

Climate Change – Drainage Division’s Response

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Good afternoon Colleagues, Friends, Guests. I thank you for inviting me to share with you some ideas on Climate Change and how it affects in particular the Drainage Division (DD), and how thus far, we are in fact coping with these conditions in our every day work. And finally, to share some of our thoughts on possible future mitigation and adaptation measures.

Let me state that I’m glad to be included in this Conference. This is not only timely and appropriate, but also crucial and essential. I must add that I had only several hours to prepare this paper and it’s therefore not really quite finished. Nevertheless I’ll do my best.

As you know the topic ‘Climate Change’ is gaining the imagination of the world over, and we here in T&T are no exception.

But first, let me give you a brief introduction of my Division, its role and responsibility to our country as a whole. The DD is one of the many Divisions of the Ministry of Works & Infrastructure. Our HO is located at Sackville St POS. DD consists of 4 Regions, North (with 2 District Offices at Diego Martin and Mount Hope), East (with 2 District Offices at Mayaro and Rio Claro), South and Central (with a District Office at Guayamere). We have 8 pumphouses and 4 proposed ones.

The DD is divided into 2 Branches at this time (with 2 more proposed) – the Construction & Maintenance Branch which is in charge of the 4 Regions mainly dealing with Recurrent Works and Public Complaints. The Live wire of the Division, the Planning Branch, which, among its many functions, is responsible for the Strategic Planning of the Division, formulates the Drainage Development Programme for the Country, including formal Drainage approval for Land Development.

OUR MISSION STATEMENT

To develop and maintain main watercourses and irrigation systems; design and construct hydraulic and coastal structures; provide advisory services to ensure efficient and effective flood erosion and sedimentation control, drainage, irrigation, coastal protection and reclamation, in a cost effective manner, providing a better quality of life to the citizens of Trinidad and Tobago.

STRATEGIC OBJECTIVES

The Drainage Division:-

- **Provides effective and efficient drainage services to reduce flooding**
- **Provides adequate water supply for irrigation to farmers**
- **Mitigates coastal erosion**

- **Designs and Constructs Hydraulic and Coastal Structures**
- **Provides advisory services to ensure efficient and effective flood, erosion and sedimentation control**
- **Provides Value for Money Services on all drainage and related services.**
- **Develops and implements policies, plans, standards, regulations, rules and requirements for quality drainage, flood control and prevention of coastal erosion**
- **Is proactive in the planning provision of drainage services, and the maintenance of all watercourses**
- **Maintains a heightened sense of security, comfort and satisfaction in the minds of the public**
- **Provides communication, information and an avenue for consultation to create awareness and participation by the public in drainage management.**

SERVICES PROVIDED BY THE DIVISION

Statutory Obligations to:

- **Construct, re-build, alter and maintain of any hydraulic structure over, in or under any controlled channel**
- **Alter to the banks or bed of a controlled channel**
- **Maintain all major watercourses under the jurisdiction of the Division via the use of hired heavy equipment and in-house labor to de-silt, clean and clear all obstructions.**
- **Produce, provide, realign and create major watercourses as necessary.**
- **Respond effectively to and deal with flooding and erosion complaints from the public**
- **Monitor major watercourses to ensure compliance with law from citizens, corporations, Govt Agencies, etc.**
- **Maintain Sea Defense works**
- **Develop and operate Irrigation Systems**
- **Advise the public on Drainage matters.**
- **Manage Shoreline as considered fit by the Division.**

Climate Change – a topic discussed by many, scientists, engineers, architects, homeowners, etc. when did it start? Why is it here? Some postulate 'it's our imagination'. Others say 'this has been around always, so what's the problem?'

Within recent times the rapid increase in the number of natural disasters has put a major strain on world's economy. Some of these disasters (2001-2010) are:

- 6 major earthquakes (out of 26 : 8+ on richer scale) recorded over the past 1000 yrs) inc 2 of the deadliest of 14 recorded since yr 525
- 3 of the deadliest hurricane (from 21 powerful hurricanes ever recorded in the Atlantic Basin- all in this past decade)
- 20 massive floods worldwide
- Several thousand tornados
- Many wildfires & volcanic eruptions.

As for the most disastrous earthquakes (6.6 and higher with great loss of lives), MSNBC reported - one on record in China in 1556, then none for nearly four centuries until the major San Francisco quake in 1906, and none again until 1964. From 1964 to the latest Haiti and Chile earthquakes in February 2010, there have been eleven major earthquakes – six of them since 2003 alone.

