NATIONAL ADAPTATION STRATEGY

TO ADDRESS CLIMATE CHANGE IN THE AGRICULTURE SECTOR OF GUYANA

SYNTHESIS AND ASSESSMENT REPORT

Prepared for the

Caribbean Community Climate Change Centre

Belmopan, Belize

by the

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The views and opinions expressed in this report are those of the Authors and do not necessarily represent the views and opinions of the Government of Guyana, the Caribbean Community Climate Change Centre or the World Bank.

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LIST OF ACRONYMS

ACCC	Adaptation to Climate Change in the Caribbean
ACP	Africa, Caribbean and Pacific Countries
AEDP	Agricultural Export Diversification Programme
APCU	Agriculture Project Cycle Unit
ASSP	Agricultural Services Support Programme
BPOA	Barbados Plan of Action
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community
CBI	Caribbean Basin Initiative
CDC	Civil Defence Commission
CDM	Clean Development Mechanism
CET	Common External Tariff
CFNI	Caribbean Food and Nutrition Institute
CIDA	Canadian International Development Agency
CLSS	Crops and Livestock Support Services
CPACC	Caribbean Planning for Adaptation to Climate Change
CROSQ	CARICOM Regional Organization for Standards and Quality
CSEC	Caribbean Secondary Examination Council
D&I	Drainage and Irrigation
DAI	Dangerous Anthropogenic Interference
ECLAC	Economic Commission for Latin America and the Caribbean
EDCB	East Demerara Conservancy Board
EDWC	East Demerara Water Conservancy
EIA	Environmental Impact Assessment
EITD	Education, Information and Training Division
EMD	Environmental Management Division
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organization
FAR	Fourth Assessment Report
FCPF	Forest Carbon Partnership Facility
FD	Fisheries Department
GAP	Good Agricultural Practice
GATT	General Agreement on Trade and Tariffs
GCC	Global Climate Change
GCCAP&IS	Guyana Climate Change Adaptation Policy and Implementation Strategy
GDP	Gross Domestic Product
GEA	Guyana Energy Agency
GEF	Global Environment Facility
GFC	Guyana Forestry Commission
GHG	Greenhouse Gas
GMP	Good Management Practice
GMPIS	Guyana Management Pesticide Information System
GNBS	Guyana National Bureau of Standards
GNVASLR	Guyana National Vulnerability Assessment to Sea Level Rise
GoG	Government of Guyana
GRB	Guyana Rice Board

GRDB	Guyana Rice Development Board
GRPA	Guyana Rice Producers Association
GS&WC	Guyana Sewerage and Water Commission
GSA	Guyana School of Agriculture
GuySuCo	Guyana Sugar Corporation
GUYWA	Guyana Water Authority
GWI	Guyana Water Incorporated
HACCP	Hazard Analysis and Critical Control Point
HD	Hydrometeorology Department
HIES	Household Income and Expenditure Survey
IAST	Institute of Applied Science and Technology
ICZM	Integrated Coastal Zone Management
IDB	Inter-American Development Bank
IFAD	Institute for Agricultural Development
INC	Initial National Communication
IPCC	Inter-Governmental Panel on Climate Change
MACC	Mainstream Adaptation to Climate Change
MARDS	Mahaicony Abary Rice Development Scheme
MDG	Millennium Development Goals
MFN	Most Favoured Nation
MMA-ADA	Mahaica-Mahaicony Abary Agriculture Development Agency
MoA	Ministry of Agriculture
MPW&C	Ministry of Public Works and Communication
NARI	National Agricultural Research Institute
NCC	National Climate Committee
NCCAP	National Climate Change Action Plan
NCSA	National Capacity Self-Assessment
NCU	National Climate Unit
NDC	Neighbourhood Democratic Council
NDDP	National Dairy Development Programme
NDIA	National Drainage and Irrigation Authority
NDS	National Development Strategy
NEAP	National Environmental Action Plan
NEEPAS	National Environmental Education and Public Awareness Strategy
NGMC	New Guyana Marketing Corporation
NGO	Non-Governmental Organization
NIS	National Insurance Scheme
NMMAP	National Mangrove Management Action Plan
NREAC	Natural Resources and Environment Advisory Committee
OAS	Organisation of American States
OPEC	Oil Producing and Exporting Countries
PD	Planning Deaprtment
PRSP	Poverty Reduction Strategy Paper
PSIP	Public Sector Investment Programme
PTCCB	Pesticide and Toxic Chemical Control Board
R&D	Research and Development
RDC	Regional Democratic Council
REDD	Reducing Emissions from Deforestation and Forest Degradation
RTP	Regional Transformation Programme
SDB	Sea Defence Board
SEES	School of Earth and Environmental Sciences

SES-PAP	Socio-Economic Survey and Public Awareness Programme
SIDS	Small Island Developing States
SNC	Second National Communication
SRDD	Sea and River Defence Division
SWOT	Strengths, Weaknesses, Opportunities and Threats
UG-FAF	University of Guyana Faculty of Agriculture and Forestry
UG-SEES	University of Guyana School of Earth and Environmental Sciences
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Convention to Combat Climate Change
USDA	United States Development Agency
VCA	Vulnerability and Capacity Assessment
WUA	Water Users Association
WWF	World Wildlife Fund

A1 The A1 storyline and scenario family describes a future world of a very rapid economic growth, global population that peaks in mid century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with substantial reductions in regional differences in per capita income. The A1 scenario develops into three groups that describes technological emphasis: fossil intensive (A1F1), non-fossil energy sources (A1T), or a balance across all sources (A1B) where balance is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.

A2 The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita growth and technological change more fragmented and slower than other storylines.

B1 The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initative.

B2 The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

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EXECUTIVE SUMMARY

1. INTRODUCTION

This Synthesis and Assessment Report (SAR) provides an assessment of the effects of climate change on Guyana's agricultural sector. It was produced under the auspices of the Mainstreaming Adaptation to Climate Change (MACC) project on the Caribbean Community Climate Change Centre (CCCCC) with funding from the World Bank (WB). This assessment was coordinated locally by the National Climate Unit (NCU) and executed by Development Policy and Management Consultants (DPMC) and local firm.

This SAR is based on a macro-economic overview and technical, policy and institutional assessments that examine closely the likely impacts on the agricultural sector due to climatic changes. The assessments provide the backdrop for the development of the Adaptation Strategy to Climate Change and Action Plan for the agriculture sector of Guyana. The assessments were compiled using a plurality of approaches, inclusive of an extensive review of the relevant scientific literature and measurements and data collected and published by national and regionally agencies, an extensive content analysis, structured interviews, economic analyses and workshops over a period of approximately six (6) months. The team of authors includes experts in the fields of agriculture, hydrology and climatology, economic analysis, and institutional assessments from academia, national laboratories, and government agencies.

2. SCOPE

The climate projections have been looked at for over the next 100 years (2100), even though the Strategy and Action Plan the follows are looked at over the next 10 years (2018). In compiling the assessments the following questions were pertinent:

- Will climate change significantly affect domestic agricultural production?
- Will climate change lead to increase pest infestations and pathogens?
- Will climate change affect the competitiveness of Guyana's agricultural exports?
- Will climate change cause food shortages and lead to an increase in hunger?
- Will Climate change threaten agricultural exports or create opportunities for new markets?
- Will climate change affect key government policies in relation to agricultural pricing, financial support and research and development?
- Will climate change increase food prices to consumers nationally?

Our charge from the Client was to conduct the sector assessment and develop a draft strategy. This strategy was then presented at a National Stakeholders Workshop with the feedback being refined into specific action for implementation. We were not required to develop an agricultural strategy and have not sought to do so. Instead, our focus has been on adaptation mechanisms that can be implemented to allow the agricultural strategy to adapt to the challenges this phenomenon may present, and take advantage of the opportunities presented. We briefly sketch

the outline of the various assessments before providing a collation of the major findings and conclusions.

3. ASSESSMENTS

3.1 Economic Review

The agriculture sector remains important to the Guyanese economy in terms of its 35% contribution to gross domestic product (GDP), 40% of export earnings, employing nearly 30% of the country's workforce and being an important source of food for the local populace. In fact, this last point takes on greater significance for communities in the hinterland areas of Guyana that depend on subsistence agriculture for their survival.

Despite many changes that have occurred in the sector since political Independence in 1966 and various initiatives to diversify the agricultural base of the country, the sector remains heavily dependent on sugar, rice, shrimp and forestry resources. While the fruits and vegetables sub-sectors have seen substantial increases in output and exports in the past two years, their contribution to national income in still relatively small at just about 1.7%.

Agriculture though is more than an economic activity in Guyana, for many communities it is a way of life and an 'institution' around which social and cultural ties remain strong. For example, the Guyana Sugar Corporation (GuySuCo) alone reports employing approximately 18,500 persons directly at all levels, with most of these employees coming from the rural areas of Guyana where poverty is greatest. Additionally, GuySuCo has been involved in providing a number of allied services, such as medical centres and primary health care services, provision and maintenance of community grounds and facilities, training to private cane farmers, maintenance of some rural infrastructure, and transport services (Shutt *et al*, 2007). Thus, any impact of climate change that may negatively affect this Corporation such as destruction of crops forcing the Corporation to down-size its operations will also impact the quality of services it can offer, the quality of life in some communities, and a source of revenue for other social service schemes like the National Insurance Scheme (NIS). Similarly, the rice and fisheries sub-sectors employ an estimated 50,000 persons directly and indirectly, with most of those within the fish processing plants being women, many of whom are single parents. Hence the multipliers can be significant, should climate change affect the spawning and survival rates of shrimp in particular.[1]

The sector is also a vital source for nutritious agricultural output in the fight against food insecurity in pockets of Guyana. While commercial agriculture remains an imperative for many households on the coast, small-scale agriculture is more central to the survival strategy of many rural households. In particular, Amerindian communities remain heavily dependent on the sector to provide cassava, their main staple, which is then converted into various food items. In fact, even along the coast, it is quite common to find the embankment of rice fields being cultivated with vegetables, as rural families seek to bolster their incomes and diversify their production base, thus spreading their risks (Shutt *et al*, 2007).

As such, while the vast majority of agricultural activities take place on the coastal plain of Guyana, which is likely to be hardest hit from climatological changes unless appropriate actions are taken, it is a misnomer to think that this is the only area that is likely to be affected. In fact,

[1] FAO (2008) Climate Change and Food Security: A Framework Document, FAO/UN, Rome.

the interior locations are likely to suffer even more severe from a sociological standpoint and these impacts need to be captured and studied in a comprehensive manner.

This analysis indicates that there are at least six (6) direct impacts projected from climate change that will impact the sector. These are:

- Sea level rise that can lead to increased flooding in coastal areas and destruction of crops and livestock,
- Inundation from more intense rainfalls and over-topping from higher than normal tides,
- Soil erosion from greater run-off,
- Saltwater intrusion in the dry season,
- Limited freshwater availability during the dry season, and
- Increased pest infestation due to longer warm water.

Furthermore, our demand analysis indicates that future demand for agricultural products will be determined, *inter alia*, by drivers such as, the rate of population growth, the size of disposable income, taste, cultural issues, government policies and natural conditions. At the same time, the quality of the products and ease with which they can be obtained will remain important considerations in the demand for agricultural products. All of these factors are likely to cause the price of agricultural products to remain relatively buoyant, providing opportunities for Guyanese farm households.

On the supply side, while Guyana maintains a competitive advantage in the region in freshwater and land, it will be necessary for the country to rehabilitate aspects of its rural infrastructure, such as drainage and irrigation schemes, farm to market roads, and extension services to expand agricultural production. Other issues that must be addressed include:

- Vulnerability to seasonality and natural disasters,
- Unsustainable use of land resources,
- Scarcity of labour and an aging farmer population,
- Insufficient capital for agricultural activities,
- Unreliability of Suppliers,
- Insufficient enforcement of quality standards and surveillance,
- Weak research and technology systems,
- Dualistic structures,
- Underdeveloped agro-processing industry,
- Insufficient market transparency,
- Weak transportation networks,
- Lack of volume, and
- Need to recapitalize some industries.

3.2 Technical Assessment

Global warming and sea level rise resulting from climate change are projected to have adverse impacts on land based activities and the environment. The projection of global sea level rise of 0.51m towards the Century, not including the addition of melt water from glaciers, and an increase in temperature to 5.4 C by the Century (IPCC, 2007), are predictions that will

necessitate appropriate adaptation responses. The immediate cause for concern is the extremely high vulnerability of low lying coastal states, whose coastal areas are of high economic importance and those other vulnerable sectors of which agriculture is a highly weather sensitive one. As a result of climate change there will be impacts on rainfall, water resources, heating effects on plants and animals, leading to higher evapo-transpiration rates leading to stress in both organisms. The increase in temperatures will add to the energy budget in the atmosphere and oceans, this will create more intense storms occurring at more regular intervals.

In Guyana, there is a bi-modal pattern of rainfall annually, the intervening periods are dry. In order to maximize the land resources for cropping and livestock production, then a source of water must be in place to supplement the variable rainfall in sufficient quantities. Hence, water resources are stored for use in reservoirs or extracted from flowing rivers, to support agriculture. The projected scenarios and modelled data (INC, 2002) indicate that there will be increased intensity of storms, leading to higher runoff resulting in flooding, leaching of soils which do not have good cover or may have been cleared for planting, leading to increase of sedimentation of waterways. Almost all drainage and irrigation depend on gravity flow; any changes in elevation or bed profile of streams will result in inefficiency in operation or create additional costs due to the need to pump water for drainage or irrigation.

Sea level rise will threaten the coastal areas with inundation, coastal riverain areas with saline intrusion into surface and ground water resources. Drainage will become a critical factor in preventing losses due to water-logging of soils and flooding. There will be need to maintain storage levels at a level to supply irrigation demands which will require better management of resources. The adverse impacts of climate change in subtropical areas leading to decrease water availability hence reduction of productivity will create demands for increase food production in those areas that are capable of increasing production. With the projected expansion of Agriculture in several Regions it will be prudent to plan with the projected impacts of climate change in focus in order to reduce losses and minimize the risks that always accompany such ventures.

3.2.1 Predicted Impacts on the Agriculture Sector

As far as agriculture in Guyana is concerned, the prediction is that there will be an increase in temperature, a slight decrease in total rainfall together with a decrease in the length of the rainy period. This therefore means that there will be more intense rainfall during the wet season. In coastal Guyana where much of the agricultural sector is concentrated the resilience is likely to be tested by several climate change events notably flooding, high temperature, high relative humidity, more pests and diseases incidence, saline intrusion, high evaporation rates and greater plant stress.

It is projected that there will be higher rates of photosynthesis. Despite the increase in photosynthesis the changes in temperature may have a far greater detrimental effect, resulting in a general trend of reduction in productivity for even small increases (1-) in temperature. This is because there will be an increase in plant transpiration rates and evaporation, leading most likely to deficits in soil moisture supply.

Climate change and sea-level rise are expected to result in greater risk of coastal erosion. Our mangroves may be negatively affected by sea-level rise.

Aquaculture

The species used are tilapia (*Oreochromis niloticus*), hassar (*Hoplosternum littorale*), fresh water pacu (*Colossome macropomum*), and swamp shrimp (*Mesopenaeus tropicales*).

One effect of climate change, salt water intrusion, can have a debilitating impact on aquaculture production since the hassar and pacu will not be expected to survive under saline conditions. Tilapia has been known to withstand salinity levels up to 28 parts per thousand (ppt)(sea water); however, there is need for fresh water for reproduction and survival of the fries. High salinity is also expected to affect predator fishes e.g. houri.

Changing rainfall patterns may also impact on the spawning activity of hassar. In Guyana it is expected that the intensity of rainfall will increase, leading to a sharp change in conductivity of the water, and thus probably, an increased rate of spawning.

High temperature and increased rainfall should dilute the brackish water where swamp shrimp are reared, resulting in faster rates of growth. A rise of up to one foot of water in the pond will not have any detrimental effects on the crop.

A major problem for the expansion of aquaculture is that suitable lands (class I) are in direct competition with crop production. This is because the pH of the land is crucial. Only pacu can be reared on lands unsuitable for many crops. Class II and III lands also need much infrastructure and inputs.

Farmers should be encouraged to adopt fish/rice culture of production to offset detrimental changes on the soil.

Salinity

Salinity has not been a major problem for the Guyana Sugar Corporation (GuySuCo) or National Agricultural Research Institute (NARI). With climate change if there is too much salt intrusion into the land then pasture establishment and production may be a problem because none of the recommended pasture grasses (tanner, antelope nor para) are very tolerant to high salinity.

Livestock

There are three anticipated problems that may arise as a result of climate change:

Nutrition - reduced food (forage) and lower quality of forage especially for beef
Diseases – respiratory and digestive diseases may increase especially for Holstein off-springs.
Availability of food for human consumption – there is likely to be increased incidence of mastitis which will lead to lower levels of milk production.

Crops

NARI is responsible for the development of all crops with the exception of rice and sugar cane, which are the responsibility of the Guyana Rice Development Board and GuySuCo respectively.

At NARI lines/strains are introduced and evaluated extensively for suitability to our growing conditions, response to pests and diseases, general growth, development and yields. GuySuCo is engaged in developing its own cultivars for at least one of three characteristics i.e. sugar, fiber and

alcohol content. High fiber content is known to be closely linked with increased resistance to borers. This is essential since there has been a new borer (*Elasmopalpus lignocella*) emerging. The response of this insect pest to changing climatic conditions is still to be ascertained.

An emerging disease is ratoon stunting disease. In its breeding programme there is selection for resistance to smut and leaf scald. With this new disease becoming more prevalent, then the objective of the breeding programme may very well have to be adjusted to include an evaluation for resistance to this new disease.

Burma Rice Research Station is involved in the development of new rice lines. To offset climate change effects the plant materials intended to be the precursors of new rice varieties are being evaluated for salt tolerance and to tolerate increasing levels of water especially during vegetative growth.

A consideration of climate change is that the rice plant may physiologically be unable to have higher yields. This is because of the impact of growing degree days. With higher predicted temperatures the crop cycle will most probably be shortened, hence there may not be enough sink available to maintain current yields.

Plant Responses to Carbon Dioxide

Plants grow and develop in response to a range of stimuli but especially to the availability of carbon dioxide, water and mineral nutrients and to the quality and quantity of light. Most of these stimuli will be affected directly or indirectly by climate change, except that light quality and the natural rhythm of variation in day length will remain unaltered.

Current carbon dioxide concentrations limit plant photosynthesis. If other factors remain favourable, increased carbon dioxide concentrations will lead to greater rates of photosynthesis in plants.

Temperature and Growth Development

Since rates of plant development increase linearly with temperatures above a threshold, events such as germination, leaf appearance and flowering often occur after a fixed accumulation of heat above a base temperature (called day degree).

With an estimated increase in temperature by 1.2 for Guyana then there will be accumulation in the growing degree day. For instance a 105-110 day maturing rice variety will now mature in 100-105 days. The crop cycle will be shorter for all our crops and they will have a shorter time in which to accumulate their storage products. Hence, overall uptake rate will have to increase; if water deficit becomes a problem then there is likely to be drastic reduction in yields.

Plant Responses to Water

Water availability to the plant depends on the relative rates at which water is taken up from the soil by the roots and lost from the leaves. If water is in short supply in the soil, or water loss from the leaves is too high because of increasing temperatures and increasing light levels, the plant will suffer water stress. It will react by closing its stomata (leaf pores) to conserve water and will therefore shut off its carbon dioxide supply. Growth will suffer. Prolonged stress will cause loss of leaves and hardening of the plant. Extreme stress will kill it.

Responses of Pests, Diseases and Weeds to Climate Change

Effects on pest, diseases and weeds are among the most difficult to extrapolate from climate change scenarios because of the complexity of interactions, particularly in relation to specialized feeding relationships of pests.

Temperature is probably the single most important environmental factor influencing insect behavior, distribution, development, survival, and reproduction. An increase in the mean annual temperature of 1.2°C (Guyana by the 2040s) will mean that many insects will be active for a longer period of time. The range and distribution may also shift since the regions which have cooler nights (Hilly Sand and Clay region) may now experience more of these insects as a result of a rise in the minimum temperature.

Higher average temperatures will mean shorter intervals between generations of pests. Thus, just one more generation over a growing season can have a profound effect on population numbers. This effect will be exacerbated in the case of many sucking pests, as higher temperatures will be accompanied by increased water stress, leading to increased uptake of increasingly concentrated plant sap.

Thrips, aphids and mites are likely to be most responsive to the effects of climate change as they produce many generations in a single season. One of the most important natural controls of aphid populations is rainfall, as the impact of raindrops dislodges the aphids or damages their feeding parts. On the other hand, reduced water supplies will lead to increases in cell sap concentration. Sucking insects and mites will have a more concentrated food supply and may increase more rapidly.

Additionally, the general impact of climate change on diseases can be summarized as follows:

- Wetter and warmer seasons will favour diseases such as *Phytophthora* that need water to spread;
- Drier seasons will favour disease such as powdery mildew that can spread in dry conditions;

Pests and diseases are likely to be more troublesome as a result of climate change, because higher temperatures will allow increased survival and activity. Some pests (mites, aphids) and diseases (powdery mildews, rusts) will be favoured by hot, dry seasons. Leaf eating pests may be slightly disadvantaged by the higher carbohydrate status (and therefore reduced protein content) of host plants growing in the higher concentrations of carbon dioxide, and higher light levels associated with climate change.

Higher growth rates of leaves and stems observed for plants grown under high concentrations may result in denser canopies with higher humidity that favour pathogens. Pathogen growth can be affected by higher concentrations resulting in greater fungal spore production.

Increased carbon dioxide levels will favour growth of competitive annual weeds more than it will favour plants in general. Higher temperatures and increased water availability, where the latter does not result in water-logging, will allow growth of many annuals. Perennial weeds will grow more quickly and most will flower earlier, if not controlled. Chemical weed control, with glyphosate in particular, will be less effective in hot, dry conditions.

How Will This Affect Farmers?

Most likely there will be an overall increase in the number of outbreaks of a wider variety of insects and pathogens. For farmers in the riverain areas and coastal Guyana:

- The possible increased use of fungicides and insecticides resulting from an increase in pest outbreaks will likely have negative environmental and economic impacts for agriculture.
- The best economic strategy for farmers to follow is to use integrated pest management practices to closely monitor insect and disease occurrence.
- Increased temperatures will likely mean higher populations of pathogens;
- More frequent and more intense rainfall events will tend to favour some types of pathogens over other.

Farmers would incur increased costs as a result of increased frequency of insecticide treatment and the accompanying negative environmental impacts would mount. Resistant varieties are the most effective method for control. Farmers' profitability could thus be impacted by the varieties they grow to combat a disease.

3.3 Policy and Legislative Assessment

The assessment notes that the challenges for the sector arise mainly from flooding during some periods of the year, water deficit at others, soil erosion, inundation, salinization, and other stresses posed by varied climatological conditions on crops and livestock. But it also notes that, given Guyana's competitive in arable lands and freshwater supplies, climate change can become a boon to the industry, with proper planning, and the implementation of adaptive techniques, and diversifying the agricultural based. To ensure that the country takes full advantage of the opportunities presented, it will become critical that an appropriate policy environment exist and that

The assessment of the existing laws governing the agricultural sector found that while generally, statutory powers are established in existing legislation to respond to the potential or likely effects of climate change, there are some gaps and weaknesses that need to be addressed in order to make them more responsive and to position the sector to respond appropriately.

Some of the legislation is generally too outdated to offer any significant influence and require amending. This is reflected vividly in the inadequacy of fines and penalties legislation, the lack of coordination among agencies, inadequate institutional arrangements, the absence of modern day principles such as the precautionary principle and reliance upon alternative enforcement and compliance methods. More importantly, the legislative process has not kept pace by passing the required implementing legislation. And in the isolated circumstances where regulations were made, they have become rigid and inflexible and their application to the issues presented by sea level rise and climate change is generally inadequate.

3.4 Institutional Assessment

The Ministry of Agriculture (MoA) has a two-fold strategy to address climate change: *policy intervention*, related to the reactivation of the multi-stakeholder National Climate Committee (NCC) and the establishment of the National Climate Unit (NCU), and; *other interventions* related to research, data collection, infrastructure improvement and incorporation of climate issues into sector plans.

However, many institutions that support agricultural development in Guyana operate with a *limited human resource base*, especially at the professional level, and would therefore seem to be constrained by this resource to effectively support implementation of a strategy for climate change adaptation within the sector. The main constraint factors hindering human resource capacity to support climate change adaptation include:

1. *Poor salaries*
2. *Scarcity of personnel with the requisite skills and qualification*
3. *Improper physical facilities and insufficient technical resources to support staff*

Encouragingly, the majority of agencies (76%) are highly aware of the likely impacts of climate change on the agriculture sector. Agencies' level of awareness of climate change is determined by their access to information. Agencies that have a high awareness of climate change have access to information, from both local and international agencies, such as the Hydrometeorolgical Department (HD) and World Meteorological Organization (WMO), respectively.

However, the policy capacity within agencies to address climate change issues is tangential as there are vague or no provisions in the mandates of agencies directly related to climate change adaptation. However, semi-autonomous agencies do have flexibility to incorporate climate change into their mandate due to the fact that:

1. *The institutions' mandate has an open-ended objective.*
2. *The institution may be research-oriented or academic organization.*
3. *The institutions' mandate relates to the management of the country's natural resources and the maintenance of infrastructure.*
4. *The institutions' mandate relates to environmental/disaster management.*

At the sectoral (and national) level policy and legal capacity to address climate change is also tangential as current laws/policies governing the agriculture sector do not directly address climate change.

Most entities are operating with information systems that are antiquated, non-functional or insufficient, making it difficult for them to perform at a high level of efficiency. Additionally, financial resources remain a major bug-bear.

Lastly, there is little or no formal mechanism in place for information sharing nor one centralized clearinghouse facility of important climatological information and data. This can often lead to significant delays and increased transaction costs.

3.5 Summary

With the true extent, magnitude and impact of climate change on agricultural systems still not fully understood, innovations today so that farmers can better avoid risk today will stand them in good stead for the uncertain tomorrow.

Most adaptation options are not discrete technical measures likely to be undertaken specifically with respect to climate change. Rather, they are modifications to on-going farm practices and public level policies with respect not only to climate change but also to climatic other political, economic and social conditions. Agricultural decision-making with respect to adaptation to climate change is not likely to be considered as separate from other agricultural decisions. Nor is agricultural adaptation likely to be considered as independent of non-climatic stimuli (such as

economic conditions, institutional arrangements, social norms and politics). At both the producer (farm) and government levels, decisions are made continuously, in an on-going, 'incremental' fashion, in light of multiple stimuli and conditions.

4. OVERARCHING RECOMMENDATIONS

4.1 Improved Competitiveness of the Agricultural Sector

Entities that are pursuing environmental-related investments or are operating in this area find that today as a requirement is the need for the entity's environmental, health and safety, and social standards to be documented and management systems clearly specified. These provide buyers, and potential buyers alike, with the confidence that the product was produced via a sustainable operation. For the producers, they improve competitive agility in dynamic markets. As such, any adaptation strategy must be cognizant of these realities. Necessary actions therefore are:

- Increased agricultural investment in drainage and irrigation schemes, farm to market roads and sea defences to maintain current agricultural lands as well as with a view to bringing new lands under cultivation.
- Continued increases in production costs, especially in energy-related costs due to increased pumping to rid the land of excess water or to access irrigation water, can restrain production response. Higher costs of fertilizers, fuel and seeds could cause farmers without ready access to credit to plant less than they otherwise would have or shift to crops requiring less. Designate drainage and irrigation canals public goods so that their operational costs are borne by the entire society rather than the farmers alone. At the same time, the water pricing regime needs to be re-examined and, if possible, be adjusted to demonstrate the value of the resource.
- With climate change threatening the globe it will become necessary to bring additional croplands under cultivation. However, before this is done it is necessary that a comprehensive national land use plan be prepared and feasibility studies conducted.
- A necessary condition for increasing agricultural supplies is to improve the technology with which farmers are asked to work. In this regard, it will be necessary to ascertain, *inter alia*, crop rainfall threshold for various cultivars and work with farmers to develop alternative crops. At the same time, many farmers in the country are dependent upon rain fed irrigation. As such, when the rains fail the crops suffer, resulting in reduced output and productivity levels. It is becoming increasing evident that alternative forms of irrigation systems are necessary, inclusive of drip irrigation. Such systems can also bring additional lands that are currently difficult to cultivate because of limited freshwater, such as the Intermediate Savannahs in Guyana, into the realm of cultivable lands.
- As discussed earlier in the economic review, the average age of a farmer in Guyana is above 40 years old. This has often meant that the transmission of new technical ideas is not always simple and straight-forward. Additionally, many farmers continue to utilise obsolete and outdated methods of production which, while they were acceptable for a lower population threshold, are now being challenged. Hence there is the need for improved management, through the adoption of newer and improved best practices. But these improvements can be facilitated via the dissemination of the newer findings by the research focused institutions. Additionally, it is imperative that the tertiary institutions be engaging in current and appropriate researches to assist this fledgling sector.
- The time is opportune for the research institutions to pursue more biotechnology options, especially of genetically modified seed for crops and for future research to be

focused more on yield-enhancing rather than cost-reducing innovation. To facilitate this, better agro-meteorological data is a prerequisite.

- Too often the discussion on promotion tends to centre around the so-called public awareness. But awareness that is not targeted and focussed tends to be less effective. As such, the Region has come to the juncture where it needs to pursue a vigorous public education programme about the benefits of agriculture and healthy living. These programmes must aim to change lifestyles and be targeted at specific catchment groups.

4.2 Diversification of the Sector

Agricultural exports from Guyana are centred on a few products. As a result, the economy is particularly vulnerable to external shocks, such, as declining terms of trade on agricultural products, or a catastrophic event like the global financial crisis. Nationally, given the country's vulnerability to natural disasters such as floods and droughts indicate the fragility of the sector nationally. With a significant number of rural households dependent upon these sectors directly and indirectly, it is imperative that an active diversification programme be pursued, seeking to identify those products or services in which the country may have a competitive advantage. In seeking to diversify the economic base of the country and reduce to agriculture sector to the vulnerability of climate change and extreme weather events the following actions can be pursued:

- The private sector should be encouraged through accompanying research and market studies to invest in non-traditional crops that may be endogenous to the country, while also focussing on the production of speciality foods and ethnic (nostalgic) markets. However, before these efforts are pursued, it will be necessary to conduct in-depth market researches and analyses. Additionally, it may become important to select specific products/crops to pursue investment opportunities, i.e., the idea of product chains.
- The agricultural sector needs to be supported by stronger market intelligence and processing facilities. Clearly, one factor that has militated against stronger processing capacity in the country is the cost of energy that is as high as US$0.39/kwh (IDB, 2006), with nearly 50% of this being taxes paid to government coffers. This would need to be re-examined with a view to bringing the cost of energy down.
- Other measures of a public good nature that will be necessary and to build upon those initiatives already occurring in some areas are training and knowledge sharing aimed at small groups of farmers and quality improvement programmes that will enhance food quality by introducing Hazard Analysis and Critical Control Point (HACCP) and quality assurance protocols. Here the efforts being undertaken by CARICOM Regional Organisation for Standards and Quality (CROSQ), Caribbean Food and Nutrition Institute (CFNI), and the Guyana National Bureau of Standards (GNBS).
- The following agricultural support services to agricultural producers or exporters will become necessary. While, as discussed earlier there is some existing capacity in some of the national institutions, it remains very limited given the high rates of migration experienced in the country and the declining interest shown in agricultural by the younger population. These supporting services should include extension, marketing, financial services, planning, research, and related strategic information. Examples of interventions in each of these areas are the following: (i) Extension: on-farm demonstrations (e.g., irrigation, chemicals use), on-farm training (e.g., post-harvest handling, packaging); analytical services (e.g., soils, entomology, and pathology analysis); other training such as strategic international trade, cold chain, packaging and labels, logistics; implementation of good agricultural practices (GAP), good management practices (GMP), and traceability systems; (ii) Marketing: packaging and labelling design, marketing plans; (iii) Research:

adaptive research, product development (e.g., prototype development); (iv) Financial services: trade finance agreements among parties such as buyer/export credit, input supplier credit, and contract farming through alliances between large farmers/supermarket chains; (v) Information: Benchmarking analysis (e.g., local or international costs of production)

- The research entities such as CARDI, CARIRI and NARI should be facilitators in this process, receiving the technological information obtained as a result of the research and development partnerships, evaluate it, and disseminate the information to groups that could also adopt the same technology. These entities should implement a database with the information collected that will be made available to the public across the Region, using the FAO-Carib Net, SIDSNET or some other such electronic media. The rights for the technology acquired or licensed will belong to research institutions.
- Rehabilitate systems to improve the effectiveness of the animal health, plant health and food safety units of the Ministry of Agriculture, transforming such Units in an integrated system to protect domestic consumers from illnesses, and domestic production from disease and contamination while ensuring that the nation's exports meet international standards. This aspect of the Strategy should ensure that the system is established and strengthened to realise policy and regulations coordination.
- Research and technological develop needs to focus on the biophysical response of agricultural production to climate change. For example, the following questions need to be answered: (i) how and under what conditions will climate change increase and/or reduce production? and (ii) In affected areas, how difficult will it be for producers to shift to different crops, to adopt new cropping patterns, and to adjust production practices to the new environment?

4.3 Information Systems Management

Globally it has become firmly recognised that information sharing is critical for avoiding catastrophes, and destruction of lives and livelihoods. In Guyana this is even truer because of the vulnerability of the country to natural disasters, some of which are said to be occasioned by climate change. In this scenario therefore, the following actions are vital.

- The country has benefited and is expected to continue to benefit from the establishment of the CCCCC in Belize. Additionally, under the Regional Programme on Mainstreaming Adaptation to Climate Change, the country is benefiting from the erection of early warning systems to natural disasters. But such systems will need to be supported and maintained. In this regard, public involvement and education programmes are necessary. Additionally, it will be imperative that scholarships are offered to persons to pursue studies in meteorology, climatology, and other such disciplines to ensure that the human capacity is present within the region to support these systems. But early warning systems are not only necessary for climatological changes, but market intelligence as well.
- As one of the objectives of the Strategy is to substantially increase the sale revenue accruing to rural, farming and vulnerable households, it will be imperative to ensure that producers have access to information on new markets on a timely basis. Additionally, it is imperative that information pertaining to benefits derived is disseminated throughout the country through the electronic media, workshops, seminars, etc., and advising on how the pitfalls can be avoided. Through these efforts, one would expect other stakeholders to become engaged.
- Expand and educate farmers and Extension Officers nationally on the use of the FAO-Carib Net forum for the exchange of ideas, discussion of best practices and country experiences. But even this would not be sufficient since many small farmers in Guyana do

not have access to the Internet. In this vein therefore, there is the need to strengthen the extension services, as well as to establish information centres where farmers can be trained in the use of the Internet and have access to same.

4.4 Improved Coordination of Programmes

There is undoubtedly a significant amount of diverse initiatives being pursued nationally having varying degrees of impact on the agricultural sector. However, quite often there is the absence of an effective coordinating mechanism. It is therefore becoming increasingly clear that there is the continued development of national and regional initiatives that seek to link policies and programmes across sectors and advocacy to apprise governments as to the dimensions and impacts of climate change on the agricultural sector. However, there are still a number of critical issues to address.

- To enhance the coordinating mechanism for the pursuance of agricultural expansion through strengthening or resuscitating the Agricultural Development Unit of the CARICOM Secretariat
- Create a mechanism, whether via existing arrangements under other programmes or new arrangements, monitor, track and disseminate information related to agricultural production nationally and regionally
- Implement a regional development fund called for by President Jagan since 1993 that will focus on investing in rural areas and in initiatives to create opportunities for employment of rural youths and vulnerable groups. For example, this fund can also be used to ensure that re-tooling of those displaced by the new and emerging challenges are being addressed. Another purpose of this fund will be to assist the efforts of the NGOs in the region that are working with sectors and individuals that impact food and nutritional security.

4.5 Data Management

Adaptive techniques must be informed by the requisite information to determine, not only what is physically possible, but also what is economically feasible and socially acceptable. In this regard, therefore, it is necessary to improve data collection on coastal and interior morphology, sea level, wind and current and water quality, surface and groundwater. Rainfall and runoff data in the watersheds of the major river basins and the Conservancies would also be vital to capture and retain to allow for informed decisions to be made.

4.6 Water Management

One of Guyana's main challenges is how to deal with floods during periods of excessive rainfall, and water shortages during El Nino type events. Furthermore, floods come from two sources, sea defence breaches, likely to become more frequent with sea level rise, and heavy intensity rainfall. It will therefore be important to improve the monitoring and maintenance of the sea defence infrastructure, involving communities as 'rangers' in the monitoring process and also providing an environment where they can take some degree of ownership of these resources. Additionally, an activity programme of public awareness building should be pursued to inform communities about the importance of the mangrove forest and receive feedback from communities on what may be the best way to manage these resources.

To adapt to the challenges posed by high intensity rainfall, it may be opportune to empolder areas along Mahaica and Mahaicony rivers to reduce flooding, but the cost for this must be first

worked out to determine the feasibility of such actions. At the same time it may become necessary to construct more sluices at higher drainage capacities, with supplementary pumping to assist at high tides. But there may be opportunities here as well for Guyana to commence thinking about developing freshwater farms, given that water scarcity globally is fast increasing.

In responding to water shortages and water quality issues the following is recommended:

- Pursue best farm management practices which have improved water use efficiency. For example, conserving available water on the farm (dugouts, stock water dams, reservoirs), and implementing cutting edge technologies in irrigation efficiencies, or implementing farming practices which cope with lower soil moisture.

- The socio-economic aspects of farmers adoption of best management practices (BMPs) is an important issue which needs to be researched to address how and why people change and adapt, before the adoption of such BMPs can take place to any successful and wide ranging extent. For example, if commodity prices are low, adoption of BMPs may not be as swift. One means of showcasing BMPs would be the establishment of public funded demonstration farms to research and demonstrate cutting edge technologies in water conservation and management.

- Better understanding of the groundwater resources available in terms of the spatial extent and quantity would increase the resilience of farms to water shortages, by putting in wells to tap into the resource.

There are also a number of cross-cutting issues that require urgent attention if the agricultural sector in Guyana is to respond appropriately to climate change impacts. These include:

- The need for models to be downscaled from a global to a watershed or regional level, which would enable more accurate decisions to be made with regards to managing water resources in light of climate change. These models can provide key input into decision making, as such, there is a need to address the lack of access to real time hydrological, hydrogeological, and climate information for decision-makers.

- Accurate pricing strategies were deemed necessary to be put in place so that the real cost of adaptations are accounted for.

4.7 Government Programmes and Insurance

Some adaptation measures will be undertaken as the need arises e.g. with greater intensity of floods there can be more and wider sluices installed, access dams raised, canals can be deepened or dug, and key rivers (e.g. Mahaica, Mahaicony, Abary and possibly the Pomeroon) dredged. The NDIA should ensure that there is the continued rehabilitation and maintenance of drainage and irrigation systems. The VCA cited rehabilitation as one of the deterrents to rice production in MARDS, and also recommended that canals be dug (GuySuCo, 2007).

Long-term strategies include shoring up the concrete sea defence as well as the rip rap system. Mangroves are also a part of our coastal defence; hence policies (and possibly laws) need to be implemented to ensure the re-planting and protection of the mangrove areas. This is critical especially in the Essequibo Islands where other forms of sea defence are poor or non-existent.

However, by far the greatest strategy would be the establishment of a National Climate Change Research Fund so that persons engaged in a wide cross section of activities relevant to climate change can tap into this fund. Greater collaborative research must occur between the public and private institutions. In this way there will be a pool of local, current and relevant information that can be used by policy makers to make the most informed decisions.

In addition, there is need for flood control and disease surveillance systems. Tighter border control will be needed to restrict movement of plants, animals and their products into the country. This is necessary due to increasing human migration may well be the source of new pests and diseases entering Guyana.

However, the effectiveness of these efforts can seriously be constrained by lack of basic information, observation and monitoring systems, lack of capacity building and appropriate political, institutional and technological frameworks.

Crop insurance is also another option available to reduce the risk to farmers. However, there will be the need for long-term reliable data for the productivity of staple crops or of crop failure. In the absence of these data, it is difficult to design appropriate insurance instruments.

An emergency fund should be established from which farmers can access resources in times of emergency. Farmers should be required to contribute to the fund. This can be similar to the fund for fisher folks established by the Ministry of Agriculture in 2008[2].

4.8 Technological Development

Medium term adaptation measures include crop and animal improvement (breeding/biotechnology) to ensure that crops, pasture and livestock species are better adapted to the changing climate. Concerted efforts by both GRDB and GuySuCo will have to be made to ensure crop cultivars are adapted to perceived changes in climate. Plant breeding is a lengthy process, but remains a cost-effective way of getting stress-tolerant materials into the hands of farmers.

Farmers will have to make greater use of the internet to access information. Once persons can source and process accurate information they will become knowledgeable about the emerging issues in climate change and will be better able to adapt appropriate measures to mitigate any adverse effects.

4.9 Farm Production Practices

The Hydrometeorological Division will have to improve its weather predictions so that farmers can better plan all field activities. Weather predictions over days or weeks have relevance to the timing of operations such as planting, spraying or harvesting. Seasonal forecasts, such as estimates of the likelihood of conditions associated with ENSO phenomena, have the potential to aid risk assessment and production decisions over several months

4.10 Farm Financial Management

Diversification is a valid risk avoidance strategy already used by many farmers, which certainly puts them in a better position to cope with climate change. In fact, it is a common practice for

[2] Fund is to compensate (partially) the fisher folks who have suffered from piracy

small farmers to be engaged in a mixed cropping system or a system with both crops and livestock.

One problem associated with many of these risk avoidance strategies is that they generally aim to lower the exposure to risk, but in so doing limit potential and have considerable opportunity costs. They often tend to hinder the efforts of small farmers to break out of poverty (Jarvis et al, 2006).

4.11 Enhance the Policy Environment

Some of the legislation is generally too outdated to offer any significant influence and require amending. This is reflected vividly in the inadequacy of fines and penalties legislation, the lack of coordination among agencies, inadequate institutional arrangements, the absence of modern day principles such as the precautionary principle and reliance upon alternative enforcement and compliance methods. More importantly, the legislative process has not kept pace by passing the required implementing legislation. In the isolated circumstances where regulations were made, they have become rigid and inflexible and their application to the issues presented by sea level rise and climate change is generally inadequate. Thus, the following interventions are recommended:

- Primarily because the impacts of climate change are cross-cutting in nature, the preparation of comprehensive climate change legislation might not be an obvious priority for Guyana. Given Guyana's early stage of economic development and its difficulty in implementing extensive legislation which are already in place, a comprehensive review of the relevant legislation to fill the existing gaps for effective monitoring, implementation and enforcement is recommended. Priority should be given to the *Town & Country Planning Act, Environmental Protection Act, State Lands Act, and the Sea Defences Act* as the principal legislative instruments to provide adequate preventative responses to climate change. Provision should therefore be established for regulating marine and sand mining, the development of coastal protection works, the establishment of a regime of port management, establishment of a regime for the protection of special areas including wetlands and mangrove protection and with particular reference to administration of lands, and the establishment of procedures and safeguards for effects of the legislation on private property interests in the coastal areas.
- Conservation-oriented legislation should also be reviewed to ensure consistency with the national climate change policy.
- Enforcement of national legislation is generally weak in Guyana. In addition the existing fines and penalties are extremely low and do not serve as a deterrent to the commission of offences. Any legislative review should establish adequate fines and penalties.
- Limited zoning by-laws or building codes exist in Guyana and generally building applications are determined on their own merits. Construction and design standards should be developed for agricultural infrastructure.
- The existing EP Act should be amended to expressly include provision for the consideration of climate change impacts as among the considerations that should be taken into account in the preparation of EIA's for agricultural based projects.
- Efforts should be taken to resuscitate the Integrated Coastal Zome Management (ICZM) Committee and update and implement the ICZM Action Plan.

4.12 Institutional Enhancement

Several changes are needed for the agriculture sector to develop the adaptive capacity to respond to the impacts of climate change. These relate to:

- *Human resources policy review* - Human resource policies need to be comprehensively reviewed to include provisions for skills development through regular training on climate change. Further, policies related to job recruitment in lead agencies (e.g. HD) should be reviewed to revise employee compensation packages for key positions that remain vacant.
- *Development of public awareness programme-* Awareness programmes must be designed to increase the knowledge of all stakeholders in the industry. The capacity of extension services can be developed to provide such training to farmers along the coastal regions. Further, such programmes can be integrated into the EPA's NEPAS programme.
- *Medium term systemic policy review/reform* - The policy framework needs to be reviewed at the sectoral level and amendments made to guide agencies in addressing climate change issues.
- *Institutional policy review-* Sector plans need to be reviewed to include mechanisms that relate to climate change adaptation for the issue to be accorded greater policy priority.
- *Human resources development programmes-* Training programmes need to be conducted to build staff awareness of climate change and its implications for the agriculture sector. Training should focus largely on training trainers, that is, training staff at the supervisory level that can more effectively disseminate knowledge within the institution.
- *Upgrade of institutional arrangement* - Authorized staffing structures should be amended to incorporate specialists with training in climate change.
- *Mobilize additional resources-* Additional financial resources should be mobilized from developed countries and donor agencies to support resolving key capacity constraints.
- *Development of data management mechanism and central repository-* A mechanism should be established within agencies to enhance data management. The system should act as the main repository and point of dissemination of information within agencies. At the systemic level, a central repository should also be created, utilizing existing capacities, to manage and disseminate information on climate change.
- *Policy changes to address inter- agency collaboration for climate change adaptation-* Addressing inter-agency collaboration from a policy perspective is one means of realizing its effectiveness for climate change adaptation.
- *Prioritise constraints in terms of urgent and immediate need for building adaptive capacity*-Given resource constraints, endogenous capacity constraints should be prioritised and addressed with regards to urgent and immediate needs for adaptation.
- *Implement the recommendations and strategy options of other capacity assessment studies*-Lead agencies should implement the recommendations related to climate change adaptation that have emerged out of major policy studies. This would seek to ensure that the institution is strengthened in every respect to support adaptation to climate change.

APPENDIX A. AN ECONOMIC REVIEW

1. INTRODUCTION

The agricultural sector has remained pivotal to Guyana's economic development. It continues to be an important contributor to the country's gross domestic product (GDP), is a major foreign exchange earner, employer of the domestic workforce and a significant foil in the fight against food insecurity, particularly for small-scale farmers in rural coastal and hinterland areas, and poor urban households. However, recent global events, inclusive of trade liberalization and climate change, are inducing changes in the sector in terms of agronomic practices, the way it organises and conducts business, and pursuance of adaptive technologies, if it is to remain competitive nationally, regionally and internationally. Before exploring the natural and market forces underlying much of these changes, Section 2 provides a necessary overview of the importance of the agricultural sector to the economic well-being of Guyanese.

1.2 Objectives

The main purpose of this review is to provide an understanding of the economic realities confronting Guyana and the roles played by the agricultural sector in the national, regional and local economies. The review, therefore, provides the context within which the assessments can be properly appreciated.

1.3 Methodology

A variety of methodological approaches were utilised in conducting this economic review. These included:

- A comprehensive content review of pertinent literature on the Guyanese economy;
- Structured interviews with heads of institutions to get a better understanding in relation to demand drivers and supply opportunities and constrains, as well as what programmes are being pursued to address the constraints;
- Feedback from the National Climate Committee and the National Stakeholders Workshop; and
- Statistical analyses to project the effects of climate change on the sector and by extension, the local and national economies.

1.4 Constraints

The main constraint encountered was the inability to acquire data at a sufficiently disaggregated level to make more pointed interventions. Nonetheless, the review is informed by a variety of data sources.

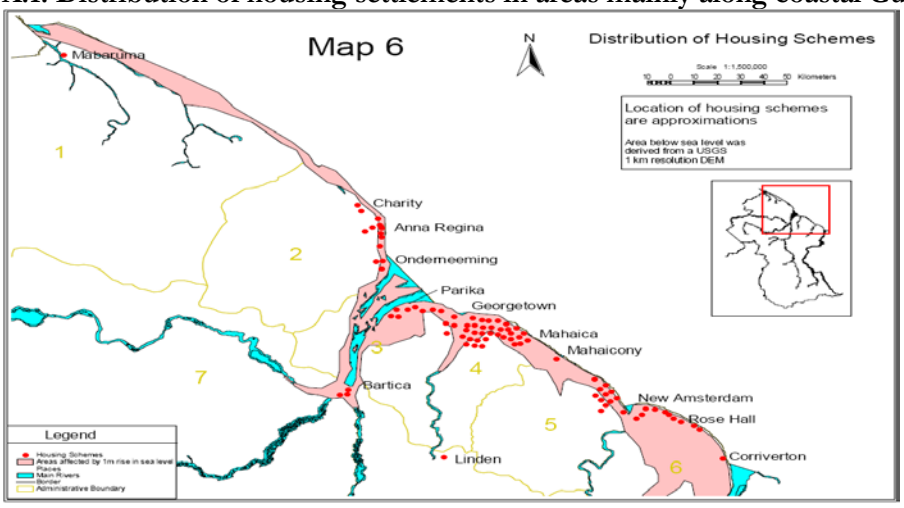
2. DESCRIPTION OF THE AGRICULTURAL SECTOR

Ever since political independence in 1966 the agricultural sector has been dominated by two main crops, i.e., sugarcane and rice. These two crops are primarily relics of Guyana's historical development, with sugarcane plantations being developed to support the plantocracy. With the abolition of slavery, the colonial powers were forced to import indentured labourers in the mid-1830s. For many indentured rice was their main staple, and so they began cultivating this crop, first on a subsistence basis, and later commercially. These two crops have well developed chains from production to marketing, with recent trade liberalization events likely to bring increased benefits, if concomitant challenges as well.

In recent times, the government has made a conscious effort to diversify the agricultural base, placing greater emphasis on non-traditional crops,[3] and the fisheries and forestry sub-sectors. Measures have included rehabilitating some drainage and irrigation schemes and sea defence structures, installing new drainage pumps, rehabilitating sections of the East Demerara Water Conservancy (EDWC) dam, developing a marketing database, and encouraging research in developing more adaptive plant and animal species to climatological changes. Many of these measures are being pursued based on Government's strategic vision for the sector, as well as responding to the challenges and opportunities presented by current global events, such as globalization of free trade, climate change, and the drive for food security.

With a mid-year population of approximately 766,183[4] inhabitants in 2008 occupying 21.5 million hectares, Guyana is a sparsely populated country by any standard. However, approximately 90% of this population occupies the narrow coastal strip (Map A.1) that is no more than 1.5 million hectares and is also the main area of commercial agriculture (Map A.2). This coastal area lies below the mean high tide mark and is prone to flooding from the Atlantic Ocean due to breaches in the seawall or over topping of the sea defences, as well as during the raining season, when most of the water from the elevated hilly sand and clay belt region (Map A.3) is released on the coastal plain, given that gravity flow is the main means utilised for draining excess water in the country.

Map A.1: Distribution of housing settlements in areas mainly along coastal Guyana

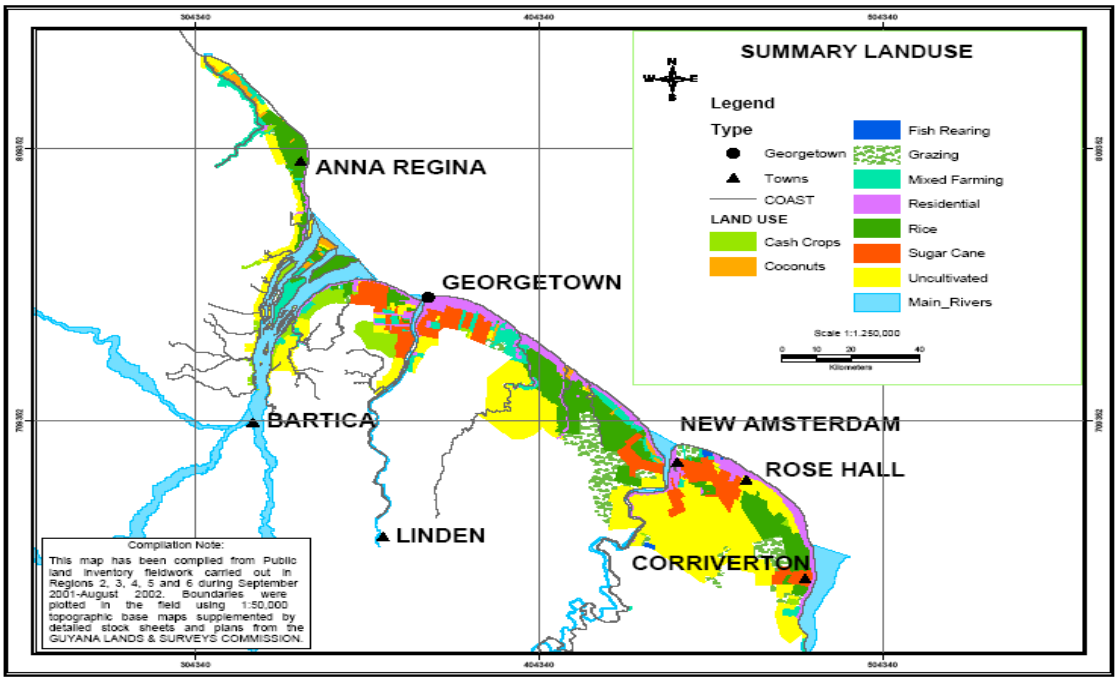


Source: Environmental Protection Agency (2002)

[3] These include all crops (fruits and vegetables) other than rice and sugar.

[4] Bureau of Statistic (2008). Statistical Bulletin (2008), Statistical Bureau, Georgetown.

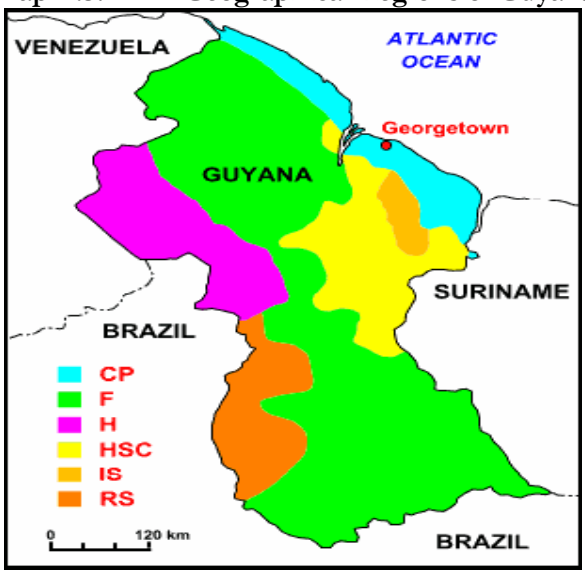
Map A.2: Summary of Land Use along the Coastal Plain



Source: Guyana Lands and Surveys Commission (2008)

The remaining population is scattered mainly in the hinterland areas (Map A.4), some of which are difficult to access and others which are themselves affected by floods during the rainy season.[5] Hinterland residents are engaged mainly in small-scale, subsistence type agriculture, mining, logging and/or serving as tour guides.

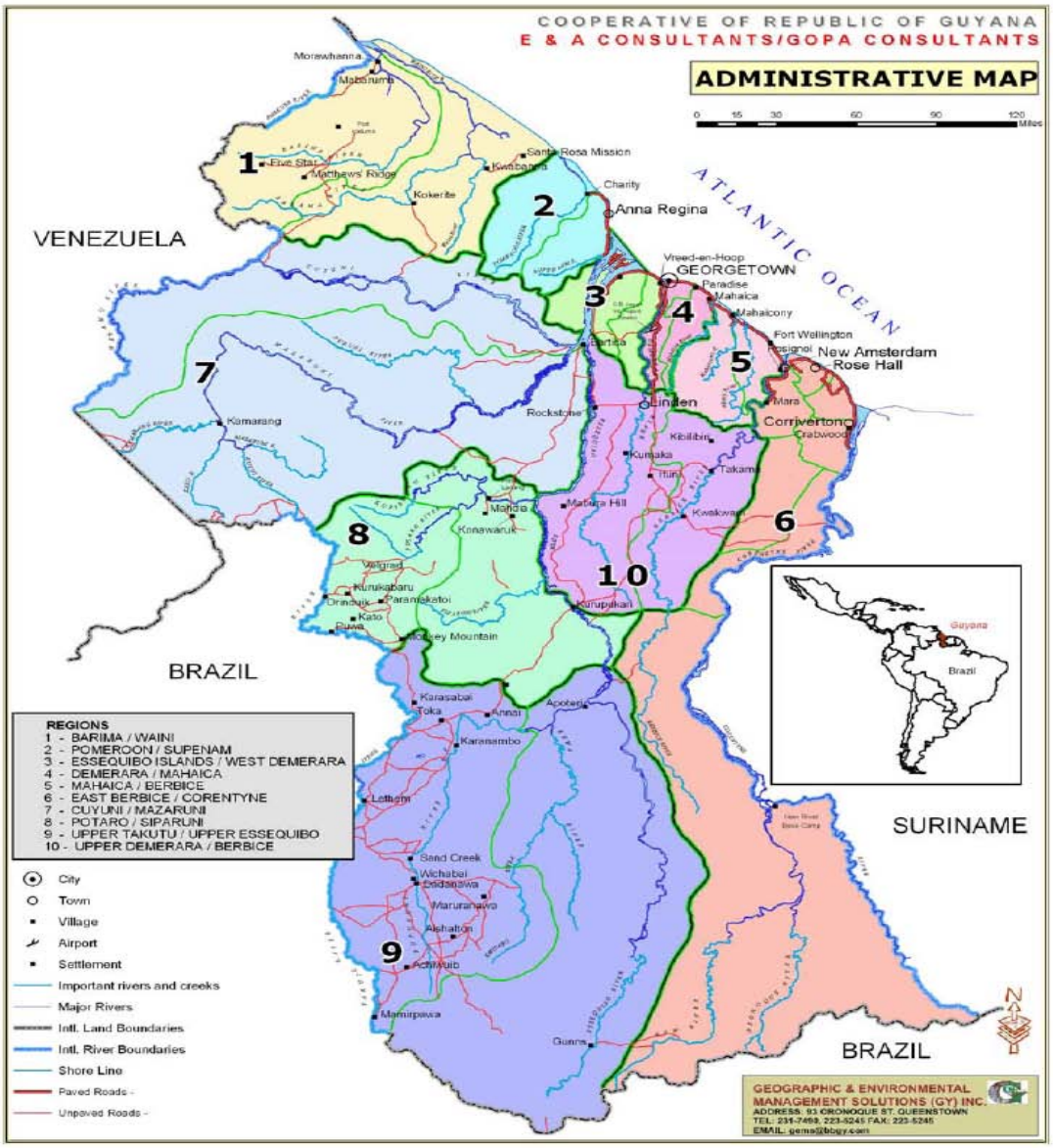
Map A.3: Geographical Regions of Guyana



Source: Ministry of Agriculture (2002) Guyana Initial National Communication, pp 34 (*CP – Coastal Plain, F – Forest Region, H – High Land Region, HSC – Hilly Sand and Clay Belt Region, IS – Intermediate Savannahs, RS – Rupununi Savannahs*)

[5] This is particularly a problem in the Rupununi Savannahs.

Map A.4: Map of Guyana Showing the Administrative Regions



Source: Geographic and Environmental Management Solutions Inc (GEMS), 2006

Guyana is one of the few remaining countries globally without major population pressure on its natural resources. More than 16 million hectares of the country is covered by tropical forests, many of which are not economically feasible to exploit with current levels of technology, about 1.2 million hectares are in permanent pastures, mainly in the Rupununi and Intermediate Savannahs (refer to Map A.1) and 500,000 hectares are suited for cultivation with current levels of technology (Table A.1). Guyana has about 25,000 farm households; some 90% are concentrated along the narrow coastal plain farming approximately 140,000 hectares along this plain.

Table A.1: Agricultural and Forested Land Use Patterns in Guyana

Land Suitability	Area ('000 hectares)	Percentage of Land Area
Arable Land	480	2.4
Permanent Crops	15	-
Permanent Pastures	1,230	6.2
Forest and Woodland	16,360	83.1
Other	1,600	8.3
Total Agricultural Land Use	**19,685**	**100**

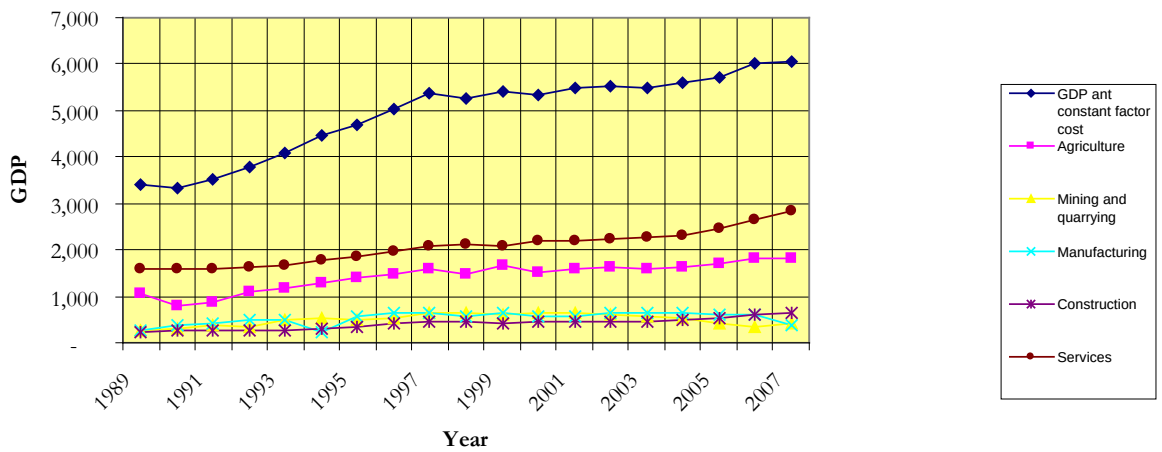
Source: Inter-American Institute for Cooperation in Agriculture (IICA) (1991) Guyana Agricultural Sector Assessment, Georgetown

2.1 Importance of the Agricultural Sector

Although the features of the agricultural sector are often envisaged as a sector dominated by poor rural households, most producing on lands from which they are barely able to eek out a living, their essence is more in function than form. The sector is more complex than this often trite description, with a number of complementary activities occurring to support a vibrant rural sector and supply food to an ever expanding urban industrial and service sector.

In the case of the Government of Guyana (GoG) then, the agricultural sector (inclusive of fisheries and forestry) remains one of the most important sectors in the economy in terms of its contribution to GDP (Figure 1) and employment creation. For example, between 2004 and 2007, the sector contributed approximately 35% annually of the country's GDP (inclusive of value added from the rice and sugar sub-sectors) (*Appendix A. 1*) and employed between 30-35% of the labour force (Bureau of Statistics, 2008). Furthermore, as Figure A.1 shows, the importance of the sector, with regard to value added has been trending upwards.

Figure 1:Value Added by Sector at Constant Prices (1988), 1989 - 2007



Source: Bank of Guyana (2008) Annual Report, Financial Statement of Accounts 2008, Table 9-II, and the Bureau of Statistics, Statistical Bulletin, September 2008, Table 10.2

While the sugar and rice sub-sectors, cultivated commercially exclusively along the coast, have remained dominant contributing a combined total of 14.6% of GDP in 2007, the fisheries sub-sector has also grown in importance in this regard.[6] Other important crops include: ground provisions, plantains, pineapples, citrus and coconuts. Despite Guyana's expansive forests, this

[6] Sugar and rice combined accounted for 47.2% of agriculture's GDP in 2007 and fish a further 22.7%.

sector accounts for less than 4% of overall GDP. Given that Guyana is a small open economy, most of the products from these sectors are exported. For example, in 2007, the sector accounted for nearly 40% of the country's export earnings (Bank of Guyana, 2008; Statistical Bureau, 2008).

But agriculture is more than an economic activity in Guyana, for many communities it is a way of life and an 'institution' around which social and cultural ties remain strong. For example, the Guyana Sugar Corporation (GuySuCo) alone reports employing approximately 18,500 persons directly at all levels, with most of these employees coming from the rural areas of Guyana where poverty is greatest.[7] Additionally, GuySuCo has been involved in providing a number of allied services, such as medical centres and primary health care services, provision and maintenance of community grounds and facilities, training to private cane farmers, maintenance of some rural infrastructure, and transport services (Shutt *et al*, 2007). Thus, any impact of climate change that may negatively affect this Corporation such as destruction of crops forcing the entity to down-size its operations, will also impact the quality of services it can offer, the quality of life in some communities, and a source of revenue for other social service schemes like the National Insurance Scheme (NIS). Similarly, the rice and fisheries sub-sectors employ an estimated 50,000 persons directly and indirectly, with most of those within the fish processing plants being women, many of whom are single parents. Hence the multipliers can be significant, should climate change affect the spawning and survival rates of shrimp.[8]

Lastly, the sector is a vital source for nutritious agricultural outputs in the fight against food insecurity in pockets of Guyana. While commercial agriculture remains an imperative for many households on the coast, small-scale agriculture is more central to the survival strategy of many rural households.[9] In particular, Amerindian communities remain heavily dependent on the sector to provide cassava, their main staple, which is then converted into various food items. In fact, even along the coast, it is quite common to find the embankment of rice fields being cultivated with vegetables, as rural families seek to bolster their incomes and diversify their production base, thus spreading their risks (Shutt *et al*, 2007).

As such, while the vast majority of agricultural activities take place on the coastal plain of Guyana, which is likely to be hardest hit from climatological changes unless appropriate actions are taken, it is a misnomer to think that this is the only area that is likely to be affected. In fact, the interior locations are likely to suffer even more severely from a sociological standpoint and these impacts need to be captured and studied in a comprehensive manner.

At the same time, it is imperative to note that coastal soils are fertile but extremely vulnerable to flooding due to their low-lying nature. As such, drainage and water control remain major challenges. Furthermore, agricultural development and expansion has always been tied to the defence against saltwater intrusion from the sea and rainwater runoff and is likely to continue with climate change.

In the main, crops and livestock production (with the exception of sugarcane) are characterized by the predominance of small farmers, farming less than 15 hectares of land (Mott MacDonald, 2004).[10] It is estimated that about 60% of these small holdings are geared toward rice production, with the remainder producing food crops. Many of these small farms combine their crop

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[7] See the Statistical Bureau's Living Condition and Marginality Indices (2007)

[8] FAO (2008) Climate Change and Food Security: A Framework Document, FAO/UN, Rome.

[9] Sustainable Agriculture and the Development of the Amerindians in Guyana: *The case of the Mabaruma/Hosororo Organic Cocoa Project*

[10] This survey was carried out for nine (9) drainage and irrigation areas under the Agricultural Services Support Programme (ASSP).

production with some cattle rearing. There are several large farms, however, that include private rice growers, some medium-and large-scale forest and fishing operations, and large public-sector enterprises. The most important parastatal is the GuySuCo.

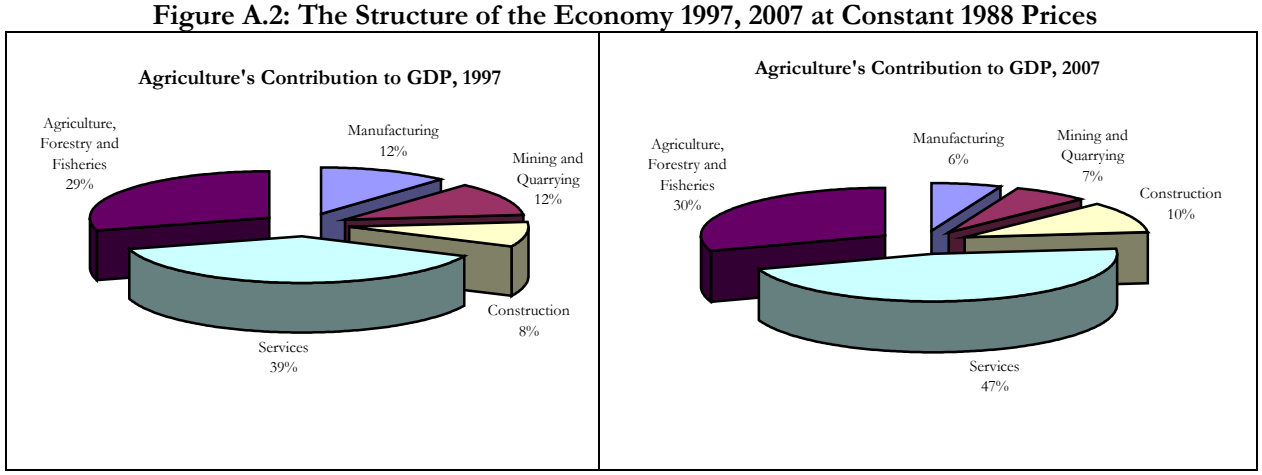
Growth in the agriculture sector has been highly volatile, alternating between periods of stagnation, pronounced declines, and rapid growth. Over the 1993-07 period, agricultural activities expanded at an average annual rate of 3%, compared with average GDP growth of 4.2%. Agricultural exports are dominated by traditional products, especially sugar and rice, which accounted for over 30% of Guyana's total merchandise exports in 2007. Exports of shrimp have gathered importance in recent years. Traditional agriculture faces major competitive challenges in the global market since it has been sustained largely by preferential access to the CARICOM and EU markets. Recently, the Government has been seeking to improve productivity in the traditional sectors while also promoting non-traditional crops. Greater attention and emphasis are being given to the cultivation of crops such as oil palm, coconuts, green vegetables, ground provisions, fruits, and flowers. The authorities report that while a significant amount of these products would be utilized locally, the greater proportion would be destined for the tourist resorts of the Caribbean, and the niche markets of North America and Europe.

Various projects emanating from the Food and Agriculture Organization (FAO) under the umbrella Regional Transformation Programme (RTP) have been designed to encourage increased diversification away from traditional crops. The RTP is designed to achieve international competitiveness and food security for the region and to redress the balance between food imports and exports.

2.2 Economic Policies and Sectoral Performance

The economy is primary resource-based with agriculture, mining, and forestry accounting for some 50% of GDP. In the last decade, the share of mining and sugar production has fallen, whereas services have grown to 47% of the GDP (Figure A.2). Private businesses are present in all sectors and contribute about two thirds to the economy. The private sector is composed of about 6-10 large groups, a few medium-sized companies and many small enterprises. The State is dominant in the sugar industry and the provision of public services, but there is also a large underground economy (Faal *et al*, 2002).

Figure A.2: The Structure of the Economy 1997, 2007 at Constant 1988 Prices



Source: Bank of Guyana (2008) Annual Report, Financial Statement of Accounts 2008, Table 9-II

Since 1989 the government has followed a liberalized, free-market model of development, with the private sector being touted as the main source of growth. Under this model, public

enterprises, such as, the Guyana Rice Board (GRB) were divested, foreign exchange regimes were liberalized making it easier for the farming sector to access resources for retooling and investment purposes, price controls were removed, import and export licenses were eased up, and the creation of an environment for investment. In the agricultural sector, some of the most important aspects of the economic reforms have been the managerial changes in GuySuCo and the liberalization of the rice market and the exchange rate regime.

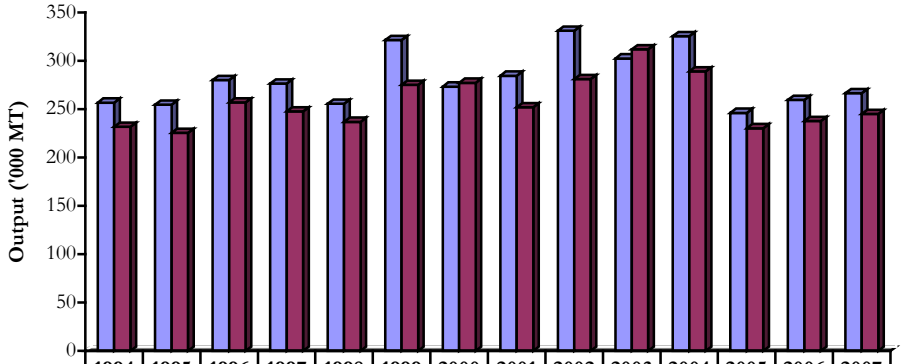
2.2.1 Main Crops

2.2.1.1 Sugar and Sugar-Derived Products

Sugar and sugar-derived-products accounted for 9.2% of Guyana's GDP and 30% of its agricultural GDP in 2007. The industry is the largest net earner of foreign exchange and the biggest contributor to public revenue; it employs directly 18,500 persons or 7% of Guyana's labour force (Bank of Guyana, 2008) and incurred a wage bill of US$74.5 million in 2006.[11] Additionally, the sub-sector employs another approximately 25,000 indirectly (Shutt *et al*, 2007). Within Guyana, sugar production has enormous spillover effects on the rest of the economy, for example, in retail and distribution and in maritime transport services.[12] Sugar cane is transported in small flat-bottomed steel barges, mostly by boats to eight factories in the Berbice and Demerara counties. From there, the sugar and molasses is transported by road or coaster to the port of Georgetown.

The sugar sub-sector is export-oriented. In 2007, exports accounted for almost 92% of production; the rest was consumed in the home market (Figure A.3). The main export markets are the in the European Union (EU), CARICOM countries, and the United States (US), all under some type of preferential scheme that has come under increasing pressure from globalization of free trade initiatives. Sugar exports totalled US$137 million in 2006 (Ministry of Finance, 2008). Exports of unrefined cane sugar are subject to a tax of G$1 per ton.

Figure A.3: Production and Exports of Sugar



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Production	256.7	254.5	280.1	276.4	255.5	321.4	273.3	284.5	331.1	302.4	325.3	246.1	259.5	266.5
Exports	231.7	225.4	257	247.6	236.9	275	277.2	252	281	311.8	289	230.3	237.7	244.9

Source: Bureau of Statistics (2008), Statistical Bulletin, Bureau of Statistics, Georgetown

[11] Guyana Sugar Corporation (2006) Business Plan, GuySuCo, Georgetown.
[12] Ministry of Agriculture (2006) Guyana National Action Plan for the Sugar Industry, Ministry of Agriculture, Georgetown

GuySuCo was created in 1976 by the Government's nationalization and merger of the sugar estates operated by Booker Sugar Estates Limited and Jessels Holdings. It now operates five sugar estates comprising 66,397 hectares, and runs eight factories (four in Demerara and four in the east of the country on the banks of the Berbice and Corentyne Rivers). GuySuCo is still the only producer of sugar, and exports all cane products other than rum. Although state-owned, GuySuCo has been managed since 1990 under a contract with the privately owned British company Booker-Tate. In 2003 the Government announced plans to introduce a new management contract, with an incentive structure that emphasizes profitability in a sustainable manner.[13] Under this private management contract the corporation has been able to increase yields per ha and tripled the output from the level it was in 1990. The yields have reached 75-80 MT/ha and the company is currently the most competitive in the region. However, the production costs have remained high and are above the global market prices (Table A.2).[14]

The sugar industry suffered a period of crisis in the late 1980s and early 1990s, with output dropping from some 395,000 tons in the early 1970s to about 130,000 tons by 1990. Since then, however, production has increased (Figure A.3). Production reached 331,057 tons in 2002, a 16.4% increase over 2001; and earnings from sugar exports reached US$119.5 million.[15] However, since that time the sector's performance has been sluggish. The authorities report that the target for 2010 is to produce 450,000 tons and reduce production costs to a level where Guyana's sugar can be competitive in the world market.

Guyana is a high-cost sugar producer compared with other countries. GuySuCo's estimated average cost of production over the last nine years is US$0.40/kg; this is higher than other producers in developing countries such as Brazil, Mauritius, India, and Fiji, but also above the costs of production in the United States.[16] Production costs are not evenly distributed across Guyana; they are higher in the Demerara estates (Wales, Uitvlugt, LBI, and Enmore) than in the other four estates (Skeldon, Albion, Rose Hall, and Blairmont).

Due to its relatively high costs, the industry has depended heavily on its preferential access to foreign markets. The ACP/EU Sugar Protocol[17], the EU Special Preferential Sugar Agreement[18], and the U.S. Sugar Programme all grant access to imports from Guyana at prices higher than world-market prices (Table A.2). Guyana's exports of sugar also benefit from duty-free access to CARICOM markets, where Most Favoured Nation (MFN) imports of sugar face a 40% tariff. In 2002, direct exports to the EU accounted for more than half of the volume and nearly two thirds of the value of Guyana's sugar exports (GuySuCo, 2008). The EU was responsible for another 11.9% (by volume) under the Special Preferential Sugar Agreement. Other major export markets, by volume, were CARICOM (21.2%), the United States (4.3%), and Haiti (2.7%) (Table A.3). Despite these special conditions, about one fifth of GuySuCo's output was not profitable and needed cross subsidization (within the company).[19]

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[13] Ministry of Finance (2003a), p. 24.
[14] World Bank (2003) Guyana Development Policy Review, World Bank, Washington.
[15] Ministry of Finance (2003a), pp. 7 and 9.
[16] NDS (2000).
[17] This protocol is being phased out and replaced by the Economic Partnership Agreement, which allows for duty free quota free access to the European market but void of the preferential prices. The phasing out of the SP is 2009.
[18] The conditions of the SPS agreement include a minimum delivered price to be paid by EU refiners, equivalent to approximately 85% of the ACP guaranteed price for raw sugar. The minimum delivered price is calculated by deducting 8.1 euros per 100kg from the ACP guaranteed price for raw sugar fixed under the ACP/EU Sugar Protocol.
[19] European Union (2005), Guyana Transport Sector Study, Working Paper #4, pp 18-19, Georgetown

Table A.2: Main indicators of the sugar industry, 1990-2007

Year	GuySuCo's Production costs (US cents/kg)	World Market Price (US cents/kg)	EU import price (US cents/kg)	U.S. import price (US cents/kg)	Brazil price (US cents/kg)
1990	..	27.72	58.19	51.15	35.07
1991	..	19.80	61.09	47.41	26.11
1992	..	20.02	62.66	46.86	24.46
1993	..	22.00	61.82	47.54	25.54
1994	..	26.62	62.04	48.47	28.91
1995	..	29.26	68.66	50.73	30.25
1996	..	26.40	68.53	49.19	28.82
1997	..	25.08	62.44	48.25	27.15
1998	..	19.58	59.69	48.53	22.81
1999	33.00	13.86	59.05	46.51	14.83
2000	34.32	18.04	55.35	42.68	17.49
2001	39.16	18.92	52.54	46.95	..
2002	36.10	15.18	50.60	39.60	17.6
2003	50.14	15.62	50.91	..	..
2004	45.43	15.84	51.74	..	..
2005	49.70	20.90	56.36	..	..
2006	46.82	19.80	54.96	..	..
2007	48.55	22.22	59.84	..	..

.. Not available.

Source: World Bank: Commodity Forecasts (various years), Guyana Sugar Corporation Business Plan (2006); Bank of Guyana, and information provided by the authorities.

The ACP/EU Sugar Protocol (SP), which took effect in 1975, is of particular importance for Guyana due to the large market share of its exports to the EU. The SP is a government-to-government agreement covering individual agreed quantities of cane sugar for each ACP party, as well as guaranteed prices. The SP has an 'indefinite duration', and is annexed to the Cotonou Agreement. Guyana's agreed quantity under the SP is 159,410 tons of white sugar equivalent or 167,000 tons per year. ACP guaranteed prices are negotiated annually between the EU and the ACP states signatory to the SP.[20]

Guyana has also, traditionally, benefited from the Special Preferential Sugar Agreement between the EU and ACP states, reached on 1 June 1995, initially for six years. Under the agreement, the EU undertook to open annually a special tariff quota for the importation of raw cane sugar for refining that originates in ACP states, on the basis of the needs determined by the European Commission. The conditions of the Special Preferential Sugar Agreement include a minimum delivered price to be paid by EU refiners, equivalent to approximately 85% of the ACP guaranteed price for raw sugar. Quantities are determined annually for each marketing year (July-June).

[20] Under the Sugar Protocol, guaranteed prices for the ACP white or raw sugar apply to bulk sugar cost, insurance and freight paid (c.i.f.) to European ports.

Table A.3: Breakdown of sugar exports by destination, 2000-

Destination	Quantity exported (tons)			Value exported (US$ million)			Unit value (G$/ton)		
	2000	2001	2002	2000	2001	2002	2000	2001	2002
EU SP Protocol	179,222	163,642	158,426	78.61	72.92	77.00	438.62	445.58	485.75
Special Preferential Sugar Agreement	31,757	31,912	33,720	11.93	12.08	14.24	375.57	378.39	422.41
United States	24,253	12,094	12,184	7.67	4.53	4.63	316.09	374.15	380.17
CARICOM	42,038	44,683	60,043	12.33	13.01	17.82	293.21	291.05	296.73
Total	277,270	252,331	282,659	110.53	102.52	116.29	398.63	406.29	411.41
					Share of total				
EU Protocol	64.6	64.9	56.1	71.1	71.1	66.2	110.0	109.7	118.1
Special Preferential Sugar Agreement	11.5	12.6	11.9	10.8	11.8	12.2	94.2	93.1	102.7
United States	8.7	4.8	4.3	6.9	4.4	3.9	79.3	92.1	92.4
CARICOM	15.2	17.7	21.2	11.2	12.7	15.4	73.6	71.6	72.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**-**	**-**	**-**

Source: Guyana Sugar Corporation and information supplied by the authorities.

The United States Department of Agriculture issues sugar quotas under the Tariff Rate Quota system on a country-by-country basis. Under this system, raw sugar is allowed to enter duty-free into the United States. Guyana's quota in 2002-03 was 12,636 tons raw value.

2.2.1.2 Rice

Rice has been trading places with the fisheries sector in terms of its importance to Guyana's economy in terms of export earnings. However, there are an estimated 30,000 farm families involved in rice cultivation and thousands more in milling, exporting, transportation, and other activities linked to the industry (Guyana Transport Sector Study, 2005)[21]. It is estimated that 20% of the population depend directly on the rice industry. In 2007 rice accounted for 4.2% of GDP that represented a 17.6% decline over the 2005 figure (*see Appendix A1*). Furthermore, the industry contributed approximately 10% of total exports.

Rice production fell dramatically during the 1980s, partly due to the effect of price controls, which discouraged production (*see Appendix A2*). The industry was also characterized then by strong government intervention and subsidies, and a low level of international competitiveness. During the 1990s, the rice industry showed major increases in the acreage harvested, and the quantity produced and exported (Table A.4). Much of this success is attributed to the removal of price controls, and the privatization of the milling and export industries. The authorities also credit an increase in drainage and irrigation activity after 1992, better marketing, the freeing up of foreign exchange controls, and improved land tenure. In 2007, Guyana produced 298,128 tons of rice, representing a 9.1% increase of the 2005 level, but a decline by 3% over the previous year's total of 307,037 MT. At the same time, exports value in current US dollar increased by 63% between 2005 and 2007 attributed mainly to rising commodity prices.[22]

The domestic market absorbs around 60,000 MT of rice equivalent. About a half of exports are of low priced semi-milled rice (cargo); white rice has a share of one third and the higher priced parboiled rice a share of only one eighth of total rice exports (in 2007)[23]. In the long-term, the share of parboiled rice might rise, though modestly, because it requires substantial investment in processing plants.

[21] The Study estimates that approximately 100,000 persons depend on the sector directly and indirectly.
[22] Trostle, Ronald (2008) *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices*, United States Department of Agriculture, Washington.
[23] US$232/ton for cargo rice, US$ 310 for white rice and US$ 415 for parboiled rice (in 2000, FOB), Agrotec SPA: Feasibility study of CARIFORUM Rice Industry. 2002, p.40

Productivity in the rice industry has improved considerably; per-hectare yield rose by 55% between 1975 and 2007 (Table A.4). These improvements, however, appear to have reached a plateau in recent years. Furthermore, while the volume of rice exports has been fairly steady, the prices obtained in foreign markets declined sharply until the later part of 2007 and 2008 due to global commodity shortages. Whether these prices will remain buoyant is a moot point, but they do seem to be encouraging persons who had abandoned lands, to return to paddy cultivation, as the venture has once again become feasible for some persons (*see* Figure A.4). Despite the spike in prices though, average yields still seem to be well below potential and are lower than those of other countries in the region.[24] Furthermore, low processing efficiency remains a major concern (World Bank, 2003).

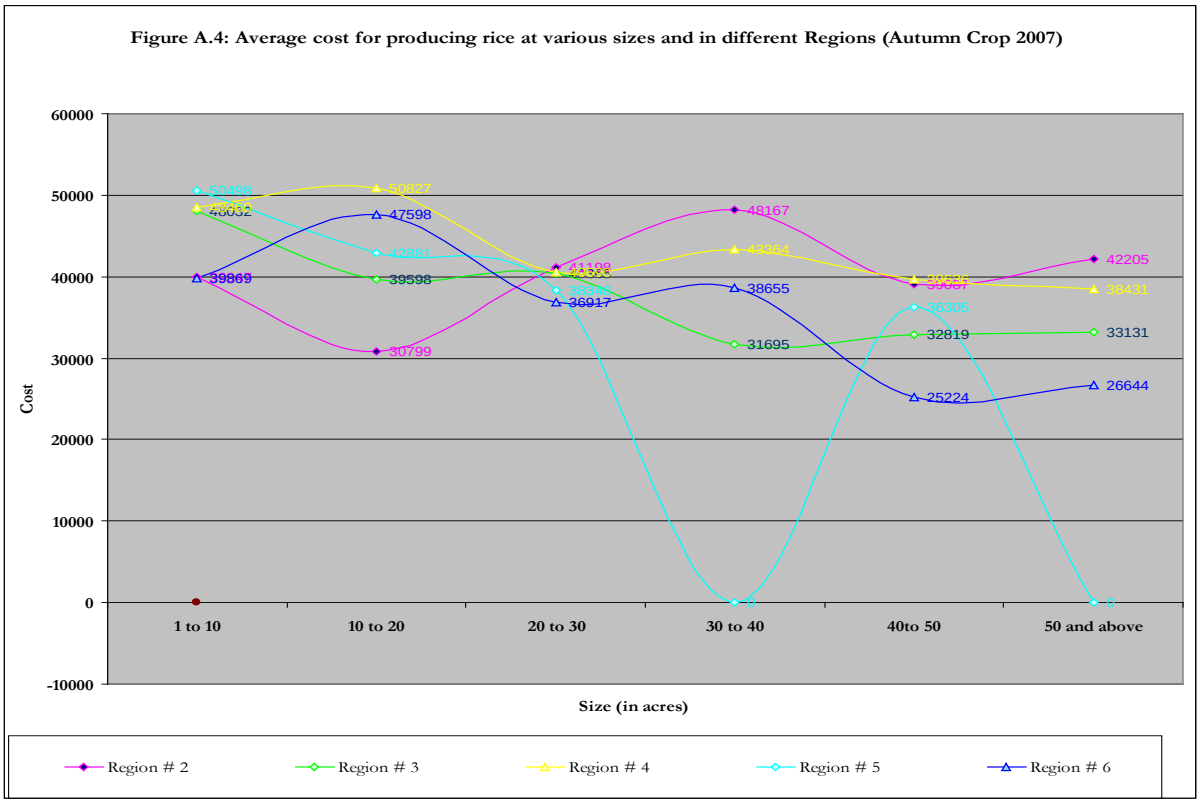
Table A.4: Rice statistics, 1975-2007

(year to year percentage change, unless otherwise specified)

	1975	1980	1985	1990	1995	2000	2005	2007
Acreage harvested	267,961	237,100	192,110	126,878	326,892	286,204	263,526	261,598
Yield per acre (ton)	1.11	1.19	1.35	1.23	1.61	1.57	1.6	1.7
Rice equivalent (ton)	172,259	169,107	156,124	93,444	315,301	291,967	273,238	298,128
Quantity exported (metric ton)	82,035	81,008	29,339	50,943	200,336	207,638	182,175	269,436
Value exported (G$ million)	84.9	87.5	56.6	513.2	10,242	51,790	90,498	146,725
Value exported (US$ million)	..	..	13.26	12.99	76.33	42.03	46.09	75.17

.. Not available.

Source: Adapted from Guyana Rice Development Board (2008), *Annual Report 2001*, Appendix I.



