 – Guyana's natural regions.

1.1.2. Guyana is divided into 10 administrative regions. The regions are divided into 27 neighborhood councils.

Table 1 – Guyana's regions.

No	Region	Area km^2	Population (2012 Census)	Population (2012 Census) per km2
1	Barima-Waini	20,339	26,941	1.32
2	Pomeroon-Supenaam	6,195	46,81	7.56
3	Essequibo Islands-West Demerara	3,755	107,416	28.61
4	Demerara-Mahaica	2,232	313,429	140.43
5	Mahaica-Berbice	4,19	49,723	11.87
6	East Berbice-Corentyne	36,234	109,431	3.02
7	Cuyuni-Mazaruni	47,213	20,28	0.43
8	Potaro-Siparuni	20,051	10,19	0.51
9	Upper Takutu-Upper Essequibo	57,75	24,212	0.42
10	Upper Demerara-Berbice	17,04	39,452	2.32
	Guyana	**214,999**	**747,884**	**3.48**

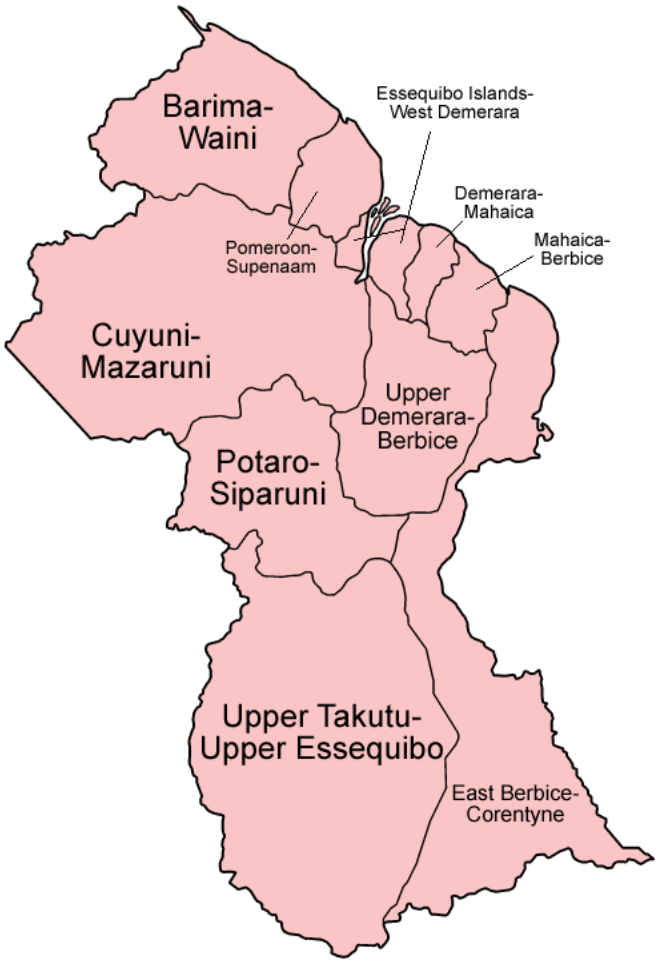


Figure 2 – Guyana's Administrative Regions.

1.2. Drought

1.2.1. Predicting droughts after the rains have disappeared is not science, but the study of history. It has little value for protecting populations and economic activities of Guyana. The success of a Drought Early Warning System (DEWS) depends in eighty percent, on the capacity of the country to detect a drought several months in advance, allowing the dissemination of the news and preparedness to mitigate the effects. The early warning component of a drought plan is essential because it provides the foundation on which timely decisions can be made by decision makers at all levels.

1.2.2. Drought is a normal part of climate and occurs in virtually all regions of the world. Recent droughts have illustrated the vulnerability of South America and the Caribbean to extended periods of precipitation deficiency. Drought preparedness planning has become a widely accepted tool for governments at all levels to apply to reduce the risks to future events.

1.2.3. Because of drought's slow onset characteristics, monitoring and early warning systems provide the foundation for an effective drought mitigation plan. Drought differs from other natural hazards in several ways. First, since the effects of drought often accumulate slowly over a considerable period of time and may linger for years after the termination of the event, the onset and end of drought is difficult to determine.

1.2.4. Another distinguishing feature of drought is its duration. Droughts usually require a minimum of two to three months to become established but then can continue for months or years. The magnitude of drought impacts is closely related to the timing of the onset of the precipitation shortage, its intensity, and the duration of the event. As with other natural hazards, drought has physical, social, and economic components. Well-conceived policies, preparedness plans, and mitigation programs can greatly reduce societal vulnerability and, therefore, the risks associated with drought.

1.2.5. There are many challenges to improving the management of droughts. Because of its slow onset characteristics and lack of structural impacts, it is often disregarded. This lack of recognition of the importance of drought as a natural hazard by some actors has been an impediment to obtaining adequate financial support and, in many instances, an obstacle to building awareness among policymakers at the local, national, regional, and international level. This lack of awareness, in turn, has resulted in an under-appreciation of drought and its far-reaching impacts. It has also perpetuated the process of dealing with drought in a crisis management mode.

1.2.6. A drought protocol has three components: monitoring and early warning; risk assessment; and mitigation and response. The monitoring and early warning component of a drought plan is essential because it provides the foundation on which timely decisions can be made by decision makers at all levels.

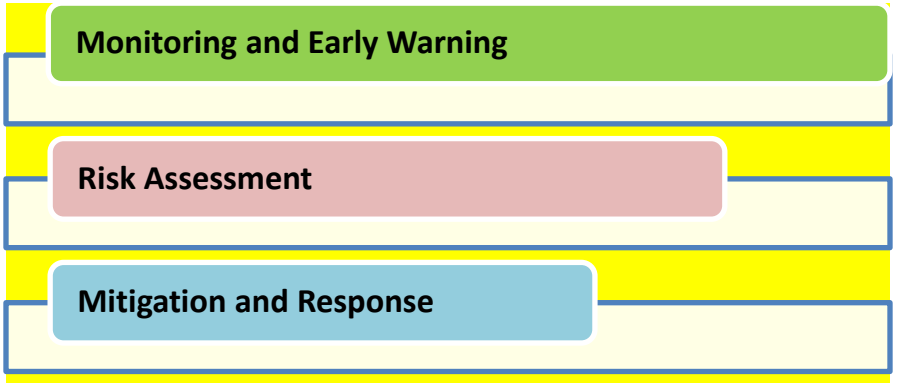


Figure 3 - Three Components of a Drought Protocol.

1.3. A Simple Model for the DEWS Protocol for Guyana

1.3.1. This paper presents a simple model for a Drought Early Warning System (DEWS) Protocol for Guyana. The goal is to allow the authorities to forecast well in advance prolonged drought and take preventive measures to reduce or mitigate the impacts. The model does not have the sophistication of the models used in countries more advanced than Guyana in financial or human resources, but has the virtue of being able to be implemented immediately, with very low cost and with high reliability.

1.3.2. he DEWS is relatively new to the Guyanese population and as such, there is a need to be as clear and detailed as possible in every aspect of this paper. The language of this report is simple to allow government officials, municipal institutions, NGOs and all stakeholders to understand it and assimilate its results.

1.3.3. The main purpose of having a DEWS is to protect lives and livelihoods from droughts, minimizing negative impacts on economy and environment. An effective DEWS constitutes one of the key elements of any disaster reduction approach. Devising measures to help the citizens of Guyana to be previously informed about the coming drought and adjust through adaptations efforts is a foundational concept throughout this paper.

1.3.4. The next figure shows an abstract of the proposed DEWS Protocol.

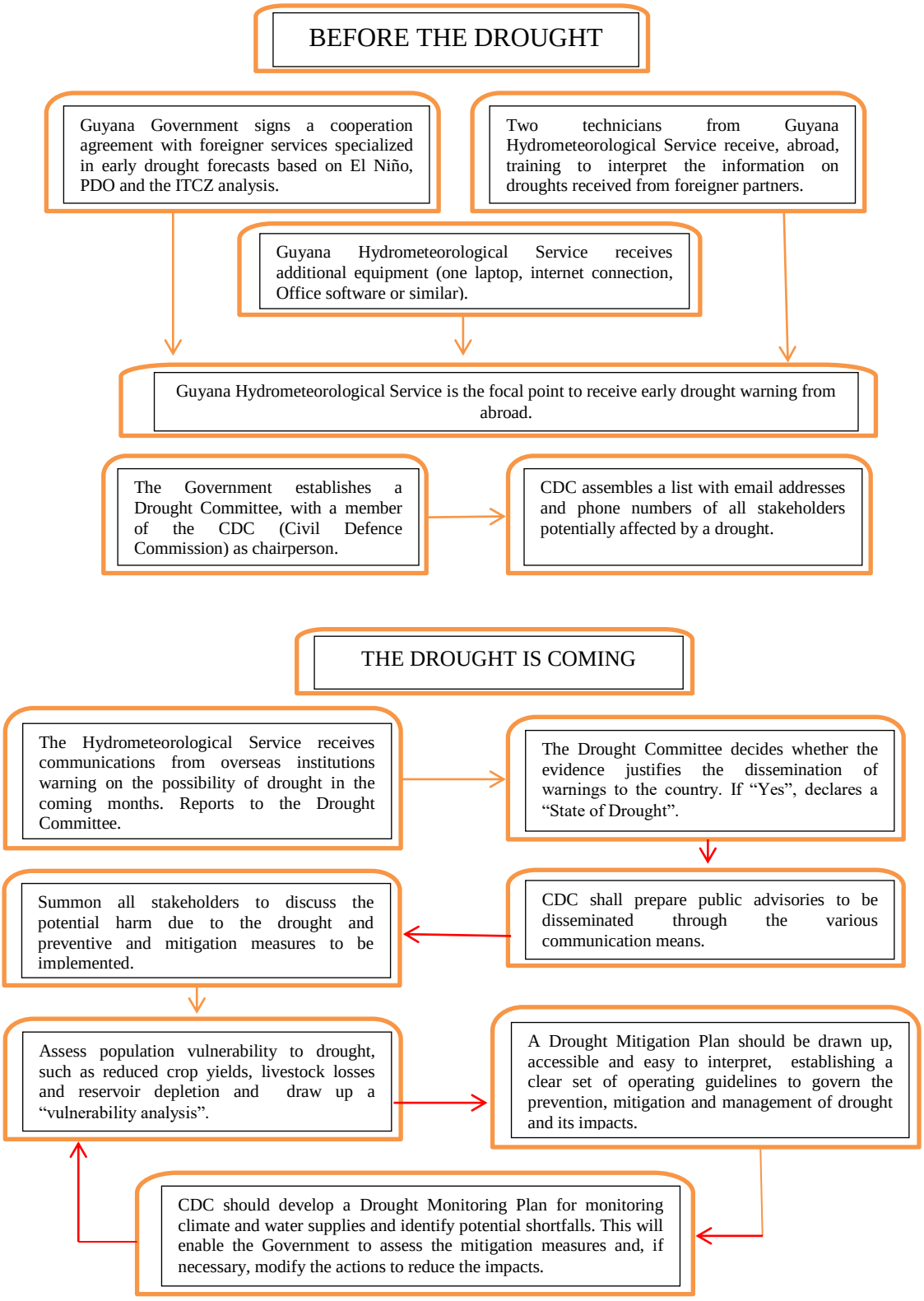


Figure 4- An abstract of the proposed DEWS Protocol.

