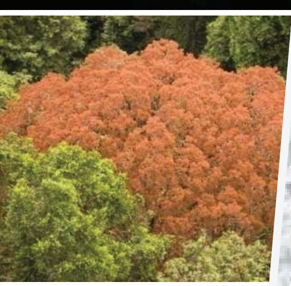

Guyana

Second National Communication to the United Nations Framework Convention on Climate Change

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Prepared by the Government of Guyana with support from the UNDP and the National Communication Support Programme

March 2012

GUYANA

Second National Communication to the UNFCCC

This report is Guyana's Second National Communication (SNC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC).

The softcopy version of the report is available at www.lcds.gov.gy.

Funded by	*The Global Environment Facility*
Implementing Agency	*The United Nations Development Programme (Guyana)*
Executing Agency	*The Ministry of Agriculture*
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Cover Page Photos *Lynton Lam; Fotonatura; http://www.alltravels.com/guyana/all-regions/mackenzie/photos/current-photo-51083821; Graham Watkins*

Chapter Title Photos

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Text Photos

Kaieteur News, P. Pitamber, S. James, Fotonatura, http://www.gina.gov.gy/archive/, http://www.kerrykriger.com/travel/guyana.html

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Table of Contents

List of Figures

List of Tables

Foreword

It is now clear that warming of the climate system is unequivocal. According to scientists, the largest and fastest warming trend in earth's history has occurred during the last century. The Inter-Governmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) projections indicate that average global temperatures could rise by as much as four degrees by the end of the twenty-first century. Climate Change will have wide ranging effects on the environment: on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems, biodiversity, and coastal zones.

Developing countries such as Guyana are highly vulnerable to the impacts of climate change. Guyana will face serious challenges from sea-level rise and extreme weather events such as intense rainfall and extensive dry periods. This coupled with the fact that ninety per cent of the population live on the relatively flat coast, which is below mean sea-level, and seventy per cent of the population depend on agriculture and agriculture-related activities for their livelihood, amplify the country's vulnerability to these extreme weather events. However, though many do not understand the complexities of climate change, Guyanese have already started to note, with concern, the trend of above normal rainfall, the frequency with which longer, wetter spells occur, and the intense dry periods, as well as the greater frequency of marine inundation due to rising sea-levels.

In recognition of the need for global action to combat climate change, Guyana became a Non-Annex I party to the United Nations Framework Convention on Climate Change in June 1992, and has since made significant progress in the implementation of the Convention's principles to combat global climate change. In 2002, Guyana prepared its Initial National Communication (INC) where the Greenhouse Gas Inventory (GHG) Inventory findings show Guyana as a net sink for greenhouse gas removal, due mainly to the country's large tract of tropical forests. The INC also highlighted the country's vulnerability to sea-level rise and extreme weather events. This Second National Communication has built on the findings of the INC and the experiences in recent years, both national and global, to provide more credible assessments and identify realistic solutions for climate change adaptation and mitigation.

Particularly in recent years, Guyana has received international recognition for its efforts in combating global climate change. In May 2010, the Government of Guyana launched the world's first national scale model for a low carbon economy - Guyana's Low Carbon Development Strategy (LCDS). The LCDS seeks to provide an innovative approach on how to stimulate the creation of a low-deforestation, low-carbon, climate-resilient economy. Guyana is also one of the first fourteen (14) countries to be formally approved as a participant in the World Bank’s Forest Carbon Partnership Facility (FCPF), looking at ways of Reducing Emissions from Deforestation and Forest Degradation (REDD). The Government has also recognized that adaptation will cost Guyana billions of dollars. Nevertheless, Guyana will continue to be a leading and active participant for the establishment and implementation of mechanisms and programmes to mitigate greenhouse gas emissions and strengthen adaptation.

This SNC is not only important as a submission to the UNFCCC, but as a capacity building and institutional strengthening process for national climate information and understanding. In this regard, I wish to commend all those involved, directly or indirectly, in the preparation of Guyana's Second National Communication, 2012.

Mr Shyam Nokta
Presidential Adviser and Head, Office of Climate Change
Chairman, National Climate Committee

Acknowledgments

The Government of Guyana and the Ministry of Agriculture express their gratitude to the Global Environment Facility, the United Nations Development Programme – Guyana, and the National Communications Support Programme for funding and support in the preparation of this National Report.

Special thanks to the various Ministries, Agencies, Departments, and other key stakeholders for their active participation and collaboration in providing pertinent information and reviews.

The expertise of the authors of the various chapters, editors, the Project Management Team and the Project Steering Committee are appreciated.

Executive Summary

Background

Guyana became a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED) in Rio de Janiero on June 13,1992 and attained ratification on August 29, 1994. The Convention entered into force for Guyana on November 17, 1994. Under Articles 4.1 and 12.1 of the Convention, Guyana being a Non-Annex I and Non-Annex II Party to the Convention is required to submit national reports to the Conference of Parties (COP) on its efforts to implement the Convention and address climate change. In 2002 Guyana submitted its Initial National Communication (INC) to the COP.

On July 10, 2007, the Ministry of Agriculture on behalf of the Government of Guyana and the United Nations Development Programme (UNDP) signed an agreement for the preparation of Guyana's Second National Communication (SNC) to the UNFCCC. Through the preparation of the SNC, the institutional and technical capacity of Guyana has been strengthened to allow the country to meet its UNFCCC obligations.

The SNC comprise of seven main components/chapters, namely: National Circumstances of the country; Greenhouse Gas Inventory from base year 2000; Measures to facilitate Adaptation to climate change; Measures to Mitigate climate change; Research & Systematic Observation Systems including a Technology Needs Assessment; Public Education & Capacity Building; and identification of gaps & constraints related to financial, technical and capacity needs.

A Project Steering Committee(PSC) comprising several key government agencies; the National Climate Committee(NCC) and the Office of Climate Change (OCC), Office of the President provided overall guidance, technical and otherwise, for the preparation of the SNC. The activities for the various components were done through local and international consultancies. The base year for the SNC is 2000.

1.0 National Circumstances

Guyana is a tropical country located on the Northeastern coast of South America. It has a total territory of 214,970 square kilometers and is bounded by the Atlantic Ocean on the north, Suriname on the East, Venezuela on the West and Brazil on the West and South. The Coastline with the Atlantic extends for 430 Kilometers. This coast lies at 1.4 metres below mean high tide level of the Atlantic Ocean and is particularly vulnerable to flooding, erosion and salinisation. This relatively flat coast is protected by concrete and earthen sea-defence structures, with remaining areas covered by mangrove, sand and shell beaches.

South of the coast, 18.39 million hectares of tropical rainforests cover approximately eighty-five percent of the total land area. Through sustainable management Guyana has had relatively low historical rates of deforestation - 0.1 to 0.3 percent. However, these rates can increase as well as greenhouse gas emissions, if efforts to control deforestation and degradation are not applied.

Guyana has a high level of rainfall variability and the seasons and climate are determined mainly by this variability. There are two wet seasons (April to July & Nov. to Jan.) and two dry seasons (Feb. to April & July to Nov.). The Major weather system is the Inter-tropical Convergence Zone (ITCZ) and the Major climate system is the El Nino Southern Oscillation (ENSO)[1].

Over the last century, Guyana has experienced significant changes in its climate. The records suggest an increase by 1.0°C of the mean annual temperature within the last century. In recent years, there has been many extreme weather events that have resulted in high levels of flooding especially along the coast and in some inland areas. In Guyana, it is projected that by the end of this century, temperatures can increase by up to 4°C and weather patterns will become more extreme. Sea level is projected to rise at a rate of 1cm/year, about 40cm-60cm by the end of the 21st century. Such rise in sea level will inundate wetlands and lowlands; accelerate coastal erosion; exacerbate coastal flooding; threaten or destroy coastal structures; raise water tables and increase the salinity of rivers and aquifers.

Over the past two decades, Guyana has experienced more positive economic growth in almost every year ranging from 2.0% to 7% GDP growth rates. External debt is now less than half what it was in the early 1900's. This has enabled considerable expansion in social sectors, such as , education and health. The major economic sectors are agriculture which contributes some 35% of GDP and employs between 30-35% of the labour force. The other sectors include the extractive industries (forestry and mining); manufacturing and tourism.

Guyana is highly dependent on fossil fuel imports to meet its energy needs. Energy demand per capita in Guyana has been fairly stable, fluctuating between 5bbls/year in 1998 and 4.2bbls/year in 2006. Energy demand per capita in Guyana can reasonably be expected to increase as a result of climate change, mainly for space cooling due to the warmer climatic conditions in the country. Guyana's vast natural resource base provides the country with significant options for the development of renewable energy. Energy from biomass is also an important source of

[1] Initial National Communication, 2002

energy in Guyana. Solar technology has increased in hinterland areas and for domestic hot water. Guyana has a large hydro-power potential of an estimated 7000 mega watts. The Amaila Falls hydro-electric project is a major energy investment with an estimated 165MW potential and is expected be completed in 2014 thereby reducing the country's dependence on fossil fuels for energy generation.

Adapting to climate change is one of the biggest challenges for Guyana. Total adaptation is projected to exceed about US$1B – a conservative estimate. In protecting the coast from the Atlantic Ocean the government needs to fortify 360 Km of sea defences at an approximate cost of US$4.4-6.4 Million per Km. Guyana's vulnerability is further amplified with 90% of its population residing on the low-lying coastal plain; main agriculture lands; and all major administrative, economic, service and infrastructure facilities. Although the country is very rich in natural resources, its economic base is very narrow with a strong dependence on a very small range of primary products for export.

Nevertheless, despite its high vulnerability to the impacts of climate change, Guyana has been undertaking significant efforts at the national and international level to combat this phenomenon in the context of sustainable development. In 2010, the Government of Guyana launched a pioneering and historic, national scale model for addressing climate change - Guyana's Low Carbon Development Strategy (LCDS). The LCDS is a comprehensive approach to addressing climate focusing on both mitigation and adaption priorities while simultaneously promoting economic growth and development. Guyana is also one of the first fourteen (14) countries to be formally approved as a participant in the World Bank's Forest Carbon Partnership Facility (FCPF), looking at ways to Reduce Emissions from Deforestation and Forest Degradation (REDD).

2.0 Greenhouse Gas Inventory

In conducting the GHG Inventory of the SNC, the government of Guyana has estimated GHG emissions by sources and removals by sinks, along with time series analyses for the years 1990 to 2004. However, for purposes of Reporting of the SNC of Guyana to the UNFCCC, the year 2000 is to be considered the Reference Year. The greenhouse gases included in the inventory include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO) and oxides of nitrogen (NOx). Methane (CH_4) and nitrous oxide (N_2O) are also reported as CO_2 equivalents (CO_2e) based on their respective 100-year global warming potentials. For the major GHG gases, namely CO_2, CH_4 and N_2O these are also presented as CO_2e. SO_2 emissions are insignificantly small and are not included.

CO_2 emissions derive mainly from the Energy sector and produced mainly from the energy generation and transport sub-sectors. CO_2 removals derive exclusively from the Land use Change and Forestry sector derive mainly from the forest and grassland conversion sub-sectors. CH_4, especially when expressed as CO_2e derive mainly from the rice cultivation and domestic animals sub-sectors in the Agriculture sector. N_2O, emissions are minimal even when expressed as CO_2e and derive mainly from the domestic animals and manure management sub-sectors. NOx emissions are also minimal and derive from the Energy and Agriculture sectors. CO emissions are slightly higher and derive from the Agriculture, Energy and Land Use Change and Forestry sectors. Finally, NMVOC emissions are also minimal and derive from the Energy and Industrial Activities sectors.

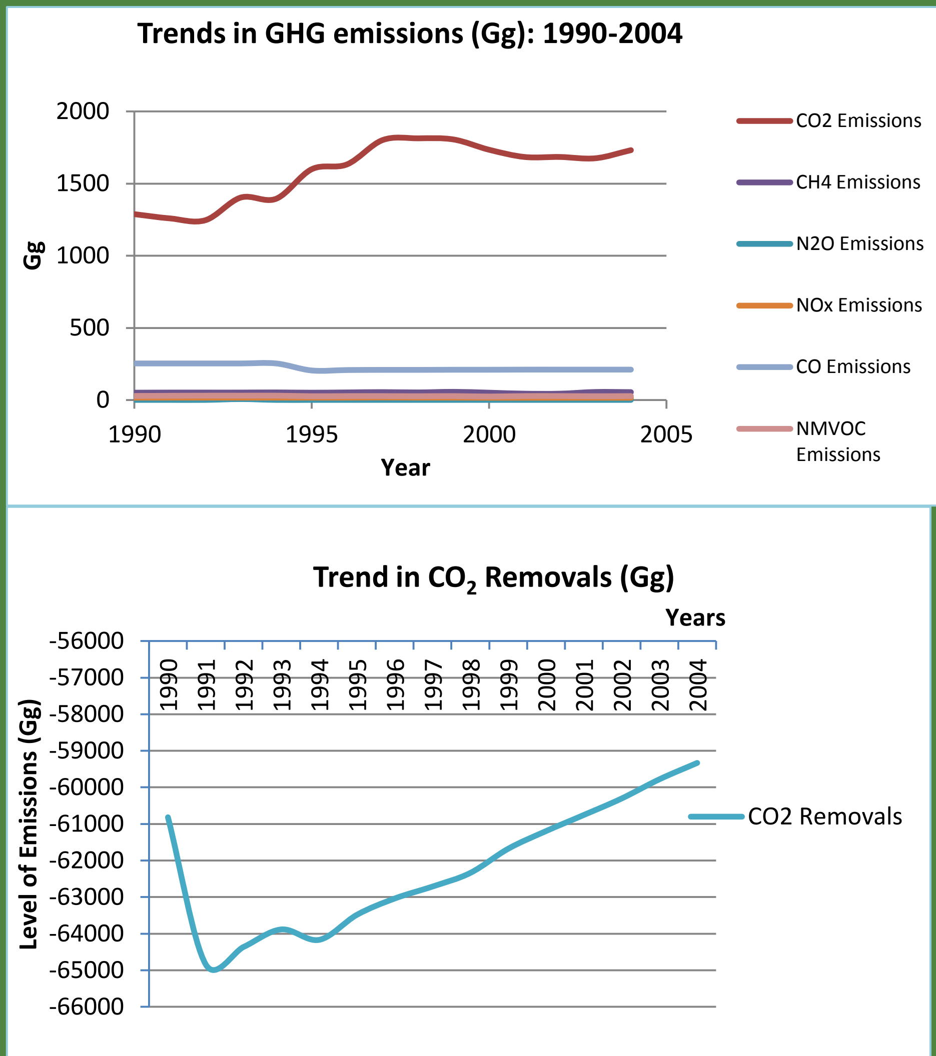
For the period examined (1990-2004), there is an apparently slight upward trend in GHG emissions. CO_2 emissions (Reference) range between 1,246 Gg (1992) and 1,813 Gg (1998), whereas GHG Removals (Forestry) vary between -60,818 Gg (1990-1993) and -62,468 Gg (2001).

The non-CO_2 gases emissions are also remarkably stable from year to year. CH_4 emissions vary between 44 Gg (2002) and 56 Gg (2001). N_20 emissions remain stable at around 1 Gg for all years. CO however ranges from 149 Gg (1999) to 254 Gg (1990-1994). Finally, NMVOC emissions vary between 24 Gg (2000) and 30 Gg (1992-1994).

There are a number of uncertainties pertaining to the GHG inventory for Guyana for the years 1990-2004. Some sectors suffered from a lack of comprehensive activity data; lack of disaggregation and almost all conversion and emission factors used were default values extracted from the relevant IPCC guidelines.