Source: Guyana Rice Development Board (2008)

[24] The yield in the Dominican Republic is 5.2ton/ha,while in Latin America it is above 6 ton/ha.

With an average yield of 4.19 MT/ha[25], the yields are lower than in competing countries in the region. Moreover, wages are reported to be some 4-5 times higher than in low-cost Asian countries[26]. However, given the hike in commodity prices, our estimates indicate that the average price received for paddy exports was US$324 in 2007 (Table A.5). Thus, rice production, which was at the edge of the profitability in the former years, has become profitable again (*see Farm budgets in Appendix A4*), but this should not gloss over the need to reduce field costs and improve productivity levels.

Rice exports are subject to fees of US$2.50 per ton for rice by-products, US$3 per ton for broken rice, and US$6 per ton for whole grain rice. The revenue from these export fees is devoted to funding the operations of the GRDB. Guyana has long enjoyed a preferential market in the EU via the Lomé Convention and more recently the Cotonou Agreement. Guyana has been successful in broadening its marketing base by increasing sales in the Caribbean and currently supplies 50% of the CARICOM market. As a result, virtually all of Guyana's rice exports go to these two markets, at prices above the world market. In 2007, over 59.3% of Guyana's rice exports went directly to the EU, with CARICOM countries imported the remainder.[27]

Table A.5: Estimated Milling Costs of Rice in Guyana in 2007

Category	Output Differentials		
Yield/ha	4	4.7	5.5
Equivalent cost US$/t paddy	90	75	64
Equivalent cost US$/t rice products	150	125	107
Milling Costs	180	172.5	165
Total costs US$/MT rice	330	297.5	272
Value of by-products	80	80	80
Cost of white rice (FOB)	250	217.5	192
Thai white rice (FOB)	**326.4**	**326.4**	**326.4**
Estimated profit margins (US$/MT of rice)	**76.4**	**108.9**	**134.4**

Source: Compiled from the Guyana Rice Development Board (2008) and World Bank Commodity Forecasts (2008)

The sub-sector has for a long time benefited from the preferential access to the EU market and is still protected within CARICOM by an external tariff. Exports to the EU account for some 100,000 MT annually (during 2001-03) and benefit from EU-prices which used to be some two-times higher than the average world market price. However, this preferential access will be phased out by the ending of 2008 and makes the future of the rice sector somewhat uncertain. Additionally, in 2003 the EU decided to reduce the internal (intervention) price for paddy rice by 50%. But there are efforts afoot to find alternative markets and to increase the value added from the sector.

However, the revenue of Guyanese exporters will decrease less, because the tariff has been reduced also from €88 to €8. Secondly, the EU-market prices will not fall immediately to the new intervention price, but will rather remain some where in between these prices. For example, the prices received by exporters in 2004 were below the EU prices, i.e., US$220 and US$320

[25] Guyana Rice Development Board (2008) Annual Report: 2007, GRDB, Georgetown
[26] The World Bank estimates this costs at US$ 340-400 per MT; World Bank: Guyana Development Policy Review, 2003, p.48.
[27] Calculated using raw data supplied by the Guyana Rice Development Board.

respectively[28], because importers were able to appropriate most of the difference between production costs and the EU-market prices. The lower export price will not decrease in the same proportion then the EU.

The EU established a support programme for 2004-10 to enhance the competitiveness of the rice industry in Guyana in view of the phasing out of the preferential access. This programme aims to enhance production, processing, logistics infrastructure and management functions. After the last decision on the reduction of EU (interventional) prices, additional measures to support the adjustment process are being studied.

The CARICOM market protects the rice trade by a 25% common external tariff. The exports are profitable. However, there are signs that the CARICOM countries are less and less willing to accept this regulation and simply do not always pay the custom on imported rice from outside the region.

In the future, some cost reduction can be achieved by improving the reliability of water supply and dispersal of drainage outflows, both areas projected to be significantly impacted by climate change.[29] According to a World Bank study completed in 2003, it was estimated that a substantial improvement in the sector's profitability would require an injection of between US$60 million and US$65 million for the rehabilitation of drainage and irrigation infrastructure, improvement of farm to market roads, and storage facilities.[30] Since that time, Government has embarked on a massive drainage and irrigation programme under the Agriculture Services Support Programme (ASSP), as well as under an EU-funded programme to support the sector. The need for these improvements was made even more urgent after the 2005 and 2006 rainy seasons, where poor drainage in some areas exacerbated the situation, resulting in substantial losses in the sector.

2.2.1.3 Livestock

Livestock production has remained sluggish (*see Figures A.5 & A.6*). Between 1998 and 2002 there was a significant upswing in the poultry industry. This led to the country being self sufficient in eggs and nearly 90% in poultry meat. [31] While the country is still able to meet much of its local demand, some of the companies that emerged at that time have since ceased operations for a variety of reasons. But at the same time, other smaller producers have been investing in the sector. The poultry industry comprises about 3,400 enterprises including about 500 pluck shops, four processing plants, 50 commercial farms, 3,000 small farmers, 12 hatcheries, 80 trucks, and four stock-feed factories. It employs some 5,000 people.

[28] ADE: Study into impact of changes in the EU'S rice regime on the rice sector of ACP countries Draft Report, 6 January 2005, Chapter: Main Findings, p.29
[29] Agrotec SPA: Feasibility study of CARIFORUM Rice Industry. 2002, p.65.
[30] World Bank :Guyana Development Policy Review, 2003, p.47
[31] Ministry of Fisheries, Crops and Livestock with Responsibilities for Forestry online information. Available at: http://www.sdnp.org.gy/minagri/moa_mfcl/mfcl/index.htm.

Figure A.5: Livetsock Producition Data, 1992 - 2007 ('000 MT)

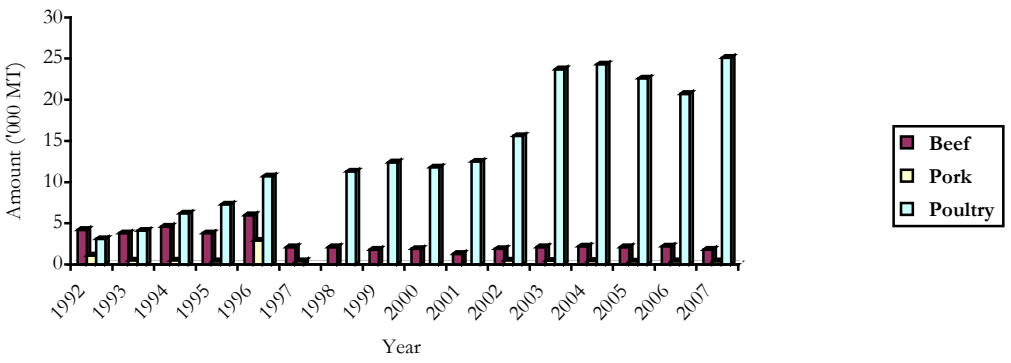
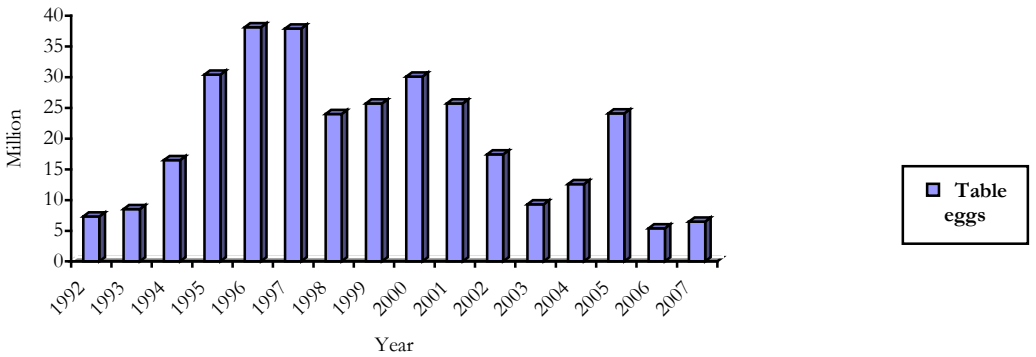


Figure A.6: Production of Table Eggs, 1992 - 2007 (million of eggs)



Livestock production in Guyana is currently oriented completely to the domestic market, which means that there is almost no export activity to serve as a signal that such export activity could be potentially profitable. Nevertheless, the cost of meat production in Guyana is low and Guyana has several advantages as a beef exporter including abundant land and water resources necessary for raising grass fed cattle, and having been certified Foot and Mouth Disease free since 2001. These characteristics position Guyana as one of the few players with the comparative advantage required to be a potential long-run player in the export of beef. But presently, beef is not exported from Guyana because of a number of constraints which include the need to implement appropriate animal health legislation, develop veterinary diagnostic facilities, establish an abattoir of international standards, utilize improved quality forage, introduce improved cattle breeds, promote improved husbandry techniques, and develop measures to tackle the problem of rustling.

The Ministry of Agriculture implemented a Livestock Development Programme in 2006 to promote efficiency in the rearing of poultry, cattle, swine, sheep, and goats. The aim is to increase production and productivity and attain self-sufficiency of livestock and livestock products. Furthermore, under a recently signed Agricultural Export Diversification Programme (AEDP), the government is providing substantial breeding material and technical assistance to farmers, with the aim of lifting sanitary and phytosanitary standards, improving the disease surveillance system, as well as pasturage for the beef/cattle industry.

As regards the poultry sector, Guyanese producers have concerns over the competitiveness of the industry *vis à vis* major producers in North America with increasing globalization. A regional study concluded that, on the basis of the importance of the broiler industry in CARICOM and given its vulnerability to low priced imports, a clear case exists for treating the industry as sensitive in a global trade context.[32] In this regard, imports already face relatively stringent market-access conditions since, in addition to the 100% tariff imposed on most chicken cuts, imports of poultry into Guyana require a sanitary permit.

2.2.1.4 Non-traditional and Processed Products

The non-traditional sector includes all components of the agricultural sector with the exception of rice, sugar, forestry and fishing. The National Development Strategy (NDS) conveniently identifies the major non-traditional crops as the following: Cereals and Legumes: corn, blackeye, mimic; Oilseeds: peanut and coconut; Ground Provisions: cassava, sweet potatoes, eddoes, yam, tania/dasheen, plantains; Vegetables and Greens: tomatoes, cabbage, pumpkin, bora, ochro, boulanger, squash, cucumber; Herbs, Spices and Seasonings: eschallot, hot pepper, ginger, tumeric; Fruits: banana, pineapple, pear, carambola and watermelon; Other Fruits: mangoes, genip, cherry, awara: Citrus: lime, grapefruit, orange: Other Crops: coffee, cocoa and cotton; pasture/forage, ornamentals and floriculture. The major producers in this sector are poor rural households, many depending directly on the sub-sector for their livelihood, while others are supplementing their income from the output produced in this sub-sector.

This sub-sector has been experiencing substantial growth of late (*see Appendix A5*) under government's 'Grow More Food' campaign, but also due to the increased emphasis placed on the sector and the assistance provided by the New Guyana Marketing Corporation (NGMC). As detailed later in this assessment, the fruits and vegetables supply chain has strong potential for growth. Guyana's non-traditional agricultural exports (mainly of vegetables and fruits) grew by 35% in value in 2007 over the 2005, accounting for just above 2% of total exports. In recent years non-agricultural products have increased both in terms of output and exports. As before, products with the most promising marketing opportunities include coconut base products, pineapple, pepper, plantain, pumpkin and passion fruit.

The Government has repeatedly espoused its plans to introduce sustainable cut-flower, honey, and integrated fish and crop farming industries.[33] At the same time, efforts have been made to exploit the organic niche markets for pineapple, sugar, cocoa, peanuts, cashew nuts and heart of palm. In this respect, a peanut production programme has been put in place with the aim of improving the volume and quality of the product to suit local and overseas markets. Organic farming programmes have been started, with the rehabilitation of 45.5 hectares of cocoa plantations, and an export target of 22,727 kilograms per year, mainly to Europe. Also, the company processing heart of palm in Guyana, has secured certification for its operations and is now seeking to extend this into the area of pine apple cultivation. Its pineapple operations are mainly done with indigenous communities in the Mainstay/Whyaka area of Region 2.

Exports of non-traditional agricultural products may be facilitated as a result of effective fruit-fly trapping programmes. In early 2003, the United States began to permit the importation into Miami of cucumbers, peppers, eggplant, and pumpkins from Guyana and Guyana has benefitted ever since.

[32] Singh et al. (2001), p. xi.
[33] Ministry of Finance (2002a), p. 27.

2.2.1.5 Fisheries

Fisheries in 2001 accounted for some 3% of GDP, but grew to some 7% by 2006. Exports have been rivalling the rice sector as the second most important agricultural export sub-sector (see *Appendix A1*). Exports from the sector have consistently surpassed US$50 million since 2004, with shrimp being the main export from the industry. Exports of shrimp faced a 10% export duty, but this has been waived by the Ministry of Finance since 1997; exports of aquarium fish are subject to a 5% levy. Imports of fish and fish products face a relatively high average tariff rate of 27.7%, ranging up to 40%.

Guyana's fishing fleet consists of around 120 trawlers based in Port Georgetown; they exploit the waters in the continental shelf. Their main objective is the smaller shrimp and fin fish that are found in depths of 13 to 30 metres. Another 65 ships are based in Guyana but are foreign-owned, and fish for larger prawns at depths of 25 to 90 metres. Guyana also has a fleet of some 1,200 artisanal boats that fish in river mouths, and near the shore at shallow depths and are an important source of employment in these rural areas.[34]

The Ministry of Agriculture is responsible for policies in the fisheries sector. A Fisheries Advisory Committee has been established to advise the Minister on matters affecting the industry. The authorities have noted that research and development (R&D) subsidies are provided to the industry, but that no direct support is granted.

The Fisheries Act No. 12 of 2002, which replaced the Fisheries Act, 1957 (Cap. 71:08) regulates fisheries in Guyana. It provides for the registry of fishing boats with the Chief Agricultural Officer, the inspection of vessels, and the licensing of fishing operations, both domestic and foreign. Foreign fishing vessels may be granted licenses if they are locally based, or if they engage in test fishing, unless there is a fishing agreement with the flag country.

The Maritime Boundaries Act, 1977 (Cap. 100:01) establishes a territorial sea of 19.2 kilometre and a fishery zone that extends 320 kilometre out from the baseline of the territorial sea. Foreign ships, other than warships, enjoy the right of innocent passage through the territorial sea. The law also gives the President the authority to designate an exclusive economic zone in an area beyond and adjacent to the territorial sea. Research and other activities can be conducted in such a zone with a licence from the Government of Guyana. The law declares Guyana's full and exclusive sovereign rights over the seabed and subsoil resources of the continental shelf, while also providing for the licensing of operations by domestic or foreign persons.

Some aquaculture projects have been developed in recent years and the cultivated acreage has risen from 1.01 hectares in 1997 to over 1,619.4 hectares in 2006. A freshwater aquaculture demonstration farm and training centre has been set up at Mon Repos, East Coast Demerara, to promote freshwater aquaculture development by providing on-site training of farmers. The project is funded by the Canadian Development Agency (CIDA), Food and Agricultural Organization (FAO), and the Government of Guyana.

Commercial aquaculture is one of the most promising economic activities in Guyana with high potential for rapid export and job creation growth. Aquaculture also has great potential for improvements in food security status of rural communities, especially as other farming systems (in particular rice) can be adapted to incorporate aquaculture production, thereby increasing production endowments.

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[34] *Guyana Review* "Fishing in Troubled Waters," Volume 10, No. 116, August 2002.

At present aquaculture is a nascent sub-sector in the initial stages of development, though with potential for strong growth. It is estimated that some 2,000 hectares are cultivated. This land area produced a production value of US$1.2 million in 2006, experiencing average annual growth of 14.4% since 1995.

However, in the wider context of regional production, Guyana's output is still low and made up only 0.02% of the total production of Latin American and Caribbean Countries in 2006. There are a number of pioneer investors operating in the sub-sector. Of these *New Line Aqua Farm*, based in the West Demerara Zone is the most advanced, and has been the only company to begin small scale exports in 2006.

There have been several important developments for aquaculture in recent years:

Mon Repos Aquaculture Station: In June 2001, Mon Repos Freshwater Aquaculture Demonstration Farm and Training Centre were commissioned. These facilities main functions are to conduct basic adaptive research, provide training to farmers and to supply seed-stock for the emerging aquaculture sub-sector.

Introduction of Suitable Species: In 1999, the Jamaican Red Tilapia was officially introduced into Guyana as a viable species for commercial rearing. Also, at this time, a re-introduction of the Nile Tilapia was made, since the existing stock had deteriorated. The Giant Malaysian Freshwater Prawn, *Macrobrachium rosenbergii*, was introduced for experimental rearing, which proved successful. Efforts are being made to establish a commercial hatchery for this species. More recently, in 2003, *Colossoma macropomum* was introduced from Brazil, also for experimental rearing.

New Fisheries Act: The Government of Guyana has recently prepared a new Draft Fisheries Act, a part of which has already been presented in Parliament. The additional parts, which contain among other things the Draft Aquaculture Bill, will be presented in Parliament shortly.

Food and Agriculture Organization: The FAO has recently completed a successful project in Region 6 to introduce Aquaculture and Integrated Pest Management practices to rice farmers, where fish are introduced to rice fields in order to replace pesticides. This allows Rice farmers to diversify production for increased income and improved nutrition.

Tilapia is one of Guyana's native aquaculture products with the best market opportunities due to a number of key factors including climatic suitability, high productivity, hardiness, high growth rates, disease resistance and market accessibility. Estimates of local pioneer investors have shown that Tilapia production can be a very profitable operation; estimates indicate that net revenue per hectare in the sector is approximately US$8,398 which is considerably higher than the margins for producing rice in Guyana that amount to between US$198 – US$295 per hectare currently. Estimates for Export Price of fish indicate a figure of US$6.05 per kilogram, which would increase estimated gross revenue to over US$40,000. However, it should be noted that while aquaculture production for the local market yields much higher absolute returns, net margins can be higher on some high yielding and large rice farms.

Infrastructure developed for rice production can be easily adapted for Commercial Aquaculture. The cost per hectare of converting an existing rice field to aquaculture is estimated at US$3,300. This is compared to the development of a "Greenfield Site" which would entail costs of between US$8,360 and US$12,100.

There is already established technical support within the country in the form of the Mon Repos Aquaculture Station, which conducts research, provides training and supplies seed stock. Moreover, there have been successful experiences of rapid growth of Commercial Aquaculture in neighboring countries. Brazil, Chile, Ecuador and Colombia are all showing impressive growth in production and have become leading aquaculture producers in the world.

2.2.1.6 Forestry

Forestry products over the past 7 years, the annual average contribution of the forestry industry to Guyana's GDP have been 3.49%, with 2006 being an exceptional year. It is estimated that Guyana has 22,400 square kilometres of commercial forest; another 64,000 square kilometres of forest are potentially commercial.[35] Export earning in 2006 was US$59.5 million, representing a 67% increase over the 2000 figure (Table A.6).[36]

Table A.6: Annual Export Values (US$M) of Forest Products for the years 2000 – 2006

PRODUCT	2000	2001	2002	2003	2004	2005	2006
Logs	2.8	3.2	4.6	8.5	5.8	12.0	22.3
Sawnwood*	6.2	7.6	10.7	9.2	13.8	17.7	20.4
Roundwood	0.7	0.4	1.1	3.8	2.5	1.2	2.3
Splitwood	0.2	0.3	0.4	0.5	1.2	1.1	1.2
Total Timber	**9.9**	**11.5**	**16.8**	**22.0**	**23.3**	**32.6**	**46.2**
Plywood	23.6	16.7	12.3	12.4	15.5	11.3	8.8
Total timber and Plywood	**33.5**	**28.2**	**29.1**	**34.4**	**38.8**	**43.9**	**55.0**
Other Value-Added Products**	…	2.5	3.0	3.5	4.3	4.5	4.3
Other Products***	2.2	2.4	0.1	0.1	0.3	0.2	0.2
Total Other Products	**2.2**	**4.9**	**3.1**	**3.6**	**4.6**	**4.7**	**4.5**
Total Export Value	**35.7**	**33.1**	**32.2**	**38.0**	**43.4**	**48.6**	**59.5**

Source: Guyana Forestry Commission (2008)

The Ministry of Agriculture, with responsibility for forestry, oversees policies in the sector; it is trying to promote value-added activities. The forestry sector is regulated by the Guyana Forestry Commission (GFC) under the authority of the Forests Act of 1953 (Cap. 67:01), as amended. The law provides for the issuing of exploratory permits: it specifies that *only citizens of Guyana may be granted permits as individuals, but either domestic or foreign corporations may be granted such permits.*[37] The law makes these permits contingent upon various factors, including the applicant's proposals for the employment and training of Guyanese. Any area of State land may be declared a State forest, and the law mandates that all forest produce from State forests remains the property of the State until the prescribed royalty thereon has been paid. The GFC has the authority to sell timber from State forests, or to issue permits for the harvesting of timber in these forests. The law authorizes the MoA to prohibit or regulate the export of forest produce from State forests and to prohibit or regulate the importation of sawmill equipment (Article 45(c) and (j)).

The GFC monitors forest operations to ensure compliance with its operational and environmental standards. It has established a 24-hour monitoring unit to reduce the incidence of illegal activities by loggers, and is aiming to have Guyana certified internationally as an exporter of wood and wood products in accordance with environmentally friendly practices. In this regard, it is working with the Guyana National Initiative of Forest Certification (GNIFC), established in 2003 to take the process forward.

[35] Bernard (1999).
[36] Guyana Forestry Commission (2008) *Forestry in Guyana: 2007*, p. 4
[37] These laws are elaborated further in section 3 of this report

The Guyana Forestry Commission produced a National Forest Plan in 2001. The overall objective of this plan is the conservation, protection, management, and utilization of Guyana's forest resources, while ensuring that the productive capacity of the forests for both goods and services is maintained or enhanced.[38] Among the points emphasized in the plan is the need to promote greater conservation of the country's forest resources. As such, in 2002, Conservation International, under a Timber Sales Agreement (TSA), undertook to conserve and protect approximately 80,000 hectares of State Forest Estate over a period of 30 years. In this concession, no logging is permitted and the GFC is to be compensated on the basis of a timber valuation of the concession.

Additionally, Guyana is one of 14 states that have been selected to receive funding to engage in programmes that help combat tropical deforestation and climate change.[39] The country will receive funding from the Forest Carbon Partnership Facility (FCPF) in an innovative approach to finance efforts to combat climate change. Guyana will receive grant support as it seeks to build its capacity for Reducing Emission from Deforestation and Forest Degradation (REDD)

The NFP also promotes export trade and underpin this with research and development aimed at both processing and marketing, as well as offering training and extension programmes. The plan called for the approval of a new Forests Act which was passed in 2007.

There is substantial foreign involvement in Guyana's forestry sector. Among the major foreign investors are: Caribbean Resources Ltd., owned by the Colonial Life Insurance Company (Trinidad and Tobago); the Barama Timber Company, a joint South Korean/Malaysian venture; Demerara Timbers Ltd., owned by a consortium of European banks; and the UNAMCO/Case Timbers, a Guyanese/Malaysian enterprise that manufactures plywood. Some of these investments in the sector are the result of privatization in the late 1980s and early 1990s, such as the purchase of the formerly state-owned Guyana Timbers by Caribbean Resources, and Demerara Timbers' purchase of assets that were held by the state-owned Demerara Woods.[40] In 2000, Jailing Industries (Guyana) Inc. of China, and Forest Enterprise Limited of the Netherlands committed to new investments of some US$32 million in Guyana's forestry sector.

[38] Guyana Forestry Commission (2001), p. 1.
[39] The others are the Democratic Republic of Congo, Gabon, Ghana, Kenya, Liberia, Madagascar; Bolivia, Costa Rica, Guyana, Mexico, Panama and Nepal, Lao PDR, and Vietnam.
[40] U.S. Department of State (2001), pp. 29-30.

3. POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE AGRICULTURAL SECTOR

According to the INC (2002) report, the effects of climate change on the agricultural sector, particularly along the coastal plain of Guyana, will include sea level rise, inundation of parts of the coast during the rainy season, seasonal changes in weather patterns, soil erosion, saltwater intrusion and pest infestation (*kindly see* Section B - Technical Assessment for an elaboration of these effects). These issues are, however, succinctly dealt with here.

3.1 Sea Level Rise

According to the IPCC Fourth Assessment Report (FAR) global sea level is expected to rise between 0.23 – 0.51 meters by 2090, even with mitigation measures aimed at reducing the greenhouse gases. It is important to note that this does not take into account the melting of the ice caps. At the local level, current sea level rise is at least several times the global average, estimated to be 10.2 mm/year according to Guyana's National Vulnerability Assessment to Sea Level Rise Report of 2002.

Given that Guyana's coastal plain is below the mean sea level, and the importance of this area for agricultural development, it may become necessary to increase protective initiatives for this zone. Currently, of a coastline representing 430 km, only an estimated 100 km is protected by relatively adequate sea and river defences (Mott MacDonald, 2006). But even these areas do not seem to have been built to accommodate the projected rise in sea level.

As such, using the Ministry of Public Works and Communication (MPW&C) estimate of approximately US$3,500 – US$4,000 for a metre of sea defence masonry, this would mean that adaptation cost of at least US$1.2 billion, almost one and half time the size of Guyana's GDP. Fuller analyses are required to estimate the direct and indirect costs, and those associated with protecting riverain areas, as well as the benefits to be derived from such adaptation efforts.

3.2 Inundation

As noted earlier, the coast of Guyana lies below the mean sea level and therefore with more intense rainfall is likely to suffer from greater levels of surface run-off, moreover, as there have been some changes in land-use, with some areas previously used for sugarcane cultivation being converted to housing and industrial purposes (IDB, 2008; Pitt per comm., 2008). For example, in 2005, Guyana had the highest rainfall on record since 1888 leading to extensive flooding (ECLAC, 2006). Since most of the coast depends on gravity flow much of this water can only be drained when the tide is low.

Alternatively, the authorities may decide to pump this excess water, but as the 2005 and 2006 floods demonstrated, this is a costly exercise and is much more time consuming. For example, the IDB in 2005 estimated that GuySuCo alone incurred pumping costs of approximately 0.37 million above average, to rid five (5) of its estates of excess water occasioned by the above normal rainfall.[41]

[41] Inter-American Development Bank (2005) Damage Assessment Report of the 2005 Floods, Georgetown.

Increased inundation can lead to a loss in crops, decline in crop yields and loss of livestock (see *Appendix A5*). It may also increase the cost of production of specific crops like rice, sugar, vegetables, and fruits making them less price competitive and threatening the livelihood of significant number of farming households directly, and those who depend on the agricultural sector indirectly.

In the livestock industry, cattle, many of which are reared in Regions 5 and 6, are known to be affected by foot rot and influenza in the wet season. These impacts are quantified at a more disaggregated level in the technical assessment.

More indirectly are the effects on the rural infrastructure on which the sector depends. For example, in 2005 one of the most severe flooding led to the destruction/degradation of farm to market roads (many are constructed of mud and burnt earth) and made it virtually impossible for farmers to access their farms. The estimated damages totalled nearly US$17.5 million or nearly 2% of agriculture's GDP for that year (ECLAC, 2005; IDB, 2005).

But exposure to inundation has focussed the minds of all stakeholders about the risks posed by climate change and the vulnerability of the coast. It has also magnified the increased need for improved water management that has seen the rehabilitation of a number of drainage outfalls, the construction of new koker doors, the installation of electric and diesel pumps, redesigning of drainage outlets, and efforts that seek to change attitudes of stakeholders in terms of how water systems should be managed generally. These are all effects that need to be built upon, but also the time may be opportune to have a single water management authority rather than disparate management that currently obtains (see Section C on the Policy Assessment). This exacerbates the problem. Lastly, simple training exercises for farmers, in terms of timing of fertiliser application and how to apply these, will be critical to reduce wastage and inefficiency all aimed at reducing production costs in the face of the global challenges posed by climate change.

3.3 Soil Erosion

Most of the soils along the coast and further inland are shallow peat soils. Constant inundation is likely to worsen soil erosion with the topsoil being removed as water is drained. This would have severe implications for crops that depend on these soils. The projections are for increased use of inorganic fertilisers to increase the fertility of soils. This particular input has increased by more than 60% over the past 2 years (Trostle, 2008). Thus, further augmenting production cost by a factor of at least 10%.

For example, based on information collected from secondary sources, the team estimates that should Guyana be exposed to rainfall similar to those experienced in 2005 and 2006, this would cause overall production costs to increase in the magnitude of between 23.85% and 66.87% using 2004 as the base year (Table A.7).

This would make small farming in the main to become unprofitable. While there is some possibility for increased use of organic manure, and the sugarcane and rice husk residues generated from the boilers of some sugar factories and rice mills respectively, there is need for further research in these areas before they can be seen as viable substitutes.

Table A.7: Estimated Percentage Change in Production Costs for the Highest and Lowest Cost Producers (Base Year, 2004)

Area	Lowest Cost Producer (farming 8.10 – 40.3 hectares)	Highest Cost Producer (farming 2.02 – 7.89 hectares)
Region 3 (Essequibo Islands)	27.71	43.28
Region 3 (West Demerara)	29.74	45.56
Region 4	23.85	38.94
Region 5	48.75	66.87

Source: Calculated from information obtained from the Guyana Rice Development Board and Mott Mac Donald Feasibility Reports (2004)

Additionally, to reduce soil erosion a number of soil conservation techniques can be adopted. These include the development of agro-forestry practices as a possible option. Agro-forestry, apart from distributing production risks and maintaining productivity, can also act as a soil conservation technique. However, once again the feasibility of these operations will have to be examined thoroughly.

3.4 Salt Water Intrusion

One of the most serious effects on commercial agriculture is the possibility of saltwater intrusion. This occurs when the freshwater level in the irrigation canals falls below the saltwater level. Increased salinity can reduce both productivity and output and can have long-term deleterious soil effects. In some cases farmers may be forced to lift water via pumps. Like in the case of the other effects, this will increase production costs.

3.5 Water Changes

In some hinterland areas water deficit can lead to a destruction of some crops as witnessed in the 1997/98 El Nino period in which case Region 9 was declared a disaster area due to the destruction of the main cassava crop. To the extent that this occurs, the livelihood impacts will be severe. But there may be opportunities for adaptive techniques to be developed through experimenting with cassava strains that have shorter growing periods. However, the effects in pursuing such an initiative can be complemented by improved climatological data as pointed out in the Section D of this report in the Institutional Assessment and better dissemination of this information. Here capacity building will be a key requirement.

One of the most significant effects of climate change is flooding resulting from temperature variations. For example, the INC Report (2002) projects that the intermediate savannahs and hinterland areas there would be increases in temperature, for a doubling of of 1. by 2040 and a projection of a 4. for a tripling of for the century (INC 2002). At the same time, rainfall is projected to decrease for a doubling and a tripling of (INC 2002). There is expected to be some crops that will benefit, e.g. maize in some studies, but without any irrigation system in place then crops can only be grown during the rainy season, which can produce highly variable yields.[42] The success of subsistence and commercial farming in these areas will have to be based on plant breeding to withstand high temperatures and sound agronomic practices. Heat and drought tolerance will be the key mitigating factors. It was found that UF 717 *Brachiariha humidicola* was

[42] While there has been some discussion on installing drip irrigation in this area, this remains an expensive undertaking that may then make agricultural products from this area uncompetitive from a price standpoint.

suitable for growth to support livestock in the savannah region, Caribbean Agricultural Research and Development Institute (CARDI).

3.6 Pest Infestation

One of the foremost predictions is for warmer temperatures, thus leading to increase pest production and infestation. Farmers in the sector are continually battling against the paddy bug, various types of worms and insects, and this is likely to increase. To the extent that it is perceived that this problem may be dealt with via increased application of pesticides can carry important costs and food safety implications. The latter implications can also affect Guyana's agricultural export markets as has been known to occur in the past.

Therefore, two measures will become important. There are improved farm husbandry, inclusive of integrated pest management, and secondly improve product testing. In the former case, the issue will be to deal with the issue at source, while the latter is addressing the issue later in the production chain. To improve the farm management practice, it will be critical to improve the agriculture extension section of the MoA.

4. DEMAND ANALYSIS

The issues here are relatively straightforward and are becoming better known (though they do not seem to have been fully addressed in a number of analyses of the agricultural commodity markets). Demand for agricultural products comes from households, agro-processors, industries, research institutions and regional and international governments. Primarily, these consumers are often interested in price, moreso, as it makes it difficult for them to access a particular commodity, through squeezing their respective budgets. Future demand for agricultural products will be determined, *inter alia*, by drivers such as, the rate of population growth, the size of disposable income, taste, cultural issues, government policies and natural conditions. At the same time, the quality of the products and ease with which they can be obtained will remain important considerations in the demand for agricultural products.

In economic terms this means that price-elasticity[43] is high, in other words consumers will normally be influenced by the commodity's price in their decision whether or not to purchase a particular commodity. Demand for agricultural products tend to be highly responsive to price. A primary reason for this is that there are a number of close substitutes for many agricultural products and some of these issues will be elucidated further in this section. The best way of conducting this demand analysis for agricultural products in the next 10 years or so is to focus on those external factors that are likely to have a significant effect on agricultural commodity demand. However, it will be unfortunate if such an assessment did not take into consideration global events apart from climate change. While climate change is expected to have profound impacts, it will not be looked at in this assessment as mutually exclusive. Furthermore, since climate change is a global phenomenon, along with the fact that a very small proportion of Guyana's rice, sugar, forestry products, and fisheries are consumed domestically make it imperative that this approach be taken.

A number of international events have been occurring for the past decade or more and others more recently, which will ultimately influence the demand for Guyana's agricultural products (Hatfield, 2008). However, it should be noted that since there may be counteracting influences, the full effects are unclear, requiring more in-depth sensitivity analysis. This assessment, therefore, is based on a number of assumptions made by the analyst as well as those made by the United States Agricultural Department (USDA). Nonetheless this assessment seeks to highlight possible areas in which Guyana can reposition itself and possibly benefit from the climate change and other global events, inclusive of the recent global financial crisis.

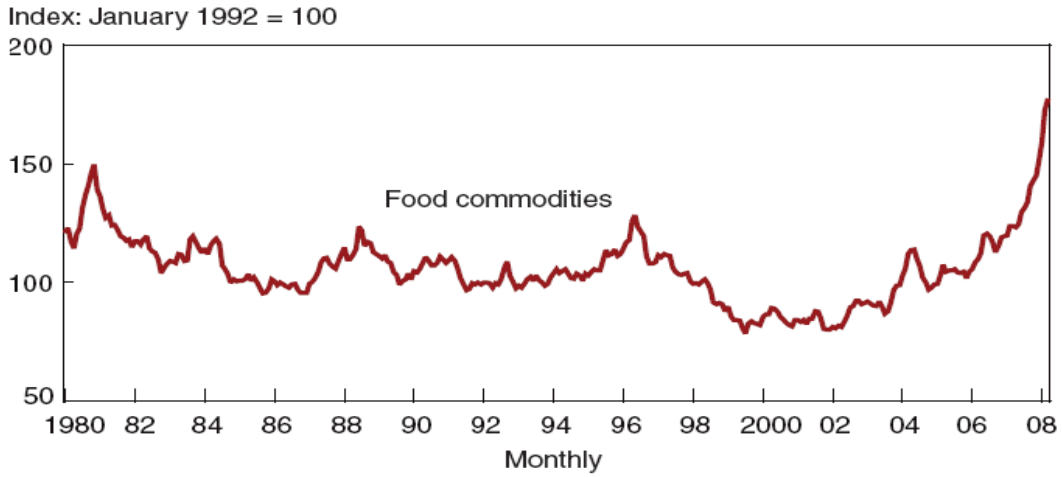
In the past year, world market prices for major food commodities such as grains (inclusive of rice) and vegetable oils rose to historic highs – more than 60% above levels just two years ago (Figure A.7). Retail food prices in many countries also rose, though all of these prices have been falling in the past three months or so, but still remain above the 2006 level.

No one factor has been responsible for these price increases, but to the extent they remain buoyant, these price spikes can be an important boon to the Guyanese agricultural sector. Furthermore, what is more significant to note is that many of these factors still exist in the economic system, thus leading to likely spikes in retail food prices for some substantial time to come. Some of these factors reflect underlying trends in supply and demand for agricultural products that began more than a decade ago (Trostle, 2008). Other factors have occurred more recently. Some factors reflect significant structural changes in the supply and demand

[43] This is where a small change in price causes a larger than proportionate change in the quantity demanded.

relationship; while others are temporary, short-term shocks. Both sets of influences have implications for the demand of Guyana's agricultural products.

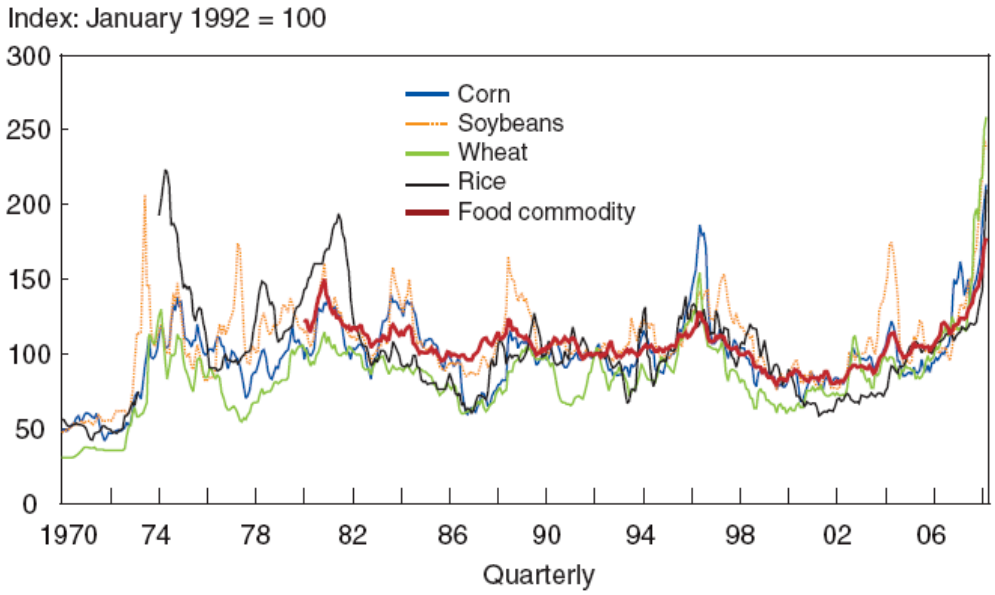
Figure A.7: Index of Food Commodity Prices



Source: International Monetary Fund, International Financial Statistics

Figure A.8 below puts the evolution of the food commodity price index into a broader perspective. For example, wheat and rice account for much of the world food consumption of grains. Corn is used for both food and animal feed. Soybeans provide vegetable oil for human consumption and protein feed for animals. Combined, the four crops account for a large share of the staple foods that are consumed globally and given the demand drivers[44] discussed below, are likely to keep the demand for these products relatively high in the foreseeable future.

Figure A.8: Food Commodity Price Spikes Since 1970



Source: International Monetary Fund, International Financial Statistics

A number of long-term, slowly evolving trends have affected the global supply and demand for food commodities. The impact of these trends has been to slow growth in production and to strengthen demand. The resulting tightening of the global supply and demand balance has

[44] These include population growth, demand for feedstock, the expansion of bio-fuels production that may utilise current and future agricultural lands.

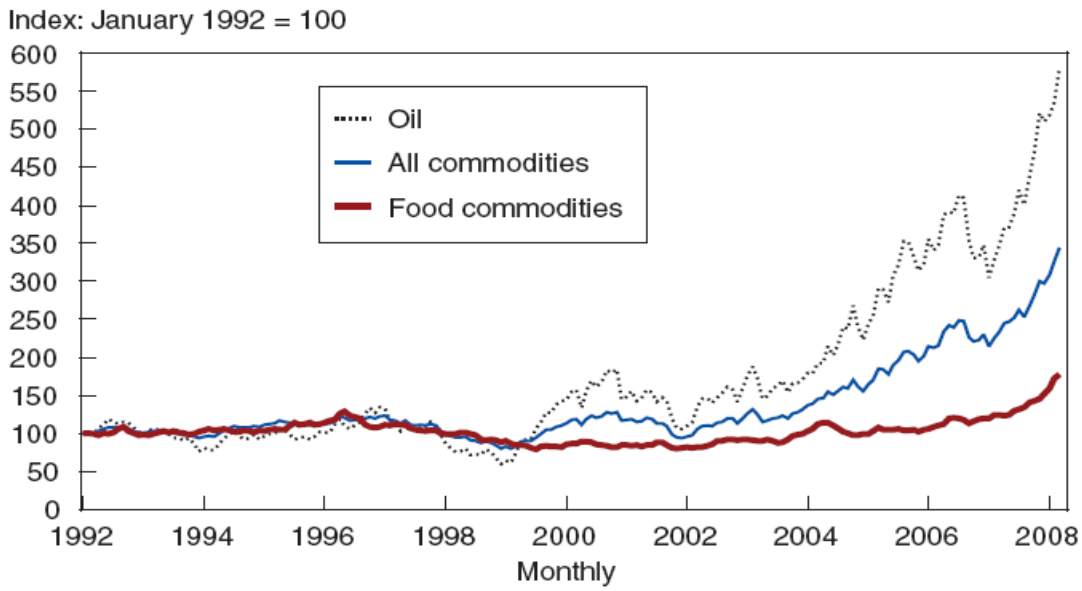
gradually put upward pressure on agricultural prices, and some of these effects are projected to be exacerbated by climate change. Many of these long-term trends have been aggravated by the more recent developments that have put additional upward pressure on world prices by further reducing supplies and increasing demand.

The demand for agricultural commodities is projected to keep increasing, despite the recent financial crisis, though at a decreasing rate. If the last decade is any indication, strong global growth in average income combined with rising population numbers are likely to increase the demand for food, a basic necessity. This demand is likely to come mainly from other developing countries, such as China, India, and Brazil. Though Guyana has limited exports to these markets, there may be two possibilities: (i) either seek ways to export to these countries, or (ii) seek to export to those countries where deficits may be created from other agricultural exporters seeking to fulfill these emerging demands. Guyana is well positioned to exploit these opportunities given its competitive advantage in land and freshwater resources.

As per capita incomes have increased, particularly in China, India, Brazil and South Africa consumers in these developing countries are expected to increase per capita consumption of staple foods, as well as diversify their diets to include more meat, dairy products, and vegetable oils, which in turn, will amplify the demand for grains and oilseeds. This rise in per capita income has been mainly due to the fact that global economic growth has been strong since the late 1990s, but this is likely to weaken with the recent global financial crisis. Exactly how this will impact demand commodities is yet to be determined. For developing countries, growth has been quite strong since the early 1990s. Growth in Asia has been exceptionally strong for more than a decade and though likely to decline as these countries begin to plateau and their growth blunted by the economic crisis. Unusually rapid economic growth in China and India, with nearly 40 percent of the world's population, will continue to provide a powerful and sustained stimulus to the demand for agricultural products.

But rapid economic growth in developing countries has also resulted in very rapid growth in the demand for energy for electricity and industrial uses, as well as for transportation fuel. The associated increase in petroleum use in developing countries has contributed to rapidly rising oil prices since 1999 (Figure A.9).

Figure A.9: Oil Price Index Relative to Other Commodities



Source: International Monetary Fund, International Financial Statistics

Another driver is the world's population. Though the population growth rate has been trending down before 1970s, the number of people on earth is still rising by about 75 million (1.1 percent) per year. This rising population adds to the global demand for agricultural products and energy. The impact on demand is amplified because the most rapid population growth rates tend to be in developing countries. Many of these have rapidly rising incomes, again particularly important for agricultural demand due to diet-diversification.

Global consumption of meat has been growing much more rapidly than consumption of grains and oilseeds. Between 1985 and 1990, production of meat (beef, pork, chicken, and turkey) rose more than 3 percent per year. Since this was well above the world's population growth rate of 1.7 percent per year, per capita consumption was able to climb by 1.4 percent per year. Although the average growth rates in production and per capita consumption of meat have declined somewhat since 1990, they are still well above the growth rates for aggregate use of grains and oilseeds. As the demand for meat rises, the demand for grain and protein feeds used to produce the meat grows proportionally more quickly. Feed-to-meat conversion rates vary widely depending on the class of animal and the production practices used to produce the meat. So, there may also be possibilities for Guyana to begin to explore opportunities to expand grain production, particularly in the areas of rice, corn and soybean.

As countries have sought to reduce greenhouse gases biofuels use has been increasing. Brazil and the United States account for most of the world's ethanol production. Brazil uses sugarcane as a feedstock, while the United States uses nearly all corn. A number of other countries have policy initiatives designed to increase ethanol production, but so far the total augmentation in production capacity has been small relative to the combined capacity of Brazil and the United States. In 2007, China reversed its decision to invest in facilities to produce more ethanol from grain. Given its food policies, China is now focusing on using cassava and sweet potatoes as feedstocks for future increases in ethanol production.

But the European Union is the largest biodiesel producer, and rapeseed oil is its main feedstock. The EU has mandated that biofuels account for 10 percent of transportation fuel use by 2020. The EU cannot produce sufficient rapeseed to fill the mandate and will have to import either some feedstocks for producing biodiesel, or some biodiesel. Russia and the Ukraine are increasing rapeseed production destined for export to the EU as rapeseed, rapeseed oil, and perhaps as biodiesel. Brazil and Argentina are using soybean oil as a feedstock to expand biodiesel production. Brazil's biodiesel will mostly be produced in the Center West part of the country and will replace petrol-diesel traditionally trucked in from the coast. Most of Argentina's biodiesel production is destined for the export market. Canada is expanding biodiesel production in the Prairie Provinces using rapeseed as the feedstock.

U.S. ethanol production began to expand rapidly in 2002. There were several incentives for expanding ethanol production: the increasing price of petroleum; concerns about the reliability of some traditional exporters; concerns about the pollution effects of methyl tertiary butyl ether (MTBE) and initial switching from MTBE to ethanol; and an environmental objective to increase the use of cleaner burning fuels. Without the concerns about petroleum, the increase in U.S. and world biofuels production would not have been nearly as great.

Corn used for ethanol rose from about 1 billion bushels in 2002/03 to a projected 3.1 billion bushels in the current (2007/08) crop year. With this increase, corn used for ethanol production now accounts for about 24 percent Ethanol output increased rapidly after 2002, and from the perspective of global market changes from 2002 onward, provides a somewhat different picture. Between 2002 and 2007, the quantity of U.S. corn used to produce ethanol rose by 53 million

metric tons. This accounted for 30 percent of the global growth in wheat and feed grains use. Feed use grew by 48 million tons and accounted for 27 percent of the increase in total use. Food and other non-feed uses climbed 79 million tons and accounted for 44 percent of the global increase in wheat and coarse grains use.

The data suggest that while U.S. corn used for ethanol production had only a small effect on global markets in the 1980s and 1990s, the increase in U.S. ethanol production over the past 5 years and the related significant changes in the structure of the U.S. corn market have had a more pronounced impact on the world's supply and demand balance for total coarse grains recently. Importantly, since the United States is the world's largest corn exporter, some of the higher prices resulting from increased U.S. demand have spilled over onto world markets.

If petroleum prices remain high, costs of agricultural production will rise, as will the cost of processing, and the cost of transporting products to markets both within Guyana and exporting to other countries. Continued high petroleum prices will also sustain the global incentives to produce more biofuels.

The rapidly increasing world prices for food grains, feed grains, oilseeds, and vegetable oils caused domestic food prices at the consumer level to rise in many countries. In response to rising food prices, some countries began to take protective policy measures designed to reduce the impact of rising world food commodity prices on their own consumers. However, such measures typically force greater adjustments and higher prices onto global markets.

The result of adverse weather in 2007 was a second consecutive drop in global average yields for grains and oilseeds. In historical perspective, two sequential years of lower global yields occurred only three other times in the last 37 years. The lower production caused yet another decline in the global stocks-to-use ratio and created a world market environment characterized by concern among importers about the future availability of supplies. This situation is expected to become more frequent with climate change.

Lastly, large foreign exchange reserves held by some major importing countries enabled them to contract for their import needs regardless of how high the world price rose. There have been very large accumulations of foreign exchange reserves held by oil producing and exporting countries (OPEC, Russia, and Ukraine) and by countries with large non-oil trade surpluses (China, Japan, and other Asian countries). Countries holding these large foreign exchange reserves are able to import large volumes of food commodities in order to meet their consumption needs and allay their domestic food price inflation. In essence, they can bid supplies away from other traditional importers that do not hold significant foreign exchange reserves.

In conclusion then, global events like climate change, the global financial crisis, and rising global populations are all likely to have significant impacts on the demand for agricultural products from Guyana and other developing countries. However, the exact nature and extent of these impacts require intensive economic analysis.

5. SUPPLY ANALYSIS

Guyana remains a major food producer within CARICOM, accounting for more than 7% of the region's agricultural trade (CARICOM, 2005), supplying rice, sugar, fruits and vegetables and fisheries mainly. But output from the sector continues to face a number of challenges as discussed in the succeeding section. For Guyanese agricultural producers, the traditional factors that affect agricultural output are well known and include access to land and freshwater, insufficient maintenance of the drainage and irrigation infrastructure, inappropriate husbandry practices, and limited research and technology capacity. However, the effects of climate change on the sector are less well known. The major concern seems to be how climate change would affect the fundamental structures on which the sector is based. As with demand, price is important for the suppliers of agricultural products. Producers seek to access markets that will allow them the greatest return on their investment. The success of producers, therefore, is partly a function of them being able to assess the demand in future market places. In this regard, having an understanding of how climate change is likely to affect local, regional and global output remains critical.

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) on Climate Change Impacts, Adaptation and Vulnerability observed changes in the natural and human environment as a result of climate change are projected. The changes show that natural systems have been affected by climate change and temperature increases in particular. Changes include those in hydrological, terrestrial, biological and marine and freshwater systems. These changes have also impacted human systems, although specific impacts are hard to discern due to adaptation and non-climatic drivers. Some of the impacts include changes in agricultural and forestry management. Other observations, that cannot be verified as trends yet that are relevant to Guyana, include increased flooding risk due to sea level rise and excessive rainfall, warmer and drier conditions in parts of the earth, and sea level rise impacting coastal development.

The effects of the foregoing impacts globally have been to slow the production of aggregate grains globally. For example, between 1970 and 1990 production rose an average 2.2 percent per year. Since 1990, the growth rate has declined to about 1.3 percent. USDA's 10-year agricultural projections for U.S. and world agriculture see the rate declining to 1.2 percent per year between 2009 and 2018, due to climate change and other drivers elaborated in the following section of this assessment.

Additionally, growth in productivity, measured in terms of average aggregate yield, has contributed much more to the growth in production globally than has expansion in the area planted to grains and oilseeds. Global aggregate yield growth averaged 2.0 percent per year between 1970 and 1990, but declined to 1.1 percent between 1990 and 2007. As discussed above, rice yields in Guyana appear to have plateau. Global yield growth is projected to continue declining over the next 10 years to less than 1.0 percent per year. The growth rate for area harvested has averaged only about 0.15 percent per year during the last 38 years. In USDA's agricultural projections, crop prices are not projected to decline much over the next decade, despite the current financial crisis and fall in oil prices.[45] The continued higher prices, therefore, should provide the incentive for producers to respond by increasing the area allocated to crops

[45] This is because demand is projected to remain strong from population growth, crop failure associated with the El Nino and La Nina weather patterns, and rising disposable income.

during the coming decade nationally.[46] Some of this expanded area planted may come from land converted to cropland from non-cropland uses, such as pasture and brush. Area harvested will also increase as a result of more intensive use of existing cropland, generally from shorter cropping cycles and reduced fallow area, though each of these will carry their own challenges, such as reduced soil fertility, increased production costs, and quite possibly, increased used of agro-chemicals.

Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are still key factors in agricultural productivity (Kane *et al.*, 1991; Tobey *et al.*, 1992). Many persons have argued that climate change will result in extended growing seasons; rising sea levels causing Guyana's fragile sea defenses to come under increasing pressure concomitantly resulting in more breaches and flooding of the land; increased incidence of pest infestation, and the possible over-use of agrochemicals to treat with the pests[47] while also seeking to raise agricultural productivity as soil fertility declines (Bynoe and Bynoe, 2000; EPA, 2001). These effects are projected to negatively affect both agricultural productivity and output. For tropical regions like Guyana, crop productivity is projected to decrease for even small local temperature increases of 1-2°C (USDA, 2005; IPCC, 2007). Increased frequency of droughts and floods would affect local production negatively, especially in subsistence sectors. This will have much more serious consequences for chronic and transitory food insecurity and for sustainable development than shifts in the patterns of average temperature and precipitation.

To the extent that these projections are accurate, they will lead to less food being available directly for human consumption, and indirectly since even animal fodder becomes scarce causing an increase in food prices with poorer households having less access to these foods. This projection is based on the assumption that climate change will cause a disruption in global weather patterns, leading to, in some instances, longer drier summers, wetter ones on other occasions, and drier winters or shorter rainy seasons. This trend is already manifesting itself in the temperate areas where changing weather patterns have adversely affected the wheat crop for the past two seasons. This, along with increasing demand, has caused wheat prices to increase to a 10 year high on the world market (World Business Report, 2007). This has had the knock-on effect of increasing flour prices in Guyana from G$4,435 per 45kg bag to G$5,025. At the same time, unseasonal rains in Guyana in 2007 caused significant damage to the rice crop in the Black Bush Polder area due to the soggy condition of the ground that prevented the use of combine harvesters. This problem becomes more acute if the research continues to emphasize cost-reducing innovations that can be sold to producers rather than yield enhancing technological developments.

But these impediments can also be advantages to the agricultural sector of Guyana if effective adaptation measures are pursued. For example, globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease. As such, adaptations, such as altered cultivars and planting times, and greater investments in bio-technology, would allow Guyanese grain and cereal producers to maintain yields at, or above, baseline yields for modest warming.

Another concern often expressed is the increase pest infestation due to faster rates of propagation due to warmer climates. These pests threaten agricultural output that may decline in

[46] This point finds further support from Government's AEDP, ASSP, EU-rice support project, and the Competitiveness Programme, all aimed at enhancing agricultural output through addressing the fundamentals on which the sector is built.

[47] Unless Guyana is able to have an effective agricultural extension service, the folly of linear thinking may take over which indicates '*that if one dosage is good two must be better*'.

the short-term. To combat this pest problem, while aiming to increase yields, farmers may be encouraged to increase the use of agro-chemicals. However, this is both environmentally and economically unwise. In the first instance, this will affect the quality of the products being produced, and quite possibly, their nutritional content. Additionally, economically, the cost of agro-chemicals has been increasing steadily over the past two years and is estimated to now make up approximately 30% of the total production costs of rice farmers (Bynoe, 2006). This type of increase will reduce the profitability of the venture, affecting some households' ability to meet their food demands and other necessities, vital for an acceptable lifestyle. As such, whilst there is no immediate threat of Guyana having a food deficit, pockets of the country are likely to be so affected, i.e., hinterland areas, such as areas in Regions 7, 8 and 9 that already have relatively high rates of poverty according to the last Household Income and Expenditure Survey (HIES) of 1999, and other anecdotal information.

Other analysts have pointed to the possible increases in the frequency of droughts and floods, projected to affect local production negatively, especially in subsistence sectors as occurred in Region 9 (Upper Takatu/Upper Essequibo) in 1997/1998. Similarly, floods in 2005 and 2006 caused losses within the agricultural sector in terms of lost crops, damaged infrastructure and approximately 6% of GDP annually (ECLAC, 2005 and 2006). To the extent that this trend becomes pervasive, climate change can restrict the agricultural output, particularly of crops and livestock. Similarly, regional changes in the distribution and production of particular fish species are expected due to continued warming, with adverse effects projected for aquaculture and fisheries.

However, the forestry sector is expected to benefit from climate change, at least in the short and medium terms. Globally, commercial timber productivity is projected to rise modestly with climate change in the short to medium term. These may provide opportunities for Guyana's forestry sector to play a greater role in the economy's development.

Furthermore, it is well established that natural disasters tend to have disproportionate impacts on the poor. Given this, to the extent that climate change will adversely affect crop production, fisheries due to changing water temperature and currents, and faunal species, it is the poor that are likely to be most affected. Hence, for a country like Guyana, one can expect increased food prices, restricting poor households from being able to acquire nutritious meals, increases in malnourishment, particularly amongst the hinterland poor as availability and access to nutritious foods become distinctly more difficult to acquire. This is particularly the case as many do not benefit from remittances in the same manner as their coastal counterparts, nor are they able to access in the same way, the public support provided by the Government of Guyana and Civil Society.[48]

But climate change may also offer an opportunity for Guyanese producers to increase farm incomes. For example, regional food production figures in the main indicate a downward trend since 1996. This has been partly due to the de-emphasizing of agriculture in the region, as well as the challenges posed by liberalizing previously protected markets to which CARIFORUM[49] countries had access. With the exception of Guyana, and to a lesser extent Suriname, most of the other CARIFORUM countries have indicated a decline in agricultural output for the period 1996 – 2004 (see *Appendix A6).* This trend is partly responsible for the increasing food import bill in the region. This situation is further compounded by imports to sustain the tourism industry on which so many of the economies depend. This may therefore provide an opportunity for Guyanese producers, who are also protected in the CARICOM market, to exploit this position.

[48] These are due mainly to logistical and structural issues, rather than any overt discriminatory practices.
[49] All CARICOM countries plus the Dominican Republic.

Given limited safety net support provided to aquaculture farmers, some risk averse small farmers may prefer the less risky option of rice farming. Global market demand for aquaculture products has been growing dramatically. According to the FAO aquaculture is the fastest growing food production sector in the world, with output growing at 10% per annum. This is coupled with the fact that there has been a sharp decline in the world's ocean captures. In the past decade total world capture fisheries has reached maximum sustainable yield in terms of volume.

Thus with increasing demand for fish products the price for fish products has seen a general increase worldwide. The US market in particular is very promising for Tilapia. With Guyana having achieved the necessary Sanitary and Phytosanitary Standards (SPS) for the export of fish products, there is not a problem in accessing the US market. The US import demand has also been rapidly increasing, with average annual growth since 1997 at 24.9%, and annual imports of Tilapia into the US at 112,939 MT in 2004.

Access to growing export markets, especially in the US but also in the Caribbean, where demand is likely to increase to satisfy a growing regional tourism industry. Exports to the Caribbean Region will benefit from the protection of the CET, with average tariff rate for fish products at 31%. Whilst there is considerable potential for growth of the sub-sector, the logistics of maintaining freshness throughout the entire distribution chain must be carefully assessed. At the moment there are questions of the reliability of supply and transportation. Airline cargo transportation (critical for the transport of fresh fish to markets such as New York) is limited due to the small size of the country and limited exports.

Furthermore, semi-intensive tilapia aquaculture and processing requires the extensive use of electricity; high oil prices and the unreliable nature of electricity provision in Guyana are limiting factors to the development of aquaculture in Guyana. Access to finance is also a major constraining factor for the Agriculture Sector in general, with banks offering only restrictively high interest rates and short pay-back periods. This issue is exacerbated for the aquaculture sub-sector due to the fact that aquaculture is in its early stages of development. Banks do not have previous experience in lending to the aquaculture sector and this has led to pioneer investors experiencing problems in obtaining credit. Technical support provided by the Government is also currently limited, due to the fact that the human capacity of the Mon Repos Aquaculture Station is in short supply, and so cannot satisfy the needs of the entire country.

There is a lack of legislative support for the aquaculture sector. A clear example of this are the problems attached to the export of fresh fish on ice, an export market with good opportunities for exploitation by Guyanese producers. Procedures for certifying fresh fish for export involve delaying export by a few days. This is compromising for the freshness of products to demanding markets.

Lastly, the effects of climate on agriculture in Guyana cannot be considered in isolation. Agricultural trade has grown dramatically in recent decades and now provides significant increments of national food supplies to major importing nations and substantial income for major exporting nations (*see* Rosenzweig, C., M. L. Parry, G. Fischer, and K. Frohberg, 1993). These examples emphasize the close links between agriculture and climate, the international nature of food trade and food security, and the need to consider the impacts of climate change in a wider global context.

6. CHALLENGES TO AGRICULTURAL EXPANSION

The ECLAC 2005 and 2006 damage assessment reports indicated some challenges facing the agricultural sector of Guyana. These are discussed and augmented with other constraints facing the sector that are likely to be magnified with the advent of climate variability and climate change.

Rural Infrastructure: Possibly the main challenge facing the sector is the state of the rural infrastructure, inclusive of drainage and irrigation canals, farm to market roads and sea defences. These structures are critical for the survival of the agricultural sector and those that depend on it. Much of this infrastructure was not properly maintained for decades, and while the current government has been making efforts to improve the situation mainly under various donor funded projects, it still remains a millstone for the sector.

Seasonality and vulnerability to natural disasters: Agricultural production in Guyana is severely affected by the various seasons, with the El Nino and La Nina phenomena becoming more dominant in recent times. For example, during the rainy season food production is often affected by pests and disease infestations, flooding and glut on the market for vegetables. On the other hand, during the dry season, production is affected by lack of irrigation water, salt water intrusion, and increased cost of production all of which cause a contraction in supply. By affecting agricultural output, these major weather patterns, can adversely affect output. Moreover, the country lacks sufficient capacity to store and process most of these items, thus reducing their shelf life and making the country particularly vulnerable to cyclical shifts. Additionally, there is limited adaptation capacity to these natural disasters, worsening the food availability situation in a number of regions.

Unsustainable use of Land Resources: Though well endowed with natural resources, insufficient policies, enforcement of these policies where they exist, and conflicting resource management strategies have often resulted in their unsustainable utilisation. For example, land tenure in Guyana falls into two main categories (1) State lands, and (2) Private freehold lands. This type of public-private division has brought its own set of challenges. For example, lands held within the public domain are often confronted by illegal occupation mainly by poor households. Whereas, on the privately own lands, threats arise from unclear ownership of the land due to cultural factors, lack of enforcement policies, and irrational land uses. As s result, land use conflicts remain a reality in many parts of Guyana. Furthermore, the fact that a significant proportion of the land on the country is still under the control of the State, the root cause for these conflicts are issues related to the institutional and legal framework, lack of proper coordination and communication, and insufficient resources allocated for land management. These conflicts have often led to poor land management, leading to deteriorating land quality, increasing soil erosion and reducing agricultural output and productivity even further.

Scarcity of labour and an aging farmer population: People are not attracted to working on farms due to the low returns and wages, and young people especially are not attracted to the agricultural sector. With an aging farmer population (estimated at 55-60 years) this poses a serious threat to the survival of the sector. Furthermore, the young labour force is attracted to higher paying jobs both within the formal and informal sectors, thus reducing labour available to increase agricultural output. Moreover, with limited capitalization within the agricultural sector, productivity remains low, thus affecting productivity and output even further.

Lack of Capital for Agricultural Activities: Because of the risks and uncertainty associated with agricultural enterprises, most of the financial institutions are not accommodating to this sector. Moreover, there are few commercial institutions specifically dedicated to providing capital to the

agricultural sector. Hence, operatives within the sector often have to access loans at rates that make them uncompetitive, even nationally, thus reducing operations within the sector. Furthermore, the sector is devoid of safety nets. There is still no crop insurance and almost all the risks of crop failure are borne by the farmer.

Unreliability of Suppliers: A major weakness in the agricultural sector is the virtual absence of formal contract farming arrangements. This has often meant that some farmers are reluctant to invest to expand their operations. Additionally, they remain vulnerable to the vagaries of the open market operations. There are examples in the country where farmers were advised to cultivate specific crops without formal contract arrangements that ultimately led to over-production, price cuts, and significant losses. Farmers therefore remain skeptical about increasing output unless they can immediately perceive a market.

Quality standards and surveillance: One of the main challenges facing the sector is poor institutional support. The sanitary systems do not have enough technical and financial resources, and work under an outdated legal framework. Thus quality may often be compromised. These issues are expected to be addressed under the IDB's AEDP programme.

Weak Research and Technology Systems: Much of the services are not effectively linked with specialized networks to facilitate the adaptation of new varieties for these products, so critically needed to increase the supply. In fact, in Guyana, the research and extension services are weak. Limited funding, staff shortages, and infrequent meetings of personnel impede collaboration and coordination. Research is sometimes unrelated to farmers' needs and spread out over a wide range of crops in diverse geographical zones. This has made it difficult for the farmers to adopt new varieties that can increase output for an expanding regional and global market. Furthermore, there is weak technological awareness and business practices. There is limited knowledge on the technologies available for setting up plots, pastures, and raising cattle, as well as on meeting Good Manufacturing Practices (GMP) and Good Agricultural Practices (GAP).

Dualistic Structures: The agricultural sector in Guyana is characterised by a dualistic structure in production and marketing. Large-scale, well-organized farms and markets exist alongside small-scale, low technology and highly disorganized farms. This dualism often means that the small scale farmers in particular, so vital for the production of fruits, vegetables and livestock do not often receive, or are able to optimise, the support necessary to increase output and contribute more meaningfully to agricultural output.

Underdeveloped Agro-processing Industry: **W**ithin Guyana the agro-processing sector remains nascent and underdeveloped. Moreover, there are weak linkages with regional manufacturers. This means that most products remain available to consumers at specific periods during the year as their shelf lives are significantly compromised. This issue is attributed mainly to the seasonality of some products and the high processing costs. As such, in many instances, primarily after a natural disaster, food items are in short supply, aggravating an already tenuous situation in various parts of the country.

Insufficient market transparency: Production of most crops and livestock in the country is not guided effectively by market intelligence services. Seasonality of export demand, weather patterns, and input price fluctuations create a very unstable supply of produce ranging from gluts to scarcity. Input availability, soil types, farmers' experiences and perceived demand govern production levels and farmers' choices of commodities. There is often poor organisation among farmers at local and national levels, and hence there is little exchange of experiences on these crops and limited coordinated effort to obtain information on external markets.

Weak transportation networks: Lack of an adequate transportation infrastructure and services remain major impediments to the marketing of agricultural products within and out of Guyana. Poor transportation services contribute to the wide spread between ex-farm and retail prices. Rural producers and consumers are subject to very poor transportation linkages. Water and road transport are unreliable and high priced. Local roads are often in poor conditions. Additionally, exporters are inconvenienced due to poor port facilities and limited cargo space. These have resulted in some farmers turning to other occupation and a decline in agricultural output.

Lack of volume: Most farmers in the fruits and vegetables, and livestock subsectors are small scale producers. They are often far below an economically viable scale for export purposes.

Recapitalization: The sugar industry suffers from inadequate infrastructure and equipment. According to the National Development Strategy (NDS), even though extensive repairs have been undertaken in recent years and much of the old farm machinery replaced, the eight sugar mills in Guyana are generally obsolescent and are hampered by a low capacity, which prevents GUYSUCO from making the overall productivity gains that the industry needs to become competitive.

To respond to this and other challenges GUYSUCO developed its National Action Plan which is being implemented over the period 2006-2012 and includes three overall objectives:

1. Market oriented expansion of the sales, profitability of production and structural diversification of the sugarcane industry in Guyana – investment budget €499 million, the main components of which are:
   - Construction of a new raw sugar factory and establishment of new cane cultivation at Skeldon estate (€110 mn)
   - Establishment of a cogeneration plant at Skeldon (€26 mn)
   - Construction of refinery at Skeldon (€30 mn)
   - Expansion of cane production / upgrading of factories and establishment of cogeneration at Albion, Enmore and Blairmont estates (€56 mn)
   - Installation of a packaging plant for raw sugar at Enmore (€8 mn)
   - Construction of a deep water berth at Berbice (€61 mn)
   - Ethanol production from cane (€114 mn)
2. Promotion of the growth and development of specific non-traditional agriculture sub-sectors – budget € 29 million,
3. Provision of infrastructural and human resource development support to achieve the above – budget € 24 million.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Improved Competitiveness of the Agricultural Sector

Globalization poses significant opportunities and threats to historically protected regional business enterprises. For example, the trade liberalization effects of the Doha Round of The General Agreement on Tariffs and Trade (GATT) are being reinforced by the EU/ACP agreement, and, to a lesser extent, by recent progress in finalizing a new phase of the Caribbean Basin Initiative (CBI). Collectively, these new trade regimes will improve the country's ability to participate in unfettered capital, labour and technology markets for both imports and exports of goods and services.

But such reductions in tariffs, import quotas, and preferential trade subsidies can only help firms and industries operating locally if they are prepared to compete within value chains and product markets that are increasingly sensitive to obtaining quality and environmentally friendly components at competitive prices and volumes. Furthermore, the natural resource-based industries such as agriculture, fisheries and forestry are finding that the traditional way of conducting business is compromising their ability to market their products. Global buyers are applying consumer preferences and corporate social responsibility requirements. Entities that are pursuing environmental-related investments or are operating in this area find that today as a requirement is the need for the entity's environmental, health and safety, and social standards to be documented and management systems clearly adumbrated. These provide buyers, and potential buyers alike, with the confidence that the product was produced via a sustainable operation. For the producers, they improve competitive agility in dynamic markets. As such, any agricultural strategy for Guyana must be cognizant of these realities.

Action Needed

- Increased agricultural investment in drainage and irrigation schemes, farm to market roads and sea defences to maintain current agricultural lands as well as with a view to bringing new lands under cultivation.
- Designate drainage and irrigation canals public goods so that their operational costs are borne by the entire society rather than the farmers alone. At the same time, the water pricing regime needs to be re-examined and, if possible, be adjusted to demonstrate the value of the resource.
- With climate change threatening the globe it will become necessary to bring additional croplands under cultivation. However, before this is done it is necessary that a comprehensive national land use plan be prepared and feasibility studies conducted.
- A necessary condition for increasing agricultural supplies is to improve the technology with which farmers are asked to work. In this regard, it will be necessary to ascertain, *inter alia*, crop rainfall threshold for various cultivars and work with farmers to develop alternative crops. At the same time, many farmers in the country are dependent upon rain fed irrigation. As such, when the rains fail the crops suffer, resulting in reduced output and productivity levels. It is becoming increasing evident that alternative forms of irrigation systems are necessary, inclusive of drip irrigation. Such systems can also bring additional lands that are currently difficult to cultivate because of limited freshwater, such as the Intermediate Savannahs in Guyana, into the realm of cultivable lands.
- As discussed earlier in this assessment, the average age of a farmer in Guyana is above 40 years old. This has often meant that the transmission of new technical ideas is not always simple and straight-forward. Additionally, many farmers continue to utilise obsolete and

outdated methods of production which, while they were acceptable for a lower population threshold, are now being challenged. Hence there is the need for improved management, through the adoption of newer and improved best practices. But these improvements can be facilitated via the dissemination of the newer findings by the research focused institutions. Additionally, it is imperative that the tertiary institutions be engaging in current and appropriate researches to assist this fledgling sector.

- The time is opportune for the research institutions to pursue more biotechnology options, especially of genetically modified seed for crops and for future research to be focused more on yield-enhancing rather than cost-reducing innovation. To facilitate this, better agro-meteorological data is a prerequisite.
- Too often the discussion on awareness building tends to centre on the so-called public awareness. But awareness that is not targeted and focussed tends to be less effective. As such, the Region has come to the juncture where it needs to pursue a vigorous public education programme about the benefits of agriculture and healthy living. These programmes must aim to change lifestyles and be targeted at specific catchment groups.

7.2 Diversification

Agricultural exports from Guyana are centred on a few products. As a result, the economy is particularly vulnerable to external shocks, such, as declining terms of trade on agricultural products, or a catastrophic event like the global financial crisis. Nationally, given the country's vulnerability to natural disasters such as floods and droughts indicate the fragility of the sector nationally. With a significant number of rural households dependent upon these sectors directly and indirectly, it is imperative that an active diversification programme be pursued, seeking to identify those products or services in which the country may have a competitive advantage.

Action Needed

In seeking to diversify the economic base of the country the following actions can be pursued:

- The private sector should be encouraged through accompanying research and market studies to invest in non-traditional crops that may be endogenous to the country, while also focussing on the production of speciality foods and ethnic (nostalgic) markets. However, before these efforts are pursued, it will be necessary to conduct in-depth market researches and analyses. Additionally, it may become important to select specific products/crops to pursue investment opportunities, i.e., the idea of product chains.
- The agricultural sector needs to be supported by stronger market intelligence and processing facilities. Clearly, one factor that has militated against stronger processing capacity in the country is the cost of energy that is as high as US$0.39/kwh (IDB, 2006), with nearly 50% of this being taxes paid to government coffers. This would need to be re-examined with a view to bringing the cost of energy down.
- Other measures of a public good nature that will be necessary and to build upon those initiatives already occurring in some areas are training and knowledge sharing aimed at small groups of farmers and quality improvement programmes that will enhance food quality by introducing Hazard Analysis and Critical Control Point (HACCP) and quality assurance protocols. Here the efforts being undertaken by CARICOM Regional Organisation for Standards and Quality (CROSQ), Caribbean Food and Nutrition Institute (CFNI), and the Guyana National Bureau of Standards (GNBS).
- The following agricultural support services to agricultural producers or exporters will become necessary. While, as discussed earlier there is some existing capacity in some of

the national institutions, it remains very limited given the high rates of migration experienced in the country and the declining interest shown in agricultural by the younger population. These supporting services should include extension, marketing, financial services, planning, research, and related strategic information. Examples of interventions in each of these areas are the following: (i) Extension: on-farm demonstrations (e.g., irrigation, chemicals use), on-farm training (e.g., post-harvest handling, packaging); analytical services (e.g., soils, entomology, and pathology analysis); other training such as strategic international trade, cold chain, packaging and labels, logistics; implementation of good agricultural practices (GAP), good management practices (GMP), and traceability systems; (ii) Marketing: packaging and labelling design, marketing plans; (iii) Research: adaptive research, product development (e.g., prototype development); (iv) Financial services: trade finance agreements among parties such as buyer/export credit, input supplier credit, and contract farming through alliances between large farmers/supermarket chains; (v) Information: Benchmarking analysis (e.g., local or international costs of production)

- The research entities such as CARDI, CARIRI and NARI should be facilitators in this process, receiving the technological information obtained as a result of the research and development partnerships, evaluate it, and disseminate the information to groups that could also adopt the same technology. These entities should implement a database with the information collected that will be made available to the public across the Region, using the FAO-Carib Net, SIDSNET or some other such electronic media. The rights for the technology acquired or licensed will belong to research institutions.
- Rehabilitate systems to improve the effectiveness of the animal health, plant health and food safety units of the Ministry of Agriculture, transforming such Units in an integrated system to protect domestic consumers from illnesses, and domestic production from disease and contamination while ensuring that the nation's exports meet international standards. This aspect of the Strategy should ensure that the system is established and strengthened to realise policy and regulations coordination.
- Research and technological development needs to focus on the biophysical response of agricultural production to climate change. For example, the following questions need to be answered: (i) How and under what conditions will climate change increase and/or reduce production? and (ii) In affected areas, how difficult will it be for producers to shift to different crops, to adopt new cropping patterns, and to adjust production practices to the new environment?

7.3 Information Systems Management

Globally it has become firmly recognised that information sharing is critical for avoiding catastrophes, and destruction of lives and livelihoods. In Guyana this is even truer because of the vulnerability of the country to natural disasters, some of which are said to be occasioned by climate change. In this scenario therefore, the following actions are vital.

Action Needed

- The country has benefited and is expected to continue to benefit from the establishment of the Caribbean Community Climate Change Centre (CCCCC) in Belize. Additionally, under the Regional Programme on the Mainstreaming Adaptation to Climate Change (MACC), the country is benefiting from the erection of early warning systems to natural disasters. But such systems will need to be supported and maintained. In this regard, public involvement and education programmes are necessary. Additionally, it will be

imperative that scholarships are offered to persons to pursue studies in meteorology, climatology, and other such disciplines to ensure that the human capacity is present within the region to support these systems. But early warning systems are not only necessary for climatological changes, but market intelligence as well. This point is discussed under the next bullet.

- As one of the objectives of the Strategy is to substantially increase the sale revenue accruing to rural, farming and vulnerable households, it will be imperative to ensure that producers have access to information on new markets on a timely basis. Additionally, it is imperative that information pertaining to benefits derived is disseminated throughout the country through the electronic media, workshops, seminars, etc., and advising on how the pitfalls can be avoided. Through these efforts, one would expect other stakeholders to become engaged.
- Expand and educate farmers and Extension Officers nationally on the use of the FAO-Caribnet forum for the exchange of ideas, discussion of best practices and country experiences. But even this would not be sufficient since many small farmers in Guyana do not have access to the Internet. In this vein therefore, there is the need to strengthen the extension services, as well as to establish information centres where farmers can be trained in the use of the Internet and have access to same.

7.4 Improved Coordination of Programmes

There is undoubtedly a significant amount of diverse initiatives being pursued nationally having varying degrees of impact on the agricultural sector. However, quite often there is the absence of an effective coordinating mechanism. It is therefore becoming increasingly clear that there is the continued development of national and regional initiatives that seek to link policies and programmes across sectors and advocacy to apprise governments as to the dimensions and impacts of climate change on the agricultural sector. However, there are still a number of critical issues to address.

Action Needed

- To enhance the coordinating mechanism for the pursuance of agricultural expansion through strengthening or resuscitating the Agricultural Development Unit of the CARICOM Secretariat
- Create a mechanism, whether via existing arrangements under other programmes or new arrangements, monitor, track and disseminate information related to agricultural production nationally and regionally
- Implement a regional development fund called for by President Jagan since 1993 that will focus on investing in rural areas and in initiatives to create opportunities for employment of rural youths and vulnerable groups. For example, this fund can also be used to ensure that re-tooling of those displaced by the new and emerging challenges are being addressed. Another purpose of this fund will be to assist the efforts of the NGOs in the region that are working with sectors and individuals that impact food and nutritional security.

BIBLIOGRAPHY

ADE (2005) Study into impact of changes in the EU'S rice regime on the rice sector of ACP countries Draft Report, 6 January 2005, Chapter: Main Findings.

Agrotec SPA (2002) Feasibility study of CARIFORUM Rice Industry, Georgetown.

Bank of Guyana (2008) Annual Report, Financial Statement of Accounts 2008, Georgetown.

Bernard, Deryck M., (1999), *A New Geography of Guyana,* London.

Bureau of Statistic (2008). Statistical Bulletin (2008), Statistical Bureau, Georgetown.

Bureau of Statistics (2008) Statistical Bulletin, September 2008, Georgetown.

Bynoe, Paulette and Bynoe, Mark. (1999). *Final Report on a Socio- Economic Assessment of the Vulnerability of Guyana's Coast'*, Georgetown.

Bynoe, Mark (2006) Are Guyanese Rice Farmers Doing the Best they Can Under the Current Circumstances, Unpublished Paper.

CARICOM (2005) Statistical Bulletin, Georgetown.

Economic Commission for Latin America and the Caribbean (2006) Guyana Macro-Socio Economic Assessment of the Damage and Losses Caused by the January-February 2005 Flooding, Port-of-Spain.

Environmental Protection Agency (2002) Guyana's National Vulnerability to Sea Level Rise, Environmental Protection Agency, Turkeyen.

European Union (2005), Guyana Transport Sector Study, Working Paper #4, pp 18-19, Georgetown.

Faal, Abrima (2002). 'Currency Demand, the Underground Economy and Tax Evasion: The Case of Guyana', IMF Working Paper WP/03/7. IMF, Washington, D.C.

FAO (2008) Climate Change and Food Security: A Framework Document, FAO/UN, Rome.

Government of Guyana (2000), National Development Strategy (2000 – 2010).

Government of Guyana (2006) *Poverty Reduction Strategy Progress Report – 2005*, Georgetown (unpublished report).

Guyana Forestry Commission (2001), *National Forest Plan,* Georgetown.

Guyana Forestry Commission (2008) *Forestry in Guyana: 2007,* Georgetown.

Guyana Rice Development Board (2008) Annual Report: 2007, GRDB, Georgetown.

Guyana Sugar Corporation (2006) Business Plan, GuySuCo, Georgetown.

Inter-American Development Bank (2005) Damage Assessment Report of the 2005 Floods, Georgetown.

Inter-American Development Bank (2008) Support for a Second Low Income Settlement Program: Plan of Operations, Washington, D.C.

Inter-American Institute for Cooperation in Agriculture (IICA) (1991) Guyana Agricultural Sector Assessment, Georgetown.

Kane, S., Reilly, J. and Tobey. J. 1991. *Climate Change: Economic Implications for World Agriculture*. US Department of Agriculture. Economic Research Service. AER-No. 647.

Ministry of Agriculture (2002) Guyana Initial National Communication, Georgetown.

Ministry of Agriculture (2002) Guyana Initial National Communication, Georgetown.

Ministry of Agriculture (2006) Guyana National Action Plan for the Sugar Industry, Ministry of Agriculture, Georgetown.

Ministry of Amerindian Affairs (2003) Sustainable Agriculture and the Development of the Amerindians in Guyana: *The case of the Mabaruma/Hosororo Organic Cocoa Project,* Georgetown.

Ministry of Finance (2003a), *Budget Speech* Eighth Parliament of Guyana*,* Sessional Paper No. 1 of 2003, Georgetown World Bank (2003) Guyana Development Policy Review, World Bank, Washington.

Ministry of Finance (2008) Budget Speech: 2008, Georgetown.

Mott MacDonald (2004) Guyana Drainage & Irrigation Systems Rehabilitation Project Feasibility Study of Principal Areas, Georgetown.

Mott MacDonald (2006) Feasibility Study for the Sea Defences Programme financed under the 9th EDF for "The Co-operative Republic of Guyana": Feasibility Report (Final Report), Georgetown.

Rosenzweig, C., M. L. Parry, G. Fischer, and K. Frohberg, (1993) *Climate change and world food supply*. Research Report No. 3. Oxford: University of Oxford, Environmental Change Unit.

Shutt, Harry, Moore, David and Bynoe, Mark (2007) Social Impact Assessment of the Guyana National Action Plan on Sugar (Final Report), Georgetown.

Singh, Ranjit *et al.*, (2001), *The Caribbean Poultry Industry: Competitiveness Trade Policy and Development Strategies,* Kingston.

Statistical Bureau (2007) Living Condition Index, Georgetown.

Statistical Bureau (2007) Marginality Index, Georgetown.

Tobey, J., Kane, S. and Reilly, J. 1993. An empirical study of the economic effects of climate change on world agriculture. *Climatic Change*. EarthScan.

Trostle, Ronald (2008) *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices*, United States Department of Agriculture, Washington.

World Bank (2003) Guyana Development Policy Review, World Bank, Washington.

Appendix A1: Percentage Contribution by Sector to the GDP at Current Factor Cost

Sector	Actual				Budget
	2004	2005	2006	2007	2008
AGRICULTURE, FORESTRY AND FISHING	**31.3**	**30.3**	**30.2**	**27.3**	**27.3**
Sugar-cane	11.0	8.3	9.5	6.6	6.6
Rice paddy	4.7	5.1	4.8	4.2	4.1
Other crops	2.5	2.6	2.3	2.4	2.4
Livestock	4.5	5.0	4.6	4.9	5.0
Fishing	6.8	7.1	6.6	7.0	7.1
Forestry	2.0	2.2	2.4	2.1	2.2
MINING AND QUARRYING	**12.1**	**10.5**	**9.7**	**11.2**	**10.6**
Bauxite	1.4	2.6	2.3	3.2	3.4
Other	10.7	7.8	7.4	8.1	7.2
MANUFACTURING	**9.6**	**8.0**	**8.7**	**7.6**	**7.3**
Sugar	4.4	3.4	3.8	2.6	2.6
Rice	2.1	1.1	1.2	1.2	1.0
Other	3.1	3.6	3.6	3.7	3.8
ENGINEERING & CONSTRUCTION	**5.2**	**6.2**	**6.4**	**6.8**	**6.9**
SERVICES	**41.7**	**45.0**	**45.0**	**47.1**	**47.9**
Distribution	4.1	4.7	5.2	5.8	6.0
Transportation	9.7	11.3	11.3	12.8	13.6
Rental of Dwellings	4.2	4.7	4.8	5.0	5.0
Financial Services	3.6	3.9	4.0	4.4	4.5
Government	18.3	18.4	17.6	17.0	16.5
Other	1.8	2.0	2.1	2.3	2.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Appendix A2: Agricultural Statistics

Rice Production (mt), Export Volume, Export Value				
Year	**Production**	**Exports**		
		Qty (M/T)	**Val (US$000)**	**F.O.B. Price (US$)**
1983	147,639	41,715	21,608	518
1984	179,785	47,498	21,517	453
1985	156,124	29,339	13,261	452
1986	171,044	38,634	13,290	344
1987	145,879	68,987	15,867	230
1988	132,281	55,926	13,926	249
1989	142,309	40,574	13,511	333
1990	93,444	50,943	12,990	255
1991	150,783	54,047	18,592	344
1992	170,977	115,102	34,991	304
1993	201,702	124,090	33,008	266
1994	233,111	182,586	55,506	304
1995	315,301	200,336	76,328	381
1996	332,542	262,265	93,629	357
1997	340,911	285,051	84,090	295
1998	339,890	249,755	75,975	304
1999	365,469	251,519	62,427	248
2000	291,967	207,638	42,026	202
2001	322,311	209,042	36,039	172
2002	228,375	193,415	37,116	192
2003	355,018	200,432	45,097	225
2004	325,593	243,092	54,939	226
2005	273,238	182,175	46,090	253
2006	307,037	204,577	53,804	263
2007	298,125	269,436	75,173	279

Appendix A3: Annual Exports of Selected Commodities by Value (G$'000)

(G$ '000)

Period	Sugar	Rice	Bauxite		Shrimp/ Prawns	Rum	Molasses	Timber/ Plywood
			Dried	Calcined				
1989	2,310,000	367,400	733,530	1,288,457	442,000	212,454	1,420	89,106
1990	3,266,000	513,200	1,178,292	1,993,750	906,142	330,281	1,085	181,473
1991	11,692,000	2,102,600	3,257,536	5,764,205	2,026,179	268,494	424	458,032
1992	16,598,800	4,307,747	2,062,575	4,290,777	1,702,612	416,329	43,254	468,070
1993	14,809,359	4,144,480	2,132,191	4,714,029	1,447,466	520,306	180,164	568,112
1994	16,763,401	7,264,606	1,444,960	3,887,945	1,832,183	560,913	63,417	1,042,918
1995	17,907,241	10,838,341	6,768,298	4,746,202	1,614,322	748,685	72,942	1,111,976
1996	21,256,836	12,558,046	8,547,810	3,235,784	1,648,251	959,028	108,103	6,301,696
1997	18,497,537	11,288,876	8,568,034	3,170,750	1,995,381	839,381	98,370	5,493,030
1998	18,314,142	10,309,517	8,836,052	2,808,151	2,490,437	663,670	24,105	4,235,636
1999	25,090,713	10,219,765	9,450,887	2,475,893	2,878,418	497,303	391,753	5,946,888
2000	22,106,015	7,455,082	11,654,957	2,195,056	5,983,610	679,253	250,765	7,992,400
2001	19,698,728	8,745,834	9,946,840	2,323,404	7,841,568	822,158	307,432	6,864,223
2002	22,562,977	8,501,691	5,240,347	1,479,236	6,563,565	1,471,607	543,705	6,623,915
2003	25,160,107	8,463,601	6,074,392	1,757,791	6,931,364	1,135,448	605,447	5,798,765
2004	18,632,374	10,470,322	4,357,419	3,256,365	6,811,780	1,019,876	579,651	8,920,079
2005	23,522,498	9,051,705	6,839,050	5,726,055	8,023,585	411,660	764,240	9,909,964
2006	27,388,228	10,706,027	8,725,503	4,440,332	7,503,284	517,669	812,245	14,062,998
2007	30,309,683	15,190,602	12,653,659	7,882,937	8,494,666	490,106	554,622	11,190,724

Source: Bureau of Statistics

Note 1: 2005 figure for shrimp was revised.