2. THE DEFINITIONS OF DROUGHTS

2.1.1. Drought can be defined as a moisture deficiency that has serious adverse effects on a community usually by reducing food production or surface water supplies. Drought can be highly destructive and it is now thought that climate change is fuelling a rise in the intensity and frequency of drought around the world. Drought is sometimes called a "creeping phenomenon" because it moves slowly but steadily into an entire region and lingering for long periods of time. To deal with drought effectively, it is crucial to determine when it started, how severe it is and when it is likely to end.

2.1.2. There are at least three different types of droughts. Meteorological drought refers to precipitation deficits, agricultural drought refers to abnormally low soil moisture and hydrological droughts reflect below-average water levels in lakes, rivers and streams.

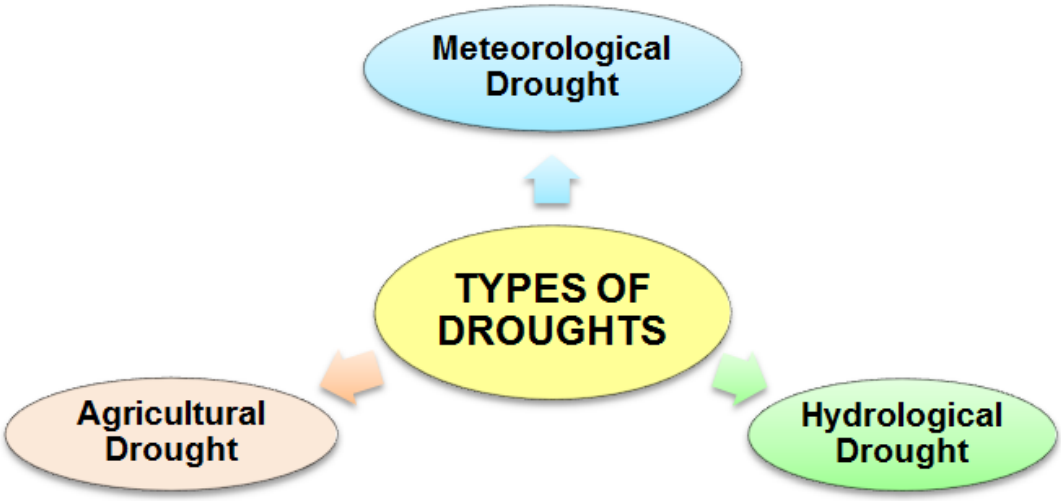


Figure 5 - Diagram showing types of droughts

3. IMPACTS OF DROUGHTS ON GUYANA

3.1. Rainfall in Guyana

3.1.1. Guyana is a water-rich country. It has two wet seasons, and two dry seasons: First Dry Season: February to April; First Wet Season: April to July; Second Dry Season: July to November; Second Wet Season: November to January.

3.1.2. Figure 6 shows a map of the average rainfall in all regions of Guyana.

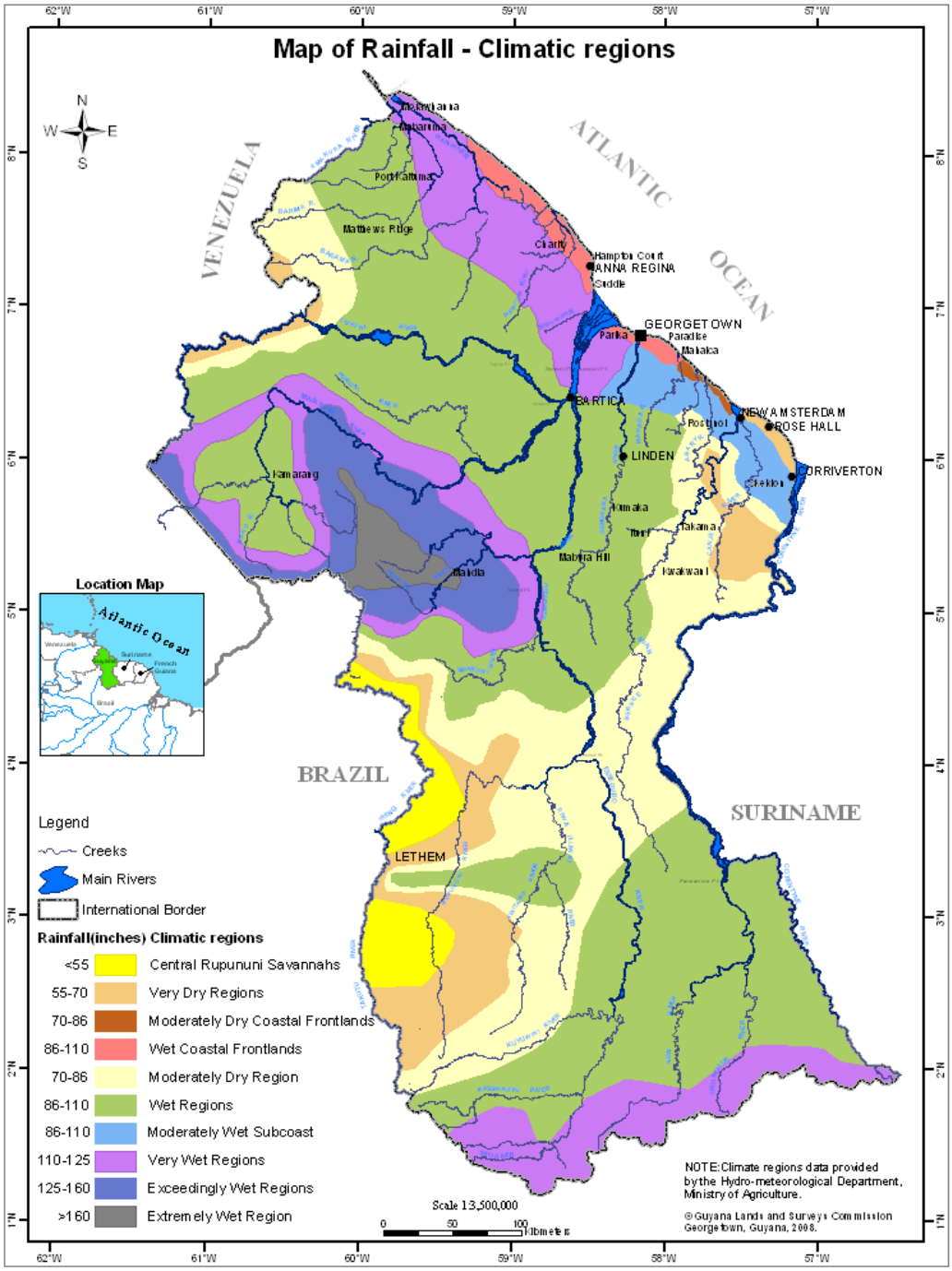


Figure 6 – Map of rainfall and climatic regions.

3.2. The 1997 – 1998 Drought

3.2.1. In July 1997 a severe drought in Guyana affected 607,200 persons and resulted in an economic loss of US$29 Million. The drought produced unprecedented drought conditions throughout the country. Rainfall was 50% below 1996 rains, and rainfall during March 1997 was 85% lower than usual This has resulted in severe water shortages that affected 80% of the population (759,000 inhabitants) and had dramatic effects on the economy. On 26 March, 1998, the President of Guyana declared a state of national emergency.

3.2.2. During the drought of 1998, Guyana experienced water rationing, cessation of logging and river transport in some places and the loss of livestock. The rains between August 1997 and February 1998 were 75% below the normal precipitation.

3.2.3. The lack of rain has not only created shortages of drinking water but it also reduced food supplies, as sea water moves upstream into agricultural areas and crops fail.

3.2.4. According to the Guyana- Initial National Communication, April 2002, "The salinity of an estuary represents the outcome of, (1) the tendency for the ocean salt water to completely mix with the estuarine water and, (2) the tendency of fresh water flowing into the estuary to dilute the saline water and push it back towards the ocean. During droughts, the salt water penetrates upstream, as has been observed in the estuary of the Canje river, while during the rainy season, low salinity levels prevails. A rise in sea level has an impact similar to decreasing the freshwater inflow.

3.2.5. Drinking water shortages occurred throughout the country, and particularly in the capital, Georgetown. Rivers, creeks and ponds shrunk and in some instances dried up completely or were contaminated by sea water, while wells and springs had run dry in hinterland areas. Unsafe drinking water and the risk of waterborne or water-related diseases constituted health threats: an increased number of malaria and dengue fever outbreaks were reported. Depleted river levels also hindered the use of waterways for transportation purposes.

3.3. The 2009 – 2010 drought

3.3.1. The drought of 2009 - 2010 affected the whole Caribbean region. Stations recorded their lowest six month (October 2009 to March 2010) totals, leading to water rationing and major crop losses. In one of Guyana's regions the delivery of water through pumping and creation of canals reached a cost of US$ 16,000 per day, pumping saline water to about 150 acres of rice lands. In February 2010, the Government of Guyana allocated US$ 1.3 million for farmers relief in Region 2.

3.3.2. The 2009 – 2010 drought caused in Trinidad and Tobago an inflation of 61% in the price of fruits, 160 bush fires in Dominica, and land degradation – flooding and landslides after drought, particularly where there was denudation of slopes from fires.

3.3.3. In 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). An increased incidence of diarrhea was attributable to the use of unsafe water. Most of Guyana's population live in a 30 kilometer band along the Atlantic coast (see Coastal Plain on the Natural Regions Map above). Much of the coastal plain is below mean sea level and is situated between freshwater reservoirs (Conservancies), and natural and man-made sea defense structures. A complex network of drainage and irrigation canals links with the East Demerara Water Conservancy (EDWC) to provide agricultural lands and urban areas with irrigation and drinking water. During times of heavy rainfall, this system functions as a regional drainage and flood control mechanism. (Source:- Document of the World Bank, FOR OFFICIAL USE ONLY, Report no: 39120-GY, Project Appraisal Document on a Proposed Grant From The Global Environment Facility Special Climate Change Fund in the amount of US$3.8 Million to the Republic of Guyana for a Conservancy Adaptation Project, September 19,2007)

3.4. The 2015 Drought

3.4.1. Following extended periods of dry weather in 2015, Region Nine (Upper Takutu-Upper Essequibo) (see Map of Administrative Regions below) has been hit by a severe case of drought, causing all the water wells to dry up and frequent bush fires to break out – the latest of which destroyed several farms at Aranaputa.

3.4.2. The situation was caused by the low seasonal levels of rainfall in Region Nine and parts of Region One (Barima-Waini), due to frequent periods of severe drought experienced in the north-east region of neighboring Brazil. This region has been experiencing droughts since 2011 resulting in millions migrating to São Paulo. However, even this major city is at risk of ending up without water since the February 2015 rains were not extensive.

3.4.3. In Region Nine, residents do not have access to potable water for domestic and agriculture use. The drought has also attracted a resurgence of pests that are attacking the few crops that survived the drought.