The Key Sectors are the Energy Industries, Agriculture and Land Use Change and Forestry sectors. It is therefore evident that the major focus of GHG mitigation for Guyana, as part of its Nationally Appropriate Mitigation Actions (NAMAs), should be directed at the Energy Industries, Agriculture and Land Use Change and Forestry sectors. Not being highly industrialized, the Industry sector contributes minimal amounts of NMVOC emissions. Similarly, the Waste sector, on account of the relatively small population and the absence of industrial, commercial and residential waste water treatment facilities, emits small amounts of N_2O and NOx.

Figure 1: Trends in Greenhouse Gas Emissions and Removals



3.0 Vulnerability and Adaptation

Guyana is particularly vulnerable to climate change impacts because of its narrow, low-lying coastal zone that hosts over 90% of the population as well as the main livelihoods, economic activities and infrastructure of the country. This zone is threatened by sea level rise, increase in storm surges and changes in rainfall patterns. Any impact on the coastlands will have serious consequences for the country's economy, basically sustained in the sectors of Agriculture, Forestry and Fishing, which are also economic activities highly sensitive to changes in climate.

The vulnerability assessments were carried out at the territorial level, focusing on the coastal plain as the territory that holds Guyana's main social and economic assets; and at a sectoral level, including, agriculture, water, fisheries, health, energy, forestry and tourism. The results provided credible scenarios on the vulnerability of the coastal zone of Guyana to future sea level rise and storm surges. According to the scenarios, a large area of the coastal zone is likely to be flooded. Rice cultivation, residential areas, sugar cane, mixed farming and cash crops are the land use categories that will be most highly impacted.

While sea levels are rising on a global scale at a rate of 2-4 mm/year (IPCC, 2007), this trend in sea level is consistent with the work conducted by Douglas (1995) and Smith *et al.* (1999) which indicate that sea level in the region of Guyana is increasing at a rate in excess of 10 mm/year - or 2 to 5 times faster than the global estimate. Changes in the sea level, increases in the severity of individual rainfall events, and variations in annual rainfall levels pose significant threats to Guyana's East Demerara Water Conservancy system and drainage infrastructure; future agricultural production, and the overall welfare of inhabitants of the low-lying coastal zone of Guyana.

For the storm surge categories considered, the minimum (2.0 cm - moderate) scenario is very likely, whereas, the maximum (5.0 cm - catastrophic) scenario is less likely. Not only would settlements, infrastructure and people be at risk of coastal inundation, but also, valuable agricultural lands and crops that form part of the most significant economic sector of Guyana. Given these potential losses, investing in the most beneficial adaptation measures would significantly increase estimated national income in Guyana, and would likely be essential to attracting investors.

Table 1: Projections of land inundation during minimum and maximum storm surge

Model	Year	Land area in the coastal zone that is likely to be inundated (minimum-maximum)
CGCM2	2031	79,851- 140,245 hectares
	2051	82,881- 140,986 hectares
	2071	88,591- 142,480 hectares
HadCM3	2031	75,578- 139,123 hectares
	2051	78,038- 139,784 hectares
	2071	79,483- 140,152 hectares

Guyana will experience increases in temperature, increased rainfall in rainy season and less precipitation in months where there are already water deficits. Already, mean annual air temperature in Guyana has increased by 0.3°C since the 1960s and projections of future climate indicate that it will rise from 2 to 4^0C by the end of this century.

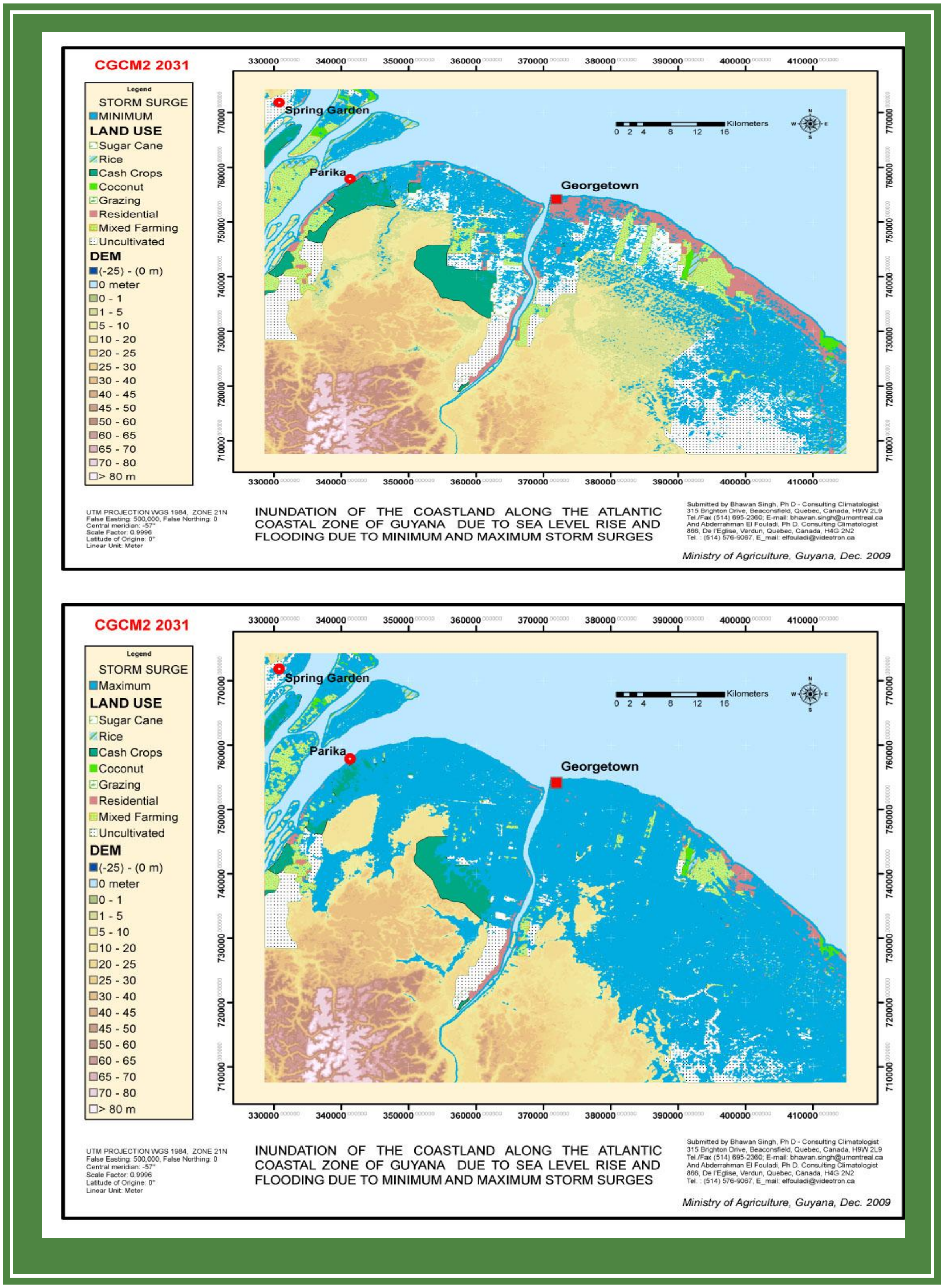
The following projections have been estimated for Guyana:

- Sea level will rise more than 1 meter by 2100, due to increased mass loss from the ice sheets mainly in the Artic regions (Meehl et al., 2007; Jonathan et al., 2004); different sea level scenarios estimate a increase of at least 25 to 51 cms by 2071.
- In the 2060s, the mean annual air temperature is projected to increase between 0.9 °C to 3.3 °C according to the B1, A1B and A2 (McSweeney et al, 2008).
- A-OGCM projections of mean annual rainfall vary between a reduction of 34% to an increase of 20% by the 2090s with median values of -18 (reduction) to -4% (increase) (McSweeney et al., 2008).

The rainfall patterns would experience considerable temporal and spatial change along the country. Guyana may suffer water deficits in October and November, as projected for the 2040 – 2069 period. Rainfall and temperature projections (2040-2069) show an increase in max temperature (by between 0.50°C and 1.10°C), an increase in min temperature (by between 0.90°C and 1.5°C) and a decrease in rainfall (by between -7 and -9.7%). These increases in temperature will eventually lead to increases in evapo-transpiration (ET) and when combined with decreases in rainfall (P) will result in increased water deficits (P-ET), causing shortages of water for agricultural, domestic and industrial purposes.

The low-lying coastal plain is the most vulnerable to sea level rise from climate change. The projections show that by the year 2031 the increase in sea level could reach 26 cm and for 2071 it could reach as high as 51 cm. In addition, by 2031 storm surges could result in a 2.94 cm sea level rise (in a moderate scenario) and as high as 5.94 cm (in a catastrophic scenario).

Figure 2: Projections showing inundation of coastland at minimum and maximum storm surge for the year 2031 using the CGCM2 model



The **agriculture sector**, especially sugarcane, is very likely be negatively affected by climate change through decreasing yields caused by greater drought like conditions mainly. Rice production would be less impacted, since it relies heavily on irrigation. However, impacts on the water sector, through increasing drought conditions, or salinization from sea level rise and storm surges may indirectly impact upon the agriculture sector. Other sub-sectors of the agriculture, such as livestock and fisheries may also be subject to similar types of climate and sea level risks, e.g. livestock depends on the availability of grazing pastures which are at risk of being subject to drought and flooding along the coast. In the case of fresh water fisheries and shrimp farms, saline intrusions and inundations will affect the sub-sector negatively.

It is evident that climate change and sea level rise would pose serious threats to the agriculture in areas where the greatest impact of adaptation, food security and poverty will be achieved. It is therefore imperative to develop a land use plan (land zoning strategy) to identify the best-suited land for sustainable agriculture in the future. The economic challenge for Guyana therefore is to identify specific agricultural and rural development needs and opportunities, and to focus investment expansion and diversification, to undertake climate change vulnerability studies on all the major crops that are threatened, and identify suitable alternative varieties where feasible.

Some effects of climate change, such as changes in precipitation (rainfall), temperature patterns, and sea level rise, will potentially result in a number of changed health outcomes. Some of these outcomes include increased death and injuries, and higher incidence of vector-borne (i.e. malaria and cholera) and water-borne (i.e. dengue and diarrhea) diseases. Climate change also affects health indirectly through the disruption of agricultural systems due to drought or excess rain, leading to malnutrition or famine.

All the changes projected may translate into ecosystems disruptions, floods, landslides, storm surges and droughts, among other impacts. These threats will impose severe social and economic constraints to Guyana and will need to be addressed with adaptation policy and measures. Effective adaptation will require a combination of enforceable regulations and economic incentives to redirect new settlement to better-protected locations and to promote investments in appropriate infrastructure, all of which require political will as well as financial and human capital. Climate change may worsen the access to basic urban services and the quality of life in cities. The experience of 2005 flooding revealed that planning for disaster preparedness, relief and post disaster is critical.

4.0 Mitigation Assessment

Mitigation assessment documents the progress that Guyana has made to limit emissions of greenhouse gases (GHGs), enhance its carbon sinks, and identify the potential to introduce measures to mitigate climate change. The scope of the MA has been limited to the energy, waste, agriculture and forestry sectors based upon the findings of the greenhouse gas inventory. Energy (including use of fuels in transportation), agriculture and waste are major emitters where as the forest sector is a significant CO_2 sink. Baseline scenarios were constructed based on the trends, plans and policies prevailing in Guyana at the time the analyses were undertaken. A Technology Needs Assessment (TNA) identified and prioritised a range of technologies (including practices and policy reforms) that may be considered for Guyana.

As indicated in the greenhouse gas inventory, the Energy **Sector** is the principal source of GHG emissions in Guyana. Although, energy demand per capita in Guyana has been fairly stable, oscillating between 5BBLS/year in 1998 and 4.2BBLS/year in 2006, energy demand per capita in Guyana can reasonably be expected to increase as a result of climate change, mainly for space cooling due to the warmer climatic conditions in the country. However, it is clear that much has been achieved in reducing emissions from the energy sector. According to the demand side management scenario, a reduction in transmission losses can lead to significant reduction in carbon dioxide emissions.

Guyana's renewable energy potential is being examined and harnessed through several projects, namely hydropower, wind, solar and biofuels. RE technology would substantially reduce Guyana’s reliance on imported oil products. Thus more studies on RE potential, actual implementation of feasible projects, improvement of transmission losses and especially modernisation of power plants (energy efficiency, retro-fitting, decarbonisation, distribution efficiency) are key recommendations in the short term. There is a need for Guyana to develop a market base to effectively distribute renewable energy technologies; raise the level of confidence in renewable energy technology and guarantee a competitive price compared with fossil fuels. Switch to less carbon-intensive fuels and renewable energy production, thus reducing the country's dependency on fossil fuels and its carbon emissions.

In reducing emissions from the **transportation sector** some measures have been taken, such as introduction of unleaded gasoline, import restrictions, awareness raising in terms of energy saving tips for car transports, and others in progress such as National Vehicle Emission Standards and the National Transportation Strategy. The biofuel projects have also been developed at pilot and commercial scales.

Short-term to long term measures include switching to less carbon emitting device; changes in the types of fuels and lubricants used; the use of alternative fuel, such as biodiesel; development of Vehicle Emission Standards and adopt more fuel efficient vehicles.

In the **building sector,** energy efficiency is the biggest challenge. Building codes are being developed but they do not incorporate energy efficiency measures. To reduce energy use in buildings, energy efficiency cooling devices, more efficient lighting and cooking appliances are recommended. Building codes that integrate these issues developed, regulations and programmes to promote energy conservation labels, the development of regulations with mandatory energy efficiency standards for building and voluntary measures for builders and manufacturers to apply.

In addition to its vast **forest** tract ~ 18.39 million hectares, Guyana also has important mangrove forests which play an important role both in protecting the country's estuarine and coastal areas from the effects of sea-level rise and in the abatement of climate change through carbon sequestration.

Modelling the effects of actions to protect Guyana's forest resource clearly demonstrates that the benefits of taking action to protect Guyana's forests are high in relation to the costs. Mitigation activities that are additional to those already planned under the LCDS and REDD+ result in carbon savings of 1.5 million tonnes under a baseline scenario in which incentives from REDD+ outweigh the incentives to log, and savings of 1.67 million tonnes under a baseline scenario where the rate of deforestation continues at existing levels. The cost of saving each additional unit of carbon is estimated to be around US$2, which is consistent with estimates provided in the LCDS.

Despite the relatively small scale of emissions from the **waste sector** (around 2% of total GHG emissions), there are certain mitigation options which can control GHG emissions from waste while at the same time these can contribute to wider national objectives including the protection of the public health and the natural environment.

Mitigation options for solid waste disposal sites are classified into two broad groups: (i) gas recovery and (ii) waste diversion such as recycling, composting and reducing the waste at source. Engineered and sanitary landfills can achieve landfill gas recovery rates as high as 90% while recovery rates for open and managed dump sites vary between 30% and 60%. Based on similar projects it is envisaged that the annualised costs for the construction and operation of the flaring systems may vary between US$2-5 per tonne of CO_2e saved.

However, there may be opportunities for Guyana to sell Certified Emissions Reductions (CERs) if the landfill gas recovery and flaring project is considered eligible as a Clean Development Mechanism (CDM) project under the Kyoto Protocol. On the basis of the above, there appears to be a case for investigating the technical viability and economic feasibility of introducing gas recovery and flaring systems at Le Repentir and Haags Bosch landfill sites.

Meanwhile, the Solid Waste Management Programme should focus on capacity building amongst waste management authorities at both the national and local levels and awareness raising amongst individuals, households and commercial operations of the need to reduce waste at source, and the opportunities available for waste re-use and recycling. This requires that the infrastructure to support waste recycling and recovery is in place.

Agriculture in Guyana is responsible for around 33% of total greenhouse gas emissions and is the single largest source of methane and nitrous oxide (accounting for around 82% and 94% of total methane and nitrous oxide emissions respectively).