Appendix A4: Farm Budgets

Estimated Cost of Production for an Acre of Sugar Cane (2006)				
	Unit	Unit Price	Units/ha	G$/ha
Gross Returns				
Sugarcane	ton	3,500	86.45	302,575
Total Gross Returns			0	302,575
			0	0
Variable Costs			0	0
Materials			0	0
Planting material	kg	7	988	6,916
Urea	kg	60	370.5	22,230
DAP	kg	70	12.35	864.5
MoP	kg	60	123.5	7,410
Herbicide	litre	1,200	0	5,928
Fungicide	kg	1,500	1.24	0
Insecticide	litre	1,750	0	2,161.25
			0	45,509.75
			0	0
Hired Labour			0	0
Sowing	day	1,000	2.47	2,470
Harvesting	day	1,000	148.2	148,200
			0	150,670
			0	0
Machinery hire			0	0
Tractor ploughing	day	1,500	0.49	741
Tractor harrowing	day	1,200	0.49	592.8
Irrigation pumping	day	1,000	0.25	247
			0	1,580.8
			0	0
Interest on seasonal credit	%	10	0	9,887.41
			0	0
Total Variable Costs			0	207,648
			0	0
Gross Margin per acre			0	94,927.04

Estimated Cost of Production of an Acre of Rice (2006)				
	Unit	Unit Price	Units/ha	G$/ha
Gross Returns				
Paddy	Bag	1,450	74.1	107,445
Straw	Tons	250	4.94	1,235
Total Gross Returns			0	108,680
Variable Costs			0	0
Materials			0	0
Seed	bag	2,250	2.47	5,557.5
Urea	kg	60	185.25	11,115
TSP	kg	72	61.75	4,693
Herbicide	litre	1,000	2.47	2,470
Fungicide	kg	1,500	0.49	741
Monocrotophos	litre	1,200	3.70	4,446
Pestac	litre	2,250	0.49	1,111.5
Karatox	kg	1,750	0.49	864.5
			0	30,998.5
Hired Labour			0	0
Harvesting/bagging	bag	30	74.1	2,223
			0	0
Machinery hire			0	0
Tractor ploughing	acre	1,700	4.94	8,398
Tractor harrowing			0	0
Tractor raking/levelling	acre	1,000	2.47	3,705
Irrigation pumping	acre		0	0
Combine harvesting	bag	170	74.1	12,597
			0	26,923
			0	0
Transport to mill	bag	75.0	74.1	5,557.5
			0	0
Interest on seasonal credit	%	10.0	0	3,638.31
			0	0
Total Variable Costs			0	76,404.51
			0	0
Gross Margin per acre			0	-11,258.3

Estimated Cost of Production for an acre of Vegetables (2006)				
	Unit	Unit Price	Units/ha	G$/ha
Gross Returns				
Vegetables	kg	145.0	56.81	63,911.25
Crop residue	kg	1.0	4.94	1,235
Total Gross Returns			0	65,146.25
			0	0
Variable Costs			0	0
Materials			0	0
Seed	bag	2,250.0	2.47	5,557.5
Urea	kg	60.0	185.25	11,115
TSP	kg	65.0	61.75	4,013.75
Herbicide	litre	1,000.0	2.47	2,470
Fungicide	kg	1,500.0	0.49	741
Monocrotophos	litre	1,200.0	3.71	4,446
Pestac	litre	2,250.0	0.49	1,111.5
Karatox	kg	1,750.0	0.49	864.5
Bags/twine	bag	200.0	5.68	1,136.2
			0	31,455.45
			0	0
Hired Labour			0	0
Sowing	Day	1,000.0	2.47	2,470
Fertilising	Day	1,000.0	4.94	4,940
			0	7,410
			0	0
Machinery hire			0	0
Tractor ploughing	acre	600.0	4.94	7,410
Tractor harrowing	acre	500.0	4.94	5,928
Tractor raking/levelling	acre	400.0	2.47	2,470
Aerial broadcasting	acre	700.0	2.47	1,729
Aerial spraying/Fertilising	acre	500.0	17.29	8,645
Irrigation pumping	acre	400.0	9.88	3,952
Combine harvesting	bag	50.0	56.81	2,840.5
			0	23,588.5
			0	0
Transport to mill	bag	75.0	56.81	4,260.75
			0	0
Interest on seasonal credit	%	10.0	0	3,265.34
			0	0
Total Variable Costs			0	68,559.79
			0	0
Gross Margin per acre			0	-3,413.54

Appendix A5: Production Statistics of Traditional and Non-Traditional Agricultural Products (1992 – 2007)

PRODUCTION OF SELECTED AGRICULTURAL COMMODITIES 1992 – 2007

Source: Ministry of Agriculture

COMMODITY	Unit	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Rice (GRDB)	000 mt	*170.9*	*207.4*	*235.4*	*301.7*	*310.7*	*340.9*	*339.9*	*365.5*	*291.9*	*322.3*	*288.3*	*355*	*325.6*	*273.2*	*307.0*	*298.1*
Sugar	000 mt	246.9	246.5	256.7	253.8	280.1	276.4	253.9	321.4	273.3	284.1	331.1	302.3	325.3	302.3	259.5	
Refined Oil	000 gals	536.9	442.6	590.2	789.3	730.7	628.7	708.8	425.1	.8	.5	186.9	372	115.1	107.6	171.1	208.0
Coconut (dry)	mill nuts	56.3	63.0	72.0	91.5	131.5	435.6	71.0	90.0	98.9	52.5	72.3	105.3	78.2	74.2	61.9	68.5
Peanut	000 mt	1.6	2.0	1.9	1.7	2.3	2.3	2.3	2.3	2.3	1.3	1.3	1.31	1.3	1.3	1.3	1.3
Blackeye	000 mt	0.4		0.5	0.4	0.4	0.9	0.3	0.3	0.3	0.2	0.04	0.05	0.06	0.6	0.1	0.6
Minica	000 mt	0.2		0.2	0.5	0.5	0.5	0.3	0.2	0.4	0.3	0.9	0.5	0.4	0.5	0.4	0.5
Corn	000 mt	3.2	3.5	3.3	3.8	3.1	7.9	3.1	3.2	3.8	2.0	1.0	1.1	1.43	1.3	1.5	1.0
Other Legumes	000 mt	0.9	0.9	1.0	2.3	0.1	0.2	0.1	0.1	0.1	0.0	7.9	0.02	0.01	1.9	0.02	0.01
Plantain	000 mt	13.0	13.2	19.4	21.2	17.6	13.6	8.2	6.5	23.3	16.9	9.2	5.42	5	4.3	4.2	4.2
Ground Provision	000 mt	13.3	13.5	13.4	12.9	12.9	16.0	6.9	8.6	15.3	11.4	5.4	8.73	11.01	7.8	8.6	7.1
Cassava	000 mt	30.8	30.1	29.2	35.1	35.3	40.5	26.0	28.1	44.9	28.9	20.0	27.4	27	20.1	23.2	20.2
Tomato	000 mt	1.6	1.9	2.0	3.3	2.5	3.0	1.2	1.6	4.7	2.6	0.3	2.62	1.3	0.8	4.0	2.0
Cabbage	000 mt	1.3	1.7	1.8	2.6	1.8	1.2	0.9	0.7	0.3	0.3	0.4	1.9	1.15	1.1	1.8	1.5
Citrus	000 mt	7.2	7.6	7.6	6.6	2.8	2.8	4.3	6.5	14.5	11.9	3.5	7.9	8.6	6.4	10.0	7.6
Pineapple	000 mt	8.8	9.5	10.1	10.6	7.2	10.5	1.2	2.5	3.2	4.4	0.5	1.7	3	1.4	3.1	1.3
Banana	000 mt	13.3	13.6	16.1	16.7	14.3	11.0	11.2	9.1	18.6	17.1	20.0	16.81	8	6.6	6.7	5.9
Milk	mill gals	8.6	8.6	8.7													
Beef	000 mt	4.2	3.8	4.6	3.8	6.0	2.1	2.1	1.8	1.9	1.3	1.9	2.1	2.2	2.1	2.2	1.8
Pork	000 mt	1.1	0.5	0.5	0.4	2.9	0.4					0.5	0.45	0.43	0.38	0.39	0.40
Poultry	000 mt	3.1	4.1	6.2	7.3	10.7	.7(15)	11.3	12.4	11.8	12.5	15.6	23.7	24.3	22.6	20.7	25.1
Table eggs	mill eggs	7.3	8.5	16.5	30.4	38.1	30.3(37.9)	24.0	25.7	30.1	25.7	17.4	9.3		24.1	5.4	6.5
Fish	000 mt	37.1	37.2		37.0	39.0	36.9	39.4	41.3	28.6	25.2	23.7	61.9	36	30.3	24.6	27.4
Shrimp/Prawns	000 mt	6.0	6.1		17.0	22.9	24.5	31.2	14.4	19.3	25.8	19.9	22.6	16.3	18.4	17.3	36.5

Appendix A6: Summary of Damage Caused by the 2005 Floods[50]

REGION	SUGAR	RICE	OTHER CROPS	LIVESTOCK	FISHERIES	FORESTRY	FARM ROADS	NARI	GSA	TOTAL
DIRECT DAMAGE										
2	-	44,632,000	159,811,000	-	-	-	3,525,000	-	-	207,968,000
3	475,473,719	185,040,000	1,598,412,000	38,707,300	-	-	9,306,000	-	-	2,306,939,019
4	1,606,191,140	69,859,200	3,337,318,000	445,275,670	194,925	56,000,000	38,540,000	26,992,000	12,691,300	5,593,062,235
5	-	1,087,752,798	584,694,000	92,567,920	-	-	75,576,000	-	-	1,840,590,718
6	-	55,287,200	-	-	-	-	14,946,000	-	-	70,233,200
TOTAL	2,081,664,859	1,442,571,198	5,680,235,000	576,550,890	194,925	56,000,000	141,893,000	26,992,000	12,691,300	10,018,793,172
INDIRECT DAMAGE										
2	-	6,595,160	11,447,785	-	-	-	-	-	-	18,042,945
3	77,463,963	30,385,300	118,644,615	2,119,230	-	-	-	-	-	228,613,108
4	177,207,739	11,591,804	144,245,371	23,659,605	34,200	14,000,000	-	22,140,500	10,218,343	403,097,562
5	-	183,920,746	23,539,365	5,167,685	-	-	-	-	-	212,627,796
6	-	13,074,500	-	-	-	-	-	-	-	13,074,500
TOTAL	254,671,702	245,567,510	297,877,136	30,946,520	34,200	14,000,000	-	22,140,500	10,218,343	875,455,911
TOTAL DAMAGE										
2	-	51,227,160	171,258,785	-	-	-	3,525,000	-	-	226,010,945
3	552,937,682	215,425,300	1,717,056,615	40,826,530	-	-	9,306,000	-	-	2,535,552,127
4	1,783,398,879	81,451,004	3,481,563,371	468,935,275	229,125	70,000,000	38,540,000	49,132,500	22,909,643	5,996,142,297
5	-	1,271,673,544	608,233,365	97,735,605	-	-	75,576,000	-	-	2,053,218,514
6	-	68,361,700	-	-	-	-	14,946,000	-	-	82,857,700
GRAND TOTAL	**2,336,336,561**	**1,688,138,708**	**5,978,112,136**	**607,497,410**	**229,125**	**70,000,000**	**141,893,000**	**49,132,500**	**22,909,643**	**10,894,249,083**

[50] Please note that these figures are in Guyana dollars. A conversion of G$200 = US$1 should be used to take these figures to US$.

Appendix A7: INTRA REGIONAL MERCHANDISE TRADE WITHIN CARICOM, 1993-2003

Intra- regional Exports												AAGR (%)
US $mn	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	1993-2003
The Bahamas	…	…	…	…	…	…	…	…	…	…	…	…
Barbados	71	65	91	103	102	112	119	121	111	102	103	3.7
Belize	5	5	6	5	8	12	10	9	12	11	18	13.9
Guyana	35	39	48	47	56	44	61	76	72	90	99	11.1
Haiti	0.0	0.0	0.0	0.3	0.1	0.3	0.5	0.4	0.3	0.2	0.2	…
Jamaica	62	62	62	57	49	46	45	52	54	52	63	0.0
Suriname	8	10	12	24	27	25	24	21	26	34	40	17.5
Trinidad & Tobago	370	395	552	636	663	690	756	1,022	1,080	825	1,059	11.1
OECS 1/	72	68	73	67	74	84	80	80	78	79	85	1.6
CARICOM (-) T&T	254	249	290	302	315	324	340	359	353	368	408	4.9
CARICOM 2/	624	644	843	938	978	1,014	1,095	1,381	1,433	1,194	1,467	8.9

Share of CARICOM Intra- regional Exports												Share (%)
Share (%)	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	1993-2003
The Bahamas	…	…	…	…	…	…	…	…	…	…	…	…
Barbados	11	10	11	11	10	11	11	9	8	9	7	9.5
Belize	1	1	1	1	1	1	1	1	1	1	1	0.9
Guyana	6	6	6	5	6	4	6	5	5	8	7	5.8
Haiti	0	0	0	0	0	0	0	0	0	0	0	0.0
Jamaica	10	10	7	6	5	5	4	4	4	4	4	5.2
Suriname	1	2	1	3	3	2	2	2	2	3	3	2.2
Trinidad & Tobago	59	61	66	68	68	68	69	74	75	69	72	69.3
OECS	12	11	9	7	8	8	7	6	5	7	6	7.2
CARICOM	100	100	100	100	100	100	100	100	100	100	100	100.0

Intra- regional Imports												AAGR (%)
US $mn	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	1993-2003
The Bahamas	…	…	…	…	…	…	…	…	…	…	…	…
Barbados	110	117	123	124	124	163	163	230	218	158	285	10.0
Belize	11	11	13	11	11	11	13	14	21	15	15	3.5
Guyana	75	79	109	117	99	91	80	98	107	105	166	8.3
Haiti	3	2	11	10	11	9	10	29	31	33	40	…
Jamaica	116	153	240	289	318	311	368	401	434	400	484	15.4
Suriname	71	67	51	70	76	65	82	73	64	80	94	2.9
Trinidad & Tobago	60	52	54	85	97	106	132	125	121	92	95	4.7
OECS 1/	176	181	194	206	224	235	249	261	242	238	271	4.4
CARICOM (-) T&T	561	611	741	826	863	884	966	1,095	1,126	1,030	1,356	9.2
CARICOM 2/	620	663	795	911	960	990	1,097	1,221	1,248	1,122	1,450	8.9

Share of CARICOM Intra- regional Imports												Share (%)
Share (%)	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	1993-2003
The Bahamas	…	…	…	…	…	…	…	…	…	…	…	…
Barbados	18	18	15	14	13	16	15	19	18	14	20	16.4
Belize	2	2	2	1	1	1	1	1	2	1	1	1.3
Guyana	12	12	14	13	10	9	7	8	9	10	11	10.2
Haiti	0	0	1	1	1	1	1	2	2	3	3	1.7
Jamaica	19	23	30	32	33	31	34	33	35	36	33	31.7
Suriname	11	10	6	8	8	7	8	5	6	7	6	7.2
Trinidad & Tobago	10	8	7	9	10	11	12	10	10	8	7	9.2
OECS	28	27	24	23	23	24	23	21	19	21	19	22.4
CARICOM	100	100	100	100	100	100	100	100	100	100	100	100.0

Notes: OECS excludes Antigua and Barbuda. CARICOM excludes Antigua & Barbuda and The Bahamas.
Source: IDB Integration and Regional Programs Department estimates using IMF and UN data.

SHARE OF INTRA-REGIONAL EXPORTS IN TOTAL EXPORTS 1993-2003

CARICOM 1/	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR (%)
Total Exports (US$mn)	4,107	4,733	5,517	5,697	5,869	5,506	6,122	7,634	8,288	6,835	8,575	7.6
Extra –regional (E-R)	3,482	4,089	4,675	4,759	4,891	4,492	5,027	6,252	6,854	5,641	7,108	7.4
Intra-Regional (I-R)	624	644	843	938	798	1,014	1,095	1,381	1,433	1,194	1,467	8.9
I-R / Total Exports (%)	15.2	13.6	15.3	16.5	16.7	18.4	17.9	18.1	17.3	17.5	17.1	

OECS 2/	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR (%)
Total Exports (US$mn)	275	236	254	222	226	224	224	256	223	216	210	-2.6
Extra –regional (E-R)	202	168	181	156	153	161	144	176	145	138	125	-4.7
Intra-Regional (I-R)	75	68	73	67	74	84	80	80	78	79	85	1.6
I-R / Total Exports (%)	26.4	28.7	28.8	30.0	32.6	34.2	35.8	31.3	35.0	34.6	40.5	

CARICOM (-) T&T 3/	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR (%)
Total Exports (US$mn)	2,444	2,779	3,050	3,128	3,300	3,242	3,316	3,360	3,174	2,981	3,334	3.2
Extra –regional (E-R)	2,191	2,530	2,760	2,826	2,984	2,919	2,997	3,001	2,821	2,613	2,926	2.9
Intra-Regional (I-R)	254	249	290	302	315	324	340	359	352	368	408	4.9
I-R / Total Exports (%)	10.4	8.9	9.5	9.6	9.6	10.0	10.2	10.7	11.1	12.4	12.2	

BARBADOS	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR (%)
Total Exports (US$mn)	181	182	238	279	283	259	251	273	259	215	250	3.3
Extra –regional (E-R)	110	117	147	177	181	144	132	172	148	113	147	3.0
Intra-Regional (I-R)	71	65	91	103	102	112	119	121	111	102	102	1.7
I-R / Total Exports (%)	39.5	35.6	38.1	36.7	36.0	43.4	47.5	44.2	42.9	47.3	41.1	

BELIZE	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR (%)
Total Exports (US$mn)	127	143	162	168	176	162	176	200	182	164	203	2.2
Extra –regional (E-R)	122	138	156	163	169	151	166	191	170	153	185	0.9
Intra-Regional (I-R)	5	5	6	5	8	12	10	9	12	11	18	11.1
I-R / Total Exports (%)	3.9	3.5	3.2	2.8	4.3	7.1	5.7	4.5	6.6	6.9	8.9	

GUYANA	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	AAGR (%)
Total Exports (US$mn)	414	456	455	517	644	484	523	498	477	493	515	2.2
Extra –regional (E-R)	379	417	407	470	588	440	462	422	405	403	416	0.9
Intra-Regional (I-R)	35	39	38	47	56	44	61	76	72	90	99	11.1
I-R / Total Exports (%)	8.4	8.6	10.5	9.1	8.7	9.1	11.7	15.2	11.1	18.2	19.3	

APPENDIX B. TECHNICAL ASSESSMENT OF CLIMATE CHANGE ON THE AGRICULTURAL SECTOR

1. INTRODUCTION

Increasing weather variability and its consequent impacts on lives, infrastructure and well being of people are being experienced more regularly. There are frequent reports of intense storms that often lead to of flooding and a loss of lives, livelihoods and food security[51] on one side of the planet, drought on another side, and intense storms that wreak havoc and threaten man's ability to exist as well as his food security. The World Meteorological Organization (WMO) had established the Intergovernmental Panel on Climate Change (IPCC) with a mandate to provide the world community with the most current and comprehensive scientific, technical and socio-economic information on climate change. This has motivated governments to ratify and implement multilateral environmental agreements, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, and have implemented policies in response to climate change.

Climate change involves a general trend of temperature increase across the globe, but also entails fundamental changes in weather patterns, including changes in the persistence and magnitude of El Nino-Southern Oscillation (ENSO) occurrences; events such as hurricanes, tornadoes and droughts that fundamentally change everyday rainfall patterns and sea levels (IPCC, 2007).

Agriculture remains pivotal to the Guyanese economy as discussed in the economic review section of this report. A dense network of drainage and irrigation canals service the sector supported by natural (mangrove forests mainly) and man-made sea defences that for the most part keeps the Atlantic Ocean at bay. Guyana enjoys some competitive advantages in agriculture within the Caribbean given its arable and pastoral lands, and freshwater supply. As such, given the importance of the agricultural sector to Guyana and its historical and new markets that are emerging, climate change poses both challenges and opportunities for the sector.

Based on projections, it is anticipated that there will be an increase in temperature, a slight decrease in total rainfall varying over the country, together with changes in the length of the seasons (INC, 2002). This, therefore, means that there will be more intense rainfall during the wet season.

Global warming means that there will be an increase in atmospheric temperature as a result of the increased concentrations of greenhouse gases (GHG), methane () from agricultural practices, nitrous oxides () from degrading of nitrogen fertilizers, carbon dioxide () from burning of fossil fuels, and other compounds containing carbon and chlorofluorocarbons (CFCs) used in the refrigeration and cooling industry. Increased levels of are projected to result in higher rates of photosynthesis. Despite the increase in photosynthesis the changes in temperature may have a far greater detrimental effect, resulting in a general trend of reduction in productivity. This is because there is likely to be an

[51] Food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food security includes at a minimum (1) the ready availability of nutritionally adequate and safe foods, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (that is, without resorting to emergency food supplies, scavenging, stealing, or other coping strategies) (FAO, 2006)

increase in plant transpiration rates and evaporation, leading most likely to deficits in soil moisture supply (GuySuCo, 2007). The presence of CFC gases in the atmosphere not only adds to the greenhouse effect but also causes depletion of the ozone layer. This depletion will allow the entry of UV-B radiation on plants and animals leading to genetic mutations, suppression of the immune system, thus reducing the resistance to diseases; it may also cause blindness, skin cancer and disruption of the food chain due to warming of the environment.

1.1 Intent of the Report

The intent of this assessment is to highlight the technical, agricultural and economic impacts of climate change on the agricultural sector. By so doing, it is hoped that adaptation measures that will be crafted in the agricultural strategy will be mainstreamed in the planning cycle of current and future development plans, programmes and projects. Such an approach may assist in placing the agricultural sector on a firm technological foundation to deal with climate impacts, while making the sector more competitive and diversified to take advantage of the opportunities presented by climate change and adapt to the challenges that it will pose.

1.2 Overall and Specific Objectives

The overall objective of this assessment is to conduct a technical analysis of the agricultural sector. Emanating from this assessment, the specific objectives that are expected to be fulfilled are:

- To determine the vulnerability of the agriculture sector to climate change impacts based on the downscale scenario;
- To survey key institutions in the sector in an effort to identify current and planned programmes they may have to address climate change issues; and
- To determine what opportunities are presented by climate change and how these might be exploited by the agricultural sector nationally.

1.3 Guiding Questions for this Report

In compiling this assessment certain key questions were considered. These included:

- Will climate change significantly affect domestic agricultural production?
- Will climate change lead to increase pest infestations and pathogens?
- Will climate change affect the competitiveness of Guyana's agricultural exports?
- Will climate change cause food shortages and lead to an increase in hunger?
- Will Climate change threaten agricultural exports or create opportunities for new markets?
- Will climate change affect key government policies in relation to agricultural pricing, financial support and research and development?
- Will climate change increase food prices to consumers nationally?

1.4 Methodology

This technical assessment was informed by a plurality of methodologies that were both quantitative and qualitative in nature. These included:

- Client interview - key policymakers were interviewed in the MoA, including the Minister of Agriculture, the Chair of the National Climate Committee, the Coordinator of the NCU, and the Project Manager of the MACC Project.
- Collection and study of reports and relevant documents, including documents on models and forecasts of future climate and utilizing the UNEP IVM Handbook Methodology.
- Conducting our own modelling analyses that included looking at climate related data and correlating this with agricultural data.
- Stakeholder consultations/survey analysis - in order to acquire a better understanding of the level of knowledge present within the various agencies on climate change and its impacts on the agricultural sector, and what programmes were being pursued that may inform the Strategy and Action Plan that emerged out of the respective analyses.

1.5 Constraints

The main constraint was acquiring data of a sufficient quality to conduct the type of detailed analysis necessary. As such, we were forced to use secondary sources, our professional judgment and what meagre information that was made available.

2. GLOBAL AND NATIONAL CLIMATE CONTEXTS

The Fourth IPCC Report (IPCC, 2007 a, b, c) concludes that there is significant evidence that the observed changes in the global climate systems are influenced by human activities. In support of the conclusions of the IPCC Third Assessment Report (IPCC, 2001), the Fourth Assessment Report stresses how human-induced climate change will not only affect global temperature, but will lead to changes in the entire climate system, including precipitation patterns and intensity, wind patterns, accelerated sea level rise, frequency and intensity of extreme weather events. It also notes that the impacts of these changes will vary in severity in different regions of the world.

The Report notes the following biophysical impacts of climate change:

- Global sea level rise, IPCC best estimate towards Century is 0.26m - 0.51m by 2090,
- Changes in rainfall patterns, increased intensity, and shifts in seasons.
- Global temperature increase with a likely range of 2.4-6.4 towards the Century.
- High humidity or an increase in water vapour in the atmosphere.

According to the IPCC Assessment Report (2007) coastal areas are projected to be exposed to increasing risks from sea level rise associated with climate change and melting ice caps. This may make coastal areas more susceptible to erosion that maybe exacerbated by human induced-pressures on coastal areas that include, *inter alia*, increased population growth, removal of mangroves, and increased fossil consumption and pesticide usage (see Table B.1). Coastal wetlands including salt marshes are projected to be negatively affected by sea level rise especially where they are constrained by their landward side or starved of sediment (IPCC, 2007). Furthermore, the bio-physical impacts on coastal and low lying States are likely to be more austere from climate change than elsewhere (Bijlsma *et al*, 1996). These impacts include:

- Inundation and displacement of wetlands and lowlands,
- Erosion of shorelines,
- Increases in storm surges, coastal storms and flooding, and overtopping of wave walls with increasing regularity, and
- Increase in the salinity of estuaries, threatening freshwater aquifers, impairing water quality and the raising of water tables.

2.1 Sea Level Rise

Guyana's coastal plain, lies below mean high tide level, extend about 430km east to west and vary in width from 26km to 77km. This flat plain of which 360km is protected from the sea by a mixture of natural defences, sand banks, earthen embankments within mangrove stands (250km) and a combination of concrete walls and rip rap structures (110km). These latter structures are a strategic response to the threat of rising sea levels, as the crest level can be raised to accommodate future rises in sea level (Mott MacDonald, 2006).

Table B.7: Global and Local Climate Scenarios With Some Recommended Adaptation Options

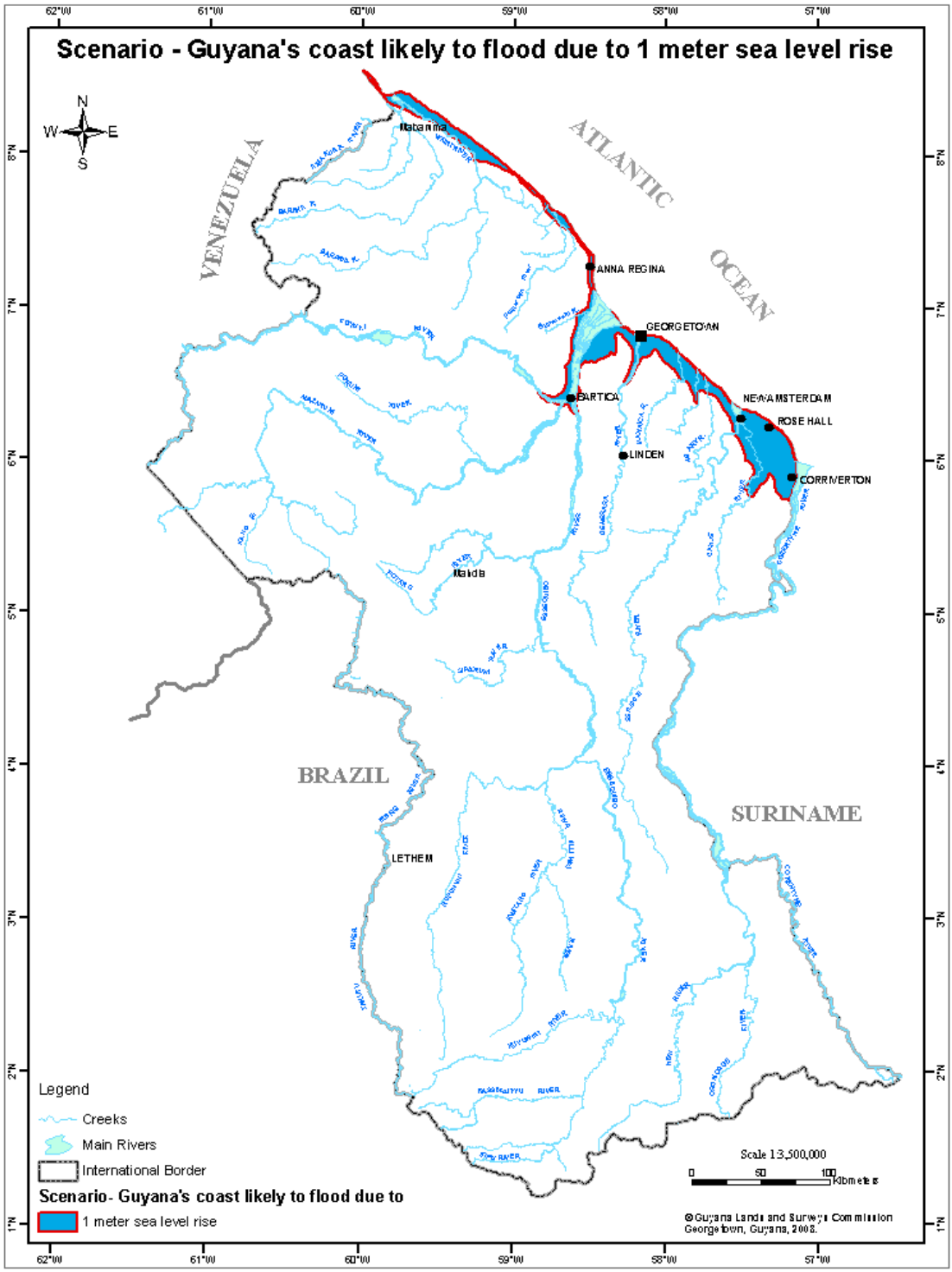
Global Climate Scenarios Assessment Report of the IPCC, models and data.	National Climate Scenarios, data analysis	Adaptation responses of the agricultural and allied sectors.
Warming of South American Continent inclusive of low latitudes of 0.2 to 1.0 from1970 and-2004. Models have indicated best estimate of 3.4 , with a likely range of 2.0 to 5. at 2090 to 2099. (A2)	i) An increase of the maximum temperature by 0., from ii) Minimum temperature has shown an increase of 1.2 . A mean annual increase of 1.0 over the same period. (INC 2002).	a) Develop heat resistant varieties, diversify crops. b) Use shade & greenhouse to control heat exposure. b) Improved infrastructure to ensure irrigation in dry season. c) Better designs of animal pens, to allow for more airflow.
Global sea level is expected to rise by 0.23m to 0.51 by 2090, even with mitigation measures of reduction of GHG emissions. This does not take into account melting of ice caps.	Current sea level rise is at least several times the global average, in Guyana it is 10.2 mm /year. (Guyana's National Vulnerability Assessment to Sea Level Rise 2002)	a) Salt tolerant varieties. b) Increased water management to prevent saline intrusion. c) Improved sea and river defences protection. d) Land use change e) Increased public awareness about climate change, the role of mangroves and efficient waste management techniques
Impacts on Rainfall: By mid-century, annual average river runoff are projected to increase by 10-40% at high latitudes during wet seasons. Fresh water resources are projected to be less including a reduction of groundwater recharge. Other impacts are intense storms and regular ENSO events	Increasing rainfall intensities will contribute to higher runoff and increase flooding. The data supports the former; the latter is supported by the frequency of occurrences in floods currently, such as in 2005 and 2006 along the coast, but also in segments of Region 9.	a) To improve drainage capacity. b) To accommodate more storage in conservancies. c) Acquisition and deployment of more pumps. d) Recirculation of water. e) Better maintenance of drainage outfalls

Sources: IPCC Assessment report, GNVSLR 2002, INC 2002, Survey information of Agriculture Sector Agencies.

This coastal plain remains vulnerable to the impacts of sea level rise (see Map B.1 and *Appendix B1*). These impacts include flooding, storm surges, saline intrusion into aquifers and coastal rivers, and rising water tables as discussed earlier in this synthesis report. In the Intermediate Savannahs and hinterland areas there would be increases in temperature, for a doubling of of 1. by 2040 and a projection of a 4. for a tripling of for the century (INC, 2002) Rainfall is projected to decrease for a doubling and a tripling of . (INC, 2002) There is expected to be some crops that will benefit, e.g. maize in some studies, but without any irrigation system in place then crops can only be grown during the rainy season, which can produce highly variable yields.[52] The success of subsistence and commercial farming in these areas will have to be based on plant breeding to withstand high temperatures and sound agronomic practices. Heat and drought tolerance will be the key mitigating factors. It was found that UF 717 *Brachiariha humidicola* was suitable for growth to support livestock in the savannah region, CARDI.

[52] While there has been some discussion on installing drip irrigation in this area, this remains an expensive undertaking that may then make agricultural products from this area uncompetitive from a price standpoint.

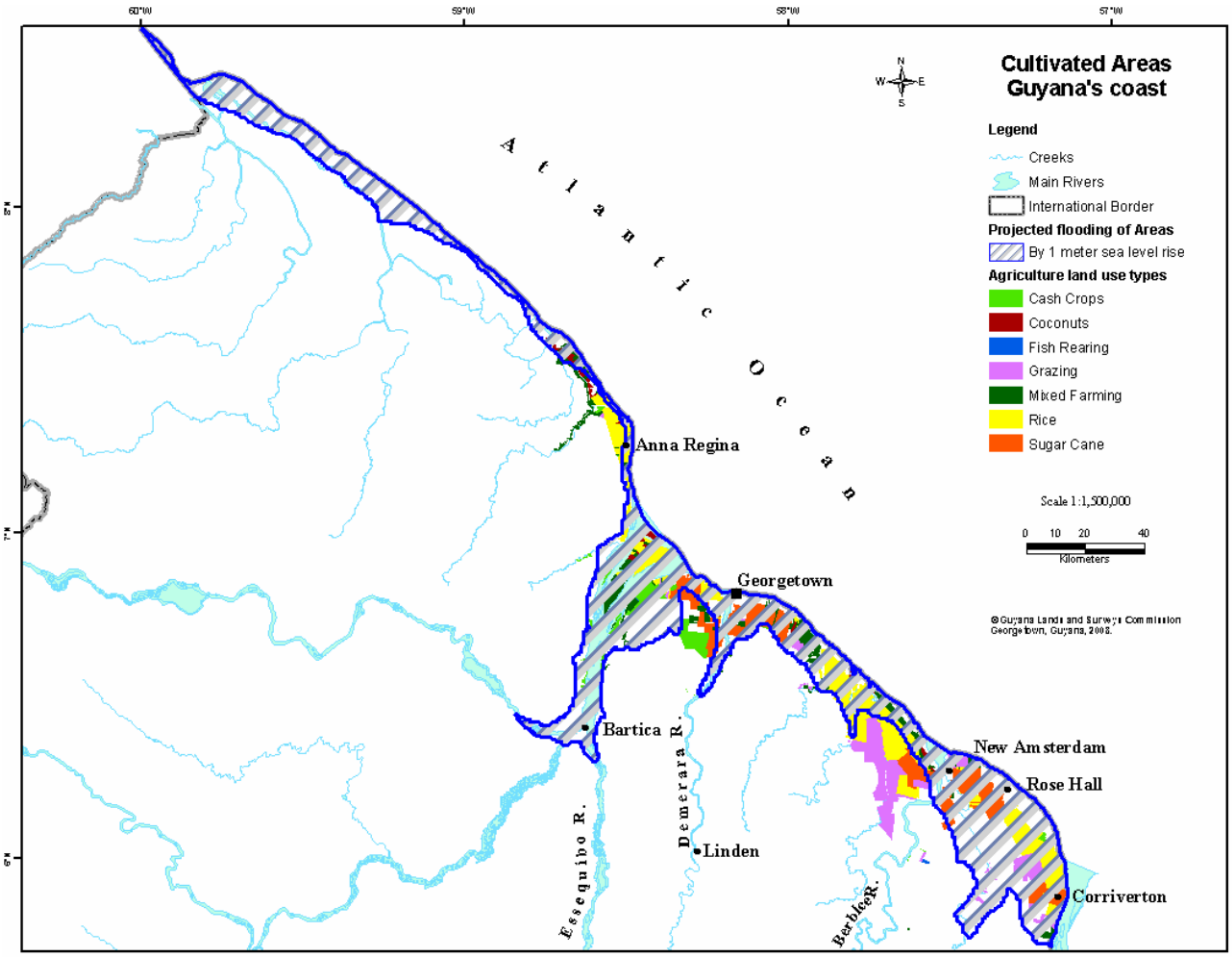
Map B.1: Coastal Areas that are Likely to be Flooded by a 1m Rise in Sea Level.



Source: Guyana Lands and Surveys Commission (2008)

Coastal land loss due to a combination of inundation and coastal erosion is projected to have widespread adverse consequences in the low-lying coastal plain of Guyana. Land loss from sea level rise especially in coastal locations is likely to be of a magnitude that can disrupt virtually all economic activity and impact the social sectors in the country. For example, recent estimates indicate that with a 1m sea level rise, up to of land could be lost, solely on account of inundation according to GNVSLR (2002) (see Map B.2). This figure would increase more than threefold to 37 (14%) with storm surge superimposed on a 1m sea level rise scenario. Similarly, based on the Brunn rule, a retreat of up to 100 m is projected with a 1m elevation of sea level (GNVSLR, 2002).

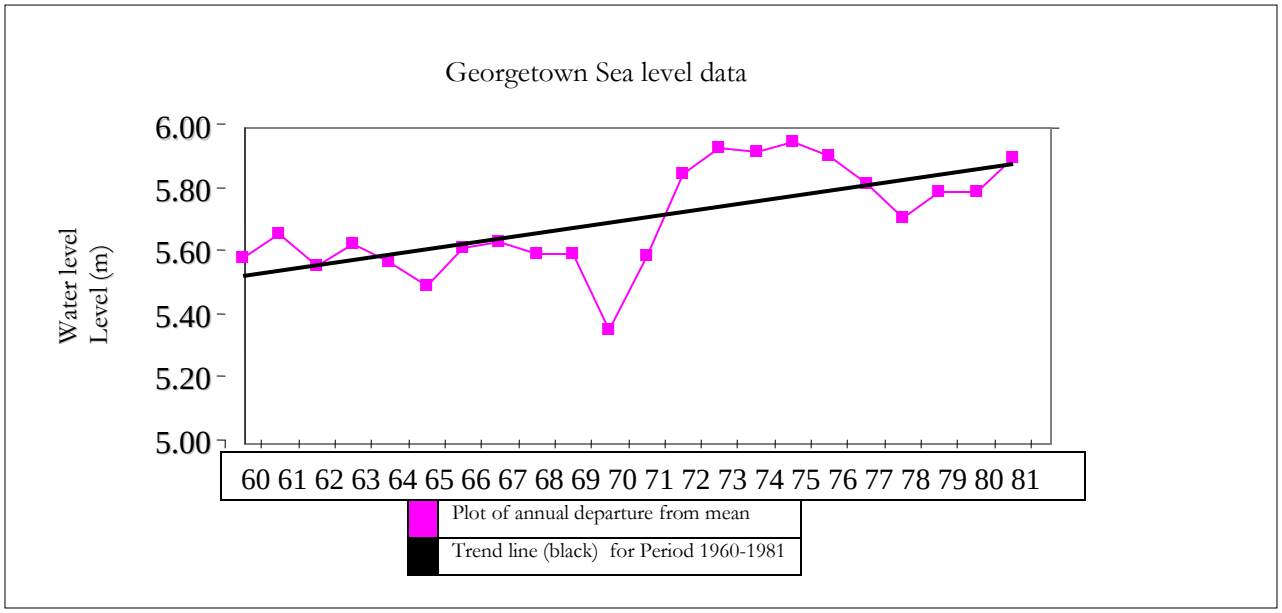
Map B.2: The Extent of Agricultural Activities on the Coast and Areas Likely to be Flooded by a 1m Rise in Sea Level



Source: Development Policy and Management Consultants (2008)

A plot of available sea level data 1960 to 1981 from the Transport & Harbours Department (T&HD) showed an increase of sea level of the magnitude that is about 5 times that of global average (Figure B.1), which could be attributed to the probability of land subsidence (Bassier 1976). Bassier's premises his argument based on the abstraction of water from the aquifers and continued falling of piezometric levels, which was measured on the coast from several meters above ground in the early 1900s to over 14m below ground in some wells currently. These wells are classified as semi-confined due to the coastal strata.

Figure B.4: Plot of Sea Level Data from Georgetown



Source: Transport and Harbours Department, Plot of annual data, departures from the mean red line, and a trend line, black, showing rate of rise of sea level over two decades, in the Port of Georgetown. (T&HD and Hydromet2002)

The Initial National Communication Report (2002) based on available tide gauge data for the period 1951 to 1979 for Port Georgetown, found mean relative sea level rise, using a linear extrapolation as 10.2 mm yr^{-1}. This rate of relative sea level rise is about 5 times the global average and close to that observed in Trinidad, albeit for a later time period. This is therefore suggestive of some mechanism other than eustatic sea level rise, such as subsidence due to water extraction, ocean floor sediment loading or plate tectonics. Plate tectonics however, does not appear to be contributing to this problem (INC, 2002).

Subsidence and sediment loading may both be contributing to the high rises noted in Guyana. The high rises observed in Trinidad and Guyana may suggest a generalized increase of sea level in the region, supported by the WG1 in the Fourth Assessment Report to the IPCC which states that sea level rise will not be uniform globally. Narayan calculated saltwater intrusion up the three coastal rivers using various sea level rise scenarios (see Table B2.). This will have impacts on the withdrawal of water in these areas for agricultural purposes as well as the likelihood of Salinization of the soil whenever the rivers flood their banks. The water table which is also projected to rise will create water logging of soils onshore within the areas of influence of the river.

2.2 Tidal Impacts

The coastal plain lies below mean tide level (GNVSLR, 2002), therefore at high tides the elevation of the surface of the sea is usually above the land level, thus the need to maintain the sea defences and other protection, for example mangroves, for the continued occupation of the coastal areas. In the event of high tides accompanied by high winds there could be storm surges that could overtop the walls, and cause flooding, similar to what occurred during 2008 at the Montrose to Better Hope area (Guyana Chronicle March 23, 2008), and at several instances over the past decades, (Dalrymple 2004). In his paper on the vulnerability of the coastal areas, Dalrymple (2004) examined two areas, at

Hope and Vreed-en-hoop and concluded that it is necessary to incorporate sea level rise and coastal topography into the design of sea defences (Dalrymple 2004). In addition in an earlier study it was also recommended that it was necessary to institute better sea defence management, involve local communities in the programmes and minimize the destruction of mangroves (Bynoe and Bynoe 2000) as possible solutions to alleviate flooding due to tidal impacts and sea level rise on coastal areas.

Table B.8 Calculated Saline Intrusion for Three Future Scenarios of Sea Level Rise

River	Sea level rise (m)	Salt water intrusion (river mouth km)	Extent (km)
Mahaica River	0.2	2.2	23
	0.5	2.5	25
	0.9	2.8	28
Demerara River	0.2	4.4	55
	0.5	5	58
	0.9	5.6	64
Essequibo River	0.2	6.6	65
	0.5	7.5	72
	0.9	8.5	80

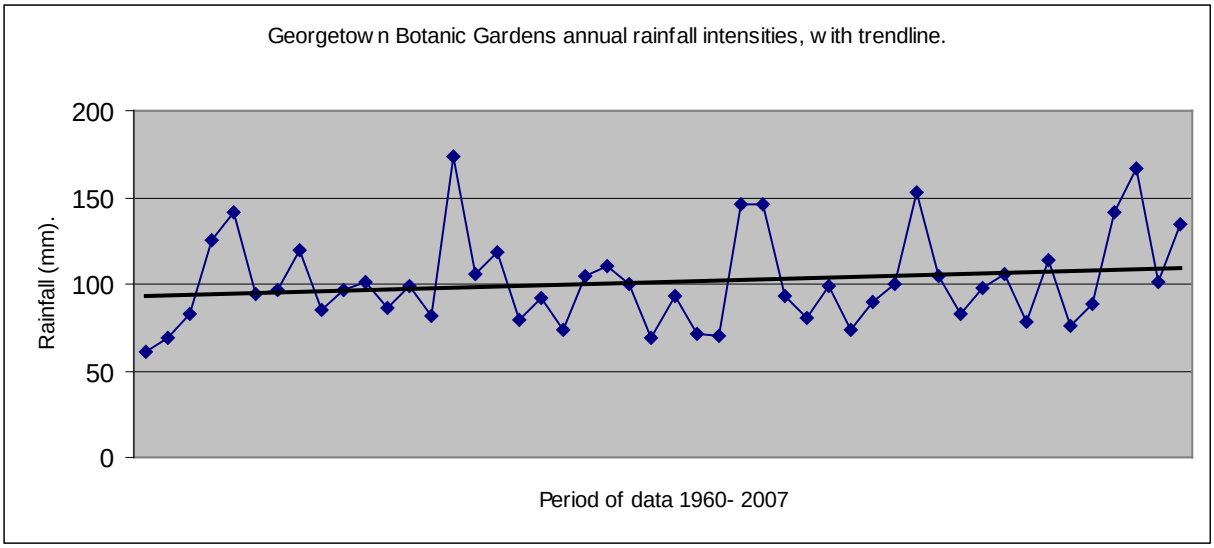
Source: Guyana's National Vulnerability Assessment to Sea Level Rise 2002

2.3 Drainage

Drainage structures were designed to accommodate 38.1mm of rainfall over a 24 hour period. In the past and in normal conditions these structures were functioning adequately in the Drainage and Irrigation (D&I) areas. However, as can be seen in Figure B.2 below of annual rainfall intensities taken from the Georgetown Botanic Gardens, rainfall intensity has increased. Thus in the recent past the existing designs of drainage structures are unable to cope with the resulting demand culminating in more frequent flooding and losses, estimated to be in excess of US$453 million in 2005 causing real GDP to decline by 2.5% (ECLAC, 2005).

The rate of sea level rise has consequences for drainage in Guyana that is currently mainly done via gravity flow. This flow is accommodated by the difference in elevation of the water levels in the upstream canals to the sea and river levels. Since the coastal area is below mean high tide level, ranging from 0.5m to 1.0m, then the sea or river has to be lower in elevation for drainage to take place. Higher intensity rainfall will require efficient drainage either through sluices or pumps, but the latter will require energy, hence there are two areas of concern; production of energy and the increase in emission of greenhouse gases if the energy source used to power the pumps is not renewable. In the case of the former, the NDIA indicated that one of their adaptation strategies has been to modify the design of the drainage system to increase discharge capacity. For example, where resources are available, they have sought to widen the sluice doors and have a shallower depth of the drainage canals to take care of the same or greater volume of water being drained as if there was a deeper channel (Wordsworth, per comm. 2008).

Figure B.5: Georgetown Annual Rainfall Intensities for the Period 1960-2007



Source: Hydrometeorological Department (2008)

2.4 Future Sea Level Change and Adaptation

Most models indicate global sea level rise of 0.2m, 0.5m and 1.0m towards the Century. The Guyana Sea Defences are currently designed to accommodate sea level rise of 6 mm y^{-1} and is also using the rip-rap design, which can facilitate raising of the crest level easily, as protection is seen as a viable option. Agricultural losses could be as high as 20% of GDP in low lying coastal states (IPCC, 2007). Further, under the European Union funded Shore zone Management System Project (EDF) is a component to collect data on water levels, coastal morphology, waves, wind and current and also to undertake mangrove restoration studies. Another component is the development of a strategy and Master Plan for the continued maintenance of the Sea defences. This phase has been completed and will restart under the EDF (Per. Comm. Chief Sea and River Defence Officer, 2008). The data collected will be used in the next phase under the EDF to undertake rehabilitation of the sea defences, (Per. Comm. SRD Officer 2008). (This will add to previous efforts undertaken by the Environmental Protection Agency (EPA) under the Integrated Coastal Zone Management Plan (ICZM) (2000).

2.5 Sea Defence as an Option

The elevation of mean sea level at Georgetown on the coastal plain of Guyana is 15.56m Georgetown Datum (GD). Furthermore, the mean elevation of the land area on the coastal plain of Guyana is below 16.76m GD (this being the elevation of the roadway). The elevation of the highest tide level recorded at Georgetown is 17.19m GD and the elevation of the high spring tides is usually around 16.86m GD. These elevations indicate that without sea level rise, inundation of coastal areas would take place whenever there are unusually high tides, more so whenever there are spring tides. Since there is substantial infrastructure, inclusive of that which supports the agricultural sector, protection at the current cost of about US$4.5 million per kilometre may be a viable option (Dalrymple per comm., 2008). However, the projection of future sea level rise along with the melting of the ice caps will elicit decision to be made to consider other alternatives, such as a setback or retreat given the risks of future losses due to sea defence breaches and the astronomical costs to

protect the coast and other inland resources and livelihoods. Guyana can learn from New Orleans experience, where in 2005 Hurricane Katrina brought huge storm surges that broke sea and river defences, resulting in flooding, loss of life and property damages to the value of US$150 billion. The Forestry sector suffered losses to the value of US$2.4 billion. Other losses due to shipping, oil and infrastructure damages were estimated at US$147.6 billion. This experience indicates the damages and costs associated with severe climate events. (http://en.wikipedia.org/wiki/Economic_effects_of_Hurricane_Katrina#Industrial_and_commercial_effects). Similarly, the 2005 and 2006 floods in Guyana, due in main part to extreme rainfall, demonstrated major damage to physical infrastructure and loss of income.

2.6 Rainfall

On the macro-scale Guyana can be described as having a wet tropical climate. However, due to geographical influences such as mountains, ocean, etc. there is spatial variability of rainfall resulting in three major climate types on the meso-scale. These, based on our local classification are as follows:

- Wet-Dry – These are areas with rainfall between 1778mm and 2800mm. This climate type is the most widely experienced one in the country and can be further subdivided into moderately dry, moderately wet and wet.
- Very Wet – areas with annual rainfall above 2800mm. This climate type can be subdivided into exclusively wet, exceedingly wet and extremely wet.
- Very Dry – Areas with annual rainfall less than or equal to 1788mm. Such areas are the Rupununi Savannah, the Intermediate Savannah, the Upper Cuyuni and the East Berbice Coast. The secondary wet season is absent in the Rupununi Savannah and often absent in the Intermediate Savannah (*see* Map B.3 below).

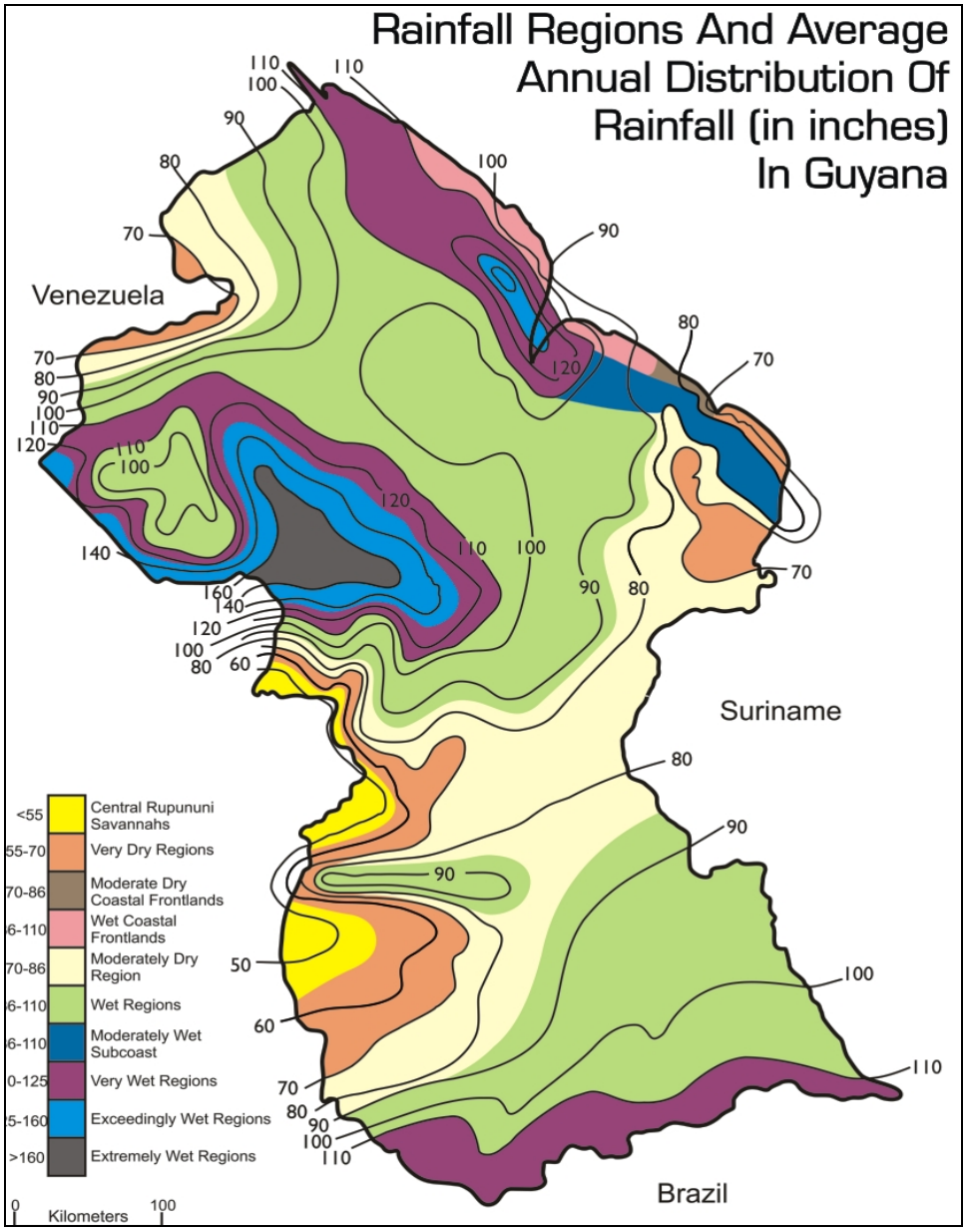
Globally, heavy precipitation events are predicted with a very likely projection for the Century using the IPCC Special Report on Emission Scenarios (SRES, IPCC 2007). The Special Report on Emissions Scenarios was developed using the 4 storylines A1, A2, B1 and B2 (these are explained in the Table of Acronyms).

The INC (2002), using rainfall data from the period 1961- 1990, analyzed by plotting the 5 year running mean anomalies have discerned that there are more below normal periods than above normal periods. There is an indication that there is a decreasing trend of rainfall volume during this series of data. This indicates that the monthly rainfall is being accounted for by fewer days with higher rainfall, hence there are higher rainfall intensities occurring during the period. El Nino Southern Oscillation (ENSO) events have been shown to affect Guyana (Simon 1997; Wardlaw 2007) there seems to be a mechanism that is resulting in decreased total rainfall in the last two decades, when surface air temperature has been increasing (INC, 2002).

It appears that increased evaporation due to higher surface air temperatures did not result in higher rainfall. In the recent past it could very well be that cloud cover has increased but this was due to more stratiform cloudiness rather than connective cloudiness. However, within the 1990s it has become apparent that convective storms have become more intense but fewer. The result was high intensity rainstorms leading to short-period flooding. The clusters in the Inter Tropical Convergence

Zone (ITCZ) off the Guianas are smaller and fewer but more intense. The monthly rainfall is therefore being accounted for by fewer days with higher rainfall, even when there are ENSO neutral conditions prevailing. Increased cloudiness could have an impact on the photosynthetic rate of crops; hence although all the other conditions for production may be available this could lead to decrease in yield, especially in grains (INC 2002).

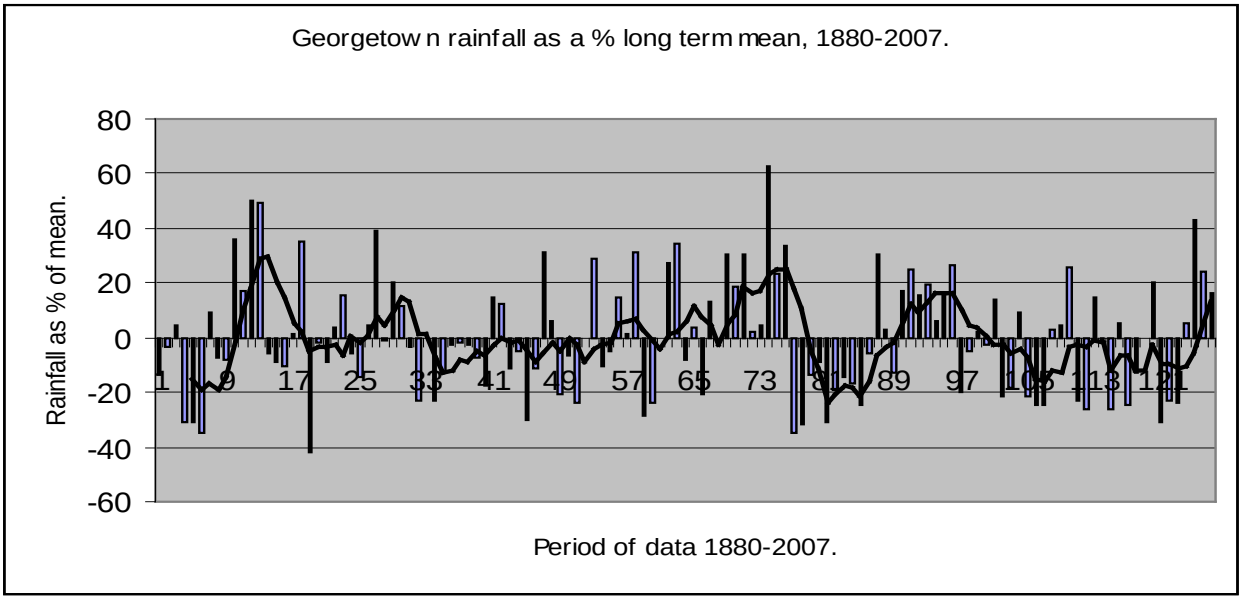
Map B.3: Showing Rainfall Distribution in Guyana



Source: INC (2002)

Intense rainfall could also account for losses of crops that are ready to be reaped, this occurred in 2005 when about 70% of the rice crop was lost due to intense rainfall, flooding fields which were about to be reaped in Region # 5.

Figure B6: Georgetown Rainfall as a Percentage of Long Term Mean 1880-2007



Source: Hydrology & Water Resources Final Report Mott Mc Donald, Final Report (2007)

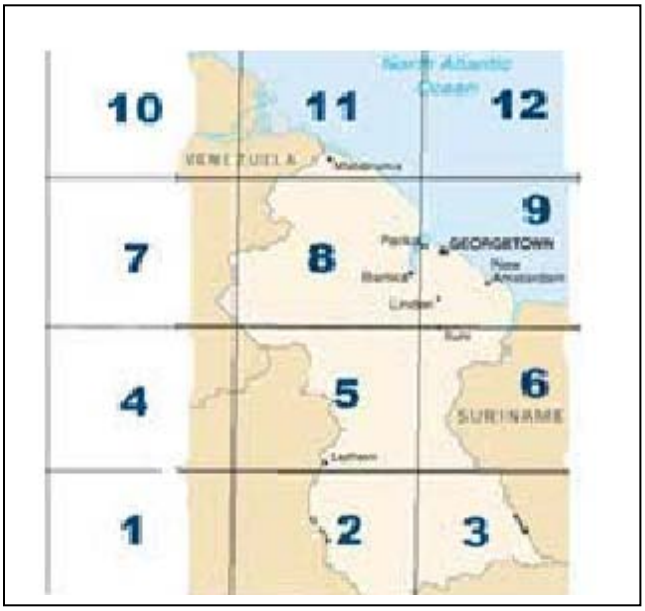
This long term mean with a 5 year running average clearly indicates a decreasing trend. This corroborates the results of the Atmosphere – Ocean Global Circulating Models (AO-GCM) predictions, of reduced rainfall going towards the Century.

3. MODELS USED FOR THE IMPACT ASSESSMENT

Recent Atmosphere – Ocean Global Circulating Models (A-O GCMs) adequately couple the atmospheric and oceanic circulations and in some cases emission scenarios of future greenhouse gases, and tropospheric aerosols, and assumptions on population and economic growth, energy availability and fuel mix, are considered (IPCC 1992). The climate simulations derived from these A-O GCMs have been extensively used in the development of scenarios of regional climate change for impact assessments.

In this case, the results generated by the most recent A-O GCM of the Canadian Climate Centre (CGCM 1) run in transient mode with increasing by the observed values to the present and then by 1% per year into the future, to create regional climate change scenarios for the region in and around Guyana *(see Figure B.4)* is used. Cells 2, 3, 5, 6, 8, 9 and 11 include the major part of the territorial area of Guyana. For each of the grid cells, Climatological data for 3 time slices: 1975 – 1995 (past), 2020 – 2040 (2 x CO2) and 2080 – 2100 (3 x CO2) are selected. For each of these time periods, changes in near-surface rainfall (Table B.3), temperature (Table B.4), evaporation (Table B.5) and water deficit (Table B.6), as simulated by CGCM 1 are extracted in monthly groupings corresponding to the First Dry Season (FDS: February to April), the First Wet Season (FWS : May to July), the Second Dry Season (SDS : August to October) and the Second Wet Season (SWS : November to January) of Guyana.

Figure B7: Selected Grid Cells in and around Guyana for CGCM 1



Source: INC 2002

Table B.3: The Canadian A -OGCM (CGCM 1) Projections of Rainfall (mm dy-1) for Guyana

	Doubling CO_2 (2020 to 2040) - (1975 to 1995)				Tripling CO_2 (2080 to 2100) - (1975 to 1995)			
CELL	FDS	FWS	SDS	SWS	FDS	FWS	SDS	SWS
2	-0.30	-0.69	-0.31	+0.30	-0.39	-0.16	-0.14	+0.25
3	-0.96	-0.93	-0.51	-0.15	-1.36	-0.92	-0.35	-0.07
5	+0.08	-0.65	-0.68	+0.30	+0.22	-0.34	-0.80	+0.29
6	-0.41	-1.44	-1.02	+0.07	-0.79	-2.49	-1.47	-0.12
8	-0.26	+0.09	-0.38	+0.11	+0.26	-0.80	-1.63	-0.09
9	-0.17	-0.04	-0.51	-0.71	+0.08	-1.83	-2.10	-1.48
11	-.0.23	-0.26	+0.52	-0.50	-0.19	-0.59	-1.02	-1.15
AVERAGE	-0.32	-0.56	-0.41	-0.08	-0.31	-1.02	-1.07	-0.34

Source: INC (2002)

The rainfall deficits in the model for the doubling of concentrations going into the 2040's will be more pronounced in Southern regions of Guyana and the lower part of Region 6, while the Second Wet Season (SWS) of cell number 9, representing Regions 4, 5 and part of 6 will have the largest deficit in the SWS. This is also borne out using the data generated by the HADCM for rainfall data plotted, see graph below

Figure B.5: Plot of HAD CM, Modelled data, of MARDS, Showing Declining Trend of Rainfall

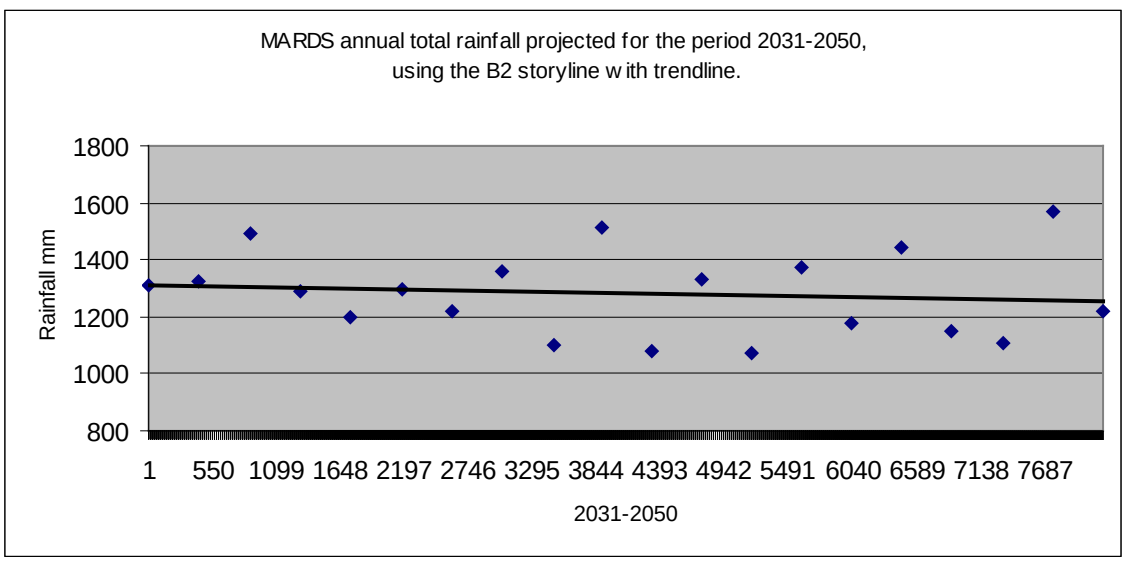


Figure B.6: The Decline in Monthly Average Rainfall, in the Region #5 Area of Guyana, using the Modelled Data from the HAD CM Supporting the INC Forecasts

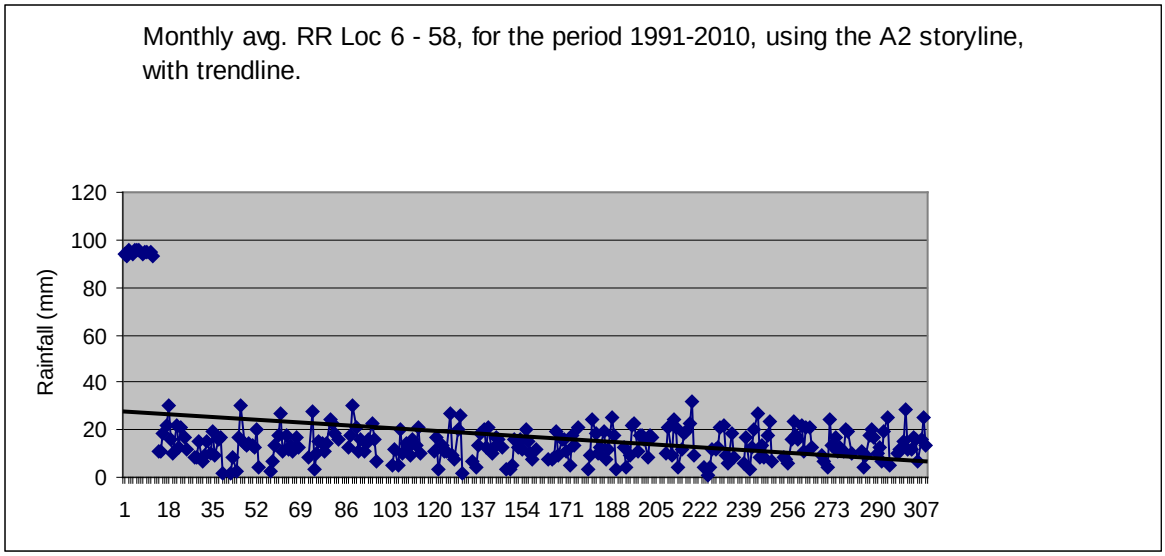
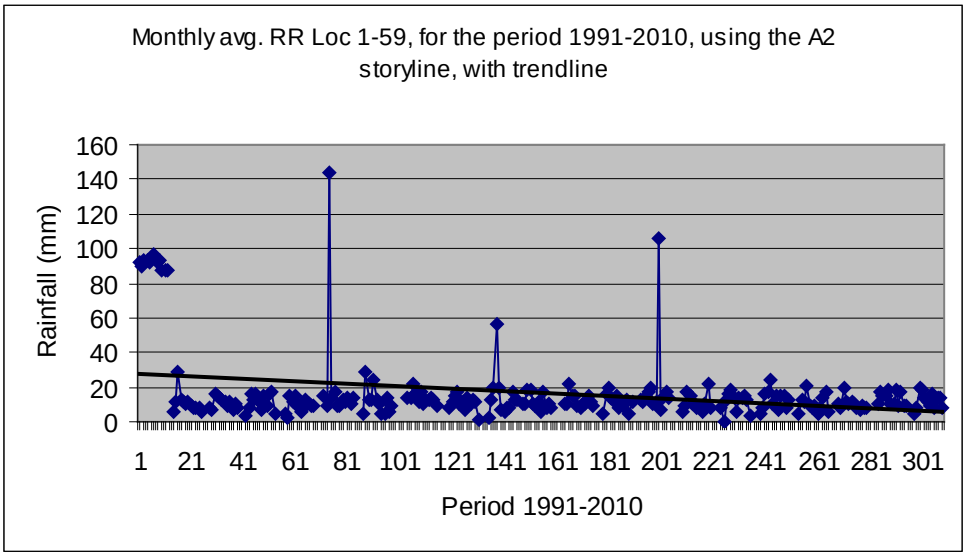


Figure B.7: The Projected Decline in Rainfall in the Southern Regions of Guyana Using the HAD CM Modelled Data



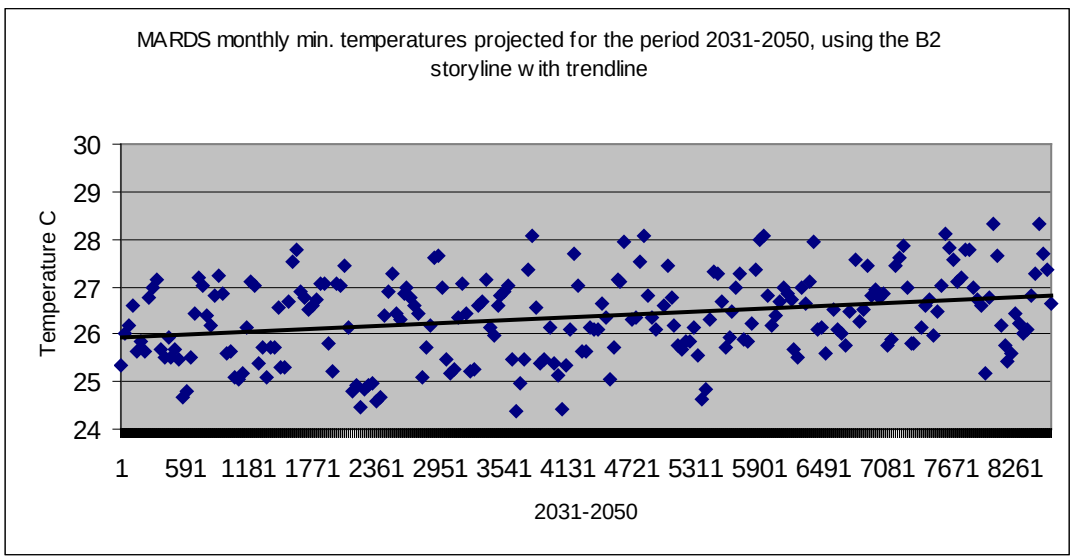
For tripling of concentrations going into the century cell number 9 will also have the largest deficit of rainfall. This will have implications for continued coastal agriculture. The establishment of Conservancies for irrigation and accompanying drainage networks will have to be maintained at fully functional levels to ensure that adequacy in both drainage and irrigation are able to meet the requirements. It is quite possible that given the quality of the land Guyana may be in a position to expand cultivation of some specific crops that are discussed later in this technical assessment.

Table B.9: The Canadian A -OGCM (CGCM 1) Projections of Air Temperature () for Guyana

	Doubling CO_2 (2020 to 2040) - (1975 to 1995)				Tripling CO_2 (2080 to 2100) - (1975 to 1995)			
CELL	FDS	FWS	SDS	SWS	FDS	FWS	SDS	SWS
2	+1.20	+1.04	+1.64	+1.73	+4.35	+3.99	+4.53	+4.79
3	+1.13	+1.06	+1.59	+1.77	+4.28	+3.99	+4.90	+5.08
5	+1.22	+1.17	+1.35	+1.62	+4.24	+4.06	+4.45	+4.76
6	+1.09	+1.01	+1.08	+1.20	+4.01	+3.93	+3.93	+4.00
8	+1.10	+1.12	+1.09	+1.16	+4.14	+3.99	+3.96	+4.07
9	+1.05	+1.01	+1.01	+1.02	+4.10	+3.95	+3.91	+3.88
11	+1.21	+1.05	+1.01	+1.07	+4.18	+3.84	+3.74	+3.87
AVERAGE	+1.14	+1.07	+1.25	+1.37	+4.19	+3.96	+4.20	+4.35

Source: INC (2002)

Figure B.8: The increase in air temperature at MARDS, Region 5, using the modeled data from the HAD CM



The Temperature projections show increases in all the cells of similar magnitudes for all the cells, ranging in average from +1.07 in the FWS to 1.37 in the SWS. Similarly in the tripling of projections, the averages range from +3.96 in the FWS to +4.35 in the SWS.

Table B.10: The Canadian A -OGCM (CGCM 1) Projections of Air Temperature CO for Guyana

	Doubling CO_2 (2020 to 2040) - (1975 to 1995)				Tripling CO_2 (2080 to 2100) - (1975 to 1995)			
CELL	FDS	FWS	SDS	SWS	FDS	FWS	SDS	SWS
2	-0.17	-0.12	-0.37	-0.36	-0.22	+0.02	±0.00	-0.18
3	-0.13	± 0.00	-0.33	-0.65	-0.20	+0.11	-0.45	-0.66
5	-0.15	-0.11	-0.06	-0.38	-0.18	+0.05	+0.03	-0.37
6	+0.01	+0.02	+0.14	-0.05	+0.27	+0.28	+0.39	+0.14
8	+0.08	± 0.00	± 0.00	-0.06	+0.13	+0.16	+0.34	+0.13
9	+0.11	-0.12	+0.01	-0.04	+0.33	+0.22	+0.30	+0.28
11	+0.15	+0.10	+0.02	+0.16	+0.54	+0.55	+0.63	+0.41
AVERAGE	-0.01	-0.03	-0.08	-0.19	+0.10	+0.19	+0.18	-0.04

Source: INC (2002)

3.1 Evaporation and Water Deficits

As for the change in evaporation rate, the slight (~ 1) average increase in temperature, as a consequence of doubling, does not translate into significant evaporation (less than 0.1 mm/dy). However, for a tripling of the concentration, evaporation generally increases, in response to the higher temperature increase, to about 0.11mm/dy. The southern parts of Guyana is not projected to be significantly affected, that is Regions # 8, # 9 and part of # 6 but north-eastern areas of Guyana, in Region # 1 are expected, in general, to experience increases of about 0.22 mm/ dy or 7 mm per month. The northwest region will be subjected to evaporation rate increases in excess of 0.40 mm/dy or 12 mm per month in all seasons, hence requiring irrigation of some crops during the growing seasons. Large scale agriculture will only be successful if irrigation systems are in place.

With a doubling scenario, the average deficit is expected to be 0.27 mm/dy or about 8 mm per month. Southern Guyana will experience large water deficits especially in the FWS and SWS. With a tripling scenario, the average deficit becomes 0.8 mm/dy or 24 mm per month. However, in this case it is northern Guyana which will encounter deficits in excess of 0.73 mm/dy or 22 mm per month with large deficits expected in the FWS and SDS.

A common observation, with both scenarios, is that southern Guyana encompassing Regions #9, #8 and parts of #6 are expected to have positive water deficit values in the SWS. That is, rainfall is expected to be higher than evaporation, hence it is likely that supplemental irrigation will not be required, affording the opportunity for the increase in production of a variety of crops and livestock.

The rate of evaporation for the cell number 9 is only exceeded by cell number 11, in the first dry season, for a doubling of the in the atmosphere. However, for a tripling of , cell number 11 has the highest rate followed by cell number 9, which includes the Regions #4, #5, #6 with the highest agricultural practices.

Table B.11: The Canadian A -O GCM (CGCM 1) Projections of water deficit (mm dy-1) for Guyana

	Doubling CO_2 (2020 to 2040) - (1975 to 1995)				Tripling CO_2 (2080 to 2100) - (1975 to 1995)			
CELL	FDS	FWS	SDS	SWS	FDS	FWS	SDS	SWS
2	-0.13	-0.58	+0.06	+0.66	-0.17	-0.18	-0.14	+0.43
3	-0.83	-0.93	-0.18	+0.49	-1.17	-1.03	+0.09	+0.59
5	+0.23	-0.54	-0.62	+0.68	+0.40	-0.39	-0.83	+0.66
6	-0.42	-1.46	-1.16	+0.12	-1.06	-2.77	-1.87	-0.26
8	-0.33	+0.09	-0.37	+0.17	+0.13	-0.96	-1.97	-0.22
9	-0.28	+0.07	-0.52	-0.68	-0.25	-2.05	-2.40	-1.76
11	-0.38	-0.36	+0.50	-0.66	-0.73	-1.14	-1.65	-1.56
AVERAGE	-0.31	-0.53	-0.33	+0.11	-0.41	-1.22	-1.25	-0.30

Source: INC (2002)

The water deficit is the highest for the doubling of , in cell number 6 in the FWS, the lower Region #6 area and some parts of Region #10. For a tripling of , the cell number 6 has the highest deficit in the FWS followed by cell number 9; in the SDS and SWS cell number 9 has the highest water deficit. Hence the area enclosed by cell number 9, will be under higher temperature and water deficit stress. The data presented in the HAD CM models for projected evaporation did not provide conclusive evidence of increasing evaporation leading to water deficits generally, unlike the modelled data from the INC (2002).

Guyana's rainfall is impacted by the occurrence of ENSO (El Nino Southern Oscillation) episodes. Ropelewski and Halpert (1987, 1989, and 1996) outline an approach for classification of ENSO events. They classified an El Nino event (or warm episode) as one in which the five month running mean values of the SOI remains below -0.5 standard deviations for a period of five months or longer. The reverse is true for La Nina episodes. During the 1990's and onwards there have been occurrences where the threshold have been met at more regular intervals, resulting in a shorter time interval for ENSO events. Periods falling into neither El Nino nor La Nina classifications are considered to be neutral (see Table B.7).

By combining the monthly data, and classifying the SOI data into three classifications (cold, warm or neutral), the impacts of local climate variability are masked and clearer associations emerge between Georgetown rainfall and ENSO events. Each season in every year of the common historic record has been classified and seasonal rainfall totals determined. In each season there are distinct differences between the three classifications, although these are clearly most distinct for the NDJ season. The data clearly fits well to the gamma distribution (Mott Mac Donald, 2004).

Table B.12: NOAA National Weather Service

DESCRIPTION: Warm (red) and cold (blue) episodes based on a threshold of +/- 0. for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v3 SST anomalies in the Niño 3.4 region (-, -)], based on the 1971-2000 base period. For historical purposes cold and warm episodes (blue and red colored numbers) are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1950	-1.7	-1.5	-1.4	-1.4	-1.3	-1.2	-0.9	-0.8	-0.8	-0.8	-0.9	-1.0
1951	-1.1	-0.9	-0.7	-0.4	-0.2	0.1	0.3	0.5	0.6	0.7	0.7	0.6
1952	0.3	0.2	0.1	0.1	0.0	-0.2	-0.3	-0.3	-0.1	-0.2	-0.2	-0.1
1953	0.1	0.3	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2
1954	0.3	0.2	-0.2	-0.6	-0.8	-0.8	-0.8	-1.1	-1.2	-1.1	-1.1	-1.0
1955	-1.0	-0.9	-0.9	-1.0	-1.1	-1.0	-1.0	-1.0	-1.4	-1.8	-2.0	-1.7
1956	-1.2	-0.7	-0.6	-0.6	-0.5	-0.5	-0.6	-0.8	-0.8	-0.9	-0.8	-0.7
1957	-0.5	-0.1	0.3	0.6	0.7	0.9	0.9	0.9	0.9	0.9	1.2	1.5
1958	1.7	1.5	1.1	0.7	0.5	0.5	0.4	0.2	0.0	0.0	0.2	0.4
1959	0.4	0.5	0.4	0.2	0.1	-0.2	-0.4	-0.5	-0.4	-0.3	-0.2	-0.3
1960	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1	0.0	0.0	0.0	-0.2	-0.2	-0.2
1961	-0.1	-0.2	-0.2	-0.1	0.1	0.2	0.1	-0.3	-0.6	-0.6	-0.5	-0.4
1962	-0.5	-0.5	-0.4	-0.5	-0.4	-0.3	-0.2	-0.3	-0.4	-0.6	-0.7	-0.7
1963	-0.6	-0.3	0.0	0.1	0.1	0.3	0.7	0.9	0.9	0.9	1.0	1.0
1964	0.9	0.4	0.0	-0.5	-0.7	-0.7	-0.7	-0.8	-1.0	-1.1	-1.1	-1.0
1965	-0.8	-0.5	-0.2	0.0	0.3	0.7	1.0	1.3	1.5	1.6	1.6	1.5
1966	1.2	1.1	0.8	0.5	0.3	0.2	0.2	0.0	-0.2	-0.2	-0.3	-0.3
1967	-0.4	-0.5	-0.6	-0.5	-0.2	0.0	0.0	-0.2	-0.4	-0.5	-0.4	-0.5
1968	-0.7	-0.8	-0.8	-0.7	-0.4	0.0	0.3	0.3	0.3	0.4	0.7	0.9
1969	1.0	1.0	0.9	0.8	0.6	0.5	0.4	0.4	0.6	0.7	0.7	0.6
1970	0.5	0.3	0.2	0.1	0.0	-0.3	-0.6	-0.7	-0.7	-0.7	-0.8	-1.1
1971	-1.3	-1.4	-1.2	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.9	-1.0	-0.9
1972	-0.7	-0.3	0.0	0.3	0.6	0.8	1.1	1.4	1.6	1.8	2.1	2.1
1973	1.8	1.2	0.5	0.0	-0.5	-0.8	-1.0	-1.2	-1.4	-1.7	-1.9	-2.0
1974	-1.8	-1.6	-1.2	-1.1	-0.9	-0.7	-0.5	-0.4	-0.5	-0.7	-0.8	-0.7
1975	-0.6	-0.6	-0.7	-0.8	-0.9	-1.1	-1.3	-1.3	-1.5	-1.6	-1.7	-1.7
1976	-1.6	-1.2	-0.9	-0.6	-0.5	-0.2	0.1	0.3	0.6	0.8	0.8	0.8
1977	0.6	0.5	0.3	0.2	0.2	0.4	0.4	0.4	0.5	0.7	0.8	0.8
1978	0.8	0.5	0.0	-0.3	-0.4	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.1
1979	-0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.2	0.3	0.5	0.5	0.6
1980	0.5	0.4	0.3	0.2	0.3	0.3	0.2	0.0	-0.1	0.0	0.0	0.0
1981	-0.2	-0.4	-0.4	-0.3	-0.2	-0.3	-0.3	-0.3	-0.2	-0.1	-0.1	0.0
1982	0.0	0.1	0.2	0.4	0.7	0.7	0.8	1.0	1.5	1.9	2.2	2.3
1983	2.3	2.1	1.6	1.3	1.0	0.7	0.3	-0.1	-0.5	-0.7	-0.9	-0.7
1984	-0.4	-0.2	-0.2	-0.3	-0.4	-0.4	-0.3	-0.2	-0.2	-0.6	-0.9	-1.1
1985	-1.0	-0.9	-0.8	-0.8	-0.8	-0.6	-0.6	-0.5	-0.6	-0.4	-0.4	-0.4
1986	-0.5	-0.5	-0.3	-0.2	-0.1	0.0	0.2	0.4	0.6	0.9	1.0	1.2
1987	1.2	1.3	1.2	1.1	1.0	1.2	1.5	1.7	1.6	1.5	1.2	1.1
1988	0.7	0.5	0.1	-0.3	-0.9	-1.3	-1.4	-1.2	-1.3	-1.6	-2.0	-2.0
1989	-1.8	-1.6	-1.2	-0.9	-0.7	-0.4	-0.4	-0.4	-0.4	-0.3	-0.2	-0.1
1990	0.1	0.1	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4
1991	0.4	0.4	0.3	0.3	0.6	0.8	1.0	0.9	0.9	0.9	1.3	1.6
1992	1.8	1.7	1.5	1.4	1.2	0.9	0.5	0.2	-0.1	-0.1	0.1	0.3

1993	0.4	0.4	0.5	0.7	0.7	0.7	0.4	0.3	0.3	0.3	0.3	0.3
1994	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.5	0.7	0.9	1.3	1.3
1995	1.2	0.9	0.6	0.3	0.2	0.1	-0.1	-0.2	-0.5	-0.6	-0.8	-0.8
1996	-0.8	-0.7	-0.5	-0.3	-0.2	-0.2	-0.1	-0.2	-0.1	-0.2	-0.3	-0.4
1997	-0.4	-0.3	-0.1	0.3	0.8	1.3	1.7	2.0	2.2	2.4	2.5	2.5
1998	2.3	2.0	1.4	1.1	0.4	-0.1	-0.7	-1.0	-1.1	-1.2	-1.4	-1.5
1999	-1.5	-1.2	-0.9	-0.8	-0.8	-0.8	-0.9	-1.0	-1.0	-1.2	-1.4	-1.7
2000	-1.7	-1.4	-1.0	-0.8	-0.6	-0.6	-0.4	-0.4	-0.4	-0.5	-0.7	-0.7
2001	-0.7	-0.5	-0.4	-0.3	-0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2
2002	-0.1	0.1	0.2	0.4	0.6	0.8	0.9	0.9	1.1	1.3	1.5	1.4
2003	1.2	0.9	0.5	0.1	-0.1	0.0	0.3	0.4	0.5	0.5	0.6	0.4
2004	0.4	0.2	0.2	0.2	0.3	0.4	0.7	0.8	0.9	0.8	0.8	0.8
2005	0.6	0.5	0.4	0.5	0.5	0.5	0.5	0.3	0.2	-0.1	-0.4	-0.8
2006	-0.8	-0.6	-0.3	-0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.2	1.1
2007	0.8	0.4	0.1	-0.1	0.0	-0.1	-0.2	-0.5	-0.8	-1.1	-1.2	-1.4
2008	-1.5	-1.4	-1.1	-0.7	-0.5	-0.4						

Adopting these classifications, an analysis has been carried out of monthly SOI and rainfall at Georgetown Botanical Gardens using the entire period of historical record. The analysis has been carried out on seasonal data using the following classifications:

FMA **- February, March, April**
MJJA **- May, June, July, August**
SO **- September, October**
NDJ **- November, December, January**

The foregoing provides a basis for giving probabilistic forecasts of seasonal rainfall, linked to forecasts of ENSO activity. Seasonal rainfalls for a range of non-exceedance probabilities under each of the ENSO classifications are given in Table B.8 below.

Table B.8: Seasonal Rainfall (mm) at Selected Probabilities under Different ENSO Conditions

Non-Exceedance Probability	FMA			MJJA			SO			NDJ		
	La Nina	Neut.	El Nino	La Nina	Neut.	El Nino	La Nina	Neut.	El Nino	La Nina	Neut.	El Nino
0.1	194	119	86	865	780	784	105	55	54	482	337	226
0.2	270	187	146	958	863	854	119	90	80	622	412	280
0.5	444	349	284	1146	1043	995	180	161	135	878	613	408
0.8	660	560	455	1351	1254	1144	309	237	198	1119	906	573
0.9	790	691	558	1465	1378	1226	411	280	234	1240	1102	676

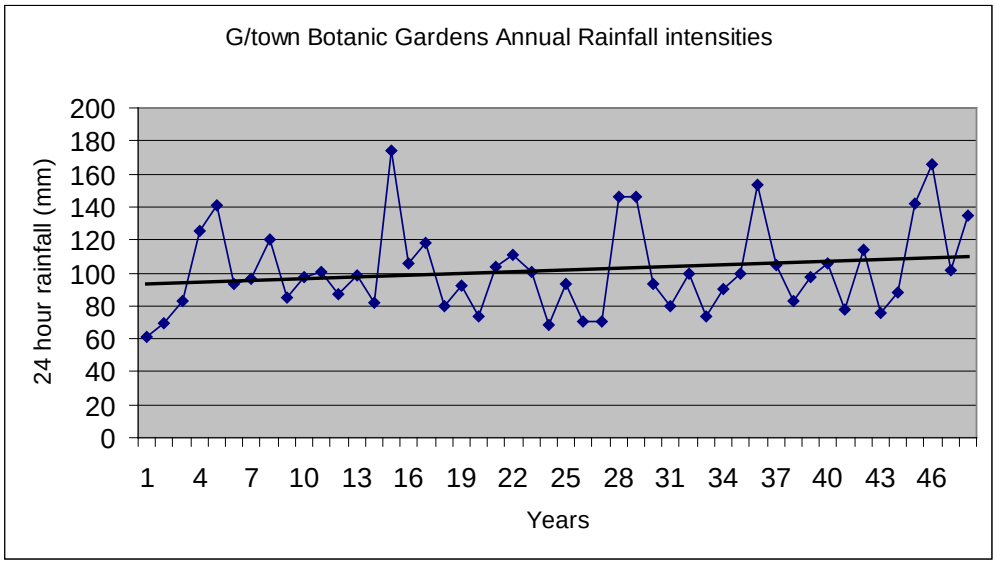
Source: Mott MacDonald *(2004)*

La Nina events are clearly associated with significant higher rainfall than normal, and El Nino events with significantly lower rainfall. The probability distributions are divergent in each season, with larger differences at higher non-exceedance probabilities. Of particular note is the difference for the

NDJ wet season, when rainfall in El Nino years is generally about half of the La Nina year. This is experienced countrywide as in the strong ENSO event in 1997-1998.