3.4.4. Farmers and ordinary householders in Guyana, Suriname, Trinidad and Tobago, Barbados, Grenada and St. Lucia, among others, were expressing concern about looming water shortages resulting from the prolonged dry season that saw vastly reduced annual year-end rainfall levels. Guyana's authorities have spent $1.2M to improve irrigation and to pump water into farmlands that are feeling the effects of largely absent year end rains. The latest forecast indicates the situation will continue up to March 2016. According to the climatic regions, some areas are more vulnerable than others due to the topography and vegetation cover (see Map of Climatic Regions above).

3.4.5. In response to this situation, the Guyana's Civil Defense Commission (CDC) was mandated to coordinate a response which is being led by the Ministries of Amerindian Affairs, Local Government, Housing and Water, and Public Works along with the Guyana Water Incorporated (GWI).

4. FORECASTING DROUGHT

4.1. The Standard Precipitation Index (SPI)

4.1.1. Unlike the floods that can occur suddenly, droughts are long-term phenomena that, by using the right models, can be predicted or inferred several months in advance.

4.1.2. Unlike other hydrometeorological hazards, drought risk remains poorly understood, without a credible global drought risk model. Until 2009, when the World Meteorological Organization - WMO adopted the Standard Precipitation Index as the global standard to measure droughts, there is no agreed standard measure of meteorological droughts. As a result Drought Early Warning Systems are relatively less developed globally than other EWS.

4.1.3. A critical component of planning for drought is the provision of timely and reliable climate information, including seasonal forecasts, that aids decision makers at all levels in making critical management decisions. This information, if properly applied, can reduce the impacts of drought and other extreme climate events.

4.1.4. Local knowledge had been a critical component of EWS for droughts in the past. But very few formal successful rain based drought early warning systems exist around the world. The reason is that the decreasing of rain fall appears only after the drought started.

4.1.5. Currently, meteorological services cannot predict droughts from past meteorological data in their own country. The reason is that the drought is caused by external factors that are not reflected in the meteorological data that precede it. The use of local meteorological data to predict drought has the disadvantage that they only predict the drought after the drought already begun, which may be too late.

4.2. Use of Standard Precipitation Index in Guyana

4.2.1. The long-term mean annual rainfall of Guyana shows a pattern of two distinct wet seasons, mid-year and end-of-year. The drier months are usually between February to April, and July to November. Of notably significance is that this pattern can vary annually.

4.2.2. The Hydro-meteorological Service is responsible for monitoring, analyzing and archiving the rainfall records of Guyana. Its Meteorological Branch maintains a rainfall network of rain gauges and rainfall recorders located strategically across the country. From the information collected the values for the country's drought Index can be computed. This index could be used to determine the onset, intensity and end of a drought in Guyana, but it has the great disadvantage of only indicating that there will be a drought after the strong impacts are being felt.

4.2.3. The Standardized Precipitation Index (SPI) is a tool which was developed primarily for defining and monitoring drought. It allows an analyst to determine the rarity of a drought at a given time scale (temporal resolution) of interest for any rainfall station with historic data. It can also be used to determine periods of anomalously wet events. The SPI is not a drought prediction tool.

4.2.4. Mathematically, the SPI is based on the cumulative probability of a given rainfall event occurring at a station. The historic rainfall data of the station is fitted to a gamma distribution, as the gamma distribution has been found to fit the precipitation distribution quite well. This is done through a process of maximum likelihood estimation of the gamma distribution parameters, α and β. In simple terms, the process allows the rainfall distribution at the station to be effectively represented by a mathematical cumulative probability function. Therefore, based on the historic rainfall data, an analyst can then tell what is the probability of the rainfall being less than or equal to a certain amount.

4.2.5. The biggest disadvantage of this process is that it does not address the real source of droughts. A DEWS Protocol should seek external factors that produce the drought and can give an alert well in advance the phenomenon will occur. As we shall see below, without knowing this source, any DEWS is doomed to failure because it will alert the authorities when the drought has already occurred.

4.2.6. Considering these disadvantages, it is not recommended that Guyana spends more resources using this method in the interim while a better forecasting method is being developed because (i) it does not forecast drought and (ii) the next drought after the 2015 /16 one will happen in the next El Niño, which may take two or more years. In the meantime, the recommendations of this Protocol will allow Guyana prepare herself for the next drought.

5. THE ORIGIN OF DROUGHTS IN GUYANA

5.1. The El Niño

5.1.1. Researchers in various meteorological organizations in the Americas and the Caribbean found a strong correlation between El Niño and drought in several regions of the area, including the Guyana.

5.1.2. El Niño is a warming of surface waters in the eastern tropical Pacific Ocean. Together with La Niña, these make up two of the three states of the constantly changing El Niño/Southern Oscillation (ENSO) that can affect weather patterns around the globe. Scientists realized that El Niño was part of a much larger, recurring phenomenon that can bring about abnormal and often severe changes in temperature and precipitation throughout the tropics. Once it has begun, an El Niño or La Niña event usually lasts about 12 to 18 months.

Table 2 - Droughts in Guyana and Relation to El Niño

DROUGHT	PACIFIC OCEAN
Mar 1987	El Niño
Jan 1988	El Niño
Oct 1997	Severe El Niño
Apr 2003	Immediately after El Niño
Sep 2006	El Niño
Feb 2007	Immediately after El Niño
Nov 2009	El Niño
Jan 2010	El Niño

Source: Desinventar and NOAA

5.1.3. The cycling of ENSO between El Niño and La Niña is irregular, but recurs about every two to ten years. This cycle is not a regular oscillation like the change of seasons; it is much more erratic in strength, timing, and pattern. Some decades have seen an ENSO event occur every few years while some decades have passed without even one.

5.1.4. Because of the wide variability in events leading to their onset, ENSO episodes are difficult to predict. For decades, scientists lacked the observational data that could be used in predictive models. However, widespread damage from the 1982-1983 El Niño event prompted a major study of the phenomenon. This 10-year program, named Tropical Ocean–Global Atmosphere (TOGA), developed an extensive oceanographic observation system to support climate studies. Since the completion of TOGA in 1995, the combined Tropical Atmosphere and Ocean (TAO) Triangle Trans Ocean Buoy Network (TRITON) Project has continued to monitor the equatorial Pacific Ocean with a series of moored buoys. With this monitoring network in place, ENSO events are now often predictable up to a year in advance.

5.1.5. In Figure 7 one see the strong correlation between rainfall and the occurrence of El Niño.

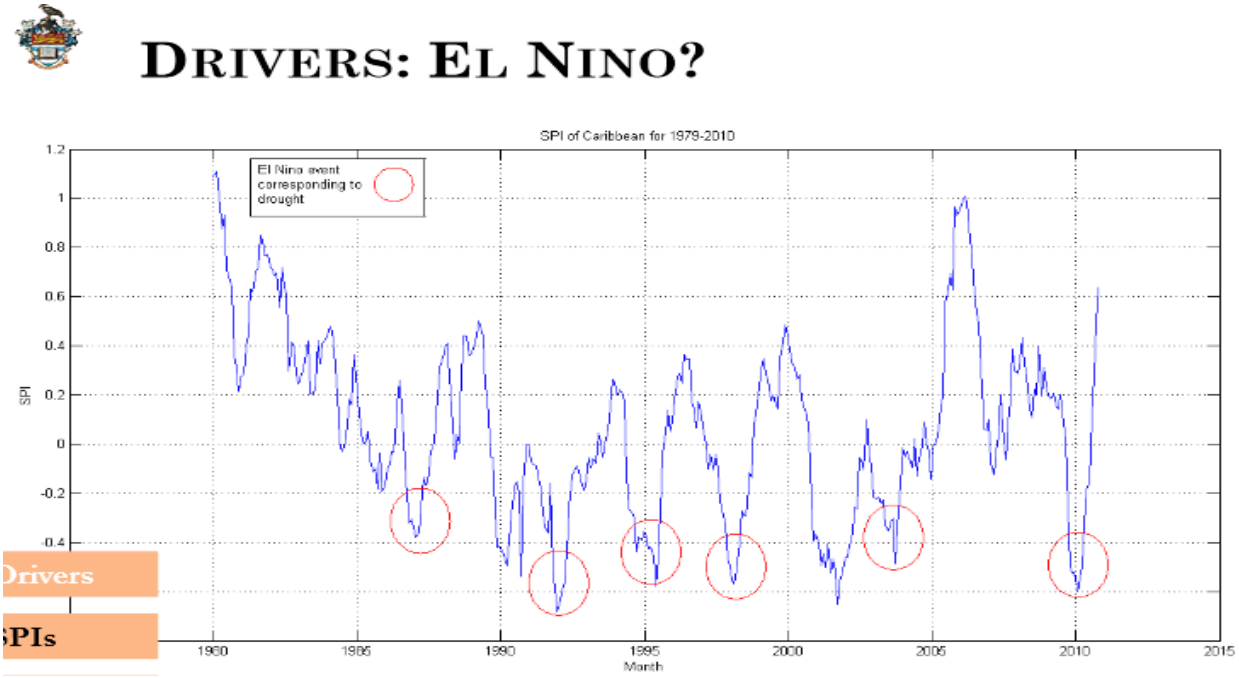


Figure 7 - Correlation between rainfall in the Caribbean and the occurrence of El Niño. Source: Walters et alii.

5.1.6. A major reason for the 2015 drought in Guyana is a paucity of precipitation due to a particularly harsh El Niño since March 2015. The situation is further aggravated by the presence of an abnormal amount of dust and dry air over the southern Atlantic. A region vulnerable to devastating hurricanes, the Caribbean is enduring, in 2015, its worst drought in at least five years due to the El Nino weather pattern. The phenomenon, which has dried Canadian wheat fields, caused palm oil prices to rise and risks boosting global food inflation, resulted in some islands with as little as half their average rainfall. There is at least a 90 percent chance that El Nino, caused by above-average sea surface temperatures off equatorial South America's Pacific coast, will last through next winter and an 80 percent chance it will endure into spring 2016, according to the U.S. National Oceanic and Atmospheric Administration (NOAA).

5.1.7. As seen in the Figure 8, the warming of the Pacific Ocean in 2015 has a similar (and bigger) pattern to the 1997 El Niño, confirming again the present knowledge that the El Niño is one of the main reasons for the droughts in Guyana.