Rice cultivation and enteric fermentation in animals are the two main sources of CH_4 emissions although field burning of agricultural residues and prescribed burning of savannah also contribute to this source. N_2O emissions emanate from the use of synthetic nitrogen fertilisers on agricultural soils, manure management, field burning of agricultural residues and prescribed burning of savannahs. CO_2 emissions are derived exclusively from the field burning of agricultural residues and, to a lesser extent, from prescribed burning of savannah. Additional emissions in agriculture might occur from energy use.

The Guyana Rice Development Board (GRDB) has already begun making efforts towards limiting emissions from rice production and post harvest management practices. Similar efforts are being made to control emissions from agricultural waste through the installation of biogas collection and combustion systems in several areas. Fertiliser application and research on developing new cultivars is also taking place in Guyana. There are a limited number of additional mitigation measures suitable for Guyana; the focus should therefore be on providing the necessary support to ensure that the available options are effective, sustainable and implemented more widely amongst farmers. Further opportunities for reducing emissions from agriculture include:

- Installation of biogas collection and combustion systems
- Effective livestock nutritional management
- Effective management of rice paddies.
- Changes in cultivation practices
- Crop rotation

Despite Guyana's progress in developing strategies to address climate change, particularly the LCDS, and in attracting the investment necessary to implement measures to protect its valuable forest resource, several **barriers** presently exist to the introduction of climate change mitigation measures in Guyana. These include, the costs of procuring and maintaining renewable and energy efficiency technologies; the financial feasibility of options; and limited availability and continuity of technical expertise within relevant institutions to design effective research and development programmes and policies, implement and measure their effectiveness, and operate and maintain mitigation technologies so that they work to their full potential.

The mitigation framework as outlined in the SNC is intended to support Guyana's response to Paragraph 1 (b) (ii) of the Bali Action Plan, which calls for "Nationally Appropriate Mitigation Actions (NAMAs) by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity building, in a measurable, reportable and verifiable manner." It sets out the structure within which Guyana is focusing both its existing and envisaged future efforts to reduce, limit or control GHG emissions, and maintain or enhance the country's role as a globally important carbon sink.

Both the Greenhouse gas inventory and the Mitigation Assessment suggest that the major focus for Guyana's mitigation efforts should be directed at the energy, agriculture and forestry sectors. Emissions from industry and waste are relatively low at present and are not expected to grow significantly in the future as a result of both the low rate of population growth (which inhibits demand for industrial outputs and the generation of waste), and low levels of industrialisation.

Measures to introduce new or enhance existing mitigation options include:

- Capacity building and institutional strengthening.
- Measures to provide a more supportive policy and regulatory environment. For example, designing and introducing incentive measures that discourage carbon-intensive activities, encourage investment in more energy efficient or low carbon technologies and manage the demand for energy.
- Education, communication and public awareness.
- Mobilisation of financial resources.
- Development and transfer of appropriate technology.
- Fostering international connections and partnerships **-** develop relationships with other forest-rich countries to share experiences – particularly neighbouring countries such as Brazil.
- Measures for participation in global carbon markets.

Figure 3: Mitigation Scenario for Energy Demand

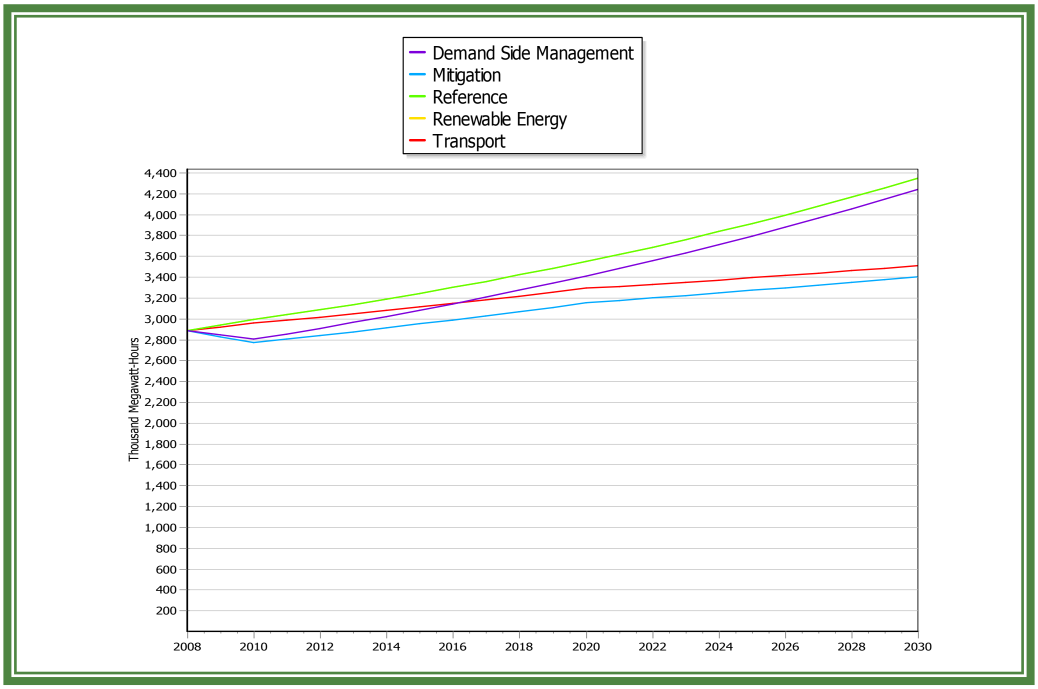
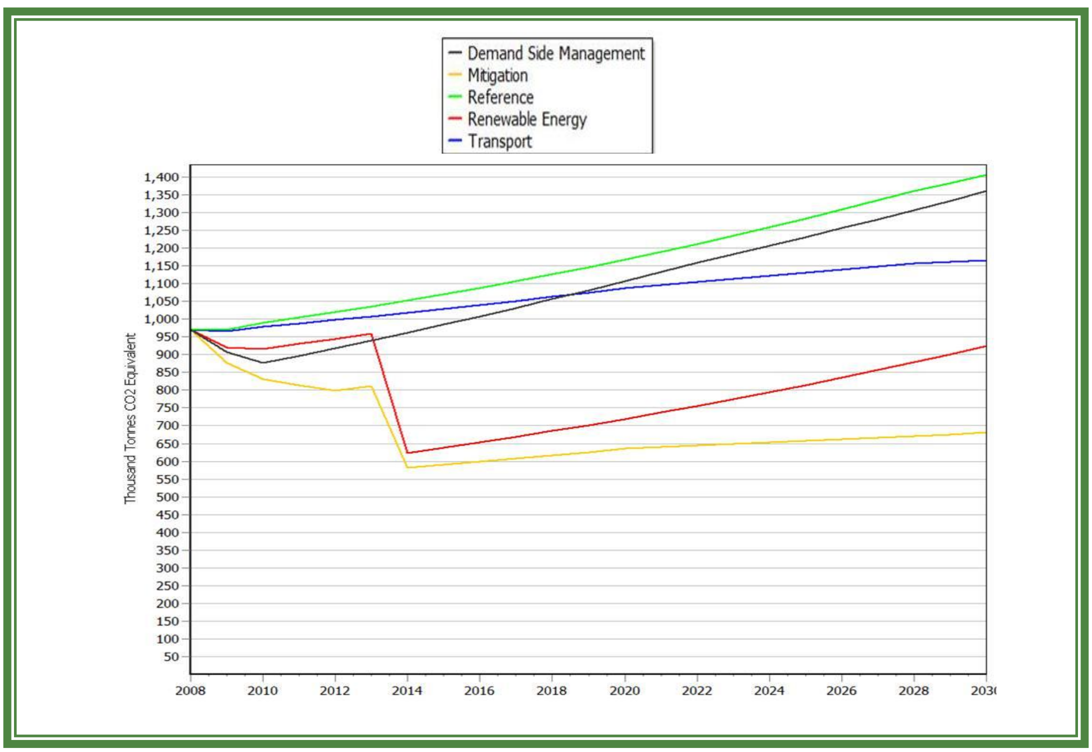


Figure 4: Mitigation Scenario CO2 Emissions



5.0 Research and Systematic Observation Systems

Research and systematic observations provide information and tools for better understanding of the climate system at various scales. Non-Annex I Parties are encouraged to provide information on their participation in, and contribution to, activities undertaken, on a global, national, regional and sub-regional basis in the areas of climate change research and systematic observations, as well as in global change research networks.

A Technology Needs Assessment (TNA) component was also conducted as part of the SNC. TNA change enables countries to identify the most appropriate technology options for controlling, reducing or preventing GHG emissions and/or adapting to the impacts of climate change. Technology options may include any or all of uptake of hard technologies or equipment, changes in practice, policy and regulatory reform, design and implementation of fiscal and financial incentives and capacity building. The priority sectors for mitigation are forestry and energy, with forest conservation, hydropower development and implementation of energy efficiency measures identified as the priority technologies within these sectors.

The priority measures identified within the sectors are forest monitoring and management; vulnerability mapping and risk reduction; energy efficiency in transport and improving the resilience of agriculture.

The hydrometeorological monitoring network is concentrated in the north and east of the country with relatively few inland monitoring stations and especially sparse coverage in the southern part of the country. To increase the accuracy of forecasts, a representative network across the country is needed. However, significant resource constraints (including lack of funding for field staff and installation of automated weather stations) limit the extent to which the network may be extended.

In 2003, the European Commission approved a 13.2 million Euro regional project to construct and install four new digital weather radars in the Caribbean to upgrade the obsolete radar network. The project, which began full implementation in 2005, involves the construction and installation of four new Doppler radars in Barbados, Belize, Guyana and Trinidad & Tobago. The project links the new radars with others already in place in the region to form a modern network of nine radars as part of the Caribbean Early Warning System (EWS) for severe weather conditions and will greatly enhance Guyana's capacity to predict extreme weather events.

There have been some attempts to assess land cover through remote sensing imagery analyses and forest inventory assessment. The Guyana Forestry Commission has implemented a Change Detection system for recording and updating roads and forest disturbances from satellite data. The use of images for change detection can therefore serve as a mechanism to alert GFC to possible forestry activities and to justify targeted ground-truthing activities or the use of higher-resolution satellites. Where higher resolution images are available, these should allow for more accurate assessments of the cause and nature of the change (i.e. forestry, mining, agriculture, residential).

Work has also begun in biomass estimation in various soil types. The National Biomass Monitoring System (NBMS) is intended to provide data for REDD project assessments of current forest biomass, and forest biomass change over time in response to REDD-oriented government policies relating to forestry and land use planning. A system of permanent monitoring plots is proposed to measure and detect changes in forest biomass.

The GFC is also actively in the process of developing a national Monitoring, Reporting and Verification System (MRVS) to support REDD+ implementation in Guyana. A roadmap and draft Terms of Reference for Developing Capacities for a national MRVS have already been developed. This road map lists expected outcomes and capacity improvements necessary for each of the key phases within the REDD preparation and implementation process in Guyana, as well as the specific activities required to address gaps in data, stakeholder involvement, capacity and institutions and methodological approaches.

Guyana's Hydrometeorological department also undertakes research activities in support of the agricultural sector. Services include generating agro meteorological products in aid of farming, land management, selection of improved varieties of plant and breed of animals that are adaptable to different climatological conditions and climate variability.

The Guyana Energy Agency (GEA) bears responsibility for regular analysis and reporting of petroleum imports, energy database management and energy and economic activities within the energy sector. Amongst its activities are to monitor the importation of petroleum products within and outside the PetroCaribe Agreement and monitor the renewable energy projects/activities for optimum use, efficiency and cost-effectiveness.

Since 2002, Guyana has become a member of several international climate-related research and monitoring organisations including the World Meteorological Organisation (WMO), the Intergovernmental Panel on Climate Change (IPCC) and the World Climate Programme. Membership provides several important benefits to Guyana including access to the most current scientific knowledge and data and opportunities to exchange information and best practice with both developed and developing countries.

The operation of systematic observation systems in Guyana is presently constrained by a number of factors including:

- Lack of technical capacity to operate and maintain equipment
- A lack of strong analytical skills or interpretative capacity to make use of the models and data that is generated
- Outdated and/or obsolete equipment and inadequate resolution of models
- Incomplete coverage of the observation network due largely to a lack of funding for staff to operate and maintain recording stations in remote locations
- Lack of financial resources to upgrade existing technologies and to provide specialised training in the use of new technologies
- The length of time it takes to repair or receive spare parts for faulty or damaged equipment

The LCDS provides an important framework for directing investments towards low carbon development but the training and retention of suitably qualified staff within the departments responsible for systematic observation will be crucial to the realisation of the strategy's objectives.

Taking into account the large surface area and diverse environments of Guyana, much better physical coverage is needed for most observations (particularly meteorology and hydrology) in order to generate spatially and temporally reliable information. Greater capacity is also required to capture, process and interpret these data. Capacity-building initiatives should involve Guyanese educational institutions (i.e. the University of Guyana) as well as specialised institutes such as IAST. Where possible, linkages should also be forged with regional and international institutions to provide opportunities for postgraduate students to acquire the relevant skills but then also to apply them in a professional capacity in Guyana.

A wide range of institutions within Guyana are already actively involved in research to better understand the climate system and the impacts of climate change, and to support the development of appropriate responses. Several agencies are working together on the development of early warning systems to protect vulnerable communities from the impacts of flooding.

A coordinated approach between government departments and research institutes is needed to ensure that there is no duplication of efforts, that key research gaps are covered and so that the knowledge generated can be shared and used as inputs into other areas of research (i.e. research on climate impact predictions should inform research into the development of appropriate responses, etc).

Funding support is needed to allow researchers to participate more actively in regional research programmes. This will allow sharing of knowledge and information from which Guyana could significantly benefit. More formal linkages may also be established with research institutions in developed countries in order to provide opportunities for student/research exchanges.

6.0 Public Education & Capacity Building

Public Education and Capacity Building outlines the progress Guyana has made in public awareness, education and training, climate change integration into national development plans, policies and programmes, and initiatives taken to building technical, financial and institutional capacity.

Initiatives taken by Guyana include, development of educational materials such as booklets for schools and farmers; and brochures; climate change workshops and seminars particularly for persons who reside outside of the immediate coastland of Guyana; public lectures and presentation of specific papers at special events; and high level engagements between civil society, the academic community and political figures to discuss climate change issues and targeted workshops. Additionally, locally and specialised programmes/courses regionally and internationally were organised: for example, Watershed Modelling and Management for key environment and natural resource agencies, and Greenhouse Gas Inventory; Vulnerability Adaptation Assessment and Mitigation Assessment Tools and Technology Needs Assessment training workshops for key sector Agencies through the Second National Communication Project.

Recent strategic developments to integrate climate change into national policies, plans and programmes include Guyana National Development Strategy, National Capacity Self Assessment of the UNFCCC, Guyana's Low Carbon Development Strategy; establishment of a REDD Secretariat and a National Climate Committee.

A Public Education Programme and Implementation Strategy was developed which aims to build the capacity of the citizens of Guyana to take actions (individually and collectively) to mitigate and adapt to climate change. It identifies five strategic goals, including Enhanced awareness and understanding of all social groups (in Guyana) of climate change causes, impacts and solutions; and increased public access to information on climate change. The major target groups are identified as: households; children and youth; teachers and teacher trainers; policy and decision makers (including Parliamentarians); consumers; religious groups; mothers diocese; indigenous peoples; tradesmen and technicians; private sector; media personnel; resource users (farmers, fishermen, miners and loggers); professionals from various sectors; and the scientific and academic community.

Some of the key activities are: television documentaries; live radio and television programmes; public exhibitions; curriculum development through integration and infusion; formation of Environmental Clubs in schools and communities; Science Fair focusing on Climate Change; quizzes and debates; regional training seminars and workshops; jingles for radio and television; Awareness Seminars; media symposia; demonstration projects; and short professional training courses. The lead facilitators represent governmental ministries and agencies, academia and nongovernmental organisations, as well as a number of regional and international institutions that will provide: training, technical advice to facilitators on specific project activities; financial support for education activities; as well as education materials.