Annual one day maximum intensity rainfall for the Georgetown Botanic Gardens with trend line indicates that the increase in intensity as projected by the Intergovernmental Panel on Climate Change (IPCC) and the AO-GCM Models is taking place.

Figure B.9: 24 hour rainfall intensities from 1960 to 2007



Source: University of Guyana, Faculty of Technology in collaboration with the Hydrometeorological Department, Ministry of Agriculture (2008)

3.2 Sunshine

As a result of Guyana's proximity to the equator there is little variation in the hours of daylight. It varies from a minimum of 11.6 hours per day in December to a maximum of 12.5 hours per day in June. Bright sunshine is inversely proportional to rainfall. It therefore varies from an annual average of 4.5 hours per day in the Pakaraima Mountains to 7.0 hours per day on the coast. During the Wet Seasons, it can average as low as 3.0 hours and 6.0 hours per day respectively at these locations.

3.3 Temperature

The diurnal variation of temperature is smallest on the coast where the maritime effect is most pronounced. In this area, daily maximum temperatures average 29. while daily minimum temperatures average . However, the lowest temperatures occur in the mountainous regions. At Kamarang, daily maximum averages 28.6 , with a daily minimum of 19.6 .

Seasonally, temperatures are higher in the dry periods with the highest temperatures occurring in September/October and the lowest in January/February. The October average daily maximum temperature ranges from in the Savannahs to at Kamarang and less in the higher regions

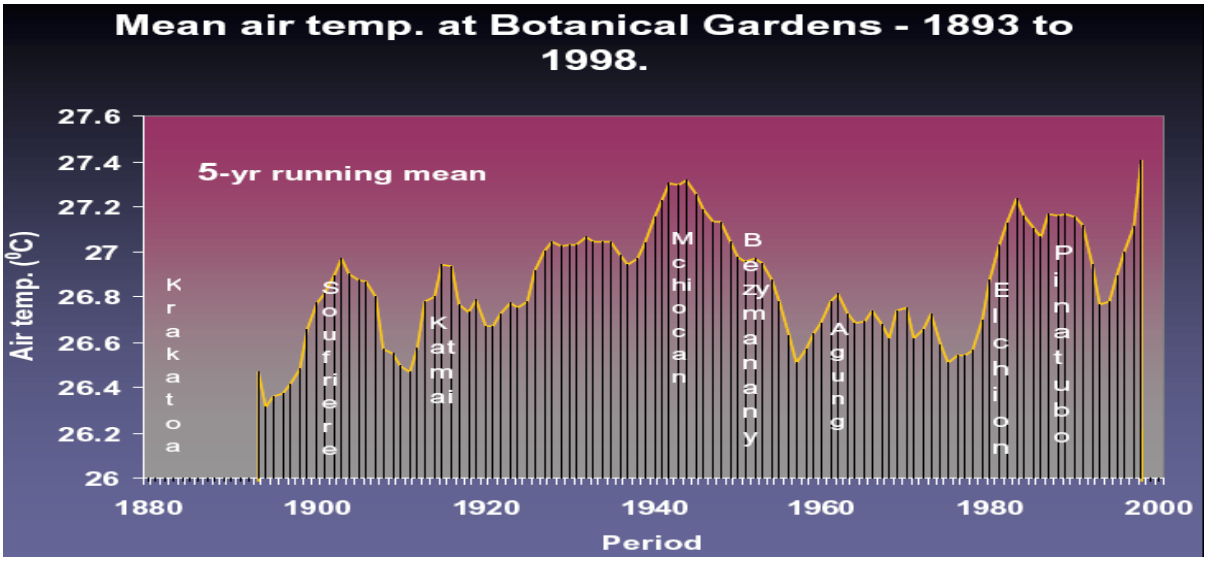
The January average daily maximum temperature ranges from in the Savannahs to at Kamarang while the daily minimum ranges from in Georgetown to at Kamarang.

When Georgetown Botanical Gardens mean air temperature data is compared to global average temperatures there are some similarities:

- Temperatures have been rising from about 1890 up to about 1940,
- Then there was a decrease until the late 1970s, when temperatures increased again,
- The highest average temperatures were recorded in the 1980s and 1990s.

However, there was a short period about 1940 when comparable high average temperatures were recorded.

Figure B.10: Plot of 5 Year Running Mean Air Temperature



Source: INC (2002)

A plot of the modelled minimum temperature data over the period 2011-2030 for Wales and Leguan combined show that there is a an increasing rise of the minimum temperature. The same period of minimum data for MARDS and also the 2031-2050 period indicates that a similar trend of increase is projected (see Figure B.11).

Figure B.11: Plot of Minimum Temperatures of Leguan/Wales, Region 3 for the Period 2011-2030

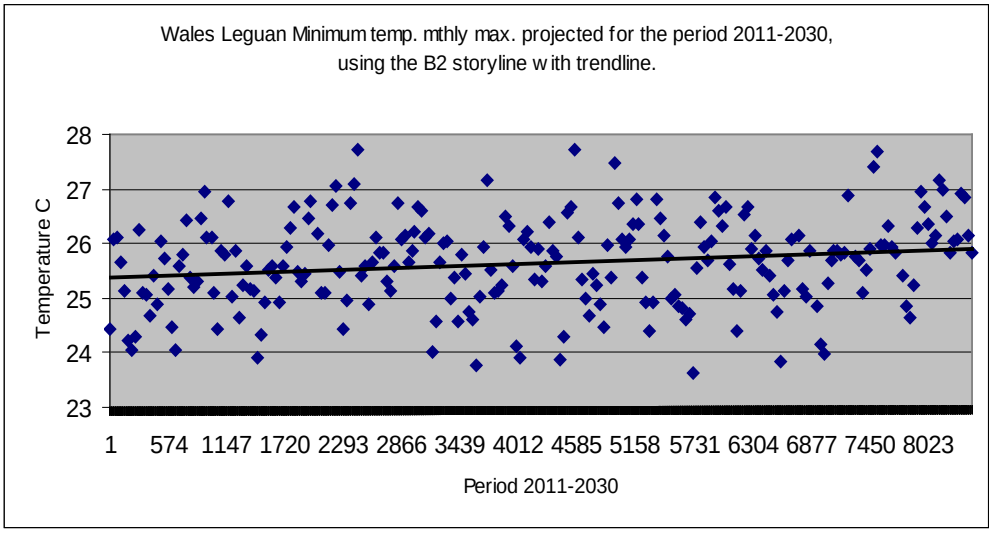


Figure B.12: Plot of Minimum Temperatures of Leguan/Wales combined for the period 2011-2030

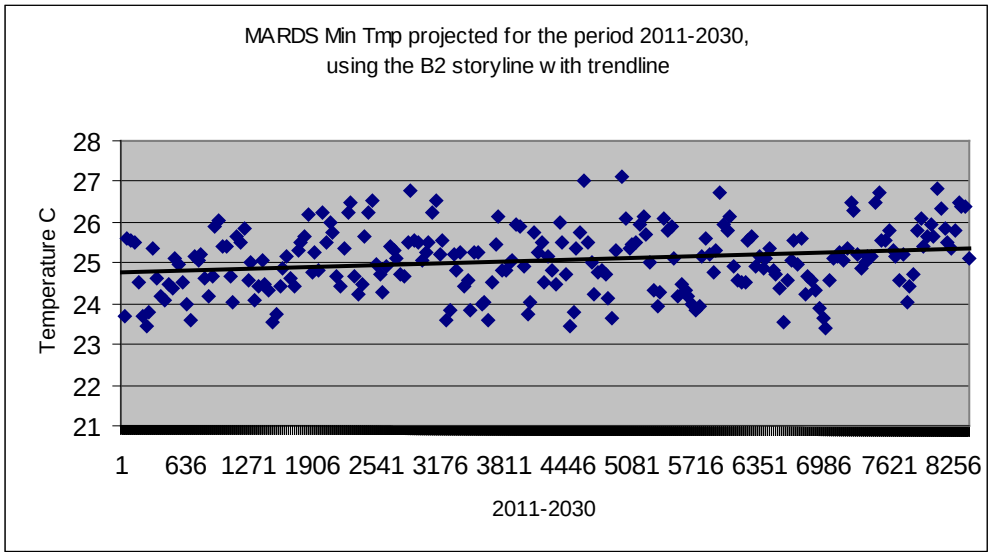


Figure B.13: Plot of Minimum Temperatures of MARDS for the period 2011-2030

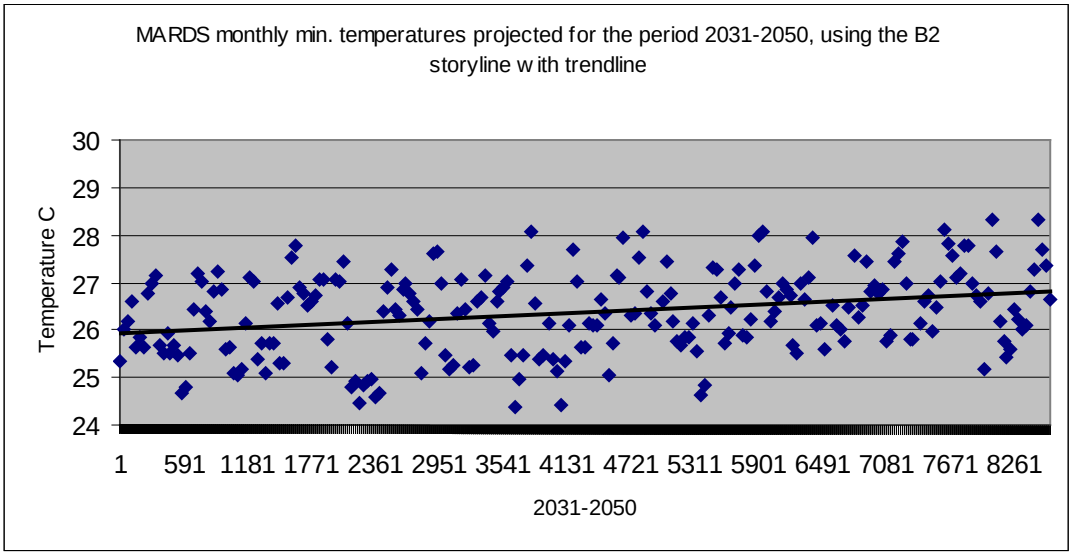
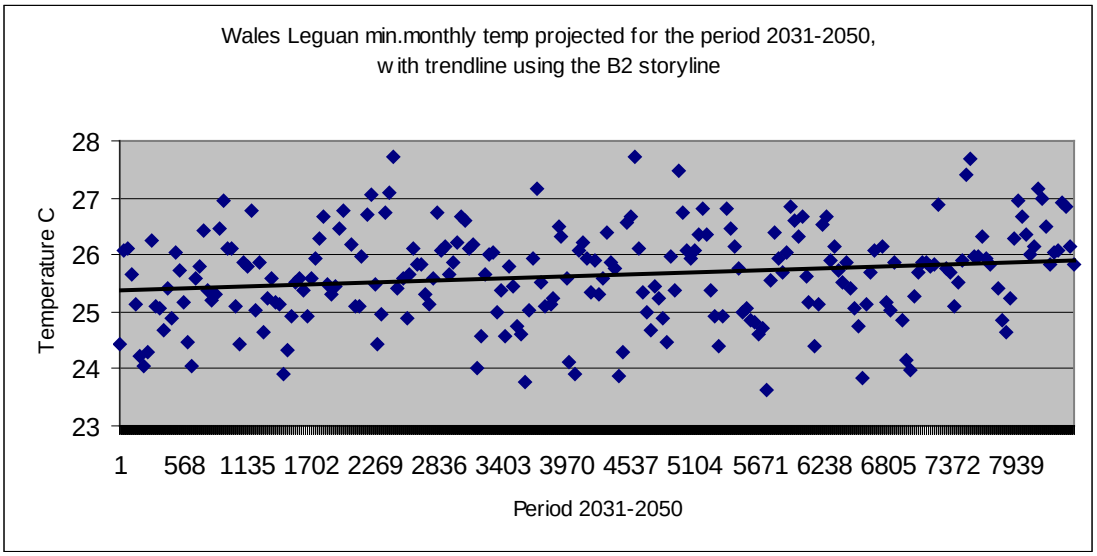


Figure B.14: Plot of MARDS Minimum Temperature for the period 2031-2050



3.4 Relative Humidity

Relative humidity is high averaging about 70% in the Savannahs, 80% on the coast and 88% in the rainforest. Morning fog can be widespread and persistent in the hinterland districts. The projection was for an increase in relative humidity, in the global climate scenario. In the projections for the future scenarios at Wales/Leguan and at MARDS, it was found that there seems to be an increase over the period 2011 to 2030 at MARDS while at the other location it does not appear to increase.

3.5 Wind

Guyana's coast is subject to the north easterly trade winds with speeds of about 6 m/s decreasing further inland where light winds generally prevail. However, in the Rupununi Savannahs the wind speeds are similar to that on the coast.

During rainfall events gusts have been recorded at over 120 m/s, these have taken off roofs, blown over communication towers, trees, electrical poles and caused houses on stilts to fall.

4. ECOLOGICAL AND BIOLOGICAL CONTEXT

Increases in temperature leads to higher evaporation and evapo-transpiration rates, warming of water bodies, faster degradation of some chemicals used as fertilizers, weedicides and pesticides. Hence, their impacts will either not be beneficial or they will become more reactive with naturally occurring elements. It is generally known that some species of animals will remove in reaction to some stimulus or adverse environmental conditions, plants also will adapt by reducing their rate of photosynthesis under water deficit conditions, by closing of the stomata, these are autonomous adaptation responses (GNVSLR 2002). Others will remain but will lose some of their functions while others will die and be replaced by invasive species (Per comm. Dr U. Trotz). In the case of inland aquaculture, there will be positive responses to warming in the increase of growth and weight gain of fishes over a shorter period, hence maximizing returns on the investment (Per. Comm. Geer 2008). This will be so once the water, which is evaporated quickly due to the increased heating is replenished regularly, otherwise the saline content of the water increases which could lead to loss of stocks. The need for additional water is likely to lead to further shortages and possible conflicts with other users of this resource. There will be need to exploit other sources such as ground water to meet the increased demand, due to the impacts of climate.

Intense rainfall on areas that are cleared for farming or mining, as in open pits is likely to lead to more runoff, less percolation, erosion of topsoil, which is the most productive section of soil, increase in sedimentation of streams and conservancies . In these water bodies and large rivers this influx of freshwater has to be released and this will flow into estuarine areas changing the water quality and affecting the natural habitat, even causing economic loss such as fish kills or causing the moving away of commercial pelagic species (Per. Comm, Geer 2008). This creates hardship to the persons engaged in harvesting, as there are less fishes, and what are available are further away, costing more resources and danger to pursue and catch. Hence, the impact of Climate Change resulting in increase in temperature and sea level rise will impact on the ecosystems through systemic actions. These impacts are elaborated upon later in this report.

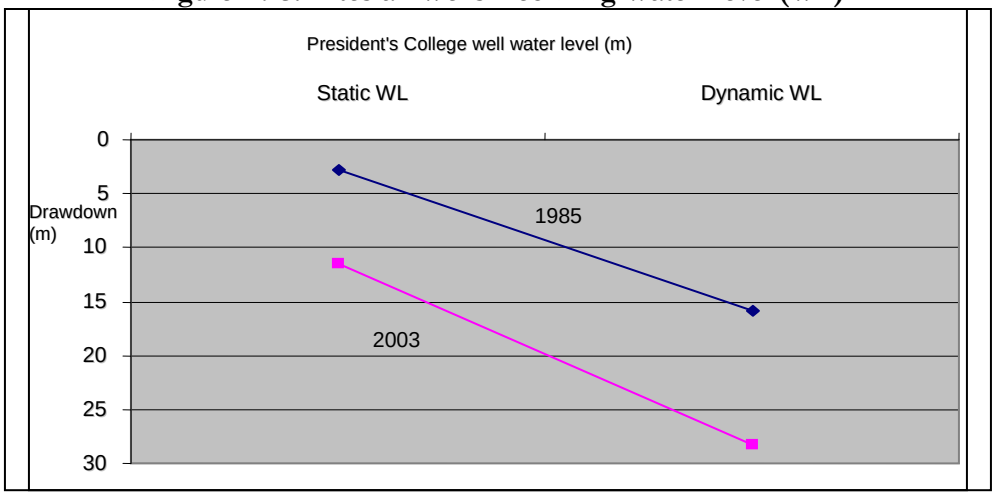
4.1 Water Resources

There are three large rivers that dissect the coastal plain, namely, the Demerara, Berbice and Essequibo Rivers, effectively providing drainage to all of the interior areas in the southern highlands. There are several smaller rivers that are equally important inclusive of the Waini, Pomeroon, Mahaica, Mahaicony and Abary Rivers, all discharging into the Atlantic Ocean.

There is also a large amount of ground water resources. In the underlying strata there are three well established aquifers, Upper sands, A- sands and the B sands. These lie between 20m to 600m deep along the coast with the deepest locations being in the east. The upper sands water quality is not good for human consumption without extensive treatment, but this resource can be used for other purposes, such as completing domestic chores and agricultural support. Over 90% of extraction is done from the A-sands, which yield good quality water for potable use, while a small percentage of potable water is extracted from the B-sands that have the best quality water but because of the high economic costs associated with water extraction from this zone, it is not much used. There has been consistent falling of the piezometric levels in the A and B-sands aquifers over the years, which can be due to over extraction, and low and slow recharge due to variations in rainfall or land use changes

in the recharge zone. The need to identify the causes and be able to act is very important, as saline interface can intrude into the areas being used for extraction, causing contamination and loss of use of the aquifer concerned. Figure B.15 indicates the trend of head loss over the years.

Figure B.15: Artesian Wells Declining Water Level (WL)



Source: Guyana Water Incorporated (2008)

The plot charts the actual decline in aquifer levels, i.e., static - before pumping, and dynamic - during pumping, from two periods 1985 and 2003, in the A-sand aquifer in a coastal well at Golden Grove.

Water resources availability will be affected adversely due to the impacts of climate change. The models, A-O GCM and HADLEY have predicted that there will be higher temperatures, increased evaporation and more intense storm events. The need to provide irrigation, coupled with the highly variable occurrence of rainfall has lead to the creation of Conservancies. There are, from the west, the Tapakuma, Boeraserie, East Demerara and the Mahaica Mahaicony Abary /Agriculture Development Authority (MMA/ADA). In the projections of future climate scenarios, resulting water deficits due to changes in precipitation and higher temperature leading to increasing evaporation, it means that these Conservancies would have to be maintained efficiently. It will be necessary to increase storage if possible, reduce losses or be able to supplement supply when needed The MMA/ADA, only empolders the watershed areas of the Abary River above Copeman. All these Conservancies serve dual purposes, flood control and storage of irrigation water for their respective areas based on the agricultural sector's water needs.

4.1.1 The Tapakuma Conservancy

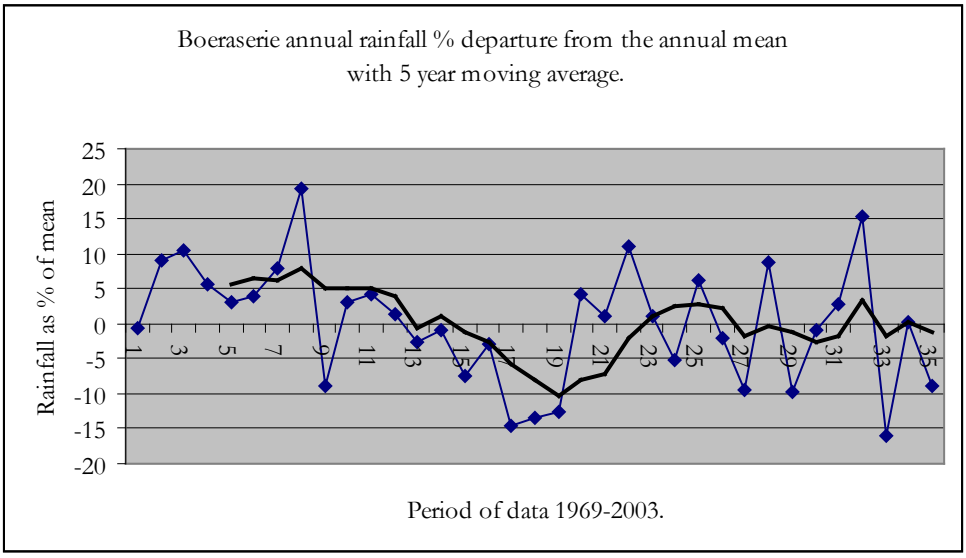
This is a storage area that links several water bodies in Region #2, such as the Itirubisi, Capoey, Mainstay and Tapakuma Lakes and is surrounded by an earthen dam with associated outlets. The current supply flow to the irrigated areas is by gravity, hence it is necessary to maintain a high water level, particularly during the paddy sowing season when water demands are high, to ensure that all agricultural plots are adequately serviced. The Dawa pump station, recently rehabilitated with the installation of new pumps will be able to irrigate over 13,000 hectare of rice and other crops in this Region on the Essequibo Coast. The pump will discharge water into the Tapakuma River when the Conservancy is too full and will extract water from the Tapakuma River to replenish water whenever the storage level is low. The variability of rainfall with the watershed and environs will create the

need for careful management of the operations, as in the past this Conservancy was blamed for flooding in surrounding areas and communities along the Pomeroon River. A proper management system taking into account the concerns of the users and the predicted impacts of climate change needs to be implemented. The climate projections for the area are for higher temperatures leading to increase evaporation and a likely increase in water demand. There is projected to be no significant reduction in rainfall, however it will be prudent to ensure that proper management strategies are put in place to prevent wastage of the water resource, due to leaking structures and vandalism of sluice doors.

4.1.2 The Boeraserie Conservancy

This conservancy in Region #3 was built to serve the needs of the farmers and sugar estates in the surrounding areas. The catchment area is 256 but at spill level the area is 182 . The high intense rainfall experienced recently often causes the earthen embankment to overflow and this situation is projected to worsen with climatic changes taking place (GINA 2005). Its main discharge is via a 244m long weir and sluices at Waramia into the Essequibo River to the West, and several outlets leading to the Coast, and along the West Bank towards the Demerara River. Along these outlets are agricultural farms and sugarcane fields, which are fed by gravity drainage. Hence there is need to maintain high levels to allow for flow to the farms and fields. Maximum storage level is 18.84m GD. Usable bottom is 16.31m GD. Storage level is usually 2m above the surrounding land level. Rainfall in the Conservancy, although highly variable has shown a decreasing trend (see Figure B.16).

Figure B.16: Plot of Annual Rainfall Percentage Departure from the Mean for Boeraserie Conservancy



It exhibits the variability clearly and indicates the trend of decreasing rainfall over the period (Mott Mac Donald, 2004).

4.1.3 East Demerara water Conservancy

The East Demerara Water Conservancy in Region #4, which was constructed in the Century, serves several purposes, flood control, the irrigation needs of villages in the surrounding areas, sugar estates, and about 80% of the potable water supply to the Georgetown area. Its catchment area is 333 . Maximum water level is 17.68m GD, usable bottom is 16.31m GD (Mott MacDonald, 2004). It is a very important contributor to maintaining occupancy on the coast, where all the main rivers are brackish to saline as the seasons change from wet to dry. The high rate of irrigation and potable water supply necessitates that storage be maintained at a level to meet requirements. All supply is through gravity flow by maintaining higher heads above field level. The decade during the 1997-1998 El Nino (dry) events the water level dropped to extremely low elevations, where only pumps could have taken out water from the storage and the management had to resort to pumping water from the Mahaica River to increase the supply within the Conservancy. The vulnerability of this Conservancy increases in the event of climate change as its storage capacity can be easily exceeded, which can place pressure on the earthen embankment resulting in failures, or erosion and gullying by overtopping. In the aftermath of the floods of 2005, the Dutch government sent over two of their engineers to undertake an assessment, along with the UNDP prepared a set of strategic responses that were executed. These included assembling a Task Force, under the UNDP to institute a management plan for the operations of the Conservancy, the identification of improved drainage, through other outlets to the Demerara River and clearing of these. A main outlet is at Land of Canaan into the Demerara River which discharges through a five door sluice. In the past 2 years a number of outlets have been reactivated after the 2005 floods. A good management system has to be maintained, as its secondary discharge canals are ones that flow through human settlements and farming areas.

The floods of 2005 severely tested the holding capacity of this conservancy, magnified weak areas and also necessitated international intervention to maintain its integrity and operations. The result was the compilation of an Operational Manual for the control of the water levels in the conservancy by the operations staff. Interventions by International Agencies through the UNDP assisted in identifying weaknesses in the conservancy infrastructure and resulted in the preparation of an Adaptation Project of US$3.0m to reduce the vulnerability to similar severe events. Recommendations emanating from this Adaptation Project are currently being implemented. However, there needs to be a water balance of the Conservancy to assist in the management of this resource. Some recommendations offered by Mott MacDonald (2004) to establish the water resource/conservancy management plans for the East Demerara and Boerasirie Conservancies may be summarized as follows and include:

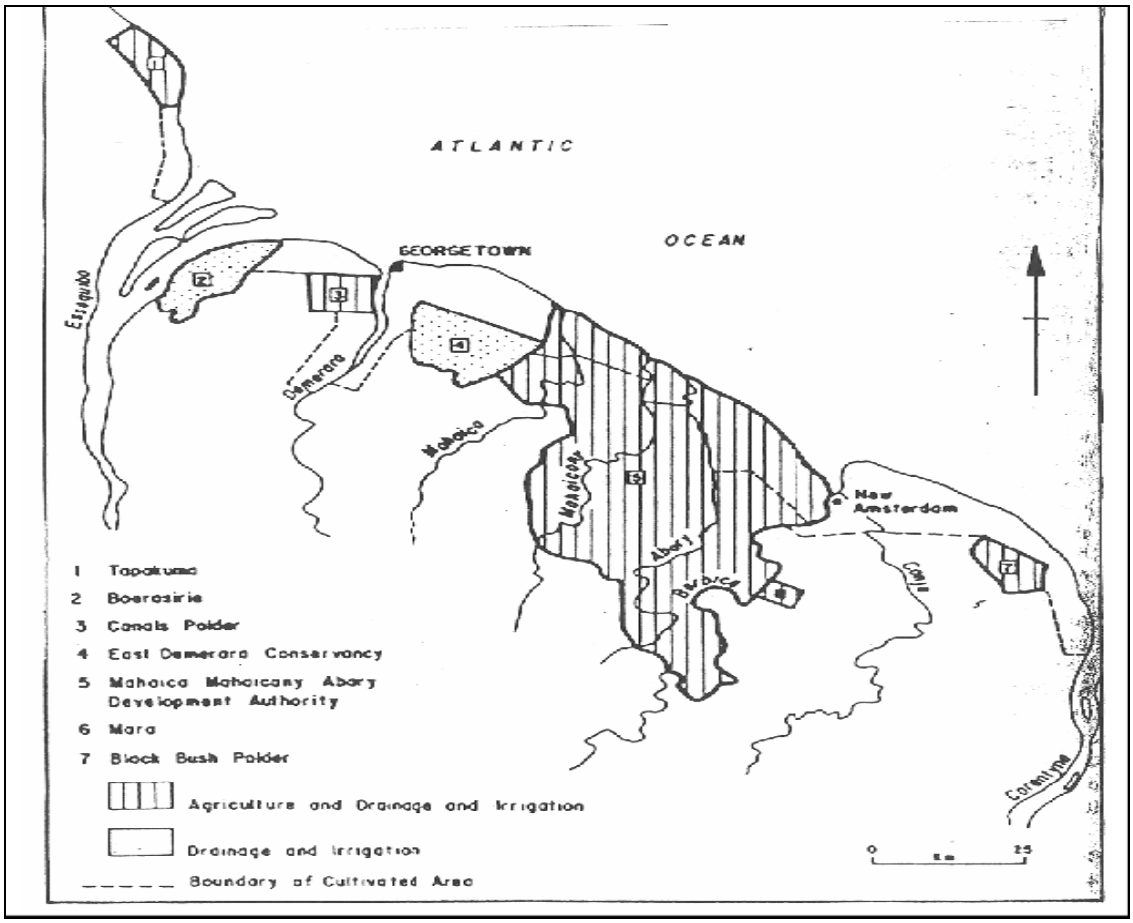
1. Rehabilitate all outlet structures from the conservancies, and establish means of routine measurement at these structures.
2. Establish routine monitoring and data collection and storage procedures for conservancies. This will help to ensure true discharge measurements at outlet structures and pumping to augment storage when necessary.
3. Survey command areas of all outlet structures and establish demand patterns, and scope for improved water use efficiency and recycling of drainage water.
4. Determine appropriate demand scenarios for all outlets.
5. Set up and improve calibration of hydrological model to synthesize conservancy inflows.

6. Establish Automatic Water Level Recorders at the Boerasirie Conservancy.
7. Following one full year of observation of releases, water levels and pumped inputs, use simulated inflows and a reservoir model to refine elevation-storage-area characteristics for conservancies.
8. Use reservoir model and simulated historic inflows to determine appropriate operation rules for the conservancies, including the use of pumping to augment storage.

4.1.4 The Mahaica Mahaicony Abary Agricultural Development Authority (MMA/ADA).

The section empoldering the Abary watershed of the MMA/ADA Scheme was completed in 1980s. The conservancy was constructed to serve two purposes, a flood control and also irrigation supply to the front lands that were being cultivated, this by gravity flow. It has been maintained to a level that allows for the supply of irrigation water to farmers, however it has not been able to control the flooding in the Mahaicony and Mahaica riverain areas, which are also flat with dependency on tides for drainage. The flood control of the conservancy is assisted with a mile long spillweir, which discharges into the Berbice River, and other structures discharging into the Abary and other high level irrigation canals. All of the discharges except from the spill weir passes through cultivation or populated areas.

Map B.4: Coastal Areas Showing Irrigated Areas and Storage Conservancies in Regions #2, #3, #4 and #5



Source: GNVSLR (2002)

4.1.5 Irrigation in Region #6

In Region #6, a total of some 52,700 hectare of rice and sugarcane are irrigated from the Canje River. The total agricultural area is 68,400 hectares, and the land use is as follows:

- Rice 41%
- Sugar cane 36%
- Other crops 5%
- Pasture 18%

Rice, sugarcane and other cash crops are irrigated by pumped abstraction from the Canje River, at several pump stations located on its right bank. There is no man made conservancy, the Ikuruwa Lake in the Canje and the swamps, along with the numerous lakes on the Berbice River flow outwards and provide irrigation supply. The Berbice River, about 80 km upstream, is linked to the Canje River through the Torani canal. Abstraction from the Canje is through a number of pumped intakes. Since there is no man made storage in place on either river, the flow is subject to the variations and volume of rainfall the respective watershed receives, and saline intrusion up the Canje River during periods of low flow is a constraint to abstraction. There have been many episodes during which pumps have had to be shut down, particularly during the 1997 to 1998 ENSO event. The brackish water reached to the pumps located at Brothers pump station, 35 km upstream from the mouth of the Canje River and pump attendants at the Albion pump station 15.6 km upstream take hourly readings of water quality when irrigating from the river. The Guyana Sugar Corporation has established a limit of <500 electrical conductivity (specific conductance) μS/cm. Measurements at Albion pump station during high tide have been as high as 510μS/cm at the water surface. It will be higher at the bottom as the saline water is denser, at the same location during the low tide it goes to just over 100 μS/cm and below.

4.2 Forestry

Guyana is ranked in the world by the International Timber Trade Organization (ITTO) for practicing sustainable forestry management. The Food and Agriculture Organization (FAO) has indicated in a recent report that the rate of deforestation in Guyana over the last decade was less than 1%. This is also due to the low rate of timber extraction by concessionaires, about one third. The Guyana Forestry Commission has over 150 staff in the Forest Monitoring Division and also has staff consigned to and living on large concessions. They have introduced a Code of Good Practices and concessionaires are regularly trained. The combination of regulations, monitoring, enforcement and guidance prevents damage to the ecosystem especially in the watershed areas, which is so important in the hydrological cycle. The forestry sector is also well placed to benefit in mitigation to climate change through the Carbon trading mechanism, as sequestration of carbon through standing forests and re-growth are being considered as "sinks" with a value. The President of Guyana in 2006 offered to the global community the opportunity to trade in Carbon offsets in Guyana's Forests. The global community up to now does not recognize the true value of standing forests, so Guyana's position is to bring this to the fore, and adopt positions at negotiations that would the recognize the contribution standing forests make to global mitigation efforts and justly reward countries' efforts at sustainable practices and avoiding deforestation. In some forested areas and in the intermediate savannahs there is an expansion of agriculture in the citrus and spices production. In this new development there will be more trees planted and it is likely that this would add to the

carbon sequestration and hence the mitigation efforts in reducing ghg emissions and creating the environment for more benefits to Guyana through the Carbon trading mechanism of the Kyoto Protocol and Clean Development mechanism.

In summary then, agriculture is sustained in its present capacity through the established drainage and irrigation areas and through the proper maintenance of infrastructure. However, in other areas, farmers tend to rely on the stability of the weather to sustain their crops and to be able to reap. The variable rainfall along with the impact of climate change also causes losses to farmers in the D&I areas, as sometimes the arises for excess water to be pumped out of fields, access dams become impassable and other means of transportation have to be used to transport produce. The shorter time cyclic occurrences of strong ENSO events will surely test the existing system and increase weather variability. Hence, it is necessary to recognize this and put systems in place to reduce vulnerability and enhance agricultural production and productivity. In addition to the increase in temperature and a very likely increase in the incidence of pests and diseases on crops and livestock must be addressed by improved technology and vigilance (an issue discussed in the next section of this report). The issue of sea level rise and its impacts on flooding of agricultural land and saline intrusion are issues that are critical to sustainable occupation of the coastal areas, more studies should be done on coastal areas including elevation surveys to determine topographic variations that will be useful in GIS mapping of vulnerable areas.

Additionally, in order to more accurately establish the water resource of the Canje River, and to subsequently manage that resource effectively, there are a number of steps that will have to be taken to improve regular data collection, and to establish relationships between river flow and location of the saline front.

There is need to increase data collection, water quality, rainfall and water level in the Canje and Berbice River basin with the installation of gauges at locations that can be visited and read The monitoring of flows in the Torani Canal and a continuous check of the channel is necessary to ensure that the sediment build up is identified early and cleared to prevent reduced flow downstream. Currently, the water resources from the Canje and Berbice river basins support irrigation of over 68,400 ha of land, planted with sugar, rice and other crops. In planned expansion of cultivation and livestock in this Region, therefore and with the rainfall deficits projected due to climate change it is necessary to ensure adequate supplies to reduce the risk of losses.

5. SCOPE OF THE AGRICULTURAL SYSTEM AND CONTRIBUTION TO THE NATIONAL ECONOMY

Climate Change issues are fast becoming more and more prominent in the world today. More than likely it will impact on all aspects of human existence. Consideration, therefore, should be given to the likely impact on key sectors including agriculture, health, water, and tourism since adverse effects in these sectors will be felt immediately and will impact the GDP. Agriculture has been contributing significantly to Guyana's economy, and in order to ensure this trend continues it is important that we fully understand and appreciate the issues and threats of climate change to the sector. Agriculture is practiced primary on the coastland (Regions # 1 to 6) of the country. However, there are also substantial levels of production inland (Regions # 7 to 10). The agro-climate in these areas varies and projections are that there will continue to be changes. Therefore, knowledge of these changes and possible impacts will assist us in crafting strategies to ensure that the agricultural sector continues to be a key driver in Guyana's development.

Man depends on crops and livestock to satisfy his nutritional needs. Livestock feed on plants which source of nutrients is the environment. Climate change is likely to impact crops in a variety of ways. Changes (either increases or decreases) in soil moisture will affect the availability and uptake of nutrient. Interaction between nutrients can lead to reduced yield as a consequence of a single limiting nutrient element.

Plants must survive, grow and produce in the environment in which they live. A key consequence of climate change globally is rising sea levels. If adequate measures are not in place much of our coastland (major agriculture areas) will be adversely affected. This can lead to low availability of food, increase hunger and reduce exports.

Climate change will also affect the rate of photosynthesis of crops, the performance of a crop variety or breed of livestock as well as their susceptibility /resistance to pests and diseases. Thus, it is vital that we have an understanding of how climate change is likely to impact agriculture in order for us to effectively strategize to overcome or benefit from its effects.

5.1 Organic Farming

Organoponics is being used for the production of vegetables at Mon Repos. While at Kairuni pineapples are being produced organically. Tree crops (fruits) are also being fertilized using organic litter. Overall, organic farming may be the way to go to reduce the impact of climate change since it has many benefits to the soil.

Pineapples are being produced in the Tri-lakes area of Mainstay, Capoey and Tapakuma of Region # 2. Heart of the Palm is being obtained in Region # 1 and 6, while tomato and pepper are grown in Region #1.

NARI acknowledges that varieties of crops and breeds of animals may be brought illegally into the country across Guyana's borders with Brazil and Venezuela. How this practice will impact on the country and its strategy for climate change for the agricultural sector is unknown.

An area for exploration is the use of the effluent from fish ponds for fertigation of crops. Generally, the ponds are drained for harvesting of the fishes, and the water discarded into adjacent canals. This waste water is definitely a source of nutrients for crops (trees and vegetables) and it is recommended that where possible it be used for such purposes.

5.2 Aquaculture

In aquaculture the species used are tilapia (*Oreochromis niloticus*), hassar (*Hoplosternum littorale*) and fresh water pacu (*Colossome macropomum*). The history of aquaculture in Guyana dates back to the late 1940's /early 1950's when tilapia was introduced. However, this sub-sector declined significantly since it did not receive much attention. Only in the late 1990's did interest soar again as government (through the Ministry of Agriculture) played a central role through the establishment of the Aquaculture Demonstration Unit at Mon Repos. The industrial and artisanal fisheries sectors may be impacted on negatively due to high runoff forecasts, as a result of high intensity rainfall, and sea level rise causing a shift in the spawning ground for aquatic species (Geer, 2008 pers. comm.). In addition, increased temperature can increase the metabolism of fishes such as tilapia resulting in faster growth and maturity (Ibid.).

There has always been the production of swamp shrimp (*Mesopenaeus tropicales*) especially in Region # 6 though this is not an area where much focus has been placed. There are about 100 persons, with a total of about 2,000ac, involved in swamp shrimp production using sea water. About 90% of these are in Regions # 6. Fresh water aquaculture occupies about 200 acres owned by 20 persons in Regions 2, 3, 4 & 6; about 50% of these rear hassar and pacu .

Tilapia and hassar can be cropped in 6 months when the fish are expected to have approximately 450g and 50 – 60g respectively. This corresponds to about 12,000 lb/acres and 3,000 lb/acres respectively. Pacu reaches 250g in about 4-5 months. These fish are sold to local processors who degut the species and sell to markets in North America (Hassar) and the Caribbean (Tilapia). Pacu fingerlings are imported from Brazil.

From 1990 to present there has been an increase in yield because of improved management practices and higher protein content in the feed. Previously, the fish were fed ration ideal for poultry. However, this did not have sufficient protein, thus the growth and development of the stock were limited. Today there is one company (Maharaj oil mills) that prepares feed specifically for fishes.

One effect of climate change, salt water intrusion, can have a debilitating impact on aquaculture production since the hassar and pacu will not be expected to survive under saline conditions. Tilapia has been known to withstand salinity levels up to 28 parts per thousand (ppt)(sea water); however, there is need for fresh water for reproduction and survival of the fries. High salinity is also expected to affect other predator fishes e.g. houri (*Hoplias malabaricas*).

Changing rainfall patterns may also impact on the spawning activity of hassar which need a demarcated change in conductivity of the water for breeding. When the conductivity of the water is high (occurs in dry season where evaporation is great) the fish begins storing body reserves. Rainfall lowers the conductivity and the breeding season commences. In areas where rainfall levels decreases and there is no sharp demarcation in conductivity then reproduction rate will decline. However,

since in Guyana it is expected that the intensity of rainfall will increase then an even more sharp change in conductivity will occur, leading to, probably, an increase rate of spawning. It is expected that spawning activity will continue to be synchronous with the rainy season. For hassar, grass is usually placed in the pond at the onset of the rainy season for them to nest.

For the swamp shrimp water at 60 ppt can improve the shell quality of the crop. High temperature and increased rainfall should be good for aquaculture. It will dilute the brackish water and can cause faster rate of growth. A rise of up to one foot of water in the pond will not have any detrimental effects on the crop. After that, a properly constructed pond will have overflows to remove excess water.

Pests and diseases are not a problem in aquaculture. This may be because the culture is relatively new and also the system is semi-intensive i.e. the stocking rate is lower than in an intensive system. Thus fishes are hardly stressed and pests and diseases have not become a problem. As cultivation continues we may see the emergence of pests and diseases. Elsewhere, tilapia is known to suffer from viral diseases and shrimp from white spots; however, these are not prevalent in Guyana (Geer, 2008 pers. comm.).

A major problem to the expansion of aquaculture is that suitable lands are not readily available. Suitable lands are essentially the class I agricultural lands which are needed for crop production. This is because the pH of the land is crucial. Tilapias need a pH of 6.5-9.0, hassar 5.5-8.0 and pacu 3.5-7.5. Thus only pacu can be reared on lands unsuitable for many crops. The very lands which are rendered unsuitable for crop production either through high salinity or low pH are also unsuitable for aquaculture production. Class II and III lands also need much infrastructure and inputs. Tilapia is not recommended for inland because they can destroy the local /indigenous species.

If we are to include new (local) species e.g. lukanani (*Cichla ocellaris*) or arapaima (*Arapaima gigas*) (as some persons have suggested) then other considerations will emerge. For instance, these are predators and will have to be fed a diet of other fishes. Generally, predators have a low (uneconomical) food conversion ratio.

Much has been said of an integrated fish /rice culture system. This has even been demonstrated to farmers. However, farmers have not been too inclined to adopt the field modifications needed to enable this practice. In addition, this new venture demands attention from the rice farmers who are not inclined to provide the level of husbandry required for success.

One of the reasons for the low take off of aquaculture is the initial high capital investment. Pond construction is about G$162,000/ha while recurrent expense for the cropping season is about G$1,080,000 (10,909 kg @ G$99/kg). This is money to be spent even before any earnings are realized.

Aquaculture also does not benefit in any significant way from the support that 'traditional agriculture' i.e. rice and sugar enjoys, such as:

1. Extension services
2. Input support
3. Research

- training
- fingerling production

4. Industry support – feed
   - loans

5.3 Land Availability

Production at the Skeldon Estate is important since this estate has been expanding its area of production. The old estate is 4,955 ha. With the expansion programme 4,685 ha more will be under cultivation. In addition it is planned that farmers will cultivate 5900 ha too, bringing it to a total of 15,540 ha of land under cultivation of sugar cane.

Burma Rice Research Station has used all of its available lands for research, and production of seed paddy. Consequently, no new lands are available for production. Within the Mahaica- Mahaicony-Abary scheme additional lands for production are only available (20% remaining) in the Mahaica-Mahaicony area. However, heavy initial capital is needed to clear and develop these lands. All 18,219 hectares of rice lands in the Abary-Berbice area have been leased out to farmers.

The National Dairy Development Programme does not have its own lands for pasture. Instead pastures are established on private lands in Regions #2 to #6. In Regions #7 & #10 the Programme has earmarked farmers to begin assisting with pasture establishment using UF717 and elephant grass (*Pennisetum purpureum*).

Approximately 30% of the land at NARI'S Ebini location is unutilized. The nurseries in the regions are fully utilized, while at Mon Repos there are about 16.19 hectares for joint ventures and seed production.

5.4 Formal Training

The Guyana School of Agriculture (GSA) offers a course to its students that cover agro-meteorology, hydrology, and issues on climate change. The School is not currently practising any strategy for climate change in its production. However, its land is drained by culverts and there are also pumps available for supplemental irrigation or to assist with drainage.

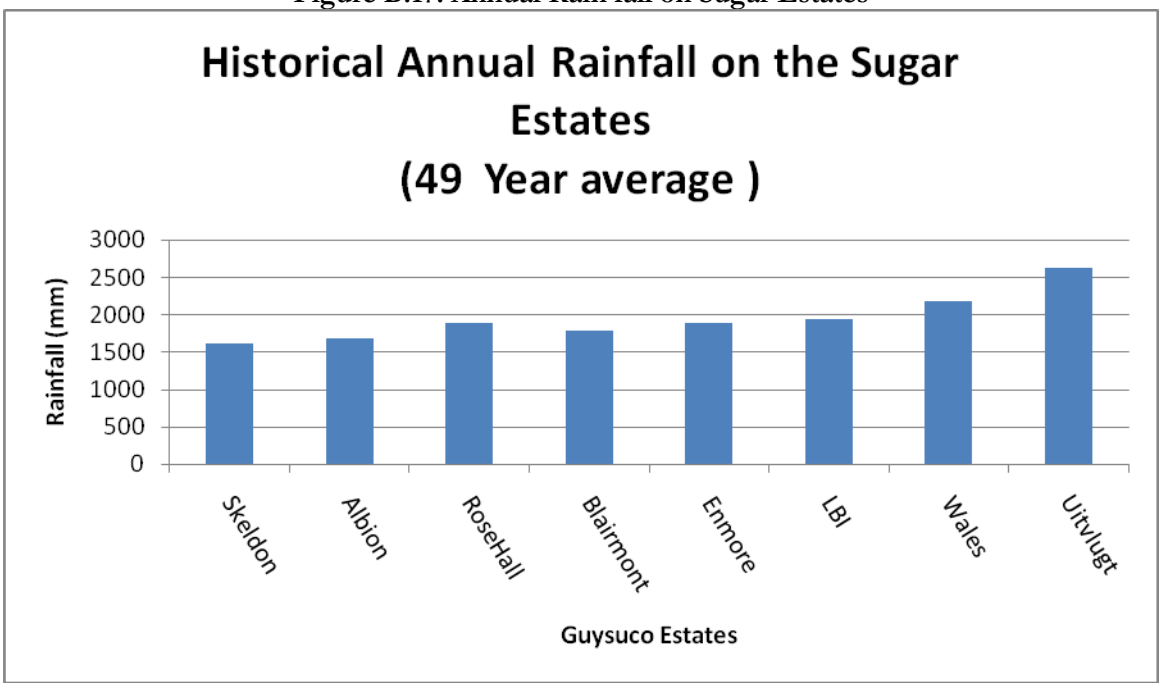
The School is tasked with training persons in the theory and practice of agriculture. Though not involved in agricultural research it is heavily involved in production of both crops and livestock. Training is carried out on about 2.02 hectares of land for vegetable production and 4.05 hectares for livestock production. In addition there are about 1.22 hectares of crop museum. The acquisition of the lands formally under the REPAHA has provided the School with an additional 16.19 hectares of lands for production purposes.

The University of Guyana (UG) has at its Turkeyen location 2.02 hectares of land which is used primarily for teaching and research purposes. At its Johns Campus there is about 1.22 hectares of land for similar activities.

5.5 Response to Flooding

On the coastland of Guyana there is an increase in the annual precipitation as one traverse from east to west. For instance, the 49-year annual rainfall for the Skeldon estate, which is most easterly of all the estates, is 1615mm while Uitvlugt estate (most westerly) receives 2631mm of rainfall (Guysuco, 2004). With an average of 2.7 meters of rainfall on the coast, West Demerara had an average of 3.4 meters in the last three years (Davis, 2008 pers. comm.). If this level of rainfall is now concentrated over a shorter period as anticipated, there will be a higher risk of flooding on the coast. This water may reach its cultivation whether directly from rainfall or via overflows from rivers and the conservancy.

Figure B.17: Annual Rain fall on Sugar Estates



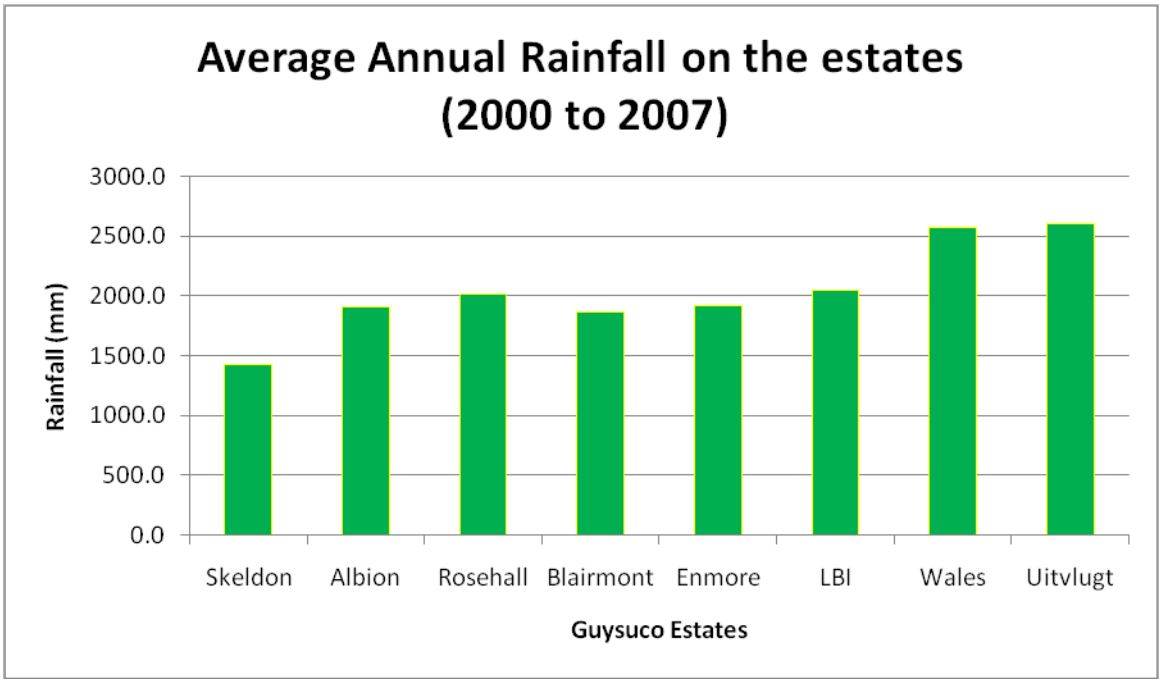
Source: GuySuCo, (2004)

GuySuCo has developed and installed extensive drainage and irrigation systems throughout its cultivation areas. GuySuCo works very closely with the National Drainage and Irrigation Authority (NDIA) to ensure that there is adequate drainage for many of the lands contiguous to its cultivation. However, with climate change there will be the need for additional drainage structures to offset the anticipated increase in water that will be on the land. This infers that the cost to drain the land will increase.

The layout of the new lands for the Skeldon Estate expansion will be of such that GuySuCo's drainage and irrigation will be independent of the farmers' drainage and irrigation. The farmers will have their own river sluices (i.e. projected to be 5) that drain into the river. It is felt that additional structures can readily be in place if needed to combat the adverse effects of climate change. Since GuySuCo is a commercial entity only the price of sugar on the world market can seriously impede its ability to counter any adverse effects of climate change.

At Skeldon the June-July months are the wet period, hence this is the close crop time. If there are too high levels of rain the tilling and planting will be affected because machines will be unable to traverse the fields. It is also believed that the ratoons will be adversely affected by more rainfall. Increased intensity of rainfall will lead to more leaching of nutrients from the soil. Hence there will have to be greater addition of fertilizers.

Figure B.18: Average Annual Rain fall on Sugar Estates



Source: Adams (2008)

At the Burma Rice Research Station much of the lands now being used are subjected to floods during the wet season. However, the station has pumps that can be driven using the Power Take Off (PTO) of a tractor to offset floods. It is also strongly opined that the Mahaica- Mahaicony- Abary scheme may need to be completed (possibly using an updated design) in order to have the best possible drainage and irrigation system in place to counter the undesirable impacts of climate change.

The Mahaica- Mahaicony- Abary Scheme is of tremendous benefit to both crop and livestock farmers. A large cattle population (approximately 20,000 head) is located behind the arable land. Here the animals are left to forage for themselves on the natural range since there are no established pastures. If as a result of climate change there is continued flooding in the backlands then there is expected to be increased mortality of cattle. In times when the Abary area floods cattle must migrate further into the backlands. The drawback is that the higher grounds do not have good pastures.

The Scheme is designed to drain 38mm of water in 24 hr. Therefore, if there is an increased in the intensity of rainfall then, with the present system, the discharge will take a longer time. This will likely affect (adversely) cattle, rice and vegetable production. High rainfall will also lead to greater incidence of duckweed (*Sagittaria guyanensis*).

To combat the above anticipated problems there will either have to be the installation of more sluices or additional pumps installed. Building and installing sluices are the cheaper long-term option. However, where the water level in the river is higher than that on the land, then drainage must be by pump.

Farmers attitude with respect to the drainage and irrigation canals need to change. Often large items e.g. discarded vehicle shells, bottles, and garbage are disposed of in these canals resulting in severe blockages. This, together with the advent of the rainy season, leads to ready flooding of crop lands and domestic residences. Improved drainage and irrigation can occur especially if there is coordination among GuySuCo, MMA-ADA, and NDIA. Drainage in West Berbice depends to a large extent on gravity flow at D'Edward sluice and two GuySuCo pumps.

In the pasture establishment and management operations the National Dairy Development Programme does have a pump to assist in its operation. Responses to climate impacts have improved through better farm management, diversification, raising of polders and plant beds where possible, and increasing drainage and irrigation infrastructure with the help of local and international help (Mott MacDonald, 2004).

Improved water resource management will be vital to sustaining crop productivity levels in the face of climate change. With possible increasing pressure on available water resources (and especially, net irrigation requirements), improved water management is one of the most important long-term measured to be pursued.

5.6 Salinity

Salinity has not been a problem on any of the sugar estates (Davis, 2008 pers. comm.), neither is it expected to be a problem in the near future. On the Demerara estates a huge reservoir of fresh water is available in the East Demerara Water Conservancy (EDWC). On occasions salt water has been used in the canals to float the punts that take the canes to the factory.

Salinity is not a hindrance to production for NARI (Homenauth, 2008 pers. comm). However, the institute does have pumps for irrigation.

With climate change if there is too much saltwater intrusion into the land then pasture establishment and production may be a problem because none of the grasses (tanner, antelope or para) are very tolerant to high salinity. Presently there is occasionally seepage of sea water unto pasture lands. This high salinity hinders the growth and development of both pasture and crops; sometimes crops may perish as a result. However, antelope and para grass can withstand flood especially, if zero-grazed. If open or semi-open grazing is practised they are unable to tolerate and survive the flooded conditions. It is also anticipated that the grasses may have to be given supplemental applications of fertilizer.

5.7 Livestock Improvement

NARI is responsible for the development of all livestock with the exception of pigs, cattle, and fish. The GSA and MoA have responsibility for pigs, the National Dairy Development Programme (NDDP) is responsible for cattle, and fish is under the purview of the MoA.

Established in 1984, the NDDP is tasked with the development of dairy and beef cattle in Guyana. Previously, it concentrated only on dairy but beef has recently been included in its mandate. It is also involved in pasture development and management. The principal pasture species used are tanner grass (*Brachiaria radicans*) for sandy reefs, antelope grass (*Echinochloa pyramidalis*) for clay soil and para grass (*Brachiaria mutica*) for loam soils. In the Intermediate Savannahs (sandy soils) UF 717 (*Brachiaria humidicola*) (yield is 34,000kg/ha) is used.

Antelope grass is by far the most widely propagated pasture species. It is also the highest yielding in terms of forage (fresh weight) produced. When antelope grass is to be zero grazed, cutting can be done at 90 days from establishment. However, 6 months should be allowed to elapse if the pasture is to be grazed. The rotation cycle is 28 days.

The entity is heavily involved in genetic improvement of dairy and beef cattle. Semen is imported and the Holstein semen is used for improvement up to the generation. Beyond the generation other breeds are used.

It has been observed that Holstein off-springs are not performing well under high temperature and high relative humidity conditions, thus semen from the Jersey and Brown Swiss breeds are now used for better adaptation. In addition Holstein require 10% of its body weight in food daily while Jersey and Brown Swiss need only 7% of the body weight in forage to get comparable yields. Another breed of which semen is used is Semental, which is a dual purpose breed.

There are three anticipated problems that may arise as a result of climate change:

- Nutrition - reduced food (forage) and lower quality of forage especially for beef
- Diseases – respiratory and digestive diseases may increase especially for Holstein off-springs.
- Availability of food for human consumption – there is likely to be increased incidence of mastitis which will lead to lower levels of milk production.

There are about 75,000 heads of small ruminants in Region # 5. These suffer a lot from the ailment known as foot rot which is prevalent during the wet season. However, recently NARI has introduced artificial insemination using semen from the Texel sheep. This practice is expected to lead to an improvement in overall meat production as well as offering some tolerance to 'foot rot'. The outlook is, if drainage does not improve in Region # 5 then, sheep production will be negatively affected. The GSA does utilize artificial insemination for livestock to improve yields and the quality of the animals.

5.8 Crop Improvement

5.8.1 Plant Breeding

There is variability within the population of any one species and this will lead to some adaptation to climate change by natural selection. The pace of change anticipated by climate change scenarios is such that plants in the natural environment may be unable to adapt sufficiently quickly and may face elimination, but in a horticultural context the plant breeder will have a marked influence in accelerating the selection process and in shaping plant responses to the environment. This will be the case especially in annual plants, where the life-cycle is very short, and in plants of widespread use

and value, such as turf grasses. For trees and for plants which have very limited commercial importance, intervention by plant breeders is unlikely.

NARI is responsible for the development of all crops with the exception of rice and sugar cane, which are the responsibility of the Guyana Rice Development Board (GRDB) and GuySuCo respectively.

NARI is not involved in the breeding of crops. Instead lines /strains are introduced and evaluated extensively. Evaluation is done on several farms as well as NARI stations in the various regions. For instance, crops such as tomato, potato, and beans are being evaluated for suitability to our growing conditions, response to pests and diseases, and general growth, development and yields. With this kind of evaluation /testing programme a large percentage of the lines /strains are eliminated. Testing also involves the acceptance by consumers e.g. shape and size of tomatoes. With this kind of work, NARI has found that introduced varieties can change about every five years.

GuySuCo is engaged in developing its own cultivars from 'scratch'. However, the entity does have a very strong link with the West Indian Breeding Station in Barbados. There are cultivars specially bred for good growth in either the wet or dry season. The company is selecting cultivars for three characteristics i.e. sugar, fiber and alcohol content. High fiber content is known to be closely linked with increased resistance to borers. This is essential since there has been a new borer (*Elasmopalpus lignocella*) emerging. The response of this insect pest to changing climatic conditions is still to be ascertained.

As a result of continuous breeding, GuySuCo has changed many of its cultivars from the 1900s to present. The present standard cultivar is DB 7869 which became the standard in 1998. Previous to this the standard was DB 66113, which lasted about 18 to 19 years. DB7869 is grown on about 35% of the cultivation. It is anticipated that the standard may have to change in a shorter time period because of pressure to produce more sugar.

An emerging disease is ratoon stunting disease. In its breeding programme there is selection for resistance to smut and leaf scald. With this new disease becoming more prevalent, then the objective of the breeding programme may very well have to be adjusted to include an evaluation for resistance to this new disease.

There is need for a better ratoon management to reduce the severity of ratoon decline. Management system should include better control of pest and weeds as well as changing the cultivars more often.

Burma Rice Research Station has been involved in the development of new rice lines since July 8, 1974. However, prior to this there has been breeding practices done in the Botanical Gardens by the Department of Agriculture (in colonial Guyana) since 1902.

The standard cultivar is Rustic which was released in 1977. One of the main reasons for changes in cultivars is to stay ahead of the effects of the devastating disease (blast) caused by the fungus *Pyricularia oryzae* (*Magnaporthe grisea*).

Farmers are currently experiencing 5.5 tons per hectares but the station aims to develop cultivars with 6.5 – 7t/ha yield. However, the plan is to reach 9 -10t/ha in about 10 years.

However, to offset climate change effects the plant materials intended to be the precursors of new rice varieties are being evaluated for salt tolerance and to tolerate increasing levels of water especially during vegetative growth. In fact, seedlings are now being selected that have emerged through six inches of standing water. Research personnel also opine that block cultivation by farmers will be one of the ways to offset the adverse effects of climate change. However, personnel from the MMA-ADA stated that block planting may not be achievable because of individualized thinking e.g. the irrigation season is normally the whole of August, however not all farmers will plant to coincide with this. Some will plant in September and then expect the MMA-ADA to supply water to their land. When this is not done then farmers may approach powerful political figures for their intervention. Hopefully, educational and extension programmes can curb/reduce the above dodgy practice by farmers.

The ecology of rice is such that it is cultivated from the cooler areas of the Himalayas to the hotter () regions of the world (Persaud, 2008). Therefore, whatever is Guyana's future climate it is more than likely that there are already developed commercial varieties being produced under similar climatic conditions. Thus developing cultivars to adapt to climate change will not be too difficult. Only the time taken to develop a cultivar by traditional means may be the limiting factor to be considered. However, the grain yield of rice was reduced about 10 percent per 1ºC temperature increase above 25ºC, until reaching zero yield at 35-36ºC mean temperature, using a 7ºC day/night temperature differential (Baker and Allen 1993a; Peng et al. 2004 as cited by Hadfield).

Another consideration of climate change is that the rice plant may physiologically be unable to have higher yields. This is because of the impact of growing degree days. With higher predicted temperatures the crop cycle will most probably be shortened, hence there may not be enough sink available to maintain current yields.

5.8.2 Plant Adaptability

At the Skeldon Estate, most of the cultivars grown are of 48-week duration except for D89138 which is of 54-week duration and DB75159 that matures in 42 weeks. With the anticipated increase in growing degree days then these are expected to mature faster. Climate change may pose a problem for D89138 with its longer crop cycle.

NARI has been promoting the use of shade houses for vegetable production. This technology is becoming popular with vegetable farmers in Region # 5. Here the facility is constructed about one foot off the ground and saran netting is being placed on the roof with plastic at the side. Previously, coconut branches were placed on the roof causing uneven shade. Crops such as celery, shallot and tomato (high-priced cash crops) are being grown under these facilities. A 60ft x 30ft structure can cost between US$1,500 and US$2,500 based on the type of net used. Nets sourced from Brazil results in the lower price.

Excessive heat and inadequate pollination will lower yields through increased flower abscission and reduced fruitset (Bisgrove and Hadley, 2002). For the shade house ventilation and radiation control (through appropriate plastic film properties, shade) are important considerations. The timing of pollen transfer (hour of day) and the prevailing environmental conditions (heat, humidity, wind) at transfer are critical determinants of achieved pollination. Climate recording instruments are important tools to have in the shade house. If the temperatures in greenhouses are not well

controlled then there can be poor yield especially in tomatoes. This is because of elevated temperatures due to the plastic and no effective extraction of hot air. Once the shade house is completely enclosed there is need for hot air to be removed. Some farmers use tools which vibrate the plants to assist with pollination.

5.9 Climate

The terms "global warming" and "climate change" are now being used very popularly around the world. This is because there have been some recent extremes in rainfall pattern, which may only be explained by a shift in the weather pattern. There is now less skepticism over the reality of climate change and more discussion on how it will impact the earth's systems and the world's population, and what can be done about it.

Three possible responses to climate change are (Jarvis *et al*, 2006):

1. The crop benefits from climate change.
2. Minor reductions in yield occur.
3. Devastating crop losses ensue.

The first case may apply to Regions # 2, 3 and 7 where increasing temperatures and better rainfall is expected (CGCM 1). Thus crops grown in these Regions e.g. ground provisions, cocoa and pineapple will benefit. The second case is widespread and applies to most of the other regions of Guyana where there is expected to be decreases in rainfall and increased soil moisture deficit. Here, solutions should lie in plant breeding and sound agronomic management. Heat and drought tolerance will be the key parameters here. The third case is a worst-case scenario and fortunately the CGCM 1 model does not predict any part of Guyana experiencing so drastic a change in rainfall or soil moisture deficit as to be catastrophic.

Recommendations for adaptation to climate change cannot strictly be regional but must be made locally specific (in conformity to the grid cell as proposed in the model). Much can be done by using farmers' knowledge of variation in the past to adapt to future extreme events. This indeed is how climate change will be experienced—not as a gradual process, but as a change in the frequency of extreme events (Ibid).

Climate change is also likely to impact on agricultural genetic resources. For example, impacts on the distributions of crop wild relatives (themselves bearers of genes potentially critical for adaptation) are predicted to be significant, with 18% of species in important crop gene pools likely to become extinct by 2050 (Lane et al. in press as cited by Jarvis et al). Additionally, farmers may drop traditional landraces[53] no longer adapted to the local climate, resulting in genetic erosion and a lowering of the diversity in crop gene pools.

The magnitude and timing of impacts will vary with the amount and timing of climate change and in some cases, the capacity to adapt. In coastal Guyana where much of the agricultural sector is concentrated the resilience is likely to be tested by several climate change events notably rising

[53] Landraces are early cultivated forms of a crop species, evolved from a wild population

levels, flooding, high temperature, high relative humidity, more pests and diseases incidence, salt water intrusion, high evaporation rates and greater plant stress.

At lower latitudes, especially tropical regions, crop productivity is projected to decrease for even small increases (1-) in temperature. This could increase the risk of hunger and reduce exports. Greater frequency of droughts and floods are projected to affect local crop production negatively (IPCC, 2007).

The distribution and production of particular fish species are expected to change with continued warming; this can have adverse effects on projected aquaculture and fisheries (Ibid).

Climate change and sea-level rise are expected to result in greater risk of coastal erosion. Our mangroves are projected to be negatively affected by sea-level rise, especially where they are constrained on their landward side, or starved of sediment (Ibid).

5.10 Plant Responses to Climate Change

5.10.1 Plant Responses in General: At the Level of the Individual

The direct effects of climate change on individual plants and plant communities may occur in the absence of pathogens, but may also bring about changes in plants that will affect their interactions with pathogens. Changes in plant architecture may affect microclimate and thus risks of infection. In general, increased plant density will tend to increase leaf surface wetness and leaf surface wetness duration, and so make infection by foliar pathogens more likely. How abiotic stress factors interact to affect plants will be key to understanding climate change effects on plants. It is generally accepted that stress (nutritional and water) increases the plant's susceptibility to pathogens. However, will the same hold true for climate induced stress or will there be induced general defense pathways which increase resistance? Elevated levels tend to result in changed plant structure. At multiple scales, plant organs may increase in size: Increased leaf area, increased leaf thickness, higher numbers of leaves, higher total leaf area per plant, and stems and branches with greater diameter have been observed under elevated . Enhanced photosynthesis, increased water use efficiency, and reduced damage from ozone are also reported under elevated . Since many foliar pathogens benefit from denser plant growth and the resulting more humid microclimate, there is the potential for these changes in plant architecture to increase infection rates, all else being equal (Garrett *et al*, 2006).

Interactions with other changing climatic variables may complicate the effects of elevated . For example, warming, altered precipitation, addition of nitrogen, and elevated each increased net primary productivity when applied as single factors (in a California annual grassland trial); but in multifactor treatments, elevated appeared to suppress the positive effects of the other factors. Since the effects of several climate change variables cannot be isolated it is the combined interactive effect that will be important for agriculture in Guyana. Most experiments and even models of scenarios deal with the impact on one factor on plant yields, pest and diseases etc. There is limited, if any, studies available from the Caribbean to show the likely impacts of climate change on our crop; thus it is very difficult to predict what the combined effects of several factors will be (Ibid).

When high-temperature stress is exacerbated, plant responses may be similar to those induced by water stress, with symptoms including wilting, leaf burn, leaf folding, and abscission, and

physiological responses including changes in RNA metabolism and protein synthesis, enzymes, isoenzymes, and plant growth hormones. These changes will certainly affect susceptibility to pathogens, though the wide range of changes may make interactions difficult to predict. Elevated ozone concentrations can change the structure of leaf surfaces, altering the physical topography as well as the chemical composition of surfaces, including the structure of epicuticular wax. These changes in leaf structure may alter leaf surface properties such as leaf wettability and the ability of leaves to retain solutes, all influencing the ability of pathogens to attach to leaf surfaces and infect. Ozone exposure has been proposed to enhance attacks on plants by necrotrophic fungi, root-rot fungi, and bark beetles (Ibid). However, ozone exposure is not expected to be a problem for Guyana in the medium term (up to 2040).

5.10.2 Host Resistance

Detecting the effects of drought stress on plant resistance to infection is complicated by the fact that foliar pathogens will tend to have lower infection success under dry conditions. Temperature may have important repercussions on the effectiveness of resistance genes, though it may generally be challenging to discriminate between temperature effects on host resistance genes versus effects on pathogen virulence (Ibid).

Elevated and ozone also have the potential to influence the effectiveness of host resistance. The potential for accelerated pathogen evolution, if it is found in many pathosystems, may be one of the most important effects of elevated .

More data about the population genetics of defence genes in natural plant populations will be important for determining the potential for adaptation under potential changes in pathogen pressure due to climate change (or other factors). If climate change increases or decreases environmental conduciveness, the shift in selection pressure on the host populations could result in shifts in the diversity of resistance genes present (Ibid).

5.10.3 Plant Responses in General: At the level of the Population

Research on plant community responses to climate change has tended to focus on plant species range shifts. However the slow rate of migration of plants from one region to another, combined with land use patterns that fragment plant populations, may make adaptation the more important factor in plant responses to climate change (Ibid).

Changes projected in climate will favour certain species more than others. This is because:

1. Reproductive efficiency of species is reduced under high temperatures.
2. Interaction of stress factors would alter species response to an environmental factor.

But the current state of research in plant adaptation to climate change suggests that plant populations will tend not to have sufficient time to adapt to altered climates, so that populations of plant species will be subject to rapid changes in their genetic structure, perhaps especially for plant species with long generation times. Even if there is genetic variation present in a population for traits that could support adaptation to a location with altered climate, correlations between traits that do not support selection for the new climate may limit adaptive evolution. Also, different

populations of the same species may differ in both their genetic structure and the extent to which climate change will push the species to its physiological limits. As a result of climate change, the abundance of particular species may change rapidly, as species may lose their ability to recover from other perturbations such as diseases, insect herbivores, and climatic extremes within a background of climate changes. Novel plant communities may result, with the increased potential for new patterns of host-sharing by pathogens. The above is important in wild populations that may hold the key to further adaptation and resistance in our cultivated crops (Ibid).

In agricultural systems, questions about plant population structure are different. There is no direct concern about whether plant populations can successfully migrate through fragmented landscapes, rather the concern is whether farmers will be able to identify and acquire crop genotypes that are adapted to their changing climate. In traditional agricultural settings, another problem is whether in situ conservation of traditional landraces can be meaningfully maintained when local conditions change too rapidly and whether populations of wild crop relatives will be out-competed by other species better adapted to the new climate. Where seed from variable landraces is saved, processes of adaptation will change the selection pressures on these populations and, while new and potentially valuable populations may be generated, much genetic diversity may be lost in subsequent selection to the changing climate (Ibid).

Consideration has to be given to any possible threat that some crops (e.g. cassava) may face. There is a wide and varied assortment of the cassava germplasm in the Amerindian communities. Though propagated vegetatively, it is not unusual for plants to be left to flower (and produce seeds through cross pollination); this contributes to maintaining/ widening the variability seen. Grid cell 8 in the CGCM I model encompasses Region # 2, 3, 7 and parts of Region # 1. The projection is that there is going to be higher temperature in all seasons with greater water deficits in the dry seasons. We have to ask ourselves whether selection pressure can cause a shift in the genotype frequencies of the cassava in the Amerindian communities. Are there genes that make a variety well adapted to a particular locality? If there are, then it is likely that as the climate in that area is altered then that variety may not occur in as much abundance. On the other hand, selection pressure may see the emergence of genotypes presently found in low abundance.

In current crop breeding programs, comparable concerns would include the following: Can climate change result in shorter useful lives for resistance genes? Will less emphasis on local adaptation be possible, as conditions change rapidly? Will it be possible to produce varieties that are as productive if they must be adapted to a more variable environment?

5.11 Plant Growth and Development

Plants *grow*, by accumulating material to become larger, and they *develop*, in response to internal and external stimuli, from juvenile to mature state, from vegetative to flowering, and from active to dormant for example. The fundamental process driving plant growth is photosynthesis, by which the green tissues of the plant, especially its leaves, combine carbon dioxide from the air with water taken up from the soil by roots to produce carbohydrates (sugars, starch and cellulose), the basic building materials of the plant. Oxygen is also produced in the process. The photosynthesis process may be summarized as:

(carbon dioxide) + (water)→ (glucose) +
with energy from sunlight (a carbohydrate) (oxygen)

The carbon dioxide needed for photosynthesis diffuses into the leaves through small pores (stomata) mainly in the undersides of the leaf. In order to survive the plant has to balance its need to take in carbon dioxide with the need to reduce loss of water vapour through the stomata. It does this by opening and closing the stomata through very sensitive feedback mechanisms which respond to carbon dioxide and water availability. The energy required for photosynthesis comes from sunlight. The plant then combines the products of photosynthesis with nitrogen (usually as nitrate), phosphorous, potassium and other nutrients taken up from the soil in solution, to produce proteins and other complex materials. The factors which most affect the growth of a plant are those required for photosynthesis (light, water and carbon dioxide) and the levels of available nutrients (nitrogen, phosphorus, potassium and minor nutrients). Water plays a key role in plant growth by making nutrients in the soil available to the plant, but it is also vital in keeping the plant turgid. If water supplies in the soil are inadequate, or if evaporation from the plant's leaves exceeds the ability of the plant roots to replenish this loss, the plant will suffer water stress (Bisgrove and Hadley, 2002).

The immediate response to water stress is closure of the stomata, thereby preventing further water loss but at the cost of cutting off the carbon dioxide supply needed for growth. If water stress continues the plant will usually react by wilting, then shedding leaves to reduce its evaporative surface. Continued water stress will lead to damage to cell tissues and ultimately to the death of the plant. Plants not only grow, by accumulating carbohydrates and proteins, but they develop by germinating from seed, producing new shoots and leaves, by flowering, and setting seed. The growth of a plant is controlled mainly by light levels, the availability of carbon dioxide, water and nutrients, and temperature. Its development, from vegetative to flowering to resting for example, is often controlled by more complex mechanisms such as changes in day length or changes in temperature. The onset of dormancy and release from it are particularly complex processes. In some plants temperature change is the main stimulus. In others the process is entirely or predominantly controlled by day length while in other plants day length and low temperature will substitute for each other in varying degrees. From this brief and very much simplified description of plant growth and development it is clear that some aspects of growth and development will be significantly affected by climate change (when carbon dioxide concentration, temperature or water availability are important for example) while other aspects, especially those controlled by day length, will be largely unaffected (Ibid).

5.12 Plant Responses to Carbon Dioxide

In most climate change impact studies carbon dioxide concentration is important only insofar as it is the principal driver of climate change. In studying the impact of climate change on agriculture, forestry and nature conservation, carbon dioxide itself has a significant impact by its involvement in photosynthesis (Ibid).

5.12.1 Carbon Dioxide and Growth

Plants grow and develop in response to a range of stimuli but especially to the availability of carbon dioxide, water and mineral nutrients and to the quality and quantity of light. Most of these stimuli

will be affected directly or indirectly by climate change, except that light quality and the natural rhythm of variation in day length will remain unaltered (Ibid)

If other factors remain favourable, increased carbon dioxide concentrations will lead to greater rates of photosynthesis in plants. Current carbon dioxide concentrations limit plant photosynthesis. Growers of protected horticultural crops have known for some many years that artificially raising the concentration of carbon dioxide in greenhouses can substantially increase crop growth and yield. It is generally accepted (Kimball *et al.*, 1983; Poorter, 1993) that a doubling of carbon dioxide concentrations will lead to approximately a 40-50% increase in the growth of plants. However, there are strong interactions between increased temperature and carbon dioxide such that increases in carbon dioxide concentration will not always lead to increases in the yield of food crops (Bisgrove and Hadley, 2002).

Response to elevated carbon dioxide concentrations varies between different species. Leguminous species capable of symbiosis with nitrogen fixing organisms had larger responses to carbon dioxide compared to other species. There is also a tendency for herbaceous dicotyledons (broadleaved plants) to show a larger response than monocotyledons like grasses. It is suggested (Poorter,1993) that the more responsive plants are those with a greater sink strength, that is in those plants with active regions such as developing fruits or rapidly expanding shoots capable of utilizing the products of photosynthesis. The benefits of elevated carbon dioxide levels may, however, be relatively short term. A process of acclimation is often seen in plant responses to carbon dioxide. Here, the short term photosynthetic response to instantaneous changes in carbon dioxide is much larger than the long term response. Long term exposure to elevated carbon dioxide leads to the accumulation of carbohydrates in the photosynthetic tissues of the plant and this accumulation leads to a reduction in photosynthetic rates (Clough *et al.*, 1981). At higher temperatures there may be increased soil nitrogen availability (Bisgrove and Hadley, 2002)

In the long term, leaves developing under elevated carbon dioxide concentrations appear, in many species, to have fewer stomata than under lower carbon dioxide levels (Woodward, 1993). Nevertheless, although photosynthetic responses to carbon dioxide are less marked in the long term than those anticipated from short term measurements, these responses are significant and contribute substantially to the increase in growth and dry matter accumulation under climate change conditions. The increase in carbohydrate concentration of tissues leads to higher dry matter content (cellulose, starch etc) of plant tissues which could have implications for the quality of some horticultural products (Bisgrove and Hadley, 2002).

5.12.2 Partitioning of Assimilates

About half of all assimilates (carbohydrates and proteins) are exported from the shoot to below ground parts of the plant where they are used for root respiration, nutrient uptake and transport processes in the roots, and as an energy source for nitrogen fixing bacteria and mycorrhizal fungi associated with the plant (Lambers, 1987). Under optimal levels of water and nutrient supply this partitioning of assimilates to the roots does not appear to be changed by elevated carbon dioxide concentrations (Stulen and Hertog, 1993). When nutrients are in limited supply, varying responses have been noted but some experiments (e.g. Oberhauer *et al.*, 1986) have demonstrated a higher allocation to roots in elevated carbon dioxide conditions where naturally occurring species are growing under nutrient limited conditions. This suggests that, in soils with low nutrient status, the

higher carbon dioxide concentrations associated with climate change may enable plants to forage more effectively for their nutrients (Bisgrove and Hadley, 2002)..

Experiments in which the effects of elevated carbon dioxide on the responses of plants to water stress have been examined show a variable response. In some species, partitioning to the root is not influenced by elevated carbon dioxide concentration whereas in other species there is an increased proportion of photosynthetic products moving to the root system implying a greater investment in roots to increase their access to available soil moisture (Tolley and Strain, 1985). In these species, higher carbon dioxide concentrations in the air will enable the plant to tap limited soil water resources more effectively (Bisgrove and Hadley, 2002).

GCM (CCC 11) outputs and high, medium, and low emission scenarios coupled with a crop model (FAO) to simulate crop yields, found that sugarcane yields may decrease by 20-40% under a 2xCO2 climate change scenario in Trinidad and Tobago in the southern Caribbean (Singh and El Maayar, 1998). The decrease in yields is attributed to increased moisture stress caused by the warmer climate. These reductions in sugarcane yields deriving from climate change are similar to those found for corn—another crop—in nearby Venezuela (Maytin et al., 1995). These results are supported by similar findings in Mauritius, which are derived from the Agricultural Production Systems Simulator Model (APSIM-Sugarcane) developed by the Agricultural Production Systems Research Unit, Australia. The study projects a decline in sucrose yield by more than 50% with a doubling of (Cheeroo-Nayamuth and Nayamuth, 1999 (Climate change 2001: Impacts Adaptation and Vulnerability)

5.12.3 Carbon Dioxide and Development

Carbon dioxide is important because carbon atoms form the structural skeleton of the plant. A doubling of carbon dioxide levels may increase plant growth by 40-50% though continuous high levels saturate the plant's ability to use carbon dioxide and the benefits decrease with time. Higher carbon dioxide levels also allow the plant to use water more efficiently and may make the plant sturdier, more fruitful and more resistant (or less appetizing) to pests (Bisgrove and Hadley, 2002). However, unrestricted root growth, optimum fertility, and excellent control of weeds, insects, and disease are also required to maximize benefits (Wolfe 1994, as cited by Hatfield, 2008).

In addition to their impact on photosynthesis and therefore plant size, carbon dioxide levels can also affect other aspects of plant development. Flowering and fruiting of trees are likely to be hastened under conditions of elevated carbon dioxide. The yields of Valencia orange (*Citrus sinensis*) (Downton *et al.*, 1987) and orange trees (*Citrus aurantium*) (Idso and Kimball, 1997) were increased when they were grown in elevated carbon dioxide levels. These increases in yield resulted from increases in both fruit numbers and fruit size (Bisgrove and Hadley, 2002). species are less responsive than species to increased atmospheric .

5.12.4 Interaction of Responses to Carbon Dioxide and Water

The plant manages its intake of carbon dioxide and its control of water loss by the same mechanism, the opening and closing of its stomata. The plant responds to water stress by closing its stomata. Conversely, if the supply of carbon dioxide is greater than the plant can utilize, it will react by closing its stomata and it will, in so doing, reduce its water use. Leaves are able to detect and

respond rapidly to carbon dioxide concentration. Stomatal opening decreases in response to increased carbon dioxide concentrations (Woodward *et al.*, 1991 as cited by (Bisgrove and Hadley, 2002. Decreased stomatal aperture under conditions of elevated carbon dioxide also leads to an increased resistance to water loss from leaves. Thus, as carbon dioxide concentration increases, the water use efficiency (carbon dioxide gained in relation to water lost) also increases. This suggests that the rate of evapo-transpiration decreases under conditions of elevated carbon dioxide. Crop simulations used to predict the irrigation requirements of potatoes under climate change conditions suggest that there will be very little change in irrigation requirements under most climate change scenarios, as reduced precipitation is balanced by increased water use efficiency (Wolf, 2000 as cited by (Bisgrove and Hadley, 2002. The model (CGCM 1) predicts that for Guyana most areas will have reduced precipitation and increased water deficits, thus we will have to employ strategies to optimize water use efficiency if yields are to be maintained or only slightly affected. The beneficial effects of elevated carbon dioxide may, in some instances at least, compensate for increased evaporation from plants in the drier conditions anticipated by climate change scenarios (Bisgrove and Hadley, 2002).

5.12.5 Responses to Elevated Carbon Dioxide may be influenced by Water Stress

It is important to remember, though, that while the impact of the environment (in terms of higher carbon dioxide levels) on the plant may be to increase the efficiency of water use, the impact of the plant on the environment will be to reduce humidity (Ciesla, 1995) and, by not using energy for evaporation, to increase the temperature of both the plant and its surroundings. The valuable air-conditioning effect of plants will be reduced during periods of water stress (Bisgrove and Hadley, 2002)

5.12.6 Interaction of Responses to Carbon Dioxide and Nitrogen

The increase in carbohydrate content of tissues under elevated carbon dioxide is not necessarily accompanied by increases in nitrogen uptake and so a likely response to climate change is a decrease in the nitrogen concentration in plant tissue and an increase in the nitrogen efficiency of plants. Overall, therefore, nitrogen use by plants may stay essentially the same and fertilizer requirements will be unaltered by increasing carbon dioxide levels.

One of the many uncertainties surrounding climate change impacts is whether nitrogen availability in the soil will increase (as a result of higher nitrous oxide levels in the atmosphere and higher rates of mineralization in soils) (Medlyn *et al.*, 2000) or will decrease as a result of increased leaching (Jeffery, 2001). The response to carbon dioxide may also change under conditions of low soil fertility. Data (Kimball *et al.*, 1993) showed that even under nitrogen limited conditions, the response to a near doubling of carbon dioxide concentration led to a 53% increase in seed cotton yields under both irrigated and dry conditions (Bisgrove and Hadley, 2002).

5.13 Plant Responses to Temperature

There are two main categories of temperature effects on plant growth and development. The first is the effect of temperature and temperature fluctuations on general growth and development; the second is the effect of temperature extremes on survival (Bisgrove and Hadley, 2002).

The major crops grown for export are rice and sugar. Lately there has been a push to diversify the crops grown, as new market opportunities open up, so there is currently an Agricultural Diversification Project, with the intention of maintaining employment and earnings through the filling of demand of high value agricultural products. The climate impact of higher temperatures will lead to increase evapo-transpiration and drying, which can be alleviated by increase irrigation if available. There will be need to adapt by using efficient irrigation methods, drip irrigation or using shade houses/greenhouses, to sustain cultivation. These practices are currently being transferred by NARI to farmers throughout the country.

5.13.1 Temperature and Growth

Temperature has very complicated effects on plant growth. Higher temperatures increase growth and speed up the rate of plant development so plants will flower earlier, though the scale of the response is different in different plants. Excessive heat and inadequate pollination will lower yields through increased flower abscission and reduced fruitset (Bisgrove and Hadley, 2002).

Each plant species has its own characteristic response to temperature. Higher temperatures, like higher carbon dioxide concentrations, will favour plant growth if other factors are not limiting. As temperatures exceed the optimum for any particular plant its growth rate then falls, often sharply, to the point at which damage to tissues leads to complete cessation of growth and ultimately to the death of the plant (Ibid).

5.13.2 Temperature and Development

Plant developmental responses are somewhat different to the growth response to temperature, in that developmental rates increase approximately linearly with temperature above a threshold temperature which is often referred to as the 'base temperature' for plant development (Ellis *et al.*, 1990 as cited by (Bisgrove and Hadley, 2002.

This base temperature is generally taken as for tropical species and for temperate species. However, based temperatures for some crops are shown in Table B.9.

This linear increase in the rate of plant development reaches an optimum typically at between and but again this varies between species, varieties and even different developmental processes in the same plant. Above this optimum temperature, developmental rates often decline at approximately the same rates at which they increase at sub-optimal temperatures. Because rates of plant development increase linearly with temperatures above a threshold, events such as germination, leaf appearance and flowering of day length insensitive species and varieties often occur after a fixed accumulation of heat above this base temperature, often called 'thermal time' and measured in day degrees (number of days multiplied by degrees above the base temperature). This can be very useful in predicting the effects of climate change. For example, if time from germination to flowering for a particular species occurs after the accumulation of 900 day degrees above , then flowering time will be 90 days at (90 days x 10 degrees above). The effects of an average increase in season temperature of above over the period of flower development would then lead to a date of flowering 15 days earlier (75 days at 12 degrees above). Thus, providing that the thermal time requirements for particular events are known, the effects of increased temperature on these events can be estimated relatively easily. However, the resources needed to determine thermal time

requirements are such that the information is likely to be available only for important crop plants. This may yield useful information for the management of kitchen gardens and allotments but for most ornamental plants, phenological studies of flowering dates and other developmental responses to temperature change are likely to be more informative (Bisgrove and Hadley, 2002).