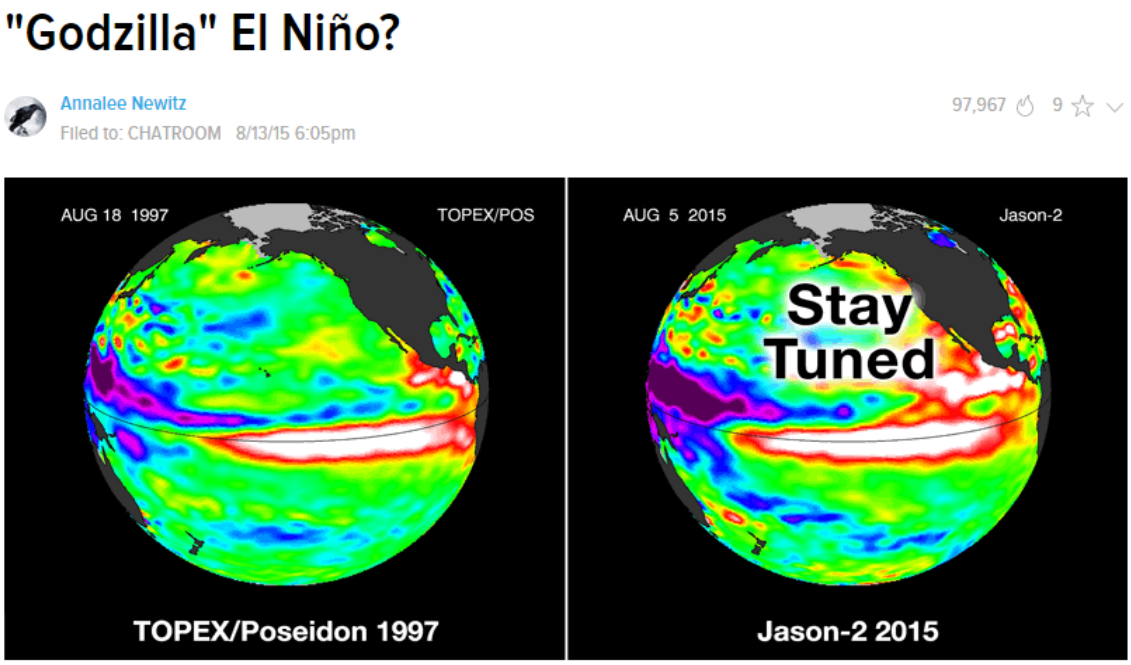


Figure 8 - Warming of the Pacific Ocean (in red) in 1997 and 2015. Source: Newitz, Annalee.

5.2. The ITCZ

5.2.1. Another weather phenomenon known since the eighteenth century and called by climatologists ITCZ – Inter-tropical Convergence Zone, is a moist air ring surrounding the Earth near the equator. The ITCZ is between the latitudes of 10 ° north and 5 ° south, the region where the trade winds from the northern and southern hemispheres meet. This phenomenon is also called 'Hadley cell', due to the English meteorologist George Hadley (1685-1768) who in 1735 described its operation.

5.2.2. Depending on its location, the Inter-Tropical Convergence Zone can mitigate or exacerbate droughts caused by El Niño.

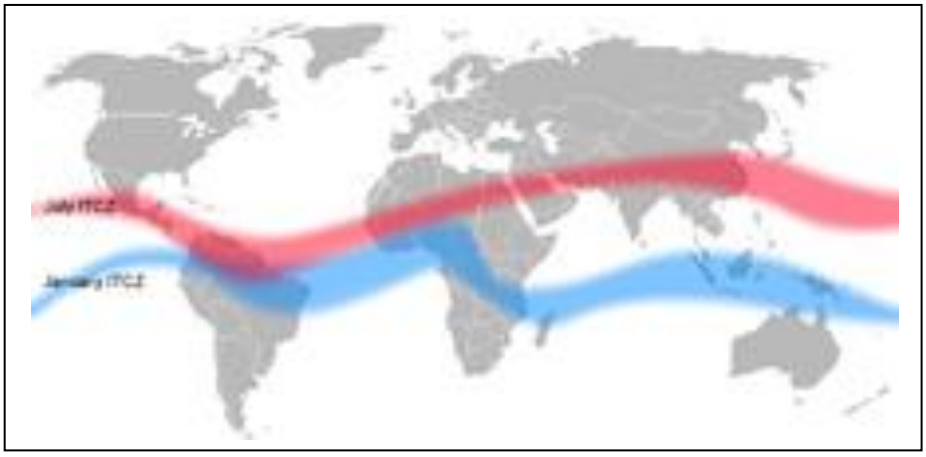


Figure 9 - The ITCZ – Inter-tropical Convergence Zone Wikipedia 2015).

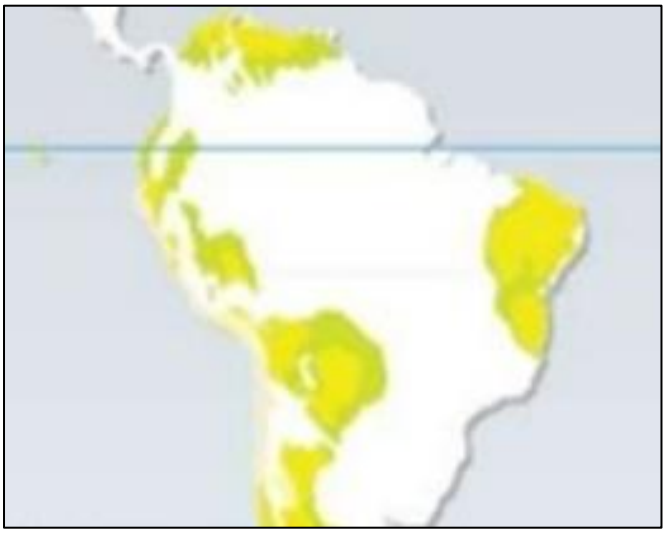


Figure 10 – Areas of South America most affected by drought due to the combination of El Nino and the ITCZ.

5.3. The PDO

5.3.1. The Pacific Decadal Oscillation - PDO is characterized by the succession between warm and cold phases in the tropical area of the Pacific Ocean. The cycles last 20-30 years and are broader than the El Niño and La Niña, which alternate between two and seven years. In 1999, the ocean has entered a cold phase, which should last until 2025 and is reflected in El Niño mild and La Niña more intense.

5.3.2. Currently, the Pacific is at the height of the cooling cycle, which, according to experts, historically brings four consecutive years of summers with rainfall below normal in the Central-South region of Brazil. Since 2012, it has been raining below average in the South, Southeast and parts of the Midwest during the summer. In principle, the rains will return to its average in 2016.

6. GUYANA'S FEASIBILITY TO DEVELOP ITS OWN DROUGHT FORECASTING MODEL

6.1. In House Forecasting

6.1.1. For the DEWS to be activated, it is necessary to detect hydrometeorological conditions that could bring drought to the region. In the case of Guyana, these conditions are, mainly but not only, the El Niño, the PDO and the ITCZ.

6.1.2. An option for the DEWS is Guyana doing its own analysis of weather data. But this is high science that requires extensive years of data on temperature of the Pacific and Atlantic oceans and of the atmosphere on a large surface of the Earth, and complex computational models that require super computers to process. Guyana is a small country with limited resources. Doing research in DEWS is expensive and requires a large team of scientists.

6.1.3. The recommendation of this Report is that it is better and more efficient for Guyana to have technical cooperation agreements with other national and international agencies, with more financial and human resources, working on droughts forecast in South America and the Caribbean. This would allow Guyana focus to remain on mitigation and relief.

6.2. How the Guyana Meteorological Service Should be Adapted to Forecast Droughts

6.2.1. It is suggested that the existing Guyana's Hydrometeorological Service works as the focal point for receiving drought forecasting from abroad. The necessary additional equipment would be: a computer (laptop) of the latest generation; a fast internet connection; an Office program or similar; and a communication software that allows the transmission of information to all national stakeholders that have interface with the problem of drought.

6.2.2. The Guyana's Hydrometeorological Service, through the National Government, should seek a technical cooperation agreement with major institutions that do drought research and forecasting, in the USA, in Brazil, in the Caribbean, with the WMO and other institutions that specifically monitor the El Niño and the other hydrometeorological phenomena that can result in drought in Guyana.

6.2.3. Two or three technicians from Guyana should receive, abroad, training to interpret the information on droughts received from institutions with which the Government of Guyana will make a cooperation agreement to forecast droughts. However Hydromet should take incentives to avoid the trained staff members from moving on when they would have received the training. After the training, their task will be to receive daily reports on potential droughts forecasts from the institutions abroad. They will not use droughts models but just receive the forecasts from abroad and translate them to the local conditions.

7. WHO CAN ASSIST GUYANA IN FORECASTING DROUGHTS

7.1. Institutions Forecasting Drought Abroad

7.1.1. Droughts do not recognize geographical boundaries. Major droughts may often simultaneously affect several countries in a particular period of time. It will be the national endeavor of the Guyana Government to develop close cooperation and coordination at the international level in all spheres of Disaster Risk Management.

7.1.2. Among the organizations that can help Guyana to obtain data on El Niño, PDO and the ITCZ, including drought forecasts, one finds:

- Caribbean Disaster Emergency Management Agency - CDEMA, (www.cdema.org/);

- Caribbean Meteorological Organization provides training for the Region's weather observers and technicians, weather forecasters, specialists in hydrology, agro meteorology and other related disciplines. (www.cmo.org.tt/);
- The main institution in Brazil forecasting droughts and floods for all South America with an excellent record is the INPE - National Institute For Space Research (www.inpe.br/ingles/). Brazil also gathers hydrological and meteorological data from rivers basins close to the border that might be suitable for enhancing Droughts Early Warning Systems (DEWS) in Guyana, but no Memorandum of Understanding has been established in this regard.
- Center for Weather Forecasting and Climate Research – CPTEC is a branch of INPE dedicated to weather forecast, including droughts (http://www.cptec.inpe.br/home/in). CPTEC is willing to help Guyana;
- The Caribbean Climate Outlook Forum (www.cimh.edu.bb/pdf/caricofmamjja.pdf);
- Global Drought Monitor (www.drought.gov/gdm/content/welcome);
- The U.S. Drought Monitor – USDM (droughtmonitor.unl.edu/). USDM relies on several key indicators and indices such as the Palmer Drought Severity Index (PDSI), the Standardized Precipitation Index, stream flow, vegetation health, soil moisture and impacts, as well as Keetch-Byram Drought Index, reservoir levels, Surface Water Supply Index, river basin snow water equivalent, and pasture and range conditions.;
- The National Integrated Drought Information System (www.drought.gov/);
- NOAA - National Oceanic and Atmospheric Administration (Weather) (http://www.noaa.gov/wx.html);
- Climate Prediction Center – NOAA (www.cpc.ncep.noaa.gov/products/predictions/90day/);
- National Drought Mitigation Center (http://drought.unl.edu/);
- Caribbean Drought and Precipitation Monitoring Network (CDPMN) (http://www.cimh.edu.bb/cami/files/cdpmn.pdf). Guyana is a member of the (CDPMN) which was established as part of the Caribbean Water Initiative (CARIWIN) Project. Information is shared with the National Drainage and Irrigation Authority, Civil Defence Commission, all of the agencies that reports to Ministry of Agriculture, extensions officers.
- Caribbean Centre for Climate and Environmental Simulations – CCCES (http://www.cimh.edu.bb/?p=ccces). The mission of the CCCES is to provide climate and environmental researchers in CARICOM Member States with state-of-the-art computational resources to (i) develop solutions to challenging climate and environmental problems in the region to inform decison-making; (ii) further climate and environmental research in the region; and (iii) support risk-based early warning systems across the region.
- Caribbean Agricultural Research & Development Institute (www.cardi.org/).
- WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (http://www.wmo-sat.info/vlab/), a global network of specialized training centers and meteorological satellite operators working together to improve the utilization of data and products from meteorological and environmental satellites.