Key challenges include: inadequate training to inform appropriate response, particularly at the municipal levels; limited research to meet the current challenges posed by climate change; and slow response of the private sector to take on the challenge of new areas of investment that will lead ultimately to effective climate change adaptation measures. Recommendations includes: developing a policy paper that will outline an agenda for climate research in Guyana;

strengthening of the Hydrometeorological Services Department for improved climatologically monitoring and forecasting, and capacity building in climate modelling; and greater collaboration among agencies that address climate change issues.

7.0 Gaps & Constraints

Guyana, like other developing countries, faces a number of challenges in implementing its obligations under the UNFCCC. These challenges include the availability of resources - technical, physical and financial - to put in place adequate measures to mitigate the causes and, more importantly for Guyana, the consequences of climate change.

In a previous assessment[2] a number of deficiencies in relation to Guyana's ability to implement relevant articles of the UNFCCC were highlighted. These included:

- **Insufficient mainstreaming** of climate change concerns into national and sectoral policies, programmes and projects;
- **Insufficient co-ordination amongst sector agencies** involved in research and implementation of climate change measures, particularly in knowledge- and data-sharing and in identifying synergies that may result in more effective approaches to mobilisation and use of resources (financial, technical and human);
- **Insufficient capacity** to undertake the necessary research, to implement automatic monitoring systems and to produce consistent weather and climate data;
- **Inadequate communication and low levels of public awareness** of the actions that may be taken to address the causes and consequences of climate change; and
- **Insufficient funding** to address climate change priorities.

In addition to these cross-cutting constraints, a number of sectoral gaps and constraints were identified through the preparation of the SNC. These include:

- Gaps in the knowledge and data necessary to compile the greenhouse gas inventory, evaluate mitigation and abatement technologies and understand the likely impacts of climate change;
- Lack of technical capacity and funding to implement and maintain mitigation technologies;
- Insufficient coverage of climate and weather monitoring systems;
- Insufficient deforestation monitoring system
- Biophysical vulnerability to climate change, particularly along the coastal strip where agriculture and human settlements are focussed;
- Insufficient technical knowledge to downscale General Circulation Models to estimate the impacts of climate change at the national and sub-national level;

[2] National Capacity Self-Assessment 2007

- Absence of knowledge on the impacts of climate change on key sectors, such as public health, energy, forestry and fisheries;
- Insufficient progress in embedding the projected impacts of climate change into decision making and planning across all sectors; and
- Failure to establish mechanisms for successfully implementing many climate change mitigation and adaptation initiatives that have been identified since the publication of the National Climate Change Action Plan in 2001.

Until recently, one of the most persistent barriers to the implementation of activities to assist Guyana in its efforts to mitigate and adapt to climate change has been a lack of funding. Addressing climate change issues requires significant financial resources. National financial support for climate change related activities is currently insufficient. Agency budgets do not contain direct allocations for climate change issues. These projects are mainly financed/co-financed by donors and multi-lateral lending agencies such as the World Bank, Inter-American Development Bank (IDB), UNDP and GEF. There are now several potential sources of funding for which Guyana is eligible and which could assist in leveraging funds for investment in, and deployment of, low carbon technologies and adaptation measures. These include financial support pledged by the Government of Norway, as well other potential interim REDD+ agreements, the GEF Trust Fund, the Clean Technology Fund (CTF), the Global Energy Efficiency and Renewable Energy Fund (GEEREF) and initiatives arising from the Copenhagen Accord including the Copenhagen Green Fund.

Globally, the absence of adequate financial resources is cited as one of the major barriers to implementing climate change mitigation and adaptation policies. Financial barriers include the following:

- High costs of new technologies;
- Limited concessional project finance;
- Restrictions on foreign investment;
- Lack of financing instruments/systems and difficulties in securing credit and loans from commercial banks, especially for unproven technologies;
- Weak or absent price signals (e.g. tiered water and energy tariffs that discourage wasteful use) and barriers to introduction of technologies (e.g. energy efficiency options);
- Weak competition (particularly in the energy supply sector) that reduces incentives to innovate and potentially erects barriers to new entrants (e.g. independent electricity producers who wish to sell to the grid have little bargaining power; they are price-takers;
- Limited market size to justify investment (e.g. in recycling or composting technologies, etc);
- Import tariffs (including import restrictions) and intellectual property issues; and
- Some unsupportive macroeconomic policies, particularly import regulations.

A further significant constraint to the implementation of the Convention is a lack of public awareness of the threat of climate change and the actions that may be taken to mitigate the adverse impacts of change, particularly as these affect vulnerable coastal communities and agricultural land.

Units

Units

mm	millimetres
cm	centimetre
m	metre
km	kilometre
km^2	square kilometre
ha	hectare
m^3	cubic metre
mcm	million cubic metres
g	gramme
kg	kilogramme
t	tonne
Gg	gigagramme
Mt	million tonnes
toe	tonnes of oil equivalent
ktoe	kilo tonne of oil equivalent
M toe	million tonnes of oil equivalent
tCO_2e/tCO_2eq	tonnes of carbon dioxide equivalent
kWh	kilowatt hour
KWp	kilowatt peak
MW	megawatt
MWh	megawatt per hour
GWh	gigawatt hour
TJ	Terajoules
M	million
C	celcius
mg $CO_2m^{-2}s^{-1}$	miligram CO_2 per square metre per second
µmol $m^{-2}s^{-1}$	micro mol per square metre per second

Gases

CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	equivalent carbon dioxide
CH_4	methane
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NOx	nitrogen oxides
SF_6	sulphur hexafluoride
SO_2	sulphur Dioxide

Conversion Table

1 tonne =	10^3 kg $=10^6$g
1 k tonne =	1Gg= 10^6 kg = 10^9kg
1 M tonne =	10^3Gg= 10^9kg =10^{12}g
1 km^2 =	100 hectares

Acronyms

A1B	Median Emissions Scenario
A2	High Emissions Scenario
ACTO	Amazon Co-operation Treaty Organization
AF4	IPCC Fourth Assessment Report
AFTN	Aeronautical Fixed Telecommunication Network
A-OGCM	Atmosphere-Ocean General Circulation Model
B1	Low Emissions Scenario
BBLS	Billion Barrels
BOE	Barrels of Oil Equivalent
CAP	Conservancy Adaptation Project
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum of ACP States
CAS	Country Assistance Strategy
CCCCC	Caribbean Community Climate Change Centre
CDC	Civil Defence Commission
CDM	Clean Development Mechanism
CEIS	Caribbean Energy Information System
CERs	Certified Emission Reductions
CFC	Chlorofluorocarbon
CGCM	Canadian General Circulation Model
CHP	Combined Heat and Power
CPAC	Caribbean Planning for Adaption to Climate Change
CI Guyana	Conservation International Foundation (Guyana) Inc.
CIDA	Canadian International Development Agency
CIMH	Caribbean Institute for Meteorology and Hydrology (Barbados)
CLICOM	Climate Computing
CMO	Caribbean Meteorological Organization
COMAP	Comprehensive Mitigation Analysis Process
COP	Conference of the Parties (of the UNFCCC)
CPACC	Caribbean Planning for Adaptation to Climate Change
CREDP	Caribbean Renewable Energy Development Programme
CTF	Clean Technology Fund
CTI	Climate Technology Initiative
DFID	Department for International Development (of the United Kingdom)
DSM	Demand-Side Management
DSSAT	Decision Support System for Agrotechnology Transfer
ECD	East Coast Demerara
ECLAC	Economic Commission for Latin America
EDF	European Development Fund
EDWC	East Demerara Water Conservancy
EEZ	Exclusive Economic Zone
EFDB	Emission Factors Database
EIA	Environmental Impact Assessment
ENPEP	Energy and Power Evaluation Program
ENSO	El Niño-Southern Oscillation
EPA	Environmental Protection Agency
ESTs	Environmentally Sustainable Technologies
EWS	Early Warning System
FAO	Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility (of the World Bank)
FiT	Feed-in Tariff
FPA	Forest Products Association
GDP	Gross Domestic Product
GEA	Guyana Energy Authority

GEEREF	Global Energy Efficiency and Renewable Energy Fund
GEF	Global Environment Facility
GFC	Guyana Forestry Commission
GGMC	Guyana Geology and Mines Commission
GHG	Greenhouse Gas
GHGs	Greenhouse Gases
GHG-I	Greenhouse Gas Inventory
GINA	Government Information Agency
GIS	Geographic Information System(s)
GL&SC	Guyana Lands and Surveys Commission
GMSA	Guyana Manufacturing Services Association
GoG	Government of the Republic of Guyana
GPL	Guyana Power and Light
GRDB	Guyana Rice Development Board
GRIF	Guyana REDD+ Investment Fund
GSA	Guyana School of Agriculture
GTS	Global Telecommunication System
GUYSUCO	Guyana Sugar Company
GWh	Gigawatt hour
GWP	Global Warming Potential
HadCM3	Hadley Centre General Circulation Model (version 3)
HS	Hydrometeorological Service
HFC	Halo Fluorocarbon
HFO	Heavy Fuel Oil
I(A)DB	Inter-American Development Bank
IAST	Institute of Applied Science and Technology
ICAO	International Civil Aviation Organization
ICB	Institutional Capacity Building Project
ICZM	Integrated Coastal Zone Management
IDA	International Development Association
IFC	International Finance Corporation
IICC	Iwokrama International Centre for Rainforest Conservation and Development

INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
JSDF	Japan Social Development Fund
kW	Kilowatt
LCDS	Low Carbon Development Strategy
LEAP	Long Range Energy Alternatives Planning System
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land-Use Change, and Forestry
MAA	Mitigation and Abatement Analysis
MACC	Mainstreaming Adaptation to Climate Change
MAGICC	Model for the Assessment of Greenhouse-Gas Induced Climate Change
MARKAL	Market Allocation Model
MoA	Ministry of Agriculture
MoH	Ministry of Health
MOU	Memorandum of Understanding
MRVS	Monitoring, Reporting and Verification System (for Guyana's REDD+ Programme)
MW	Megawatt
NAMAs	Nationally Appropriate Mitigation Actions
NAREI	National Agricultural Research Extension Institute
NBMS	National Biomass Monitoring System
NCC	National Climate Committee
NCCAP	National Climate Change Action Plan
NCSA	National Capacity Self-Assessment
NDIA	National Drainage and Irrigation Authority
NDS	National Development Strategy
NEEPAS	National Environmental Education and Public Awareness Strategy
NMVOC	Non-Methane Volatile Organic Compound(s)

NREAC	Natural Resources and Environment Advisory Committee
OCC	Office of Climate Change
ODP	Ozone Depleting Products
ODS	Ozone Depleting Substances
OECD	Organisation for Economic Co-operation and Development
PAHO	Pan American Health Organization
PCMDI	Climate Model Diagnosis and Inter-Comparison
P-ET	Preciptitation-Evapotranspiration
PFC	Per Fluorocarbon
PM10	Particles measuring 10µm or less
PMU	Project Management Unit
PRSP	Poverty Reduction Strategy Paper
PSC	Private Sector Commission
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
RE	Renewable Energy
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RETScreen	Renewable Energy Technology Screening Programme
RIL	Reduced-Impact Logging
RMSE	Root Mean Square Estimate
RPIN	Readiness Plan Idea Note
R-PP	Readiness Preparation Proposal (for participation in the REDD+ mechanism)
RSOS	Research and Systematic Observation Systems
SAR	IPCC Second Assessment Report
SCADA	Supervisory Control and Data Acquisition
SCENGEN	SCENario GENerator
SDSM	Statistical DownScaling Model
SEES	School of Earth and Environmental Sciences
SFM	Sustainable Forest Management
SFP	State Forest Permission
SIEE	Latin American Information System
SLM	Sustainable Land Management
SNC	Second National Communication
SRDD	Sea and River Defence Division
SRES	Special Report Emissions Scenarios
SSMP	Skeldon Sugar Modernization Project
SWDS	Solid Waste Disposal Sites
TAR	IPCC Third assessment Report
TNA	Technology Needs Assessment
TSA	Timber Sales Agreements
UAEP	Unserved Areas Electrification Programme
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation
V&AA	Vulnerability and Adaptation Assessment (of the SNC)
WMO	World Meteorological Organization
WWF	World Wildlife Fund
WWW	World Weather Watch

Chapter 1
National Circumstances

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National Circumstances

1.0 Introduction

The Co-operative Republic of Guyana is a tropical country located on the northern shoulder of South America. It shares borders with Suriname on the east, Venezuela on the west, and Brazil on the west and south, and is bordered by the Atlantic Ocean along the entire length of its coastline on the north. This coastal plain lies about 1.4 metres below the mean high-tide level of the Atlantic Ocean, and is therefore particularly vulnerable to flooding, erosion and salinization.

The only english-speaking country in South America, Guyana has a total land mass of 21.5 million hectares, a relatively small population of 766,183 persons and a population density of less than four persons per square kilometre. The country is considered a highly forested one, with 18.39 M hectares of tropical forest. Through sustainable management, Guyana has had relatively low historical rates of deforestation.
There are three main rivers, the Berbice, the Essequibo and the Demerara, all of which drain into the Atlantic Ocean. The country's three Counties are named after these three main rivers (Berbice, Essequibo and Demerara). Guyana has five natural geographic regions: a coastal plain, a hilly sand and clay region, a highland region, a forested region, and intermediate and inland savannahs.

Climatologically, at the macro-level Guyana has a wet-tropical climate, which is further classified into three categories: very dry, very wet, and wet-dry. There are two wet seasons and two dry seasons in a calendar year. A high level of rainfall variability mainly determines the seasons and climate. Rainfall levels result from the north/south movement of the Inter-Tropical Convergence Zone (ITCZ).

Although the country is very rich in natural resources, its economic base is very narrow, with a strong dependence on a very small range of primary products for export. The agricultural base of the economy has repeatedly suffered from a combination of unfavourable terms of global trade and extreme weather events which led to floods and droughts.

Guyana, like many other developing countries, is extremely vulnerable to the negative impacts of climate change. Economic challenges, geographical characteristics and limited capacity to predict and respond to environmental hazards compound the threats Guyana is confronted with as a result of global climate change.

1.2 History

The original inhabitants of the lands which form the territory of Guyana were the indigenous Amerindians.

However, in the early seventeenth century the Dutch settled in Guyana. Settlements grew along the largest rivers, the Essequibo and Berbice, and later Demerara, leading to the formation of three colonies named after these rivers. The Dutch controlled the colonies for almost two centuries. From 1781, the colonies changed hands from one colonial power to another until it came under full British control in 1803.

Essequibo and Demerara were united with Berbice in 1831 to form the single colony of British Guiana. The period of Dutch rule established many lasting influences on the settlement pattern, the drainage and irrigation system and the agricultural base of the economy.

The introduction of sugar cane cultivation in the 1650s and its growth led to a greater demand for slave labour from Africa. After Emancipation in 1838, labour for the plantations was brought under the Indentureship System, with indentured labourers being sourced from Portugal (Madeira) (1835), India (1838) and China (1853). The system of indentureship was discontinued in 1917.

Political Independence was achieved on 26 May 1966, with the country's name officially changed from British Guiana to Guyana, and on 23 February 1973, Guyana became a Republic. Legislative power rests in a unicameral National Assembly, generally referred to as Parliament. Executive authority is exercised by the President, who appoints and supervises the Prime Minister and other Ministers. The highest judicial body is the Court of Appeal, headed by a Chancellor of the Judiciary. The second level is the High Court, presided over by a Chief Justice.

Each Administrative Region is headed by a Chairman who presides over a Regional Democratic Council. Local communities are administered by Neighbourhood Democratic Councils or Municipal Councils.

1.2.1 Demography

According to the 2010 National Budget, the Population of Guyana was stated to be 769,600 at the middle of 2009. The administrative Regions with the lowest population densities (7, 8 and 9) are the Regions most distant from the coast, and include large areas of the highland region and the forested region. These administrative Regions however do attract a sizeable number of workers from the coast for the forestry and mining operations. The highest population density occurs in Region 4, which includes the capital city of Georgetown.