In 2006, [The European Journal of Public Health](#) reported: "Natural disasters are increasing in frequency because of the worldwide deterioration in the natural environment. The incidence of floods, storms, earthquakes and droughts and the number of people affected by them are escalating greatly.

Weather-related disasters throughout the world continue to rise, from an annual average of 200 in 1993–1997 to 331 per year in 1998–2002.”

The [United Nations Bureau for Crisis Prevention & Recovery](#) more recently stated: “The 21st Century has already been marked by escalating economic losses and human devastation caused by natural disasters. In 2008 alone, more than 300 disasters killed more than 235,000 people, affected more than 200 million others and caused losses and damage worth US \$billion.”

[The U.S. National Oceanic and Atmospheric Administration \(NOAA\)](#) reported the “Worst Weather of the Twentieth Century” in a chart. It speaks mostly of hurricanes, floods and tornadoes. On their list, the escalation increases from spaces of over twenty years between disasters to at least one happening nearly every year:

From 1900 to 1925 there were no significant hurricanes, floods or tornadoes in the United States. From 1928 to 1938 there were three. From 1938 to 1974 there were four. And from 1975 to 1999 there were seven.

The NOAA’s worldwide report reflects the same percentage of increase as in the U.S.

In total, the worldwide natural disasters of the past twenty years outweigh any other similar period in written recorded history.

If global temperature change is a primary parameter, then climate change is a reality. The mean global temperature increased just under 1°C over the 20th century. The debate is between those who attribute this rise to man i.e. anthropological warming, and those who attribute it to natural causes.

Additionally,

- Some glaciers retreated
- Sea level rose about ~15cm last Century, and is estimated to rise 23cm in the 21st century
- Water tables fell significantly (China: 1.5m/year, India: 1-3m/year)

As the debate continues, those who say it’s a natural process, site:

- Temperature rise and CO₂ increase seem weakly correlated
- Glacier retreat commenced some 150 years before sharp CO₂ rise
- Sea levels started rising some 100 years before sharp CO₂ rise
- Temperature rise due to CO₂ increase seems hard to detect

So, do you think that these occurrences are as a result of Climate Change? Of course, anything we may say may be conjecture. *In any case, it’s a probability issue!*

Well, what’s Climate change?

Yes, one of the most zealously debated topics on earth is the matter of climate change. The IPCC (Intergovernmental Panel on Climate Change) is the most senior and authoritative body to provide scientific advice to global policy makers. The IPCC was established by the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to assess the scientific, technical and socio-economic information relevant for the understanding of human induced climate change, its potential impacts and options for mitigation and adaptation.

The IPCC defines climate change as a change in state of climate that can be identified by changes in mean and or variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, either due to natural variability or as a result of human activity.

Human civilization over the ages have depleted natural resources (and we continue to do so) which is detrimental our environment. We continue to cut down trees, fill wetlands, remove mangroves, construct numerous buildings, build highways, etc (not even mentioning fossil fuel) thereby modifying our local climate. Climate change is likely to have wide-ranging effects from increased storms to increased earthquakes, from extra heavy rainfall to droughts, from extreme cold to heat wave, from inadequate fresh water supply to potentially serious health consequences, from arid lands to extreme shortage of food.

The greenhouse effect

The greenhouse effect is a natural process by which some of the radiant heat from the Sun is captured in the lower atmosphere of the Earth, thus maintaining the temperature of the Earth's surface. The gases that help capture the heat, called "greenhouse gases," include water vapor, carbon dioxide, methane and nitrous oxide. Without this Greenhouse effect, life on earth would be impossible!

The main sources of these emissions, particularly carbon dioxide, methane and nitrous oxide, are the combustion of large amounts of fossil fuels in the energy and transport sectors, deforestation and the use of intensive farming methods.

However human activity has been increasing the concentration of these greenhouse gases in the atmosphere (mainly carbon dioxide from combustion of coal, oil and gas) resulting in Global surface temperature to increase.

Did you know that seven of the last eight warmest years on record have occurred since 2001?

While the controversy about global warming continues, there is no denying that glaciers and ice caps are melting at an alarming rate, while at the same time, world industrialization is increasing and the world's forests are being cut down (~ 2,000,000 Ha/yr) to produce farm land and housing space.

Do you think these processes are interlinked?

At very least the world must have considerable vegetation and trees to provide people with oxygen and to remove superfluous CO₂. The photosynthetic process of plants releases oxygen. Plants remove the carbon dioxide that combustion produces from the air. Our world travels on combustion, of jet fuel for example. Our factories and power plants burn organic materials, like natural gas and coal. When organic materials burn the reaction produces carbon dioxide and water, as well as heat. Carbon dioxide and water vapor produce even more heat because of the greenhouse effect.