Table B.9: Temperature Thresholds for selected crops

Crop	Base Temp Veg	Opt Temp Veg	Base Temp Reprod	Opt Temp Reprod	Opt Temp Range Veg Prod	Opt Temp Range Reprod Yield	Failure Temp Reprod Yield
Corn	8	34	8	34		18-22	35
Soybean	7	30	6	26	25-37	22-24	39
Rice	8	36	8	33	33	23-26	35-36
Sorghum	8	34	8	31	26-34	25	35
Cotton	14	37	14	28-30	34	25-26	35
Peanut	10	>30	11	29-35	31-35	20-26	39
Bean					23	23-24	32
Tomato	7	22	7	22		22-25	30

Source: J.L Hadfield , USDA-ARS

Two major implications of -induced temperature increase and changing climatic patterns for the growth of agricultural crops and pasturage are:

- A lengthening of the potential growing season, and
- An increase in plant growth rates and thus a shortening of the required growing period (INC, 2002).

The problem of growing season length is not projected to affect tropical countries such as Guyana. However, shortening of the growing season, through a more rapid accumulation of growing degree days, has been shown to lead to acceleration of maturation and reduced yields, especially for cereal crops such as rice (Ibid). In fact, in Guyana, it is rather the changes in soil moisture conditions as controlled by rainfall, rather than temperature that may influence crop yields through excessive moisture that may cause flooding or soil moisture deficit that may restrict crop growth and yields. Should ENSO events intensify and occur more frequently, then soil moisture changes may be important (Ibid).

As already stated, higher temperature generally increases the rate of growth and of development of plants, particularly at the lower end of the range of temperatures suitable for growth. One of the most important effects of climate warming is likely to be changes to the onset and cessation of growth (i.e. the beginning and the end of the growing season. This will affect the rate of development (the 'phenology') of the plant (Bisgrove and Hadley, 2002)

Yield responses to temperature vary among species. However, changes in yield with increasing temperature in field conditions may not be due to temperature alone, as high temperatures are often associated with lack of rainfall in many climates. The changes in temperature do not produce linear responses in yields with increasing temperature because the yield response to temperature is

nonlinear, therefore, as the temperature increases these effects may be larger. Temperature and water deficits tend to interact negatively to affect crop yields (Hatfield, 2008).

5.13.3 Interaction of Responses to Temperature and Carbon Dioxide

Temperature and carbon dioxide concentrations interact. Higher temperatures and higher carbon dioxide levels combine to stimulate more rapid growth and development but the end result is not always a higher yield. Increased speed of development may mean that the plant is unable to use the full length of the growing season before it dies. Plants like carrot, which are harvested early in their development, will increase in yield. Plants harvested at the end of their natural growing season, like broccoli, cauliflower and onion, may produce lower yields as the accelerating effect of temperature exceeds the increase in growth caused by carbon dioxide.

Two major implications of -induced temperature increase and changing climatic patterns for the growth of agricultural crops are: a lengthening of the potential growing season, and an increase in plant growth rates and thus a shortening of the required growing period. The problem of growing season length will not affect tropical countries such as Guyana. However, shortening of the growing season, through a more rapid accumulation of growing degree days, has been shown to lead to acceleration of maturation and reduced yields, especially for cereal crops such as rice. In fact, in Guyana, it is rather the changes in soil moisture conditions as controlled by rainfall, rather than temperature that may influence crop yields through excessive moisture that may cause flooding or soil moisture deficit that may restrict crop growth and yields (Bynoe and Bynoe, 2000).

Response to higher carbon dioxide concentrations is greater at higher temperatures (Idso *et al.*, 1987) and the optimum temperature for photosynthesis increases with increasing carbon dioxide concentration (Allen *et al.*, 1990). The combination of increased temperature and increased carbon dioxide predicted in all climate change scenarios suggests that for some species the growth stimulation may be greater than 40-50%. In general, all crops show a positive effect of carbon dioxide on yield. However, it appears that only crops that are harvested at an early stage of their physiological development (e.g. radish, lettuce, carrot) show a positive effect of increased temperature. This is mainly because any factor that speeds leaf area growth (whether or temperature) speeds the exponential phase of early growth. However, this effect does not appear to apply to closed canopies or to reproductive grain yield processes (Hatfield, 2008). Hence, crops that are harvested later in their physiological development (e.g. onion and cauliflower) show a negative effect of increasing temperature. The net effect of increased carbon dioxide levels and increased temperatures therefore varies from plant to plant. In carrots a 1°C increase in soil temperature increased yield by 34%. Responses to increased carbon dioxide are also large: an increase in carbon dioxide concentration from 325 to 530 ppm also increased yield by 34%. This reflects the responses to climate change of most root crops which are considered to be larger and more positive than most other crops (Kimball, 1983).

Since higher temperatures tend to shorten the crop duration then the overall effect of climate change is likely to reduce yield, because the stimulation in growth brought about by carbon dioxide is more than offset by a shorter period of vegetative growth brought about by elevated temperatures (Bisgrove and Hadley, 2002)

Plants grow and develop in response to a range of stimuli but especially to the availability of carbon dioxide, water and mineral nutrients and to the quality and quantity of light. Most of these stimuli will be affected directly or indirectly by climate change, except that light quality and the natural rhythm of variation in day length will remain unaltered.

5.14 Plant Phenology

The most conspicuous manifestation of climate warming will be earlier flowering times of many plants. In Central England a rise in temperature resulted in plants flowering earlier by 4-10 days (Sparks et al., 2000 as cited by (Bisgrove and Hadley, 2002. This means that there is an accumulation in the growing degree days. With an estimated increase in temperature by 1. for Guyana then the growing season is likely to be shorter for all our crops. Thus, plants will have a shorter time in which to accumulate their storage products. Hence, overall uptake will have to increase; if water deficit becomes a problem, or any other primary input factor is limiting, then there is likely to be drastic reduction in yields.

5.15 Dormancy

The rest and quiescent period are often described as periods of innate and induced dormancy respectively and have evolved to ensure that plants have no soft, young growing tissues that could be damaged by unfavourable conditions. Although the plant appears to be inactive during dormancy, this is often a period of high internal activity, with the plant producing leaf and flower initials in readiness for rapid growth. After the completion of the rest period, plants enter a quiescent period in which they have the potential to grow but are limited by the prevailing conditions. Once temperatures attain a certain threshold, plants then begin their active growth period. During this growth phase, providing the temperature is warm enough, the amount of growth is a function of the amount of light intercepted by the plant canopy and the efficiency of photosynthesis (Bisgrove and Hadley, 2002).

5.16 Plant Responses to Water

Water plays a vital role in plant growth and survival in three ways: as one of the 'raw materials' of photosynthesis, in transport of dissolved nutrients from the soil into and through the plant, and in maintaining plant turgor. Before one can consider the impacts of climate change resulting from plant responses to water, it is necessary to have a basic understanding of the distinction between water supply and water availability.

5.16.1 Water Supply

Water supply to the plant is derived from precipitation and in some situations from the net result of inflow to and outflow from the catchment area in streams or rivers. There is predicted to be the decrease in water supply in northern Guyana but an increase in southern Guyana.

5.16.2 Water Availability

Water availability to the plant depends in part on the presence of an adequate water supply, but it is also affected by evaporation from the plant which, in turn, depends on solar radiation. Water

evaporates from the cells inside the leaf and is lost to the atmosphere through the stomata. This process of transpiration uses energy supplied by solar radiation and depends on the humidity of the air and on wind speed.

As the temperature increases, the capacity of the air to carry water vapour increases very steeply. The humidity of the air decreases or, put another way, its drying capacity (and therefore its capacity to 'pull' water from a plant) increases. If water is available it will evaporate and, by absorbing very large amounts of energy in so doing, will cool the plant and its surroundings (or prevent them heating up). If the water supply is limited, evaporation is necessarily reduced and more energy will be used in heating the plant and its surroundings. The valuable air-conditioning role of plants will decrease when they are subjected to water stress.

The plant is not a passive tube conducting water from the soil to the air. Water movement through the plant results partly from active uptake by the roots (requiring food reserves and oxygen) and partly from evaporation by the leaves. If root uptake cannot keep pace with evaporative loss, as is often the case in hot, dry and windy weather, the plant will close its stomata (Bisgrove and Hadley, 2002).

This prevents further water loss, but also prevents carbon dioxide uptake for photosynthesis. The impacts of climate change on water availability and the resulting impacts on plant growth will arise in part from changes in the water supply itself, but also from increased temperatures and decrease in atmospheric humidity. Changes in supply to the plant will result from increased precipitation in the wet season (when water is least useful for growth) and decreased precipitation in the drier months. The change in temperature is expected to be upwards in all seasons in all scenarios (INC, 2002), leading to increased evaporation of water.

5.16.3 Impacts of Water Deficits

Water deficits in the plant will lead in the short term (seconds, minutes, hours), to closure of stomata, loss of ability to take up carbon dioxide for photosynthesis and wilting of soft plant tissues. Even short periods of wilting can cause substantial reductions in plant growth. In the longer term (days, weeks, months), the plant will respond to water stress by shedding its older leaves and by becoming more compact with smaller, thicker leaves. It may also divert more resources to root development in order to exploit water resources in a greater soil volume. Annual plants, especially, will often flower more rapidly in conditions of water stress in order to set seed before they die, so the flowering season will be curtailed. In the very long term (centuries, millennia), plants subject to the continuous selective pressure of water stress evolve adaptive mechanisms such as hairiness (to reflect light and thus reduce evaporation) or waxiness (to reflect light and reduce water loss through the surface), resulting in grey or silver foliage. In continuously dry environments, evolution results in very compact habits, succulent water storage tissues (as in cacti and succulents), and specialized metabolism to allow photosynthesis to take place while stomata are closed. These long term adaptations, which often have an ornamental value in themselves, are also subject to short term variation. With plentiful water supplies, leaf hairiness will be reduced and normally grey or silver leaved plants will become greener. Water deficits and their impacts on plant survival and growth may be severe, especially for long established plants attuned to a softer climate (Bisgrove and Hadley, 2002).

Soil type will also have a major influence. The drying of heavy and poorly drained soils in reduced precipitation scenarios will increase the range of plants which can be grown, and will reduce the risk of water-logging, though it will, of course, reduce the opportunity to grow plants specifically adapted to wet conditions (and may have serious implications for factors other than plant growth, such as the oxidation of soils).

With a doubling of atmospheric levels Regions # 4, 5 and parts of #6 (Grid cell 9) are more likely to experience significant water deficits in the short wet season. Thus for continuous crop production to be carried out there is likely to be the necessity for supplemental irrigation. This can have serious impact on the water resources in these regions, namely EDWC, MMA-ADA and the Canje River. Close monitoring (good management) of these water resources will have to ensue to avoid them falling below critical levels.

5.16.4 Impacts of Water Deficits

On light soils (of Regions # 2, 3, 7 and parts of Region # 1)(grid cell 8), increasing precipitation will be a great benefit in improving the health of trees and in recharging the water table, thus extending the period for which water will be available. Water surplus will only be damaging to the plant if it causes water-logging of the soil. The impact of water-logging is to deprive the plant roots of oxygen so that they cease to function. In the short term, the symptoms of water-logging of leafy plants are similar to those of drought: roots are unable to pump water into the plant, so the upper part of the plant wilts. More seriously, in the anaerobic conditions of waterlogged soils, plant metabolism is altered and toxic compounds accumulate. If conditions do not improve, the roots and then the whole plant will die (Bisgrove and Hadley, 2002).

The low night temperatures in places such as Bartica can allow for the growth of exotic crops such as onions (this has been done before). Regions # 7 & 8 can be explored as centres for seed production since they are 'isolated' from the coastland where crop production occurs. Therefore, the common diseases and pests found on the coastland will either be absent or in very low amounts. Parts of these areas experience less rain (and the trend is projected to continue) than the coast which will be a positive for seed production.

Some plants are highly adapted to waterlogged conditions in the soil, with air channels in the leaves, stems and roots e.g. soap bush (*Sphenoclea zeylanica*) - - conducting atmospheric oxygen down to the roots. Many other plants will tolerate short periods (hours, days, even weeks) of water-logging especially if the plant is inactive so that oxygen demand is minimal. Others are very intolerant of water-logging e.g. bora, or even of wet soils, and will quickly be killed either as a direct result of reduced oxygen supply or indirectly as a result of succumbing to root pathogens. In general, those plants which are most highly adapted to dry conditions (xerophytes) are the least tolerant of wet and especially waterlogged soils.

One important implication of climate change is that increasing temperatures will increase the activity (and therefore the oxygen demand) of plants, so roots may become less tolerant of water-logging (Ibid).

In southern Guyana (Regions # 8, 9 and parts of Region # 6) (grid cells 2, 3 and 5) there is a projected positive water deficit, i.e. precipitation is expected to be greater than evaporation, in the

short wet season under both a doubling and a tripling of atmospheric . This area encompasses the savannah region of the country. This could therefore have implications since it can be the 'new frontier' for agriculture in Guyana. In Region # 8 there can be greater production of spices e.g. black pepper, tumeric (dye), nutmeg and ginger. In the 1970's there was the production of crops such as Irish potatoes, onions, peas and beans in the Kato Valley. However, the high transportation cost of the produce to markets (coast) may have been detrimental to continued production. The intermediate savannahs have long been touted as the 'new frontier' for agriculture. However, the soil and fragile nature of the ecosystem in this area, along with poor accessibility have been a serious challenge to agriculture.

Perhaps it is time for greater attention to be paid to the savannah region as an area for expanded agricultural production. This should not mean abandoning the intermediate savannahs for large-scale agriculture. However, we should improve the accessibility to both regions and allow natural development to occur as people migrate to these areas.

Water is vital to plant growth and to all life. Water availability to the plant depends on the relative rates at which water is taken up from the soil by the roots and lost from the leaves. If water is in short supply in the soil, or water loss from the leaves is too high because of increasing temperatures and increasing light levels, the plant will suffer water stress. It will react by closing its stomata (leaf pores) to conserve water and will therefore shut off its carbon dioxide supply. Growth will suffer. Prolonged stress will cause loss of leaves and hardening of the plant. Extreme stress will kill it.

Adaptability to water stress varies greatly. Plants adapted to growing in cool, shady positions, ferns for example, will wilt after a few minutes in full sun even if the roots are freely supplied with water. Succulents, on the other hand, have reduced or fleshy leaves and very thick, waxy or hairy light-reflecting leaf surfaces, so can tolerate very severe drought for months or years. With too much water, plant roots will be deprived of oxygen and will die. Again, plants differ widely in their tolerance of water-logging, but those most adapted to very dry conditions will be least tolerant of wet soils and vice versa.

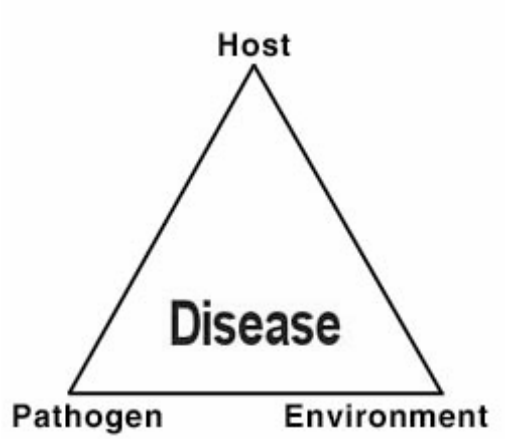
5.17 Plant Responses to Changes in Pest, Disease and Weed Incidence

The general increase in temperatures, combined with wetter or drier periods, are likely to have considerable impact on the severity of pest and disease attack on vegetable crops. These effects are among the most difficult to extrapolate from climate change scenarios because of the complexity of interactions, particularly in relation to specialized feeding relationships of pests.

Where the interactions extend to the synchronous development of the host plant, an insect pest and a disease transmitted by the insect, each with its own particular responses to climate change attempts to extrapolate from climate change scenarios to disease incidence become increasingly difficult. This is clearly an area in which further research is needed in relation to vegetables crops. In contrast to our two major crops (rice and sugar cane) the three main pasture grasses are not prone to attacks by pest and diseases. This is seen as a plus with or without any climate change effects.

5.18 Climate Change and Diseases

The study of plant disease often begins with a discussion of the "plant disease triangle".



The three points of the triangle – host, pathogen, and environment – must be present and interact appropriately for plant disease to result. If any of the three factors is altered, changes in the progression of a disease epidemic can occur. The major predicted results of climate change – increases in temperature, rainfall intensity and – can impact all three points of the plant disease triangle in various ways. Precisely predicting the impact of climate change on plant disease is difficult.

5.18.1 How Rising Temperatures Will Affect Pathogens and Diseases

Temperature has potential impacts on plant disease through both the host crop plant and the pathogen. Generally, fungi that cause plant disease grow best in moderate temperature ranges. For example, predictive models for tomato late blight (caused by *Phytophthora infestans*) show that the fungus infects and reproduces most successfully during periods of high moisture that occur when temperatures are between (7.) and (26.) (Wallin et al, 1950 as cited by Petzoldt and Seaman). In addition, the bacterium (*Xanthomonas campestris*) that causes black rot of cabbage has its optimum growth between - (26. –).

5.18.2 How Changes in Moisture Will Affect Pathogens and Diseases

Moisture can impact both host plants and pathogen organisms in various ways. Several vegetable pathogens (e.g. cercospora leaf spot and anthracnose in pepper) are more likely to infect plants with increased moisture. Other pathogens like the powdery mildew species tend to thrive in conditions with lower (but not low) moisture. More frequent and extreme precipitation events that are predicted by some climate change models could result in more and longer periods with favourable pathogen environments. Host crops with canopy size limited by lack of moisture might no longer be so limited and may produce canopies that hold moisture in the form of leaf wetness or high canopy relative humidity for longer periods, thus increasing the risk from pathogen infection (Coakley et al, 1999 as cited by Petzoldt and Seaman).

5.18.3 How Rising Levels Will Affect Pathogens and Diseases

Increased levels can impact both the host and the pathogen in multiple ways. Some of the observed effects on disease may counteract others. Researchers have shown that higher growth rates of leaves and stems observed for plants grown under high concentrations may result in denser

canopies with higher humidity that favour pathogens. Lower plant decomposition rates observed in high situations could increase the crop residue on which disease organisms can survive across seasons, resulting in higher inoculum levels at the beginning of the growing season, and earlier and faster disease epidemics. Pathogen growth can be affected by higher CO2 concentrations resulting in greater fungal spore production. However, increased CO2 can result in physiological changes to the host plant that can increase host resistance to pathogens (Coakley et al, 1999 as cited by Petzoldt and Seaman).

Farmers would incur increased costs as a result of increased frequency of insecticide treatment and the accompanying negative environmental impacts would mount. Resistant varieties are the most effective method for control. Farmers' profitability could thus be impacted by the varieties they grow to combat a disease.

As with pests, it is very difficult to determine the exact impact of climate change on the development of a particular disease because of the complexity of the relationship between pest, host plant and environment. It is also very difficult to differentiate between the effects of climate change and the effects of increased international travel as causes of increased attack. The general impact of climate change on diseases, however, can be summarized as follows:

- Wetter seasons will favour diseases such as *Phytophthora* that need water to spread;
- Drier seasons will favour disease such as powdery mildew that can spread in dry conditions;

Faster rates of reproductive development under higher temperature conditions may well also increase the rate of disease spread, as will the more rapid increase of insect vectors of disease. For example, higher aphid vector populations generally mean that virus diseases will increase (Zhou *et al.*, 1995). Generally, virus diseases are always more serious when plants are infected at an early stage of development. As a plant becomes older it has a greater inherent tolerance of attack by virus diseases. Thus, the effects of climate change on virus diseases may well be more serious plant infection.

Many diseases are spread by insect vectors (aphids and thrips are vectors for a number of disease) and the effect of climate change on the biology of vectors may also effect the spread of disease (Ibid).

Phytophthora is an important disease associated with poor drainage, as its spores are spread by water movement through the soil and host plant resistance is decreased in anaerobic conditions. Increased rainfall and higher temperatures, allowing the fungus to develop during periods of water-logging, are likely to lead to increased incidence of the disease and symptoms will be exacerbated when plants suffering root loss caused by *Phytophthora* are further stressed by dry weather (Ibid).

Plants will be affected by climate changes indirectly, by the effects of these changes on the virulence of pest and disease attack, as well as directly. Pests and diseases are likely to be more troublesome as a result of climate change, because higher temperatures will allow increased survival and activity. Some pests (mites, aphids) and diseases (powdery mildews, rusts) will be favoured by hot, dry seasons. Leaf eating pests may be slightly disadvantaged by the higher carbohydrate status (and therefore reduced protein content) of host plants growing in the higher concentrations of carbon dioxide, and higher light levels associated with climate change. Warmer but wetter winters will

favour root rots of various kinds, especially *Phytophthora*. With increasing human migration, more care will be needed to monitor pests and to develop quarantine procedures to prevent the import of new pests and diseases (Ibid).

5.18.4 Pathogen and Vector Responses to Climate Change

The range of many pathogens is limited by climatic requirements of the pathogen or vector to survive from one season to the next. Temperature requirements for infection differ among pathogen species. Similarly, the introduction of new vector species and changes in vector survival requirements and other effects of change on insects may have important effects on pathogen survival, movement, and reproduction. Interactions between pathogens may also shift with climate change (Garrett et al, 2006).

Temperature is a key factor in seasonal survival. Other factors such as acid rain may also influence disease. Pathogen movement is difficult to study at large scales even in a relatively homogeneous environment, so few studies have addressed changes in movement with changing climate. But new diagnostic techniques will make it easier to study large numbers of pathogen species over larger scales. Such approaches can be applied to monitor changes in pathogen populations over time and space, with the potential to revolutionize our understanding of pathogen communities and their movement (Ibid).

In many cases, temperature increases are predicted to lead to the geographic expansion of pathogen and vector distributions, bringing pathogens into contact with more potential hosts and providing new opportunities for pathogen hybridization.

Increased transportation and human movement may act synergistically with temperature changes. Increased pathogen ranges may also have the effect of including exposure to reservoir host species that increase prevalence of disease in other adjacent taxa (Ibid).

5.18.5 Microbial Interactions

Soil microbial communities are likely to shift with climate change. Researchers have emphasized that elevated , temperature and nitrogen deposition are important factors in driving soil communities. Soil nitrate concentrations are reduced under elevated in grassland microcosms. Similarly, increasing temperature by in a tall grass prairie increased plant growth, which facilitated plant uptake of N and dominance of fungi in the microbial community. These studies suggest that microbial communities may generally experience decreased available N, though plant community composition and soil type will generally have large effects on the type of responses observed (Ibid).

5.18.6 Climate Change Effects on Virulence, Aggressiveness or Fecundity of Pathogens

Pathogen evolution rates are determined by the number of generations of pathogen reproduction per time interval, along with other characteristics such as heritability of traits related to fitness under the new climate scenario (Ibid).

Temperature governs the rate of reproduction for many pathogens; longer seasons that result from higher temperatures will allow more time for pathogen evolution. Pathogen evolution may also be

more rapid when large pathogen populations are present. Climate change may also influence whether pathogen populations reproduce sexually or asexually, thus increasing the evolutionary potential of a population. Under climate change, pathogens, like plants, may potentially be unable to migrate or adapt as rapidly as environmental conditions change. But most pathogens will have the advantage over plants because of their shorter generation times and, in many cases, the ability to move readily through wind dispersal. Climate variability itself may be an important form of selection (Ibid).

5.18.7 Host-Pathogen Interaction Responses to Climate Change: Gene Expression and Plant Physiology

Some mechanisms of effects of elevated on plants are fairly well understood, such as reduced stomatal opening and changes in leaf chemistry, so that disease caused by pathogens that infect through stomata may be reduced. But combining the direct effects of elevated on plants with the effects on disease will make predictions of plant productivity even more challenging. Benefits from elevated counterbalanced negative effects from ozone but did not compensate for the effects of fungal infection (von Tiedemann & Firsching, as cited by Garrett *et al*, 2006).

In a study of plant disease elevated increased the pathogen load of grasses, perhaps due to increased leaf longevity and photosynthetic rate (Mitchell et al., as cited by Garrett et al, 2006). This suggested that one result of climate change for grassland ecosystems could thus be increased pathogen load. Many of our cultivated crops are plants and the results of this study can be applicable. At present our major grasses are not known to suffer from pathogens. This may be because pasture production is not widespread and also because the main grass species are introduced (not native), therefore their natural enemies are not yet present in Guyana (Garrett *et al*, 2006).

Plant pathologists have studied the relationship between precipitation and disease for decades. Even without the added impetus of predicting climate change effects, this interaction is of primary importance for predicting disease severity. Decreases in precipitation, or increased intervals between precipitation events, have been predicted for a greater geographic area than are increases (Ibid).

Drought stress and disease stress may have additive effects on plants. l. The concentration of carbohydrates in host tissues as a result of drought stress may benefit pathogens such as *Macrophomina phaseolina* that can survive in extremely dry soils (Mayek-Perez et al, as cited by Garrett *et al*, 2006).

5.18.8 Plant Disease and Management

Disease management strategies may require adjustment under climate change. Strategies such as delaying planting to avoid a pathogen may become less reliable. One of the major problems with applications of biological control for plant disease management in the field has been the vulnerability of bio-control agent populations to environmental variation and environmental extremes. If appropriate temperature and moisture are not consistently available, bio-control agent populations may reach densities that are too small to have important effects, and may not recover as rapidly as pathogen populations when conducive conditions recur (Garrett et al, 2006). In Guyana, bio-control for plant diseases is not being practiced.

Models of the risk of movement of invasive pathogens to a new area are typically based on climatic variables such as temperature, rainfall, and humidity. Such risk models are of great economic importance when they bear on what trade restrictions may be applied against regions where a pathogen is present. For many invasive pathogens, models of climatic conditions and requirements need to be supplemented by information about the availability of susceptible hosts and the likelihood of transport of pathogens by trade and other human networks (Ibid).

5.18.9 How Climate Change Could Impact Plant Disease Management Practices

While physiological changes in host plants may result in higher disease resistance under climate change scenarios, host resistance to disease may be overcome more quickly by more rapid disease cycles, resulting in a greater chance of pathogens evolving to overcome host plant resistance. Fungicide and bactericide efficacy may change with increased , moisture, and temperature. The more frequent rainfall events predicted by climate change models could result in farmers finding it difficult to keep residues of contact fungicides on plants, triggering more frequent applications. Systemic fungicides could be affected negatively by physiological changes that slow uptake rates, such as smaller stomatal opening or thicker epicuticular waxes in crop plants grown under higher temperatures. These same fungicides could be affected positively by increased plant metabolic rates that could increase fungicide uptake. It is not well understood how naturally-occurring biological control of pathogens by other microbial organisms could change as populations of microorganisms shift under changed temperature and moisture regimes – in some cases antagonistic organisms may out-compete pathogens while in others pathogens may be favoured. Exclusion of pathogens and quarantines through regulatory means may become more difficult for authorities as unexpected pathogens might appear more frequently on imported crops (Petzoldt and Seaman)

Diseases such as *Fusarium* wilt in Boulanger are favoured by high temperatures and sandy loose soils. In the climate change scenario of higher intensity of rainfall then this disease will continue to pose a serious threat since short term flooding often leads to high severity of the disease.

5.18.10 How this will affect farmers?

Although the specific impacts of climate change on plant disease are difficult to predict given our current knowledge, it seems possible to make several generalizations for farmers in the riverain areas and coastal Guyana:

a) Increased temperatures will likely mean higher populations of pathogens to initially infect plants;
b) More frequent and more intense rainfall events will tend to favour some types of pathogens over others (Coakley *et al* 1999 as cited by Petzoldt and Seaman).

One conclusion about the effects of climate change for disease management is that changes, especially if they lead to greater variability in climate, will tend to add extra uncertainty to decision making. In tropical regions where food security is a particular concern, there may tend to be both greater climate variability and uncertainty and less investment in technologies supporting production of regionally important crops. Information about changing disease-management needs will be particularly important for such crops. In fact, incorporating climatic predictions based on El Niño patterns will be useful for general decision making (Garrett *et al*, 2006)

Finally, global climate change will affect plant disease in concert with other global change phenomena. If agricultural land use expands in the tropics, the development of land use policies will face related challenges to maintenance of agricultural productivity and plant biodiversity in a changing world (Ibid).

5.19 Climate Change and Weeds

As weeds are simply plants in the wrong place, the impacts of climate change on weeds will be the same as for plants in general. Increased carbon dioxide levels will favour growth of competitive annual weeds more than it will favour plants in general. Higher temperatures and increased water availability, where the latter does not result in water-logging, will allow greater survival and growth (high sink strength) of many annuals, as well as earlier seeding. Perennial weeds will grow more quickly and most will flower earlier, if not controlled. Chemical weed control, with glyphosate in particular, will be less effective in hot, dry conditions (Bisgrove and Hadley, 2002).

Many annuals will be able to germinate and grow through the wet period and to set seed before the onset of the dry season. Drier conditions may reduce weed growth, but will also reduce the effectiveness of glyphosate and hormone weed killers such as 2-4D and MCPA which work best when the treated plants are in active growth. It will be more necessary to ensure that herbicide spraying is carried out earlier in the year, with a narrower window between the weed achieving sufficient leaf cover for chemical uptake and the onset of dry conditions, and the prospect of having to spray at a time when maintenance demands are at a peak. It is important, though, to maintain a sense of proportion when dealing with this potential problem (Ibid).

Most tropical grasses (and therefore our weeds) are plants while many of our crop species are plants. This means that the grasses are more evolutionary adapted to the tropical region. The anticipated changes in the climate projected for Guyana will not make our climate less tropical; instead it will be 'more' tropical. This may indicate that the grasses (weeds) will have a more competitive advantage over the crop.

Our weed control programme will have to be adjusted because instead of the first 2 to 3 weeks being crucial for weed control, there will very likely be a scenario where the first 4 weeks of the crop need to be weed-free.

There will continue to be rapid breakdown of chemicals in the soil i.e. problems of high chemical residual in soils arising from overuse /abuse of chemicals may not be a problem now nor in the near future.

With the likely effects of higher rainfall intensity in the future there is anticipated to be more weed problems in our sugar cane fields. As a result of this there may be more cattle on the estate, poor sanitation, hence outbreaks of rodent infestation (Ahmad, 2008 pers. comm).

At the Uitvlugt estate a major weed is tanner grass (*Brachiaria radicans*). This was introduced to feed cattle as part of the organic agriculture drive. However, it has flourished under the wet conditions of the estate and has now become a serious impediment to production. If there is no major alterations in the rainfall the estate will continue to be wet, thus it is expected that tanner grass will continue to be a problem in the future.

5.20 Climate Change and Symbiotic Organisms

Many plants have symbiotic (mutually beneficial) relationships with other organisms. This is most commonly seen in the relationships between leguminous plants (peas and beans for example) and nitrogen fixing bacteria, and between many forest trees and mycorrhizal fungi. The microorganisms benefit from the photosynthates produced in the leaves of the trees and provide in return soil mineral nutrients which the tree roots are themselves unable to acquire. Although there has been limited research in the area of climate change impacts on these symbiotic relationships, it appears that the exudation of soluble compounds from roots tends to be greater in carbon dioxide enriched plants so that more carbon is available for mycorrhizal associations (Norby *et al.*, 1986, 1987). Similarly, the greater allocation of carbon to the roots of carbon enriched legumes leads to increased nitrogen fixation as a result of greater nodule mass, although there is little evidence for any effect on specific nodule activity. This ability of mycorrhizae to extend their exploitation of soil nutrients and to supply their host plant with additional nitrates could help to offset some of the disadvantages associated with drier soils (Bisgrove and Hadley, 2002).

5.21 Climate Change Effects of Insects

5.21.1 Insects and the Environment

Insects are cold-blooded organisms - the temperature of their bodies is approximately the same as that of the environment. Therefore, temperature is probably the single most important environmental factor influencing insect behavior, distribution, development, survival, and reproduction. Insect life stage predictions are most often calculated using accumulated degree days from a base temperature and biofix point. Some researchers believe that the effect of temperature on insects largely overwhelms the effects of other environmental factors (Bale *et al*, 2002). It has been estimated that with a temperature increase insects might experience one to five additional life cycles per season (Yamamura & Kiritani, 1998). Other researchers have found that moisture and effects on insects can be potentially important considerations in a global climate change setting (Hamilton, 2005, Coviella and Trumble, 1999, Hunter, 2001 as cited by Petzoldt and Seaman).

5.21.2 Climate Change and Pests

The focus in this section is on those insects and other arthropods which cause damage to plants. For example, an increase in the mean annual temperature of 1. (Guyana by the 2040s) will mean that many insects will be active for a longer period of time. The range and distribution may also shift since the regions which have cooler nights (Hilly Sand and Clay region) may now experience more of these insects. Many insect pests cause damage by eating leaves and other plant parts, so the nutrient status of the plant has a very significant effect on its susceptibility to attack. Increasing carbon dioxide levels will result in 'harder', less succulent plants which should be more resistant to attack (Ciesla, 1995 as cited by (Bisgrove and Hadley, 2002. A well documented effect of increased carbon dioxide is a decrease in the nitrogen concentration of plant tissues, leading to a reduced nutritive value to insects (Nicolas and Sillans, 1989). Leaf nitrogen is a limiting nutrient in many herbivorous insect diets (Lincoln *et al.*, 1986). When feeding on leaves of low protein content, insects respond in a number of ways including increasing consumption, choosing more nutritious leaves or species, reduced fecundity (production of young) and/or survival, reduced population density or more efficient food use (Scriber and Slansky, 1981). Such responses have also been

observed when insects feed on plants that have been grown in elevated carbon dioxide concentrations. Consumption can be increased by 20-40%, compared to feeding on plants grown under ambient carbon dioxide conditions (Lincoln *et al.*, 1986). This has been attributed directly to the reduction of nitrogen concentration in the leaf (Lincoln, 1993 as cited by (Bisgrove and Hadley, 2002.

On the other hand, reduced water supplies will lead to increases in cell sap concentration. Sucking insects and mites will have a more concentrated food supply and may increase more rapidly. There is little direct evidence that chemical deterrents in the leaf, which many plants have evolved to resist pest or grazing attack, will be altered in plants growing under elevated carbon dioxide concentration.

Arthropod species that are likely to be most responsive to the effects of climate change are those that produce many generations in a single season ('multivoltine' arthropods). These include, for example, thrips, aphids (plant lice) and spider mites and represent the opportunistic insects and mites which, given a suitable food supply, will multiply rapidly on plants. Thrips and aphids are common insect pests on many field and vegetable crops in Guyana.

Higher average temperatures will mean shorter intervals between generations of pests. This effect will be exacerbated in the case of many sucking pests, as higher temperatures will be accompanied by increased water stress, leading to increased uptake of increasingly concentrated plant sap.

GuySuCo is committed to bio-control. This is seen in its continued quest for a control for the dreaded *Castnia* pest. Essentially the fungus, *Buvaria,* is showing much promise as a bio-control for *Castnia*. Insect population growth increases by 10-14 fold between generations, so that just one more generation over a growing season can have a profound effect on population numbers. Many aphid species (e.g. *Thrips palmi* in Boulanger) in particular are of concern to farmers, not only as plant pests but as vectors (transmitters) for a number of serious viral diseases (e.g. pepper mosaic virus is transmitted by an aphid). Many of the impacts of climate change on population dynamics of aphids will, therefore, have consequential effects on virus disease attack. Water stress in plants results in greater nutrient concentration in the sap, and thus in greater growth rates and fecundity in aphids feeding on the plants. However, predator levels would also be expected to build up in response to increased food supply. One of the most important natural controls of aphid populations is rainfall as the impact of raindrops dislodges the aphids or damages their feeding parts. Warmer conditions may also extend the period during which biological control agents can operate (Ibid).

5.21.3 How Rising Temperatures Affect Insects

Climate change resulting in increased temperature could impact crop pest insect populations in several complex ways.

Increased Temperature Could Increase Pest Insect Populations

Increased temperatures can potentially affect insect survival, development, geographic range, and population size. Increased temperatures will hasten the development of insects since this (development) is tied to degree days or phenology. Thus high temperature will result in more generations (and crop damage) per year. Parasitism could be reduced if host populations emerge and pass through vulnerable life stages before parasitoids emerge. Hosts may pass though vulnerable life

stages more quickly at higher temperatures, reducing the window of opportunity for parasitism. Temperature may change gender ratios of some pest species such as thrips (Lewis, 1997 as cited by Petzoldt and Seaman) potentially affecting reproduction rates. Insects that spend important parts of their life histories in the soil may be more gradually affected by temperature changes than those that are above ground simply because soil provides an insulating medium that will tend to buffer temperature changes more than the air (Bale *et al*, 2002 as cited by Petzoldt and Seaman). Higher average temperature (especially at nights) might result in some crops being able to be grown in highland regions – it is likely that at least some of the insect pests of those crops will follow the expanded crop areas. Insect species diversity per area tends to decrease with higher latitude and altitude (Gaston & Williams 1996, Andrew & Hughes, 2005 as cited by Petzoldt and Seaman), meaning that rising temperatures could result in more insect species attacking more hosts (Bale et al, 2002). Based on evidence developed by studying the fossil record some researchers (Bale *et al*, 2002) conclude that the diversity of insect species and the intensity of their feeding have increased historically with increasing temperature (Petzoldt and Seaman).

The interactive effect of high temperature and drier weather could see an upsurge in the diamond back moth (*Plutella xylostell*a) which is the most serious pest of cabbage in Guyana. When it is considered that large amounts of cabbage are grown in Region 6 which, on the coast, has less rain than in Regions # 3, 4 and 5, then this pest should be monitored constantly to keep abreast with climate change impacts.

Increased Temperature Could Decrease Pest Insect Populations

Some insects are closely tied to a specific set of host crops. Temperature increases that cause farmers not to grow the host crop any longer would decrease the populations of insect pests specific to those crops. The same environmental factors that impact pest insects can impact their insect predators and parasites as well as the disease organisms that infect the pests, resulting in increased attack on insect populations. At higher temperatures, aphids have been shown to be less responsive to the aphid alarm pheromone they release when under attack by insect predators and parasitoids – resulting in the potential for greater predation (Awmack et al., 1997as cited by Petzoldt and Seaman).

5.21.4 How Changes in Precipitation Will Affect Insects

There are fewer scientific studies on the effect of precipitation on insects than temperature. Some insects are sensitive to precipitation and are killed or removed from crops by heavy rains. One would expect the predicted more frequent and intense precipitation events forecasted with climate change to negatively impact insects. As with temperature, precipitation changes can impact insect pest predators, parasites, and diseases resulting in a complex dynamic. Fungal pathogens of insects are favoured by high humidity and their incidence would be increased by climate changes that lengthen periods of high humidity and reduced by those that result in drier conditions (Petzoldt and Seaman).

On the sugar estates problems experienced with low rainfall are increased incidence of thrips and *Diatraea* (borers).

5.21.5 How Rising Levels Affect Insects

Generally impacts on insects are thought to be indirect - impact on insect damage results from changes in the host crop. Increased carbon to nitrogen ratios in plant tissue resulting from increased levels may slow insect development and increase the length of life stages vulnerable to attack by parasitoids (Coviella and Trumble, 1999 as cited by Petzoldt and Seaman).

5.21.6 How This Will Affect Farmers

It is likely that farmers will experience extensive impacts on insect management strategies with changes in climate. Entomologists expect that insects will expand their geographic ranges, and increase reproduction rates and over wintering success. Insecticides and their applications have significant economic costs for growers and environmental costs for society. Additionally, some classes of pesticides (pyrethroids and spinosad) have been shown to be less effective in controlling insects at higher temperatures (Musser & Shelton, 2005). A basic rule of thumb for avoiding the development of insecticide resistance is to apply insecticides with a particular mode of action less frequently (Shelton et al, 2001, Georghiou and Taylor, 1986). With more insecticide applications required, the probability of applying a given mode of action insecticide more times in a season will increase, thus increasing the probability of insects developing resistance to insecticides. A number of cultural practices that can be used by farmers could be affected by changes in climate – although it is not clear whether these practices would be helped, hindered, or not affected by the anticipated changes. Using crop rotation as an insect management strategy could be less effective with earlier insect arrival or increased over wintering of insects. However, this could be balanced by changes in the earliness of crop planting times, development, and harvest (Petzoldt and Seaman).

5.21.7 What Can Farmers Do To Adapt?

Farmers should keep in mind that climate change is likely to be a gradual process that will give them some opportunity to adapt. It is not precisely understood how these changes will affect crops, insects, diseases, and the relationships among them. If climate is warmer will increases in yield offset losses to pests, or will losses to pests outweigh yield advantages from warmer temperatures? It is likely that plants in some regions will be attacked more frequently by certain pests. A few pests may be less likely to attack crops as change occurs. It is likely that we will not know the actual impacts of climate change on pests until they occur. It will be important for farmers to be aware of crop pest trends in their region and flexible in choosing both their management methods and in the crops they grow. Farmers who closely monitor the occurrence of pests in their fields and keep records of the severity, frequency, and cost of managing pests over time will be in a better position to make decisions about whether it remains economical to continue to grow a particular crop or use a certain pest management technique. If more fungicide or insecticide applications are required in order to successfully grow a particular crop, farmers will need to carefully evaluate whether growing that crop remains economical. Those farmers who make the best use of the basics of integrated pest management (IPM) such as field monitoring, pest forecasting, recordkeeping, and choosing economically and environmentally sound control measures will be most likely to be successful in dealing with the effects of climate change (Petzoldt and Seaman).

Thus, the precise impact of climate change on insects and pathogens is somewhat uncertain because some climate changes may favour pathogens and insects while others may inhibit a few insects and pathogens.

The preponderance of evidence indicates that there will be an overall increase in the number of outbreaks of a wider variety of insects and pathogens.

- The possible increased use of fungicides and insecticides resulting from an increase in pest outbreaks will likely have negative environmental and economic impacts for agriculture.
- The best economic strategy for farmers to follow is to use integrated pest management practices to closely monitor insect and disease occurrence. Keeping pest and crop management records over time will allow farmers to evaluate the economics and environmental impact of pest control and determine the feasibility of using certain pest management strategies or growing particular crops (Petzoldt and Seaman).

Table B.10: Climate change impacts on the agricultural sector

Climate factor	Direction of change	Consequences and threats to agricultural production and food security
Sea level rise	Increase (0.2m-0.5m).	Flooding in (agricultural) areas and salt intrusion into rivers and salinisation of other fresh water supplies. Reduction in aquaculture production. Susceptibility of mangroves to decline.

Climate factor	Direction of change	Consequences and threats to agricultural production and food security
Rainfall	Increased intensity, but of a shorter duration.	Increased run off and possibly greater erosion of soil. Increased leaching of nutrients and agricultural chemicals into groundwater and surface water. Greater overtopping of conservancies. More flooding and water logging; increase in some pests and diseases. Damage to crops and crop losses associated with anoxia, increases susceptibility to root diseases, increases soil compaction (due to use of heavy farm equipment on wet soils). Wetter conditions at harvest time could increase the potential for decreasing quality of many crops.
Temperature	Increases (rise of 1.2 in minimum temperature.	Greater evaporation and transpiration of water. Greater soil moisture deficits. Increased pressure on irrigation schemes to supply adequate water to farms. Shorter cropping season i.e. faster crop maturation. Shorter life cycle of pests and pathogens. Reduction in yields. Increase in some pests and diseases. Faster breakdown of residual chemicals in the soil.
Drought	Difficult to predict.	We may experience more extremes of weather. This can cause crop failure, yield decrease, death of livestock, as well as competition between agriculture and domestic supply of water. Loss of rural income.
Atmospheric	Increase (doubling to tripling).	Faster rate of photosynthesis and increased water use efficiency especially for plants e.g. rice, beans, and cabbages. However, other factors will influence final yield. Added weed growth and more expensive weed control practices.
Wind	Higher gusts of wind with greater turbulence especially when accompanied by rainfall.	Breakage of branches, lodging of crop. Damage to farms. Sea swells and tidal surges. Occasional flooding.

6. ECONOMIC ASSESSMENT OF CLIMATE CHANGE IMPACTS

Guyana remains a net producer of agricultural products, inclusive of rice, sugar, vegetables, fishes, forestry products and fruits. The value of agricultural commodities exceeds 30% of GDP. As such, economic viability and competitiveness are major concerns for producers trying to maintain profitability as real commodity prices have fallen by about two-thirds over the last 50 years.

Agricultural productivity has improved at over 1% per year since 1970, resulting in a decline in both production costs and prices. This trend maintains intense pressure on individual producers to continue to increase the productivity of their farms and to reduce costs of production. In this competitive economic environment, producers see anything that might increase costs or limit their markets as a threat to their viability. Extreme weather or climate events such as droughts and floods; new pests; and the development of pest resistance to existing pest control strategies fall into this category. Future changes in climate will interact with all of these factors.

This economic analysis considered crop agriculture, grazing, livestock, and environmental effects of agriculture. The focus in this document is primarily on crop agriculture which was studied most intensively in the various assessments. This analysis assumes continued technological advances and no changes in international trade.

It is likely that climate change, as defined by the scenarios examined in this technical assessment, will not imperil the ability of Guyana to feed its population and to export foodstuffs. Results of this Assessment suggest that, at the national level, productivity of many major crops will likely increase under some conditions, or at worse, remain constant under the climate scenarios used in these crop models. Crops showing generally positive results include rice, sugar cane, corn, citrus fruits, and soybeans.

In the crop yield model (DSSAT) applied to data for the period 1976 - 2007, a limited set of on-farm adaptation options are considered, including changes in planting date, dates when soil conditions were measured prior to planting, planting density, row spacing, planting depth, crop variety, irrigation, and fertilizer practices. This model was applied to both sugar and rice sectors, Guyana's two main export crops. In every respect the model indicated lower predicted yields than the measured yields which may have been due to issues with the model used since it consistently demonstrated an inability to format data after 1999. The economic models consider a far wider range of adaptations in response to changing productivity, prices, and resource use, including changes in crops and the location of cropping, irrigation, use of fertilizer and pesticides, and a variety of other farm management options. The model indicates that under both the Hadley and Canadian Scenarios, without adaptation, the 2030 prediction is for rice to yield to increase by approximately 1% under the Hadley Scenario but decline by nearly 5% under the Canadian scenario, sugar cane declines by nearly 5% under both scenarios, and citrus increases by nearly 10%. For the 2090 scenario, rice, sugar and citrus yields all increase substantially under the Hadley scenario, but sugar and rice decline under the Canadian scenario. With adaptation, under all the scenarios crop yields are positive, ranging between 5% (rice and sugar) and nearly 40% (citrus) over the various periods.These findings seem to support what is already being found, with yield in the rice sector plateauing. At the same time, with adaptation, annual yields is expected to vary between +/- 0.1% for rice and sugar and + 0.5% – 0.8% for citrus. However, it is important to note that there may be regional variations.

7. ADAPTATION INITIATIVES

The initiatives are designed to ensure that:

- Capacity building is strengthened in all institutions/agencies/Ministries associated with agriculture and the possible impacts of climate change in Guyana that is taken up more substantively in the institutional assessment.
- There is greater public awareness of climate change and its implications for the Agricultural Sector of Guyana
- All relevant sectors and agencies play an integral role in adapting/encouraging mitigation and adaptation measures to offset climate change impacts
- Climate change issues affecting agriculture are brought to the fore in agricultural planning and policies

There will be many initiatives to combat the adverse effects of climate change in Guyana. Some of these will be undertaken as the need arises e.g. with greater intensity of floods there can be more sluices installed, canals can be deepened etc. Some can be on a medium term basis e.g. crop and animal improvement (breeding/ biotechnology) to ensure that crops, pasture and livestock species are better adapted to the changing climate.

There is the need for increased organic farming which encourages excellent soil and land conservation practices. Also, there ought to be improvement in practices such as soil management, fertilizer application, pests and weed control, liming, and drainage and irrigation. In addition the country will have to improve its weather predictions so that farmers can better plan all field activities. Post harvest operations are particularly vulnerable to the vagaries of the weather; hence improved forecasting will reduce post-harvest yield losses.

However, by far the greatest initiative would be the establishment of a National Climate Change Research Fund so that persons engaged in a wide cross section of activities relevant to climate change can tap into this fund. For instance, it will not be limited only to research in agriculture but will encompass work in tourism, mining, housing and road construction etc. Research will not be confined only to the University but to other national and possibly private institutions or firms. In this way there will be a pool of local, current and relevant information that can be used by policy makers to make the most informed decisions.

Agriculture without the threat of global climate change is inherently risky, and so only increases the risk for farmers, potentially knocking back hard won gains over the past years (Jarvis et al). However, global climate change is partly predictable therefore the research challenge is to find means of managing that risk. To be successful, adaptation strategies must be put in place at a rate equal to or greater than the rate of change in climate.

Some of the major challenges come from the likely greater prevalence of drought and floods. In many cases, these weather patterns will be new in the farmers' experience. Therefore, a key research theme must be the development of risk avoidance strategies, which are still deficient under current circumstances, but will be critical if poor farmers are to manage local changes in climate (Jarvis et al). A core research area for both GRDB and GuySuCo is the development of improved germplasm. NARI, though not involved in breeding, is involved in germplasm evaluation and selection.

Concerted efforts will have to be made to secure materials that are adapted to perceived changes in climate.

In order to adapt to climate change, there may be need for crops with greater resistance to drought. Unfortunately, plant breeding takes time, so needs for improved germplasm must be identified now in order to plan for the future. We will have to have soil-plant-atmosphere chambers where some level of atmospheric 'tweaking' can be done to select crops that are adapted to change. These chambers need not be very sophisticated structures. Those that involve higher temperatures can be less expensive that those designed for elevated levels. We will have to consider that there has to be identification of the specific varieties of crops and breeds of livestock to be in demand at least ten (10) years from now. Plant breeding is a lengthy process, but remains a cost-effective way of getting stress-tolerant materials into the hands of farmers.

Adaptation such as altered cultivars and changes in planting times will need to be followed to ensure that yields are maintained with modest increases in temperature. Adaptation to climate change is likely to benefit from experience gained in reaction to extreme climatic events, specifically by implementing proactive climate change risk management adaptation plans. In addition, there is need for flood control and disease surveillance systems. Tighter border control will be needed to restrict movement of plants, animals and their products into the country. This because increasing human migration may well be the source of new pests and diseases entering Guyana.

However, the effectiveness of these efforts can seriously be constrained by lack of basic information, observation and monitoring systems, lack of capacity building, risk assessments and appropriate political, institutional and technological frameworks.

As for adaptation mechanisms employed by the farmer, informal risk avoidance strategies are common. Using little or no inputs is a common choice, but this restricts yields in the absence of stress. Borrowing money from family is another common tide over, but sale of livestock, house and farm may result. In the event of widespread crop failure, this strategy is not sustainable. Livestock may also be used as a risk avoidance strategy, whereby the sale of livestock when a farmer's crops fail can generate the income to feed the family, but under widespread drought there is little capital available for buying livestock and farmers are forced to sell at a very low price. Diversification is also a valid risk avoidance strategy already used by many farmers, which certainly puts poor farmers in a better position to cope with climate change. In fact, it is a common practice for small farmers to be engaged in a mixed cropping system or a system with both crops and livestock. This certainly spreads risk over a range of agricultural outputs.

One problem associated with many of these risk avoidance strategies is that they generally aim to lower the exposure to risk, but in so doing limit potential and have considerable opportunity costs. They often tend to hinder the efforts of small farmers to break out of poverty.

One concrete example in which innovation may provide farmers with a robust risk avoidance strategy that optimizes the opportunities is through weather insurance. At present crop or weather insurance is not available in Guyana. However, this is currently engaging the attention of the Ministry of Agriculture. When dealing with small farmers, there is a distinct lack of long-term reliable data for the productivity of staple crops or of crop failure. In the absence of these data, it is difficult to design appropriate insurance instruments. However, revolution in the availability of data on climate and weather across the tropics, coupled with the generation of better predictive weather models, permits the development of scientifically sound insurance schemes under which the risks

for both the farmer and insurer are manageable. Under future climate change, this may be an important mechanism for helping farmers face risk (Jarvis *et al*).

Farmers will have to make greater use of the internet to access information. This will empower them to seek out information. Many persons (even in the rural communities) in Guyana have access to the internet from their homes or via internet cafés. The Ministry of Agriculture is also in the process of ensuring that its extension offices have kiosks where internet access is possible. Once persons can source and process accurate information they will become knowledgeable about the emerging issues in climate change and will be better able to adapt appropriate measures to mitigate any adverse effects.

Another means of looking at climate change is by considering that in many cases the future climate for a specific site already exists in another part of the globe. Based on this, many local adaptations can be achieved through the transfer of technologies or practices from one region to another. When coupled with scenarios for global climate change, predicted future climates for a given site can be found today in another part of the globe. An example of this is the future climate of Manaus, identified to exist today in Vichada in Colombia (Jarvis et al). Transfer of technologies from one site to the next can provide farmers with the means of adapting to change, taking advantage of existing experiences. This practice can also be used for having crops and livestock that are adapted to the various regions. For instance, rice is grown in regions of very high climate to regions of cool climate. Thus, it can be anticipated that some varieties can be transferred to Guyana for further evaluation. This can certainly complement our breeding programme.

With the true extent, magnitude and impact of climate change on agricultural systems still not fully understood, innovations today so that farmers can better avoid risk today will stand them in good stead for the uncertain tomorrow. Given the local-scale heterogeneity in predicted climate change impacts, the research challenges lie in ensuring that the most appropriate technologies, practices and risk-avoidance strategies get to the individual farmers.

and species in their native systems are predicted to show a generally positive, but variable increase in productivity and water-use efficiency (WUE) in response to elevated concentrations. Projected changes in temperature may result in favourable environments for certain less dominant species, hence altering existing species composition and in turn seriously affect the local ecosystem i.e. there can be genetic shift with climate change (Reddy).

7.1 Data Management

Adaptive techniques must be informed by the requisite information to determine, not only what is physically possible, but also what is economically feasible and socially acceptable. In this regard, therefore, it is necessary to improve data collection on coastal and interior morphology, sea level, wind and current and water quality, surface and groundwater. Rainfall and runoff data in the watersheds of the major river basins and the Conservancies would also be vital to capture and retain to allow for informed decisions to be made.

7.2 Water Management

One of Guyana's main challenges is how to deal with floods during periods of excessive rainfall, and

water shortages during El Nino type events. Furthermore, floods come from two sources, sea defence breaches, likely to become more frequent with sea level rise, and heavy intensity rainfall. It will therefore be important to improve the monitoring and maintenance of the sea defence infrastructure, involving communities as 'rangers' in the monitoring process and also providing an environment where they can take some degree of ownership of these resources. Additionally, an activity programme of public awareness building should be pursued to inform communities about the importance of the mangrove forest and receive feedback from communities on what may be the best way to manage these resources.

To adapt to the challenges posed by high intensity rainfall, it may be opportune to empolder areas along Mahaica and Mahaicony rivers to reduce flooding, but the cost for this must be first worked out to determine its feasibility. At the sametime it may become necessary to construct more sluices at higher drainage capacities, with supplementary pumping to assist at high tides. But there may be opportunities here as well for Guyana to commence thinking about developing freshwater farms, given that water scarcity globally is fast increasing.

In responding to water shortages and water quality issues the following is recommended:

- Pursue best farm management practices which have improved water use efficiency. For example, conserving available water on the farm (dugouts, stock water dams, reservoirs), and implementing cutting edge technologies in irrigation efficiencies, or implementing farming practices which cope with lower soil moisture.

- The socio-economic aspects of farmers adoption of best management practices (BMPs) is an important issue which needs to be researched to address how and why people change and adapt, before the adoption of such BMPs can take place to any successful and wide ranging extent. For example, if commodity prices are low, adoption of BMPs may not be as swift. One means of showcasing BMPs would be the establishment of public funded demonstration farms to research and demonstrate cutting edge technologies in water conservation and management.

- Better understanding of the groundwater resources available in terms of the spatial extent and quantity would increase the resilience of farms to water shortages, by putting in wells to tap into the resource.

But there are also a number of cross-cutting issues that require urgent attention if the agricultural sector in Guyana is to respond appropriately to climate change impacts. These include:

- The need for models to be downscaled from a global to a watershed or regional level, which would enable more accurate decisions to be made with regards to managing water resources in light of climate change. These models can provide key input into decision making, as such, there is a need to address the lack of access to real time hydrological, hydrogeological, and climate information for decision-makers.

- Better communication strategies and a more timely and targeted diffusion of results from the researchers to the stakeholders and to the general public is necessary to adapt to climate change.

- Education and awareness of potential climate change impacts and adaptation strategies for stakeholders, researchers and decision makers are felt to be lacking.

- Accurate pricing strategies were deemed necessary to be put in place so that the real cost of adaptations are accounted for.

- Finally, the need for conflict resolution will come more and more into play, as water resources become sparser in certain parts of the country.

7.3 Risk Reduction

The VCA methodology was able to determine that many farmers at Wales are executing small and medium measures to cope with the frequency of flood events. Some of these measures are of a reflex nature while others are more calculated and deliberate. However, due to inadequate financial resources, farmers are unable to carry out these measures for prolonged periods especially in the face of increasing pressures being brought to bear on agriculture systems by climate change impacts. In addition, farmers are also being saddled by the increasing cost of production and the pressures as a result of external market forces/arrangements. In light of this, these coping mechanisms are unaffordable to most farmers rendering them helpless in the plight in which they find themselves (GuySuCo, 2007).

Check list of some measures currently employed by farmers:

1. The cultivation of flood tolerant high yielding varieties.
2. Cleaning primary and secondary drainage systems
3. Mixed farming
4. Establishment of adequate infield drainage systems
5. Excavating external drainage systems
6. Diversification of income generating activities
7. Increasing the size of holdings so as to benefit from the economies
8. Merging farms into Co-ops so as to share administrative expenses (Ibid).

BIBLIOGRAPHY

Bynoe, Paulette and Mark Bynoe. 2000. Final report on a socio-economic assessment of the vulnerability of Guyana's coast. April 2000. . Environmental Protection Agency, Guyana.

EPA. 2002. Guyana's National Vulnerability Assessment to Sea Level Rise – January 2002. Environmental Protection Agency, Guyana.

FAO. 2008. Report of the FAO Expert Workshop on Climate Change Implications for Fisheries and Aquaculture. Rome, Italy, 7–9 April 2008. *FAO Fisheries Report*. No. 870. Rome, FAO. 2008. 32p.

Bisgrove and Hadley 2002. physiological basis of plant responses to climate change. .rhs.org.uk/news/climate_change/chapter3.

Garrett, K.A, S.P.Dendy, E.E. Frank, M.N. Rouse, and S.E. Travers. 2006. Change Effects on Plant Disease: Genomes to Ecosystems. Annual Review of Phytopathology. 44:489-509. .k-state.edu/pdecology/GarrettDendy2006ARP.

Guyana Initial National Communication. 2002. In response to its commitments to the United Nations Framework Convention on Climate Change (UNFCCC).

Guysuco.2004. Guysuco Agricultural Research Centre. Annual Report 2004

Guysuco. 2007. Vulnerability and Capacity Assessment: Impacts of Climate Change on Guyana's Agriculture Sector. *Study conducted at Wales Sugar Estate, Leguan and Mahaica Abary Rice Development Scheme (MARDS).* Draft. Submitted to: Caribbean Community Climate Change Centre (CCCCC). December, 2007.

Hadfield, J.L. 2008. The effects of climate change on agriculture, land resources, water resources, and biodiversity. Chapter 2. In. US. Climate Change Science Program. Pp 21-74.

IPCC, 2007: Summary for policy makers. In. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change , M.L. Parry, O.F. Canziani, J.P. PalutikoF, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22.

Jarvis, Andy, Myles Fisher, Peter Jones, Simon Cook and Luigi Guarino 2006. , Risk and Climate Change. cgiar.org/pdf/2006_Jarvis and others-Ag_Risk_ClimateChange_2006_FIN

Kurukulasuriya, Pradeep & Shane Rosenthal. 2003. Change and Agriculture:A Review of Impacts and Adaptations. The Environment Department and the Agriculture & Rural Development Department. The World Bank. .undp.org/gef/adaptation/docs/EDP_91-W.

National Climate Committee. 2002: Guyana's Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-lying Areas –April 2002 Prepared And

Coordinated By: The National Climate Committee (NCC) With support from the Caribbean Planning for Adaptation to Climate Change (CPACC).

National Development Strategy Committee. *National Development Strategy Guyana.* Guyana. 2000.

Olszyk, D. M., and K. T. Ingram. 1993. Effects of UV-B and global climate change on rice production: The EPA/IRRI cooperative research plan. The Philippines: International Rice Research Institute. .ciesin.org/docs/004-036/004-036.

Petzoldt, Curtis and Abby Seaman. 2006. Change Effects on Insects and Pathogens. In: Climate Change and Agriculture: Promoting Practical and Profitable Responses. .climateandfarming.org/pdfs/FactSheets/III.2Insects.Pathogens.

Raja Reddy, K. 2004. Responses to climate change of C4 and C3 grass species native to South-Central Region. .tulane.edu/~nigec/Reddy.

Wolfe, David. W. 2006. Change Impacts on Northeast Agriculture: Overview .climateandfarming.org/pdfs/FactSheets/Impacts.

Agriculture's Role in. Mitigating and Adapting to Climate Change. Chapter 11:. AND CLIMATE CHANGE: THREATS AND OPPORUNITIES climateactionproject.com/docs/.../11_Agriculture_Extended_12.14.07.pdf

Blast, biotech and big business.2002. IMPLICATIONS OF CORPORATE STRATEGIES ON RICE RESEARCH IN ASIA www.grain.org/briefings_files/blast.pdf

Personal Communication

1. Adams, Ashley. 2008. Personal Communication. Agronomist. Guysuco Agricultural Research Unit.

2. Ahmad, Jaleel. 2008. Personal Communication as part of the series of interviews of key personnel in the agricultural institutions. Agriculture Manager, Skeldon Sugar Estate, Guysuco.

3. Charles, Aubrey. 2008. Personal Communication as part of the series of interviews of key personnel in the agricultural institutions. General Manager, Mahaica- Mahaicony- Abary Agricultural Development Authority, Onverwagt, West Coast Berbice.

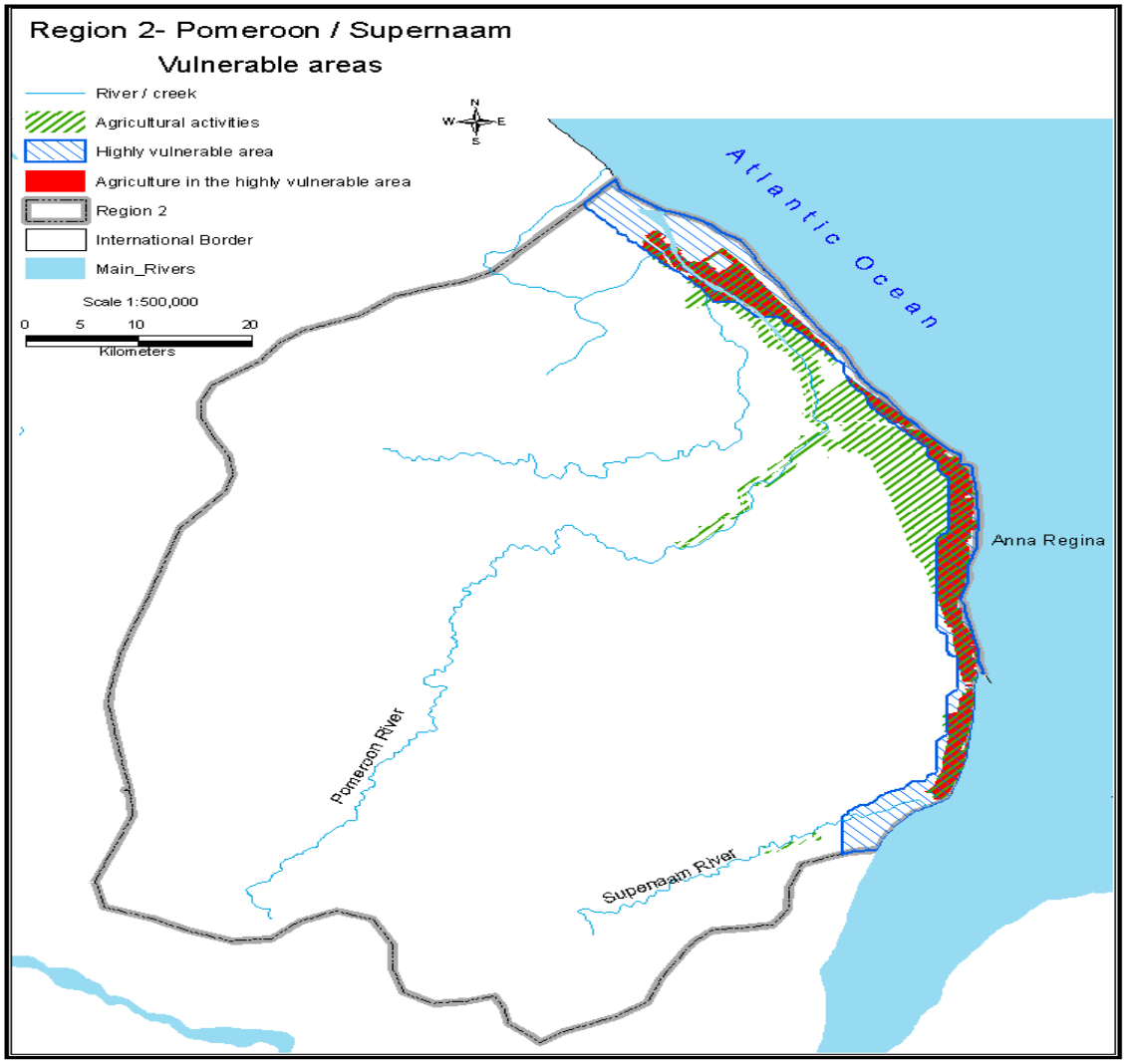
4. Davis, Harold. 2008. Personal Communication as part of the series of interviews of key personnel in the agricultural institutions. Director, Agricultural Research, Guysuco.

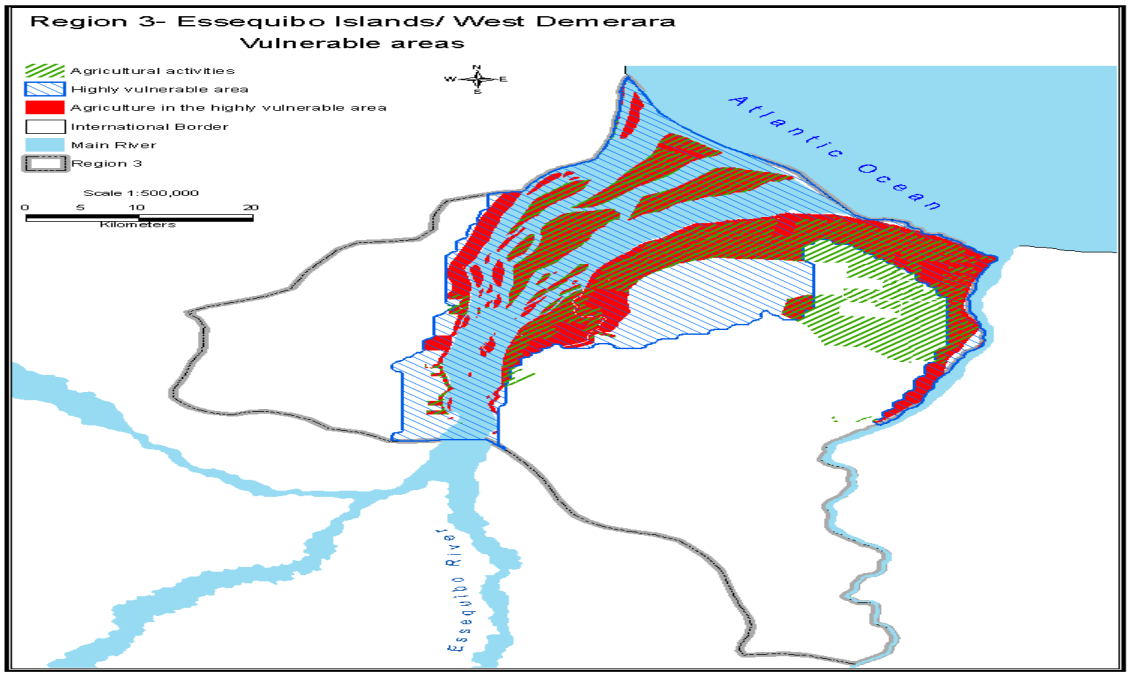
5. Geer, Tejnarine. 2008. Personal Communication as part of the series of interviews of key personnel in the agricultural institutions. Senior Fisheries Officer, Fisheries Department, Ministry of Agriculture, Guyana.

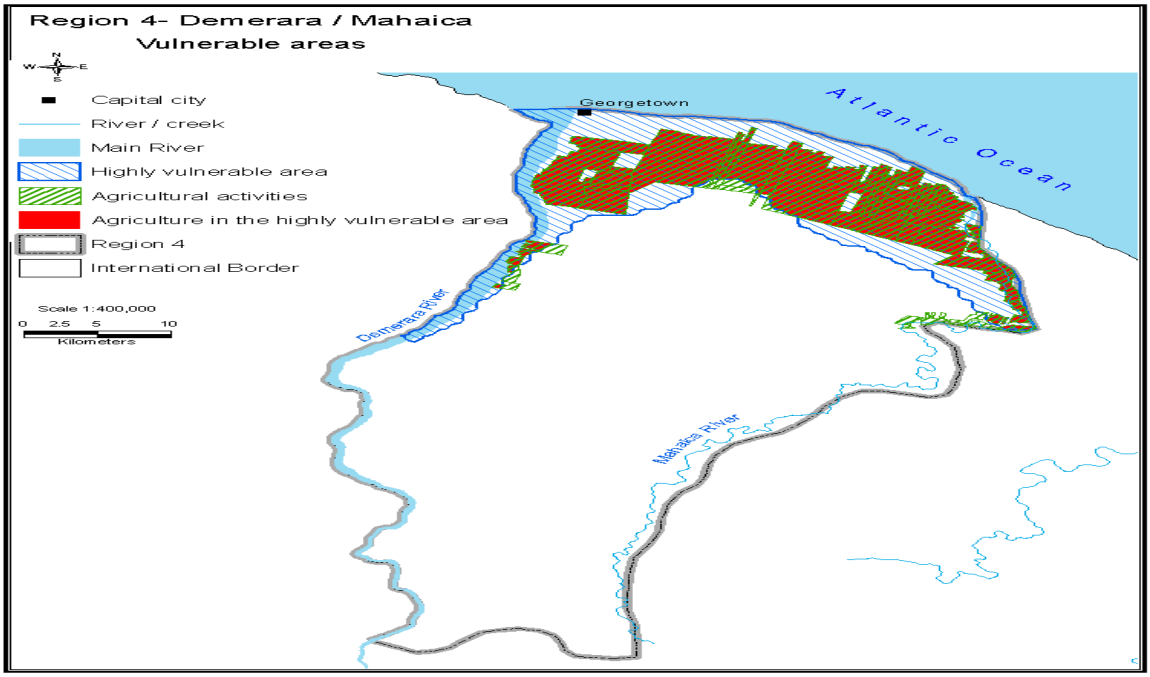
6. Homenauth, Oudho. 2008. Personal Communication as part of the series of interviews of key personnel in the agricultural institutions. Director, National Agricultural Research Institute, Mon Repos.

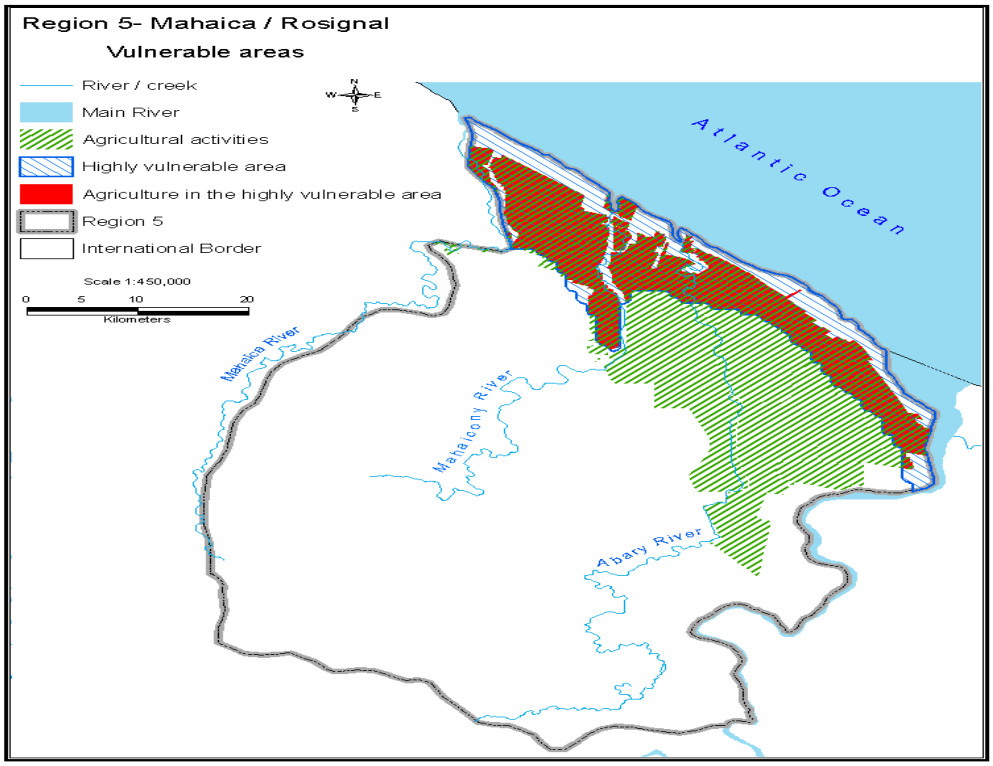
7. Persaud, Mahendra. 2008. Personal Communication as part of the series of interviews of key personnel in the agricultural institutions. Plant Breeder, Burma Rice Research Station, Guyana Rice Development Board.

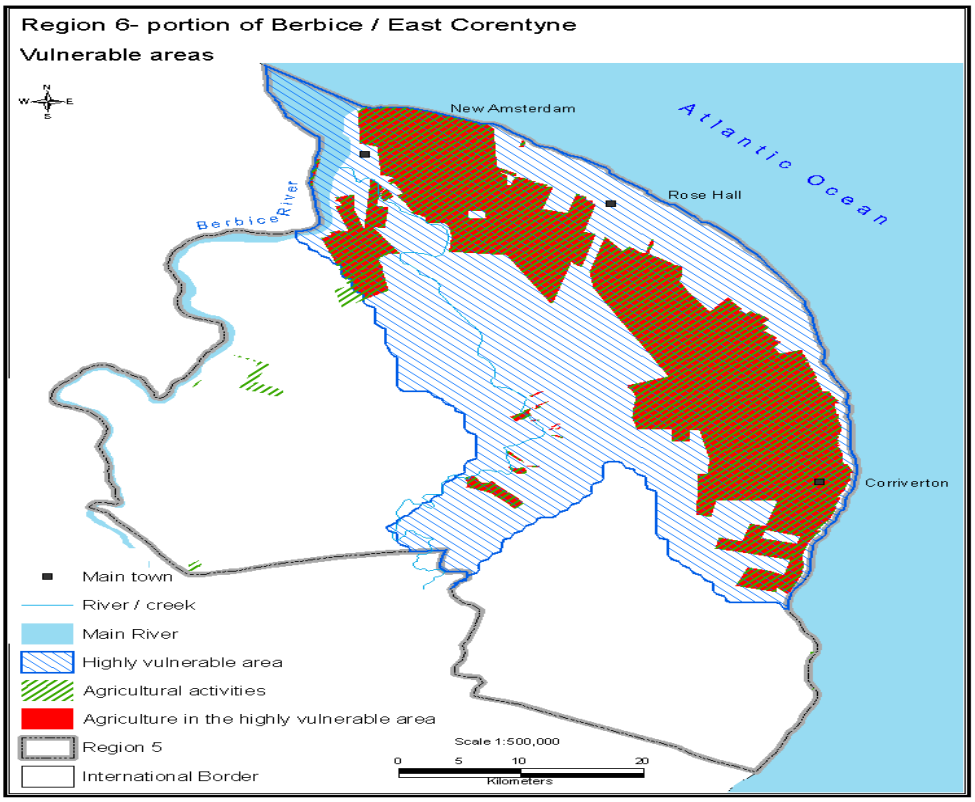
Appendix B1: Maps Showing Vulnerable areas in Regions 2 to 6




Region 3- Essequibo Islands/ West Demerara
Vulnerable areas
Agricultural activities
Highly vulnerable area
Agriculture in the highly vulnerable area
International Border
Main River
Region 3
Scale 1:500,000
0 5 10 20
Kilometers
Atlantic Ocean
Essequibo River


Region 4- Demerara / Mahaica
Vulnerable areas
Capital city
River / creek
Main River
Highly vulnerable area
Agricultural activities
Agriculture in the highly vulnerable area
Region 4
International Border
Scale 1:400,000
0 2.5 5 10
Kilometers
Georgetown
Atlantic Ocean
Demerara River
Mahaica River

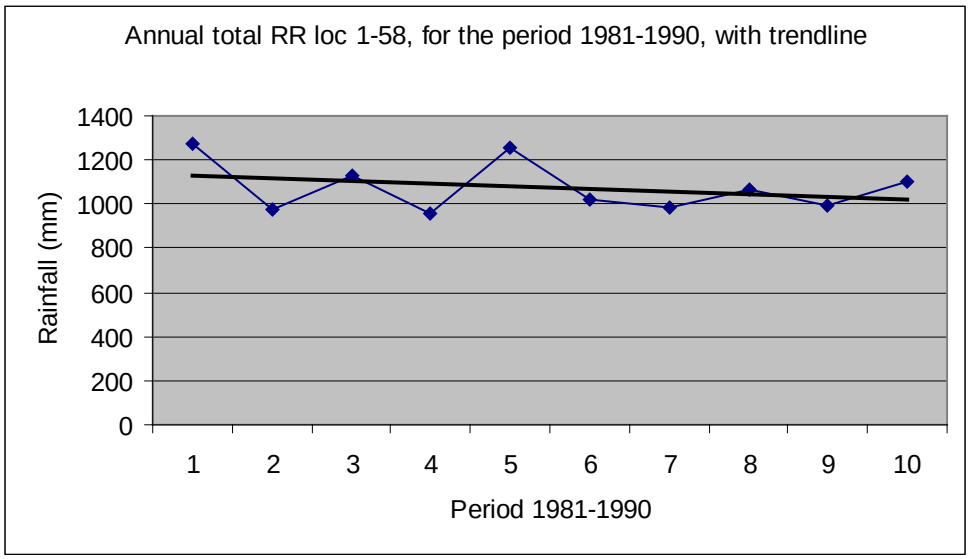

Region 5- Mahaica / Rosignal
Vulnerable areas
River / creek
Main River
Agricultural activities
Highly vulnerable area
Agriculture in the highly vulnerable area
Region 5
International Border
Scale 1:450,000
0 5 10 20
Kilometers
Atlantic Ocean
Mahaica River
Mahaicony River
Abary River

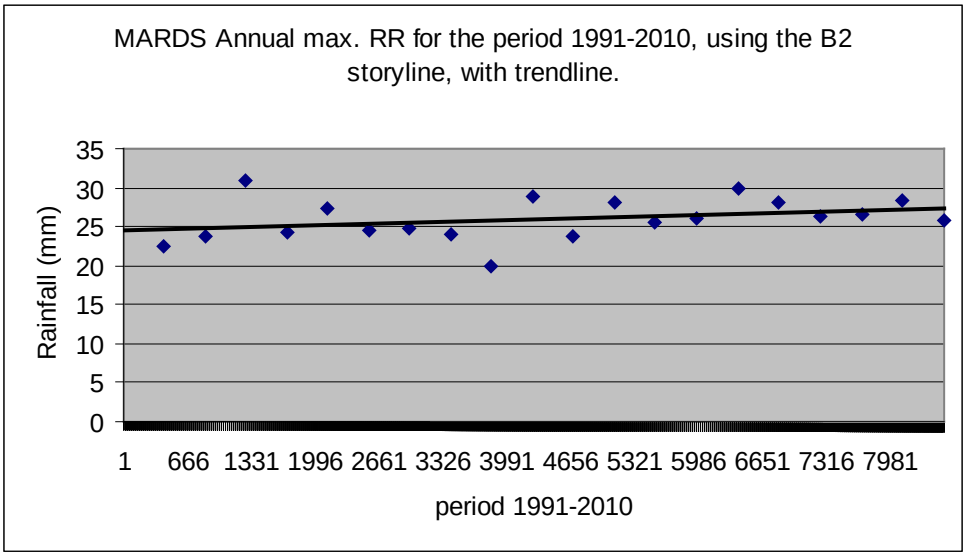

Region 6- portion of Berbice / East Corentyne
Vulnerable areas
New Amsterdam
Rose Hall
Corriverton
Atlantic Ocean
Berbice River
Main town
River / creek
Main River
Highly vulnerable area
Agricultural activities
Agriculture in the highly vulnerable area
Region 5
International Border
Scale 1:500,000
0 5 10 20
Kilometers

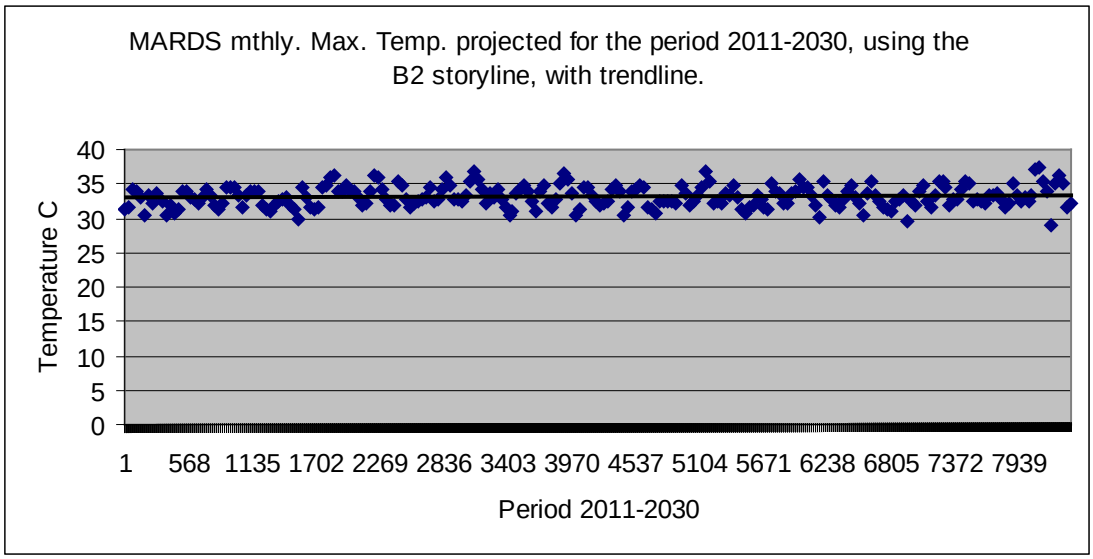
Appendix B.2: List of Agencies Consulted

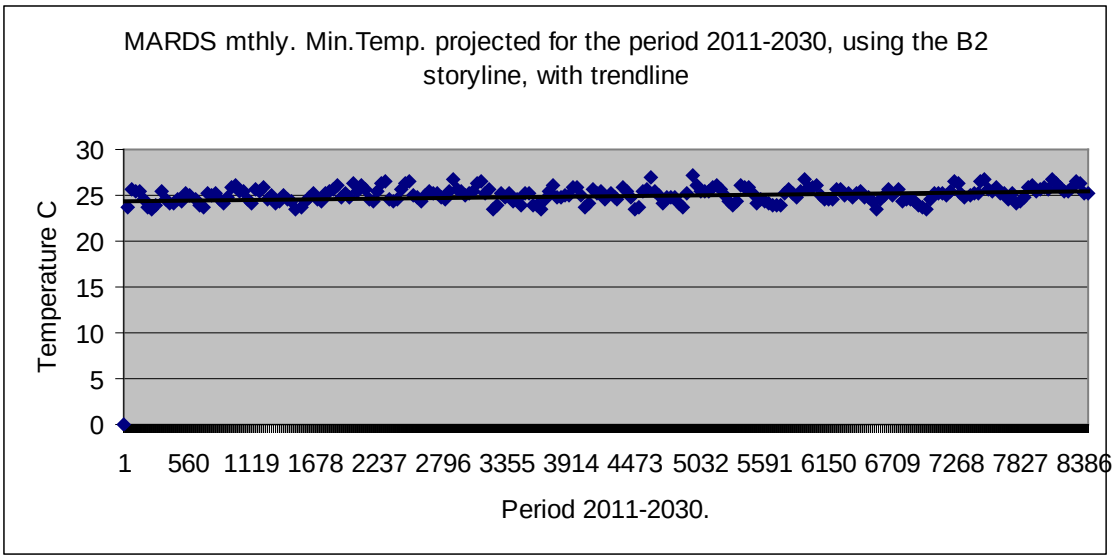
Government Ministries and Agencies	Contact Person		Date Visited
1. PD	Ms. Jacqueline Nero	Chief Planning Officer	Wednesday July 16th
2. HD	Ms. Bhaleka Seulall	Chief Hydrometeorological Department	Tuesday July 15th
3. FD	Mr. Tejnarine Geer	Chief Fisheries Officer	Tuesday July 15th
4. NDIA	Mr. Lionel Wordsworth	CEO	Tuesday July 15th
5. GUYSUCO	Dr. Harold Davis	Director of Research	Friday July 18th
6. Project Cycle Unit	Mr. Cecil Seepersaud	Head of Project Unit	Thursday July 17th
7. GRDB	Mr Jagnarine Singh	General Manager	Monday July 14th
8. NGMC	Mr. Nizan Hassan	General Manager	Thursday July 24th
9. NDDP	Dr. Dwight Walrond	Head	Monday July 21st
10. GSA	Ms. Lynette Cunha	Principal	Friday July 18th
11. NARI	Dr. Oudho Homenauth	Director	Friday July 18th
12. GFC	Mr.James Singh	Comissioner	Wednesday July 16th
13. SRDD	Ms. Agnes Dalrymple Mr. Amsterdam	Sea & River Defence Officer Director of Projects	Thursday July 17th
14. EPA	Mr. Khalid Alladin	Director (a.g)	Wednesday July 23rd
15. NCU	Ms. Chandrapaul	Coordinator	Wednesday July 23rd
16. MoA	Dr. Dindyal Permaul	Permanent Secretary	Wednesday July 23rd
17. Skeldon Estate	Mr. Vishnu Panday	General Manager	Thursday 24th July
18. MMA/ADA	Mr. Obrey Charles		Friday 25th July
19. Ministry of Fisheries Crops and Livestock	Mr. Brian Sears	Chief Crops & Livestock Officer	Friday July 25th
20. UG-FAF	Dr. Theodosius Velloza	Dean	Tuesday August 19
21. PTCCB	Mr. Dwarka	Registrar	Thursday August 21st
22. GEA	Mr. Mahendra Sharma	Acting CEO	Tuesday August 19th
23. GWI	Mr. Jackson Twidale Harry Karl Sizle	Director of projects Legal Specialist Consultant	Wednesday August 28
24. GRPA	Mr. Dharankumar Seeraj	General Secretary	Wednesday August 28

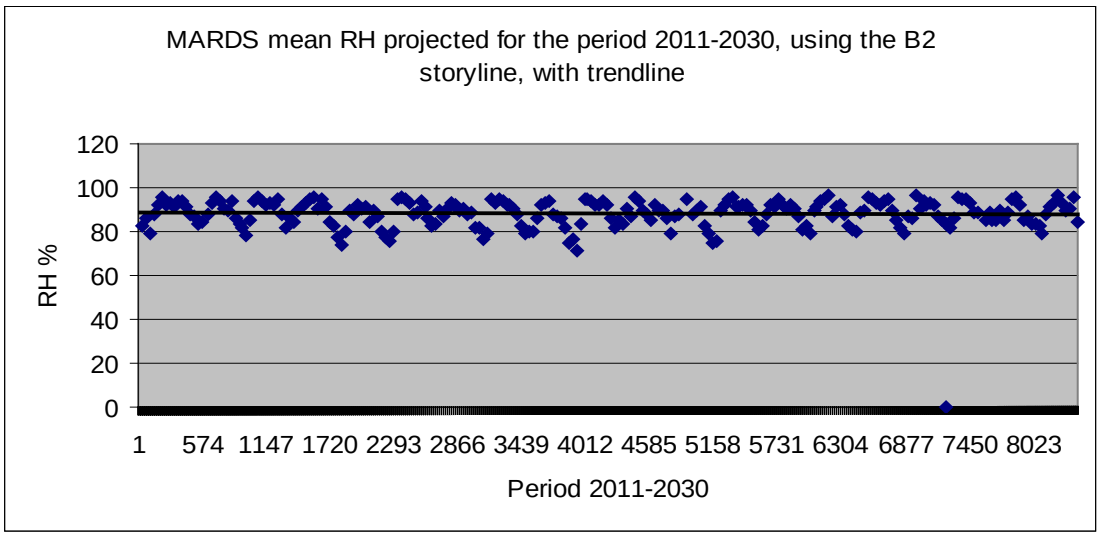
Appendix B.3: Graphs of the Various Projected Climate Change Impacts on Climatic Indicators

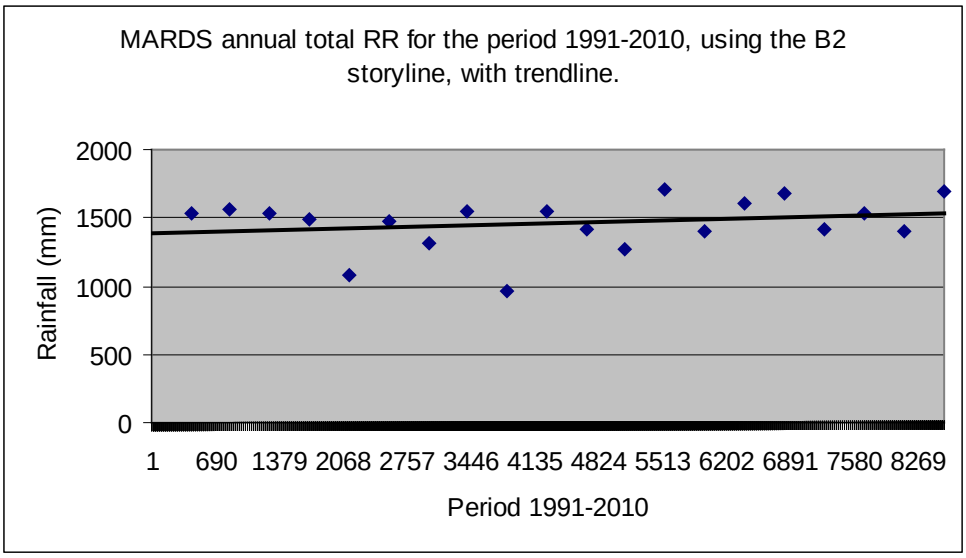


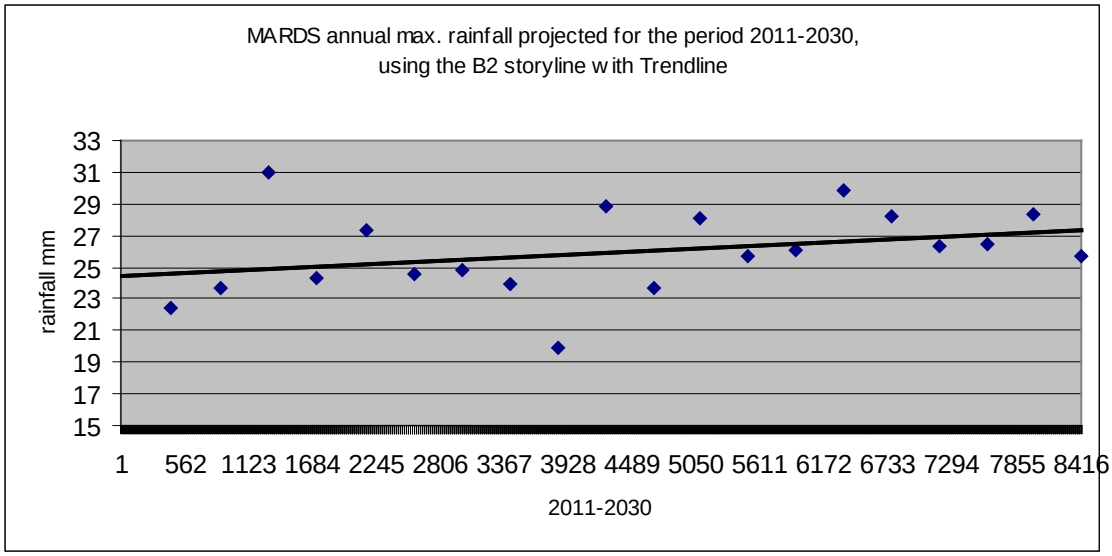


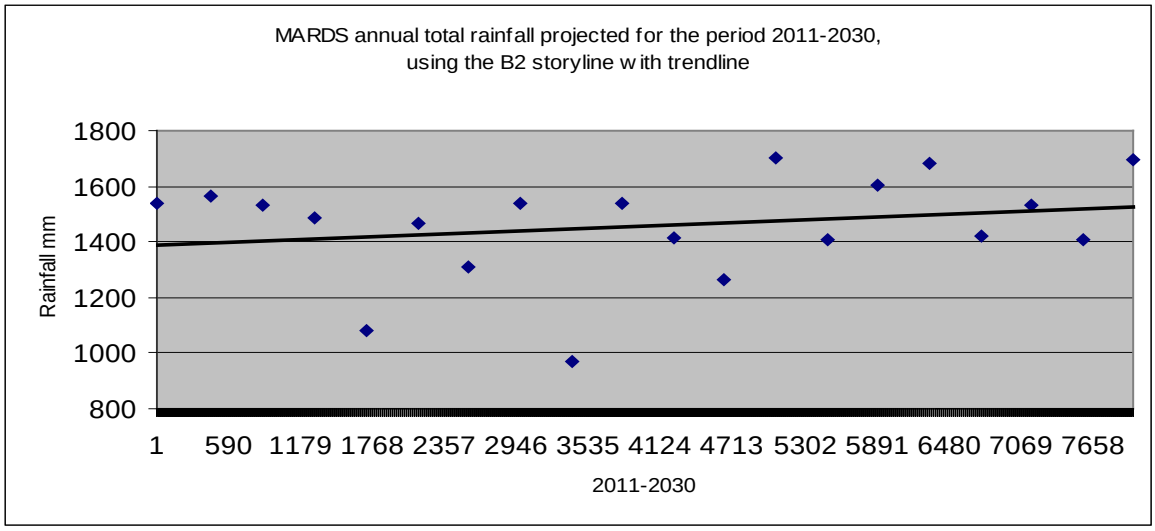

MARDS mthly. Max. Temp. projected for the period 2011-2030, using the B2 storyline, with trendline.
Temperature C
40
35
30
25
20
15
10
5
0
1 568 1135 1702 2269 2836 3403 3970 4537 5104 5671 6238 6805 7372 7939
Period 2011-2030

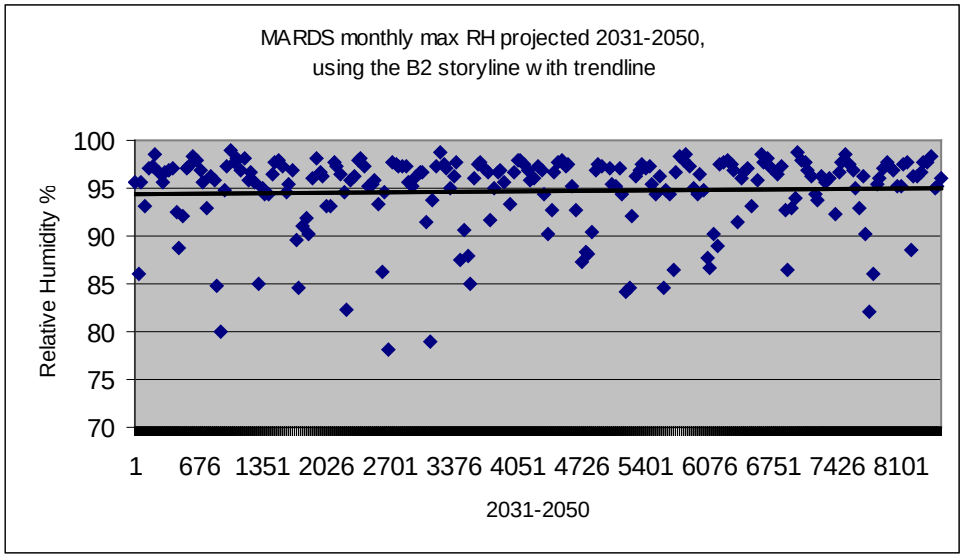

MARDS mthly. Min.Temp. projected for the period 2011-2030, using the B2 storyline, with trendline
Temperature C
30
25
20
15
10
5
0
1 560 1119 1678 2237 2796 3355 3914 4473 5032 5591 6150 6709 7268 7827 8386
Period 2011-2030.