Characteristic of its agrarian-based economy, the population is mostly rural (~60%); urban (~28%), with the rural interior having the lowest percentage (~12%). The ethnic mix comprises people from six ethnic backgrounds: African, Indian, Chinese, Portuguese, Amerindians, European, plus a Mixed Race grouping. The Afro-Guyanese and Indo-Guyanese are the two largest ethnic groups.

The World Bank and Guyana Bureau of Statistics Estimates, based on the Household Budget Survey Data 2006, show the following demographic percentages:

Table 1. 1. Distribution of population in urban, rural coastal, and rural interior

Location	Share of Group in Population (%)
Urban	28.20
Rural Coastal	60.08
Rural Interior	11.72

Table 1. 2. Distribution of population by age

Age Group (years)	Share of Group in Population (%)
0-15	36.40
16-25	16.27
26-40	23.21
41-64	19.65
65+	4.47

Table 1. 3. Demographic indicators

Life expectancy (years)[3]	67
Birth rate (per 1000 of population)	17.8
Death rate (per 1000 of population)	8.15
Urban population (as % of total population)	28.3

Table 1. 4 Distribution by gender

	Share of Group in Population (%)
Female	51.04
Male	48.96

1.2.2 Economy

Guyana has experienced positive growth in almost every year. GDP growth rates in 2006, 2007, 2008 and 2009 were 5.1 %, 7.0 %, 2.0 % and 3.3 % respectively. Inflation has been kept under control and monetary policy is implemented by an independent Central Bank. Recent years have seen the Government's stock of debt reduced significantly - with external debt now less than half what it was in the early 1900s. (LCDS, 2010.)

The agricultural sector (which includes fisheries and forestry) is a significant contributor to GDP in Guyana. Between 2004 and 2007 this sector contributed approximately 35% of the country’s GDP, and employed between 30-35% of the labour force (Bureau of Statistics, 2008). In 2006, fisheries accounted for 7% of Guyana´s GDP. The exports from this sector have consistently surpassed US$50 million since 2004 (Caribbean Community Climate Change Centre, 2009) and employs around thirteen thousand people in Guyana in the primary and secondary sector (FAO, 2005). The forest sector’s contribution to the GDP over the past few years has been around 3.10%.

Any impact on the coastlands will have consequences for the country’s GDP, directly related to the Agriculture, Forestry and Fishing sectors, and will severely affect the population that is mainly employed in these sectors. The agriculture sector, especially sugar-cane, would very likely be negatively affected by climate change through decreasing yields.

The World Travel and Tourism Council (2001) estimated the travel and tourism sector as contributing 12% to GDP and 10.6% to employment. However, with most of the tourism infrastructure located on the coastal zone, Guyana´s tourism sector is also very vulnerable

[3] World Bank.

to climate change, which may affect contribution to the national GDP and to employment.

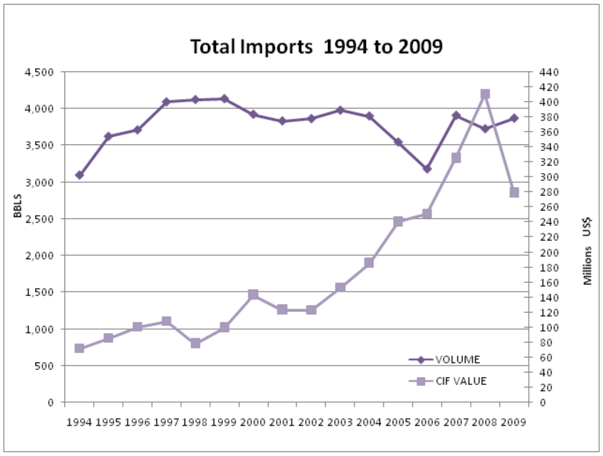
In 1999, Guyana completed a Living Conditions Survey (LCS) which indicated a decrease in poverty levels. The proportion of the population living below the poverty line was found to be 35%, with 19% living under conditions of extreme poverty (PRSP, 2001).

Energy

An important factor in the economy is the supply and cost of energy. Guyana imports all the fossil fuel it needs. Due to the country's heavy dependence on fossil fuels, it is very vulnerable to the movement of global oil prices.

In 2009, the cost of importation of fuels and lubricants was, at 24.5 per cent, nearly a quarter of all of the country's imports.[4] During the period 1992-2009, fuel imports[5] per annum fluctuated between 3 and 4M bbls. A further vital energy need for the country is adequate, reliable and affordable electricity. The installed capacity in 2009 was estimated at 314 MW and the electrical energy utilized at 819 GWh.[6]

Fig. 1.1 **Fuel imports 1994-2009**



Source: Guyana Energy Agency

[4] Guyana Budget. (2010.)
[5] Guyana Energy Agency.
[6] Guyana Energy Agency.

1.3 Geographic Profile

Guyana is located on the north-eastern coast of South America, lying between latitudes 1° and 9° N. and 56° and 62° W.longitudes. It shares borders with Suriname on the east, Venezuela on the west, and Brazil on the west and south. The coastline, with the Atlantic on the north, stretches for 430 kilometres and has a continental shelf of about 724 km. Guyana is classified as a highly forested country with 18.4M hectares of tropical forest.

There are five natural geographic regions, namely: the Coastal Plain, the Hilly Sand and Clay Region, the Highland Region, the Forested Region, and the intermediate and inland Savannahs.

Coastal Plain

Situated on the northern perimeter of the country, the Coastal Plain lies about 1.4 metres below mean high-tide level, and is protected by natural and man-made sea defences. This coastal plain is 430 km long and varies in width from 26 km to 77 km. Topographically, it is flat, comprising heavy, fluvio-marine clays, and is prone to flooding during heavy rainfall. There are a series of sand ridges (0.5 m to 2.5 m high and 10 m to 600 m wide) which can be found running parallel to the coastline. These ridges obstruct drainage, leading to the creation of pegasse swamps, and may also be responsible for the orientation of the rivers which dissect the coast (INC 2002).

Most of the land in this narrow strip was reclaimed from tidal areas. Along the coast there are alternating cycles of accretion and erosion, influenced by the equatorial and Guiana currents offshore, and by local longshore drift that contributes to the siltation of the mouth of the rivers. These factors continuously affect the condition of sand-beaches and mangroves.

This coastal area represents about five per cent of the total area of the country, but is also where approximately ninety per cent of the country's population resides. A historically established bias for occupation of the coast was largely influenced by the most fertile lands suited for agriculture being located there.

The coastal region can further be regarded as the economic and administrative hub of the country. It is where the main urban centres are located and where most of the economic activity takes place. The Agriculture sector for instance contributes 35% of Guyana's Gross Domestic Product (GDP); 40% of export earnings; 30% of the country's workforce and is important not only in terms of export earnings, but as a local food source for the population. Sugar and rice are the most important crops, accounting for some 74% of agriculture's GDP, as well as 65% of Guyana's total agriculture exports, including shrimp and timber. Thus, any external shock to this sector can significantly reduce these percentages- with cascading socio-economic consequences.

Given that the coast is below mean high tide level, Guyana is extraordinarily vulnerable to sea-level rise and storm surges. Water for irrigation of agricultural lands is managed through a system of conservancies and irrigation canals. A more elaborate system of canals and kokers further facilitates the drainage of coastal lands. This system of sea defence structures and drainage network requires significant financial, technical and human resources for any effective functioning. In 2009, the GoG spent US$6.4 million to build one kilometre of concrete sea defences. Since the country needs to fortify 360 kilometres of sea defences, adaptation to climate change will cost millions.

Hilly Sand and Clay Region

The Hilly Sand and Clay Region varies in height from 2 to 400 metres, and is found immediately south of the coastal belt. The soil comprises 85% white quartz sand with pockets of brown and yellow sand. The highly porous sandy soil does not support farming, but allows the growth of some special timbers such as Greenheart (*Chlorocardium rodiaei*), Mora (*Mora excelsa*), Crabwood (*Carapa guianensis*) and Wallaba (*Eperua falcata*). This area is also rich in bauxite deposits which have been mined throughout the century, mining being the main economic activity of the population in this region. The bauxite industry, until the late 1970s, was a major -and often the main- contributor to the economy in terms of percentages of GDP, export earnings, employment, and contribution to Government revenue. Guyana produces high-value refractory A-grade bauxite. In 2005, Guyana produced nearly 1.6 million metric tons of bauxite, 262,528 ounces of gold and 356,950 metric carats of diamonds.

There are four smaller rivers which originate in this region, namely the Abary, the Mahaicony, the Mahaica and the Canje. The reddish tint of stream water is due to high porosity which allows leaching of the thin layer of humus topsoil.

Highland Region

The Highland Region contains large areas of forest-covered mountains. The main mountain ranges are the Pakaraimas in the west, the Imataka in the north-west, the Kanuku which divides the Rupununi savannahs into two parts in the south-east, and the Akarai Mountains in the South. The Pakaraima Mountains form part of the Guiana Highlands which cover an area of 1,300,000 square kilometres within Guyana, Venezuela and Brazil. It consists of a series of horizontal beds of quartzitic sandstone, conglomerate and intrusive rocks. Mount Roraima rises to a height of 2,777 metres and is characterized by a series of plateaux and tablelands with sharp edges and precipitous escarpments. The plateaux are dissected by many streams and gullies, thereby creating deep gorges and waterfalls. Large tributaries of the Essequibo River are found in this region – the Cuyuni, Mazaruni and Potaro Rivers which are rich in mineral resources, especially gold and diamonds. There are also mineral deposits of manganese and iron ore in this region. Kaieteur Falls, a world-renowned waterfall with the highest sheer (single) drop (225 metres) in the world, is a part of the Potaro River. There are small Indigenous communities and temporary mining camps located throughout this region.

Forested Region

The Forested Region spans almost the entire length of the country with an elevation from 90 to 210 metres, culminating in the Acarai Mountains. It forms part of the Pre-Cambrian Brazilian shield with varied rock types, including granite, gneiss, amphibolite, shale and quartzite. This is the tropical rainforest region of Guyana, a part of the Amazon forest.

Economically, it provides most of the country's timber production. There are different types of forests in the country in relation to the terrain and the types of timber products available.

Very valuable wood species include greenheart (*Chlorocardium rodeaei*), crabwood (*Carapa guianensis*) and purpleheart (*Peltogyne venosa*). Guyana has historically, a relatively low level of deforestation at 0.1 to 0.3 percent as noted in the Monitoring, Reporting and Verification System (MRVS) Interim Measures Report, 2010. The administrative classification of forests and other lands allows for supervision of state forests by the Guyana Forestry Commission, and other state lands by the Lands and Surveys Commission and other Agencies (Fig. 1.2 and Appendix 1.1). Also clearly defined by law are the Titled Amerindian Lands, the Iwokrama Reserve, and the Kaieteur National Park.

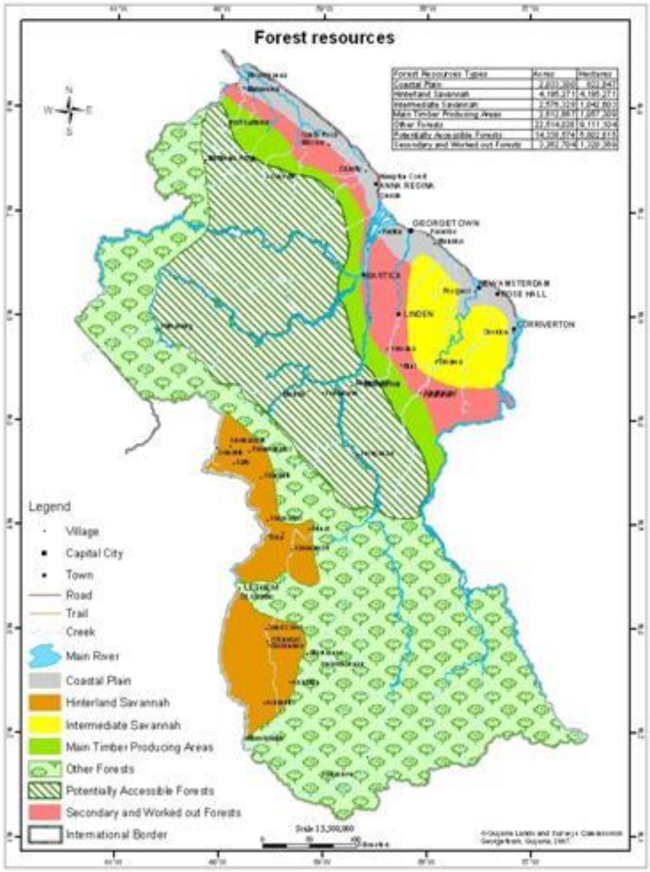


Fig. 1.2. Forest resources map

The Savannahs (Intermediate and Inland)

This Region is also called the Rupununi Savannahs or the hinterland Savannahs. It consists of the intermediate and hinterland savannahs. The Intermediate Savannah is situated between the coastal plain and the Hilly Sand and Clay region. The Rupununi Savannahs are located in the south-west of Guyana, and are divided into the North and South Savannahs by the Kanuku Mountains. Many Indigenous Communities are located in these Savannahs, in which the main economic activities are cattle ranching and farming.

1.3.1 Administrative Regions

For Administrative purposes, the country is divided into ten Regions, each administered by a Regional Democratic Council (RDC). The northern sections of six of these Regions (numbered 1 to 6) are located on the coast. The remaining 4 Regions (numbered 7 to 10) are located in their entirety in the hinterland (Fig. 1.3).

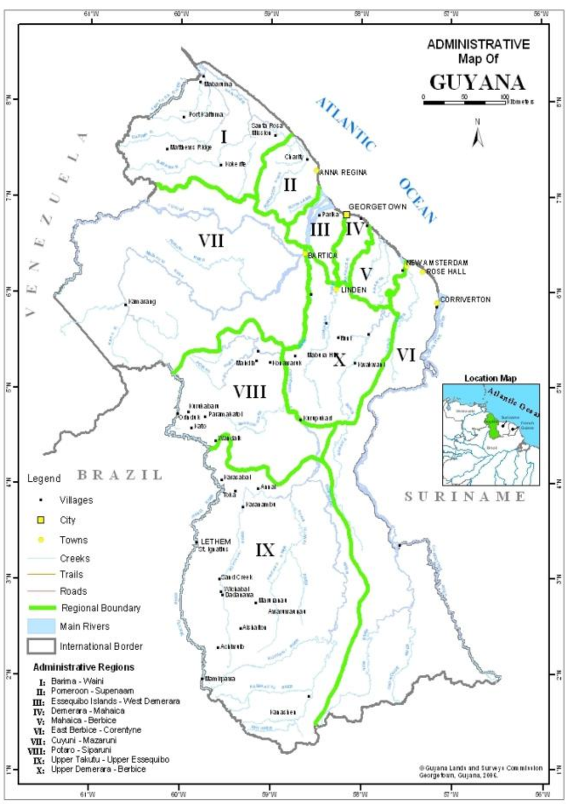


Fig. 1.3 **Administrative regions of Guyana. Source: Poverty Reduction Strategy Paper, 2001.**

1.4 Hydrology

Water management in Guyana, especially along the Coast, is influenced by a combination of factors, including the effectiveness of the Drainage and Irrigation and Sea Defence systems, the gradient of the land, the conditions of the water storage areas, and the level and frequency of rainfall. These are the factors which have contributed to the almost seasonal flooding along coastal Guyana, making this region the most vulnerable to flooding in the country. While floods pose a threat to livelihoods and economic activities, at the same time the country's seemingly limitless water resources coupled with fertile lands, form the backbone for agricultural development. The country utilizes both surface and ground water resources for agricultural, industrial, domestic and commercial purposes.

Along coastal Guyana, most of the water for domestic and commercial purposes is extracted from ground water sources derived from three main aquifer systems. Water for industry and agriculture primarily originates from surface sources. Hinterland communities primarily utilize surface water supplied by a dense network of watersheds.