However, climate change also affects the very plant life, trees and crops (grown as the main food source), which removes CO₂ from the air. Different species of plant life require very structured weather patterns to maintain their viability in a certain area. With a change in precipitation, the plants and crops may not be able to maintain their normal growth pattern or die out because they cannot adjust to the climate changes. This means that the people, and animals, that depend on these crops for both income and food will have to find an alternate food source. A strategy therefore is, instead of experimenting in increased crop yield, we may need to produce a more resilient plant!

In case we are confused about GREENHOUSE EFFECT, GLOBAL WARMING AND CLIMATE CHANGE, lets clarify: The greenhouse effect causes global warming and climate change is the consequence. The greenhouse effect causes an accumulation of heat (or energy) in the Earth's atmosphere. The global climate must then adjust to deal with that extra accumulation of energy, and these adjustments result in global warming and climate changes.

The Caribbean and Climate Change and Previous Years

Caribbean vulnerability to flooding was highlighted by the loss of life and the economic damage from flooding events of the Caroni & other rivers from the year 1981 and onwards. These floods generally were as a result of climatology phenomenon that was influenced by geology, geomorphology, land use and other conditions. Climate variability however, generally lead to higher rainfall and therefore to greater intensity of local and regional flooding.

In the Caribbean, there are two seasons namely wet season and dry seasons. The climate scenarios suggest a marked contrast between wet and dry seasons with the exception of BARBADOS and some other islands where wet seasons are becoming drier. In the dry season, there is a strong gradient of change between the extreme North and South (dry as much as - 5% per decade). It is likely that intense participation will increase in frequency especially in the wet

season. These projected changes underscore the need to increase adaptive capacity of flood associated human health risks. The damaging effects of flood are complex. These frequently cause major infrastructure damage, including destruction of roads, airports, electricity supply system, water supply and sewage disposal system. The economic effects of floods are after much greater than indicated by the physical effects of flood water coming into contact with the buildings and their contents. The local and regional economy may be badly affected by a major flood disaster and this may seriously affect the national economy.

Before, during and after a flood event activities may be undertaken by the population at risk, by policy makers and the emergency workers in order to reduce the health risks. This is accomplished in many ways inc relocating structures away from the flood prone areas. Mitigation measures may reduce but not eliminate major damage. Early warning of flood risks and appropriate citizen response could be effective in reducing disaster- related deaths (the number of deaths associated with flooding over the past 30 yrs is closely related to the behaviour of victims – in my view).

In addition, medium to long term interventions may be needed to support populations affected by flooding (Flood Plain Management, Early Warning Systems, etc).

According to adherents of the IPCC view, the *physical* consequences of warming are catastrophic: e.g. increased drought, flooding, and severe storms. For example, Gulf Stream slow-down could plunge the USA and NW Europe into cold and drought.

The *social* consequences are summarised in a few key reports (let us learn from them):

- A [Pentagan Report](#) points to possible "catastrophic droughts, famines and riots, with skirmishes over food and water, mass migration and economic disruption. Starvation and disease will decrease population size".
- The [Stern Report](#) says "climate change will affect the basic elements of life (water, food production, health and the environment). Hundreds of millions of people could be affected by coastal floding".

The thousands of scientists who believe that climate change is happening acknowledge the following facts:

- Carbon dioxide (CO₂) leads greenhouses gases [that include natural gas (methane), ozone, chlorofluorocarbons and laughing gas (nitrous oxide)] in terms of the extra warming they have produced.
- While CO₂ releases from human activities are only 4% of that produced by Nature, CO₂ concentrations are increasing indicating a net build-up of this gas in the atmosphere.
- According to the 2007 report by the U. N. Intergovernmental Panel of Climate Change, global warming observed in the past 100 years is very likely (80-90%) due to CO₂ releases by human activities, because natural global warming as large as 0.5 degree Celsius appear once or twice a millennium.
- The uncertainty in the predictions of models used to predict future climate stems mainly from their mathematical treatment of clouds and particulate matter.

These activities are mainly driven by the desire to grow "the economy". This is anything but new as we had to deal with acid rain and ozone layer depletion after the industrial revolution, and are still dealing with different forms of air and water pollution in different parts of the globe.