7.2. Literature Available

7.2.1. Many articles, manuals and protocols are available to help the training of the personnel responsible

for the reception of the drought forecasts sent by foreigner institutions:

- A guideline to the Protocol should be the United Nations Secretariat of the International Strategy for Disaster Reduction (UN/ISDR) and the National Drought Mitigation Center partnered to develop "Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action" (UN/ISDR 2007). The document provides information to assist countries in reducing their drought risk and meeting the terms of the "Hyogo Framework for Action 2005-2015" (see http//www.unisdr.org/hfa);
- Drought risk management measures- preparedness, mitigation, response & recovery. UN/ISDR (www.unisdr.org/).
- Near East Drought Manual. (http://drought.unl.edu/portals/0/docs/neareastdroughtplanningmanual.pdf);
- UN-Water (http://www.ais.unwater.org/ais/course/view.php?id=37);
- Capacity Development to Support National Drought Management Policies, UN-Water (http://www.unwater.org/activities/multi-agency-featured-projects/drought-management/en/);
- Caribbean Water Initiative (https://www.mcgill.ca/cariwin/).
- Innovative Weather Model Helps Millions in Caribbean Prepare for Drought (https://www.usaid.gov/news-information/frontlines/science-technology-innovation-and-partnerships/innovative-weather-model). In little more than a year, this new drought forecast system expanded beyond Jamaica, helping inform decision-making and bolster climate resilience in 23 Caribbean countries, which may also have to make significant changes to adapt as global temperatures rise and weather patterns shift. The agency sent the drought forecast and other information via text messages to more than 500 farmers over the course of the drought, Brown says, and to approximately 700,000 more via bulletins disseminated by agricultural extension workers. These numbers continue to grow.

PART B - THE DROUGHT IS COMING

8. DECLARING DROUGHT

8.1. Receiving the Droughts Alerts

8.1.1. The Hydrometeorological Service has the mandate to advise policy makers of any drought which has occurred or which is likely to occur.

8.1.2. After the Hydrometeorological Service receives two communications from overseas institutions warning on the possibility of drought in the coming months, it should report the fact to a Drought Committee, formed by the organs of the Government that has a direct interest in the subject.

8.2. The Drought Committee

8.2.1. There should be formed a Drought Committee, whose function is to receive the Hydrometeorological Service warnings about possible droughts and decide whether the evidence justifies the dissemination of warnings to the country. It is suggested that the Committee's chairperson should be a member of the CDC, because it is the agency most involved with natural disasters.

8.2.2. The committee should include, at least, representatives of the following agencies:

- Hydrometeorological Service (monitoring & warning);
- Government Information Agency (GINA) (communication);
- Civil Defence Commission (CDC) (communication, dissemination, preparedness & response);
- Guyana Lands & Surveys Commission (GL&SC) (knowledge);
- National Drainage and Irrigation Authority (NDIA);
- Sea and River Defence Department (SRDD);
- Guyana Bureau of Statistics;
- Guyana Red Cross;
- Environmental Protection Agency (EPA)

8.3. Declaration of State of Potential Drought

8.3.1. The Committee should adopt a workable definition of drought that could be used to phase in and phase out levels of actions in response to drought.

8.3.2. When a meteorological drought is detected, before a drought period is declared, the Committee should, in a meeting, analyze the situation, based essentially on the water storage levels in some reservoirs, particularly multi-purpose reservoirs and the imbalance between water availability and water demand prediction.

8.3.3. If the decision of the Committee is for the presence of a drought, this Committee shall proposes to the Government to declare a “State of Potential Drought” and a Drought Mitigation Plan should be drawn up. The Committee must make its information accessible and easy to interpret, and it must deliver a clear, consistent message to decision makers so that they can act on this information.

8.4. Dissemination of the Information

8.4.1. People need to be warned of coming drought as soon as it is detected, but often are not. Information needs to reach people in time for them to use it in making decisions. In establishing information channels, the Drought Committee needs to consider when people need various kinds of information.

8.4.2. Based on the information received and the approval of the Office of the President, the CDC shall prepare public advisories to be disseminated through the various communication means: print, radio, television, mobiles, internet, SMS, etc.

8.4.3. As the dissemination about drought needs a skillful entity who knows how to interact with the population, it is suggested that the dissemination of the drought forecast be done by the CDC, in coordination with the GINA. It is important to highlight that one, and only one body should be responsible for the dissemination of drought warnings to other stakeholders.

8.4.4. The CDC shall assemble a list with email addresses and phone numbers of all entities, from the government and civil society, which have a stake in programs for the mitigation of the effects of the drought. When a State of Drought is declared, all entities on the list will be informed by telephone, email, text, WhatsApp and other media about the fact. All stakeholders shall be informed. The press, NGOs and social networks should be part of the list of entities that will receive the alert.

8.4.5. Each stakeholder should have a focal point, whose function will be to receive and internally disseminate the information received from CDC within his/her organization. As there is no formal system to determine whether advisories were actually received by the general population, the messages should be accompanied by a warning such as "if you do not reply that you have received

this message, your organization will be disconnected from the drought forecasting system".

8.4.6. Only high probability of droughts messages should be publicly disseminated. The extent of the risk is usually determined by meetings among the relevant agencies.

8.4.7. Although low and medium probability messages are generally avoided, as there is no existing criteria for the determination of the magnitude of a particular risk, it is recommended that these low and medium probability messages be disseminated, at least, within the governmental institutions, at least.

8.4.8. The CDC is already making progress in incrementing the use of computer technologies for communications, but an Information and Communication Technologies (ICT) policy and a stronger human capacities are needed.

8.5. The Role of the Civil Defence Commission (CDC)

8.5.1. The Civil Defence Commission (CDC) plays the lead role in national disaster preparedness and response. CDC chairs the National Disaster Platform which has the participation of all key agencies and stakeholders. At the local level there are ten (10) Regional Democratic Councils (RDCs) that are responsible for preparing their respective disaster preparedness and response plans under the supervision of the CDC. The preparedness and response plans of the RDCs also include the community-level (Neighborhood Democratic Councils).

8.5.2. As it is a technical entity which deals more closely with droughts, and for the sake of speed dissemination, it is recommended that for a DEWS, the CDC be the authorizing body for issuing the warning, which contradicts with the current national EWS Protocol. CDC has a small staff base, however, with training and more resources it can be the leader on information on drought forecast.

8.5.3. It is recommended that the CDC improves the Multi-hazard EWS, which has little mention of drought. This paper provides much guidance for such improvements to be made.

9. PREPAREDNESS TO RECEIVE THE DROUGHT

9.1. Getting Ready

9.1.1. “Preparedness” is defined as “the knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions”.

9.1.2. Preparedness is a fundamental concept in a national drought policy. Preparedness includes drought planning, plan implementation, proactive mitigation measures, and public education.

9.1.3. Reducing the risks and therefore the impacts associated with drought in the future requires that much greater emphasis be placed on preparedness. Preparedness leads to greater institutional capacity to cope with drought events through the creation of an organizational structure that improves information flow and coordination between and within levels of government.

9.1.4. Improving Guyana’s level of readiness or preparedness for drought is about building institutional capacity at all levels of government. It is also about increasing the coping capacity of individuals, communities, and governments to handle drought events. Drought preparedness, coupled with appropriate mitigation actions and programs, can reduce and, in some cases, eliminate many of the impacts associated with droughts.

9.1.5. The preparedness to cope with the drought requires a coordinated effort between multiple stakeholders, understanding stakeholder needs and capacities, timely data collection and dissemination by multiple stakeholders across multiple sectors and human capacity to process and interpret data in a timely manner.

9.1.6. Preparedness also includes collaborative non-competitive environment between stakeholders, regular and effective communications between technical personnel and decision-makers, and an effective system of protocols for issuing and communicating alerts to various stakeholders across multiple sectors.

9.2. Involving Leaderships

9.2.1. Leaders and other high-level authorities at the apex of political, social, agricultural and economic power need to be fully aware of the danger that drought poses, aware of the hardship it creates for people whose livelihoods are vulnerable to drought, and committed to disseminating information and implementing policies to help reduce human suffering and environmental degradation. Often, people at all levels of government in both developed and developing countries are preoccupied with other faster-moving, seemingly more urgent problems, until drought strikes, at which point it is difficult to implement change.

9.2.2. Building drought resilience thus needs to be part of long-term development considerations and an integral part of policies related to agriculture, water, food security and hazard risk management, ideally, in accord with community-based policies and practices, encouraging practices that reduce vulnerability to drought.

9.3. Reducing the Impacts

9.3.1. Drought impacts and losses can be substantially reduced if authorities, individuals, and communities are well-prepared, ready to act, and equipped with the knowledge and capacities for effective drought management. It should be recognized that mitigation and preparedness have a greater impact on reducing the scale and effects of drought disasters than ad-hoc emergency response measures.

9.3.2. Experience has shown that a critical feature of effective risk reduction (prevention, mitigation and preparedness) is the extent to which different actors and entities operate in a coordinated and timely manner by avoiding gaps, duplication of effort, and parallel activities and structures. This is especially vital given the increasing number of organizations involved in disaster risk reduction, related separately with development, environment and humanitarian sectors.

9.3.3. Several international documents have been developed to assist planners in choosing appropriate drought risk reduction strategies. For example, the National Drought Mitigation Center, USA, has developed the "How to Reduce Drought Risk Guide" (http://drought.unl.edu/plan/handbook/risk.pdf), and worked with FAO Near East Regional Office to produce the "Near East Drought Planning Manual". Scientists from Cyprus, Greece, Italy, Morocco, Spain, and Tunisia have also developed Drought Management Guidelines for Mediterranean countries that discuss the selection of drought risk reduction strategies (see http://www.iamz.ciheam.org/medroplan/).

9.4. Drought Potential Impact Assessment

9.4.1. Similarly, understanding trends in drought-related impacts over time is important for projecting future impacts and understanding changing vulnerabilities. Each drought produces a unique set of impacts, depending not only on the drought's severity, duration and spatial extent but also on ever-

changing social conditions.

9.4.2. Drought impacts can be classified as economic, environmental, or social, even though several of the impacts may actually span more than one sector. These impacts are symptoms of underlying vulnerabilities. Therefore, impact assessments are a good starting point to determine underlying vulnerabilities to target response measures during drought. An impact assessment highlights sectors, populations, or activities that are vulnerable to drought.

9.4.3. Assessing population vulnerability to drought impacts begin by identifying direct consequences of drought, such as reduced crop yields, livestock losses and reservoir depletion. These direct outcomes can then be traced to secondary consequences (often social effects), such as the forced sale of household assets or land, dislocation, or physical and emotional stress. Impacts should be examined for their occurrence in past or recent droughts, but consideration should also be given to the question "What drought impacts will be seen in the future?" This last question is crucial as populations shift and water demands change.

9.5. Summoning all Stakeholders

9.5.1. In practical terms, after an alert of possible drought is released, meetings with all stakeholders should be summoned to discuss the potential harm due to the drought and preventive and mitigation measures to be implemented. After all, it is the population that has the memory of the damage suffered in the last droughts

9.5.2. The meetings should be held in the capital and in the countryside, and should have the participation of representative leaders of various economic and social sectors. The purpose of the meetings is to inform about the possibility of a new dry, get reports about the losses suffered in previous droughts and ask for suggestions on how to mitigate the impacts of the next drought.