Limited knowledge of the aquifer systems along the coast and the increasing population size in this zone continue to raise questions of the possibility of water mining and salt-water intrusion. In interior locations, the major threat to surface water bodies originates from gold and diamond mining, and the accompanying erosion of soil.

Watersheds

Many large rivers flow from south to north into the Atlantic Ocean. The largest of these is the Essequibo, which has its source towards the southern border with Brazil. Many rivers in the western part of the country flow eastwards into the Essequibo. Additionally, there are many creeks which flow into the large as well as the smaller rivers. Drainage through the rivers is very slow due to the extremely small gradient of rivers, which average about one metre in five kilometres. This is further compounded by the river mouths at the coastline being about one metre below the mean sea level, resulting in a build-up of silt and other fluvial material.

Guyana has fourteen major river basins. These river systems combine to provide large quantities of surface water. Hydrological records show that these rivers have marked seasonal differences in river flows and water quality. However, infiltration also takes place at ease in the country's tropical rainforest, allowing for the maintenance of adequate base flow in the river systems.

Conservancies

There are eight Water Conservancies: Tapakuma, Itiribisi, Lake Mainstay, Lake Capoey, Boeraserie, East Demerara, Mahaicony-Mahaica- Abary and Skeldon. These are critical for irrigation of the agricultural lands on the coast during periods of low rainfall. However, the conservancies are also a flood threat, because they store water at levels above the natural ground level contained by earthen dams which are subject to high levels of erosion and structural failure.

The drainage and irrigation system is very complex, with water from the conservancies taken into the agricultural lands by a network of irrigation canals, and then leaving these lands to be discharged into the ocean by another network of drainage canals. The drainage system consists of primary, secondary and tertiary canals. The primary irrigation canals collect water from the conservancies and or rivers. Through a control structure/pump station at the head, water is distributed to the secondary system, from where it travels through a second control system to the fields (tertiary drains). The mechanism for the drainage system is similar. The primary canals generally discharge water to the rivers or the ocean through parallel sluices. Many of the secondary drains do not flow directly into the ocean, but rather into a façade drainage canal running parallel to the coastline. The façade canals then flow into the ocean through pairs of sluice gates.

The conservancies' drainage systems consist of a series of drainage sluices along the Atlantic Coast and the main river banks. The systems were designed for gravity flow at low tides; however, this is also supported by a number of drainage pumps along the coast.

To maintain the efficient operation of the drainage system, regular maintenance is crucial. Lack of proper maintenance can result in the growth of vegetation which rapidly inhibits flow and increases siltation.

Aquifers

About ten per cent of the water used for domestic purposes on the coast is obtained from the surface, with the remaining ninety per cent from ground water sources called aquifers. The most important aquifers are in the unconsolidated, poorly sorted deltaic sands that underlie the coastland. The others are mainly in the igneous and metamorphic rocks of the Guyana shield.

The coastal aquifer system consists of three separate but hydro-geologically connected aquifers named the Upper Sand, the A Sand and the B Sand, all of which contain significant quantities of water. It is estimated that the coastal aquifer system covers an area in excess of 20,000 square kilometres and extends in excess of 250 kilometres along the coast, and as much as 150 kilometres inland. Sediment can be over 1,500 m deep onshore and be even deeper offshore. While it is generally accepted that the recharge areas for these aquifers are in the white sand region, lack of data and limited studies have prevented an accurate determination.

The A Sand aquifer lies below the Upper Sand and above the B Sand aquifers. These aquifers are high in iron content, with a recognizable reduction with depth. The Upper Sand is generally too high in iron and chloride content, and is considered unfit for human consumption. The A Sand is used as the principal source of coastal water supply, yielding between 4,000 and 40,000 litres of water per minute throughout the year. Initially, the A Sand had a piezometric head in excess of 4.5 metres above ground, but by 1993 this was reduced to more than 14 metres below ground. The B Sand aquifer can produce at a similar rate as the A Sand, but the water has a high temperature and hydrogen sulphide content. While water quality is acceptable, there is limited use resulting from the cost of reaching its depth (as much as 800 metres).

Even though the coastal aquifers are the larger and most utilized, there are also smaller aquifers in the Hilly, Sand and Clay Region, and the Rupununi Savannahs, and across most regions of the country at depths less than 30 metres.

1.5 Natural Resources

Guyana has a plentitude of natural resources: fertile agricultural lands on the coastal plain and in the riverain areas; vast areas of tropical hardwood forests of various ecosystems and with a multitude of plant and animal species; abundant fishing and shrimping grounds, both in its numerous rivers and in the Atlantic Ocean to its north; and a wide variety of minerals, including gold, diamonds, a range of semi-precious stones, bauxite, and manganese. (NDS, 2001-2010)

The abundance of freshwater is also an extremely valuable asset for the country, which is not often recognized as such. The fertile soils increase the potential also for much greater levels of agricultural production. The major uses of water resources are for agriculture, industry and domestic consumption, with the highest priority in times of shortage and low supply given to agriculture (Water Resource Assessment, 1998).

Within the highlands, the rapid flow of rivers provides numerous possibilities for the development of hydropower stations to supply not only all of the country's electricity needs, but also to export to neighbouring countries.

1.6 Climate Profile

Guyana lies within the Equatorial Trough (ET) Zone. Its weather and climate are influenced primarily by the seasonal shifts of this trough and its associated Zone of Rainbands called the Inter-Tropical Convergence Zone (ITCZ).[7] Guyana enjoys a wet tropical climate with warm temperatures and abundant rainfall without the extremes of hot or cold.

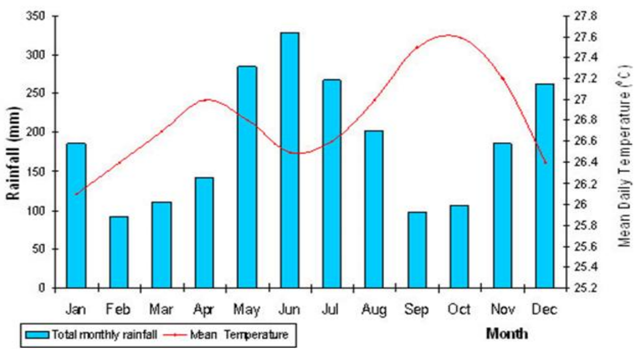


Fig. 1.4. Mean monthly temperature and total monthly rainfall in the coastal region of Guyana (Hydromet Service, MoA)

Temperature, Wind, Sunshine, Humidity

Air temperatures range between 16 °C and 34 °C with lower temperatures in the higher regions. Temperatures on the Coast range between 22 °C and 31 °C due to the stabilizing effect of the sea and the North Eastern Trade Winds. These Trade Winds flow over the coast with speeds averaging ten miles per hour, and decrease as they move further inland where light winds generally prevail.

The duration of sunshine averages seven (7) hours per day in the dry seasons and five (5) hours per day in the wet seasons.

The Relative Humidity is high, averaging 80 per cent or more on the coast. It is lower in the savannah regions at about 70 per cent. In the rainforest regions it can reach 100 per cent, especially in the mornings.

Rainfall and Climate Types

Annual average rainfall totals range between 1,600 mm to 3,000 mm. Because of geographical influences, such as mountains and oceans, there is spatial variability of rainfall resulting in three major climate types.

Tropical savannahs (very dry regions) – These are areas with annual rainfall of less than 1,788 mm. Such areas are located in the Rupununi Savannahs, the Intermediate Savannah, the Upper Cuyuni and the Corentyne Coast. The Corentyne Coast is found to be much drier than places further inland.

Very wet tropical rainforest climate (very wet regions) - These are areas with the annual rainfall exceeding 2,728 mm. These regions are found in the Pakaraima Mountains, the upper Akarai Mountains and the sub-coast.

Wet/dry tropical rainforest (wet/dry regions) - The remainder of the country experiences this type of climate. These are areas with annual rainfall between 1,778 mm and 2,800 mm. The average on the coast is about 2,300 mm.

Most places in Guyana experience a bimodal annual cycle of rainfall with distinct wet seasons.

The first rainy season known as the primary wet season extends from mid-April to the end of July, and the secondary wet season occurs from mid-November to January. The periods in between are often referred to as primary dry (long) season and secondary (short) dry season respectively.

A unimodal annual wet cycle (mid-April to August) is witnessed over the southernmost part of Guyana – the Rupununi Savannahs.

[7] Hydrometeorological Service. (2010.) Average Weather Conditions in Guyana.

1.6.1 Climate-Related Disasters

Guyana has experienced a number of climate-related disasters due particularly to extreme weather events. Short-term weather variability such as high intensity rainfall or wind or tidal/wave activity is the usual cause of floods, while sustained periods without rain cause droughts. The extent of flooding is also influenced by human factors such as the management of solid waste, and the maintenance of physical infrastructure for drainage and irrigation, conservancies and sea defences.

The Flood of January 2005 was Guyana's worst natural disaster which caused an estimated G$93 billion in damages.

Guyana is outside of the hurricane belt but has experienced occasional storms and high winds. (See Fig. 4.34)

The most destructive of these was the Flood of January 2005, which was estimated to have cost about G$93 billion. It was estimated that 37% of Guyana's population were severely affected and 48% moderately affected.

The experiences in the years identified show that the weather patterns have changed significantly in terms of both intensity and duration of periods of high and low rainfall. The result has been an increase in the occurrence of floods and droughts. The impact has been most severe on the agricultural sector, and points to the need for greater preparedness to deal with any further disasters in the coming years.

1.7 Environment and Development Framework

1.7.1 Environmental Agreements

Guyana is a Party to most of the major international conventions on the environment, including:
UN Framework Convention on Climate Change, Vienna Convention for the Protection of the Ozone Layer, Montreal Protocol on Substances that deplete the Ozone Layer, Kyoto Protocol, UN Convention to Combat Desertification, UN Convention on Biological Diversity as seen in Table 1.5 below.[6]

Table 1. 5. List of key Environmental Agreements to which Guyana is a Party

AGREEMENT	SIGNED	RATIFIED	ACCEDED
Vienna Convention for the Protection of the Ozone Layer. Vienna, 22 Mar 1985			12-Aug-93
Montreal Protocol on Substances that Deplete the Ozone Layer. Montreal, 16 Sept 1987			12-Aug-93
UN Framework Convention on Climate Change	13-Jun-92		
Kyoto Protocol to UN Convention on Climate Change			5-Aug-03
Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste and their Disposals. Geneva, 22 March 1989			4-Apr-01
Convention on Biological Diversity. Rio de Janeiro, 5 Jun 1992	13-Jun-92	29-Aug-94	
Cartagena Protocol on Biosafety to the Convention on Biological Diversity. Montreal, 29 Jan 2000			16-Jul-08
UN Convention to Combat Desertification in those Countries Experiencing Drought and/ or Desertification Particularly in Africa. Paris, 14 Oct 1994		26-Jun-97	
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. Rotterdam, 10 Sept 1998			30-Apr-07
Stockholm Convention on Persistent Organic Pollutants. Stockholm, 22 May 2001			12-Sep-07
Convention on International Trade in Endangered Species of Wild Fauna and Flora CITES		25-Aug-77	
Amendment to the article Xxi of CITES adopted in Gaborone on April 30, 1983 deposited on July 5, 2007	Not yet in force		
Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region			

Guyana participates actively in the work of the UN Commission on Sustainable Development and the Secretariats of the UN Environmental Conventions. Guyana also works closely with other countries in Regional and Global groupings such as the Caribbean Community (CARICOM); Caribbean Development Co-operation Council (CDCC); Association of Caribbean States (ACS); Organization of American States (OAS); Group of Latin American & Caribbean Countries (GRULAC); Association of Small Island States (AOSIS); Group of 77 & China; Amazon Co-operation Treaty Organization (ACTO); Union of South American Nations (UNASUR).
Through involvement in these Conventions and Organizations, Guyana has benefited from several projects resulting in improved capacity for the management of natural resources and the environment.

1.7.2 Natural Resources and Environmental Management

At the national level, the Management of Natural Resources and the Environment is guided by the Cabinet Sub-Committee on Natural Resources, which focuses on policy issues.

Over the years, there have been major developments in sectors which help to support achievement of environmental goals. These are:

- National Environmental Action Plan (1994)
- Environmental Protection Act (1996)
- Establishment of the Environmental Protection Agency (1996)
- Establishment of the Iwokrama International Rainforest Programme (1993)
- Guyana Climate Change Action Plan (2001)
- Guyana Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-lying Areas (2002)
- National Biodiversity Action Plan (2006-2011))
- National Biosafety Framework for Guyana (2007)
- Technical Report and Action Plan on a System of Indicators to monitor Forest Biological Diversity in Guyana
- Guyana National Action Programme to Combat Land Degradation (2006)
- Guyana Readiness Preparation Proposal (2009)
- Guyana Low Carbon Development Strategy (2009).

Since 2008, with the establishment of the Office of Climate Change within the Office of the President, there has been a dedicated national approach to Climate Change.

1.7.3 Guyana's Response to Global Climate Change

Guyana signed on to the Convention on Climate Change at Rio and acceded to the Kyoto Protocol of the Convention in 2003. Over the years, as a Party to the Convention, Guyana has made significant efforts and progress in the promotion of awareness and initiatives on climate change.

By 2008, Guyana had intensified its advocacy for world leaders to reach agreement on effective measures to reduce the concentration of greenhouse gases in the atmosphere. President Bharrat Jagdeo became directly involved in leading Guyana's efforts by developing and lobbying for the country's initiatives embodied in its pioneering Low Carbon Development Strategy.

Over the last few years, global recognition has been given to the critical role of Reducing Emissions from Deforestation and Forest Degradation (REDD), as well as enhancement of carbon stocks, conservation, and sustainable management of forests in developing countries - REDD+.

As a global model for REDD+ is being developed, Guyana is moving ahead to develop a workable approach to addressing deforestation and other aspects of climate change.

In 2008, the Government of Guyana facilitated a study which assigned a value to Guyana's forests according to its Economic Value to the Nation (EVN), and its Economic Value to the World (EVW).[8] The study found that most of Guyana's forest is suitable for timber extraction and post-harvest agriculture, and furthermore, significant mineral deposits exist below its surface. If Guyana chose to pursue these types of forest usage for 'development', the likely estimate of the forest's value is US$5.8 billion, which would correspond to having an annuity payment of US$580 million. This forest value is known as Economic Value to the Nation (EVN).

Conservative valuations of the Economic Value to the World (EVW) provided by Guyana's forests suggest that -left standing- they can contribute US$40 billion to the global economy each year.

On June 8th 2009 therefore, Guyana launched its Low Carbon Development Strategy (LCDS). This Strategy sets out a development path for the country that is based on Guyana deploying its forests to mitigate global climate change, and in return receiving payments from the world for the carbon service the forests provide.

[8] *Creating Incentives to avoid Deforestation*. Office of the President, Guyana. (2008.)

The Strategy has several important components. It examines how Guyana can deploy its forests in mitigating climate change, while also gaining financial and other support for doing so, and how the country can move along a low carbon development path, and support the further protection of Guyana from the effects of climate change (adaptation).

On November 9th 2009, the Governments of Guyana and the Kingdom of Norway signed a Memorandum of Understanding which set out how the two countries will 'work together to provide the world with a relevant, replicable model for how REDD-plus can align the development objectives of forest countries with the world's need to combat climate change'.

Several institutions were set up in light of the growing need for actions to be taken nationally to address the potential impacts of Climate Change for Guyana. The LCDS indicates that five main institutions will be prioritized for strengthening in **2010 and 2011**.