Again, many scientists believe that what led us to this stage of environmental degradation is we view Nature as an infinite resource of raw materials needed for our economic growth, and as an

infinite-size dumpster for the waste we generate in the process. People across the board have subscribed to this view. Such an irresponsible view of Nature by the human race on this planet is not only disturbing the cyclical and balanced interactions among all elements of Nature, but also is threatening the continuation of life in its different forms on this planet. Hence, we are at a stage in our collective human history where self-examination of one's value system is needed, particularly in defining our relation as a species with the rest of elements in Nature.

We need to safeguard natural elements as an invaluable trust so that they may avoid disturbing the inherent balanced state of the planet.

Humans should strive and excel to build a sustainable and responsible civilization that is in harmony with the rest of natural elements. We need to improve our understanding of our role on Earth (and as trustees) encourage all to lead a responsible and environmentally-friendly lifestyle in this world.

What does climate change mean to the Drainage Division

Climate change is happening and it is caused by natural processes and largely by human activity. Its impacts are beginning to be felt worldwide and will worsen in the decades ahead unless we take appropriate action. The solution to climate change will involve a broad array of technologies and policies—many tried and true, and many innovative and new.

What does Climate Change mean to the Drainage Division? Well to the management and staff of the Drainage Division, and the Ministry of Works and Infrastructure as a whole, climate change means more flood, more damage and more risk to safety of life which creates the ripple effect of more quality work.

Some of the Impacts caused by global climate change:

1. Changes in World's climate -

The Greenhouse Effect could lead to world-wide changes in weather and climate. Some places may get more rain and storms while other places may get less (from good to bad to extreme). Some places will experience colder winters while some will have to deal with extreme heat. This Greenhouse Effect therefore maybe the most important natural phenomena which may lead to major changes in our lifestyles within our lifetime

2. Sea Level rise –

During the 20th century, [sea level rose](#) about 15 cm (scientists claim) due to melting [glacier](#) ice and the [expansion of warmer seawater](#). Models predict that sea level may rise as much as 59 cm (23 inches) during the 21st Century, threatening coastal communities, wetlands, and [coral reefs](#). It seems that low lying countries may disappear entirely.

Rising sea levels will erode beaches; drown marshes and wetlands; damage barrier islands, habitat, and ecological processes; and cause saline intrusion into freshwater ecosystems and groundwater, flooding or inundation of low-lying areas, and damage to private and public property and infrastructure (Guaya sea wall and properties around).

3. Heavier rainfall –

Warmer temperatures have led to more intense rainfall events in some areas. This can cause flooding as we see happening worldwide with regularity.

4. Increase in Hurricanes & Tornadoes -

There is evidence that the number of intense [hurricanes](#) has increased in the Atlantic since 1970 (stated previously). [Scientists continue to study whether climate is the cause.](#)

5. Increase in Earthquake & Volcanoes -

Climate change may result in the development of earthquakes of the magnitude which we have experienced in the past number of years.

Wrt Volcanoes, Geologists classify volcanoes into 3 distinct groups: dormant, extinct, and active. Active volcanoes have erupted recently and are expected to continue to erupt again soon. The Smithsonian Global Volcanism Program defines an active volcano as having erupted within the last 10,000 years. A volcano finally goes extinct when there's no lava supply in the magma chamber beneath the volcano.

There are approximately 1,500 active volcanoes in the world today and 75% of them are located in the "Pacific Ring of Fire." On average, 50-70 volcanoes erupt every year. The last eruption was recently as March of 2011.

6. Falling Ground Water Supply

The leading reservoir of fresh, liquid water on earth is groundwater which exceeds water in all the lakes and rivers combined by over 20 times. While we are fortunate here to have running water in our taps (even if its 3X per week in few places), in many parts of the world water demands for domestic, agricultural, and industrial can only be met by pumping water out of the ground.

Falling groundwater tables are a worldwide phenomenon, thought not apparent to many. Groundwater supply is falling in many countries esp India, Vietnam and China (not here in T&T). even in Dubai and other Arabian countries where the blue revolution is the order of the day, overall water demand is increasing much more rapidly than what all water conservation, re-use and desalination efforts can make up for. Water tables are still falling in the Middle East at the rate of several metres per year. This sudden decline in groundwater availability will adversely affect the economy, production, tourism, but more critically make restrict the future of civilization.

7. Extinction of Species -

Other impacts could be the dying out of some species of animals and plants, coastal marine environments and coral reefs. Some plants would not be able to survive temperature increases. It takes thousands of years for forests to move north or south to cooler climates. (Joel B. Smith). An indirect effect of this could be inadequate food supply.