9.5.3. The important point here is to gather all stakeholders who suffered in the past and could suffer again in the next drought. This includes government agencies, businessmen's and farmers' associations, NGOs, social movements, representatives of the nine Regions and of municipalities, among others.

9.5.4. The importance of this meeting is that people who have had economic and quality of life losses in previous droughts will report where and in which sectors they were hardest hit. Thus, the CDC will have a data basis to perform a vulnerability analysis.

9.6. Vulnerability Analysis

9.6.1. Little attention has been given to preparedness, mitigation, and prediction/early warning actions (i.e., risk management) that could reduce future impacts and lessen the need for government intervention in the future. Because of this emphasis on crisis management, society has generally moved from one disaster to another with little, if any, reduction in risk. In fact, many response measures instituted by governments, international organizations, and donors have actually increased vulnerability by increasing dependency on internal or external assistance.

9.6.2. After the meetings are held, the CDC, along with the other entities of the National Government shall draw up a "vulnerability analysis". The result of this study will guide the development of preventive and mitigating measures to deal with the coming drought.

9.6.3. Vulnerability analysis provides a framework for identifying the human, social, economic, political, physical, and environmental causes of drought impacts. It directs attention to the underlying causes of vulnerability rather than to its result. For example, in drought conditions, the direct impact of a lack of precipitation may be reduced crop yields. The underlying cause of this impact,

however, may be that farmers did not plant appropriate crops because of cultural preference or government incentives, other seeds were unavailable or too expensive, or there was no drought warning.

9.6.4. Hence, a vulnerability analysis should begin by asking why significant impacts have occurred (or why they might occur). It is important to realize that a combination of factors (e.g., environmental, economic, and social factors) or underlying causes (e.g., livelihoods at risk, incentive preferences, and inappropriate crops) might produce a given event.

9.6.5. The purpose of vulnerability analysis is to provide government with an effective and systematic means of assessing drought impacts, developing mitigation actions and programs to reduce risk in advance of drought, and developing response options that minimize economic stress, environmental losses, and social hardships during drought.

9.6.6. The government team responsible for the vulnerability analysis should define the scope of the document, the most drought-prone areas and most vulnerable economic and social sectors.

10. THE DROUGHT PROTOCOL & MITIGATION PLAN

10.1. Basic Facts

10.1.1. Timely forecasting, preparedness and mitigation are central components of disaster risk reduction, and are more important than relying solely on ad-hoc emergency response measures. A combination of top-down and bottom-up approaches is required for development and implementation of effective preparedness and mitigation measures;

10.1.2. After the vulnerability analysis, coordinated by the CDC and other sectors of the Government, it should be drafted a "Drought Mitigating Plan". This is not a fixed plan, but a conglomerate of actions to be taken and discussed with stakeholders and authorities.

10.1.3. The drought response planning process should focus on making sure the right people are brought together, that they have a clear understanding of the process, what the drought plan must accomplish and are supplied with adequate data to make fair and equitable decisions when formulating and writing the Drought Mitigating Plan.

10.1.4. The Drought Mitigating Plan should be guided by the following principles:

- The effects of drought can be substantially reduced if people are well informed and motivated toward a culture of disaster prevention and resilience;
- Effective information management and exchange requires strengthening dialogue and networks among disaster researchers, practitioners, and stakeholders in order to foster consistent knowledge collection and meaningful message dissemination;
- Public awareness programs should be designed and implemented with a clear understanding of local perspectives and needs, and promote engagement of the media to stimulate a culture of disaster resilience, including resilience to drought and strong community involvement;
- Education and training are essential for all people in order to reduce local drought risk.

10.2. Communities and Drought Awareness

10.2.1. An important action to improve the effectiveness of the Drought Mitigation Plan is to identify stakeholders, leadership team and media leaders in the community, including individuals with responsibility for monitoring, communication, and implementation of mitigation measures during

the drought, and invite them to participate. Stakeholders may welcome the chance to work with others to reduce or eliminate the effects of drought. The sooner the community starts preparing for drought the better off it will be.

10.2.2. Community-based organizations, particularly those representing the most vulnerable, are key to people-centered drought risk reduction strategies and actions. Their indigenous knowledge and ability to cope with drought and to respond will ultimately determine the extent of risk and drought impact. They should be aware of drought hazards and the related effects to which they potentially will be exposed, and be able to take specific actions to minimize the threat of loss or damage.

10.2.3. Local communities should be encouraged to contribute to the DMP reporting their use of traditional and local knowledge and know-how to mitigate the impacts of droughts.

10.2.4. Local governments usually have direct responsibilities for citizen safety and considerable knowledge of the hazards to which their communities are exposed. They must be actively involved in the design and implementation of the Drought Mitigation Plan, its programs and actions. Local government also serves as the interface between local and national governments.

10.2.5. Local governments and communities leaders should understand all advisory and warning information received in order to be able to advise, instruct, or engage the local population in a manner that increases their safety and reduces the possible loss of resources and livelihoods on which the community depends.

10.3. The Drought Mitigation Plan

10.3.1. The Drought Mitigation Plan (DMP) should establish a clear set of principles or operating guidelines to govern the prevention, mitigation and management of drought and its impacts as well as the development of a preparedness plan that lays out a strategy to achieve these objectives.

10.3.2. The DMP shall specify the respective roles of the national and the regionals government, local communities and land users, and the resources available and required to implement appropriate drought risk reduction activities. It should also address the following concepts:

- Provide for effective participation at the local, national, and regional levels of non-governmental organizations and populations (both women and men) in mitigation planning and implementation and review of national action programs;
- Be rooted in thorough vulnerability, risk, capacity, and needs assessments, highlighting the root causes of the issues related to drought;
- Focus on strengthening the capacities of governments and communities to identify, assess, and monitor drought risks at national and sub-national levels for effective development planning, including strengthening of people-centered early warning systems and preparedness;
- It is important to establish drought management areas (i.e., subdivide the state or region into more conveniently sized districts by political boundaries, shared hydrological characteristics, climatological characteristics, or other means such as drought probability or risk);
- Incorporate both short and long-term strategies to build the resilience of governments and communities to reduce the risks associated with drought, emphasize implementation of these strategies, and ensure they are integrated with national policies for sustainable development;
- Link drought early warning indicators with appropriate drought mitigation and response actions to ensure effective drought management;
- Allow for modifications to be made in response to changing circumstances and be sufficiently flexible at the local level to cope with different socio-economic, biological and geo-physical

conditions;

- Promote policies and strengthen institutional frameworks which develop cooperation and coordination, in a spirit of partnership, between governments at all levels, local populations, and community groups, and facilitate access by local populations to appropriate information and technology;
- Designate agencies and stakeholders responsible for carrying out drought mitigation and response actions, and require regular reports on their implementation.

PART C – MITIGATION AND MONITORING

11. MITIGATION

11.1. Managing Mitigation Actions

11.1.1. Drought impacts are nonstructural, in contrast to, the impacts of floods, hurricanes, and most other natural hazards. Its impacts are spread over a larger geographical area than are damages that result from other natural hazards. For these reasons, the quantification of impacts and the provision of disaster relief are far more difficult tasks for drought than they are for other natural hazards. Emergency managers, for example, are more accustomed to dealing with impacts that are structural and localized, responding to these events by restoring communication and transportation channels, providing emergency medical supplies, ensuring safe drinking water, and so forth.

11.1.2. Disaster mitigation is aimed at minimizing the destructive and disruptive effects of hazards and thus lessening the magnitude of any disaster. Based on its insidious nature, drought response tend to be late and uncoordinated that leads to crisis management rather than risk management.

11.1.3. Mitigation and response actions should be under the responsibility of the CDC, working in cooperation with other governmental and non-governmental institutions (see item 8.3). The members should have the knowledge and experience to understand drought mitigation techniques, risk analysis (economic, environmental, and social aspects), and drought-related decision- making processes at all levels of government.

11.1.4. Mitigation and response actions must be determined for each of the principal impact sectors identified by the vulnerability study.

12. MAIN ELEMENTS FOR AN EARLY DROUGHT WARNING SYSTEM PROTOCOL

12.1. Various Aspects of Life in Guyana

12.1.1. Mitigating actions developed by the CDC and the other institutions involved in reducing the effects of drought, must take into account various aspects of economic and social life in Guyana.

12.1.2. Details of each action should be developed by the authorities, according to the region and the affected activity, always in cooperation with local people. Although the mitigating actions may have a basic model, this model should be adapted to the conditions of each site.

12.2. Actions for the Communities

12.2.1. Strengthen community organization by establishing or supporting social institutions like village Self-Help Groups (SHGs), women's groups, and village water sub-committees.

12.2.2. Set up a commune seed bank / food credit coupon system.

12.2.3. Establish 'Village emergency funds'.

12.2.4. Develop an understanding that the drought may be a recurring phenomenon and that communities should prepare themselves to minimize the impact.

12.3. Actions to Reduce Impacts on the Agriculture

12.3.1. Actions to reduce impacts on the agriculture should include adjustment of planting dates and crop variety, crop relocation, improved land management, erosion control and soil protection thought tree planting, training capacity building, crop insurance and access to new drought resistant varieties.

12.3.2. Develop drought-resistant crop varieties.

12.3.3. Provide training in dry-season cropping techniques.

12.3.4. Ensure that appropriate crop seeds are in place before the rains.

12.3.5. Develop village seed banks with seeds of traditional and improved drought-resistant crops/varieties.

12.3.6. Provide training in economical water use.

12.3.7. Subsidize/facilitate supplies of seeds and irrigation equipment.

12.3.8. Establish field schools and mobile libraries for farmers.

12.3.9. Provide meteorological forecasts and corresponding advice on cultivation.

12.3.10. Improve soil-moisture management.

12.3.11. Reduce run-off and increase rainwater infiltration by planting barriers such as vetiver, lemon grass, and agave.

12.3.12. Increase fertility and water-holding capacity of the soil through addition of organic manures and green manures.

12.3.13. Introduce proper land-use planning as per the land-capability classification system.

12.3.14. Promote mulching practices so that the limited available soil moisture is saved during critical stages of crop growth.

12.3.15. Establish zoning of territory for optimal reforestation with the aim of reducing drought exposure, and zoning of pastures based on their vulnerability to droughts and pasture load.

12.3.16. Promote better forest management and the avoidance of forest fires. Maintaining watersheds by avoiding deforestation and diversion of waterways protects water quality and quantity.

12.3.17. Promote actions for soil conservation. These actions include building rainwater cisterns and raised bunds on surrounding farmland to increase yields. This in turn reduced migration, provided a basic diet, and ensured that livestock was fed and watered.

12.3.18. Typical farming practices such as reliance on a narrow range of annual crops and clearing land of all trees, lead to lack of biodiversity and removes essential ground cover. These two factors make crop failure more likely and increase farmers' vulnerability to drought, and should be discouraged.

12.3.19. Focus on organic fertilizers to combat soil degradation. Environmental degradation such as land degradation, deforestation, desertification and loss of biodiversity has detrimental effects on the

local communities in coping with droughts. On the other hand, more sustainable land management, including protecting soils from erosion and eventual desertification through better land-use planning and sustainable farming and ranching practices, helps to reduce people's vulnerability to drought and flood.