- The Office of Climate Change (OCC) is responsible for co-ordinating work on climate adaptation, mitigation and forest conservation, as well as national consultations of the LCDS.
- The Project Management Office (PMO) is responsible for accelerating implementation of key projects identified in the LCDS.
- The Guyana REDD+ Investment Fund (GRIF) will be established in 2010 to channel REDD-plus financial support from Norway and other contributors to implement Guyana's LCDS.
- The REDD Secretariat will be involved in determining the forest payments earned by Guyana every year, and over time, will implement monitoring, reporting and verification (MRV) in accordance with international guidelines

for estimating and reporting carbon emissions and removals.

- The Environmental Protection Agency (EPA) is responsible for ensuring that national and international social and environmental standards are met in all GRIF investments.

Many sectors (such as mining and forestry) have already begun to integrate policies, legislations and programmes in line with the LCDS requirements. A REDD Secretariat has been set-up to build REDD+ capacity in Guyana.

1.7.4 GHG Inventory and National Communications

The preparation of the Second National Communication was overseen by the National Climate Committee and a Project Steering Committee, which are both chaired by the Head of the Office of Climate Change within the office of the President. Through such oversight, national priorities are taken into account and full involvement of appropriate sectors can be ensured.

Ideally, data gathered to prepare Guyana's Initial National Communication (INC) should have been available to enable a smoother flow of the GHG inventory process, in terms of understanding what was required. However, none of the INC data or worksheets was available due to inadequate back-up systems and information storage. Also, many institutions suffered loss of records and materials during the 2005 floods. There was also the challenge of the loss of institutional memory because of staff turnover since the INC period.

In the preparation of the GHG Inventory, international expertise was sourced. The inventory covered a fifteen-year period from 1990-2004. This included a revision of the INC years. Due to the lack of local capacity in the understanding of GHG Inventory, a special effort was made to train personnel from the institutions within the government, and from the private sector, to build capacity in those institutions. Representatives from the main sector Agencies were given four days of training on the use of the IPCC 1996 workbook. In this way, institutional collaboration was strengthened, and representatives participated by completing the worksheets for respective sectors, which were then reviewed by the Consultants. Institutions also submitted raw data for cross-checking. The draft and final inventory reports were then subjected to Technical Reviews by international reviewers and the National Communication Support Programme (NCSP). Further discussion on the GHG Inventory methodology can be found in Chapter II.

The preparation of this Second National Communication benefited from the policy guidance of the representatives from a wide cross-section of Organizations and Agencies who serve on the National Climate Committee and other related National Committees. The inputs of the Office of Climate Change were given through the Chair of the Project Steering Committee, which created a strong link with the process for the development and implementation of the Low Carbon Development Strategy.

Chapter 2

Greenhouse Gas Inventory

Chapter 2

Greenhouse Gas Inventory

2.0 Introduction

Guyana is required, as a Non-Annex 1 Party to the Kyoto Protocol, to communicate to the COP a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, in accordance with Article 4:1(a), and Article 12:(1)(a) of the Convention,

In producing the GHG Inventory of the SNC, the government of Guyana has estimated GHG emissions by sources and removals by sinks for the years 1990 to 2004, along with time series analyses for this period. The greenhouse gases included in this report include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), and oxides of nitrogen (NOx). Methane (CH_4) and nitrous oxide (N_2O) are also reported as CO_2 equivalents (CO_2e), based on their respective 100-year global warming potentials.

In view of data limitations, the IPCC (1996) Revised GHG Inventory methodology was used. However, in accordance with the Good Practice Guidelines relating to time series and consistency, more up-to-date emission factors and default activity data (IPCC EFDB and the IPCC 2006 GHG Inventory methodology) were used where available and applicable.

The IPCC (1996) Guidelines offer a default methodology which includes default emission factors and in some cases default activity data, which is appropriate for Guyana. Using the Revised IPCC (1996) guidelines and methodologies, and augmented, where possible, by the IPCC (2000) Good Practice guidelines and the IPCC (2006) guidelines, the Inventory was developed on a sector basis and covered the Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry and Waste sectors. The Solvents sector was not considered since this module was not available in the Revised IPCC (1996) methodology. CO_2 emissions from International Bunkers and biomass are not included in the national totals and are reported under Memo items.

All calculations were redone for the period covered by the INC (1994-1998) which focused on 1990 as the reference year.

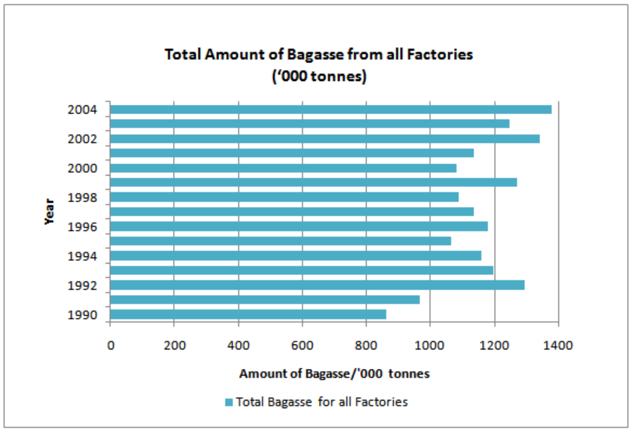
2.1 Energy Sector

Currently there is no primary or secondary fossil fuel production in the Republic of Guyana. Secondary fuels, including gas diesel oil, heavy fuel oil, gasoline, kerosene, jet kerosene, aviation gasoline and liquefied petroleum gas (LPG) are imported for local use and consumption. A very small percentage of total imports are used for international aviation and marine bunkers.

Greenhouse gas (GHG) emissions are produced through the combustion of these secondary fuels for energy in the power-generating utilities, the transport, the agriculture, the mining and fishing, the manufacturing, the commercial, the residential and the international aviation and marine sectors.

Biomass also accounts for part of the energy sources in Guyana. Bagasse is used in the sugar industry and rice husk in the rice industry and other industries for the co-generation of heat and electricity. Also, wood products such as firewood and charcoal are used in the residential sector for cooking purposes (See Fig. 2.1.)

Fig. 2.1. Production of bagasse from all sugar factories in Guyana (1990 - 2004)



2.1.1 Methodology

For the Energy Sector both the aggregate **Reference Approach** (top-down) and the source categories **Sectoral Approach** (bottom-up) were used to calculate the GHG Inventory for the years 1990 to 2004.

The Reference Approach essentially consolidates all fuel consumption for the year in question, whereas the Sectoral Approach breaks down the yearly fuel consumption by economic sectors, namely the Energy Industries, Manufacturing Industries and Construction, Transport, Commercial/Institutional, Residential, Forestry and Fishing, Memo Items and Other sectors.
Activity data on fossil fuels imported and used in the different Energy sectors and in international bunkers are provided in barrels (bbls). These units are converted to kilotonnes by use of the specific gravity of each fuel so as to derive **Apparent Consumption** in Terajoules (TJ) after using the **Conversion Factor** Tj/kilotonnes. Local values of specific gravity are used, where provided. If not, published literature values are used.

Similarly**, Biomass** fuels (in 1,000s kg), were converted to Apparent Consumption in TJ by using the IPCC default values (refer to Table 1-13, Vol.3 of the IPCC Guidelines).

In all cases, on account of the lack of country-specific data, the **Default Values** of the **Conversion, Emission** and **Carbon Oxidation Factors** were extracted from the **IPCC (1996; 2000; 2006) Guidelines,** and the **IPCC Emission Factors Database (EFDB)** were used (Table 2.1).

Table 2. 1. Conversion factors, carbon emission factors and fraction of carbon oxidized for the various fuels

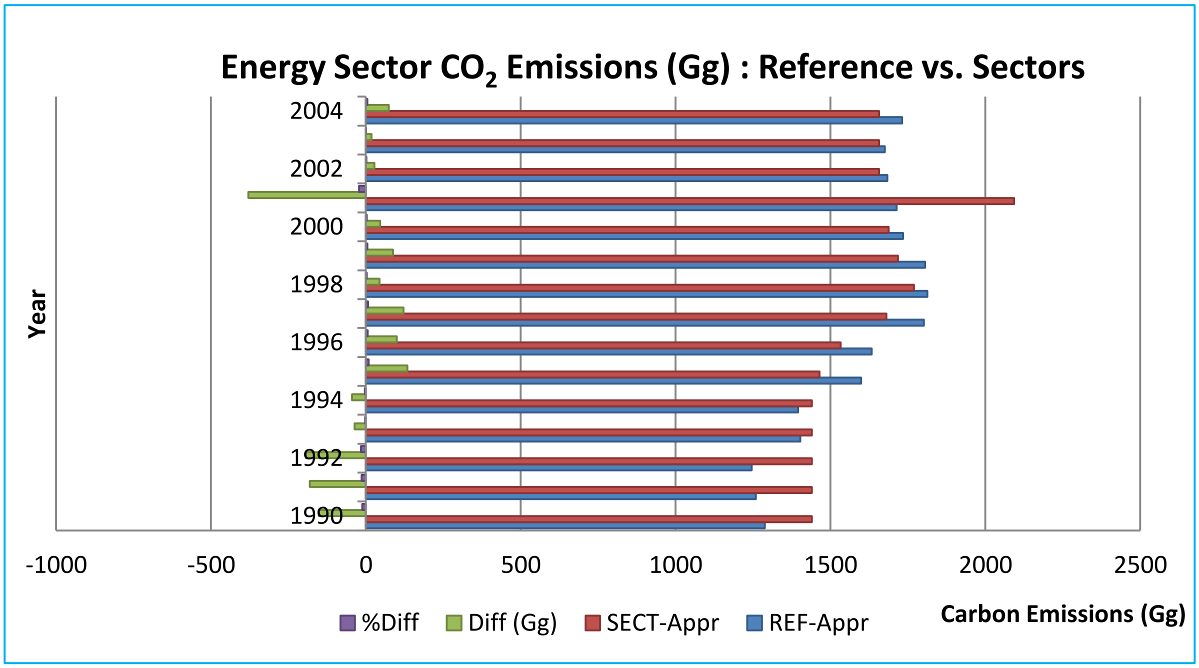
Fuel Type	Conversion Factor (Tj/kilotonnes)	Carbon Emission Factor (t C/TJ)	Fraction of Carbon Oxidized
Gasoline	44.8	18.9	0.99
Jet Kerosene	44.59	19.5	0.99
Other Kerosene	44.75	19.5	0.99
Gas Diesel Oil	43.33	20.2	0.99
Residual Fuel Oil	40.19	21.1	0.99
LPG	47.31	17.2	0.99
Lubricants	40.19	20.0	0.99
Solid Biomass	8	29.9	0.99

The sectoral breakdown of the fuel consumption seems reasonable, given the closeness of the emissions estimates (< 10 %) for most years between the Reference and the Sectoral approaches (Table 2.2 and Fig. 2.2).

Table 2. 2. Comparison of CO_2 emissions: reference vs. sectors approach, 1990-2004

Year	Reference * (Gg)	Sectors * (Gg)	Reference-Sectors* (Gg)	Difference (%) Reference-Sectors
1990	1288	1440	-152	-11.80
1991	1259	1440	-181	-14.38
1992	1246	1440	-194	-15.57
1993	1403	1440	-37	-2.64
1994	1395	1440	-45	-3.23
1995	1599	1465	134	8.38
1996	1633	1533	100	6.12
1997	1801	1680	121	6.72
1998	1813	1769	44	2.43
1999	1805	1718	87	4.82
2000	1734	1688	46	2.65
2001	1713	2093	-380	-22.18
2002	1684	1657	27	1.60
2003	1675	1657	18	1.07
2004	1731	1655	76	4.39

Fig.2.2. Comparison of CO_2 emissions: reference vs. sector



This method should give close emission estimates for the various sectors, since Guyana's fuel consumption is limited to only six fuel types, namely gasoline, gas diesel oil, fuel oil, jet kerosene, aviation gasoline and liquefied petroleum gas (LPG), and since each fuel type is used in a particular sector; for instance gasoline is used particularly in the transport sector. For certain years (1990-1993 and 2003-2004), the sectoral breakdown of fuel consumption was unavailable. Data was replicated for the years of missing data to fill these gaps (1994 for 1990-1993 and 2002 for 2003-2004).

No fuel is allotted as feedstock to manufactured items in which carbon is stored, since all fuels imported are burnt, and carbon storage in products is negligible.

2.1.2 Energy Sector GHG Emissions

For the Energy sector only CO_2 and non-CO_2 emissions of GHGs are considered, since there are no CO_2 removals for this sector. Fossil and biomass fuel combustion are the two main sources for emissions of CO_2 in the Energy sector. Guyana does not produce cement, which is a very significant source of this gas through the production process. The country also does not have metal-producing, chemical or other industries which emit CO_2 through their production processes. Gold is being mined, but the production process (electrolysis) does not emit CO_2.

Carbon Dioxide (CO_2) Emissions

When comparing the **Reference** and **Sectoral** approaches, CO_2 emissions are very similar from year to year with the differences being less than 10% for most years, except 1990, 1991,1992, and 2001 (Fig. 2.3 and Appendix

2.1 for tables). In the case of the years 1990-1993, this could simply have been due to missing sectoral data for these years, and an inadequate filling of the data gaps. For the year 2001, this would seem to be related to the significant Stock Change of fuels (-79,100 barrels of which – 66,200 barrels were attributed to gas diesel oil).

A breakdown of the CO_2 emissions from the sub-sector categories within the Energy sector shows that by far the greatest CO_2 emissions derive from the electrical energy-generating sub-sector, with values ranging from 605 Gg (42.1 %: 1990-1994) to 1,190 Gg (56.9 %: 2001). The fuels combusted in this activity are mainly fuel oil (Bunker C) and gas diesel oil (Fig. 2.3).

In the Agriculture, Forestry and Fishing sub-sectors, CO_2 emissions range from 368 Gg (25.6 %: 1990-1994) to 430 Gg (56.9 %: 1995). The fuels combusted in this activity are mainly fuel oil (Bunker C), gas diesel oil, and gasoline (Fig. 2.3).

In the transport sub-sector, consisting mainly of road transport, and to a much lesser extent inland transport via waterways and inland aviation, CO_2 emissions range from 210 Gg (14.6 %: 1990-1994) to 335 Gg (19.8 %: 2000). The fuels combusted in this activity are mainly gasoline, diesel oil and aviation gasoline (Fig. 2.3).

The next important sub-sectors are the Manufacturing Industries and Construction which account for from 188 Gg (9 %: 2001) to 263 Gg (14.9 %: 1998) of CO_2 emissions. The fuels combusted in these activities are mainly fuel oil (Bunker C), diesel oil and lesser quantities of LPG (Fig. 2.3).

The other sub-sectors, namely the Residential and the Commercial/Institutional sectors, account for minimal amounts of CO_2 emissions, with CO_2 emissions being less than 10 % combined, and with LPG being the fuel used (Fig. 2.3).

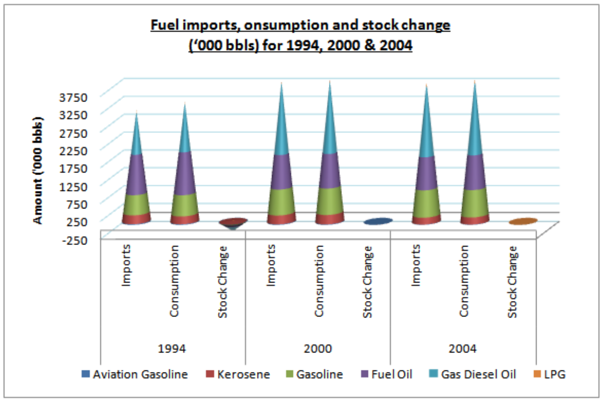


Fig. 2.3. Fuel imports, consumption and stock change for 1994, 2000 & 2004

Examples of these sub-sector CO_2 emissions within the Energy sector are provided in graphic form as pie charts in percentages for the three selected representative years, namely 1994, 1999 and 2004 (Figures 2.4, 2.5 and 2.6).