DD's Response

1. Changes in World's climate -

To control climate change, we will have to do our part and learn to live a green life and reduce our carbon footprint. We know this takes effort but begin thinking greener, acting greener, and living greener(**CONSERVATION INTERNATIONAL**):

- **Be Informed** - The first step toward being a responsible green citizen is knowing the issues and taking time to think about them. live green involve using less. Turn decayed organic materials from your yard into mulch or fertilizer.
- **Influence Your Friends, Family, and Community** - A green You is a great role model for your friends, family, and colleagues. Another huge thing a parent can do to live green is to use cloth diapers as opposed to disposables. Disposable diapers take up an enormous amount of this countries landfills, don't break down easily, cost a lot of money, put chemicals directly on the bottoms of our children, and in many cases delay potty training.
- **Be a Green Consumer** - It is becoming easier and easier to know what effects the things you buy have on the environment. Reduce your junk mail. This saves lots of paper and trees.
- **Eat Green** - Environmentally friendly eating habits are easy and healthy. Purchasing as much as we can from [local resources](#) will help reduce fuel consumption and pollution. Why not eat the oranges from Central instead of the apples from another country? Better yet, purchase food items that are grown within our same village or town as we to really reduce fuel consumption. An added benefit of purchasing locally is that you are supporting people in your own community. This could cost you a little more money depending on what is in season; however it doesn't automatically cost more to eat locally.

- **Explore Biodiversity** - The diversity of nature is everywhere. Take a look. . Use grocery bag instead of all those plastic bags the grocery store loves to give out
- **Minimize Your Carbon Footprint** -By reducing the energy and fossil fuels you use, you are saving the environment from further damage.
Turn our lights off and use natural light to use less electricity, gas or oil, combine our errands so that we use less gasoline, cook multiple items at the same time so that we turn our oven on only once a day instead of three times, and turn the water off when we brush your teeth. reuse items ziploc bags, tinfoil, plastic utensils, etc and finding new uses for things we already own. By doing this we are not consuming any more of the world's precious resources.
- Composting and growing your own food are also ways to help the environment and live green. Doing things yourself instead of hiring a third party helps the environment as well.
- **Travel Sustainably** - carpooling to work or the store, using the Diva Cup or Keeper instead of disposable sanitary products, bringing your own mug to coffee places instead of using their disposable cups borrowing books and magazines from the library instead of purchasing new (it takes 15-20 trees to make the paper for a new average sized adult book), using cloth napkins instead of paper, using rags instead of paper towels.

Living green does not have to be hard and it does not have to cost money. Start small if you need to, but try to incorporate these things, and more, into your daily life. It takes some thinking about it in the beginning, but in time you won't even notice. By living green you will be helping the environment as well as saving money.

2. **Sea Level rise** –

A recent report from the U.S. Climate Change Science Program notes that “thoughtful precaution suggests that a global sea-level rise of 1 [meter] to the year 2100 should be considered for future planning and policy discussions.”

Under TRAC, the DD will form a Unit to Monitor, Control & Manage our Shoreline and strives to preserve and protect coastal resources. There is the need however for proper legislation and the need for comprehensive management guidance a priority. These factors include the increase in use of coasts, and shrewd management of coastal resources. The objectives are to protect and preserve coastal ecosystems, manage coastal development, improving water quality, utilize economic and energy resources, and coordinate and simplify administrative procedures.

16 USC § 1451 (Section 302): Congressional Findings: “Because global warming may result in substantial sea level rise with serious adverse effects within the coastal zone, coastal states must anticipate and plan for such an occurrence that will “at least” provide for, among other issues:

- (A) the protection of natural resources, including wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone,
- (B) the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands,
- (C) the management of coastal development to improve, safeguard, and restore the quality of coastal waters, and to protect natural resources and existing uses of those waters,
- (D) priority consideration being given to coastal-dependent uses and orderly processes for siting major facilities related to national defense, energy, fisheries development, recreation, ports and transportation, and the location, to the maximum extent practicable, of new commercial and industrial developments in or adjacent to areas where such development already exists, etc.

It is postulated the new national policy “to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas,

including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels, and improved predictability in governmental decision-making.”

3,4,5. Heavier Rainfall – Increase in Hurricanes & Tornadoes - Increase in Earthquake & Volcanoes – Increase in Forest Fires

Plant trees. Plant trees, and then plant more trees!

We continuously remove trees without replacing (even elsewhere).

We fill in our wetlands and our ricelands (our natural detention) and then we complain when the floods strike!

Wrt flooding, we are fortunate to many First World Countries. There is no mass drowning, no severe loss of crops, livestock and infrastructure, etc. just nuisance flooding! We can salvage our situation. Lets start by protecting our wetlands!