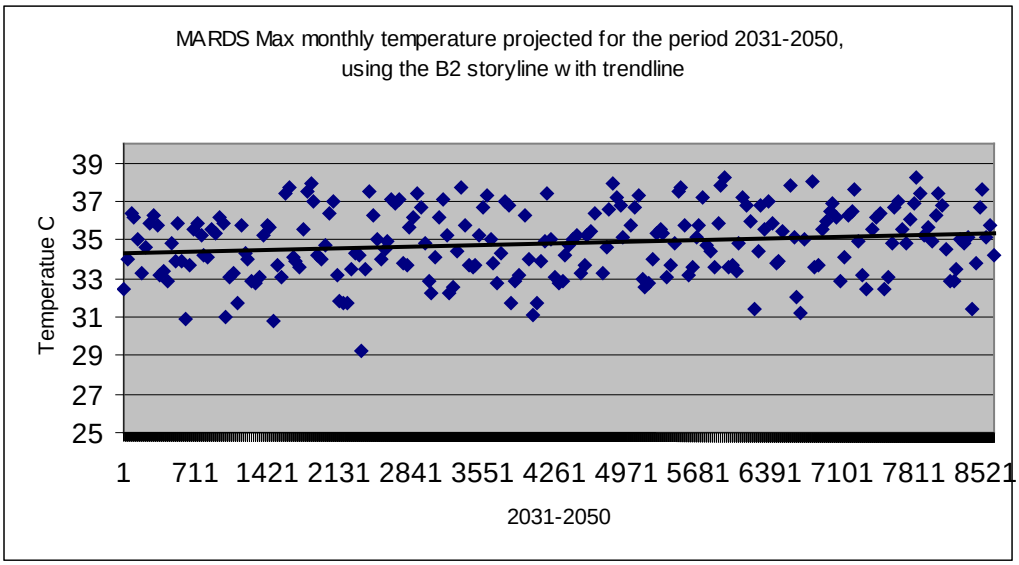

MARDS mean RH projected for the period 2011-2030, using the B2 storyline, with trendline
RH %
120
100
80
60
40
20
0
1 574 1147 1720 2293 2866 3439 4012 4585 5158 5731 6304 6877 7450 8023
Period 2011-2030

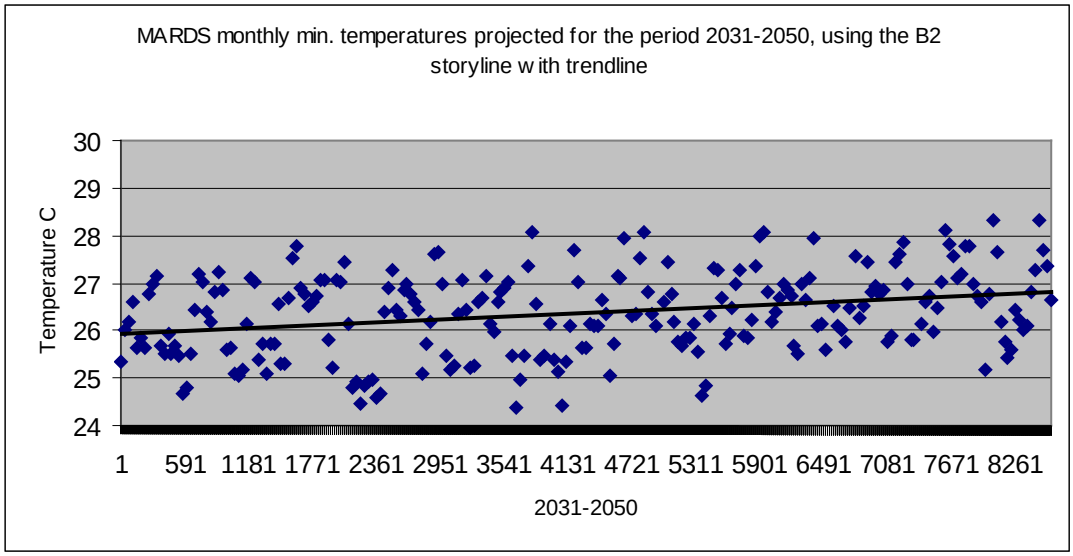

MARDS annual total RR for the period 1991-2010, using the B2 storyline, with trendline.
Rainfall (mm)
2000
1500
1000
500
0
1 690 1379 2068 2757 3446 4135 4824 5513 6202 6891 7580 8269
Period 1991-2010

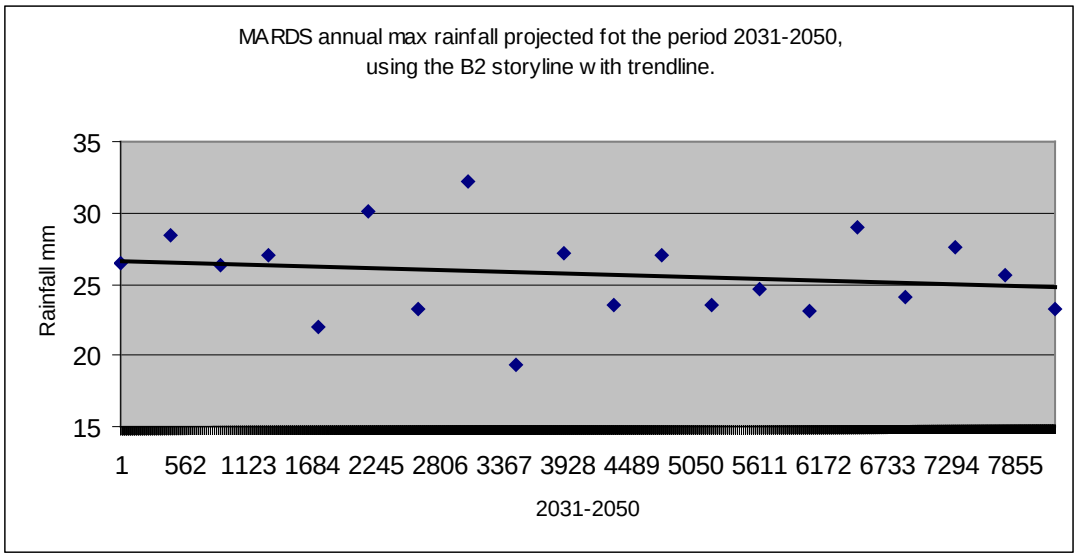

MARDS annual max. rainfall projected for the period 2011-2030, using the B2 storyline with Trendline
rainfall mm
33
31
29
27
25
23
21
19
17
15
1 562 1123 1684 2245 2806 3367 3928 4489 5050 5611 6172 6733 7294 7855 8416
2011-2030

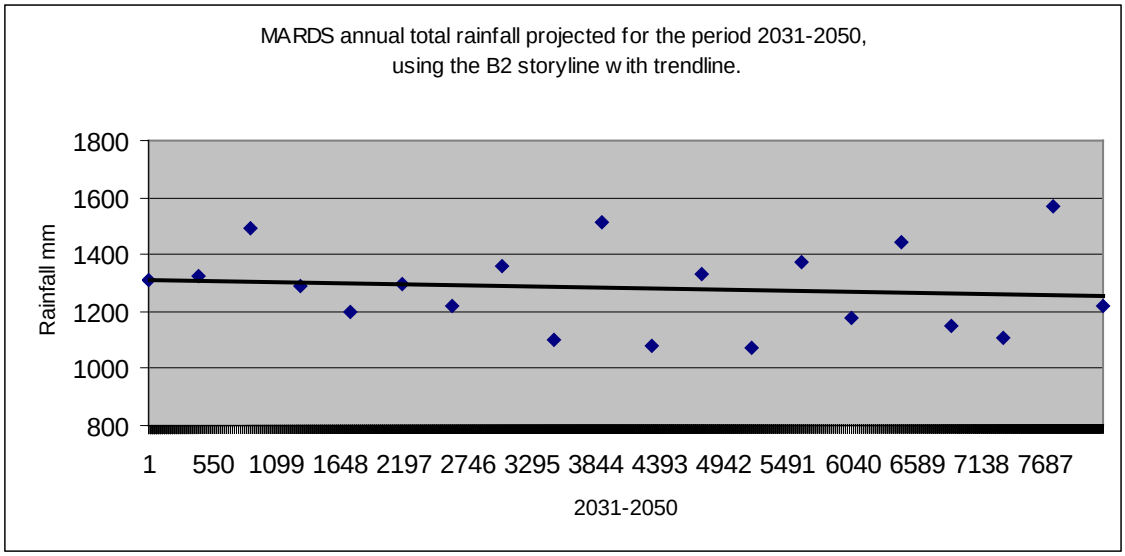

MARDS annual total rainfall projected for the period 2011-2030,
using the B2 storyline with trendline
Rainfall mm
1800
1600
1400
1200
1000
800
1 590 1179 1768 2357 2946 3535 4124 4713 5302 5891 6480 7069 7658
2011-2030

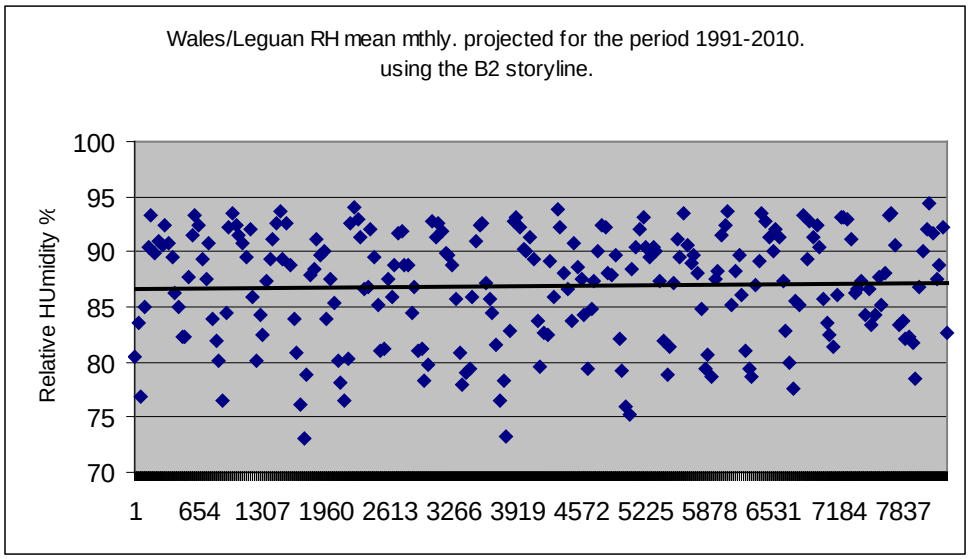

MARDS monthly max RH projected 2031-2050,
using the B2 storyline with trendline
Relative Humidity %
100
95
90
85
80
75
70
1 676 1351 2026 2701 3376 4051 4726 5401 6076 6751 7426 8101
2031-2050

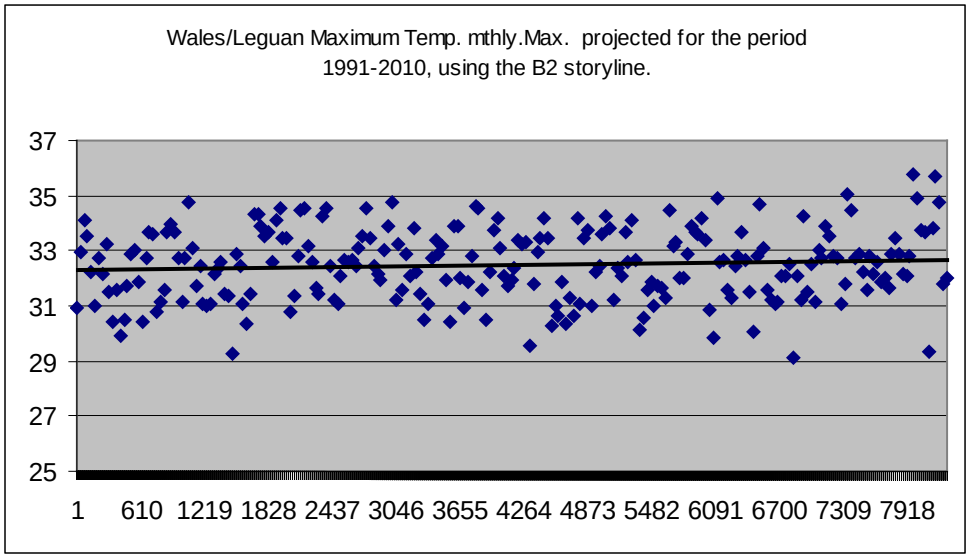

MARDS Max monthly temperature projected for the period 2031-2050, using the B2 storyline with trendline
Temperatue C
39
37
35
33
31
29
27
25
1
711
1421
2131
2841
3551
4261
4971
5681
6391
7101
7811
8521
2031-2050

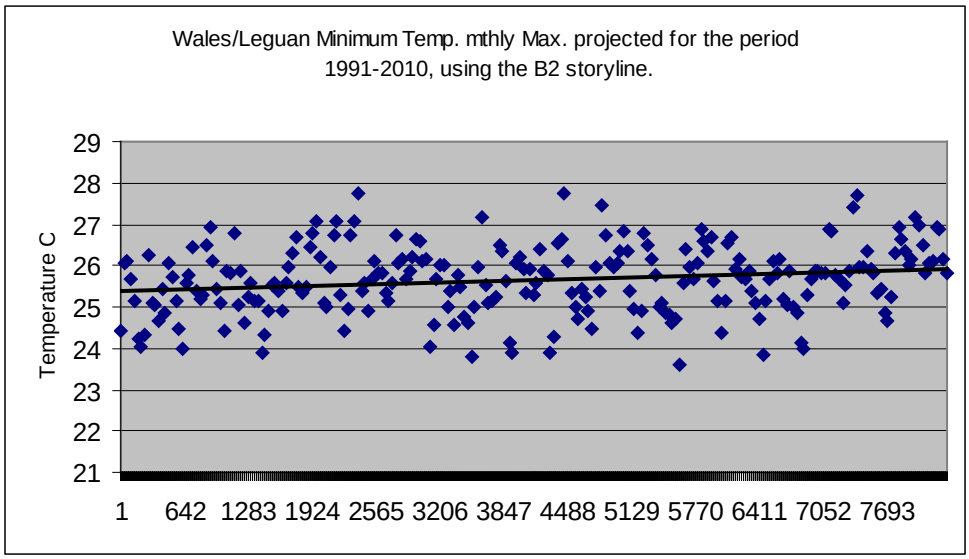

MARDS monthly min. temperatures projected for the period 2031-2050, using the B2 storyline with trendline
Temperature C
30
29
28
27
26
25
24
1
591
1181
1771
2361
2951
3541
4131
4721
5311
5901
6491
7081
7671
8261
2031-2050

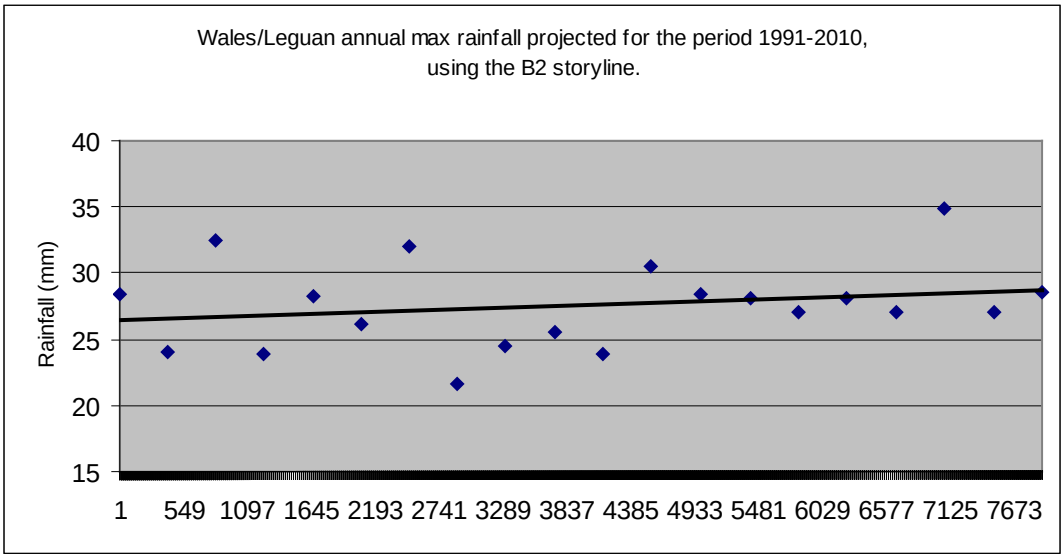

MARDS annual max rainfall projected fot the period 2031-2050,
using the B2 storyline w ith trendline.
Rainfall mm
35
30
25
20
15
1
562
1123
1684
2245
2806
3367
3928
4489
5050
5611
6172
6733
7294
7855
2031-2050

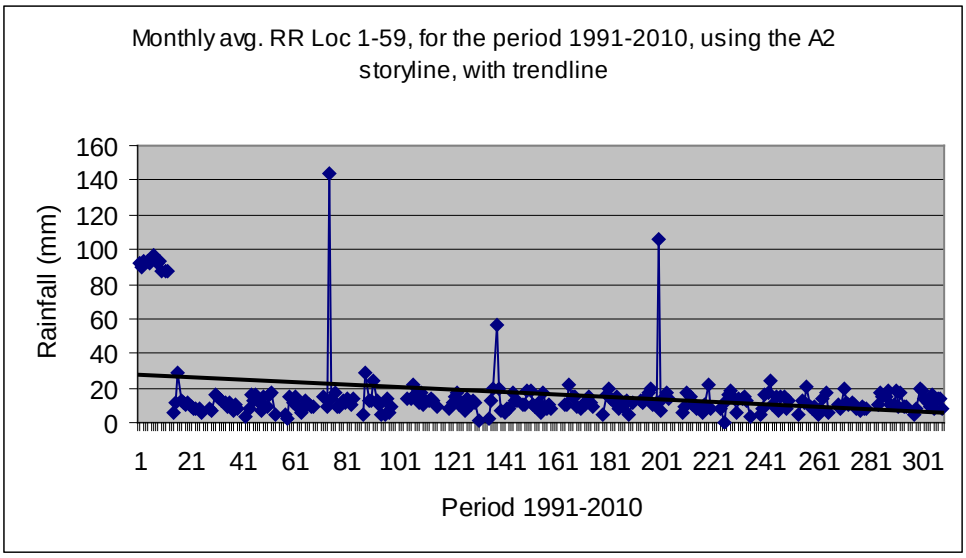

MARDS annual total rainfall projected for the period 2031-2050,
using the B2 storyline w ith trendline.
Rainfall mm
1800
1600
1400
1200
1000
800
1
550
1099
1648
2197
2746
3295
3844
4393
4942
5491
6040
6589
7138
7687
2031-2050

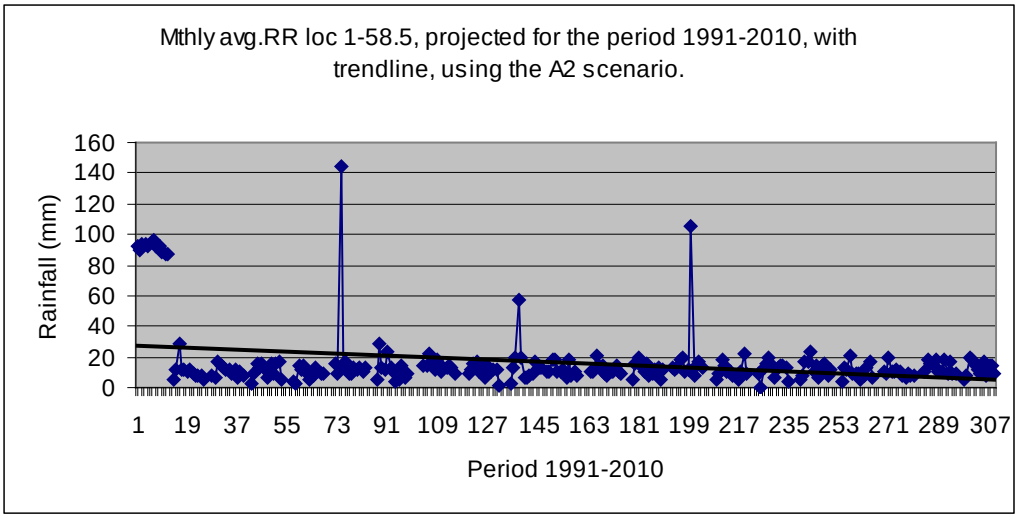

Wales/Leguan RH mean mthly. projected for the period 1991-2010.
using the B2 storyline.
Relative HUmidity %
100
95
90
85
80
75
70
1
654
1307
1960
2613
3266
3919
4572
5225
5878
6531
7184
7837

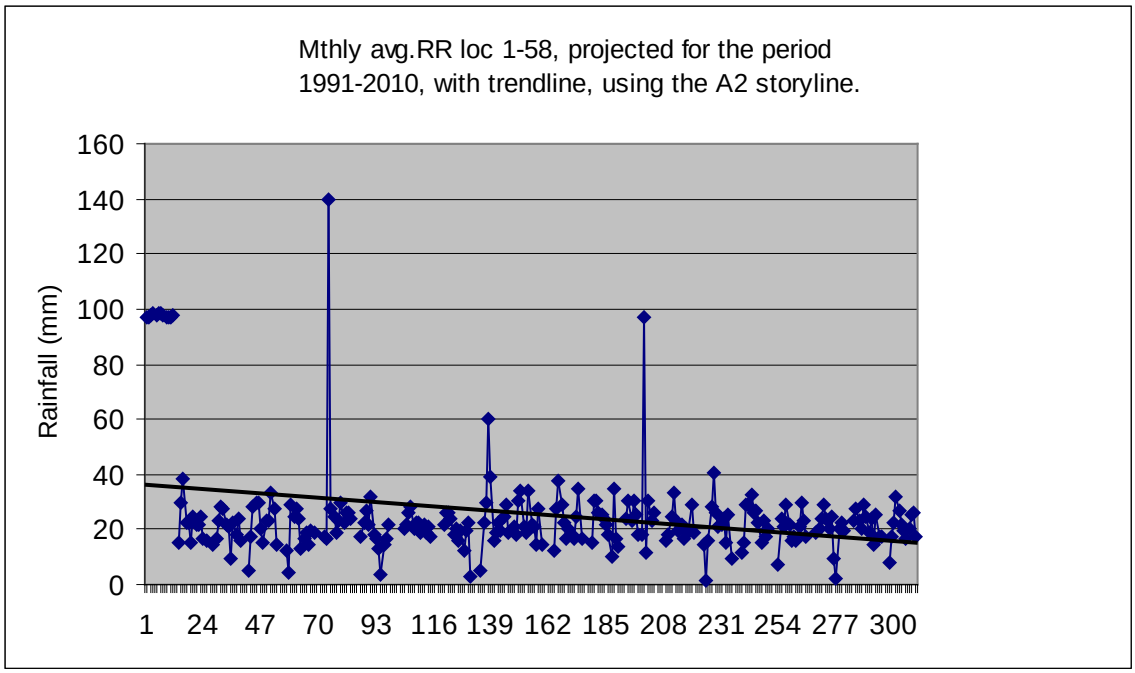

Wales/Leguan Maximum Temp. mthly.Max. projected for the period
1991-2010, using the B2 storyline.
37
35
33
31
29
27
25
1
610
1219
1828
2437
3046
3655
4264
4873
5482
6091
6700
7309
7918

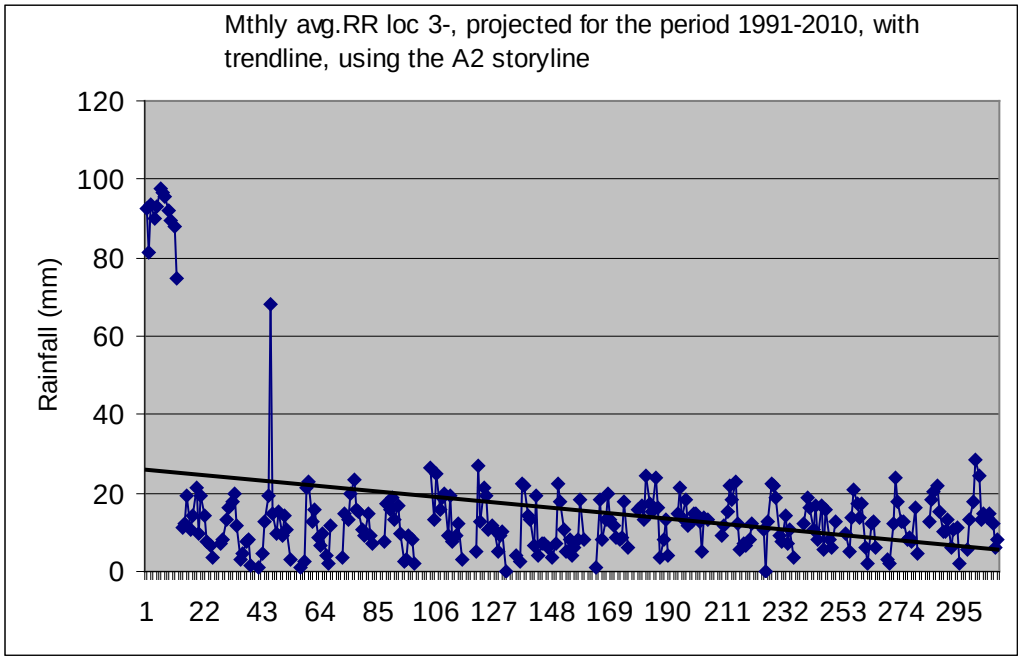

Wales/Leguan Minimum Temp. mthly Max. projected for the period 1991-2010, using the B2 storyline.
Temperature C
29
28
27
26
25
24
23
22
21
1
642
1283
1924
2565
3206
3847
4488
5129
5770
6411
7052
7693

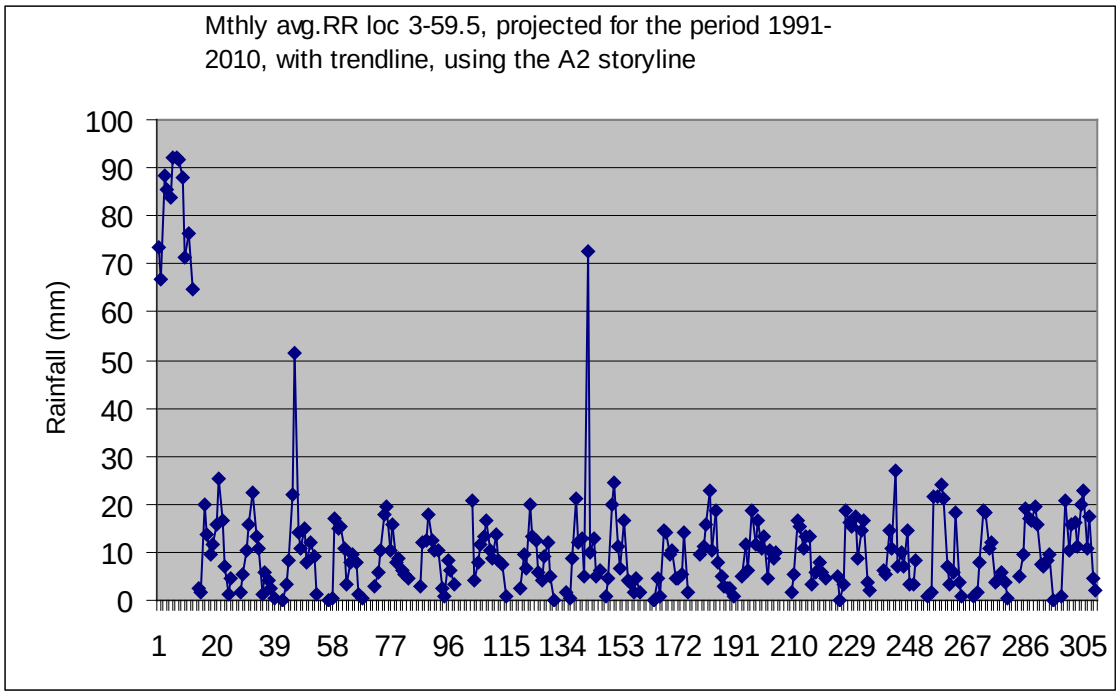

Wales/Leguan annual max rainfall projected for the period 1991-2010, using the B2 storyline.
Rainfall (mm)
40
35
30
25
20
15
1
549
1097
1645
2193
2741
3289
3837
4385
4933
5481
6029
6577
7125
7673

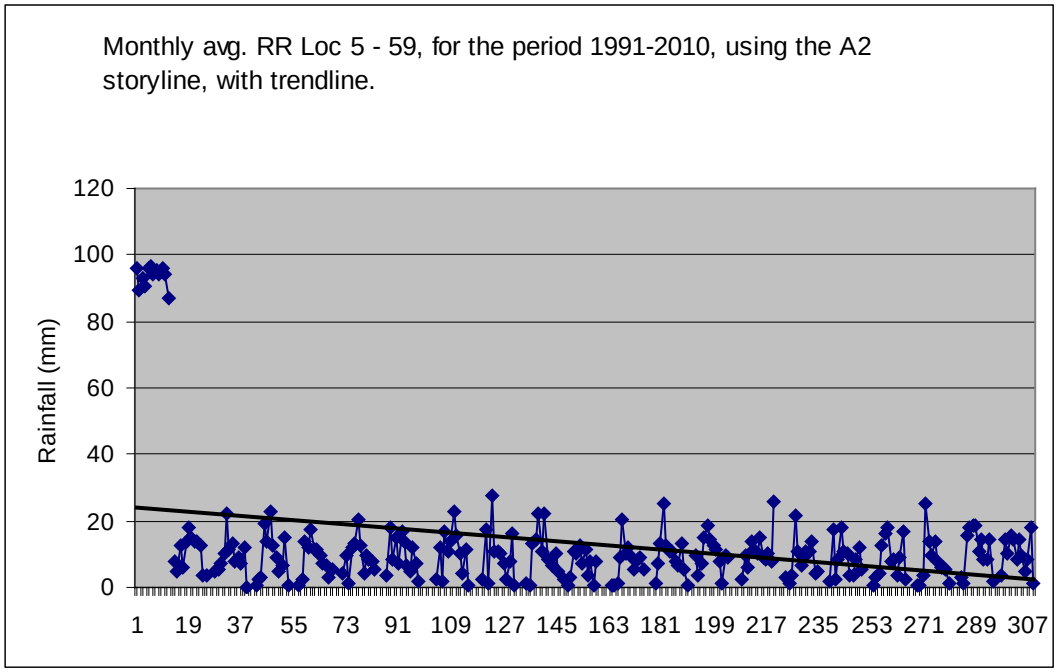

Monthly avg. RR Loc 1-59, for the period 1991-2010, using the A2 storyline, with trendline
Rainfall (mm)
160
140
120
100
80
60
40
20
0
1 21 41 61 81 101 121 141 161 181 201 221 241 261 281 301
Period 1991-2010

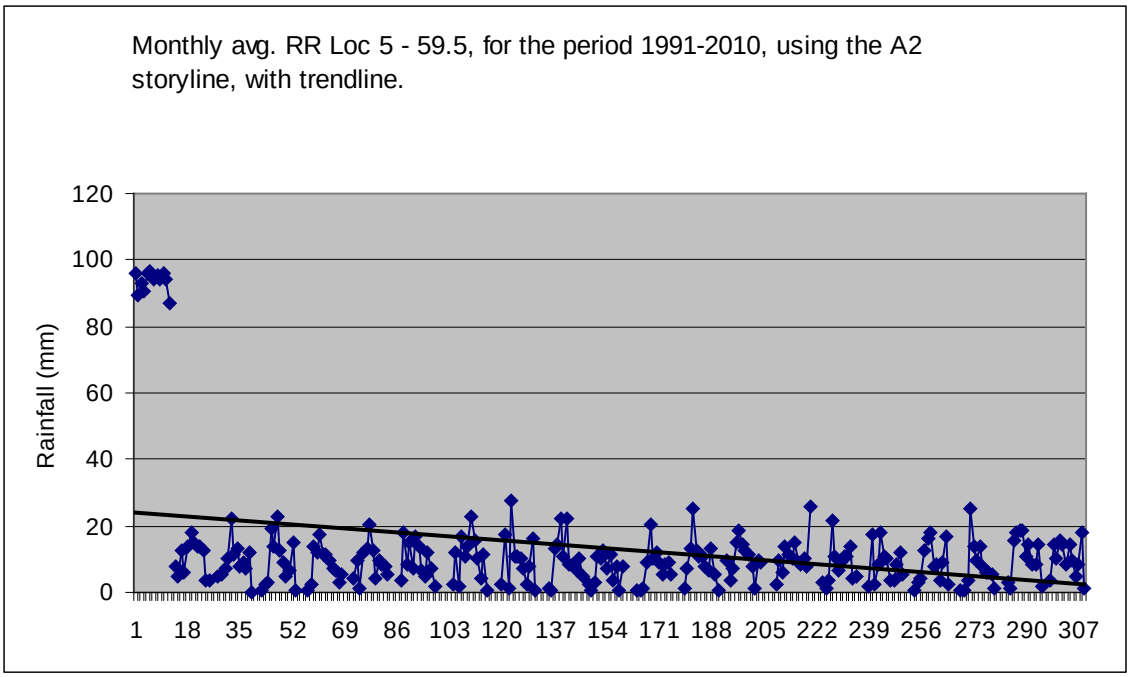

Mthly avg.RR loc 1-58.5, projected for the period 1991-2010, with trendline, using the A2 scenario.
Rainfall (mm)
160
140
120
100
80
60
40
20
0
1 19 37 55 73 91 109 127 145 163 181 199 217 235 253 271 289 307
Period 1991-2010

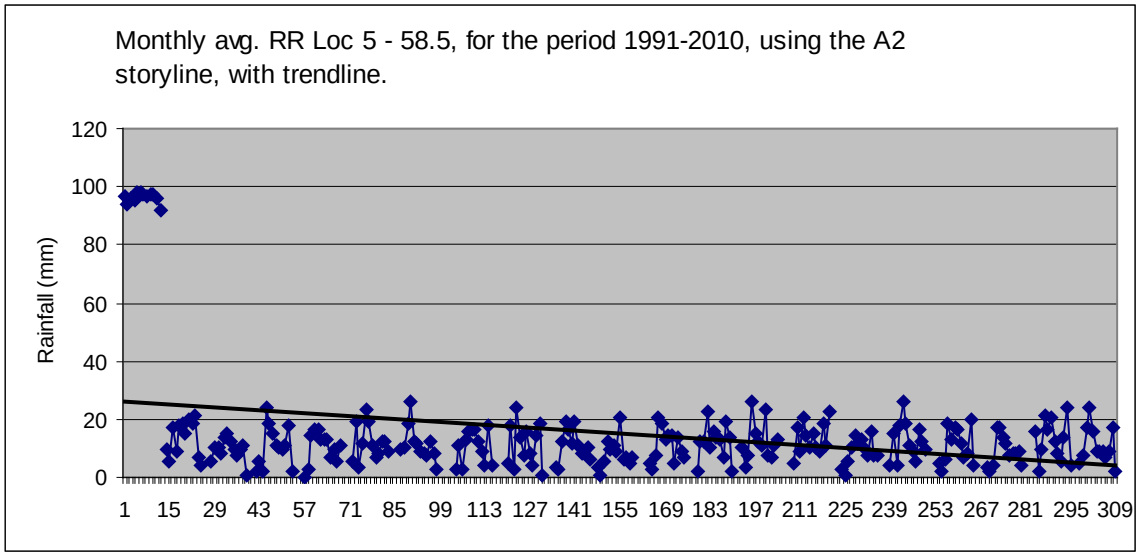

Mthly avg.RR loc 1-58, projected for the period 1991-2010, with trendline, using the A2 storyline.
Rainfall (mm)
160
140
120
100
80
60
40
20
0
1 24 47 70 93 116 139 162 185 208 231 254 277 300

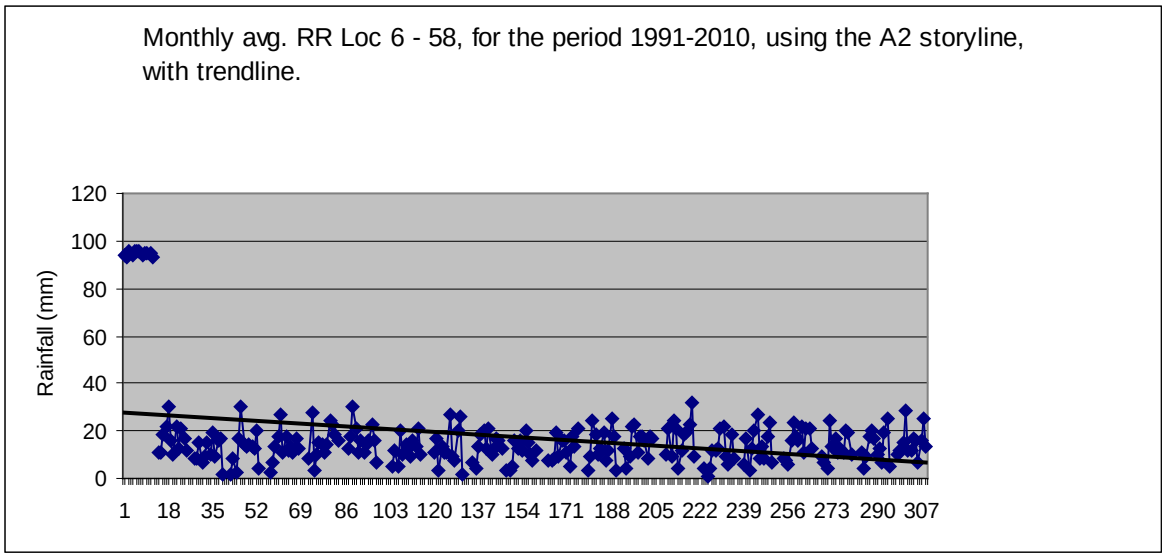

Mthly avg.RR loc 3-, projected for the period 1991-2010, with trendline, using the A2 storyline
Rainfall (mm)
120
100
80
60
40
20
0
1 22 43 64 85 106 127 148 169 190 211 232 253 274 295

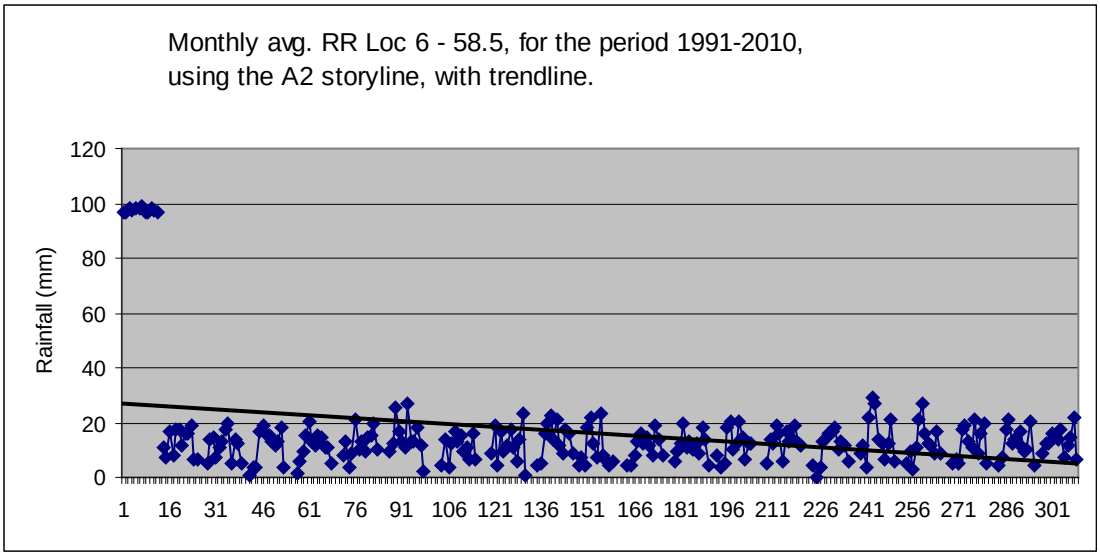

Mthly avg.RR loc 3-59.5, projected for the period 1991-2010, with trendline, using the A2 storyline
Rainfall (mm)
100
90
80
70
60
50
40
30
20
10
0
1 20 39 58 77 96 115 134 153 172 191 210 229 248 267 286 305

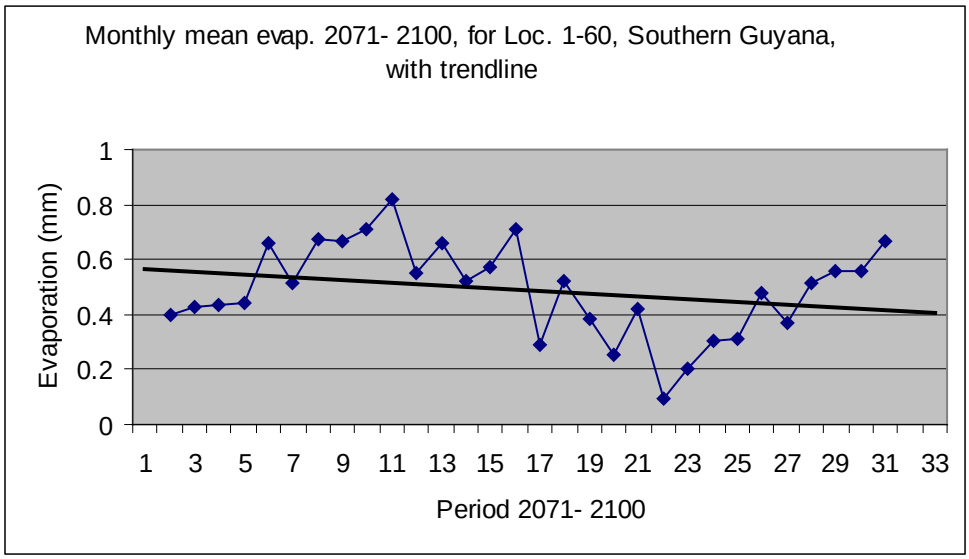

Monthly avg. RR Loc 5 - 59, for the period 1991-2010, using the A2 storyline, with trendline.
Rainfall (mm)
120
100
80
60
40
20
0
1 19 37 55 73 91 109 127 145 163 181 199 217 235 253 271 289 307

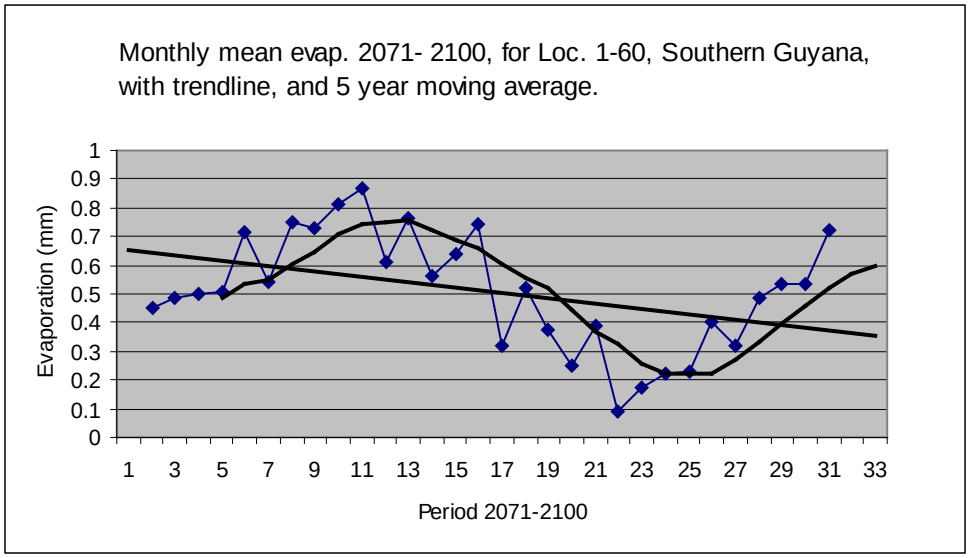

Monthly avg. RR Loc 5 - 59.5, for the period 1991-2010, using the A2 storyline, with trendline.
Rainfall (mm)
120
100
80
60
40
20
0
1 18 35 52 69 86 103 120 137 154 171 188 205 222 239 256 273 290 307


Monthly avg. RR Loc 5 - 58.5, for the period 1991-2010, using the A2 storyline, with trendline.
Rainfall (mm)
120
100
80
60
40
20
0
1 15 29 43 57 71 85 99 113 127 141 155 169 183 197 211 225 239 253 267 281 295 309


Monthly avg. RR Loc 6 - 58, for the period 1991-2010, using the A2 storyline, with trendline.
Rainfall (mm)
120
100
80
60
40
20
0
1 18 35 52 69 86 103 120 137 154 171 188 205 222 239 256 273 290 307


Monthly avg. RR Loc 6 - 58.5, for the period 1991-2010, using the A2 storyline, with trendline.
Rainfall (mm)
120
100
80
60
40
20
0
1 16 31 46 61 76 91 106 121 136 151 166 181 196 211 226 241 256 271 286 301


Monthly mean evap. 2071- 2100, for Loc. 1-60, Southern Guyana, with trendline
Evaporation (mm)
1
0.8
0.6
0.4
0.2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33
Period 2071- 2100


Monthly mean evap. 2071- 2100, for Loc. 1-60, Southern Guyana, with trendline, and 5 year moving average.
Evaporation (mm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33
Period 2071-2100

APPENDIX C: POLICY ASSESSMENT

1. INTRODUCTION

1.1 Purpose and Scope of the Assessment

This assessment examines, from an analytical standpoint, the existing policy and legislative frameworks and major policy provisions for the agricultural sector in Guyana to adapt to the challenges posed, and take advantage of the opportunities presented, by climate change. In addition to identifying challenges posed by climate change to the sector's existing legislation, this assessment also examines overlaps and conflicts with other related legislation. The major challenges surround coastal erosion and flooding, improved freshwater and sea defence management, enhance technical and informational capacities, and an effective informational and communication strategy (Guyana's National Vulnerability to Sea Level Rise, 2002). The opportunities are viewed in terms of Guyana's competitive advantages regionally in water and land, and the country's innovative human and scientific resources that need to be harnessed and collectively employed to strengthen the sector where it is able to further diversify its productive base, utilize appropriate technologies, and increase its productivity and competitiveness.

1.2 Objectives

The main objective is to examine the adequacy and flexibility of the policy and legislative environment to adapt to climate change in the agriculture sector.

1.3 Methodology

Given that climate change is a global phenomenon, it is imperative to commence from the global scale, more so, when cognizance is taken of the fact that Guyana is a signatory to the multilateral United Nations Framework Convention to Combat Climate Change (UNFCCC). Furthermore, the assessment examines regional initiatives that have been, or are being, pursued since Guyana is part of the Caribbean Small Island Developing States (SIDS) grouping. Such regional initiatives may have relevance to/for national policy. Lastly, the assessment examines the national Strategies and legislation in place to facilitate the adaptation to climate change by the agriculture sector. In presenting the national policies at the sectoral level, an assessment is done in terms of their appropriateness in the context of climate change.

The main approach used was to review secondary material sources, existing legislation, strategies and policies, conduct interviews with persons in the field, and use the analysts own judgement.

1.4 Constraint

The main constraint encountered in conducting this analysis was access to the volume of work conducted on policy reviews in Guyana. However, it is important to note at the same time that the SRDD and the GFC were particularly helpful in this respect.

2. SECTOR PROFILE

As discussed in the Economic Review agriculture is the most important sector of Guyana's economy, accounting for approximately 32% of GDP, 30% of employment[54], and 40% of export earnings (Ministry of Finance, 2008) Sugar and rice, with privileged access to the European Union (EU), account for 74% of agriculture's GDP as well as 65% of total agricultural exports, including shrimp and timber. About 75% of Guyana's sugar production is exported to the EU at prices more than double the world market prices.

But agriculture is also important for a number of domestic reasons. For example, cassava, the main root crop planted in the hinterlands of Guyana, remains the staple for the indigenous peoples. Many of these hinterland communities are almost entirely dependent on subsistence agriculture for their livelihood.[55]

Clearly then, the Guyana economy is still heavily dependent on the primary agricultural sector. Sugar, fisheries and rice are the most important agricultural commodities in Guyana on the basis of their respective contributions to agricultural exports, earnings, farm incomes employment and food security. In an effort to meet the challenges imposed by climate change, and the opportunities presented, the government has been attempting to:

- Improve the drainage and irrigation capacity,[56]
- Reinforce the sea defences,[57]
- Diversify the agricultural sector,[58]
- Pursue research and development efforts in terms of the plant and animal specifies most adaptive to the type of climate impacts Guyana is projected to receive,
- Encourage alternative fuel utilization and forestry conservation, and
- Engage stakeholders to disseminate information about how they might be impacting or would be impacted upon by a changing climate.[59]

Guyana also produces a range of domestic food crops, some of which are exported, as well as livestock such as poultry, small ruminants and beef/cattle. The major part of these products is utilized for domestic food consumption. Food crop production includes a variety of root crops (cassava, eddoes, and sweet potato), plantain, cowpeas as well as vegetables. Fruit crops such as citrus, pineapples, mangoes, papaya and carambola are also grown (Bynoe and Thomas, 2008).

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[54] Inter-American Development Bank (2006) Agricultural Export Diversification Programme Loan Proposal, http://www.iadb.org/projects/project.cfm?id=GY-L1007&lang=en

[55] Thomas, C.Y., and Bynoe, M (2006) **Trade Reforms and Food Security: A Synthesis – The Guyana Case** in "Trade Reforms and Food Security: Country Case Studies and Synthesis" FAO Publication, *ISBN 9251055335*.

[56] Ministry of Agriculture (2007) Conservancy Adaptation Plan, Ministry of Agriculture, Georgetown (unpublished report).

[57] Ministry of Public Works and Communications (undated) Sea Level Rise and Its Implications for Guyana, Ministry of Public Works and Communications, Georgetown (unpublished report)

[58] Agricultural Export Diversification Programme (2006) Loan Proposal Document, http://www.iadb.org/projects/project.cfm?id=GY-L1007&lang=en

[59] Institute of Development Studies/School of Earth and Environmental Sciences (2008) Socio-Economic Survey: Final Report, Georgetown (unpublished report).

A dual production system exists in Guyana (Bynoe, 2002). Small farms that are said to comprise more than 60% of the farms in Guyana (NDS, 2000, IFAD, 2006) are generally outfitted with traditional production technologies, that ultimately results in low volumes of output and high production costs. These farms subsist beside modern commercial farms more appropriately structured and equipped to become competitive and face the challenges of the global market place. Although mechanization is widespread in the sugar and rice industries, vegetables and fruit crops, and livestock are still mainly labour-intensive.

With respect to agro-processing, this industry is relatively underdeveloped. There is scope for significant entrepreneurial activity given the wide range of agricultural raw material that the country is capable of producing. However, the realization of this potential requires greater effort in research and development efforts and relative cheap electricity.[60]

Guyana enjoys comparative advantage in the export of other crops and livestock products, fruits and vegetables, and aquaculture (IDB, 2006). Those advantages arise from the availability of land, water, labor costs, organic production basis, and its preferential position as a potential exporter to the CARICOM. Guyana enjoys a favorable advantageous position in terms of animal and plant health status since it is free from the fruit fly and the foot-and-mouth disease. The long tradition that Guyana has had in processing seafood for exports has provided a readily available infrastructure that can easily be transferred to aquaculture. As a means to diversify its agro-exports, Guyana has already been showing progress in non-traditional agro-based exports. In 2002, Guyana exported 78 different non-traditional agricultural products. Non-traditional exports have been growing at an annual 6% rate since 1993 but they still have a low base.

[60] Singh, R., Rankine, L and Seepersad, G. (2005) *A Review of Agricultural Policies: The Case of Guyana*, *www.caricom.org/jsp/community/agribusiness_forum/agri_policy_guyana.pdf*

3. REVIEW OF GLOBAL, REGIONAL AND NATIONAL POLICY FRAMEWORK

In this section we present the global and regional policy framework along with the national strategy and policies for Guyana's agriculture sector. This is followed by specific sector related policies that may impinge on the agricultural sector and how climate change may impact on these policies. Lastly, proposals are presented to advance the policy environment to cater and adapt to the realities of climate change.

3.1. The Global Policy Framework

3.1.1 The United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) is the main global policy instrument that adumbrates an approach to address climate change. *Article 2* of the UNFCCC indicates that:

> *"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference (DAI) with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."*

The question of which impacts might constitute DAI in terms of Article 2 has only recently attracted a high level of attention globally, and the literature still remains relatively sparse (*see* Oppenheimer and Petsonk 2005; Schellnhuber et al., 2006). Interpreting Article 2 involves a scientific assessment of what impacts might be associated with different levels of greenhouse gas concentrations or climate change as well as normative evaluations by policy-makers informed by the state of scientific knowledge of which potential impacts and associated likelihoods are significant enough to constitute, individually or in combination, DAI.[61]

The references to adverse effects as significant deleterious effects in Article 1 of the UNFCCC[62] and to natural ecosystems, food production, and sustainable development in Article 2 provide guidance as to which impacts may be considered relevant to the definition of DAI (Schneider et al., 2001).

As such, interpreting Article 2 is necessarily a dynamic process because the assessment of what levels of greenhouse gas concentrations may be considered 'dangerous' would be modified based on changes in scientific knowledge, social values and political priorities.

The UNFCCC provides that all Parties must formulate and implement national programmes containing measures to facilitate adequate adaptation to climate change (*Article 4.1.b*). It lists specific domains in particular need of adaptation, namely coastal zones, water resources, agriculture, and areas affected by drought and desertification, as well as floods. Given the importance of the

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[61] Kindly refer to Schneider, S; Semenov, S; and Patwardhan, A (2007) *Assessing key vulnerabilities and risk from climate change*, Chap 19, IPCC Fourth Assessment Report.

[62] Article 1 reads, "*For the purposes of this Convention: 1. 'Adverse effects of climate change' means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.*"

agricultural sector to Guyana, this sector wishes to have an adaptation strategy designed to respond to climate change.

3.2 Regional Framework

The climate change phenomenon has emerged as a major area of concern for the Small Island and low lying coastal developing States in the Caribbean region. At the SIDS conference in Barbados in 1994, out of which emerged the Barbados Programme of Action (BPOA), climate change was identified as a major socio-economic and environmental issue. In its initial stages, the climate change debate was mainly concerned with greenhouse gas (GHG) mitigation. It was realized, however, that due to inertia in the earth's climate system, regardless of global efforts to significantly reduce GHG emissions projected changes in global climate would continue to be observed with dire consequences for SIDS and low-lying coastal States. Accordingly, the region has been involved in various initiatives to address the climate change threat, inclusive of the Global Climate Change (GCC) Project, Caribbean Planning for Adaptation to Climate Change (CPACC), Adaptation to Climate Change in the Caribbean (ACCC), and more recently Mainstreaming Adaptation to Climate Change (MACC) and Special Pilot Adaptation to Climate Change (SPACC). Under the MACC, the region is preparing a regional adaptation strategy to respond to climate change that addresses the various critical sectors across the region.

3.3 National Policy Framework

In the normal course of events, policy statements precede legislation as statutes and are essentially the legal instruments that give policy objectives legitimacy and provide the framework for implementation of policy initiatives. In Guyana, however, the situation is not quite as straightforward given that the climate change phenomenon is still relatively new, while some other related legislation in force dates back to colonial times and are directed towards achieving economic growth in a global environment, far different from that which existed when the country achieved Independence in 1966.

The foundations of current national policy were laid in 1993 when Government took the first steps towards preparing a National Development Strategy (NDS). The first draft of the NDS was later revised and eventually tabled in Parliament in August 2000. Since then policy objectives have been reiterated in other documents prepared in response to specific circumstances. Principal amongst these are the Poverty Reduction Strategy Paper (PRSP), the Millennium Development Goals (MDG), and the Competitiveness Strategy. The main features of these documents are reviewed in the following sections.

3.3.1 National Development Strategy

The National Development Strategy (NDS), tabled in Parliament in August 2000, is considered to be a compass for guiding the growth of the national economy by defining the most urgent priorities. It is also considered to be a framework for development by laying down proposals for policy

Box 1: National Development Strategy – Objectives

- *To attain the highest rates of economic growth that are possible*
- *To eliminate poverty in Guyana*
- *To achieve geographical unity*
- *To attain an equitable geographical distribution of economic activity*
- *To diversify the economy*

reforms and actions in all sectors. The objectives set for the NDS are shown in Box 1.

The NDS objectives aimed at transforming the sector to increase its productivity, output, diversification and competitiveness, and included:[63]

- Targeting investments to upgrade infrastructure in the areas of drainage, irrigation, roads and other support systems;
- Developing maintenance models and mechanisms for productive infrastructure, in particular drainage and irrigation;
- Designing and implementing systems for information generation as they relate to market intelligence and research and development;
- Increasing the relevance of agricultural training and education;
- Providing adequate support services and infrastructure to facilitate development of the sector;
- Reducing restrictions on market operations to allow for free mobility of resources and increasing domestic market access;
- Providing producers with greater control over productive resources; and
- Increasing linkages for information flows to all stakeholders in the sector to inform investment, production and marketing decisions.

While the Strategy does not directly address the climate change phenomenon, it does acknowledge that the coastal area of Guyana, lying some 0.5m to 1.0m below the mean high water mark, must be protected by defences to prevent inundation from the sea and soil deterioration due to saline intrusion. The NDS concludes that "…*without these sea defences and a proper drainage system, all coastal property would be in jeopardy.*"[64]

In its assessment of issues and constraints relating to the environment, the NDS points out that effective management of the country's natural and environmental resources are vital if they are to be utilized effectively for the development of the country. As such, it notes the need for an effective and flexible arrangement that takes cognizance of the changing global environment and emerging new challenges. Furthermore, the NDS states that "…*New policies are needed to ensure adequate funding for maintenance of the sea walls on a continuing basis. The lack of such funding in the past has led to severe deterioration of the structures, and hence the current necessity to resort to external sources of funding for major rehabilitation.*"[65]

Box 2: National Development Strategy – Sector Objectives

- *Hydrometeorological Service: to support sea defence, and drainage and irrigation activities, through the provision of services to all water-using organizations.*
- *Drainage and Irrigation: to contribute to the national goal of equitable and rapid economic growth by facilitating increased agricultural production and other economic activity on the coastland*
- *Sea Defences: to ensure that the assets, productivity and livelihood of those Guyanese who inhabit the coastal belt are protected from the ravages of the Atlantic Ocean.*

[63] Singh et al (2005).
[64] Government of Guyana, National Development Strategy (2000 – 2010), Chapter 15.
[65] Idid.

The objectives set forth in related sub-sectors that will influence the agricultural sector including the water sector are shown in Box 2.

Having established the overall objectives for the agricultural sector and water management more specifically, the NDS goes on to present a strategy for achieving these goals. These include: (i) preventive maintenance programmes of the water sector and hydrometeorology infrastructure, (ii) an effective mangrove management programme and the replacement of groynes, (iii) new and innovative sea defence structures, (iv) the instituting of a sea defence maintenance tax and improve cost recovery in the D&I areas, (v) have greater involvement of communities and stakeholders involved in the maintenance of secondary D&I structures, and (vi) strengthen the institutional infrastructure and personnel capacity building in Ministry of Agriculture (MoA) and allied institutions.

However, the lack of a costing of the strategy or its financing plan, an action and implementation plan, identified sources of financing, insufficient attention being paid to macro-economic constraints, has restricted the implementation of this strategy. Furthermore, while the document speaks to some national environmental challenges confronting Guyana, it is silent on the issue of climate change. Given that this phenomenon is possibly the most serious threat to mankind's existence, and more so to the socio-economic, cultural and even the political fabric of Guyana and the agricultural sector more specifically, it is imperative that it be given explicit recognition.

3.3.2 Poverty Reduction Strategy

In 2001, through broad consultation, the Government of Guyana (GoG) developed a Poverty Reduction Strategy Paper (PRSP) which placed sustained emphasis on policies and programmes that would markedly reduce poverty nationally[66], said to be most severe in the coastal rural and hinterland areas.[67] Ironically, most of these rural coastal areas are also major agricultural producing zones and remain vulnerable to the threat of climate change. Like the NDS, the PRSP does not speak directly to the issue of climate change, but points out some necessary objectives for the agricultural sector aimed at improving the sector's performance in a changing global environment (*see* Box 3). Worthy of note also, is the fact that the PRSP identifies four (4)

Box 3: Poverty Reduction Strategy – Objectives

***Agriculture**: to transform the sector through removing those constraints that impedes progress.*

***Sea Defence**: to reduce breaches, build local capacity to do maintenance and rehabilitation works, and increase community participation in the inspection and protection of the sea defence system.*

***Drainage and Irrigation**:*

- *To implement D&I rehabilitation master plan that was completed in 1998 which aims to bring more land under cultivation, generate quick supply responses, and benefit the poor in rural and interior locations*
- *To improve the efficiency of the D&I system through laying in Parliament a new D&I bill.*

***The Environment**:*

- *To enhance the quality of life without degrading or contaminating the environment;*
- *To ensure sustainable use of natural resources for economic growth; and*
- *To protect and conserve unique habitats, natural treasures and biodiversity.*

[66] Government of Guyana (2006) *Poverty Reduction Strategy Progress Report – 2005*, Georgetown (unpublished report).
[67] Thomas C.Y. (2000) **Poverty and the 1999 Guyana Survey Living Conditions**. Institute of Development Studies, University of Guyana. Georgetown

Regions, i.e., #1, #8, #9, and #10, where large indigenous communities exist, for special intervention to support the livelihoods of these communities. The Strategy indicates that crucial for expanding and diversifying the country's economic base would be:

Productivity increases in such sectors as sugar and rice;

- Enhancing the country's competitiveness; and
- Maintaining quality standards.

To specifically assist the agricultural sector the Strategy aimed at transforming the agriculture sector while focusing on, *inter alia*, placing greater emphasis "…*on extension services and improved drainage and irrigation services*". In particular, the PRSP noted that "…*The medium-term infrastructure strategy is to improve the maintenance, quality and coverage of sea defence, roads, and drainage and irrigation schemes. This is vital for reducing poverty and ensuring access to economic opportunities."*

To achieve the objectives the PRSP proposed that:

- Budgetary allocations should be increased to complement donor support in maintenance and rehabilitation works;
- Capacity of the industry should be improved through the training of extension officers in contextually relevant area; and
- Greater reliance should be placed on local communities to monitor potential infrastructure and protect against the destruction of the rural agricultural infrastructure.

In summary, the PRSP underscored the NDS in recognizing that adequate maintenance and protection of rural infrastructure, necessary to support the agricultural sector, are essential if the sector is to adapt to climate change and reduce poverty amongst rural coastal and hinterland communities.

3.3.3 Millennium Development Goals

Throughout the 1990s, goals and targets in key development areas were set at various international conferences and world summits. At the end of the last decade, world leaders distilled the main goals and targets into one grouping commonly referred to as Millennium Development Goals (MDGs). These goals are specific, measurable targets for the reduction of extreme poverty, improving health, education and environmental sustainability and establishing a global partnership for development. The MDGs adopted by all countries are shown in Box 4.

Box 4: Millennium Development Goals (MDGs)

Goal 1: eradicate extreme poverty and hunger
Goal 2: achieve universal primary education
Goal 3: promote gender equality and empower women
Goal 4: reduce child mortality
Goal 5: improve maternal health
Goal 6: combat HIV/AIDS, malaria and other diseases
Goal 7: ensure environmental sustainability
Goal 8: develop a global partnership for development

The main challenges to achieving the MDGs in Guyana were seen to be:

- The need to diversify the economic base;

- To improve the quality of jobs (the 1999 Living Conditions Survey showed that 83 percent of persons in the poorest quintile were gainfully employed);
- To stem the migration of the country's technical, managerial and professional personnel; and
- To accelerate the pace of reforming the economic and political structures to facilitate participatory, self-directed approaches that can result in genuine empowerment.

The strategy to overcome these challenges is to build "…*a socio-political climate that is conducive to investment and acquiring the financial resources to support the Poverty Reduction Strategy*." In other words, implementing the PRS is seen as the main route to achieving the MDGs and this link was further strengthened for the agricultural sector by repeating the PRS proposal "…*to improve the maintenance, quality and coverage of sea defences, roads and drainage and irrigation systems*" in the MDG documents.

3.3.4 The Competitiveness Strategy

The National Competitiveness Strategy (NCS), published in 2006 is the latest document that captures Government's vision for the country. It emerged out of extensive dialogue between Government and the private sector. The NCS sought to build on the NDS and the PRSP by emphasizing the need for the country and the agricultural sector to diversify their bases. The Strategy draws on the agricultural sector initiatives being pursued and seeks to direct the country in the path of sustained economic growth.

In this regard, the Strategy identifies three components to advance Guyana's development prospects in the Century. These principles are:

- Core Policies: to improve competitiveness are economy wide measures which cut across most sectors of the economy and consists of ***incentive*** (or demand side) ***policies*** including macroeconomic policy and taxation policy and s***upply side policies*** including policy measures with respect to education and training and infrastructure.
- Sector Policies: are sector strategies to address the particular obstacles and opportunities facing industries on a sector specific basis.
- Strategic Sub-Sector Polices: aim to target centers of dynamism which provide the greatest opportunities for growth and diversification, so avoiding spreading effort and resources too thinly.

All of these policy documents are of importance to the agricultural sector, not only to respond to the challenges posed by climate change, but also to explore and harness the opportunities presented. They will now need to be dissected for their relevance to the agricultural sector as government seeks to increase investment in the sector.

3.3.5 The Guyana Climate Change Adaptation Policy and Implementation Strategy

The principle piece of legislation directly addressing climate change adaptation is the *Guyana Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-lying Areas*. This Policy document completed in 2001 outlines the vulnerabilities and risks posed by rising sea level occasioned by

climatological changes to the Guyanese coastline.[68] The Guyana Climate Change Adaptation Policy is a precursor document for the development of strategies and actions to be developed and implemented to assist Guyana to adapt to climate change and also serves to address Guyana's commitments under the UNFCCC. As a result, the adaptation strategy to climate change can be seen as emerging directly out of this overarching policy document.

In responding to its commitments under the UNFCCC Guyana has sought to take incremental steps to translated this commitment into National Policy focusing on adaptation measures and mainstreaming climate change concerns. This approach is warranted, since if climate change occurs as predicted, the consequences on the agricultural sector, amongst others, can be severe. Given the fact that Guyana is particularly vulnerable to climate change and its associated impacts on the agricultural sector, while also providing some opportunities that can be harnessed, Guyana has been seeking to develop a proactive culture to respond to climate change.

The Policy indicates that in order to plan for the response to the socio-economic and environmental impacts, a prioritised set of activities must be put in place. This should include improved information management, development of a comprehensive communication strategy and public awareness campaign, formulation of plans for adaptation, the implementation of these plans, and lastly, the evaluation of the implemented plans, to measure the extent of success.

As such, in developing appropriate adaptation strategies for the sector, the following activities, amongst others, will be critical:

- The development of a comprehensive climate related database that is centralized and well managed;
- Conduct vulnerability studies that can provide precise information necessary for adaptation the sector's adaptation strategy;
- Clearly identify what actions needed to be undertaken in the short, medium and long term, who is responsible, what should be done, where an activity should be done, when these activities should be done, and how this could be implemented;
- Ensure that all Environmental Impact Assessments for the sector incorporate in them explicit and appropriate mechanisms to ensure that the impacts of climate change are integrated into the review process; and
- Work towards developing mechanisms whereby disasters can be mitigated by insurance arrangements.

As a result of the anticipated effects of climate change on the agricultural sector, it can be concluded that several legal, and policy structures will have to be implanted if Guyana will be able to adapt to these effects.

[68] While Global Climate Change will impact the entire country, the document argues that the coastal plain will have the greatest effects and hence the concentration on this area of Guyana since it is approximately six feet below sea level, is the main area for agricultural and economic activities, and is home to approximately 90% of the population, many of whom directly or indirectly depend on the agricultural sector.

3.3.6 Public Sector Investment Programme

Guyana's public sector investment is anchored in the Poverty Reduction Strategy Paper and the Public Sector Investment Programme (PSIP) 2005-2009 is broadly designed to support the PRS policy objectives and assist Guyana in meeting its MDGs. Published in 2005 and covering a five year period, the PSIP is one of the latest documents to describe government policy and to indicate government's priorities through the allocation of financial resources to key sectors. Specifically, the PSIP envisages government expenditure of G$37 billion for 2005-2009, an almost hundred percent increase over the 2000-2004 programme (*see* Box 5). This increase is, in part, due to the investments needed to rehabilitate and reconstruct essential infrastructure following the January 2005 floods that devastated the segments of the agricultural industry in Regions #3, #4, and #5.

The PSIP recognises that … "*Future expenditures for maintenance and renovations, reconstruction and enlargements of fixed assets need to be adequate to upkeep the capital base. Indeed … the Government will have to provide for a higher level of maintenance expenditures for the intricate drainage canal system, sea defences and bridges and roads that traverse the coastal belt.*"[69]

Box 5: Public Sector Investment 2004 - 2009 (G$ billion)

Year	Infrastructure
2004	5.2
2005	7.8
2006	8.7
2007	7.4
2008	7.0
2009	6.4
avg 2005/9	**7.5**

3.3.7 Summary

The five (5) documents (NDS, PRSP, MDG, NCS and PSIP) can be considered as representing government's policies and priorities. The NDS takes a long term view and presents national objectives and strategies while the PSRP takes a more focussed view on how, by ensuring a secure infrastructure, the economy can be stimulated and developed and thereby promote the reduction of poverty. The MDG presents government's priorities in a format that is universally adopted by the international community while the NCS and the PSIP present the most up to date picture of how government expresses its priorities through the allocation of available funds to different sectors.

All these documents demonstrate that government policy places a high priority on the construction, rehabilitation and maintenance of the agricultural infrastructure, recognised as being essential to the growth of the national economy and the improvement in social welfare for the majority of the population who depend on this sector. Given the urgency to adapt to climate change, it will be necessary to mainstream this latest phenomenon within existing programmes, while identifying gaps in capacity, resources, research and technology, and information to confront climate change.

[69] Government of Guyana (2005) Public Sector Investment Programme Report, Chapter 2,

4. REVIEW OF THE LEGISLATIVE FRAMEWORK

4.1 Introduction

The purpose of this section is to examine the existing legislation and their applicability to the agricultural sector, while at the same time determining their adequacy and requirements for reform if the sector is to respond effectively to the challenges posed and opportunities presented by climate change.

Clearly, adaptation to climate change for the agricultural sector impinges on a number of other allied sectors. As such, there are numerous pieces of legislation which touch and concern the efficient and effective functioning of the agricultural sector. An assessment of the policy framework governing the agricultural sector is a requirement of this consultancy and is presented below. What follows therefore, is an outline of the pertinent legislation and the adequacy of the legal framework within the agricultural sector to adapt to climate change.

4.1.1 Constitution of the Cooperative Republic of Guyana

Though Guyana is a sovereign democratic republic and governed by a written Constitution, much of the legal system in the country is English in origin and character, possibly due to the country's colonial history. Consequently, environmental laws for Guyana are to be found in the Constitution, statutes and subordinate legislation, and the Common Law (Toppin-Allahar, 1993). Apart from these domestic legal statutes, the environment in Guyana is also governed by international agreements to which the country is a signatory.

The *Constitution of the Cooperative Republic of Guyana* makes express provision in respect of the responsibilities of the State and citizens regarding the environment and management of natural resources when it states that:

> *"Every citizen has a duty to participate in activities to improve the environment and protect the health of the nation."*

(**Constitution of the Co-operative Republic of Guyana**, Chapter 2 Article 25)

Further, the Constitution states that:

> *"In the interest of the present and future generations the State will protect and make rational use of its flora and fauna, and will take all appropriate measures to conserve and improve the environment."*

(**Constitution of the Cooperative Republic of Guyana**, Chapter 2 Article 36)

It appears that the Government of Guyana endorsed the principles of sustained economic growth and the promotion of environmental protection when it published the details of its policy and actions on the environment in its National Environmental Action Plan (NEAP) 2000 - 2005. Furthermore, recognizing the challenges that climate change pose to its economy, the Government, under the CPACC Project developed the *National Climate Change Adaptation Strategy and Implementation Plan* in 2001.

4.1.2 The National Environmental Action Plan

Within the NEAP the GoG endeavours to, among other things:

- Assure all people living in the country the fundamental right to an environment, adequate for their health and well-being;
- Achieve a balance between the use and conservation of the nation's resources to meet the needs of economic development and improve standards of living;
- Conserve and use the environment and natural resources of Guyana for the benefit of both the present and future generations; and
- Ensure prior environmental assessment of proposed activities, which may significantly affect the environment; ensure that conservation is treated as an integral part in the planning and implementation of development activities.

The intention was to integrate economic, environmental and social values during planning and distribute benefits equitably across socio-economic strata and gender during implementation. This position is endorsed in the NDS, which indicates the need for environmental protection to be treated as a cross-sectoral issue in all aspects of the development process.

The major challenges to attain the objectives in the NEAP that also have implications for the agricultural sector to adapt to climate change are:

- The need for more effective land use planning nationally,
- Complete the establishment of a functional Protected Areas System,
- Modernise and implement the country's mining legislation, particularly in the hinterland area where small scale, subsistence agricultural producers are located,
- On-going institutional strengthening within the agricultural and allied institutions, such as the National Agricultural Research Institute (NARI), the Hydrometeorology Department (HD), and the Ministry of Agriculture's Extension Division,
- Greater monitoring of agricultural practices, and
- Improve maintenance of sea defences, transport networks, and drainage and irrigation infrastructure.

4.1.3 Supplementary Legislation

Other critical supplementary legislation includes:

- Environmental Protection Act (CAP 20:05)
- Drainage and Irrigation Act (May 2004)
- Sea Defences Act (CAP 64:01)
- Sea Defence Act (CAP 64:02)

4.1.3.1 Environmental Protection Act (CAP 20:05)

The Act (No 11 of 1996) was first issued in June 1996 and reprinted in 1998. It provides for the management, conservation, protection and improvement of the environment, the prevention or control of pollution, the assessment of the impact of economic development on the environment, the sustainable use of resources and for matters incidental thereto or connected therewith.

The Act provides for the establishment of several semi-autonomous bodies including the Environmental Protection Agency (EPA). The Agency is designated as a body to establish, monitor and enforce environmental regulations, co-ordinate an integrated coastal zone management programme and carry out other functions in relation with environment protection and enhancement.

The most significant section of the Act, as it relates to climate change, is the responsibility placed on the EPA to co-ordinate an integrated coastal zone management (ICZM) programme. To exercise this function, the EPA has formed an Integrated Coastal Zone Management Committee which works closely with the National Climate Unit (NCU) and has a representative on the National Climate Committee (NCC). In 2001 an Action Plan for Integrated Coastal Zone Management was produced. This Plan, which has been approved by Cabinet, addresses the need for policy development, analysis and planning, coordination, public awareness building and education, control and compliance, monitoring and measurement and information management for coastal zone management, inclusive of sea level rise associated with climate change.

Guyana was part of the CPACC project. The CPACC was a Global Environment (GEF) funded project being implemented in Caribbean countries by the Organisation of American States (OAS). CPACC supported Caribbean countries to cope with the potential adverse effects of global climate change, particularly sea level rise, in coastal areas, through vulnerability assessment, adaptation planning and capacity building. Under the CPACC initiative, Guyana was able to conduct a socio-economic assessment of sea-level rise as part of a wider vulnerability assessment and developed a Climate Change Adaptation Policy and Implementation Strategy for coastal and low-lying areas. The MACC succeeded the CPACC and have been assisting, *inter alia*, countries and the region to compile adaptation strategies to combat climate change.

The EPA considers that the Act grants them sufficient powers to exercise their functions but is aware that developers do not fully understand the need to apply to the Agency for authorization before submitting plans to other bodies for approval. Additionally, their needs to be an education building programme for potential developers/investors that will seek to indicate how their activities may either exacerbate the effects of climate change, such as flooding, or how they may be able to adapt to such change.

4.1.3.2 Drainage and Irrigation Act

The Drainage and Irrigation Act (Act 10 of 2004) replaces earlier legislation - the Drainage and Irrigation Act (CAP 64:03), initially passed in 1940 and consolidated and reprinted in 1998. The present Act provides for the establishment of the National Drainage and Irrigation Authority (NDIA) as a semi-autonomous body with the purpose of establishing an effective mechanism for the management and financing of the drainage, irrigation and flood control system to prevent its deterioration and ensure sustained use.

One of the most significant aspects of the Act is the provision contained therein that allows stakeholders to maintain the secondary water systems via Water Users Associations (WUAs).[70] This is an important development as it has not only transferred much of the management of this vital artery for the agricultural sector into the hands of communities, but more importantly, of the farmers that utilize this system. As such, any adaptation strategy must be cognizant of this fact and seek to work closer with these water 'managers'.

The Act has only recently been put into effect and the NDIA is still in the process of putting into practice the requirements of the Act.

4.1.3.3 Sea Defences Act (CAP 64:01)

This Act has its origins in the 19th century and was first promulgated in 1883 as an "*An Act to secure the Maintenance of the Sea, River, and Outer Dams of Estates*." It was re-issued in 1973, incorporating a number of amendments, and given its current title of Sea Defences Act, Chapter 64:01 in 1998 as part of a comprehensive programme to consolidate legislation.

The primary purpose of the Act is to ensure that the sea and river defences protecting estates and plantations were properly constructed and adequately maintained by the owners or proprietors. The Act empowers the government appointed Chief Officer to instruct owners to carry out any work he deems necessary. Should the owner fail to carry out the works the Minister is empowered to instruct the Hydraulics Division to carry out the works. The Act also allows the Chief Officer and Minister to carry out works to protect the foreshore of a district and to apportion the costs to the beneficiaries or to petition parliament for funds.

The Act also empowers the Minister to make regulations to protect and conserve the foreshore and prohibits cutting of trees or shrubs and the removal of shell, sand, or other material from the foreshore.

Penalties for infringements were updated in 1997 and a conviction can lead to fines of up to G$30,000 or two months imprisonment. Based on legislation now more than 120 years old, the Act is generally considered insufficient to address the current and emerging challenges, though it is currently used by the Sea and River Defence Division (SRDD) to protect the foreshore from sand removal. It has also been ineffective in preventing the removal of vegetation, including mangroves, due in large part to the failure to enforce the laws rather than the lack of powers. The Act could be improved by allowing the Minister to make regulations for setting penalties. Penalties could then be updated regularly to take account of inflation rather than having to submit the Act to Parliament for an amendment.

4.1.3.4 Sea Defence Act (CAP 64:02)

This Act was first issued in July 1933 and was consolidated and reissued in 1998 as "*An Act to Make Better Provision for the Maintenance and Construction of Sea Defences*." The act contains six parts:

[70] National Drainage and Irrigation Act (2004)

- Part I makes provision for the establishment of a Sea Defence Board which is charged with the care, maintenance, management and construction of the sea defences
- Part II allows for the creation of sea defences districts
- Part III includes provisions for the maintenance, management and construction of sea defences
- Part IV allows for parliament to provide funds for the construction and maintenance of sea defences
- Part V sets out offences and procedures for imposition of penalties
- Part VI allows the Board to make regulations with the approval of the Minister

The Act is still in use today and the Sea Defence Board meets monthly to discharge its duties. The Act empowers the SDB to prepare plans and cost estimates for the construction of new defences and to implement those plans once approved by the Minister. The Act transferred the financial burden of construction and maintenance of sea defences from estate owners to parliament with effect from 1937.