12.3.20. Another option to protect the soil and keep it moistened is to restore traditional practices that had been abandoned or forgotten. One of these was to conserve water by making bunds. A bund is an earth wall, one to two meters high, that is built around a field following the local contour lines. A large ditch is then dug out in front of the bund to help capture runoff and maintain moisture within the field. The bund not only helps prevent soil erosion caused by wind and rain, it also holds water in the soil by preventing rainwater from flowing away.

Figure 11 – Example of bund.

12.3.21. It is important to incorporate a wide range of plant species - annual and perennial, and indigenous and exotic - to reduce crop vulnerability. This includes the introduction of a range of Australian acacia trees (Acacia colei, A. torulosa, A. tumida, A. elachantha) which thrive under semi-arid conditions and produce edible seeds and timber. Crop yields and income generation when trees are integrated with the crops greatly exceed those under traditional farming systems. Farmers and communities would have alternate income sources from the sale of firewood and acacia seed during drought. They also have the option of eating acacia seed and feeding it to their livestock. Grain stocks (e.g. millet and sorghum) also last longer in villages that grow acacias because of the following reasons: (1) acacias are high in protein and filling, so less volume of food is consumed; (2) acacia flour is often mixed with flour of other traditional grains and, as a result, grain stocks last longer.

12.3.22. The consortium of crops with trees also builds soil fertility and restores degraded lands without relying upon expensive and sometimes environmentally harmful agricultural chemicals. The process is affordable and accessible to the poorest farmers and, while exotic species are used, indigenous vegetation forms the foundation of this farming approach. The main challenges have been that farmers have been slow to move away from annual crop farming to agroforestry and some farmers view trees as weeds and nuisances.

12.4. Actions to Improve Livelihood Strategies

12.4.1. Support and protect livelihoods and livelihood diversification (carpentry, petty shops, handicraft, etc.), so that people have a safety net to rely on during all stages of drought.

12.4.2. Establish or strengthen micro-credit systems.

12.5. Actions for Management of Water Resources

12.5.1. Management of water resources should include actions related to water storage, conservations techniques. water re-use, irrigation efficiency, water-related hazards management and integrated water resources management. Better management of water resources and conservation of fragile ecosystems will allow diversification of livelihoods and sustain local economies during and after drought.

12.5.2. One possible solution to water scarcity during the dry season is the groundwater dam. Groundwater dams store water underground, rather than on the surface. Water that is stored in the soil does not evaporate like ponds and streams. It is clean and healthy - parasites will not contaminate underground water. The key is to find ways to capture wet season rainfall underground. There are many ways to do this, both traditional and modern; but whatever method is used, the principle is the same: slow down the flow of water as it runs downhill. The groundwater dam requires a fair amount of labor to complete, but the technology is not difficult, and the rewards are considerable. However, each region will have its own traditional solutions, based on its own unique needs for water, its soil structure, its climate, and its social structure.

12.6. Actions to Improve Domestic Water Use

12.6.1. Encourage rainwater harvesting (e.g. roof-top rainwater harvesting).

12.6.2. Install water pumps and wells.

12.6.3. Promote 'home-made', cheap, and water efficient drip irrigation for vegetable gardens.

12.6.4. Cisterns are a viable solution to supply drinking water during droughts. These are concrete structures about 3-4 meters wide and 4 meters deep. They are located in places where good run off is known to occur at the bottom of a shallow concave pit with run off channels flowing into them. During the rainy season, channels that run into the cistern collect rainwater. Each cistern can store up to 40,000 liters and is shared by up to three families. When full, the cistern can supply drinking water to the three families all year round. It can also be used to store water brought in by tankers in times of drought.

12.6.5. Periods of drought in Guyana often result in severe water shortages due to inadequate rainfall. Communities can minimize the effect of drought if special attention is focused on water conservation. A Water Conservation Program should be developed and disseminated throughout the country. The Program should advise people to:

- Be conscious of the amount of water you use and look for ways to use less whenever you can;
- Look around for leaks and repair them immediately. Most leaks are easy to detect and easy to repair;
- Use just a glassful of water to brush your teeth;
- A typical shower uses five to 10 gallons of water per minute. Limit your shower to the time it takes to get your body wet and to wash off the lather. Install shower heads or flow restrictors;
- Make sure that the toilet you have is using the least amount of water possible per flush. Do not use the toilet as a trash can for paper and facial tissues;

- If you wash dishes by hand do not leave the water running for rinsing. If you have two sinks fill one with soapy water and the other with water for rinsing;
- Do not let the pipe run while washing dishes or vegetables. Just rinse them in a sink or a pan of clean water;
- Using a hose to wash cars, driveways and sidewalks could waste gallons of water. It is best to do this from a pan or basin, if absolutely necessary. Remember that during periods of drought and water restrictions, washing of cars and watering of lawns should not take place. When you wash your car with a bucket of water and a rag it not only saves you money, but it ensures that there will be more water when you need it most;
- Save the rinse water from your dishes and laundry for the watering of your lawn and plants;
- Do not allow children to play with pipes, hoses and sprinklers. This activity could waste hundreds of gallons of precious water;
- During periods of drought, individuals will often have to store water for domestic purposes. It is important to use safe water during the drought periods to prevent diseases and maintain good health. Safe water is treated water;
- Water taken from the following sources must be treated before drinking: water trucks, springs and rivers, community tanks, drums and catchments tanks.

12.7. Actions to Protect Health During the Droughts

12.7.1. Actions to protect health during the droughts should include actions related to heat-health suffering, emergency medical services, climate-sensitive disease surveillance, safe water and improved sanitation, public and health policies that recognize climate risk and upgrading health services;

12.7.2. Provide training in first aid (e.g., treating diarrhea and respiratory diseases).

12.7.3. Promote public health by raising awareness of health and hygiene issues.

12.7.4. Improve access to clean water.

12.7.5. Provide hygiene kits and teach women how to use them.

12.8. Actions to Protect Animal Husbandry

12.8.1. Store rice, paddy husk, and other crop residues in barns for use during scarcity.

12.8.2. Grow seasonal grasses/perennial fodder trees in community forests, fallow lands, and permanent pastures.

12.8.3. Recommend that farmers avoid burning crop residues in the field and use them instead as animal feed by treating them appropriately.

12.8.4. Establish fodder banks at community/household level.

12.8.5. Improve the quality and productivity of the existing livestock population, either through artificial insemination or other breeding practices or by replacing them with exotic breeds more tolerant to droughts.

12.8.6. Preserve endangered productive and drought resistant local animal breeds.

12.8.7. Promote the rearing of goats, sheep, and dry ducks in areas where feed and water are scarce.

12.8.8. Construct rainwater-harvesting structures (mini-ponds, tanks).

13. DROUGHT MONITORING

13.1. The Drought Monitoring Plan

13.1.1. Before the drought period starts, CDC should develop a drought monitoring plan for monitoring climate and water supplies and identify potential shortfalls. This will enable the Government to assess the mitigation measures and, if necessary, modify the actions to reduce the impacts. Responsibility for collecting, analyzing, and disseminating the data should be divided among CDC, regional and national agencies.

13.1.2. Although all types of droughts originate from a precipitation deficiency, it is insufficient to monitor solely this parameter. Effective drought monitoring must integrate other physical indicators (e.g., groundwater and stream flow, groundwater levels, reservoir and lake levels, soil moisture into a comprehensive assessment of current and future water supply conditions, crops production, energy deficit) to reflect impacts of the drought on agriculture, households, industry, energy production, and other water users. It is important to conduct regular meetings for exchange of experience with different groups of population.

13.1.3. A drought monitoring systems should be implemented to follow up the damages, coupling multiple climate, water and soil parameters and socio-economic indicators to fully characterize the drought magnitude, its spatial extent and impacts. However, a variety of obstacles are found in most developing countries and need to be addressed in order to establish effective DEWS:

- Impact assessment methodologies, a critical part of drought monitoring systems, are not standardized or widely available, hindering impact estimates and the creation of regionally appropriate mitigation and response programs;
- Meteorological and hydrological data networks are often inadequate in terms of the density of stations for all major climate and water supply parameters. Data quality is also a problem because of missing data or inadequate long-term records;
- Data sharing is inadequate between government agencies and research institutions, and the high cost of obtaining data limits their application in drought monitoring, preparedness mitigation and response;
- Information delivered is often too technical and detailed, limiting its use by decision makers. Delivery systems are often not well developed.

13.2. Parameters to be Monitored

13.2.1. During the onset of the drought and during the drought itself, some parameters must be monitored to evaluate the possible impacts on the economy, the agriculture and the environment. The main parameters to be monitored are:

- Rainfall;
- Evapotranspiration;
- Rivers flow and temperature. There is a time-dependent ‘trigger’ value for ‘low-flow’. An alert should be sent when discharges fall below the certain month dependent values and there is an expectation that this will last longer than 3 days. Red flags are raised and prevention measures should be considered on basis of real-time values of river flows, river temperature and evaporation surplus (i.e. precipitation minus evaporation). The capability of the indicator of the characterize drought impacts is not straightforward, as low river flows have a completely different impact on the drought situation depending on their occurrence in the early season or late season.

- Groundwater level, including aquifer depletion rate/ recharge rate.
- Capacity for energy production, mainly hydropower energy.
- Crops production compared with similar crops in the years before the onset of the drought.
- Outbreak of diseases related to contaminated water.
- Migration of rural communities to the cities.
- Level of water in hydroelectric plants, predicting possible power outages.
- Lack of local raw material used by the domestic industry.
- Navigability of waterways.
- Rivers' flow to protect fisheries.
- For pastoral drought, composition and vigor of rangeland vegetation, including grazing and precipitation to protect livestock.
- Availability of food for the livestock.

13.3. Governing Bodies Responsible for the Monitoring

13.3.1. The monitoring of drought impacts, in order to take mitigating or corrective measures, should be the responsibility of the governing bodies shown in the following table.

13.3.2. It is recommended that the monitoring takes place in partnership with regional government organs and with the support of the affected communities..

Table 3 - Agencies responsible for the monitoring

Resource monitored	Monitoring indicators	Agencies
Weather	Rainfall amounts; Drought index (SPI); Seasonal forecast; Short-term forecast	Hydromet; NAREI -
Livestock	Pasture condition/vegetation health (NDVI); Livestock body condition; Access to water; Price of livestock products (beef); Fisheries.	Guyana Livestock; Development Agency; Fisheries Dept.
Crops	Crop status; Crop yields; Crop prices	NAREI; GUYSUCO; GRDB; NGMC
Water Resources	Reservoir storage/levels (conservancy); River and stream (creeks) flow levels; Groundwater Access to domestic water (Lpppd); Level of saline intrusion *	Hydromet; Amerindian Affairs; GUYSUCO; GRDB; Ministry of Housing; and Water/ GWI; NDIA; NAREI
Natural resources	Quantity of Forest resources destroyed by fire; Acreage land degraded by fires; Acreage land degraded by saline intrusion; Number of fire events; Land cover change; Change in biodiversity.	GFC; EPA; MNRE; NAREI; Fisheries Dept.

14. TIMELINE FOR THE EXECUTION OF EACH ACTIVITY UNDER THE PROTOCOL

14.1.1. The timeline for the implementation of each activity described in this protocol is suggested in the table below. The figures are merely suggestions, aiming at preparing the country as soon as possible to address the effects of the drought.