Wetlands are extremely valuable to society. Wetlands can decrease flooding, remove pollutants from water, recharge groundwater, protect shorelines, provide habitat for wildlife, and serve important recreational and cultural functions. Where wetlands are lost, they may be impossible to replace (except at phenomenal costs, if at all possible). Lost wetlands can result in a nation having to invest more money in drinking water treatment or higher costs to citizens for flood insurance.

Wetlands act as natural sponges that trap and slowly release surface water over time. This ability to store water in times of heavy rainfall means that wetlands can help prevent flooding. A one Ha wetland can typically store about one 2.5 gallons of water, though the degree of flood control depends on many factors such as the type of wetland and soil permeability.

Coastal wetlands are particularly important because they can help reduce flooding from hurricane storm surges. Many of the coastal areas are in flat or low-lying areas, which are particularly vulnerable to hurricanes and tropical storms. We must pay particular attention to our east coast (our more vulnerable coastline) and control development etc.

Preserving wetlands, in conjunction with other flood control measures, often offers superior flood protection and costs less than a conventional system of dikes, levees, floodways, and stormwater retention ponds. It is important to preserve wetlands, which truly are the first line of defense against flooding.

RIVER TRAINING WORKS - an ancient practice. It requires application of human creativity continuous improvement and to correct unpredictable and sometimes eccentric changes of the rivers (requiring deep and precise study of river mechanism and behaviour). “Learning the river is quite a process” since river engineering works invariably influence water flow, sediment transport and bed morphology.

River training has assumed considerable significance due to vast annual recurring damage caused by the floods; property damage, loss of goods, loss of crops and livestock, etc. River training, in its broad aspects, covers all engineering works constructed on a river to guide and confine the flow to the river channel, and to control and regulate the river bed configuration for effective and safe movement of floods and river sediments.

In essence, river training envisages training and stabilising a river within a suitable waterway and along a certain alignment for a variety of purposes. River training works involve large outlays and it is essential to select the type of the training work and materials of construction.

River training works are provided to guide the river to flow axially through the barrages or weirs or bridge, and to check the outflanking (erosion around or behind, etc). It includes all engineering works constructed on a river to stabilize the river along the desired course with a designed waterway area to regulate the water bed configuration for effective and safe movement of water and sediment

Sluice gates and weirs are constructed across the rivers for ponding up the river flow and diverting the river supplies for irrigation, power and other processes. Bridges are put up to cross the rivers.

Objectives of River Training Works (include but not limited to):

- (a) **Flood Protection** (the main objective) - To provide reasonable cross section of the river channel for the safe passage of maximum flood without flooding of the riverine lands upstream of the sluice gates and weirs
- (b) **Stabilization of the river bed**- important objective of the river training works is to attain the stability of alignment, shape and regime of the river.
Research needs to be done to determine and evaluate strategies to sustain and improve development of the river and its basin in a changing environment.
- (c) **Protection of works.** To provide for the protection of bridges, weirs and gates, canal head works etc. from direct attack or outflanking. This is done by diverting the flow in a well defined channel. River training works minimize possible cross flows through the structure, which otherwise may endanger the structure and protection works.
- (d) **Bank Protection.** To reduce the flow away from the bank to prevent bank erosion.
- (e) **Sediment Control.** To provide for the rectification of river bed configuration and efficient movement of suspended and bed load for keeping the river in good shape.
- (f) **Sand exclusion.** To provide a favourable curvature of flow at the head regulator from the point of sediment entry into the canal. The suitable location for the canal off -take is on the outer bank, slightly downstream of a concave bend. This will result in sand exclusion.
- (g) **Land reclamation.** To reclaim land for cultivation from wide river sections in plains.
- (h) **Confined river channel.** To rectify the alignment of the river where abnormal changes have taken place e.g. splitting into various branches, development of sharp bends or meandering and formation of wide and shallow shoals.
- (i) **To prevent river from changing its course** and correct disorderly banks or flow conditions
- (j) **Navigation.** To provide sufficient depth in the river channel during low water periods for improvement in the field of navigation.

6. Falling Ground Water Supply - To prevent this in our Island we must be proactive!

We carry out our construction work to allow for storm water infiltration to ground water. Rethink strategies of paving drainage channels (paved channel stops infiltration). Encourage construction of retention ponds (lets learn from the "Ravine Sable Experience"! This act of God worked like a dream). Where geology favours holding, storing, and allowing groundwater to be extracted, include areas with deep alluvial soils, sandy loams with low clay and limestone contents that have good potential to store water for later use.