The Act defines a number of offences including obstruction of sea defences and removal of sand, shell etc. from the foreshore and sets penalties which can be imposed on offenders. The penalties are somewhat out of date, e.g. a fine of G$30,000 (or six months imprisonment) for erecting a building or G$22,500 for obstruction, but nevertheless, the act does give the Board powers to control development on the foreshore.

The Act confers considerable powers on the SDB although, similar to the Sea Defences Act (CAP 64:01), penalties are somewhat out of line with present day conditions. Nevertheless, the Act is generally sufficient for the SDB to meet its responsibilities for the care, maintenance, management and construction of the sea defences although the provisions of the Act are not always actively enforced.

This is confirmed by the fact that the Board has not yet felt the need to issue subsidiary regulations to allow it to carry out its activities.

4.1.3.5 Other Legislation

Other items of legislation which are related to or have some association with the agricultural sector and the environment are shown in Box 6. However, one other piece of legislation is worthy of note. This is the East Demerara Water Conservancy Act (55:03) that was established "…*for the purpose of making better provision for the supply of water in East Demerara*…". This facility remains essential, in the overall scheme of water management and critical for the agricultural sector, if the sector is to respond appropriately and effectively to climate change.

Related Legislation

Local Government Act (28:02)
Water & Sewerage Act (30:01)
Guyana Water Authority (55:01)
Water Commissioners Act (55:02)
Lands Department Act (59:01)
Geological Survey Act (59:02)
Guyana Lands & Surveys Commission (59:05)
Acquisition of Land for Public Purposes Act (62:05)
Guyana Forestry Commission Act (67:02)
Guyana Rice Producers Association Act (69:01)

4.1.4 Summary

The main pieces of legislation described above provide the authority for the implementation of government policy with regard to the agricultural sector relative to climate change impacts. There are undoubtedly some overlaps of responsibilities between the various Acts but this is not unusual and has been anticipated by the legal draftsmen when preparing the more recent legislation. In both the Environmental Protection Act and the Drainage & Irrigation Act the need for co-ordination, consultation and collaboration between authorities is recognised and the Sea Defence Board, Sea & River Defences Division and the Minister of Transport & Hydraulics need to be aware that they do not have powers to act unilaterally with regards to sea and river defences, necessary to protect agricultural lands.

The Integrated Coastal Zone Management Committee prepared an Action Plan in 2000 which examined existing legislation and concluded that "… *the legislative regime surrounding coastal zone management in Guyana represents a fragmented regulatory framework*…"[71]. The Action Plan proposed that the legislation be reviewed and updated to remove "…*these bottlenecks*." The review has not yet been carried out and remains urgent if climate change is to receive a central role in the various legislations with relevance for the agricultural sector.

Various reports suggest that many of the organs in the agricultural sector have experienced difficulty in carrying out their functions (IDB, 2006; Allsopp, 2004). This assessment believes that many of these constraints can be resolved through co-ordination, consultation and collaboration as envisaged in contemporary legislation. While there is need to revise some aspects of the laws to allow for climate change, arguably the most serious threat to mankind, there is no need for the Acts to be significantly updated. In almost all the Acts, there are grounds for revising the penalties for offences committed under the Acts to bring them into line with current economic values, but imposition of penalties should always be a last resort and, in most cases, disputes can be resolved through negotiation rather than enforcement.

[71] Integrated Coastal Zone Management Action Plan, EPA, December 2000

5. ASSESSMENT OF THE ADEQUACY OF LAWS TO COPE WITH THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE AGRICULTURAL SECTOR

The vulnerability[72] of Guyana to flooding in some periods and water deficit in others magnifies the need for prudent agricultural planning and an effective system of development and maintenance of drainage and irrigation canals, important in supporting the agricultural sector's adaptation efforts. Many direct and indirect impacts have been identified for the agricultural sector, linked to climate change (*see Appendix C.1*). While the results of the impacts vary in severity somewhat, they all will engage the application of the same statutes. As such the following assessment is relevant to the various impacts anticipated on the agricultural sector. The discussion below assesses the adequacy and effectiveness of existing laws that govern the agricultural sector to cope with the impacts of climate change. The discussion, supported by Appendix C.1, identifies the inadequacy in the existing law and recommends the legal responses that are required to address a particular impact.

5.1 Drainage, Irrigation and Sea Defence Laws

5.1.1 Drainage and Irrigation

The coast, which is at a level of 0.5m to 1.0 below sea level at high tide and the main area of agricultural activity, is protected from the intrusion of saline water by mangroves, dykes, sluices and concrete walls, known collectively as sea defences. With extensive drainage, irrigation and flood control network, the sea defences serve to make the coast habitable and cultivable. Without this hydraulic system, cultivation would have to be located much farther inland. Inland, such as in the Rupununi Savannahs known for its cattle ranching activities, experience seasonal flooding and El Nino like weather, affecting herds and livelihoods.

But climate change will also present a challenge for better irrigation water management. While rainfall intensity is anticipated to increase in some locations nationally, actual rainfall amounts are projected to decline (INC, 2001; Khan 2001). Managing the freshwater system that would ensure that water is available for crops year round as the country seeks to increase production, is an imperative.

Many pieces of legislation govern the management and operation of drainage and irrigation systems in Guyana, but together they do not establish a consistent body of regulations. Instead, the result is a set of complex regulations that hinder the smooth operation of the drainage and irrigation system (Mott MacDonald, 2004). Owing to the lack of adequate maintenance of the system, the impacts associated with climate change are likely to exacerbate this situation.

[72] Schneider, S et al (2007) identifies seven (7) criteria for selecting vulnerable areas that are used in this assessment. These are: (i) magnitude of impacts, (ii) timing of impacts, (iii) persistence and reversibility of impacts, (iv) likelihood (estimates of uncertainty) of impacts and vulnerabilities, and confidence in those estimates, (v) potential for adaptation, (vi) distributional aspects of impacts and vulnerabilities, and (vii) importance of the system(s) at risk.

Enacted in 2004, the Drainage & Irrigation Act established an Authority with powers to:

a) Ascertain the suitability of land as drainage and irrigation areas;
b) Regulate construction and the establishment of certain works in these areas;
c) Make regulations with respect to these areas; and
d) Include the stakeholders in the management of the secondary drainage and irrigation canals.

The Act empowers the Minister to designate drainage and irrigation areas in the context of consultations with the Authority (Section 18). The Act also provides for the modification of the designated areas and the proprietors of lands adjacent to designated areas. The institutional arrangements regarding responsibility for drainage and irrigation are also complex. There are different agencies with a role to play in Guyana's drainage and irrigation system.

There is a need for more coordination between the management of sea defences and the management of drainage and irrigation systems. This is vital because most times the two systems utilize the same drainage canals. Further, the responsibility for operating and maintaining the Boerasarie Conservancy, the Mahaica-Mahaicony-Abary Agricultural Development Authority (MMA-ADA), and East Demerara Water Conservancy is established under separate Acts. These Acts should be reconciled, with the management of the conservancies coming under a single Conservancy Board.

The *Transport & Harbours Act, 1932* established a Transport and Harbours Department for the purpose of managing Government vessels and of controlling and regulating the control of the harbours of Guyana. The removal of soil from any harbour without permission is an offence and the tools and equipment used to commit the crime are subject to seizure. But the Act does not contain provisions that address any flooding, erosion or inundation that may result from the committing of such a crime. The Act also provides that no drainage channels or canals, may be made to discharge into a harbour, nor any alterations be made to such facilities already discharging, without permission.

The mining industry in Guyana presents certain challenges to the prevention of flooding, depending on the type of mining and where the activity is conducted. Petroleum mining often produces water and air pollution, but the *Petroleum (Exploration & Production) Act, 1986* and regulations made thereunder do not consider this impact as a consideration in the grant of licenses. Bauxite mining destroys the environment in Guyana where excavation down to 100 feet below the surface is required causing frequent subsidence and erosion of fertile agricultural lands. Gold prospecting and gold mining cause several environmental problems relating to climate change and agriculture, particularly in the hinterland areas, that include the diversion of river courses, the damaging of river banks and surrounding vegetation and the destruction of animal forms in these areas. The new "dredging" machine has exacerbated the causes of soil erosion. This notwithstanding, there is no express statutory provision that addresses these concerns. Environmental clauses which are attached to the mining agreements require the operator to use "reasonable efforts" to mitigate negative impact of his/her operations on forest land quality, wildlife and human settlements.

It is apparent that the legislative framework for drainage and irrigation is not viable or comprehensive to address the likely impacts of climate change on the agricultural sector in Guyana and is in need of revision to include provisions (a) that anticipate the impacts of climate change, (b) that promote water conservation, efficient use and distribution of water, and (c) for monitoring of environmental impacts of drainage and irrigation works.

5.1.2 Sea Defences Laws

Sea Defences are a fundamental element in protecting the coastal lands and other critical areas from flooding. The frequent flooding of the coastal plain has occurred mainly because of; *inter alia*, a lack of maintenance of sea defences and sustainable management of mangroves.

The widespread lack of awareness of the value of mangroves for sustaining marine fisheries and preventing flooding and erosion of sea defences, has presented a major constraint to the conservation efforts in this sector. The Sea Defences Act prohibits the removal of earth and shells, from any lands along the foreshore within half mile of the mean high water mark but does not make express reference to this important ecosystem. Solutions for managing mangroves in a sustainable way need to be developed and implemented with the participation of the local communities who exploit the mangroves for firewood, road building and other small scale agricultural purposes. The legislative regime for the conservation of natural resources should therefore include provisions that prioritises the areas along the coast that require protection, prohibit the exploitation of mangroves, and provide for a management programme that includes the replanting and protection of mangroves.

5.1.3 Land Use Planning Laws

Land use planning plays a significantly important role in managing the impacts of climate change and the conservation of natural resources. Since the purpose for which land is developed or the use to which land is put may have adverse effects on the environment, regulation of these activities can and do have significant implications for sustainable development and in preventing or minimising the impacts of climate change in Guyana, more so, as the coast of Guyana has witnessed changing land uses over the past 20 years. This land use change has come about mainly with previous sugar cane fields being converted to housing schemes, thus increasing runoff and placing the existing drainage system under pressure. The *Town & Country Planning Act* provides the machinery for physical development planning and landuse development control. Under the Act development schemes may be prepared for cities, towns and other areas.

Such schemes may provide for preservation of areas of natural beauty, forests, and trees and plants. The Act provides for public participation in the planning process before any scheme is approved. The significance of this Act exists more in relation to the inadequacy of its provisions to establish a comprehensive development planning framework for Guyana. Generally, its limited provisions are not enforced due to the inadequacy of enforcement personnel and the prescribed penalty.

Except for Georgetown and New Amsterdam, where there are elaborate building by-laws, made under the *Municipal and District Councils Act*, no zoning by-laws or building codes exist, and applications are determined on their own merits. Under the *Public Health Ordinance* and by-laws, permission is required for the subdivision of land and the construction of buildings. Notably absent

is a requirement for environmental impact assessments to be carried out for proposed developments.

Part IV of the EP Act addresses this omission. By virtue of this enactment provisions have been introduced that require the conduct of environmental impact assessments for projects identified in the Fourth Schedule to the Act or for any other project which may significantly affect the environment. This assessment is done with a view to the need to protect and improve human health and living conditions and the need to preserve the stability of ecosystems as well as the diversity of species. The Act makes no specific reference to the consideration of potential impacts related to climate change (inundation, salinization and coastal erosion) and is deficient in this regard.

The State Lands Act and Acquisition of Land for Public Purposes Act by establishing provisions relating to the acquisition of lands and conditions governing leases contain useful provisions that make it possible for State and other lands to be brought within any management plan for preventing or mitigating the impacts associated with climate change and sea level rise. At the institutional level however proper coordinating arrangements need to be established among the agencies that administer these Acts.

The need for the rationalization of existing legislation in this area cannot be over-emphasised. There is also a need to coordinate the concurrent jurisdictions of the *Public Health, Municipal & District Councils, Town & Country and Environmental Protection Acts* to ensure efficient implementation and enforcement of the legislation taking the impacts of climate change into account.

6. CONCLUSION AND RECOMMENDATIONS TO IMPROVE THE LEGISLATIVE FRAMEWORK TO ASSIST THE AGRICULTURAL SECTOR TO ADAPT TO THE IMPACTS OF CLIMATE CHANGE

The assessment of the existing laws governing the agricultural sector contained above indicate that while generally, statutory powers are established in existing legislation to respond to the potential or likely effects of climate change, there are some gaps and weaknesses that need to be addressed in order to make them more responsive to the impacts of climate change on the agricultural sector.

Some of the legislation is generally too outdated to offer any significant influence. This is reflected vividly in the inadequacy of fines and penalties legislation, the lack of coordination among agencies, inadequate institutional arrangements, the absence of modern day principles such as the precautionary principle and reliance upon alternative enforcement and compliance methods. More importantly, the legislative process has not kept pace by passing the required implementing legislation. And in the isolated circumstances where regulations were made, they have become rigid and inflexible and their application to the issues presented by sea level rise and climate change is generally inadequate. The major gaps and weaknesses are identified as follows:

- Absence of guidelines and standards to prevent inundation as it pertains to development activities including mining, forestry and agriculture;
- Absence of finalised emergency preparedness plan and a legal and institutional framework for disaster management;
- Drainage and irrigation and legislation pertaining to navigation and the protection of water resources should be strengthened to include provisions that have the potential to cause pollution, salinization and flooding; and
- Harmonisation of legislation to avoid overlap and duplication of the functions is lacking throughout the legislative instruments that impact on climate change.

6.1 Recommendations

The assessment of the legislation in the light of these impacts identified the need to strengthen the legislative framework to address the impacts of climate change in Guyana. The following is proposed in this regard:

a) Primarily because the impacts of climate change are cross-cutting in nature, the preparation of comprehensive climate change legislation might not be an obvious priority for Guyana. Given Guyana's early stage of economic development and its difficulty in implementing extensive legislation which are already in place, a comprehensive review of the relevant legislation to fill the existing gaps for effective monitoring, implementation and enforcement is recommended. Priority should be given to the *Town & Country Planning Act, Environmental Protection Act, State Lands Act, and the Sea Defences Act* as the principal legislative instruments to provide adequate preventative responses to climate change. Provision should therefore be established for regulating marine and sand mining, the development of coastal protection works, the establishment of a regime of port management, establishment of a regime for the protection of special areas including wetlands and mangrove protection and with particular reference to administration of lands, and the establishment of procedures and safeguards for effects of the legislation on private property interests in the coastal areas.

b) Conservation-oriented legislation should also be reviewed to ensure consistency with the national climate change policy.
c) Enforcement of national legislation is generally weak in Guyana. In addition the existing fines and penalties are extremely low and do not serve as a deterrent to the commission of offences. Any legislative review should establish adequate fines and penalties.
d) Limited zoning by-laws or building codes exist in Guyana and generally building applications are determined on their own merits. Construction and design standards should be developed for agricultural infrastructure.
e) The existing EP Act should be amended to expressly include provision for the consideration of climate change impacts as among the considerations that should be taken into account in the preparation of EIA's for agricultural based projects.
f) Public awareness programmes should be developed to educate farmers in particular with regard to their role in preventing or mitigating the impacts of climate change e.g. land-clearing, erosion, emissions as a means to promoting compliance with the legislative regime for climate change; and how they can adapt to such changes. For example, via proper application of agro-chemicals and the adoption of good agricultural practices.
g) Efforts should be taken to ensure that the banking and insurance industry taken account of the effects of climate change in the delivery of their services.

Bibliography

Bynoe, M. (2002) Guyana Market Survey, Guyana Economic Opportunities Programme, Technical Report #72, Georgetown.

Bynoe, M., and Thomas, C.Y., (2008) Do Trade Reforms Help or Hurt: The Guyana Experience, in the Journal of Social and Economic Studies (forthcoming).

Daniel Julien J. An Assessment of the Adequacy of the Legal Framework to Cope with the Potential Effects of Sea Level Rise in Guyana (CPACC).

Environmental Protection Agency (2001) Integrated Coastal Zone Management Action Plan, Turkeyen.

Environmental Protection Agency (2002) Guyana's National Vulnerability to Sea Level Rise, Environmental Protection Agency, Turkeyen.

Government of Guyana (2000), National Development Strategy (2000 – 2010).

Government of Guyana (2006) *Poverty Reduction Strategy Progress Report – 2005*, Georgetown (unpublished report).

Institute of Development Studies/School of Earth and Environmental Sciences (2008) Socio-Economic Survey: Final Report, Georgetown (unpublished report).

Inter-American Development Bank (2006) Agricultural Export Diversification Programme Loan Proposal, ://www.iadb.org/projects/project.cfm?id=GY-L1007&lang=

Khan, M (2001) National Climate Change Adaptation Policy and Implementation Plan for Guyana, EPA, Turkeyen.

Ministry of Agriculture (2002) Guyana Initial National Communication, Georgetown.

Ministry of Agriculture (2007) Conservancy Adaptation Plan, Ministry of Agriculture, Georgetown (unpublished report).

Ministry of Public Works and Communications (undated) Sea Level Rise and Its Implications for Guyana, Ministry of Public Works and Communications, Georgetown (unpublished report).

Oppenheimer, M., 2005: Defining dangerous anthropogenic interference: the role of science, the limits of science. *Risk Anal.*, **25**, 1399-1407.

Schellnhuber, H.-J., W. Cramer, N. Nakićenović, T. Wigley and G. Yohe, Eds.,2006: *Avoiding Dangerous Climate Change*. Cambridge University Press, Cambridge, pp392.

Schneider, S.H. and C.Azar, 2001:Are uncertainties in climate and energy systems a justification for stronger near-termmitigation policies? *Proc. Pew CenterWorkshop on the Timing of Climate Change Policies*, E. Erlich, Eds., Pew Center on Climate Change,Arlington, Virginia, 85-136.

Schneider, S; Semenov, S; and Patwardhan, A (2007) *Assessing key vulnerabilities and risk from climate change*, Chap 19, IPCC Fourth Assessment Report.

Singh, R., Rankine, L and Seepersad, G. (2005) *A Review of Agricultural Policies: The Case of Guyana*, *.caricom.org/jsp/community/agribusiness_forum/agri_policy_guyana.*

Thomas C.Y. (2000) Poverty and the 1999 Guyana Survey Living Conditions. Institute of Development Studies, University of Guyana. Georgetown.

Thomas, C.Y., and Bynoe, M (2006) Trade Reforms and Food Security: A Synthesis – The Guyana Case in "Trade Reforms and Food Security: Country Case Studies and Synthesis" FAO Publication, *ISBN 9251055335*.

Appendix C.1: Projected Impact of Climate Change on the Agricultural Sector in Guyana

Sector	Climate Element	Likely Impact	Possible Intervention Options
Agriculture	**Less Rain/Drought**	Crop Failure	• Increase irrigation capacity. • Crop failure insurance. • Drought resistance varieties
		Lower Yields	
		Food Scarcity	• Government food relief. • Stockpiling and processing of food.
		Increased plant disease	• Develop diseases resistance plants. • Integrated pest management. • Develop good farming practices • Building aware amongst farmers about the diseases and adaptive techniques
		Heat Stroke on livestock	• Increase water supply through better water management • Re-design livestock practices, i.e., more environmentally friendly pens and holding areas
		Increase Irrigation Cost	• Provide a waylay payment system for the service • Increase water management regimes • Use stakeholders to assist with the management of the system
		Affects Land Preparation	• Improve management practices • Ensure farmers are paid promptly.
	Increase Rain/Flooding	Crops may grow quicker, but with less nutritional value	• Provision of vitamin supplements, or alternate supplies. • The use of compost and/or fertilizers. • Develop newer varieties. • Develop alternative agricultural lands.
		Affect land preparation	• Improve predictive and response capacity amongst the HD and the farmers • Seek to work with farmers to diversify their productive base to reduce their risks.
		Increase drainage preparation	• Better drainage planning, i.e., maintaining drainage system • Use communities and stakeholder to be custodians of the drainage system.
		Increase transport cost	
		Getting to and from the fields will become a major challenge	• Maintain secondary drainage system so they can be used as transportation access points

Sector	Climate Element	Likely Impact	Possible Intervention Options
			• For specific commodities like paddy, encourage more bulk loading for a faster turn around time when harvesting
	Change in season (e.g. El Nino)	Predicted farming practices will be changed	• Research for faster growing variety to catch favourable or avoid unfavourable season.
		Management of agricultural practices will change	• Improve predictive and response capacity of the HD
	Increase in Temperature	Increase water demand for livestock	• Water response management • Engage in more intensive commercial livestock farming
		Increase irrigation cost	
		Salt water intrusion	• Improve coastal protection works • Develop salt tolerant varieties • Involve communities in the management of mangrove forests • Implement the ICZM Plan
		Loss of agricultural lands from salt-water flooding	• Improved land planning regimes. • Identify alternative agricultural lands and commence developing these
		Loss of agricultural lands from relative erosion	• Improve coastal protection works • Improve mangrove management • Diversify the agricultural base
		Increase rain	• Where possible, re-design drainage system • Use stakeholders to assist with the maintenance of the system • Have an active preventive maintenance programme for the agricultural water management infrastructure
		Increase erosion	• Reforest the fringes of fields • Encourage more agro-forestry
		Loss of productivity of land from salinization and erosion	• Develop a comprehensive soil management plan
	Change in Seasonal Temperature	Longer summer seasons	
		Longer winters seasons	
		Pests and diseases will arrive and/or leave earlier	• Integrated Pest Management • Crop rotation
	Increased Ultra Violet Penetration	Affects livestock	• Protection devices Provision for shade In Pastures
		Affects agricultural crops	
		Eye cataracts	• Improve education for farm

Sector	Climate Element	Likely Impact	Possible Intervention Options
			workers.
		Skin cancer	• Improve education for farm workers.
Coastal Resources	**Less Rain/Drought**	The Coastal areas support a variety of important economic activities, including fisheries and aquaculture, recreation, industry, and transportation. That will be affected.	• Integration of policies and programs across and among sectors of the economy—e.g., economic development, transportation, recreation, and agriculture.
		Coastal wetlands are also vulnerable to changes in the source or decreased flux of fresh water and sediment, if upstream areas become more arid	• Water Management
		Decreasing freshwater flow, when combined with rising sea level could result in the encroachment of saltwater species into typically freshwater habitats. For example, in rivers, decreased freshwater inflow could result in increased salinity and, in turn, a replacement of some freshwater species by saltwater species.	• Diversifications of Agriculture. e.g., mariculture.
	Increased Rain/ Flooding	Coastal waters may not "fishable or swimmable," primarily because of nutrients and bacteria from urban and agricultural runoff and municipal wastewater	• Raising the elevation of new facilities such as sewage treatment plants to protect the integrity of the facility's use.
		Coastal resources, such as mangroves and seagrass beds, submerged systems including submerged aquatic vegetation, and mudflats, are at risk by anthropogenic factors	

Sector	Climate Element	Likely Impact	Possible Intervention Options
		Changes in these ecosystems could have major negative effects on freshwater supplies, fisheries, and biodiversity that could make coastal impacts an important economic concern.	• Taking accelerated sea-level rise into account when filling wetlands for water-dependent facilities (ports) – which requires an applicant to raise the fill level so facilities will not have to be abandoned during their year life expectancy.
			• Integration among the disciplines of coastal management, including ecology, economics, engineering, and political science.
		Coastal land, including buildings, transportation infrastructure, and recreational and agricultural areas, is vulnerable to inundation and increased erosion	• Building standards upgraded to suit all climatic conditions.
	Increase in Temperature	Climate change may significantly affect coastal biological diversity. It could cause changes in the population sizes and distributions of species, alter the species composition and geographical extent of habitats and ecosystems, and increase the rate of species extinction	• Research and development for options.
Water Resources	Less Rain/Drought	Shortage of water	• Improved water resource management for domestic storage, and water conservancies
		Increased salinity in underground water	• Leakage detection Inventories and rationalize underground water supplies (water conservancies and protection of catchments areas)
		Increase demand for water	• Regulation of water tariffs (prices).
		More strain on water infrastructure	
		Water infrastructure damage	• Improve engineering designs.
	Increased Rain/Flooding	Burst dams	• Improve engineering designs
		Water covered areas will be affected by increased	• Increase agricultural practices to decrease sedimentation. • build traps in rivers to catch

Sector	Climate Element	Likely Impact	Possible Intervention Options
		sedimentation and pesticides residue.	sediments. • dredging of rivers.
	Change in season (e.g. El Nino)	Less predictive capacity for water demand	• Improved water management by water utilities
	Increase in Temperature	Increase evaporation Small but deeper reservoirs.	• Trees to shade water. • Water lilies.
		Greater demand for water	
		Greater pumping cost	• Innovative approaches to rationalise water demand.

Source: Modified and enhanced from the Guyana Climate Change Adaptation Policy and Implementation Strategy for Guyana (2001)

APPENDIX D: INSTITUTIONAL ASSESSMENT

1. INTRODUCTION

The goal of this assessment is to comprehensively analyze the capacity of stakeholder institutions in the agriculture sector to implement, with much efficacy, an adaptation to climate change strategy for the agriculture sector.

The scope of the assessment is oriented towards climate change adaptation following acknowledgement that climatic changes have already been unapologetically unleashed, with significant economic implications for productive sectors that are not prepared to cope with the changes. The assessment is guided by the United Nations Development Programme's (UNDP) guide for Capacity Assessment and Development which demarcates four areas of focus for a capacity assessment namely the; (1) current situation (where we are now); (2) vision/mission (where we want to be); (3) strategy/options (how to get there) and; (4) sustainability (how to stay there).[73] It is also guided by the FAO definition of adaptation that informed the 2008 expert consultation on climate change adaptation and mitigation in the food and agriculture sector, which posits that adaptation refers to *"adjustments in human or natural systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."*[74]

An overview of the institutional arrangement in place to manage the agriculture sector's response to climate change is first provided by examining the organizational background of lead agencies with a role in addressing climate change issues. These institutions include the MoA (HD, NCU, MMA-ADA and NARI); Environmental Protection Agency (EPA); Guyana Energy Authority (GEA) and the MPW&C- SRDD.

Given the implications of existing resources for institutional adjustments to incorporate a strategy for climate change adaptation, the current condition of resources are assessed to ascertain whether these can support effective implementation of mechanisms to improve the resilience of the agriculture sector to the projected impacts of climate change. The assessment seeks, essentially, to answer the question of: what capacities exist within institutions to facilitate effective implementation of a climate change adaptation strategy for the agriculture sector?

Further, the adaptive capacity of institutions are analyzed by delineating their strengths and weaknesses at the institutional level and assessing opportunities or threats that climate change may pose to institutional capacity building. The assessment divulges that, generally, the current resource endowments within institutions are unable to provide adequate support to reduce the economic risks to the agriculture sector that may be posed by climate change. Limited financial resources are both the underlying cause of capacity constraints within institutions and the main capacity constraint that will hinder effective adaptation to climate change.

Based on expert judgement, the assessment determines what capacity is needed for effective implementation of an adaptation strategy and what institutional changes; government and external

[73] INC Report (2002)
[74] FAO (2008b)

assistance are needed to build and sustain the requisite capacity at a threshold where institutional and operational efficiencies are maximized.

1.1 Objectives

1.1.1 General Objective

The overall objective of the assessment is to execute a comprehensive evaluation of the capacity of agriculture and related institutions to support implementation of mechanisms for climate change adaptation within the agriculture sector.

1.1.2 Specific Objectives

The Specific objectives of the assessment are:

- To examine the institutional arrangement in place to address climate change issues in the agriculture sector by analyzing the mandate and governance structures of major institutions involved in climate change issues;
- To identify the existing financial, human, data management and technical resources within institutions and assess the capacity of these resources for effective execution of the institutions' mandates and to support climate change adaptation;
- To identify the current work of agencies that are geared towards enhancing the agriculture sector's ability to cope with the impacts of climate change;
- To determine the existence, level and efficacy of inter-agency collaboration and coordination on climate change related issues as it relates to the agriculture sector;
- To analyze the existing institutional strengths and weaknesses of agencies that may affect the implementation of a strategy for climate change adaptation in the agriculture sector;
- To ascertain the need for institutional strengthening, highlighting those areas in more severe need of strengthening to facilitate effective implementation of a climate change adaptation strategy for the agriculture sector; and
- To ascertain what assistance may be required to enhance institutional capacity to effectively adapt mechanisms to cope with the impacts of climate change.

1.2 Methodology

The institutional assessment was constructed on a plurality of methodologies that were qualitative in nature. These included:

- Client interview- Key policy makers in the MoA, including the Minister of Agriculture, the Chair of the Climate Committee and the Coordinator of the NCU were interviewed in the planning phase of the project to determine their objective and expectations of the output of the project and to ascertain what type of logistical support and literature could be provided to assist in the compilation of the assessment. The interview with these stakeholders was also focused on discussing the terms of reference and amending it accordingly.

  - MACC/ CCCCC interview- In a meeting separate and distinct from that with the Minister, the Coordinators of the NCU and the MACC project were interviewed to

determine, with much certainty, the context of the study in the National Country Strategy, their expectations as to the deliverables and their proposed level of involvement in the study. Within the backdrop of this meeting, the project's work plan was presented to the Coordinator of the NCU.

- Collection and study of reports and relevant documents- The consultant collected and studied existing capacity assessment studies that focus on sectoral and country capacity to respond to the impacts of climate change. These documents were consulted to glean other relevant background and supporting information that could have easily lent to the institutional assessment. Key documents reviewed include:

  1. The draft "Vulnerability and Capacity Assessment: Impacts of Climate Change on Guyana's Agriculture Sector" (2007) study prepared by the Guyana Sugar Corporation (GUYSUCO);
  2. "Guyana's First National Communication" (INC 2002) report prepared in response to its commitments under the United Nations Framework Convention on Climate Change (UNFCCC);
  3. "Guyana's Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low- lying areas" (2002) report prepared by the National Climate Committee (NCC) and
  4. "The National Capacity Self Assessment" (NCSA) Project Report (2006) that focused on stock-taking and thematic assessment of current work by the Government of Guyana to comply with its obligations under the UNFCCC.

The assessment was particularly oriented towards extracting key capacity issues presented in these reports in order to fully diagnose the capacity of the sector to adapt to the impacts of climate change. Further, it sought to update and augment the findings of the pilot vulnerability and capacity assessment study currently being undertaken.

- Stakeholder consultations/survey analysis- in order to undergo a gap identification of the findings of the VCA, interviews was conducted with stakeholders in the agriculture sector to determine current institutional capacity. The consultant first determined those institutions to be involved in the assessment and those to be visited. Interviews were conducted with the heads of the selected institutions over a two week period; July 14 - 28, 2008 and involved a total of 24 agencies (see *Appendix D.1*) Based on these interviews, data presented in the VCA was updated and augmented for the purpose of this current assessment. A questionnaire instrument was designed for the interview process (see *Appendix D.2*) and was crafted to capture, from the heads of agencies, information on the following main areas of focus of the assessment:

  1. *Background information on the agencies*- This section of the questionnaire sought to glean information on the institutional/organizational arrangements governing the agriculture sector that is of relevance to climate change adaptation. Information was also compiled on those non-agriculture institutions involved in climate change, as the operations of these agencies will have a bearing on the agriculture sector. To this end, the section was designed to gather information on the legal status, establishing

act, mandate and decision making structure of major institutions involved in climate change issues.

2. *Legislative/ policy capacity to enact regulations pertinent to climate change*-The aim of this aspect of the questionnaire was to determine whether the establishing acts of the institutions made any specific provision for the agency to address climate change related issues or whether the issue is even narrowly catered for in the institution's mandate.

3. *Human and technical capacity*- This aspect of the assessment was concerned with identifying the current human and technical resources within agencies. Specifically, the section was focused on ascertaining the quantity and quality of professional staff within the institutions; level of training in climate change, if any, and awareness of the issue and its impending impacts on the agriculture sector.

4. *Information management systems*- This section was concerned with ascertaining what types of systems are used within agencies to manage information; the effectiveness of these systems and the capacity of staff to handle the systems.

5. *Financial capacity*- The financial capacity assessment aspect of the survey analysis had a three-tiered objective in that it sought to first assess the adequacy of current financial resources to allow the institutions to effectively carry out their mandate and to establish mechanisms that will abet adaptation to the impacts of climate change; determine the additional resources required by the agencies to facilitate mechanisms designed to assist in climate change adaptation; and ascertain agency limitations to the acquisition of additional resources.

6. *The level of inter- agency linkages*- This aspect of the interview focused on determining the existence of linkages between agriculture institutions and other institutions, whether at the international, regional, national or local level for the purpose of climate change adaptation, the effectiveness of these linkages and the need for improvement.

7. *Institutional strengths/ weaknesses* in climate change adaptation- This section of the instrument sought to verify those areas of the institution that may either lend to or hinder the effective implementation of a strategy for the agriculture sector to cope with the impacts of climate change.

8. *Opportunities/threats* that climate change may pose to the institution- Opportunities/threats section of the questionnaire sought to determine what gains or losses may be associated with climate change for the institution. The Consulting team is convinced that climate change will provide both opportunities and threats to Guyana's agricultural sector and that these need to be properly articulated and recognized.

Interviews formed the main methodological approach of the assessment because of its time efficiency; its advantage of allowing for on-the-spot clarification unlike other methodologies and the

possibility of probing for more precise answers when vague responses are given. Interviews were also chosen to give validity to secondary information.

- Strengths, weaknesses, opportunities, threats (SWOT) analysis - The consultants undertook a SWOT analysis of agencies to determine the main capacity weaknesses that will negate effective implementation of an adaptation strategy for the agriculture sector. Further, the strengths of institutions to support implementation were also identified as existing strengths would require capacity expansion rather than the development of new capacities. Opportunities and threats were sifted out both endogenous and exogenous to institutional strengthening (see *Appendix D.3*)

1.3 Constraints

The analysis of the institutional capacity of the agriculture sector to implement a strategy for climate change adaptation originally intended not to narrowly analyze the institutional capacity of agriculture institutions but to broaden the focus to those institutions in other sectors that address crosscutting issues, including private sector interests. Therefore, the assessment intended to incorporate such institutions as the Private Sector Commission (PSC); Guyana Shippers Association (GSA) which by virtue of their mandate will affect the agriculture sector. However, time constraints hindered the specialist from consulting with all these agencies.

Additionally, the team was unable to consult with Neighbourhood Democratic Councils (NDC). Nevertheless, secondary data was examined to assess the institutional capacity of these institutions but such sources did not provide ample data to contribute to the analysis. It is necessary that the adaptive capacities of these institutions are assessed since ultimately whatever strategy is designed for implementation at the sectoral level must be implemented at the local level.

Some agencies did not enthusiastically respond to the data request of the team, even with assured written validity of the study from the MoA and the NCU. At the extreme, some agencies avoided, altogether, communication when follow up was made to access information. The assessment is therefore data- starved for important agencies such as the HD and Institute of Applied Science and Technology due to the lack of full fledged cooperation.

2. MAJOR INSTITUTIONS INVOLVED IN CLIMATE CHANGE ISSUES

This section of the assessment examines the institutional arrangement in place to address climate change issues in relation to the agriculture sector by assessing those major institutions involved in climate change issues. The agencies considered are: the MoA; the EPA; the MPW&C-SRDD and other agencies such as the Guyana Water Incorporated (GWI). The section gives an organizational overview of these agencies and inspects their on-going and planned interventions to address climate change adaptation.

2.1 Ministry of Agriculture

The MoA is the main coordinating body for the agriculture sector. It is headed by the Minister and his administrative assistant - the Permanent Secretary. The institution has several agencies/ technical units, each with a different area of focus on the sector and a separate but similar governance arrangement. This assessment analyzed 14 of the institutions under the umbrella of the MoA; nine (9) semi-autonomous bodies and six (6) technical divisions (see *Appendix D.4*).

The semi-autonomous agencies have been established by Acts of parliament that specify their governance arrangement, that is, their mandate, objectives and organizational structure (See Appendix 2.1). Such agencies are controlled by a board of directors and managed by a government appointed head that fall under the directorate of the Minister and his Permanent Secretary.

For instance, the MMA-ADA was established under the MMA Act, Chapter 69:11 of the Laws of Guyana. The main function of the Authority, as provided for in Article 4, is to support agricultural development in the MMA area by supporting the development and maintenance of infrastructures.[75] The Act further provides for the agency to be managed by a General Manager and Heads of Departments as appointed by the Minister (Article 5.1).

Technical units/ divisions are governed by public service rules and are also directly answerable to the Permanent Secretary and Minister.

Given their specified objectives under the relevant establishing act, agencies operate with several units/departments charged with the responsibility of executing specified objectives stipulated in the act with, with there being a crosscutting of some objectives across units.

For example, the MMA-ADA Act provides for the agency to have 8 units (article 5.1), that include;

i. Engineering Services
ii. Agricultural Development
iii. Lands and Surveys
iv. Finance
v. Administration
vi. Planning and Programming
vii. Operations Evaluation

[75] Mahaica- Mahaicony Abary- Agricultural Development Authority Act, Chapter 69:11 of the Laws of Guyana. http://www.geocities.com/mmaada2001/.

viii. Internal Auditor[76]

Several agencies/technical divisions within the MoA and other entities outside the Ministry have key roles in addressing climate change issues. These include: the HD; the MMA-ADA; NARI; NDIA and; the UG-FAF and UG-SEES[77] (VCA 2007). The VCA (2007) posits that these entities have direct roles in climate change by virtue of their involvement in the following areas in the agriculture sector:

- *Educating farmers and exploring new farming practices to cope with flooding*
- *Maintaining rivers and strengthening of sea defences*
- *Environmental safety practices and inland agricultural development*
- *Maintaining water control systems to prevent and mitigate flooding*
- *Courses and research projects to raise awareness and respond to climate change*

The MMA-ADA and NDIA are the key agencies involved in maintaining water control systems. Both agencies have a mandate that requires the maintenance and rehabilitation of drainage and irrigation (D&I) infrastructures. The MMA water control project was created to facilitate the development of approximately 18,219 hectares of agricultural land (in Phase 1-Mahaica Mahaicony) by monitoring and maintaining water resources within the geographical confines of the area (Farmer 2008).

The HD is one of the agencies most actively involved in climatalogical issues in the agriculture sector,. It is the lead agency addressing climate change issues. The institution is involved in monitoring the climate system by undertaking research in the hydrological, oceanographic and meteorological sciences. Further, it is responsible for providing information on weather patterns and water resources to the agriculture and other productive sectors of the economy. In fact, the creation of this agency by a Council of Ministers Decision on October 5, 1965 was aimed at having a centralized agency[78] that would be responsible for collecting and disseminating weather and water information to all the productive sectors of the economy (NCSA Study 2007).

Over the years the agency's mandate has been expanded to incorporate climate change. Five additional tasks have been added to the agency's list of activities, one of which directly relates to addressing climate change. The NCSA Study (2007) identified the following tasks as additional tasks the HD is required to undertake:

i. *Executing various programmes related to the Water Policy which was approved by Parliament;*
ii. *Conducting various programmes set by the World Meteorological Organization;*
iii. *Administering the Montreal Protocol in Guyana;*
iv. *Executing Climate Change Programmes in Guyana; and*
v. *Making short- and long-range forecasts for users in and out of Guyana.*

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[76] Ibid

[77] The Faculties of Agriculture and Forestry and School of Earth and Environmental Science of the University of Guyana

[78] Meteorological issues were addressed in a fragmented manner in the years preceding 1965. Meteorological and hydrological units existed within each sector; bauxite, rice, sugar and other sectors that required weather and water information (NCSA 2007).

The addition of the fourth task to the agency's list of activities has resulted in the division becoming more actively involved in climate change issues, particularly with regards to compiling and tracing predictions for changing weather patterns. The agency is also Guyana's focal point to the UNFCCC and the Clean Development Mechanism (CDM) of the Kyoto Protocol and has associations with the IPCC. It also chairs the NCC (NCSA, 2007).

2.1.1 Interventions for Climate Change

Climate change adaptation is one aspect of the Ministry's two-tiered strategy for addressing climate change, which also examines mitigation. To this end, the Ministry has undertaken interventions related to policy changes and infrastructure improvement and other tangible changes to increase environmental resilience to climate change.[79] The interventions are categorically linked to the type of interventions undertaken at the national level, which the 2007 VCA classified as hardware and software interventions. Hardware interventions pertain to infrastructural improvements whereas software interventions pertain to policy documents and reforms to influence the policy framework that currently obtains. These policy documents and reforms will unequivocally affect the agriculture sector and include:

1. The National Environmental Action Plan (NEAP 2000) - NEAP lays out the environmental strategy for Guyana between 2000 and 2005. However, it is outdated and therefore cannot effect policy changes to address climate change adaptation.

2. The Integrated Coastal Zone Management Action Plan (ICZMP 2000) - The ICZMAP is outdated. It gave due cognisance to the issue of sea level rise and climate change and the importance of efficiently managing the coastal zone. It was created to resolve the fragmented nature of coastal zone management.

3. The National Mangrove Management Action Plan (NMMAP) - The NMMAP focuses on promoting the conservation, sustainable use, and where practicable, restoration of the mangrove resource. It is still relevant to addressing climate change as it would, once implemented, ensure that natural sea defences play an increased role in preventing coastal erosion.

4. Initial Communication to the Conference of the Parties of the UNFCCC (INC 2002)[80]- Guyana prepared its Initial National Communication (2002) and Action Plan in response to its communication under the UNFCCC to address mitigation and adaptation measures for human- induced climate change.

5. The National Climate Change Action Plan (NCCAP 2001) - NCCAP was prepared to supplement the INC. It addresses the weaknesses highlighted by the INC. The document presents actions necessary to adapt to and mitigate climate change and to respond to the effects of global warming. Both the INC and NCCAP are still relevant to influencing the

[79] Ministry of Agriculture-Guyana. Response to Oral Question on Climate Change by Hon. Robert M. Persaud, MBA, MP Minister of Agriculture. http://www.agriculture.gov.gy/Parliament/RESPONSE%20TO%20ORAL%20QUESTION%20ON%20CLIMATE%20CHANGE.htm, (Accessed: August 3, 2008)
[80] NCSA (2007).

policy framework to address climate change.

6. National Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low- lying Areas (2002) - This document addressed the capacity needs to implement an adaptation policy to climate change for coastal and low-lying areas. The document identified several sectors and the human, financial, training and equipment needs of Guyana for the implementation of the adaptation policy.

7. The recently concluded National Capacity Self Assessment Project (2007) - The objective of the NCSAP was to identify and characterize critical capacity constraints relevant to effective environmental management in Guyana and to formulate a plan of action to address these constraints. The assessment is relevant to identifying the capacity constraints within the agriculture sector to adapt to climate change since what obtains nationally has a significant domino effect on the varying sectors.

8. The pilot "Vulnerability and Capacity Assessment: Impacts of Climate Change on Guyana's Agriculture Sector" (VCA-ongoing)- The VCA, which is currently being coordinated by GUYSUCO, is an initiative of the MACC and is executed by the CCCCC, which is currently implementing pilot VCAs in the water, agriculture and tourism sectors in selected CARICOM countries. The assessment is being done for the agriculture sector in Guyana given its socio-economic importance to the country.

9. The Second National Communication (SNC) to the UNFCCC - Guyana is in the process of preparing its SNC to the UNFCCC. The agreement for the enabling activities for the preparation of the SNC was signed on July 10, 2007 between the MoA/NCU and the UNDP. The project is scheduled to be completed by 2010 and is supported by a US$455,000.00 budget. The Project focuses on strengthening the institutional and technical capacity of Guyana to meet its UNFCCC obligations. Some areas of focus of the project include:

    a. Assessing and documenting the national circumstances of the country.
    b. Undertaking an inventory of greenhouse gases from base year 2000 and,
    c. Identify constraints and gaps; related to financial, technical and capacity needs.[81]

Implementation of the project began in April 2008 with the establishment of a project unit and project steering committee to guide implementation of the national communication. A terms of reference and advertisement has also been developed to recruit a Public Education, Information and Capacity Building Expert and a Public Awareness Coordinator to execute the public education and awareness aspect of the assessment.

[81] Enabling activities for the preparation of Guyana's second national communication project (*overview)*

A. Policy Interventions

The main policy initiative is the reorganization and reactivation of the 1995 established National Climate Committee (NCC) in March of 2007. The NCC is comprised of a wide cross-section of stakeholders. The committee has three sub-committees; energy; land use and climate change and was established to be ***the core technical body coordinating Guyana's response to climate change*** (VCA, 2007).

The NCC is tasked with the responsibility of examining national conditions relating to climate change and making recommendations to the Adviser to the President on Science, Technology, Energy and Environment and relevant Ministries on appropriate national measures to address the conditions; advising on developments and the policy and regulatory needs to govern activities addressing climate change; promoting cooperation among agencies dealing with climate change in areas related to technical, scientific, technological and financial resource; monitoring the implementation of national policies, programmes and action plans related to climate change and making recommendations for appropriate changes and revisions to other functions of the NCC (VCA, 2007).

The agencies that comprise this multi-stakeholder committee include:

1. Environmental Protection Agency
2. Hydrometeorological Division
3. Institute of Applied Science and Technology
4. Guyana Forestry Commission
5. Guyana Manufacturers Association
6. Private Sector Commission
7. Guyana Energy Agency
8. Ministry of Housing & Water
9. Ministry of Agriculture
10. Ministry of Foreign Affairs
11. Office of the President
12. Guyana National Bureau of Standards
13. Civil Defence Commission
14. Forest Producers Association
15. Lands and Surveys Commission
16. Guyana Sugar Corporation
17. Iwokrama International Rainforest Programme
18. Ministry of Local Government
19. Ministry of Public Works and Communication
20. National Climate Unit
21. National Agriculture Research Institute
22. National Dairy and Irrigation Authority
23. School of Earth and Environmental Science, University of Guyana
24. Conservation International

Its "*activities are brought to the attention of the Prime Minister via the Natural Resources and Environment Advisory Committee (NREAC) which includes all environment, energy and mining agencies.*" (NCSA, 2007; INC, 2002).

Concurrent with the reactivation of the NCC was the establishment of the NCU, also in 2007, within the HD and the establishment of 35 monitoring stations to build capacity to meet the obligations of the Kyoto Protocol and the Bali Road Map (Farmer, 2008). The NCU was created to provide support to the NCC and to act as the focal point to the UNFCCC. The establishment of this agency is essentially, a precursor to the development of a climate change centre[82].

B. Other Interventions

Other major interventions include: infrastructure improvement; research and data collection; and incorporation of climate issues into sector plans (VCA, 2007). The overall interventions adapted by the Ministry of Agriculture for adaptation to climate change and variability are channelled through the institution's autonomous bodies/technical units. As such, the Ministry's plan for climate change adaptation can be matched with the proposed activities of the relevant agencies (see Table D1).

The GRDB and NARI are two MoA agencies that are currently executing research work related to climate change adaptation with plans for expansion. Both agencies' interventions encompass developing/adopting production systems that can better cope with the impacts of climate change and variability. For example, the GRDB has devised a six-point production system that is designed to address the effect of climate change on yield. The six-point system is oriented towards developing disease resistant, high yielding and short growing season crops. The basic principles of the system are seed treatment; fertilization; date of sowing; density of plants; weed control and water management. The system has been proven to be more effective than traditional practices as yields per acre/ hectare is much higher when compared with traditional production systems. Consequently, the GRDB is pursuing the enlargement of this system among rice farmers. Support for this initiative will be provided by the establishment of 40 feeding schools for on-farm demonstration. Demonstrations will focus primarily on a comparative assessment of the six-point system with traditional practices.

NARI in collaboration with the Crops and Livestock Support Services (CLSS) is seeking to develop production systems that can cope with the predicted impacts of climate change. Techniques include; the establishment of greenhouses, raised beds to cater for flooding, the establishment of shade houses to allow crops to be able to withstand severe weather elements, altering cropping patterns and the development of drip irrigation systems to reduce the need for rain-fed irrigation.

For these agencies, their experience in undertaking research work will enhance their ability to safeguard production and productivity of agriculture produce. This is primarily because their experience will afford them greater know- how in addressing the impact of climate change on production.

Following the 2005 and 2006 floods, several response mechanisms were developed by the MoA to address infrastructure improvement. These relate predominantly to improving flood control by

[82] NCSA (2007) and VCA (2007)

undertaking rehabilitative works to D&I infrastructures such as drains, canals, dams and water conservancies. Additionally, approximately US$11 million has been spent since 2005 to improve drainage and irrigation through the NDIA, MMA-ADA and regional administrative offices. Activities that were undertaken include the acquisition of equipment such as pumps and excavators, the clearing of canals and outfall channels, the construction/heightening of embankments and rehabilitation/reactivation of structures such as sluices and kokers (Farmer, 2008). These improvements will unequivocally improve the capability of current infrastructure to support resilience to flooding.[83] Additionally, improvements in D&I structures, juxtaposed with institutional strengthening of the NDIA, is being promoted under the ASSP which commenced two years ago (VCA, 2007).

Table D.1- Institutions' Plans to Cope with Climate Change and Variability

Institutions' Plans to cope with Climate Change	
Agencies	**Plans**
1. NDIA	Infrastructure Improvement such as conservancy adaptation works at the East Demerara Water Conservancy and the review of new D&I Criteria.
2. NARI	Research work to enhance production systems to cope with the effects of climate change; e.g. establishment of greenhouse production, drip irrigation and organic farming systems in the intermediate savannahs. However, consequent to a lack of technical staff, there is no crop breeding programme for adaptation to climate change.
3. UG-FAF	The faculty has tailored projects, for both students and lecturers, relating to mitigating the effects of and adapting to climate change.[84]
4. UG-SEES	Expanding curriculum to incorporate climate change issues and heightening public awareness and research programmes.[85]
5. GRDB	Research-oriented work already geared towards increasing the sector's resistance to the effects of climate change.
6. GSA	Climate change concepts included in the school curriculum at the Diploma and Certificate level. (VCA)
7. GFC	Code of practice takes climate change into account; Established Forest Management Plan aimed at improving harvesting practices
8. CLSS	Have adaptation techniques such as raised beds, green house techniques, shade houses, cropping patterns and drip irrigation systems but there are no bonds or shelters in cases of emergency to store food for cattle.
9. HD	Established plans to enhance capacity for work related to climate change adaptation.
10. SRRD	Plans to change the design of sea defence structures to make them more durable as well as to improve natural sea defence. For this, financial support is being provided by the European Union for mangrove development under the EDF.
11. GEA	National Energy Efficiency Programme- Under this programme in-house training will be promoted; sensitization programmes will be launched; brochures published; a sensitization walk will be held all aimed at promoting energy efficiency.
12. GRPA	The institution revealed that it has plans to enhance drainage capacity. It also acquired three outboard engines and three boats from Oxfam to service riverain communities in times of floods.

[83] Ministry of Agriculture- Guyana. Response to Oral Question on Clime Change by Hon. Robert M. Persaud, MBA, MP Minister of Agriculture. http://www.agriculture.gov.gy/Parliament/RESPONSE%20TO%20ORAL%20QUESTION%20ON%20CLIMATE%20CHANGE.htm.
[84] VCA (2007).
[85] Ibid.

Future plans for infrastructure improvement to address climate change also relate to improving D&I infrastructures such as plans to enhance the storage capacity/ water management of the East Demerara Water Conservancy System[86] and other conservancies.[87] Private agriculture sector institutions, such as the GRPA also have plans to enhance drainage capacity to improve the rice sector's resilience to climate change.

2.2 Environmental Protection Agency

The EPA is a semi autonomous agency under the directorate of the Office of the President. The agency was established by the Environmental Protection Act No. 11 of 1996. The act confers upon the agency responsibility for *'the management, conservation, protection and improvement of the environment; the prevention or control of pollution; the assessment of the impact of economic development on the environment; the sustainable use of natural resources and for matters incidental and connected therewith.'*[88] The EPA reports directly to the President who is the Minister responsible for matters related to the Environment (NCSA, 2007).

Part II (Establishment and Functions of Agency) of the act stipulates that the agency is to be controlled by a board of directors[89] and managed by a Executive Director, as appointed by the Minister, on the advice of the board of directors (Part III Article 6.1). The agency currently operates with two units; Legal support unit and policy, planning, research and technical services unit; and four divisions that include;

i. Administrative Division. This division is comprised of the following units:

   - Human Resources Unit
   - Finance Unit
   - Administrative Unit
   - Administrative Director Office
   - Information Technology Unit

ii. Education, Information and Training Division (EITD)
iii. Environmental Management Division (EMD) - this division is responsible for climate change and coastal zone activities and projects within the agency (NCSA, 2007).
iv. Natural Resources Management Division (NRMD)

The NCSA (2007) identified the EPA as an agency with a role in climate change given the agencies broad mandate for protection of the atmosphere and the environment (INC, 2002), which in spite of, does not barricade its active involvement in climate change issues. The agency is involved in climate change issues from four fronts: education and awareness programmes; contribution to national assessment and consultation; the EIA review process and the implementation of environmental regulations.

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[86] The East Demerara Water Conservancy includes: a reservoir, fronted by an earthen dam; Drainage channels, used to release excess water from the reservoir during the rainy season; and a network of canals, used to provide drinking water and irrigation during the dry seasons.
[87] Ibid
[88] Guyana Act No. 11 of 1996. Environmental Protection Act 1996. pp 4.
[89] Ibid pg. 8

However, its education and public awareness programme is focused on environmental education and is only tangentially related to climate change. This programme is largely a corollary of the 1999 drafted National Environmental Education and Public Awareness Strategy (NEEPAS) (INC report 2002). It is important that an institutional mechanism is developed to specifically target information dissemination to stakeholders in the agriculture sector on climate change issues and its implications for their livelihood since farmers will receive the direct impacts of climate change and must therefore have the capacity to adapt to these impacts.

2.3 Ministry of Public Works and Communication - Sea and River Defence Division

The SRDD is a technical division of the MPW&C. The division was established in 1996 by the Sea Defences Act chapters 64:01 and 64:02 of the laws of Guyana. The Division is "*responsible for the design, construction, maintenance and rehabilitation of all sea and river defences in Guyana…*"[90] The Division is headed by a Chief Sea Defence Officer, who also acts as the vice- chairman of the Sea Defence Board (SDB)[91] and is directly answerable to the Permanent Secretary/ Minister of the MPW&C.[92] The Chief Sea Defence Officer is assisted by a Deputy Sea Defence Officer. There are two assistant sea defence officers; one in charge of design and another in charge of construction. Further, there are 8 districts.[93] These are (in order) Essequibo Coast and Pomeroon; the Island of Wakenaam; the Island of Leguan; West Coast Demerara; East Coast Demerara; Mahaica Abary; West Coast, Berbice and East Corentyne Coast, Berbice.[94]

While the agency's mandate does not make direct reference to climate change it is nonetheless, directly involved in climate change through its maintenance and strengthening of sea defences. It therefore has a key role to play in protecting arable agriculture lands from the invasion of the sea due to sea level rise and intense and severe rainfall.[95]

Given the topography of Guyana's coastal belt, which is approximately 0.5 to 1m below sea level (at high tide),[96] it is imperative that sea defence structures are durable enough to withstand increased wave action that may be associated with climate change, in order to protect coastal landforms. The NCSA Study (2007) notes that sea and river defences projects are taking climate change into consideration. Several interventions are underway to increase the durability of man-made and natural sea defence structures to accommodate predictions of sea level rise. Among these interventions are plans to change the design of man- made sea defence structures; plans to improve such infrastructure and plans to increase the role of natural sea defences in preventing flooding.

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[90] Sea and River Defence Division. http://www.guyanacoast.net/orga/srdd/index.html.

[91] The SDB was reconstituted in 1993 under the Sea Defences Act (CAP 64:02) and is responsible for the "care, maintenance, management and construction of the sea and river defences of Guyana" (SES- PAP Report, 2007).

[92] Ibid.

[93] Sea Defence Districts includes those administrative regions of Guyana (Region 2, 3, 4, 5 and 6) that comprise the country's coastal zone. The coastal zone is 430km long, and lies below sea level. 200km of this zone is protected by man made sae defence structures.

The organizational arrangement of the SRDD was changed in May of 2008 following its incorporation into the Work Services Group of the MPWC. Prior to this, the institution had two (2) units; the Project Execution Unit (PEU), established in 1994, and the Emergency Works Department (EWD).

[94] Sea Defence Act, Chapter 64:02 www.gina.gov.gy/gina_pub/laws/Laws/cap6402.pdf.

[95] Sea and River Defence Division. http://www.guyanacoast.net/orga/srdd/index.html.

[96] EPA (2000).

Interventions to improve man-made infrastructure include: construction of 2 km rip rap sea defence structures in Region 2 and 3 in critical areas (NCSA, 2007). Rip rap designs are increasingly being used to construct sea defence structures since these offer greater flexibility in design and are considered to be more resilient to the impacts of climate change. Rip rap structures allow for stones to be repacked to the required elevation in the event of a breach, unlike concrete structures, which once breached requires reconstruction from scratch. Further, because rip rap designs entail the use of rocks and stones, which are naturally occurring elements and more readily available, it is more cost efficient. Also, rip rap structures dissipate wave energy more effectively than concrete structures.

Further, under the European Development Fund (EDF) the agency will benefit from access to €17 million to rehabilitate 18km of sea defences in Regions 2, 3, 4 and 6 respectively and to construct 1.4 metres of sea defences in Region 4 (Clonbrook and Bee Hive Villages) and 6 (Villages No. 77 and 78 in Corentyne). The agency is also involved in improving the capacity of natural sea defence structures to protect the coast from erosion in order to supplement protection afforded by man-made structures.

Several of the current interventions being undertaken by the SRDD relate to several strategy and actions spelled out in the Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-lying areas (2002) for implementation by the institution. The strategies are designed to increase sea and river defences resilience to the anticipated impacts of climate change and include:

i. *Design and construct sea defences that accommodate the physiographic conditions and projected SLR and which are resilient to the impacts of climate change.*
ii. *Enforce the regulations concerning the protection of the Sea Defence Reserves, and to protect the mangrove, sand, and shells on the foreshore areas.*
iii. *Research should be carried out into the use of natural or introduced vegetation as a means of soil stabilization.*
iv. *Improve the routine monitoring, maintenance, and management of the sea defences.*
v. *Co-ordinate and promote the implementation of development programmes that address information sharing, and the rehabilitation of sea defence structures- forestry.*
vi. *Collaborate with other (sectors) agencies in promoting public awareness on the importance of sea defences especially as it relates to the impacts of climate change.*
vii. *Ensure that other agencies/individuals that execute work near sea defence structures do not damage these structures.*[97]

However, the agency pointed out that due to resource constraints work is being done on a piecemeal basis. For instance, the agency lacks the full complement of staff needed to monitor encroachments and the effect of wave action on sea defence structures.

[97] The NDIA and GUYSUCO are two of the main agencies that execute work near sea defence structures. Thee agencies have sluices near the structures that are used for drainage and irrigation and are therefore in frequent contact with such structures. However, the agency noted that no problems relating to damage to structures are encountered with these two entities since talks are in motion to address the possibility of damage to structures. However, the agency did point out that problems are experienced with fishermen that use these structures during their operation and that despite complaints remedial action is yet to be taken by fishermen.
Sluices are near sea defence structures hence the NDIA and GUYSUCO traverse the areas, fishermen also use structures.

2.4 Other Agencies

Several other agencies have a role to play in responding to the impacts of impact change. These agencies address cross cutting issues such as disaster response and technology development. They include, as considered here, the CDC; GWI, GEA and the IAST.

The GEA was established under the Guyana Energy Agency Act of 1977 "*to ensure the rational and efficient use of imported petroleum-based energy sources, while encouraging, where economically feasible and environmentally acceptable, increased utilization of indigenous new and renewable sources of energy.*" It has a deferred role to play in climate change through its regulation of the energy sector. The agency has crafted an energy efficiency programme to promote public awareness on energy conservation.

The CDC is Guyana's key disaster response body. The entity was established in 1982 and institutionalized under the authority of the Office of the Prime Minister but has subsequently been placed under the ambit of the Office of the President (1992). To date, the agency has formulated a comprehensive National Disaster Preparedness Plan (1985) and has upgraded the Standard Operation Procedures for the National Emergency Operations Centre (2001)[98]

The GWI was formed in May 2002 as a result of a merger of the Guyana Sewerage and Water Commission (GS&WC) and the Guyana Water Authority (GUYWA). The Company is managed by a Board of Directors and a Chief Executive Officer. It was established under the Water and Sewerage Act of 2002. It is mandated *to deliver safe, adequate and affordable water and to ensure safe sewerage systems for improved public health and sustainable economic development.*

The IAST has a mandate for technology development and transfer in Guyana. Recently the institution has been involved in a pilot demonstration project related to climate change mitigation. The project, which targets the energy and agriculture sectors, pertains to the development of alternative bio-fuels for vehicles (NCSA, 2007).

[98] Civil Defence Commission, http://www.cdc.gy/about.php.

3. INSTITUTIONAL CAPACITY ASSESSMENT FOR CLIMATE CHANGE ADAPTATION

This section seeks to analyze the current condition of resources in agriculture-related institutions including human, financial and technical resources; information management systems and inter-agency collaboration arrangements in order to make a determination as to the quality of support these can offer for effective implementation of a strategy for climate change adaptation in the agriculture sector.

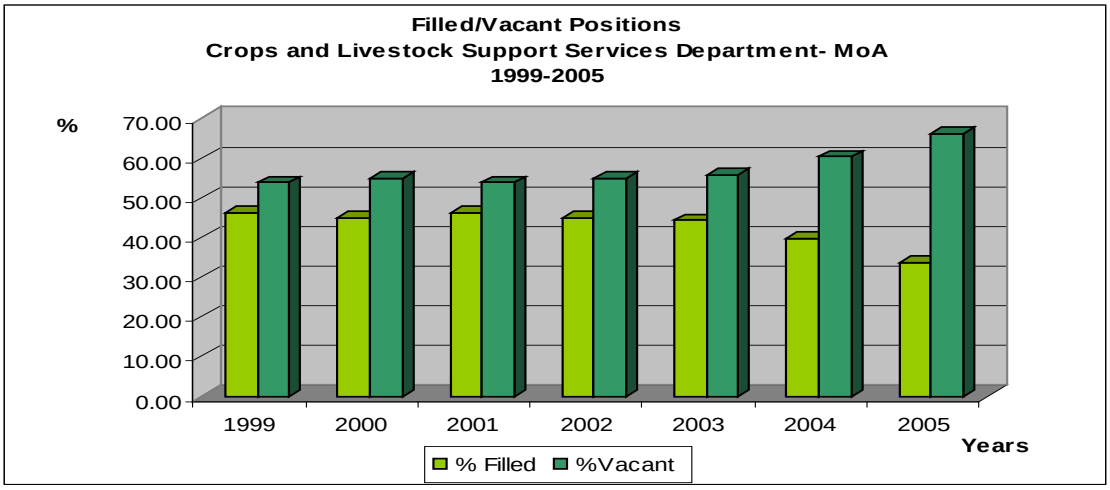
3.1 Human Resources

Institutions generally operate with a limited human resource base for the execution of their mandate. There is a significant number of vacancies given the authorized staff structure. Figure D.1 reflects this for the CLSS department of the MoA.

For the majority of the institutions the dearth of human resources pertains primarily to key professional/technical positions. For instance, in 2006, 54% (27 out of 50) of the technical positions in the Planning Department were vacant. The lack of skilled staff also affects staffing at the senior level and at the level of organization head. For instance, at the senior level, of the 11 planning positions authorized for the Planning Department, 9 were vacant in 2006 (78% of the total number of authorized planning positions).

The GFC is the only institution that is fully staffed. This is because the institution has a Memorandum of Understanding (MoU) with the University of Guyana for the provision of staff training, field exposure for students and technical assistance for curriculum building so that the University can continually produce forestry specialists.[99]

Figure D.1: Staffing Information for the Crops and Livestock Support Services



Source: Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008

[99] Forestry in Guyana (2007), Guyana Forestry Commission

Limited human resources severely constrain the effective functioning of institutions. It results in some departments being understaffed. As such, the quality of the deliverables of some units is compromised. For instance, while one aspect of the mandate of the Planning Department (PD) is to compile statistics on the agriculture sector, the department is unable to regularly compile statistics and conduct field visits in outlying areas inclusive of regions 1, 7, 8, 9 because of the lack of crop reporters.

Agencies such as the SRDD lack the full complement of human resources to monitor *infrastructures*. This will affect the expediency with which breaches/damages are addressed to prevent flooding of valuable agriculture land. Thus, while plans are on stream to develop new D&I and sea defence infrastructures, it is important that human capacity is augmented to monitor existing infrastructure since in many instances the cost of new infrastructures is significantly higher than the cost of protecting current infrastructures and above what current government subventions can support (INC, 2002). It is envisaged that mechanisms designed to foster adaptation to the impacts of climate change within the agriculture sector, will allow these agencies to be able to expand their capacity to monitor infrastructures through development assistance for capacity building.

The qualification level among staff varies from Caribbean Secondary School Certificate (CSEC)/Diplomas to Bachelors/Masters of Science degrees. Many agencies pointed out that while there are a number of staff members who possess Bachelors of Science Degrees there is an absence of staff who hold higher degrees, such as Master's of Science and PhDs. In fact, many vacant professional positions require a Master's degree and remain precisely vacant because of the lack of persons in the labour force with qualification at that level.

The lack of qualified staff is responsible for the lack of properly managed units (lack of dedicated heads of departments) as was observed in three of the agencies consulted: Fisheries Department (FD), PD and the HD. In fact, 7 of the 46 vacant technical positions within the HD are specialists to head important units (see Table D.2). This affects effective management of those units. Specifically to climate change, fully managed units are imperative to the maintenance of the work ethic and morale of staff at a sufficiently high level to support the execution of the institution's mandate and climate change objectives, particularly, where staff duties are expanded to include climate change without additional compensation.

The lack of qualified staff is also responsible for inadequately qualified persons serving in some professional positions within institutions, such as the HD. Of the three meteorology technicians/ forecasters within the HD only two have the relevant qualifications for the position. A reliance on inadequately qualified staff can severely handicap the efficiency and effectiveness with which the agency can monitor climatic changes and disseminate information to other agencies.

Table D.2: Professional Staffing Information for the Hydrometeorological Division of the MoA

Filled Positions		Number of Positions
Meteorologists		3
Hydrologist		1
Hydro Supt		1
Senior meteorology technicians/ forecasters		3
Meteorological officer		1
Total		**9**
Vacant Positions	**Specialist Required**	
Chief Hydrometeorological Officer	Meteorologist	1
Head of climatology and seasonal forecast section	Meteorologist (MSc.)	1
Head of aeronautical/ marine/ synoptic short and medium range forecast section	Meteorologist	2
Head of surface water hydrology section	Hydrologist	2
Head of ground water hydrology section	Hydrologist (MSc.)	1
Meteorological officers	Meteorologist	2
Meteorology technicians	Meteorologist	24
Hydrology technicians	Hydrologist	13
Total		**46**

Source: *Organizational Structure of the Hydro meteorological Division, MoA*

For research-oriented agriculture institutions, such as the GRDB, the lack of qualified personnel to undertake research work puts a strain on the financial resources of the institution as well as its research capacity. For instance, the GRDB lacks the capacity to undertake gene mapping of rice, which is very important to ascertaining the specific traits of rice varieties. Consequently, varieties of seedlings are sent overseas for gene mapping at a cost of approximately G$10 million for every ten varieties.

A time series examination of the staffing structure of agriculture institutions reveal no significant change in the staffing structure that could catalyze any improvement in the human resource base of the institutions. The SRDD is the only institution that recently experienced organizational changes. On the of May, 2008 the SRDD was incorporated into the Work Services Group (WSG). However, no information could be gleaned on the new organizational structure as the redesign of the organizational structure of the institution is still in the preparatory stage.

Between 1999 and 2008 the authorized staffing structure of institutions remained generally constant, increasing only marginally in some cases. Table D.3 and Table D.4, which show staffing information over a 10 year period reflect this fact for the CLSS and the HD. The lack of positive growth in the number of authorized positions in the institutions has been met with a decline in the number of filled positions in the agencies and an increase in the vacancy rate. For instance, the number of filled technical positions in the CLSS declined dramatically from 72.1% of the total number of authorized positions in 1999 to 39.3% in 2005. Concomitantly, the number of vacant positions increased from 30% in 1999 to 60.7% in 2005.

Table D.3: Staffing Details for Technical Positions in the Crops and Livestock Support services Department

Year	Staffing details for Technical positions in the Crops and Livestock Support Services Department 1999-2008				
	Number of Authorized Positions	Number of Filled Positions	Number of Vacant Positions	Percent Filled	Percent Vacant
1999	254	183	71	72.05	27.95
2000	254	122	132	48.03	51.97
2001	254	126	128	49.61	50.39
2002	254	123	131	48.43	51.57
2003	252	117	135	46.43	53.57
2004	255	98	157	38.43	61.57
2005	252	99	153	39.29	60.71
2006	-	90	-	-	-
2007	-	85	-	-	-
2008	-	88	-	-	-

Source: Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008

Table D.4: Staffing Details for Technical Positions in the Hydrometeorology Division

Staffing details for Technical Positions in the Hydrometeorological Office 1999-2008					
Year	Number of Authorized Positions	Number of Filled Positions	Percent Filled	Percent of Vacant Positions	Percent Vacant
1999	88	40	45.45	48	54.55
2000	88	38	43.18	50	56.82
2001	88	40	45.45	48	54.55
2002	88	38	43.18	50	56.82
2003	88	34	38.64	54	61.36
2004	88	34	38.64	54	61.36
2005	88	88		0	
2006	-	31	-	-	-
2007	-	31	-	-	-
2008	-	22	-	-	-

Source: Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008

The limited human resource base within institutions attests to the inability of the current human resource base to support measures for climate change adaptation. As focus is made on strengthening institutions to support effective implementation of an adaptation strategy within the agriculture sector, agencies will benefit from capacity building to augment their human resource base.

The deficit in professional staff within institutions is associated with difficulties in recruiting and maintaining staff. Agencies noted that those factors generally affecting the recruitment and maintenance of professional staff are the same factors affecting recruitment of staff with training in climate change. Those factors can be summarized as (see Table D.5).

Low remuneration- The general lack of human resources is associated with low *remuneration*, especially within government agencies. Adequate remuneration is necessary for motivating staff to work aptly and efficiently.

Inadequate remuneration is a significant constraint to enhancing human adaptive capacity to address climate change. Where staff duties are expanded to include climate change issues, without making additional incentives available, it may become increasingly difficult to motivate staff to work diligently.

Scarcity of personnel with the requisite skills and qualification also affect recruitment of specialists with training in climate change. Certain professional positions within institutions remain vacant as a result of difficulties in finding persons with the requisite qualification, particularly those posts that require master's degrees. This is mainly because the University of Guyana does not offer programmes in some specialist areas required by institutions. Migration also remains a culprit to the human resource base of the country. The HD has a number of vacant positions that require training in hydrology and meteorology because it is unable to find suitably qualified persons to fill these positions.

Table D.5: Factors Affecting The Recruitment and Maintenance of Professional Staff

Institution	Factors
GRDB	Minimum availability of persons in the labour force with the requisite skills and qualification
NGMC	Salaries
NDIA	Salaries
GSA	Salaries
MMA-ADA	Salaries
NARI	Salaries
NCU	Salaries
CLSS	Salaries
PD	Salaries Poor working conditions
FD	Low remuneration. Poor working condition Outdated and inefficient human resource policies
HD	Scarcity of personnel with the requisite skills and qualification in climate change
NDDP	Salaries
SRDD	Salaries
GRPA	financial resource constraints
UG, FAF	Salaries Working conditions.
PTCCB	Salaries
GWI	Salaries

Improper physical facilities and insufficient technical resource to support staff: Within government institutions, the state of physical facilities also acts as a deterrent to the attraction of professional staff. Agencies also lack technical resources such as computer systems, telephones and fax machines.

The FD also noted that outdated and inefficient human resource policies, which include such polices as employee promotion and employee evaluation do not offer much scope for staff development. As such, persons are sceptical about accepting employment offers with government institutions.

3.1.1 Staff Training in Climate Change

Human resources with training in climate change are of insurmountable importance to the agriculture sector's ability to adapt to climate change. Training would confer on agencies know-how in addressing climate change. Fortunately, for more than 50% of agencies assessed it was found that staff has received training or are in the process of receiving training in areas related to climate change. These agencies include the Pesticide and Toxic Chemical Control Board (PTCCB), GFC, GuySuCo, EPA, UG-FAF, NDIA, GWI, HD, SRDD, GEA, GRPA and EPA (see Table D.6). Training includes both formal academic training and skills training. For instance, three (3) staff members of the UG-FAF have received formal training, e.g., at the Masters of Science level, in areas related to climate change while two (2) attended a workshop on biophysical models and climate change impact assessment in agriculture, facilitated by the CCCCC. Staff members from the GRPA are currently receiving training through attendance at an ongoing workshop on disaster preparedness sponsored by Oxfam. Staff of the EPA and the HD have also benefited from climate change related training under the MACC project which conducted a workshop *to improve skills …on computer modelling of climate scenarios and the setting up of a CARICOM Community Climate Change Centre to serve the region* (NCSA, 2007). These agencies therefore have some knowledge and skill level to support efficient implementation of a strategy for climate change adaptation within the agriculture sector.

Academic institutions can play an increased role in turning out professionals with skills in addressing climate change. Several academic institutions such as the Guyana School of Agriculture (GSA), UG-SEES and UG-FAF have expanded their curriculum to incorporate climate change issues or have tailored projects for students and lecturers relating to climate change. For instance, the GSA offers training in meteorology and hydrology.

All institutions expressed an interest in building the capacity of their human resource base to address climate change by allowing staff to attend training programmes. However, several agencies noted that they are constrained by financial resources and lack of political commitment and that their willingness is subject to the duration and timing of training programmes given their low human resource base. Nevertheless, as mechanisms are designed to address climate change, it is envisaged that agencies will be able to build their human capacity to respond to climate change through increased training programmes in climate change.

Table D.6: Staff Training in Climate Change

Institution	No. of Staff with training in climate change	Willingness to allow staff to attend training programmes	Comments
GUYSUCO	3		2 persons have formal training in climate change
NGMC	0		
NDIA	-	Yes	Approximately 80% of the staff of the NDIA has had training in adapting to the impacts of climate change. In fact, at present, two (2) staff members are attending a workshop on modelling facilitated by the HD
GSA	0		
MMA-ADA	0	Yes	The institution is willing to make staff available for training in climate change adaptation but this depends on the duration of such programmes since staffs is small. The institution indicated that it prefers in-house training so that much time is not lost to training programmes.
PTCCB	1	Yes	One staff member has an MSc in biology and the environment.
GFC	1	Yes	
PD	0	Yes	
FD	0	Yes	The institution pointed out that while the institutional willingness to have staff attend training programmes does exist, the political support is often lacking.
CLSS	0		Given the institutions mandate there is no need for staff with training in climate change.
APCU	0		
HD	7		Approximately seven or more persons with the HD have had training in climate change.
NDDP	0		
EPA	-	Yes	
GEA	7	Yes	Two (2) staff members have formal training in climate change including the head of the agency that has an MSc In Energy and the Environment. Approximately five (5) other staff members have attended training programmes related to climate change. The willingness of the institution to allow staff to attend training programmes is dependent on the time such programmes are held and their duration.
SRDD	8	Yes	The agency did indicate its willingness to make staff available for training in climate change but pointed out that this depends on the availability of staff given the general shortage. The agency also pointed out that some staff members that have received training in climate change have subsequently left the institution.
GRPA	2	Yes	Professional staff has received training through attendance at an ongoing workshop on disaster preparedness sponsored by Oxfam that commenced in 2006.
UG, FAF	5	Yes	Three (3) staff have received formal training (MSc.) in areas related to climate change while two (2) attended a workshop on biophysical models and climate change impact assessment in agriculture, facilitated by the CCCCC. The workshop was held between January 29, 2007 and February 8, 2007.
GWI	-	Yes	Several staff members have training in areas related to climate change. However, the agency pointed out the need for continuous training given the high attrition rate within the institution.

3.2 Awareness of Climate Change

Knowledge about climate change is critical if institutions are to address the issue in a timely and efficient manner. The greater proportion of agencies assessed (76%) are highly aware of the predictions that have been made with regards to the impacts of climate change on Guyana and the likely impacts on the agriculture sector (see Table D.7). Institutions pointed to the 1996-1997 El Niño la Niña weather phenomenon and the 2005- 2006 floods as the watershed in their knowledge of climate change issues and the implications for sustainable agriculture development.

Access to information related to climate change from both local and international agencies is the main factor responsible for institution's awareness of climate change issues. At the local level, many institutions access climatic information from the HD. Several agencies have also indicated attendance at training programmes on climate change facilitated by this office. At the international level information can be accessed from various international bodies such as the Food and Agriculture Organization (FAO). The HD also communicates with the World Meteorological Organization (WMO) and executes various programmes set by this international body (NCSA Study 2007) and can therefore access information from this agency. HD is also Guyana's focal point to the UNFCC and can access information from various UN bodies addressing climate issues. The EPA and HD also communicate with the CCCCC and access information from this entity (NCSA, 2007).

Agencies with a fair to low awareness of climate change impacts are those that have minimal access to information or have a limited interest in climate change because of their mandate. Access to information is a prerequisite for knowledge building. It is therefore important that institutions have access to information for full comprehension of the issue and its implications for the agriculture sector. One agency, the MMA-ADA, suggested that this can be rectified through in-house training to increase employee awareness and understanding of climate change.

It is noteworthy that while the majority of agencies are highly aware of the impacts of climate change, knowledge of climate change within some agencies does not exist at every staff layer consequent to limited staff training in climate change but is concentrated at the senior level. This was evident in such institutions as the MMA-ADA and GEA. While this indicates limited staff knowledge in addressing climate change, the senior level is precisely the level at which policies are created; amended and enacted. Knowledge at this level will therefore allow for less institutional resistance to changes to address climate change. The GEA is seeking to redress this through in-house training and sensitization programmes for staff under its National Energy Efficiency Programme.

Table D.7: Awareness of Climate Change

Institution	High	Fair	Low	Comments
GRDB	√			The GRDB is fully aware of the impacts of climate change on rice production and has been strategically working towards increasing the sector's ability to withstand these effects. To this end, the GRDB is currently undertaking a research- oriented project that focuses on the development of high yield rice varieties; longer standing (in field) varieties and; salinity resistant strains
GUYSUCO	√			
NGMC		√		
NDIA	√			
GSA	√			
MMA-ADA		√		The institution believes that climate change can have a significant effect on the agriculture sector. However, there is little awareness among staff as no sensitization is being done
PTCCB	√			
GFC	√			The agency is seeking to sustainably mange Guyana's forest resources in light of the prognosis on climate change.
NARI	√			
NCU	√			
PD			√	The department currently lacks knowledge of climate change
FD	√			The department is fully cognizant of the likely effects of climate change on the Fisheries sector
APCU		√		
HD	√			Because of the institution's mandate it is fully aware of the impacts of climate change.
NDDP		√		
EPA	√			
GEA	√			There is some awareness of climate change issues among staff but this does not exist at every staff level. Awareness is more prominent among technical staff compared to auxiliary staff.
SRRD	√			
GRPA	√			The believes that climate change can have a significant impact on the rice industry
UG- FAF	√			
GWI	√			The agency is well aware of the impacts of climate change and has developed the emergency response plan to improve adaptive capacity to the impacts of climate change.

3.3 Legislative/ Policy Scope for Climate Change Adaptation

Agencies function within the confines of their mandate. All of the agencies have clearly defined mission statements and objectives given their legislated mandates. However, none of the agencies have mandates and objectives that directly speak to heightening the resilience of the agriculture sector to the impacts of climate change. Consequent to the lack of policy provisions to address climate change, agencies do not attach policy priority to addressing the issue. This is reflected by the absence of a sense of urgency in addressing climate change among institutions as evidenced by the lack of plans articulated to address climate change even with knowledge of its likely impacts on the agriculture sector. Climate change therefore needs to be incorporated into the mandates of

institutions for it to be accorded the same policy importance as other aspects of the institution's mandate.

The greater proportion of agriculture agencies reviewed is semi-autonomous bodies. This indicates that these agencies have the regulatory flexibility to incorporate climate change into their mandate. An analysis of the agencies' mandates reveals that at least 50% of (Semi-autonomous) agencies have scope within their mandate to address climate change adaptation (see Table D.8). This is associated with three factors:

A. The institution's mandate has an open-ended objective for the agency to address other issues that may be of importance to the sub-sector the agency has responsibility for. Agencies with such mandates include: the GRDB, GRPA.

Agencies with an open-ended objective can within their sector advocate and raise awareness among producers on the impacts and effects of climate change. More so, such agencies can make recommendations to the Minister on improvements within their sector that would allow for adaptation to the impacts of climate change (VCA, 2007).

B. The institution is a scientific research- oriented or academic organization. Agencies with such mandates include, NARI, UG, GSA, HD

Education/research institutions can play an increased role in collecting, analyzing and disseminating information on the impacts of climate change on agriculture. Institutions, such as the GSA, have sought to address climate change by expanding their curriculum to address the issue, both for staff and students (VCA, 2007). This involves collaboration with the HD to provide training in hydrology and meteorology. Climate change can allow such institutions to become premier tertiary level institutions at producing agriculture specialists with academic training in climate change.

Research oriented agencies can also play an increased role in undertaking research work related to improving the agriculture sector's resilience to climate change. In fact, the VCA (2007) notes that *"NARI pledges its full commitment for the collection, analysis and dissemination of information pertaining to improved technology and techniques in all areas of agriculture especially areas such as: Environmentally safe practices; Inland Agriculture Development - the establishment of new agricultural frontiers in the Intermediate and Rupununi Savannahs and Linden/Soesdyke Highway.*

C. The institution's mandate relates to the management of the country's natural resources and the maintenance of infrastructure such as river, dams and sea defences. Agencies with such mandates include; the MMA-ADA, SRRD, NDIA and GFC.

Agencies responsible for resource/infrastructure management must ensure that those resources are effectively functioning. For instance, the MMA-ADA has the responsibility of ensuring that all rivers within its jurisdiction are functioning effectively by removing all siltation in the river banks in order for rivers to drain at a faster rate so as to prevent flooding (VCA, 2007). Additionally, the NDIA has the role of ensuring that all drainage and irrigation structures, flood and water control systems are improved to cope with excess flooding and changes in the weather (VCA, 2007).

Table D.8: Policy Scope for Climate Change Adaptation

Agencies	Mandate	Scope for Climate Change adaptation	
		Yes	No
GRDB	i. Overseas market expansion ii. Development of research station and the facilitation of technology transfer Addressing any other issue that is of importance for the development of the sector.	√	
GUYSUCO	a. Cultivation of sugarcane b. Production and marketing of sugar and molasses		√
NGMC	i. Provision of market facilitation services to the exporters for the export of non-traditional agricultural produce. ii. Facilitate local market development iii. Develop and disseminate post- harvest technology iv. Conduct market research v. Provide market intelligence services to farmers/exporters.		√
NDIA	"To function as the nation's apex organization dealing with all public matters pertaining to management, improvement, extension and provision of drainage, irrigation and flood control infrastructure and services in declared areas of the country."	√	
GSA	i. To offer theoretical and practical training in agriculture ii. To manage, develop and operate farms and undertakings of an agricultural and forestry nature, in accordance with good farming practices.	√	
MMA-ADA	"To support agricultural development in the MMA area by supporting the development and maintenance of infrastructures"	√	
PTCCB	"To provide and promote the necessary infrastructures required for the establishment of a comprehensive registration scheme, with appropriate educational, advisory, health-care and extension services for enabling and exercising adequate control over quality, sale and usage of pesticides and toxic chemicals while ensuring that interest of end-users and manufacturer's rights are well protected".		√
GFC	To manage and control the utilization of the state's forests, ensuring an optimum and sustained yield of forest produce and the maintenance and improvement of the environment.	√	
NARI	" plan, develop and implement research designed to produce technologies and systems required to maintain national self sufficiency and export capacity."	√	
PD	To promote and support the development of agriculture in Guyana through: i. The collection, compilation, analysis and dissemination of statistics on the agriculture sector; ii. Coordination and monitoring of agricultural plans and programmes		√
FD	"To manage, regulate and promote the sustainable development of the nation's fishery resources for the benefit of the participants in the sector and the national economy."		√
APCU	"To facilitate policy analysis and development, provide overall co-ordination, direction, monitoring and evaluation for agricultural services planning, including the verification, preparation, monitoring and reporting on programmes and projects within the agricultural sector."		√

Agencies	Mandate	Scope for Climate Change adaptation	
HD	The mandate of the HD is to undertake research and provide data in the areas of hydrological, oceanographic and meteorological sciences both in accordance with the national needs of Guyana's productive sectors and the country's international obligations.	√	
NDDP	The objectives of the Programme include: i. To increase milk production via improvements in pasture availability/management, dairy herd management, breeding policies and education/extension services. ii. To be instrumental in helping to improve the facilities relative to the collection, processing and distribution of milk and milk products throughout Guyana in keeping with acceptable hygiene and nutritional standards. iii. To achieve full self-sufficiency in milk and milk products in the shortest time possible and replacing present imports with domestic production. iv. To provide an alternative and lucrative means of earning a living.		√
EPA	To promote, facilitate and coordinate effective environmental management and protection; and the sustainable use of Guyana's natural resources.	√	
SRRD	To undertake structural designs for sea and river Defence.	√	
GRPA	i. The protection, promotion and enhancement of the interests of rice producers generally. ii. The proposal of any measures including Co-operative Schemes of all kinds conducive to the maintenance or extension of production in the industry. iii. Making representations to the Minister concerning any matter affecting production in the industry, the operators of the Rice Marketing Board and the interests of rice producers.	√	
GEA	To ensure the rational and efficient use of imported petroleum-based energy sources, while encouraging, where economically feasible and environmentally acceptable, increased utilization of indigenous new and renewable sources of energy.	√	
GWI	To deliver safe, adequate and affordable water and to ensure safe sewerage systems for improved public health and sustainable economic development.	√	

Also, the SRDD whose mandate provides for the construction, rehabilitation and maintenance of sea Defence structures will have a key role in ensuring that the coastal belt is protected from coastal erosion.

The NDIA and SRDD are currently focused on improving D&I and sea defence infrastructures to build resilience against the predicted impacts of climate change. With regards to sea defence infrastructure, new structures constructed take predictions for sea level rise into consideration. Additionally, the agency is concentrating on improving the role of natural sea defences in preventing erosion. The NDIA has developed a conservancy adaptation strategy to improve the storage capacity of conservancies.

D. The institution's mandate relates to environmental/disaster management. Agencies with such mandates include; the EPA and CDC, which are responsible for environment and disaster management in Guyana respectively.

Such agencies indirectly support an enabling environment towards addressing and responding to climate change. Within the policy regime of the EPA climate change is broadly integrated under the atmospheric protection aspect of the EPA Act (NCSA, 2007).

Some institutions have sought to legislatively address climate change through the incorporation of the issue in management plans and other such documents that act as support to the management of the sector the agency is concerned with. This practice has only been noted in the case of the GFC which has a code of conduct that has provisions indirectly related to climate change adaptation.

While agencies' mandate may indirectly support climate change adaptation there is still the need for direct policies to support adaptation to this unyielding phenomenon. At the sectoral level, this need is also evident as current laws/policies governing the agriculture sector do not directly address climate change. As such, there is no legal/regulatory apparatus within the agriculture sector to address climate change issues. This follows from the national legal/regulatory framework which lacks clear legal mechanisms to address climate mitigation and adaptation (NCSA, 2007). In fact, the NCSA (2007) divulges that one of the country level constraints in adapting to the impacts of climate change is *inadequate institutional capacity*.

The legal/regulatory framework is also *generally too outdated to offer any significant influence to policies for climate change adaptation* (NCSA, 2007; &IS, 2002). This is substantiated by the VCA (2007) which notes that the policy studies that have been created to influence the policy framework for climate change at the national level are antiquated and do not include recent studies on climate change.

Additionally, the implementing legislations are not kept abreast with established legislations. (GCCAP&IS, 2002). Several agencies operate under legislations that date back to the Century. For instance, the Guyana Energy Agency *Act dates back to 1977; the GRPA and SRDD Acts to 1973* (see *Appendix D.3*).