14.1.2. The exact timing for the execution of each task will depend on the advance with which the drought is announced, the country's economy and other various problems that may overlap the drought.

Table 4 – Timeline for the execution of Each Activity.

ACTION	WHEN IT SHOULD BE IMPLEMENTED
National Government should seek a technical cooperation agreement with major institutions abroad that do drought research and forecasting.	As soon as possible.
Two or three technicians from Guyana should receive, abroad, training to interpret the information on droughts received from foreigner institutions.	Immediately after signing the agreement with institutions abroad.
Creation of a Drought Committee, to analyze the Hydromet warnings about possible droughts.	As soon as possible.
The Hydrometeorological Service informs the Drought Committee about warnings on possible droughts.	At most, two days after receiving the warnings from abroad.
The Drought Committee must decide whether the evidence justifies the dissemination of warnings to the country.	One week after receiving the notice from the Hydromet.
If the decision of the Committee is for the presence of a drought, this Committee shall proposes to the Government to declare a "State of Potential Drought".	At most, two days after the decision of the Committee.
Government declares a "State of Potential Drought".	One week after receiving the proposal from the Drought Committee.
The CDC shall prepare a preliminary public advisories to be disseminated through the various communication means: print, radio, television, mobiles, internet, SMS, etc.	A basic version should be drafted as soon as possible. They should be disseminated two days after the declaration of a "State of Potential Drought".
After Government declares a "State of Potential Drought", all stakeholders should be summoned to discuss the potential harm due to the drought and preventive and mitigation measures to be implemented.	No later than one week after the Government declares a "State of Potential Drought".
As a result of the meetings with all stakeholders, a document called Vulnerability Analysis is issued, to provide government with an effective and systematic means of assessing drought impacts, developing mitigation actions, and developing response options that minimize economic stress, environmental losses, and social hardships.	No later than one week after the stakeholders meetings.
As a result of the Vulnerability Analysis, CDC will issue, with approval of the Drought Committee, a Drought Mitigating Plan establish a clear set of principles or operating guidelines to govern the prevention, mitigation and management of drought and its impacts as well as the development of a preparedness plan that lays out a strategy to achieve these objectives.	No later than one week after the Vulnerability Analysis is issued.
Actions contained in the Drought Mitigating Plan (DMP).	As soon as the DMP is approved by the Drought Committee.

15. BIBLIOGRAPHY

"Drought Early Warning Systems in the Context of Drought Preparedness and Mitigation". (2000). http://www.preventionweb.net/files/1882_VL102149.pdf.

Caribbean Disaster Emergency Management Agency (CDEMA). “El Nino blamed for low rainfall levels” (2015). https://www.cdema.org/index.php?option=com_content&view=category&layout=blog&id=34&Itemid=266&limitstart=25
CDC Guyana. “Disaster Risk Management Policy” (2013).
CDC Guyana. “Drought”. (2009). http://www.cdc.gy/index.php?option=com_content&view=article&id=74&Itemid=83
CDC Guyana. “Early Warning Systems Framework” (2013).
CDC Guyana. “Multi-Hazard Disaster Preparedness & Response Plan” (2013).
CDC Guyana. “National Integrated Disaster Risk Mitigation Plan and Implementation Strategy for Guyana” (2013).
CDC Guyana. “Progress and challenges in Disaster Risk Management in Guyana” (2014).
Colorado Climate Center. “Enhanced drought monitoring and early warning activities in the Upper Colorado River Basin”. www.cpc.ncep.noaa.gov/products/outreach/proceedings/.../NDoesken.pdf
Colorado Climate Center. “NIDIS Upper Colorado River Regional Drought Early Warning System” (2015). climate.colostate.edu/~drought/
Columbia University. “El Niño Southern Oscillation (ENSO); Ocean-Atmosphere Interactions” (2007). http://eesc.columbia.edu/courses/ees/climate/lectures/enso.html
Desinventar Inventory System of the Effects of Disasters. “Available databases”. http://www.desinventar.org/
DEWFORA. “Implementing drought early warning systems in Africa: policy lessons and future needs” (2013). https://www.unesco-ihe.org/sites/default/files/dewfora_policy_brief_africa_-_digital_version.pdf
DROUGHT-R&SPI. “Review of current drought monitoring systems and identification of (further) monitoring requirements” (2013). www.eu-drought.org/.../DROUGHT-R-SPI-Technical-Report-No-33.
Dyer, J. A. “A Drought Early Warning System for Prairie Pasture Land” (2013). http://dx.doi.org/10.4296/cwrj1304005
Edwards, Laura. “Foundations for a Regional Drought Early Warning System in the Missouri River Basin” (2015). http://docslide.us/science/foundations-for-a-regional-drought-early-warning-system-in-the-missouri-river-basin.html
Guyana Lands and Surveys Commission (GLSC), UNDP, GEF. “Early Warning System Study” (2010)
Guyana Lands and Surveys Commission. “Guyana National Action Program To Combat Land Degradation” (2006).
Guyana National Task Force. “Guyana Climate Change Action Plan” (2001).
Guyana Times. “Regions 1, 9 hit by drought”. (2015). www.guyanatimesgy.com/2015/04/11/regions-1-9-hit-by-drought/
Guyana: El Niño Drought. An appeal. (1998). https://www.ifrc.org/docs/appeals/98/1498.pdf
Hydrometeorological Service Guyana. “Early Warning System in Guyana”. (No date). https://www.wmo.int/pages/prog/.../Mr.%20Cummings%20(Guyana).pdf
Hydrometeorological Service, Guyana. “Drought Monitoring in Guyana” (No date). drought.unl.edu/Portals/0/docs/workshops/.../Thursday/Seulall.pdf
IFAD. “Risk Management - Drought Early-Warning Systems and Contingency PlansRisk Management - Drought Early-Warning Systems and Contingency Plans”. www.ifad.org/lrkm/range/drought.htm
Institute of Industrial Science, University of Tokyo, Japan. “Satellite-based drought monitoring and warning system – New Zealand” (2015). webgms.iis.u-tokyo.ac.jp/DMEWS/NewZealand/search.php
Institute of Industrial Science, University of Tokyo, Japan. “Satellite-based drought monitoring and warning system” (2015). webgms.iis.u-tokyo.ac.jp/DMEWS/

International Strategy for Disaster Reduction . “Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action” (2009). http://www.unisdr.org/files/11541_DroughtRiskReduction2009library.pdf.

MWAR-LAC. “Development of National Drought Atlases for the Caribbean Countries”. www.cazalac.org/mwar_lac/index.php?id=54

National Drought Management Authority (Kenya). “Welcome to NDMA - Kenya”. www.ndma.go.ke/

National Drought Mitigation Center (Nebraska, USA). “Caribbean Drought Training Workshop” (2012). http://drought.unl.edu/NewsOutreach/Outreach/Workshops/CaribbeanDroughtTrainingWorkshop.aspx

National Drought Mitigation Center (Nebraska, USA). “Drought Early Warning Systems in the Context of Drought

National Drought Mitigation Center (Nebraska, USA). “Drought Early Warning Systems” (2009). http://www.wamis.org/agm/meetings/wies09/S10-Svoboda.pdf

National Drought Mitigation Center (Nebraska, USA). “Drought Monitoring and Early Warning Information Systems (DEWIS): Tools and Techniques” (2012). drought.unl.edu/Portals/0/docs/.../Svoboda_DEWS_Caribbean.pdf

National Drought Mitigation Center. “National Drought Mitigation Center Drought Services: Collaborative Efforts Towards Drought Early Warning and Information Systems” (2015). https://www.drought.uni-freiburg.de/Publications/.../Svoboda

Newitz, Annalee. “Are You Doing Anything to Prepare for the "Godzilla" El Niño?” (2015). http://gizmodo.com/are-you-doing-anything-to-prepare-for-the-godzilla-el-1723982315

NOAA – Climate Prediction Center. “Frequently Asked Questions About El Niño and La Niña”. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensofaq.shtml

NOAA/NIDIS. “What is National Integrated Drought Information System?” (2015). wwa.colorado.edu › Workshops & Events › WWA Workshops

Pulwarty, R. S. & Mannava V. K . Sivakuman. “Information systems in a changing climate: Early warnings and drought risk management” (2014). http://www.sciencedirect.com/science/article/pii/S2212094714000218

Reports to the Nation. “El Niño and Climate Prediction”. http://www.atmos.washington.edu/gcg/RTN/rtnt.html

State Climate Office of North Carolina. “Global Patterns - El Niño-Southern Oscillation (ENSO)”. http://climate.ncsu.edu/climate/patterns/ENSO.html

Trotman, A. & Robert Webb. “Drought Early Warning Information Systems: reducing drought risks in a changing climate”. http://www.climate-services.org/iccs-3-parallel-session-drought-early-warning-information-systems-reducing-drought-risks-changing

Trotman, A.R. & David A. Ferrel. “Drought Impacts and Early Warning in the Caribbean - The Drought of 2009-2010”. https://www.wmo.int/pages/prog/drr/events/Barbados/Pres/4-CIMH-Drought.pdf.

United Nations Environment Programme . “Climate Early Warning System Feasibility Report: Early Warning Systems and Hazard Prediction” (2012). www.unep.org/science/chief.../76/.../EWS_Report_Final_Version1.pdf.

United Nations Environment Programme. “Early Warning Systems: State-of-Art Analysis and Future Directions” (No date). na.unep.net/siouxfalls/publications/early_warning.pdf.

United Nations Framework Convention on Climate Change. “Vulnerability and adaptation to climate change in small island developing states”. https://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/200702_sids_adaptation_bg.pdf

USAID. “Innovative Weather Model Helps Millions in Caribbean Prepare for Drought”. https://www.usaid.gov/news-information/frontlines/science-technology-innovation-and-partnerships/innovative-weather-model

Walters, Rochelle, Michael Taylor & Tannecia Stephenson. “Some Caribbean Drought Research at Csgm, Mona”. http://drought.unl.edu/Portals/0/docs/workshops/03222012_Kingston_Jamaica/Drought%20Research%20in%20the%20Caribbean.pdf

Wikipedia. “2015 Caribbean drought”. https://en.wikipedia.org/wiki/2015_Caribbean_drought

Wikipedia. “El Niño Southern Oscillation”. https://en.wikipedia.org/wiki/El_Ni%C3%B1o_Southern_Oscillation

Woods Hole Oceanographic Institution. “El Niño & Other Oscillations”. www.whoi.edu/main/topic/el-nino-other-oscillations.

Wikipedia (2015). "Intertropical Convergence Zone". https://en.wikipedia.org/wiki/Intertropical_Convergence_Zone

Woods Hole Oceanographic Institution. “Reports to the Nation: El Nino and Climate Prediction”. www.atmos.washington.edu/gcg/RTN/rtnt.html

World Food Program. “Early-Warning System Sees Drought Coming In Namibia” (2013).https://www.wfp.org/aid-professionals/blog/blog/early-warning-system-sees-drought-coming-namibia

World Meteorological Organization. “Inter-Regional Workshop on Indices and Early Warning Systems for Drought” (2009). http://www.wmo.int/pages/prog/wcp/agm/meetings/wies09/wies09_present.php