In Riverine systems with high river flows during the rainy season where flows are not used for crops, and run out to sea (eg Caroni or Ortoire Rivers) conserving these floodwaters should be the main aim. Additionally, Places where the ground slope varies gradually and where it is not subject to flooding and/or waterlogging; also in areas with no soil salinity problems.

Develop areas of existing channel irrigation systems where the canals can be better utilized for dry season irrigation (eg GSB). Develop irrigation/storage in places where information on hydrogeology and groundwater movement are already available, thus saving the cost of detailed surveys. Of course preserving wetlands & mangrove are essential in causing water table rise.

7. Extinction of Species -

We need to feel compassion towards animals in order to understand their struggle for survival. The preservation of all species is very beneficial to all of mankind. Many organisms have a conventional splendor that goes far beyond that on any other. Many of the benefits of preservation are extremely beneficial to mankind. Chemicals found in certain plants have been proven to be medically beneficial. Two such chemicals are the alkaloids, Vincristine and Vinblastine, used in the treatment of Hodgkins disease, diabetes and some cancers. It is believed that the estimated quarter-million flowering plant species are potentially a gold mine of additional beneficial chemicals. Some animals also have very beneficial uses. Extracts from some marine animals related to those that built the giant coral reefs, show some promise as anti-cancer agents. So far, several broad-spectrum antibodies have been extracted from marine sponges. Sea Anemones, segmented worms, clams, sea cucumbers, sea squirts, moss animals, proboscis worms, sharks, and sting rays are all creatures of the sea that contain medical benefits. On land, anurod, the venom of Malayan pit vipers is used as an anti-coagulant, an agent to prevent the formation of blood clots. Rats, mice, Rhesus monkeys, and chimps have served as surrogates for human beings in a wide variety of medical experiments. Perhaps though the greatest of all benefits derived from other organisms is that of nourishment which we extract from them. We should therefore:

- Protect wildlife habitat. Stop encroachment on habitat.
- Not support illegal wildlife market.
- Join a conservation group. Spend some time and money.
- Recycle. Save money. Save the trees. Save the Planet.
- Stop/reduce use of dangerous agricultural sprays, etc. use natural fertilizers.

An indirect effect if the above is not achieved could be inadequate food supply.

CONCLUSION

In the absence of adequate scientific data, and a proper education program geared for our people (although there is enough evidence wrt climate change) the foll. **Recommendations** are suggested:

Recognizing these risks, we need now to develop a greater resilience to climate changes (rather than the more costly, reactive measures).

There are two responses to global climate change: Adaptation and Mitigation

- Adaption - Our ability to adjust to the changing climate and policies to minimize its predicted impacts (e.g., building better coastal defenses); to take advantage of opportunities, or to cope with the consequences; to reduce vulnerability by building on and strengthening existing coping strategies.
- Mitigation – Our ability to reduce the long-term risk and hazards of climate change to life & property, using both policy instruments and technology for sustainable development; and ensuring that food production is not threatened.

Among the many strategies, Coastal drainage systems therefore are rather crucial to mitigate coastal flooding: (Kuo 1980)

1. the impacts of high tides and storm surges,
The rate at which gravity drains an area depends in part on the difference in elevation between the area being drained and the place to which the water flows. The greater the difference in elevation, the greater the slope of the “hydraulic head” and the faster the water can drain.
2. low elevations,
Coastal areas generally are low-lying and thus vulnerable to flooding. High tides can decrease the elevational difference and further slow gravity drainage. Moreover, storm surges in coastal areas frequently occur during rainstorms, and can completely stop natural drainage.
3. high groundwater tables,
High water tables in coastal areas also limit natural drainage. With water tables just below the land surface, a rainstorm can rapidly saturate the soil (raise the water table to the surface). The saturated soil increases runoff by decreasing the ability of water to percolate into the ground.

Coastal flooding can also be exacerbated by problems frequently not considered in designing the drainage system. Storm waves may overtop a seawall; and sediment and debris may block inlets, outlets, and storm sewer pipes and canals. During the worst storm surges, coastal areas may be

completely inundated by the sea, leaving the drainage system ineffective until water levels have receded. Areas that are currently below sea level would require pumping.

The potential responses to drainage problems caused by sea level rise and increased precipitation fall broadly into three categories:

- enhanced gravity drainage (increase waterway area, construct new channels),
- forced drainage (using well designed pumping stations), and
- adaptation to increased flooding.

These measures vary in the extent to which implementation requires anticipation of future climate change rather than reacting as it happens.

we should plan and act even if it is a probability issue!