The UNDP-sponsored country assessment advised on a transformation of the Country's non-legislative policy- the Cabinet Decisions on Climate Change- into legislative mandates in order to improve legislative capacity to address climate change at the national front. The project's recommendation is premised on recognition of the magnitude of the effects that can be wrought on productive sectors in the economy, and the severity of economic shocks that may follow. Legislative improvements at the national level will catalyze legislative improvements within the agriculture sector since all agencies have a role to play in addressing climate change, either being directly/ indirectly or by addressing crosscutting issues.

3.4 Information Management Systems

All of the agencies have basic information management systems. Computers are the most common data management tool within agencies. The use of more sophisticated data management systems, such as a geographic information system (GIS) is absent in almost all of the agencies, with the exception of the SRDD, GFC, and EPA. The NDIA and GEA are in the process of installing GIS

to manage data generally (see Table D.9). Statistical systems, such as Microsoft Excel and Microsoft Access are two of the most popular computer software programmes used by agencies to manage data.

The effectiveness/data management capacity of the systems and the number of staff that can efficiently utilize the systems vary among institutions (see Table D.10). The GWI and PTCCB indicated that their computer systems function very effectively; while the NCU, NARI, NDIA and EPA indicated the existence of effectively functioning data management systems with adequate data management capacity to support management of climate related information within their institutions. Effectively functioning information systems will, at a minimum, enhance the efficiency with which climate information is managed and allow for faster information dissemination and more effective data management. Adequate data management capacity is also critical for the creation of institutional memory and continuity in addressing climate change given the high attrition rate within agencies. Agencies generally noted that staff can utilize the systems to do basic tasks but highlighted that more training is needed to enhance capacity to utilize the systems for more sophisticated duties.

Notwithstanding agencies' indication of possession of effectively functioning information management systems, there is still scope for improvement as many of these agencies utilize only basic information system and have no central repository/database to manage information specifically related to climate change (NCSA, 2007). Institutions have pointed out that this is primarily because there is no policy requirement for them to address climate change. Thus, given their limited human and technical resources little or no attention is directed towards obtaining or managing data related to climate change.

Table D.9: Information Systems Within Institutions

Agencies	Type of Information System	Effectiveness Rank: 1- Very effective 2- Effective 3- Not effective	Factors affecting effective data management	Comments
HD	Computer systems Software systems for hydrological and climatological database	3		
FD	Computer systems	3	Non- functioning hardware Antiquated software resulting in computers being slow	That hardware some computer hardware, such as keyboards is not working.
NDIA	Computer systems, statistical analysis systems [MS Excel, SPSS etc.], visual and/ or modelling tools radio network	2	No problems	The agency is now building a GIS database.
GUYSUCO	Computer systems, statistical analysis systems	2	No problems	
CLSS	-	-	Inadequate Human capacity to Utilize computer systems	The agency does not have a reservoir of information related to climate change and as such does not have an information system to manage climate data. However, there are plans to establish a system to manage data.
MA-ADA	Computer systems	2		Computer systems are effective and have good data management capacity. More than 60% of staff can effectively utilize these systems. This number is adequate for the current work load of the institution. However, more training is needed in accumulating/ managing/ disseminating information related to climate change adaptation.
GRDB	Computer systems	2	Inadequate Human capacity to Utilize computer systems	Computer systems have ample data management capacity. Many staff members can effectively utilize the computers, more so for internet browsing, however, very few are skilled in the use of more technical software programs such as PowerPoint.

Agencies	Type of Information System	Effectiveness Rank: 1- Very effective 2- Effective 3- Not effective	Factors affecting effective data management	Comments
NGMC	Computer systems	3	Antiquated software resulting in computers being slow	
NDDP	Computer systems	-	Inadequate Human capacity to Utilize computer systems	
GSA	Computer systems	-	Antiquated software resulting in computers being slow Antiquated hardware	
NARI	Computer systems, statistical analysis systems [MS Excel, SPSS etc.], visual and/ or modelling tools	-		Data management system has the flexibility to adjust to the needs for accumulating, managing and disseminating information.
GFC	Computer systems	-		
SRDD	GIS system	-	Inadequate human resources to Utilize computer systems	It was pointed out that millions of dollars have been spent to bring in consultants to train personnel and develop databases but database cannot be effectively maintained because of high attrition rate.
UG, FAF		2		Information is managed through the use of computer systems. The institution has seven (7) computers and noted that these are effective and have excellent data management capacity to support the work load of the institution.
GNEA	Computer systems, MS Access database.	2	No problems	The agency is currently building a GIS. Computer systems are can be utilized by approximately 95% of staff members but training to upgrade their skills will still be useful.
GRPA	Computer systems - statistical systems	2	Limited numbers of computers	The institution recently received 25 computers from the government and is expecting another 25. Computer systems generally have adequate data management capacity. However, at the field level, the effectiveness of the systems diminishes. In order

Agencies	Type of Information System	Effectiveness Rank: 1- Very effective 2- Effective 3- Not effective	Factors affecting effective data management	Comments
				to better manage and disseminate information related to climate change additional computer systems are needed.
GWI	Computers and statistical systems- Ms Access	1	No problems	Staff is quite competent at using the systems
EPA	GIS, Computer systems, statistical analysis systems [MS Excel, SPSS etc.], visual and/ or modelling tools	-		Sufficient data management capacity.
NCU	Computer systems	-		
PD	Computer systems	3	Limited number of computers Inadequate human resources to Utilize computer systems Antiquated software	There are only two computers within the department and two staff who can use the systems effectively which is clearly not adequate for the current work load of the institution. An additional 2 more computers would greatly assist the department in its work load.
PTCCB	Computer systems	1	No problems	

For those institutions that do not have effective data management systems, the main factors hindering effective data management within institutions can be summarized as follows:

1. *Antiquated operating systems*

For agencies such as the GSA; FD; NGMC and PD, computer systems are ineffective at storing and managing data as a result of operating systems not being regularly upgraded. Computer systems are therefore very slow and have limited memory capacity to manage data. Hence, it would be difficult for agencies to expand their data management capacity to incorporate databases to manage and store climate change related information without the relevant upgrade to software systems.

2. *Non-functioning hardware*

While many agencies, such as the FD, have computers, many of them are not working because of hardware related problems such as non-functioning keyboards. This limits the number of computer systems actually available to manage data and the speed with which data can be inputted for storage. It therefore negates the swiftness with which climate data can be stored and accessed.

3. *Inadequate Human capacity to Utilize computer systems*

Institutions such as the GRDB, CLSS, NDDP and SRDD do not have the requisite human capacity to effectively utilize the computer systems. This will also affect the ability of agencies to expand data management capacity to include climate change information.

Inadequate human capacity also affects the maintenance of the SRDD's GIS database. Consequently, the database is not regularly updated. The agency highlighted that due to limited human resources, an inventory of sea defence was done in 1996 while another was done 8 years later, in 2004.

4. *Inadequate numbers of computer systems to support the work load of the institution*

Agencies, such as the GRPA and PD *do not have adequate numbers of computer systems to support the work load of the institution.* They would therefore be unable to expand their data management capacity to include management of climate change information.

As the NCSA (2007) study opined, it is crucial that information and technical resources are improved, particularly in lead agencies, to support efficient management and distribution of climate change information. It is equally important that attempts to improve technical and information resources encompass maintenance of resources as poor maintenance can affect continuity in data collection and database expansion.

Several agencies have benefited from capacity building to manage climate data. As mentioned earlier, staff of the EPA and HD have benefited from training in computer modelling of climate scenarios under the MACC project (NCSA, 2007). As such, these agencies have some capacity to handle climate change data.

Also, capacity to manage climate data exists within the HD, which maintains a hydrological and climatological database using HYDATA 3.0 and CLICOM Version 3.1 Software. These softwares were made available under the Voluntary Cooperation Programme of the WMO. However, human and technical resource constraints limits consistent recording of data. A number of years are missing consequent to human and equipment deficit to digitize data (NCSA, 2007).

3.5 Technical Resources

Institutions, such as the GRPA, MMA-ADA, GSA and FD, noted that technical resources such as computers, vehicles and monitoring devices, which are managed according to Public Service regulations are inadequate to support their workload. The SRDD noted that it possessed more equipment, such as water gauges, 30 years ago compared to what it has currently. As such, small contractors are often contracted to undertake certain sea defence works that would otherwise be done by the entity.

The lack of sufficient tools and equipment deters agencies from servicing holistically, the micro needs of their respective sub-sector. The lack of equipment and communication systems also affects

the reach of some institutions across the geographical divides of Guyana. This will unequivocally hinder the dissemination of information on climate change to stakeholders in these areas as well as the provision of technical assistance or extension support to cope with the impacts of climate change. Further, the NCSA (2007) asserts that the lack of technical resources such as computers is a significant constraint to data collection and database development within key agencies involved in climate issues.

The draft VCA (2007) identifies the lack of vehicles and office space among the resource constraints faced by the EPA and HD. Notwithstanding this however, the HD has a quantum of tools and equipment that will facilitate effective monitoring of climatic changes. The agency maintains a network comprised of eight climatological stations around Guyana. Additionally, the agency has ninety rainfall stations around the country and maintains fifteen surface water hydrological system, one A-sand aquifer and two shallow wells. Further, the agency has benefited from the acquisition of resources under the Caribbean Planning for Adaptation to Climate Change (CPACC) project. Under the CPACC project two tide gauges were acquired. These tools are used to analyze climate and sea level variations (NCSA, 2007).[100]

3.6 Financial Framework

The financial resources required by agencies are satisfied through government subventions for capital and recurrent expenditure for those semi- autonomous agencies and technical units that comprised the assessment. Private institutions are self- sustained and therefore have sole authority over generation and management of their financial resources.

For the public institutions within the agriculture sector, budgetary allocations are generally insufficient for the agencies to effectively execute their duties and to support implementation of mechanisms for climate change adaptation. The NCSA (2007) postulates that this finding is characteristic of the *entire governmental structure within the country*. Finances are also inadequate in private institutions inclusive of the GRPA. (see Table D.10). Only the GRDB and Agriculture Project Cycle Unit (APCU) indicated that finances are adequate to set up mechanisms for climate change adaptation.

The HD and some agencies indirectly noted that allocations for recurrent expenditure are much more inadequate than capital expenditure allocations. This severely affects the human resource base of the institutions as it limits the number of staff that can be hired. An analysis of the budgetary allocations to public agencies corroborates this.

For many agencies the budgetary allocations have only marginally increased over the years and have decreased in some instances. This is corroborated by a time series analysis of the budgetary allocations to those institutions that have a direct role in climate change adaptation as it pertains to the agriculture sector inclusive of the MMA/ADA, NARI and NDIA among the six agencies

[100] The analysis is done through the University of the West Indies, Trinidad

pointed out by the 2007 VCA.[101] The SRDD is also considered because of its importance in protecting coastal landforms from rising sea levels.

Figure D.2 shows the trend in capital expenditure allocations to the NDIA, which has the prima facie objective of addressing the drainage and irrigation needs of the agriculture sector, between 1998 and 2006; while Table D.11 shows the change in capital expenditure over the same time period. Between 1998 and 2006 the agency operated with a budgetary deficit for five out of the nine years as actual capital expenditures surpassed budgetary allocations in all but four years. This indicates that the agency's capital budget has been increasing as purported by the VCA (2007) which underscores that *the NDIA, which directs its financial resources at water control systems to buffer climate change related impacts on the agriculture sector, has noted that its capital budget keeps increasing.*

Table D.10: Adequacy of Financial Resources to Support Climate Change Adaptation

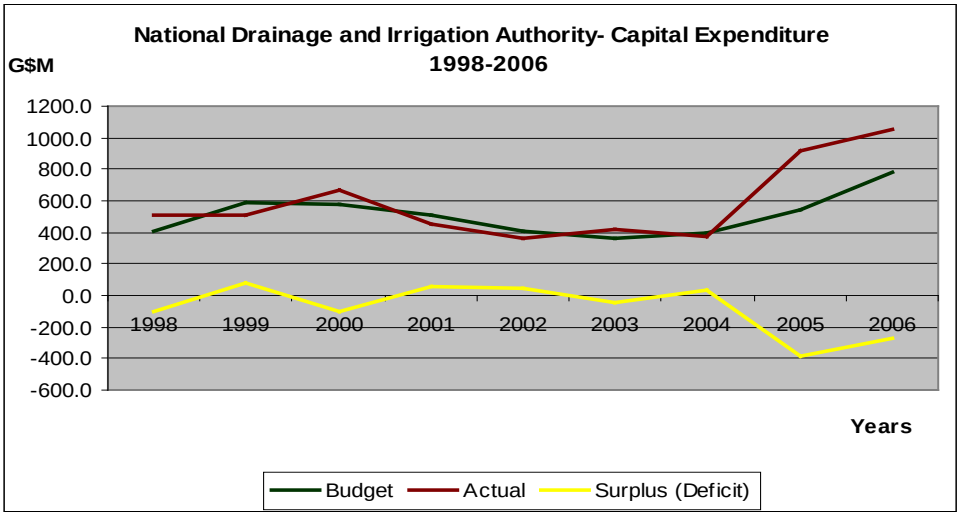
Institution	No	Yes	Comment
GRDB		√	
NGMC	√		Finances adequate for planned activities but insufficient for unbudgeted activities.
NDIA	√		
GSA	√		
CLSS	√		
MMA-ADA	√		
PTCCB	√		
NARI	√		
PD	√		
FD	√		
APCU		√	
HD	√		Capital funds are satisfactory, but recurrent is low
NDDP	√		
EPA	√		
SRRD	√		
GRPA	√		The institution generally designs programmes based on the available resources.
GEA	√		The extent to which current financial resources can support implementation of a strategy for climate change adaptation will be determined by the by the scale of the project being undertaken. If measures for climate change adaptation relate simply to information dissemination then resource will be sufficient however, beyond this resources are not sufficient.
UG, FAF	√		More money is needed for research work and to build labs. At least a 100% increase in current budgeted amounts is needed, which is G$5 million. There is generally no problem in accessing funds for budgeted activities.
GWI	√		Capital costs are funded by donors and the government of Guyana while recurrent expenses are met through water rates.

Further, for four consecutive years (2000-2003) there has been a steady decline in capital allocations to the agency compared to the previous year's allocations (see Table D.11). This will have implications for the agency's ability to improve infrastructure development in order to allow the

[101] The other three agencies are GRPA, faculties of Agriculture & Forestry and Earth & Environmental Science at the University of Guyana

agriculture sector to be able to cope with the impacts of climate change and may require that the agency increase its reliance on external funding for capital works.

Figure D.2: Annual Budget and Actual Capital Expenditure of the NDIA



Source: *Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008*

Table D.11: Annual Percentage Change in Capital Expenditures of the NDIA, 1998 - 2008

Year	Capital Expenditure	
	Budget	Actual
1998		42.2
1999	44.4	0.7
2000	-2.9	31.6
2001	-11.5	-32.5
2002	-19.4	-20.0
2003	-10.5	14.2
2004	9.0	-10.7
2005	35.0	148.4
2006	44.4	14.1
2007	0.6	-
2008	24.8	-

Source: *Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008*

Budgetary allocations are also low for the SRDD. Table D.12 shows the percentage change in budgetary capital allocations and actual expenditure of the agency between 1998 and 2003. Despite the apparent increase in capital allocations for sea defences, between 1998 and 1999 capital allocations declined by 16.5%. Further, there was an almost four fold reduction (65.5%) in budgetary allocation between 2002 and 2003.

Table D.12 - Annual % Change in Capital Expenditure- SRDD 1998-2003

Year	Capital Expenditure	
	Budget	Actual
1998		-42.6
1999	-16.5	-27.2
2000	33.9	109.9
2001	28.2	28.4
2002	-0.5	4.5
2003	-65.5	

Source: *Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008*

Several agencies, as was also verified by the NCSA (2007), rely on external funding to fill the gap in financial resources. Donor resources, via projects are used to finance capital works by institutions such as the GWI. For instance, the NDIA currently benefits from financial assistance provided by the Dutch government through the European Union to improve D&I work. In the 1990s, the EU provided funding under the EDF to assist the SRDD in sea defence works. Under the EDF funding is provided for the construction of 1.6 km of sea defence and the rehabilitation and maintenance of 18km of sea defence. Table D.13 provides a list of EU funded projects currently being undertaken by the SRDD. The low growth of budgetary allocations to these agencies and the increase in actual cost may increase their reliance on external funding. Lead agencies (HD and EPA) also depend on external funding to conduct climate change activities.

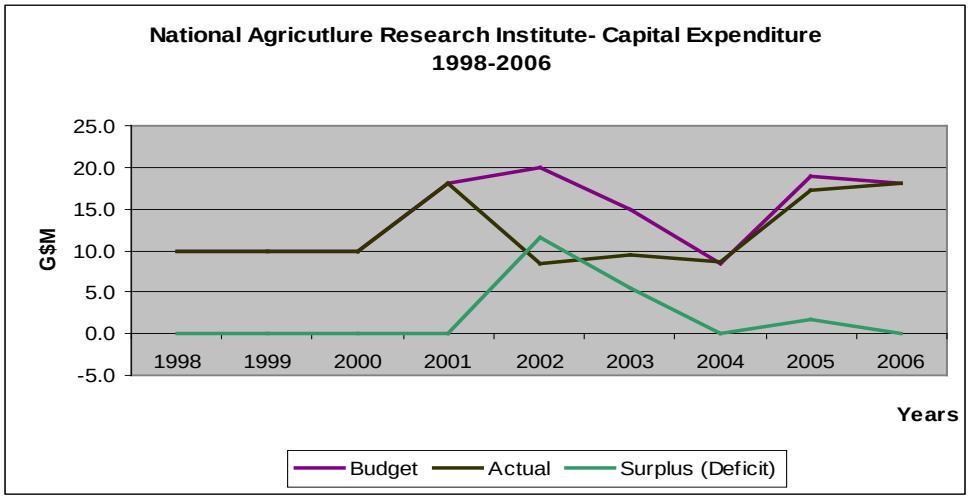
Table D.13: List of Ongoing EU- funded Projects by the SRDD

Project	Project Component Objective
Projects under the EDF	1. Immediate management to WSG
	2. Strategic environmental assessment of the sea defences sector policy in Guyana
	3. Policy framework for sea and river defence sector
Projects under the EDF	1. Reconstruction of 1.4 meters of sea defences at Clonbrook/ Bee Hive (Region #4) and villages 77 and 78 in Corentyne (Region 6)
	2. Rehabilitation of 18km of sea defences in Regions 2, 3, 4 and 6 respectively
	3. Mangrove Management
	4. Shore zone Management
	5. Institutional Strengthening

N.B. *Projects under the EDF are in the tendering stage and are valued at €17 million*
Source: Project Execution Unit, SRDD, Ministry of Public Works and Communication

The 2007 VCA highlights that many agencies such as the UG-FAF and UG-SEES operate with constant financial resources constraints even as the institutions seek to incorporate climate change programmes into their curriculum. This is true for NARI and the MMA-ADA. Figure D.3 shows that the budgetary allocations for NARI between 2001 and 2004 declined steadily. For the MMA-ADA, actual capital expenditure has been equivalent to or more than budgetary allocations for seven years between 1999 and 2006 (see Table D.14).

Figure D.3: National Agriculture Research Institute – Capital Expenditure 1998 - 2006



Source: Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008

Table D.14- Annual & Change in Capital Expenditure- MMA-ADA 1999-2008

Year	Capital Expenditure	
	Budget	Actual
1999	0.0	33.3
2000	91.7	400.8
2001	54.3	-40.9
2002	43.7	43.7
2003	30.4	30.4
2004	15.8	15.8
2005	32.5	116.9
2006	-14.6	482.8

Source: *Computed from Budget Estimates 2000; 2002; 2004; 2006; 2008*

Not all budgeted amounts or requested amounts are passed on to the respective agencies/ technical units. Many agencies face unnecessary regulatory barriers/difficulties in accessing funds. For instance, the PD pointed out that the department's acquisition of financial resource is constrained by the system of accessing funds from the MoA, which is very poor, with monies often not being released in a sufficiently timely manner for the department to conduct its required number of field visits.

The NCSA posits that all other capacity constraints that exist in Guyana, and by extension the agriculture sector, stem from limited financial resources and that *"financial constraints are the single most limiting factor…"that* will affect effective implementation of a climate change adaptation strategy.

Agencies indicated a lack of human and technical resources that may be consequential to their limited financial resources. For instance, the 2002 INC Report verified that the HD, which is *the authority for monitoring climate*, does not have sufficient funds to address training; purchasing of equipment; recruitment of field technicians and maintenance of reliable continuous records (INC, 2002).

Agencies opined that climate change will allow them to benefit from more development assistance to implement coping mechanisms. Many agencies, such as the SRDD and GWI depend on donor resources to fund capital works. Since incorporating activities to address climate change adaptation will require increased funds, which may be difficult to satisfy by government, agencies may be compelled to request assistance from special funds set up to finance development works and projects related to climate adapting/mitigating climate change such as the Global Environment Facility (GEF).

3.7 Inter- Agency Collaboration

The assessment verified that very few agencies have strong bilateral/international links with other countries for the purpose of addressing climate change, as was discovered during the VCA (2007) assessment, which noted that the greater proportion of agencies do not *"have strong bilateral and international links with other countries and hence [cannot] access support through this medium."* The VCA (2007) divulged that only the CDC, GRPA, MMA-ADA and NDIA have strong bilateral and international links with other countries.

Even at the regional level, where functional cooperation is being promoted at the policy level, agencies do not have strong inter-agency coordination. Only the EPA reported cooperating with the Regional Climate Change Offices for the purpose of information sharing. The EPA is currently collaborating with the CCCCC to undertake a Vulnerability and Capacity Assessment of the Impacts of climate change on Guyana's Agriculture.[102] The HD also cooperates with the CCCCC through the MACC project.[103]

According to the VCA (2007) the majority of agencies do not have strong bilateral or international linkages for climate change either because addressing climate change is not clearly spelled out in their mandate or they do not have mechanisms to establish links. Given resource shortcomings developing mechanism for climate change adaptation may result in stronger bilateral/international linkages being developed between agencies as the necessity to acquire technical and financial assistance increases.

At the national level, 80% of agencies indicated having some form of communication or cooperation arrangement with other agencies related to climate change. Coordination was particularly evident among government ministries/ departments. This relates predominantly to information sharing, with the HD servicing the information needs of other agencies (see Table D.15). Inter- agency collaboration is also promoted by the NCC, which has as one of its key terms of reference *the promotion of cooperation among agencies dealing with climate change in areas related to technical, scientific, technological and financial resource.* Thus, while the lack of bilateral/ international linkages does

[102] At the international/ bilateral level the VCA found that four agencies have strong linkages with other countries; CDC; GRPA; MMA-ADA and NDIA. The HD also has international linkages with the World Meteorological Organization (NCSA 2007).

[103] One of the successes of the CPACC project, the predecessor to the MACC project, was the fostering of closer ties among Member States. The Project, at its completion enabled more unification among regional parties and better articulation of regional positions for negotiations under the United Nations Framework Convention on Climate Change (UNFCCCC) and the Kyoto Protocol. It also contributed to the creation of a network for regional harmonization by initiating collaborative efforts among agencies- Caribbean Community, Caribbean Planning For Adaptation to Climate Change (CCAP&IS) Project, http://www.caricom.org/jsp/projects/macc%20project/CCAP&IS.jsp

negate resource support through this medium, the existence of national linkages does add mileage to the implementation of a climate change adaptation strategy. Such linkages point to the fact that information would be readily and easily shared among agencies and that the scope for capacity building through inter-agency collaboration does exist.

The mechanisms through which coordination occurs include:

1. Direct contact via the phone and meetings. Meetings are the principal means by which members of the NCC communicate.
2. Board meetings where representatives from different organizations are included. This is the case with agencies such at the NDIA, GRDB and SRDB. For instance, the NDIA sits on the board of the SRDD and the SRDD sits in on meetings of Regional Democratic Councils (RDCs).
3. Formal and informal meetings, committees and inter organizational units working together, such as occurs with the NCU and HD.

Agencies did not given any recommendations as to how these linkages could be modified to support adaptation to climate change but noted that such linkages are important for enhancement of their capacity to adapt to the impacts of climate change (VCA, 2007).

Research into the assessment verified the existence of several past and current (ad-hoc) inter- agency collaboration that will abet adaptation to the impacts of climate change. Notably, some agencies execute works with other agencies. For instance, the Mangrove Replanting Project to be executed by the SRDD to strengthen natural sea defences is to be conducted in collaboration with the Public Works Department of the MPW&C; the Sea Defence Commission; GFC; EPA and UG (NCSA, 2007)[104](see Table D.15).

Agencies such as, the NDIA and SRDD have very effective linkages with Neighbourhood Democratic Councils (NDCs)/RDCs and Water Users Associations (WUAs). These linkages aim to ensure that D&I infrastructure and sea and river defence structures are effectively monitored and maintained at the local level and that communication remains open for timely response to breaches.

Agencies collaborate with other international/ regional/ national/ local agencies in the execution of their mandate. In the 2006 Management Plan (2006) of the Fisheries Department, bilateral and multilateral collaboration were stipulated as guiding principles for the agency. Collaboration occurs for the purpose of capacity building and encompasses financial assistance for project execution, research support; institutional strengthening and human resource capacity building (see *Appendix D.3*).

Both the GFC and FD noted that they collaborate with other agencies for the purpose of capacity building. The GFC has linkages with several international/regional agencies. Collaboration focuses on sustainable forestry harvesting having recognised the importance of the forest in mitigating climate change through carbon sequestration. The GFC has also collaborated with the GOG/UNDP programme initiative on capacity building for natural resources and the environment. The agency is also a partner to the Forestry Training Centre Incorporated (FTCI) that also includes

[104] Sea and River Defence Division. http://www.guyanacoast.net/orga/srdd/index.html.

support from the Forest Products Association of Guyana (FPA), the Tropical Forest Foundation (USA), with funding from the International Tropical Timber Organization (ITTO), the Department of International Development and the World Wildlife Fund (WWF) (Guianas).

The NDIA currently benefits from financial assistance provided by the Dutch government through the European Union to improve D&I work. Given the NDIA's mandate any development works undertaken by the agency for the purpose of improving D&I infrastructure must be viewed as complementary to capacity building for the purpose of climate change adaptation since such initiatives will enhance, along the coastal corridor, farmers' resilience to tidal waves and flooding from intense and excessive rainfall.

Table D.15: Inter-Agency Communication/Coordination for Climate Change

Institution	International/Regional	National
GRDB	None	Obtain climatic information from the HD
GUYSUCO	Currently collaborating with the Caribbean Community Climate Change Centre (CCCCC) to undertake a Vulnerability and Capacity Assessment of the Impacts of climate change on Guyana's Agriculture.	None but cooperate with the Environmental Protection agency to GUYSUCO's environmental controls and mitigation measures are in compliance with changing EPA regulations. Member of the NCC Obtain climatic information from the HD
NGMC	None	Obtain climatic information from the Hydrometeorology Division
NDIA	None[105]	Obtain climatic information from the Hydrometeorology Division Member of the NCC
GSA	None	The HD coordinates climate change programmes for the GSA.
CLSS	None[106]	Obtain climatic information from the Hydrometeorology Division
MMA-ADA	None	None
PTCCB	None	None
GFC	None	Obtain climatic information from the HD Member of the NCC
NARI	None	Member of the NCC
NCU	MACC	Collaborates with the EPA for national assessments and consultations Obtain climatic information from the HD
PD	None	None
FD	None[107]	Obtain climatic information from the Hydrometeorology

[105] The agency has no formal arrangement with any agency to address climate change. However, it has recently entered into a cooperation arrangement with Japan for infrastructure Development. This arrangement is currently ongoing. Further, the agency has a cooperation arrangement with the Dutch government, through the European Union, aimed at improving D&I work.

[106] There is no formal arrangement between this agency and any other to address climate issues. However, the agency does relate with the FAO and IICA that have programmes related to climate change.

[107]The department has strong linkages with the Caribbean Regional Fisheries Mechanism which has incorporated climate change into two components of its second medium term plan 2008-2011: Development and promotion of risk reduction programme for fishers. This component has insurance provisions that cater for environmental risks.
Resource assessment and management- that will take climate change into consideration.

Institution	International/Regional	National
		Division
APCU	None	Obtain climatic information from the HD
HD	MACC	Collaborate with EPA for national capacity assessments Member of the NCC
NDDP	None	Member of the NCC
EPA	None	Member of the NCC Collaborates with the HD for national capacity assessments e.g. the two agencies collaborated to execute the 2001 Coastal Vulnerability and Risk Assessment.
GEA	None	Member of the NCC
SRDD	None	Obtain climatic information from the HD Member of the NCC
GRPA	None	Obtain climatic information from the HD
UG- FAF	None	None[108]
GWI	None	None

[108]With respect to the conduct of research work, the institution has good linkages with the GSA, NDDP, GUYSUCO and GRDB. These linkages can be modified to support activities related to climate change adaptation by allowing students to undertake research in areas of climate change for the institutions.

4. INSTITUTIONAL DEVELOPMENT PROPOSALS

Effective adaptation to the impacts of climate change will be largely determined by the adaptive capacity (available financial and technical skills and experience) of institutions involved in climate issues in the agriculture and other sectors (INC, 2002). Adaptive capacity refers to "*the whole of capabilities, resources and institutions of a country or region to implement effective adaptation measures*" (FAO, 2008b).

Several interventions have been undertaken and are currently ongoing to build capacity for adaptation to climate change. Institutions currently benefit from institutional capacity, knowledge and awareness building under the MACC project. Activities under this project are geared towards resolving capacity constraints that hinder effective climate change adaptation. The project has five components that will contribute to building capacity for climate change adaptation in Guyana. These components are: building capacity to identify climate change risks; building capacity to reduce vulnerability to climate change; building capacity to effectively access and utilize resources to minimize the costs of climate change; public education and outreach; and project management (NCSA, 2007).

The GRPA has recently benefited from a capacity building project financed by Oxfam. Also in the 1980s, under the IRP project, equipment and materials were supplied to the SRDD to enhance its institutional capacity.

Institutions will also benefit from institutional strengthening and technical capacity building under the SNC, which will execute sector based vulnerability studies.

There have been several strategies that have focused on climate change mitigation that will influence effective adaptation to climate change in the agriculture sector. Notably, the EPA, in collaboration with CIDA, has prepared an assessment of the reduction of greenhouse gas emission in the rice and wood industries. Also, the GUYSUCO, through its Skeldon factory, is focused on cogeneration (NCSA, 2007).

While these interventions may have indeed contributed to institutional strengthening for climate change adaptation it is still necessary for additional measures to be undertaken to strengthen the adaptive capacity of institutions. Focus needs to be made on institutional strengthening, enhancing inter- agency collaboration and improving the financial framework.

4.1 Institutional Strengthening

Capacity building is needed in human, technical, financial and information areas and the policy/regulatory framework, in both governmental and private institutions, to enhance the adaptive capacity of the agriculture sector to respond to the impacts of climate change. Capacity building can focus on *creating new capacities, mobilizing or redeveloping existing capacities or enhancing existing capacities* (NCSA, 2007). Given current national resource constraints, mobilizing/redeveloping existing capacities/enhancing existing capacities is a more realistic option for institutional strengthening for climate change adaptation in the short term. This can be realized by mainstreaming climate change into national and sectoral policies, such as economic development policy, disaster preventions and environmental management plans and the management plans and other guiding policy documents of

institutions. This is validated by the INC (2002) which notes that there are two necessary options to respond to the impacts of climate change. The first requires that capacity to detect, plan and respond to climate change exists in all sectors. The other necessity is for climate change adaptation options to be incorporated into national and sectoral policies. For agencies to develop the necessary adaptive capacity to respond to the impacts of climate change it is important to develop capacities in the following areas:

4.1.1 Human Resources

The implementation of a climate change adaptation strategy presupposes, at least, basic knowledge or familiarity with the climate change issue and institutional know-how in addressing it. Adequate adaptive human capacity for climate change therefore necessitates awareness building through academic and skills training. Neither academic nor skills training should stand alone however, since the NCSA (2007) argues that "*academic training must be complemented with experience and skills training in order to provide the best guidance in the execution of climate change related tasks*".

Developing human resources capacity by recruiting persons with academic training to fill positions in lead agencies with a role in addressing climate change is critical to effectively addressing the impact of climatic changes on the agriculture sector (NCSA, 2007). This is particularly the case for the NCU, whose recent genesis means that the institution does not yet operate at the required human resource threshold for effective execution of its mandate.

Qualified and trained personnel are of the utmost importance to the NCU as well as the HD given their direct role in addressing climate change. For the NCU, which is the secretarial apparatus of the NCC qualified and trained personnel are necessary to ensure effective coordination and dissemination of information to NCC members; and a thorough understanding and appreciation for the interdisciplinary and inter-linked characteristics of climate change.

Staff recruitment however, must be complemented by improved salaries to motivate staff to function effectively given the fact that there is a general shortage of human resources within the country (NCSA, 2007).

Existing capacities can also be mobilized and enhanced to develop human resources to support climate change adaptation. This can occur by providing training to existing staff members of stakeholder agencies, or adding tasks related to climate change to employees' duties (NCSA, 2007). Training should focus largely on training trainers, that is, training staff at the supervisory level who can disseminate knowledge (though the preparation of reports) within the institution on their resumption of duties. The NCSA Study (2007) argues that training should be continuous, that is staff should be periodically retrained as training can be forgotten when the job is done and not repeatedly quickly enough (NCSA, 2007).

The capacity of the NCU can be further strengthened to provide information and coordination support to other institutions seeking to augment human resource capacity to address. In fact, this agency can be the main executing body for training programmes on climate change in the agriculture sector. It may also be instructive to utilize capacities within academic institutions, such as the UG-SEES and UG-FAF and GSA to execute training programmes.

In addition to staff recruitment and training it may be also necessary to restructure core agencies to integrate a unit with the competence to address climate change into agencies. Existing capacities can be used to develop such units by shifting staff members to the unit and providing training to augment management of the unit and technical skills of professional staff to guide effective execution of climate change adaptation activities.

4.1.2 Monitoring and Research Capacity

Monitoring and research is important for mapping the effects of climate change on the agriculture sector and for providing relevant and up- to- date information that can influence the policy framework for adaptation planning, which the INC Report (2007) notes is *essential for addressing adaptation options*.

The key institutions with the capacity to participate in research in climate change, as identified by the INC (2002) Report, include: HD, UG, NARI, IAST, GRDB, Iwokrama Rainforest Project, and TROPENBOS (INC, 2002).

Iwokrama and TROPENBOS have been involved in research on carbon changes in the forestry sector with the ultimate objective of contributing to mitigating climate change (INC, 2002). However, the HD is the only agency that has been actively involved in research to detect climate change due to its mandate for research in hydrological, oceanographic and meteorological sciences.

Despite this agency's research work in seeking to detect climate change, the need for research and monitoring of the impacts of climate change on the agriculture sector does exist. Areas that can be monitored and researched to provide information for adaptation planning include; the Guyana Current, salt water intrusion and spatial distribution of rainfall (NCSA, 2007). Monitoring will also allow for a detection of the impact of climate change on erosion, inundation, changes in pest abundance, health problems, changes in fisheries and rice and sugar yields (INC, 2002).

The PTCCB is currently working towards enhancing its capability to monitor and detect new species of pests and disease, especially those migratory vectors that may become invasive with climate change; and to disseminate information on new species and treatment of these to farmers. PTCCB is currently developing a database called the Guyana Pesticides Management Information System (GPMIS). The GMPIS will entail a compilation of the current list of pests affecting each agricultural crop. New pest will be investigated for inclusion in the database, which will store information on pest systems, effects and treatment. Posters will be developed in tandem with this database to be strategically placed in farming communities to sensitize farmers on pests and diseases. The institution is currently purchasing new equipment for this information system.

Improving monitoring and research into the impacts of climate change necessitates enhancing the capabilities of research and science-oriented institutions such the HD, UG and PTCCB. The NCSA (2007) offers three options for developing monitoring and research capacity that include:

- Training and skills development
- Support to the UG to establish mechanisms for research into local climate change issues
- Financial assistance to support monitoring and research programmes

4.1.3 Policy/ Legislative Capacity

Current policies/legislations of institutions do not address climate change. Further, there is no law to guide climate change issues at the sectoral level. Thus, although agencies recognizance the importance of implementing mechanisms to facilitate adaptation to the impacts of climate change; current resource constraints prohibits them from attaching policy priority to the issue While some agencies have broadly written mandates and autonomy to incorporate the issue into their activities, it is important that direct reference is made to addressing climate change in the mandates; objectives; sector plans and other policy documents of organizations. This will ensure that agencies respond to climate change with much urgency.

At the institutional level, it is also important that specific policies/laws are developed/amended to address climate change adaptation; particularly policies targeting those agencies with a direct role in climate change adaptation. As posited in the NCSA study, *it is imperative that a policy framework is formulated to clearly indicate the climate change directives of each agency with a key role in addressing climate change.* According to the study, *clearly defined policy directives will ensure political support for institutional strengthening to address climate change issues*.

At a systemic level, legislative and regulatory capacity to address climate change can be developed by strengthening the coordinating/oversight role of the NCC and NCU. In fact, the current human resources, financial, technical and research limitations to addressing climate change within individual institutions remain the strongest indicators that the capacities of the coordinating entities need to be strengthened. As a precursor the legal, policy and institutional framework of the NCU should be reviewed to ascertain what changes are necessary for it to have a proper coordinating role in addressing climate change and to confirm the level of guidance and directive that should be provided by the NCC.

The need for the NCU to have a strong oversight role that can be legally verified is evidenced by the fact that the NCU is the secretarial apparatus of the NCC, which is composed of a group of heterogeneous institutions having either a tangential or direct role in addressing climate change impacts on the agriculture sector. The NCC was formulated following recognition that climate change is a cross-ministerial and cross-sectoral issue. However, these institutions are all governed by distinct laws and rules and provide alternative levels of responsibilities and functions in addressing climate change which are not clearly defined. Clear allocation of responsibilities and functions are necessary among the different institutions involved directly or indirectly in addressing climate change impacts on the agriculture sector. This could be easily addressed where the legal and institutional capacity of coordinating entities is restructured to afford greater oversight in addressing climate change. This will also ensure that some semblance of flexibility and responsiveness exist to respond to the impacts of climate change. Among other things, the entity's institutional and legal capacity should be restructured to: provide guidance and advise to other agencies seeking to devise agendas to address climate change; make representation on Guyana's behalf at regional and international forums; and to make proposal and recommendations regarding climate change policy; coordinate research, particularly providing support to the execution of the Second National Communication.

4.1.4 Public Awareness Programmes

The CCAP&IS (2002) verified a low awareness of climate change issues among the Guyanese public. The EPA, as an environmental management organization, is the only agency with a public awareness programme that incorporates climate change issues (INC, 2002). However, because the EPA is not an agriculture institution its public awareness programmes may not adequately address the implications of climate change for the agriculture sector and the importance of adaptation at a level that farmers can comprehend.

Guyana's INC (2002) posits that *"[r]econgizing that agriculture is the backbone of the country's economy, it will be necessary for the farmers to be assisted so that they adjust rapidly to the adverse effects"* of climate change. It is therefore crucial that farmer awareness programmes are developed within the agriculture sector to increase stakeholders' understanding and appreciation of the impacts of climate change (INC, 2002). Such programmes should to not only sensitize stakeholders on the genesis and characteristics of climate change but should seek to identify the likely impacts on the agriculture sector.

Since one of the functions of the NCU is to execute education, public awareness and outreach programmes, its capacity should be developed to be the main entity devising and executing climate change public awareness and outreach programmes.

Additionally however, climate change outreach programmes can be integrated into the National Environmental Education and Public Awareness Strategy (NEEPAS). The NEEPAS programme *"envisages several projects including training of teachers, incorporating studies on Climate Change into the curricula of schools, and preparation of instructional materials for education and public awareness"* (NCSA, 2007).

With regards to farmer awareness programmes, the capacity of extension services can also be developed to specifically provide training to farmers along the coastal regions.

Both public awareness initiatives undertaken by extension officers and the EPA should be done in conjunction with the public awareness and outreach agenda of the NCU in order to ensure the most effective use of resources.

4.1.5 Technical/ Information Resources

Many agencies use only basic computer systems to store data. For agencies such as the Hydrometeorological Department and SRRD, such systems alone are inadequate to manage the kind and volume of data that may be related to climate change. A GIS database can be used by the HD to map the effects of climate change.

In the 2007 VCA, the CDC and EPA- environmental management institutions- indicated that more sophisticated technology and information management systems are needed to enhance capacity to manage information related to climate change and variability. The CDC indicated the need for satellite imagery technology, which can be used to develop aerial views of physical features on the ground within a short timeframe, allowing for an enhanced disaster response programme. Satellite imagery technology can also be used to track changes in land features.

The EPA noted that dedicated systems are needed, such as a separate server and a minimum of two workstations; training for staff and a database on coastal resources.

There is also need for more widespread dissemination of computer systems in agencies. Further, hardware and software systems need to be enhanced for systems to function effectively. Additionally, training is necessary in building human capacity to utilize computer systems.

A proper climate change database and a central information office currently does not exist at the national level due to inadequate funding for equipment, trained staff and monitoring instruments (NCSA, 2007). It is important that a database and central information office is created to manage climate change data and to incorporate data on climate impacts on the agriculture sector as this is necessary to inform effective planning, design and implementation of measures to address climate change impacts on the agriculture sector.

The NCSA (2007) recommended that an information centre be created in the HD to act as a clearinghouse for information distribution and security in order to resolve capacity constraints related to management of climate change data. ***The HD can be the main body to house a repository and database for climate change information since the agency is involved in compiling and disseminating climate change data.*** With regards to the agriculture sector, the agency can be responsible for the:

1. Collection, analysis and storage of climatological data as it relates to the agriculture sector'
2. Modeling of climate and climate change processes;

The NCU can also have a greater role in the compilation of information related to climate change. However, given the fact that this entity is non- technical it would be more meaningful for the agency to collect and compile all non-technical information and reports on climate change of relevance to Guyana and for this information to be easily accessible to all members of the NCC and the public generally.

Enhancing data collection and dissemination within both the NCU and HD would require skills development among staff in the institutions, and possibly staff requirement where necessary, and the acquisition of equipment.

4.2 Enhanced Inter-Agency Collaboration

The 2001 report of the Working Group of the Intergovernmental Panel on Climate Change reinforced the importance of inter- agency collaboration. The report underscored that *"Successful adaptation [to the impacts of climate change] depends upon technological advances, institutional arrangements, availability of financing, and information exchange"* (IPCC, 1995 in INC, 2002).

Inter-agency collaboration is important in fostering resource sharing among agencies in the agriculture sector. Enhanced inter- agency collaboration would overcome many of the constraints agencies face and would enhance their capacity to implement mechanisms for climate change adaptation. Inter-agency collaboration would increase institutions' access to information and heighten institutional knowledge of climate change issues. Sadly, this understanding and appreciation

is not embraced in the sector as many agencies presently do not have strong bilateral and international linkages and have not indicated plans to support improvement of such.

The INC (2002) alluded to the capacity building benefits that can be had from structured cooperation programmes supported by multilateral agencies such as the United Nations, as well as bilateral agencies, such as the Canadian International Development Agency (CIDA) and the Japan International Cooperation Agency (JICA) that offer development assistance for environmental sustainability and climate change. Indeed, capacity building benefits can also be had where cooperation programmes are pursued with the regional climate institutions; such as the Caribbean Community Centre for Climate Change (CCCCC); the Caribbean Disaster Emergency Response Agency (CDERA); the Caribbean Environmental Health Institute (CEHI); the University of the West Indies- Centre for Resource Management and Environmental Studies (UWI- CERMES)

Inter- agency collaboration at the national level is predominant but pertains predominantly to information sharing. While this is important for developing institutional know- how in addressing climate change, it is imperative that collaboration stretch beyond basic information sharing as the need arises, to include regularly scheduled inter- agency training programmes; execution of public awareness programmes; data management; project execution and research initiatives. This can be effective where inter- agency collaboration occurs in a structured manner. For this to be realized inter- agency collaboration for the purpose of climate change adaptation must be provided for in the policies and legal apparatus of agencies.

Since climate change is not biased in its impacts, effective inter- agency linkages also need to be developed with agencies outside of the agriculture sector that address issues that cut across all sectors, such as the Ministry of Health and the Ministry of Housing and Water. It is important that agencies work together to share information, take common actions and have a clear understanding as to each other's role in responding to the effects of climate change (NCSA, 2007).

Undoubtedly, the NCC is the embodiment of inter-agency collaboration to address climate change since the committee represents an amalgamation of all stakeholder institutions with a role in addressing climate change. However, mere membership in this committee does not necessitate smooth collaboration among agencies. Enhancing the coordination role of the NCU and NCC is the most lucrative avenue to fostering effective inter-agency collaboration to address climate change. The regulatory capacity of the NCU and NCC should be improved to centralise their role as coordinating agencies for climate change issues. This should be pursued by way of an Act of Parliament that will give the entity regulatory capacity to address climate change.

Further, clear coordination procedures should be established within the NCU in order to forge more effective collaboration among member agencies of the NCC

4.3 Improving the Financial Framework

Improving the financial framework involves allocating additional resources to agencies as well as efficiently managing current financial resources.

Since inadequate financial resources were identified as the number one factor that will hinder effective adaptation to the impacts of climate change, i*dentifying and mobilizing financial resources quickly*

and timely should be the number one priority in seeking to enhance adaptive capacity, as is clearly articulated in the CCAP&IS Study (2002).

Mobilizing additional financial resources is critical to effective implementation of measures for climate change adaptation. Available financial resources will determine the extent to which other resources (human, technical and information) can be adequately strengthened to ensure continuity of activities in support of climate change adaptation.

Current government subventions are grossly inadequate for agencies to undertake measures for climate change adaptation (NCSA, 2007). Subventions to the agencies would therefore need to be drastically increased to increase the agriculture sector's adaptive capacity to climate change. Further, the system of accessing finance from the Ministry needs to be *free-flowing*. All regulatory barriers, including contention between key players, need to be removed in order for agencies to be able to access funds allocated to them in the national budget.

The current economic landscape of the country negates significant increases in government subventions to agencies. It is therefore necessary that steps are taken to identify alternative sources of new and additional finance to implement projects and execute tasks related to climate change. To this end, cooperation arrangements with international, regional and bilateral agencies should be actively pursued for the purpose of galvanizing support to alleviate current financial resource constraints.. Sources of possible funding include development assistance programmes from developed countries; multilateral agencies such as the Global Environmental Facility (GEF), UNFCCC and other agencies such as the Canadian International Development Agency *(CIDA)* and the Japan International Cooperation Agency (JICA) that offer development assistance for environmental sustainability and programmes to address climate change in developing countries.

Mainstreaming climate change into development policies plans would also contribute to alleviating current financial constraints as it would allow for climate change to 'piggy back' on existing financial resources.

5. IMPLEMENTING CHANGE

5.1 Recommendations to Improve Adaptive Capacity to Climate Change

Several changes are needed for the agriculture sector to develop the adaptive capacity to respond to the impacts of climate change. The consultants therefore make the following recommendations in order to improve institutional, human, technical and financial capacity to adapt to the impacts of climate change:

5.2 Human Resources Policy Review

Human resource constraints are one the major obstacles that will affect implementation of a strategy for climate change adaptation. As such, human resource policies need to be comprehensively reviewed to include provisions for skills development through regular training on climate change. Further, policies related to job recruitment in lead agencies should be reviewed to revise employee compensation packages for key positions that remain vacant.

5.3 Stakeholder Awareness Programmes

Public awareness should play a pivotal role in enhancing the adaptive capacity of the agriculture sector to the impacts of climate change. Farmers are often viewed as the underdogs in the institutional arrangement of the agriculture sector. However, they both influence and are affected by the policy framework within the agriculture sector. The effectiveness with which an adaptation strategy can be implemented will be determined by the level of knowledge and understanding of actors at every layer of the sector. It is therefore important that awareness programmes are established to increase farmers' understanding of the issue especially farmers in outlying regions who may not have adequate access to information/communication systems.

Awareness programmes should involve a wide cross- section of stakeholders along the coastal belt but should also target specific farming communities that are more vulnerable to erosion, salt intrusion, flooding and other negative impacts of climate change. The capacity of extension services can be developed to provide such training to farmers along the coastal regions. Further, such programmes can be integrated into the National NEEPAS programme.

5.4 Medium Term Systemic Legal/ Policy Review/ Reform

The existence of an effective legal framework is essential for implementation of measures for climate change adaptation. Given the varied mandates and polices of sub-sectors and the lack of specific reference to climate change, it is important that, at the sectoral level, policies/laws are created to guide agencies in addressing climate change issues. There is therefore the need for a comprehensive review of the existing policy framework and the amendment /creation of policies to incorporate climate change issues.

5.5 Institutional Policy Review

Since the lack of clear cut reference to climate change in the mandates and objectives of institutions reduces the priority attached and urgency with which agencies may respond to the issue, it is

important that the mandates and objectives of agencies are reviewed to incorporate measures for climate change adaptation. Sector plans should also be reviewed to include mechanisms that relate to climate change adaptation. Climate change will swiftly become a priority area for agencies to focus on once included in their mandate or incorporated into policy documents.

5.6 Human Resources Development Programmes

Programmes to encourage human resource development can be two- tiered; that is, they can have a short term and long term component. In the short term, training programmes should be developed to enhance staff awareness of climate change and its implications for the agriculture sector. This should be done in collaboration with other agencies in the sector to foster resource sharing. Agencies, should, as far as possible, take advantage of existing training programmes by seeking government financial assistance in order to increase the process of awareness building. The NCU can be the main executing body for training programmes on climate change in the agriculture sector. Training should focus largely on training trainers, that is, training staff at the supervisory level who can disseminate knowledge (though the preparation of reports and training) within the institution on their resumption of duties.

Further, a core unit with the competence to address climate change should be developed in lead agencies by shifting human resources to this unit and providing training for skills development or by recruiting staff skilled and trained in climate change. For other agencies in the agriculture sector without a key role to play in addressing climate issues, the capacity of the NCU can be developed to provide support to these agencies.

A longer term approach to developing human resources is to establish a memorandum of understating with the University of Guyana and other higher learning institutions to provide financial assistance and technical support for programmes to be developed in areas of relevance to the institution. However, this is a more realistic ideal in agencies such as the GRDB, Fisheries Department and the GRPA that generate financial resources.

5.7 Upgrade the Institutional Framework

There is a dire need for a core staff within agencies with knowledge of climate change issues or for the enhancement of the human resources capacity of the national climate change unit to successfully address climate change issues impacting on the agriculture sector. Hence, agencies should upgrade the institutional arrangement by amending authorized staffing structure to incorporate specialists with training in climate change.

5.8 Mobilize Additional Financial Resources

Additional financial resources should be mobilized from developed countries and donor agencies to ensure that all other capacity constraints are lowered to support continuity of activities in support of climate change adaptation.

5.9 Develop Data Management Mechanism

A mechanism should be established within agencies to enhance data management. This system should have adequate numbers of hardware and data management software programmes and one (1) or two (2) staff with the capacity to effectively manage the system. The system should possess adequate data management capacity and should act as the main repository and point of dissemination of information within agencies.

At the sectoral level, a database and central repository should also be created within an existing institution to manage and disseminate information on the nexus between climate change and the agriculture sector.

5.10 Prioritize Constraints in Terms of Urgent and Immediate Need for Building Adaptive Capacity

Given resource constraints, endogenous capacity constraints should be prioritised and addressed with regards to urgent and immediate needs for adaptation as all capacity deficits cannot be addressed in the short term. This would allow for concentrated efforts to progressively address those areas of critical importance to effective implementation of an adaptation strategy for the agriculture sector.

5.11 Policy changes to Strengthen Inter-Agency Collaboration for Climate Change Adaptation

From a national perspective, it is imperative that inter-agency collaboration move beyond basic information sharing. Agencies need to work together to take common actions such as, conducting regularly scheduled inter- agency training programmes; execution of public awareness programmes; data management; project execution and research initiatives; and to have a clear understanding as to each other's role in responding to the effects of climate change.

Agencies also need to pursue bilateral/international linkages to address climate change. Effective inter-agency collaboration offers agencies the opportunity to improve skills development through resource sharing. This benefit of inter-agency collaboration needs to be explored within the agriculture sector. Addressing inter-agency collaboration from a policy perspective is one means of realizing its effectiveness for climate change adaptation.

5.12 Implement the Recommendations and Strategy Options of Other Capacity Assessment Studies

It is recommended that institutions implement recommendations related to climate change adaptation that have emerged from major policy studies for lead agencies involved in climate change. It is useless for resources to be expended on policy studies that are not implemented. The recommendations of these studies are all geared towards capacity building for climate change adaptation. For instance, the overall recommendation of the NCSA (2007) for capacity building relates to collaboration and information sharing to overcome constraints.

6. ASSISTANCE REQUIRED

6.1 Need for Assistance

The capacity of both public and private, semi-autonomous agriculture institutions and technical units needs to be strengthened to support effective adaptation to the impacts of climate change Agencies are unable to effect changes given their resource constraints; assistance is therefore needed from both government and external sources to develop adaptive capacity to respond to the impacts of climate change.

6.2 Political Commitment

Given the current financial deficits within the institutions, improving capacity will require substantial increases in financial resources. Government commitment is therefore needed to increase subventions to agencies. Further, political support is needed for training programmes on climate change.

6.3 International Financial Assistance

Government subventions alone are unable to effect the institutional strengthening needed to be able to effectively implement a strategy for climate change adaptation in the agriculture sector. It is therefore imperative that financial assistance is sought from developed countries and donor agencies, particularly those with a mandate to assist developing countries in adapting to the impacts of climate change.

6.4 Technical Assistance

Technical assistance is needed for resource support- information and technical; policy reform and human capacity development.

Technical and information resources need to be buttressed in institutions to ensure adequate data management capacity and the preservation of institutional- know how in addressing climate change. Such assistance can be provided through financial subventions from multilateral agencies to purchase equipment and train personnel or via direct provision of equipment and experts to undertake in-organization training.

Assistance to develop adaptive human capacity can be provided by regional and international agencies to execute short and medium term (2-6 weeks) training programmes for staff on climate change adaptation. Such assistance can be provided in the form of specialist being sent to conduct training programmes through coordination with national agencies or financial support for national agriculture institutions to coordinate and execute training. Training can include a wide cross section of agriculture institutions rather than being agency specific so that resources are efficiently utilized.

Bibliography

Annual Budget Estimates- Current and Capital Estimates of Agencies 2000; 2002; 2004; 2006; 2008.

Caribbean Community, Caribbean Planning for Adaptation to Climate Change (CCAP&IS) Project, http://www.caricom.org/jsp/projects/macc%20project/CCAP&IS.jsp (Accessed August 31, 2008).

Caribbean Community, *Mainstreaming Adaptation to Climate* (MACC) Project, http://www.caricom.org/jsp/projects/macc%20project/macc.jsp (Accessed August 31, 2008).

Civil Defence Commission, http://www.cdc.gy/about.php (Accessed August 24, 2008).

Enabling activities for the preparation of Guyana's second national communication project (*overview).*

Environmental Protection Agency (EPA) (2000) Integrated Coastal Zone Management Action Plan.31 pp.http://www.guyanacoast.net/docs/Final%20version%20of%20ICZM%20Action%20Plan.pdf (Accessed October 19, 2007).

FAO (2008a) *Climate change for fisheries and aquaculture*. Technical background document from the expert consultation (7 to 9 April), Rome.

FAO (2008b) *Climate change adaptation and mitigation in the food and agriculture sector*, technical background document from the expert consultation held on 5 to 7 march, 2008, FAO Rome.

FAO (2008c) *Climate- related transboundary pests and diseases*. Technical background document from the expert consultation held on 25 to 27 February, 2008, FAO Rome.

Fisheries Department, Ministry of Agriculture. *Fisheries Management Plan (Draft)* (Revised October 2006).

Guyana Rice Producers Association (2008). The Farmer- RPA: Re-positioning for new challenges in the rice sector.

Guyana Forestry Commission Guyana, Forestry in Guyana 2007.

Guyana Act No. 11 of 1996. *Environmental Protection Act* 1996.

Guyana Energy Agency, (2008) *National Energy Efficiency Program.*

GUYSUCO (2007). *Vulnerability and Capacity Assessment: Impacts of Climate Change on Guyana's Agriculture Sector*. Study conducted at Wales Sugar Estate, Leguan and Mahaica Abary Rice Development Scheme (MARDS) (Second Draft). Prepared for the Caribbean Community Climate Change Centre (CCCCC) (December).

Institute of Development Studies and the School of Earth and Environmental Sciences. *Socio-economic survey* (final report) Socio-economic survey and public awareness programme:9M5189.22 ICB Guyana Bridging Phase.

Intergovernmental Panel on Climate Change. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Summary for Policymakers. A Report of Working Group II.

Khan, Sheik M. (2006) The National Capacity Self Assessment Project (NCSAP)- Stock-Taking and Thematic Assessment United Nations Framework Convention on Climate Change (Final Report). Prepared for the Guyana Environmental Protection Agency (February).

Mahaica- Mahaicony Abary- Agricultural Development Authority Act, Chapter 69:11 of the Laws of Guyana. ://www.geocities.com/mmaada2001/

Ministry of Agriculture- Guyana. Response to Oral Question on Clime Change by Hon. Robert M. Persaud, MBA, MP Minister of Agriculture. ://www.agriculture.gov.gy/Parliament/RESPONSE%20TO%20ORAL%20QUESTION%20ON%20CLIMATE%20CHANGE.

National Climate Committee (2002) *Guyana's Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low- lying areas*. Supported by the Caribbean Planning for Adaptation to Climate Change (April).

Sea Defence Act, Chapter 64:02 www.gina.gov.gy/gina_pub/laws/Laws/cap6402.pdf

Singh, Bhawan (2002). *Guyana Initial Communication in response to its commitments under the UNFCCC* (April).

Websites:

Hydrometeorological Service, Ministry of Agriculture http://www.hydromet.gov.gy/about.html

Fisheries Department, Ministry of Fisheries, Crops & Livestock: http://www.sdnp.org.gy/minagri/mfcl/fisheries/generalinfo.htm (Accessed August 3, 2008)

Sea and River Defence Division, http://www.guyanacoast.net/orga/srdd/index.html

Appendix D.1: List of Agencies Consulted

Government Ministries and Agencies	Contact Person		Date Visited
25. PD	Ms. Jacqueline Nero	Chief Planning Officer	Wednesday July 16th
26. HD	Ms. Bhaleka Seulall	Chief Hydrometeorological Departmentr	Tuesday July 15th
27. FD	Mr. Tejnarine Geer	Chief Fisheries Officer	Tuesday July 15th
28. NDIA	Mr. Lionel Wordsworth	CEO	Tuesday July 15th
29. GUYSUCO	Dr. Harold Davis	Director of Research	Friday July 18th
30. Project Cycle Unit	Mr. Cecil Seepersaud	Head of Project Unit	Thursday July 17th
31. GRDB	Mr Jagnarine Singh	General Manager	Monday July 14th
32. NGMC	Mr. Nizan Hassan	General Manager	Thursday July 24th
33. NDDP	Dr. Dwight Walrond	Head	Monday July 21st
34. GSA	Ms. Lynette Cunha	Principal	Friday July 18th
35. NARI	Dr. Oudho Homenauth	Director	Friday July 18th
36. GFC	Mr.James Singh	Comissioner	Wednesday July 16th
37. SRDD	Ms. Agnes Dalrymple Mr. Amsterdam	Sea & River Defence Officer Director of Projects	Thursday July 17th
38. EPA	Mr. Khalid Alladin	Director (a.g)	Wednesday July 23rd
39. NCU	Ms. Chandrapaul	Coordinator	Wednesday July 23rd
40. MoA	Dr. Dindyal Permaul	Permanent Secretary	Wednesday July 23rd
41. Skeldon Estate	Mr. Vishnu Panday	General Manager	Thursday 24th July
42. MMA/ADA	Mr. Obrey Charles		Friday 25th July
43. Ministry of Fisheries Crops and Livestock	Mr. Brian Sears	Chief Crops & Livestock Officer	Friday July 25th
44. UG, FAF	Dr. Theodosius Velloza	Dean	Tuesday August 19
45. PTCCB	Mr. Dwarka	Registrar	Thursday August 21st
46. GEA	Mr. Mahendra Sharma	Acting CEO	Tuesday August 19th
47. GWI	Mr. Jackson Twidale Harry Karl Sizle	Director of projects Legal Specialist Consultant	Wednesday August 28
48. GRPA	Mr. Dharankumar Seeraj	General Secretary	Wednesday August 28

Appendix D.2: Sample Questionnaire

Development Policy and Management Consultants
National Climate Change Adaptation Strategy for the Agriculture Sector of Guyana

INSTITUTIONAL CAPACITY ASSESSMENT QUESTIONNAIRE

CONTENTS OF THE QUESTIONNAIRE

Section A: Institution Background
Section B: Legislative/Policy Capacity Assessment
Section C: Climate Change Awareness Assessment
Section D: Human and Technical Capacity Assessment
Section E: Information Management
Section F: Financial Capacity Assessment
Section G: Inter-agency Linkages
Section H: Institutional Strength/Weaknesses in Climate Change Adaptation
Section I: Opportunities/ Threats

SECTION A: Institution Background

1. Name of Institution: _____

2. Mandate: _____

3. Legal Status (establishing act): _____

4. Please indicate the number and names of units/ departments within the agency
   _____
   _____
   _____

SECTION B: Legislative/Policy Capacity Assessment

1. Are there provision relating to climate change in the act establishing your organization or policy documents governing the agency? Yes [ ] No [ ]

2. Do you have the scope to implement regulations relating to climate change adaptation under the act establishing your organization? Yes [ ] No [ ]

3. Has the agency implemented the strategy and actions for the energy sector stipulated under the Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-lying Ares? Yes [ ] No [ ]

4. If yes, Please explain _____
   _____
   _____

SECTION C: Climate Change Awareness Assessment

5. What effect do you believe climate change can have on agriculture/ fisheries/ forestry?
   No effect [ ]
   Minimal effect [ ]
   Some effect [ ]
   Significant effect [ ]

6. Is your Institution aware of the predictions which have been made with regard to climate change in Guyana? Yes [ ] No [ ]

7. How would you rank the institutions awareness? High [ ] Fair [ ] Low [ ]

8. Does your institution have a plan for dealing with the effects of climate change?
   Yes [ ] No [ ]

9. If yes, please list the main points
   _____
   _____
   _____

SECTION D: Human and Technical Capacity Assessment

(**N.B.** Ask for copy of organizational chart or staff listing before asking questions 13-16)

10. How many professional staff is in your organization? _____

11. What are their disciplines and highest levels of qualification? _____

12. How many professional positions are vacant? _____

13. How many of the professional staff has had training in adapting to the impacts of climate change? _____ _____

14. Are you willing to make your staff available for training in climate change adaptation?
    Yes [ ] No [ ]

15. Do you have problems in recruiting and retaining professional staff with training in climate change? Yes [ ] No [ ]

16. Please list three of the main factors (in order of priority) affecting the recruiting and maintenance of professional staff with training in climate change?

_____
_____
_____

17. Do you have adequate support staff for the professional staff? Yes [ ] No [ ]

SECTION E: Information Management

18. How is climate related information managed in you institution? (Please complete table)

Information Management Table			
Type of information system	**Effectiveness**	**Data management capacity**	**Any other information**
	1. Very effective	1. Excellent	
	2. Effective	2. Good	
	3. Not effective	3. Fair	
		4. Poor	
		5. Non-existent	
Geographical Information System (GIS)			
Computer systems (Ms Word and other Software Programmes)			
Statistical Systems			
Any other system			

19. Please indicate the number of personnel who can use these systems effectively.
    _____

20. Is this number adequate for the current work load of the Institution? Yes [ ] No [ ]

21. If no, please indicate what increased numbers and training are needed.
    _____
    _____

22. What changes in your institution are needed in accumulating/ managing/ disseminating information related to climate change adaptation?
    _____
    _____

SECTION F: Financial Capacity Assessment

23. Are there sufficient financial resources within your institution to set up mechanisms to aid in efforts to adapt to climate change? Yes [ ] No [ ]

24. If no, please list the additional resources which may be required
    _____
    _____
    _____

25. What are the main limitations to acquiring additional resources and funding? (Please list three in order of priority)

_____
_____
_____

SECTION G: Inter-agency Linkages

26. Does your institution have bilateral and international linkages with other countries related to climate change? Yes [ ] No [ ]

27. Are these linkages very effective [ ] Effective [ ] or not effective [ ]

28. How can these linkages be modified to gain effective support for activities related to climate change adaptation?

_____
_____
_____

29. Does the institution collaborate with Ministries/ Departments or other Local agencies on climate change issues? Yes [ ] No [ ]

30. If yes, please explain the mechanism through which collaboration occurs?

_____
_____
_____

31. If no, please give reasons for lack of communication

_____
_____
_____

32. Do you have any suggestions on how Ministries/Departments/Agencies can be integrated to address climate change adaptation issues? Yes [ ] No [ ]

33. If yes, please state

_____
_____
_____

SECTION H: Institutional Strength/weaknesses in Climate Change Adaptation

34. What do you consider the strengths of your institution in adapting to climate change? (Please list three in order of priority) we have the human resource, machinery capacity to deal with climate change

_____
_____
_____

35. Does the institution have any programmes ongoing that may assist in adapting to the impacts of climate change? Yes [ ] No [ ]

36. If yes, please explain _____
_____
_____

37. What do you consider are the weaknesses in your institution in adapting to climate change? (Please list three in order of priority)
_____
_____
_____

38. Is anything being done to address these weaknesses? Yes [ ] No [ ]

(Please provide reasons for answer) _____
_____
_____

SECTION I: Opportunities/ Threats

39. Do you see any positive aspects of climate change for your institution? Yes [ ] No [ ]

40. If yes, please list three positive aspects of climate change for your institution.
_____
_____
_____

41. Do you see climate change as a threat to the socio-economic well-being your clientele? Yes [ ] No [ ]

42. If yes, please list three perceived threats in order of priority.
_____
_____
_____

Appendix D.3: Institutional Map- Major Institutions Involved in Climate Change Issues

Major Institutions involved in Climate Change Issues					
Government Ministries/Agencies					
		Institution Background		Inter-agency linkages in CC adaptation	
	Ministry of Agriculture (MoA)	Applicable Act/ Chapter	Mandate	International/Regional	National
Semi-Autonomous Agencies	2. The Guyana Rice Development Board (GRDB)	Act No. 15 of 1994	iii. Overseas market expansion iv. Development of research station and the facilitation of technology transfer v. Addressing any other issue that is of importance for the development of the sector.	No linkages for the purpose of climate change adaptation but collaborates with the Latin American Fund for Irrigated Rice (FLAR), Columbia and the International Rice Research Institute, Philippines for research purposes	NARI
	3. The Guyana Sugar Corporation	Company Act No. 29 of 1991	a. Cultivation of sugarcane b. Production and marketing of sugar and molasses	Currently collaborating with the Caribbean Community Climate Change Centre (CCCCC) to undertake a study on the Vulnerability and Capacity Assessment- Impacts of climate change on Guyana's Agriculture.	i. Cooperation with the Environmental Protection agency to ensure compliance of GUYSUCO's environmental controls and mitigation measures with changing EPA regulations. ii. National Climate Change Committee
	4. New Guyana Marketing Corporation	Section 46 of the Public Corporations Act, Cap 19:05 of the Laws of Guyana	i. Provision of market facilitation services to the exporters for the export of non-traditional agricultural produce. vii. Facilitate local market development viii. Develop and disseminate post- harvest technology ix. Conduct market research x. Provide market intelligence services to farmers/exporters.		
	5. National Drainage & Irrigation Authority (NDIA)	NDIA act of 2004	"To function as the nation's apex organization dealing with all public matters pertaining to management, improvement, extension and provision of drainage, irrigation and flood control infrastructure and services in declared areas of the	i. Cooperation arrangement with Japan for infrastructure Development. This arrangement is currently ongoing	Effective linkages with neighbourhood democratic councils (NDCs) and water users association (WUA) around.

			country."	ii. Cooperation with Dutch government through the European Union to improve D&I work.	
	6. Guyana School of Agriculture		viii. To offer theoretical and practical training in agriculture ix. To manage, develop and operate farms and undertakings of an agricultural and forestry nature, in accordance with good farming practices.		No linkages for climate change but cooperate with the following agencies with the following local institutions i. Regional Educational Programme for Animal Health Assistants (REPAHA), ii. University of Guyana; (UG), iii. The National Agricultural Research Institute (NARI), iv. Guyana Forestry Commission; (GFC), v. Caribbean Agricultural Research and Development Institute (CARDI), vi. Inter-American Institute for Corporation in Agriculture (IICA) These agencies provide advice and materials to students and lecturers.
	7. Mahaica Mahaicony Abary-Agriculture Development Authority	Mahaica-Mahaicony-Abary Agricultural Development Authority Act Cap 69:11 Act 27 of 1977	To support agricultural development in the MMA area by supporting the development and maintenance of infrastructures		
	8. Pesticides and Toxic Chemicals Control Board	Pesticides and Toxic Chemicals Control Act No. 13 of 2000	"To provide and promote the necessary infrastructures required for the establishment of a comprehensive registration scheme, with appropriate educational, advisory, health-care and extension services for enabling and exercising adequate control over quality, sale and usage of pesticides and toxic chemicals while ensuring that interest of end-users and manufacturer's rights are well protected".		
	9. Guyana Forestry	*Guyana*	To manage and control the utilization of	v. Linkages with the Food and	i. Collaborates with Conservation

	Commission	Forestry Commission Act 1979	the state's forests, ensuring an optimum and sustained yield of forest produce and the maintenance and improvement of the environment. The Guyana forestry commission addresses: i. Issues relating to forest policy, forestry laws and regulations ii. The administration and management of all state lands iii. The development and monitoring standards for forestry sector operations iv. Development and implementation of forest protection and conservation strategies v. Coordination of forest research vi. Provision of support and guidance for forest education and training.	Agriculture Organization (FAO); the International Tropical Timber Organization (ITTO) and the Barbados and Trinidad offices of the FAO. vi. Member of Caribbean Foresters' Association (CFA), the Latin American and Caribbean Forestry Commission (LACFC) and is a signatory to the Amazon Cooperation Treaty (ACTO). vii. Participates in the RED (reduced emissions from deforestation) and the foreign carbon partnership facility (FCPF) initiatives of the World Bank.	International (CI) for capacity building ii. Collaborates with the Hydrometeorological Office to ascertain information on weather patterns, which is disseminated to logging agencies. iii. World Wildlife Fund (WWF)
	10. National Agricultural Research Institute	National Agricultural Research Institute Act No. 19, which was passed on the November 1984	" plan, develop and implement research designed to produce technologies and systems required to maintain national self sufficiency and export capacity."	The Institution works in collaboration with local and regional research agencies including CARDI.	(a) Good linkages with local and international agencies
Technical Divis	11. National Climate Change Unit		To facilitate in Guyana, 'a sound knowledge base of the realities of Climate Change and the identification and		Collaborates with the EPA for national assessments and consultations

			implementation of appropriate mechanisms and actions for effective response.'		
	12. Planning department/ Statistical services of the Ministry of Agriculture		To promote and support the development of agriculture in Guyana through: 1. The collection, compilation, analysis and dissemination of statistics on the agriculture sector; 2. Coordination and monitoring of agricultural plans and programmes	Cooperate with the CARICOM Secretariat in sharing statistics.	Collaborates with the plant health unit of the MOA and the National Agriculture Research Institute (NARI) only for work within its mandate.
	13. Fisheries Department	Fisheries Act 1957	"To manage, regulate and promote the sustainable development of Guyana's fishery resources for the benefit of the stakeholders in the sector and the nation as a whole."	Has a linkage with the Caribbean Regional Fisheries Mechanism (CRFM) which facilitates linkages with the Dalhousie University. Through the CRFM, the MOF has strong links with sister Caribbean countries.	Collaborates with the Guyana Trade and Investment Support (GTIS) arm of the United States agency for International Development (USAID) for the development of clusters within the Fisheries Sector. Collaborates with the Hydrometeorological Office of the Ministry of Agriculture.
	14. Agriculture Project Cycle Unit		"To facilitate policy analysis and development, provide overall co-ordination, direction, monitoring and evaluation for agricultural services planning, including the verification, preparation, monitoring and reporting on programmes and projects within the agricultural sector."		
	15. Hydrometeorology Department		The mandate of the Hydrometeorological Office is to undertake research and provide data in the areas of hydrological, oceanographic and meteorological sciences both in accordance with the national needs of Guyana's productive sectors and the country's international obligations.		Collaborate with EPA

	16. The National Dairy Development Programme		Inherent in the above are the objectives of the Programme. These include: 2. To increase milk production via improvements in pasture availability/management, dairy herd management, breeding policies and education/extension services. 3. To be instrumental in helping to improve the facilities relative to the collection, processing and distribution of milk and milk products throughout Guyana in keeping with acceptable hygiene and nutritional standards. 4. To achieve full self-sufficiency in milk and milk products in the shortest time possible and replacing present imports with domestic production. 5. To provide an alternative and lucrative means of earning a living.	NDDP is actively involved in supporting research activities of CARDI and IICA.	No linkages for climate change. The NDDP liaises with other local (e.g. GUYSUCO, LIDCO), regional (e.g. Caribbean Agricultural & Research Development Institute (CARDI)), extra-regional (e.g. Inter-American Institute for Co-operation in Agriculture (IICA)) and other Non-Governmental Organizations whose activities are supportive and complementary to the NDDPs efforts
	Office of the President				
Statutory bodies	17. Environmental Protection Agency	Environmental Protection (EP) Act of 1996	To promote, facilitate and coordinate effective environmental management and protection; and the sustainable use of Guyana's natural resources.		a. Sits on the board of Climate Change Committee b. Collaborates with the Hydrometeorological Service of the MoA e.g. The two agencies collaborated to execute the 2001 Coastal Vulnerability and Risk Assessment.
	18. Guyana Energy Agency	Guyana Energy Act of 1977 (Cap: 56:05)	To ensure the rational and efficient use of imported petroleum-based energy sources, while encouraging, where economically feasible and environmentally acceptable, increased utilization of indigenous new and renewable sources of energy.		

	Ministry of Public Works and Communication				
Technical Units	19. Sea and River Defense Division	Cap. 64:01 and Cap. 64:02 Sea defences Acts	To undertake structural designs for sea and river defence.	SRDD does not have any bilateral and international linkages with other countries but recognizes that such linkages are important. The agency once possessed linkages with Delf Hydraulics and IUG (Netherlands) but these links were severed due to government's unwillingness to allow personnel to attend conferences and training programs.	Has good working relationship with the Regional Democratic System Sea Defense Board and the national; drainage and irrigation authority (NDIA). Collaborate with neighbourhood democratic councils (NDCs) by attending monthly meetings of RDCs. However, collaboration is not effective, as communication is sometimes poor.
Private Institutions/Agencies					
	20. The Guyana Rice Producers Association	in 1946 as a Non-Governmental Organisation	The protection, promotion and enhancement of the interests of rice producers generally. 1. The proposal of any measures including Co-operative Schemes of all kinds conducive to the maintenance or extension of production in the industry. 2. Making representations to the Minister concerning any matter affecting production in the industry, the operators of the Rice Marketing Board and the interests of rice producers		
	21. Guyana Water Incorporated	Water and Sewerage Act 2002 Cap 55:01	To deliver safe, adequate and affordable water and to ensure safe sewerage systems for improved public health and sustainable economic development.		

University of Guyana					
	22. Faculty of Agriculture and Forestry, University of Guyana		The Department of Agriculture is aimed at producing highly trained professionals through teaching, research and service to cater for the development of agriculture to meet national and regional needs. The Department of Forestry is committed to produce a cadre of professionals through excellence in teaching, research and service to meet changing demands in forestry and related sectors locally and regionally.		

Strengths, Weaknesses, Opportunities and Threats for Climate Change Adaptation

Capacity for Climate Change Adaptation					
Government Ministries/Agencies					
Ministry of Agriculture (MoA)		**Strengths**	**Weaknesses**	**Opportunities**	**Threats**
Semi-Autonomous Agencies	The Guyana Rice Development Board	(a) Sufficient financial capacity to address climate Change related issues. (b) Extension program can accommodate climate change adaptation (c) Knowledge of the prognosis on climate change (d) Research-oriented work already geared towards increasing the sector's resistance to the effects of climate change. (e) Semi- autonomous agency	(a) Difficulty in recruiting and retaining technical staff (b) Importance of climate change not sufficiently emphasized (c) Information to farmers to adopt new practices not adequately disseminated (d) Inadequate human resource capacity to undertake research work (e) Insufficient financial resources to undertake research work.	(a) Lower rainfall can increase yields. (b) Challenge to find solutions to adapt to climate change.	(a) Lower income to farmers (b) Lower production due to increased incidence of pests and diseases.
	The Guyana Sugar Corporation	(a) Sufficiently informed about climate change issues and predictions for Guyana (b) Research capacity to deal with the issue. (c) Have developed plans for adaptation to climate change. (d) Adequate human resources to respond to climate change effects. (e) Semi-autonomous agency.		(a) Exploring the possibility of biological control of pests and the use of sugar for energy	(a) Reduction of harvesting period due to intense and inconsistent rainfall and resulting loss of human resources.
	New Guyana Marketing Corporation	(a) Institutional awareness of climate change and the predictions that have been made for Guyana. (b) Current reorganization initiatives should enhance capacity to address climate change issues. (c) Semi-autonomous agency.	(a) No written plan for dealing with climate change effects. (b) Limitation in authority with regard to staffing. (c) Insufficient financial resources to cope with unbudgeted expenses. (d) Capacity deficit in technical resources (e) No strong collaboration/ linkages with local/ regional	(a) Climate change may create market opportunities for the GMC.	(a) Product quality lowered due to increased incidence of pests and diseases.

			institutions for climate change adaptation.		
	National Drainage & Irrigation Authority	(a) Institutional awareness of the impacts of climate change. (b) Have developed plans for climate change adaptation, such as improving/rehabilitating D&I infrastructure e.g. conservancy adaptation works at the East Demerara Water Conservancy; and the review of D&I criteria. (c) Human resources with training in climate change adaptation (approximately 80%). (d) Sufficiently functioning information system; computers and radio networks in place for communication with field locations. (e) Strong linkages with Regional Democratic Councils (RDCs) and Water Users Associations (WUAs). (f) Semi-autonomous agency.	(a) Inadequate financial resources to establish mechanisms to facilitate adaptation to climate change. (b) No International Linkages specifically for climate change adaptation	(a) Increased access to financial resources to improve D&I infrastructure. (b) Increased cooperation with other countries for improving D&I infrastructure. (c) Water balance could be achieved through planned storage and drainage.	(a) Loss of income by farmers (b) Increased cost of drainage and irrigation activities, more so by pumping. (c) Competition for land use; lands converted to water storage could have been used for more economical purposes.
	Guyana School of Agriculture	(a) Climate change concepts included in the school curriculum at the Diploma and Certificate levels. (b) Have good linkages with NARI (c) Semi-autonomous agency.	(a) Inadequate budgetary allocations; government tends to decide on funding priorities. (b) Data management capacity of computer systems is weak due to antiquated hard and soft wares.	(a) Can be become a premier institution at producing agriculture experts with training in climate change issues.	(a) Localized drainage problems given current state of D&I infrastructure.
	Guyana Forestry Commission	(a) Fully aware of climate change predictions and issues. (b) Code of practice takes climate change into account. (c) Established Forest Management Plan aimed at improving harvesting practices. (d) Strong linkages with National,	(a) Act mentions environmental services but no specific reference to climate change. (b) No human resources with training in climate change; only one staff member has had training in climate change issues. (c) Lack of professionals with post graduate qualification in climate	(a) Capacity building in climate change (b) Intense rainfall can compel harvesters to work more intensely; shortening the harvesting period	(a) Intense rainfall can adversely affect production and harvesting given current infrastructure and thus the welfare of those who are dependent on forestry for their livelihood.

		Regional and International agencies such as FAO, WWF, ITTO, CFA, LAFC; Signatory to Amazon Cooperation Treaty; HD of the MoA. (e) Access to information (f) Semi-autonomous agency.	change and environmental management and carbon climate methodology		
	National Agricultural Research Institute	(b) High institutional awareness of climatological issues and the predictions that have been made for Guyana. (c) Computerized data management system with flexibility to adjust to the needs for accumulating, managing and disseminating information. (d) Research work to cope with effects of climate change; e.g. establishment of greenhouse production, drip irrigation, organic farming systems in the intermediate savannahs. (e) Regularly conducted programmes for farmers and extension staff. (f) Semi-autonomous agency.	(a) No crop breeding programme for adaptation to climate change due to lack of technical staff. (b) Inadequate financial resources to adapt to the impacts of climate change.		
	Mahaica Mahaicony Abary-Agricultural Development Authority	(g) We have the human resource (h) Machinery capacity to deal with climate change	(c) Lack of information-information is provided via newspapers etc. information is needed on what is climate change- so you need basic information. (d) Lack of staff with training in climate change	(a) Opportunity for increasing knowledge	(b) Shortage of water (c) Pests and diseases to crops (d) Our inability to give the farmers the type of service they require because of effects of climate change on rivers.

Technical Divisions/Units/Committees	National Climate Unit	(a) High institutional awareness of climate change issues and predictions for Guyana. (b) Adequate computer systems (c) A specialized unit to address climate change issues.	(a) Inadequate professional staff. (b) Office at an incipient stage of development. (c) Does not legislative autonomy.		
	Crops and Livestock Support Services	(a) Highly aware of climate change issues. (b) Extension Services over the last two years have been greatly reorganized and strengthened- human and technical resources have been added to the department. (c) Have adaptation techniques such as raised beds, green house techniques, shade houses, cropping patterns and drip irrigation systems. (d) Good linkages with the Climate Change Unit	(a) Insufficient human resources (b) Lack of skilled staff in the use of computer systems. (c) Insufficient financial resources, for climate change adaptation (d) No linkages with International Agencies. (e) No bonds or shelters in cases of emergency to store food for cattle. (f) No legislative autonomy.	(a) A positive behavioural change among farmers with respect to agricultural practices. (b) Availability of International funding for implementation of adaptation measures.	(a) Severe crop and livestock losses (b) Deterioration in the economic wellbeing of farmers.

	Fisheries Department	(a) High awareness of climate change predictions for Guyana and likely threats to the Fisheries Sector. (b) Access to information from local (Hydrometeorological Office of the MoA) and international agencies (FAO) involved in climate Change.	(a) Lack of a unit/structure within the institution to deal with climate change issues. There are currently only four units within the Department. These are: i. Research and Development Unit ii.Extension Unit iii.Legal and Inspectorate Unit iv.Clerical and Support Unit (b) No legislative/ policy capacity to address adaptation to climate change. Draft Fisheries Management Plan does not include regulations for climate change adaptation (c) Insufficient budgetary allocations. (d) Lack of human resources with training in climate change adaptation. (e) No external linkages specifically for climate change. (f) Inadequate computer systems.	(a) Rising temperatures can abet production since fish grow faster in higher temperatures. (b) Intense rainfall can also improve production of prawns by diluting the salinity of brackish water.	(a) Decline in the biological presence of certain fish species (b) Increased cost of fishing as rising water temperatures force fish to go further out into the sea. (c) Severe socio-economic impacts for those who rely on the sector including; artisanals, single parents and other vulnerable groups. (d) Increased social payments by government for to affected groups in the industry. (e) Increased rainfall may affect sea bob spawning as well as spawning of small inland species.
	The East Demerara Conservancy Board	(a) Strong linkages with the MoA. (b) Adequate finances	(a) Lack of staff with training in climate change.		
	Hydrometeorology Department	(a) Extensive knowledge of climate change issues. (b) Established plans to enhance capacity for work related to climate change adaptation. (c) Strong linkages with local as well as international agencies.	(a) Difficulties in recruiting persons with the required skills due to inflexible public service rules and low emoluments. (b) No legislative capacity to address climate change issues. (c) The effectiveness and capacity of the computerization of office functions are weak (d) Insufficient financial resources. Capital funds are satisfactory, but recurrent are low. (e) No climate modelling done or technical research conducted due to lack of staff.	(a) Enhanced training for staff.	

	Planning Department		(a) Limited knowledge of climate change and its effects. (b) No plans for climate change adaptation (c) No staff with training in climate change. (d) Inadequate technical resources, such as computers and fax machines. (e) Insufficient financial resources to support climate change adaptation.		
	The National Dairy Development Programme	(a) Fair institutional awareness of climate change issues (b) Supervisory staff has been receiving training in climate change adaptation. (c) Adequate knowledge among staff, and effectiveness of computer systems for data management. (d) Local linkages related to climate change adaptation. (e) Four professional staff have had training in climate change adaptation	(a) No plans for adaptation to climate change. (b) Inadequate financial resources to support adaptation to the impacts of climate change. (c) No international linkages related to climate change adaptation.	(a) Increased export of beef.	
	Pesticides and Toxic Chemical Control	(a) Autonomous/ operate independently (b) Operate mobile (c) In constant contact with filed staff and other stakeholders	(a) Unable to monitor all importing points; depend on customs (b) Depend on data from overseas agencies; information is used under local conditions; mistakes are often made	(b) Work closely with the sector	(a) New and invasive species-need to keep apace with technology to treat new and invasive species
Office of the President					
Statutory bodies	Environmental Protection Agency	(a) A specialized semi-autonomous environmental agency. (b) Extensive knowledge of climate change impacts (c) Able to recruit and maintain professional staff. (d) Fully computerized	(a) Climate change not recognized as a priority area for the institution. As such, there is no established plan for climate change adaptation. (b) No professional staff with training in climate change adaptation. Need a climatologist.		

		information system with sufficient data management capacity. (e) Experienced in carrying out education and awareness programmes on environmental management, with some focus on climate change. (f) Involved in national assessments and consultations. (g) Effective implementation of environmental regulations and the EIA review process.	(c) Inadequate financial resources to support climate change adaptation. (d) In adequate local linkages with climate agencies. Linkage mainly through National Climate Committee.		
	Guyana Energy Agency	(h) Involved in information dissemination related to energy efficiency.	(e) Insufficient numbers of personnel with training in climate change.	(a) Resource assistance to achieve mandate which relates to utilizing cleaner sources of energy.	(b) Increased environmental, economic and social cost to find alternatives sources of energy.
Ministry of Public Works and Communication					
Technical Units	Sea and River Defense Division	(a) Division now incorporated into the Work Services Group. (b) Full awareness of climate change predictions. (c) Flexibility in sea defence design which can accommodate climate change effects. (d) Good working relationship with the Regional Democratic Councils and Governmental agencies. (e) Financial support for project execution to undertake development works that will aid in climate change	(a) No legislative capacity to address climate change adaptation as there are no provisions within the establishing act to address the issue. (b) Human resource capacity deficit. Only about 60-70% of authorized staff positions are filled. This affects monitoring of sea and river defences. (c) Only one staff member trained in climate change adaptation (d) Inadequate information management capacity. (e) Inadequate financial resources. Some sea defence structures are	(a) Innovation in sea defence designs. (b) Improved monitoring and enforcement.	(a) Increased possibility of breaches in the weaker sea defences and overtopping in low embankments

		adaptation.	designed to accommodate available finances. (f) No International linkages.		
Private Institutions					
	GRPA	(a) Acceptance of the issues and willingness to incorporate it into our work plan (b) Training and awareness	(a) No legislative/ policy capacity (b) Resource limitations- finance, human and technical	(a) can expand production given natural resource endowments	(a) Increased cost of production (b) Lower productivity (c) Lower product quality (d) Increased incidence of migratory pests and diseases.
	GWI	(a) The development of the emergency response plan (b) officers participated in disaster management conferences (c) have personnel with the capacity to learn	(a) High attrition rate leading to high training cost	(a) Expansion of water access systems in the Rupununi (b) Improving soci-economic systems	(a) Increased flooding
Ministry of Education					
	UG, FAF	(a) educational and research institution- staff would be readily willing to learn new information (b) willingness to train and be trained (c) can implement courses if necessary	(a) Small staff numbers	(a) access to funding for courses (b) technical resource support- possibility of accessing equipment	