(Remember,

⇒ Gravity drainage can be enhanced by using larger pipes or wider drainage channels. Communities with drainage systems in place can either install supplemental pipe systems or replace old pipes with larger ones.

⇒ Because of the low elevations of coastal areas, gravity drainage is not always possible. To be drained by gravity, a road must not only be above sea level, but must have sufficient elevation for drainage pipes underneath to have adequate cover and be above sea level themselves. Thus, some areas have forced drainage (pumps). As sea level rises, some areas that currently have gravity drainage may have to shift to forced drainage. Sluice and flap gates provide a cost-effective interim solution for such areas. During low tide, the gates could be open to permit gravity drainage, while during high tides they could be closed.

Areas that currently use forced drainage will also require modifications. Larger pumps may be necessary to work against the higher tailwaters and to handle the larger capacity resulting from decreased natural drainage and percolation, and possibly increased runoff. While new systems may require larger pumps, existing systems are more likely to use additional pumps. In addition to increasing pump capacity, it will often be necessary to increase the capacity of the system that delivers the stormwater to the pumping station.

⇒ Detention (and Retention) basins are widely used to control surface runoff in many areas. The concept of detention can be applied in ways other than detention basins, such as rooftop detention, infiltration trenches, porous pavement, storage in low playgrounds and parking lots, and in-line storage in the stormsewer pipes. The detention scheme would be able to reduce the peak discharge, delay the peak time of a storm, and therefore reduce the flow into drainage channels, etc. After the storm has ended, the runoff volume stored in the detention facilities could then be released gradually into the drainage systems without exceeding its capacity.

In addition to improving their drainage systems to prevent flooding, communities might choose to implement a combination of planning and structural measures to adapt to increased flooding.

Strengthening capacities

- Improve the capacities to access to available resources (HR, tools & funds), inc Training,
- Assist in restoring and conserving of wet lands that have a special role for the reduction of climate change effects
- Promote the eco-hydrological approach for the management and conservation of wet lands
- In Land Development Designs, easy access to Planners, etc to reliable and up to date information (charts, etc)

And,

1. Stop building in the increasingly flood-prone areas. If you must, then floodproof;
2. Basement construction should be avoided in specific areas
3. Construct new buildings and streets at higher elevations (unlike what is happening in POS this past decade).
4. Implement zoning measures (T&C) and enforce them,
5. Promote flood insurance (make the citizens understand and stop the 'handouts')

Also, DD recommends that:

1. emphasis be shifted from disaster response to risk management, including the improvement of flood forecasting and warning systems, the addition of health protection as a goal and consideration of how climate change may increase or decrease flood hazards;
2. environmental impact assessments include health risks from flooding as an issue;
3. assessments be made of communities' capacity to respond to and manage flooding;
4. government's support monitoring of and research on the health impact of all categories of flooding; and
5. coordination be promoted among disciplines, policy-makers and international organizations.

In some instances the most appropriate response to sea level rise and climate change can be implemented if and when the consequences occur. In other instances—particularly urban systems being overhauled today—the most cost-effective approach would be to prepare for these consequences before they occur; possibly before people are certain that they will occur.

As I conclude, allow me pl to use a verse from the Torah (Old Testament) from *the book of Revelations where God describes Heaven as a place where trees abound laden with fruits and where rivers flow, where man will enjoy tranquility, comfort and where man will not toil.*

Also, allow me to use a different slant to explain this verse to which Priests use.

You see, God spoke about trees (the priest speaks of the tree of life...even so its in the garden of Eden), and I postulate this is one of man's greatest resource; also God spoke of rivers flowing, another one of man's major resource.

You see, God didn't speak of high rise blgds or elaborate highways or spaceships.

(Remember this is from the book of revelations, and) we are being warned: take away the trees, we take away the rain. Take away the rain, we take way the flowing rivers, Take way the flowing rivers, we take away the food. Take way the food, we take away the peace- we cause riots! Now we toil!.

Lets us be the Professionals we are, and do the right things. When we build massive buildings and elaborate highways, lets include trees (think green) and insist on ponds! We are professionals, we have responsibility. We are responsible! We are responsible for our children's future, and if we fail, IF WE FAIL, we shall be held accountable! When Planners, Architects & Civil Engineers begin to consider the implications of the increasing greenhouse effects on earth, and to think green, and then realize there are **only two methods to deal with Global worming (Mitigation and Adaptation)** then will it be possible to take advantage of all the recommended solutions.

I thank you! And I thank those who assisted in this anthology.