Table 2. 3. Energy sub-sector CO_2 emissions (Gg): 1990-2004

Energy Sub-Sectors in Gg	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Energy Industries	605	605	605	605	605	562	590	718	746	739	791	1190	741	741	741
Manufacturing & Construction	188	188	188	188	188	175	200	188	263	195	214	188	192	192	192
Transport	210	210	210	210	210	215	267	275	310	323	335	326	314	314	314
Commercial/ Institutional	4	4	4	4	4	4	5	5	5	8	7	7	8	8	8
Residential	64	64	64	64	64	79	70	82	75	83	87	73	77	77	77
Agriculture, Forestry, Fishing	368	368	368	368	368	430	402	412	370	370	254	310	325	325	325
Total	**1440**	**1440**	**1440**	**1440**	**1440**	**1465**	**1533**	**1680**	**1769**	**1718**	**1688**	**2093**	**1657**	**1657**	**1657**

Table 2.4. Energy sub-sector CO_2 emissions (%): 1990-2004

Energy Sub-Sectors	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Energy Industries	42.1	42.1	42.1	42.1	42.1	38.4	38.5	42.7	42.2	43	46.9	56.9	44.7	44.7	44.7
Manufacturing & Construction	13.2	13.2	13.2	13.2	13.2	11.9	13	11.2	14.9	11.4	12.7	9	11.6	11.6	11.6
Transport	14.6	14.6	14.6	14.6	14.6	14.7	17.4	16.4	17.5	18.8	19.8	15.6	18.9	18.9	18.9
Commercial/ Institutional	0.28	0.28	0.28	0.28	0.28	0.27	0.33	0.3	0.3	0.5	0.4	0.3	0.5	0.5	0.5
Residential	4.4	4.4	4.4	4.4	4.4	5.4	4.6	4.9	4.2	4.8	5.2	3.5	4.6	4.6	4.6
Agriculture, Forestry, Fishing	25.6	25.6	25.6	25.6	25.6	29.4	26.2	24.6	20.9	21.5	15	14.8	19.6	19.6	19.6
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Fig. 2.4. Energy sub-sector CO_2 emissions (%): 1994

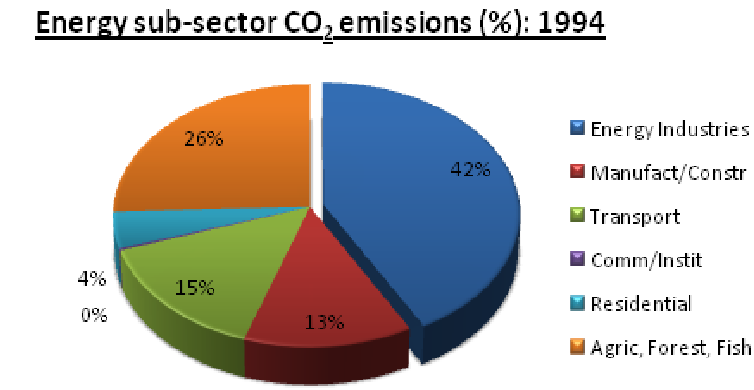


Fig. 2.5. Energy sub-sector CO_2 emissions (%): 2000

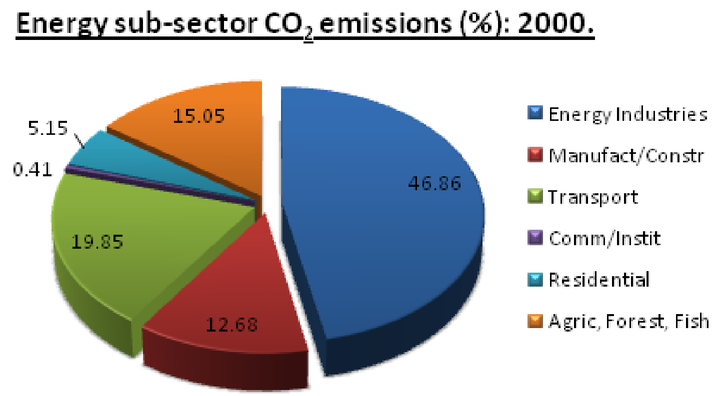
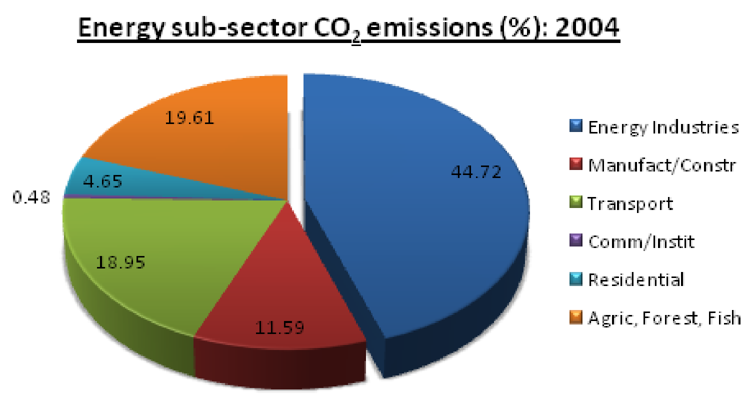


Fig. 2.6. Energy sub-sector CO_2 emissions (%): 2004



2.1.3 Memo Items

Parties using the IPCC Revised (1996) methodology are not required to incorporate **Memo Items** including **international aviation and international marine bunkers** and the **burning of biomass** in their total emissions or removals of CO_2. However, countries are obliged to report these items separately.

The Guyana Sugar Corporation uses bagasse for the co-generation of steam and electricity, but these emissions are reported under **Biomass Emissions.** This is because, according to the IPCC, the CO_2 emitted is reabsorbed in the next growing season of sugar cane. This justification applies to all biomass fuels, which are used as a source of energy. Emissions from biomass are therefore reported for information purposes only.

Data for missing years are replicated from adjacent years to fill data gaps, because of a paucity of Activity Data.

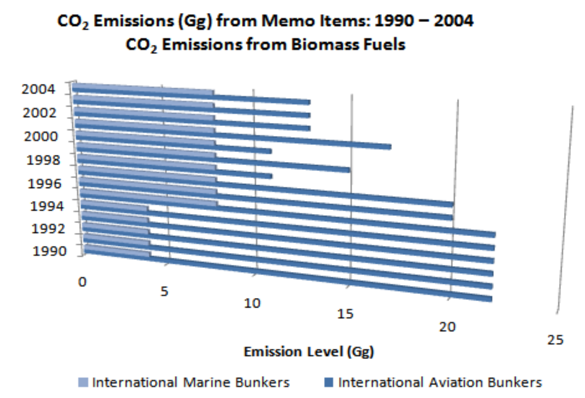
Carbon Dioxide Emissions from International Bunkers

Total CO_2 emissions from **international bunkers** are very minimal, ranging from 19 Gg (1998 and 2000) to 30 Gg (1990-1995). This is mainly because most of the vessels engaged in international air and marine transport in Guyana purchased their fuel outside of the country. The fuels consumed in these operations are aviation jet kerosene and some aviation gas for aviation, and gasoline and diesel oil for marine transport (Fig. 2.7).

CO_2 emissions from international aviation bunkers declined sharply after 1995, falling from 22 Gg of CO_2 emissions down to 13 Gg (2002-2004) and even to 11 Gg in 1998. This reduction of CO_2 emissions in 1998 was due to the fact that the national airline, Guyana Airways Corporation, had reduced operations in that year (See Fig 2.7).

On the other hand, CO_2 emissions from international marine transport showed a slight increase of CO_2 emissions from roughly 4 Gg prior to 1995 to approximately 8 Gg after 1995 (See Fig. 2.7).

Fig. 2.7. CO_2 emissions (Gg) from Memo Items: 1990 – 2004 CO_2 emissions from biomass fuels



In Guyana the biomass fuels that are burned for energy generation are primarily bagasse, firewood, rice husks and charcoal.

Reliable data for examining CO_2 emissions (Gg) from biomass using the Reference Approach, where all biomass fuels are lumped together, are only available for 1994 to 1998. . Owing to this lack of data the same data for 1990-1994 and then from 1998-2000 was therefore used. As can be seen from Fig. 13 and 14, this caused divergences between the emissions, especially between 1995 and 2000. Based on this data set, emissions are roughly 1487 Gg prior to 1994 and approximately 716 Gg after 1998, with the highest emission (1571 Gg) occurring in 1997 (Fig. 2.8).

By further examining total biomass fuel consumption, using the Sectoral Approach (Gg and %) for firewood and charcoal in the Residential Sector and rice husk and bagasse in the Energy Sector for the years 1994 to 1998, it is evident that combustion of bagasse accounts for over 90 % of CO_2 emissions for all years except 1998 (Fig. 2.9 and Table A2.5 in Appendix 2.1).

Smaller amounts (less than 10 %) derive from the combustion of wood and wood wastes in the **residential** and **manufacturing** sectors and from **rice husk** in the **manufacturing** sub-sector. **Charcoal** combustion in the **residential** sector accounts for a very small percentage (< 1 %) of CO_2 emissions for all years (Fig. 2.9).

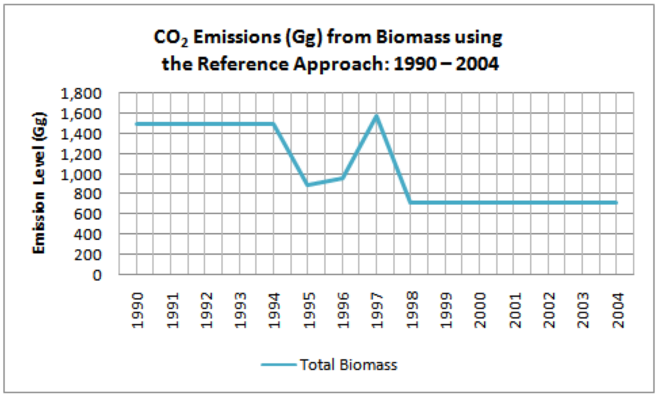


Fig. 2.8. CO_2 emissions (Gg) from biomass using the reference approach: 1990 – 2004

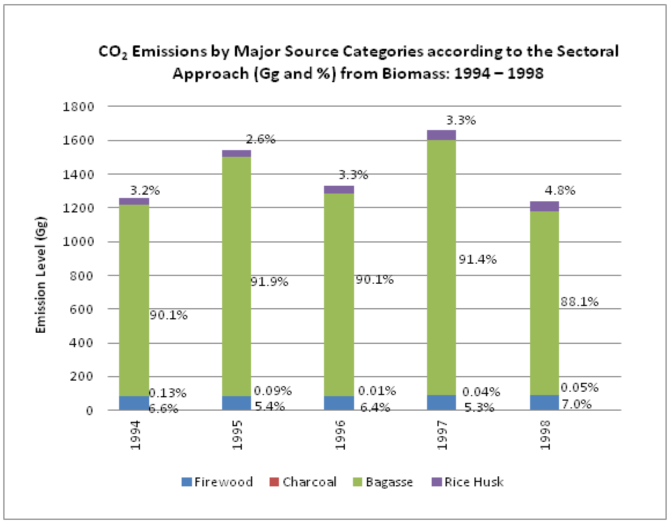


Fig. 2.9. CO_2 emissions by major source categories according to the sectoral approach (Gg and %) from biomass: 1994 – 1998 (Source: INC, 2002)

2.1.4 Non-CO_2 Emissions

Non-CO_2 emissions of **methane** (CH_4), **nitrous oxide** (N_2O), **nitrogen oxides** (NOx), **carbon monoxide** (CO), **non-methane volatile organic compounds** (NMVOC) and **sulphur dioxide** (SO_2) are relatively small for the Energy sector in Guyana (See Table 2.5). Only **CO** emissions, ranging from 35 Gg (1995) to 84 Gg (1990-1994), **NMVOC** emissions, ranging from 10 Gg (1995) to 15 Gg (1990-1994), and **NOx** emissions, ranging from 9 Gg (2000) to 11 Gg (1996-1999) seemed significant. **CO** emissions are derived mainly from fuel combustion in the road transport and energy industries sub-sectors. **NOx** emissions on the other hand, are produced by the mobile fishing, energy industries, and road transport sub-sectors. The abrupt change in CO emissions starting in 1995 is due to data being missing for the Commercial/Institutional sub-sectors (Table 2.5 and Fig. 2.10).

SO_2 emissions range from 6.8 Gg (2001) to 9.0 Gg (1998)**. CH_4** emissions are comparatively minimal, whereas **N_20** emissions are negligible (Table 2.5 and Fig. 2.10).

Table 2. 5. Non-CO_2 emissions (Gg) for the energy sector: 1990 – 2004

GHG(Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CH_4	3	3	3	3	3	0	1	1	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO*
N_2O	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO
NOx	10	10	10	10	10	10	11	11	11	11	9	10	10	10	10
CO	84	84	84	84	84	35	38	39	39	40	40	41	41	41	41
NMVOC	15	15	15	15	15	11	11	12	11	12	10	11	11	11	11
SO_2	7.5	7.5	7.5	7.5	7.5	8.1	7.7	8.2	9.0	7.0	7.1	6.8	6.9	6.9	6.9

*I/NO: Insignificant emissions or not occurring

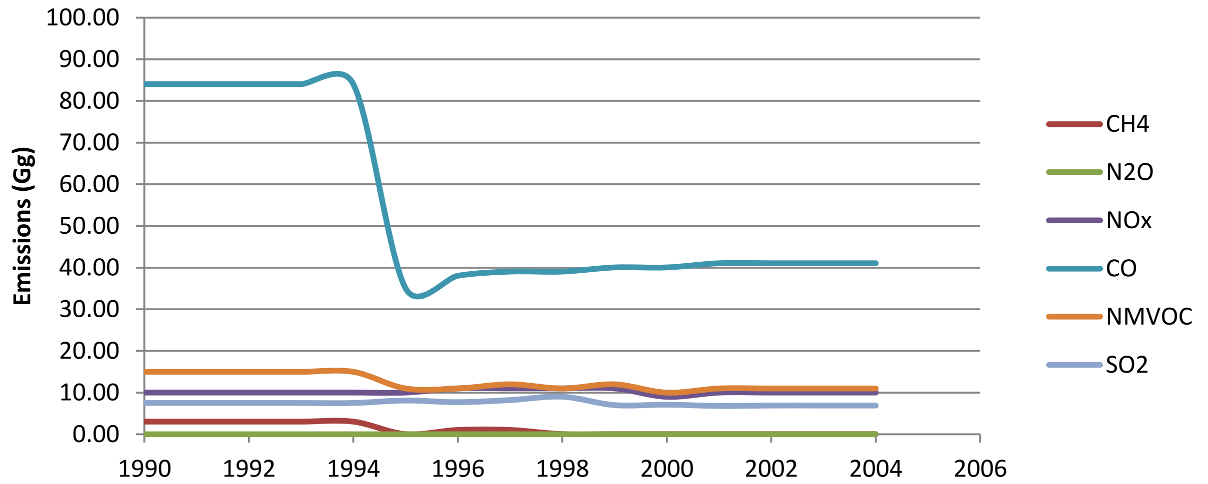


Fig. 2.10. Non-CO_2 emissions (Gg) for the energy sector: 1990 – 2004

Fugitive Emissions

For the period considered (1990-2004), oil and gas mining activities were non-existent in Guyana. Imported fuels were stored but also used up quickly, thereby significantly limiting fugitive emissions, which are therefore considered to be zero.

2.2 Industrial Sector

Guyana does not have a strong Manufacturing or Industrial sector, therefore GHG emissions from light manufacturing or heavy industries are minimal. GHG emissions in the Industrial sector are limited to **NMVOC** emissions from the **food and beverage industry** and from **asphalt** used in road paving. There are no emissions of Kyoto F-gases (PFCs, HFCs and SF 6); the major gases used for refrigeration and cooling are the HCFC – 22 family of gases covered under the Montreal Protocol.

NMVOC emissions are derived from **bitumen used in road paving with asphalt**, and from the **manufacture of alcoholic beverages** (rum, beer and stout, shandy and wine) and **food production** (bread, biscuits, meat, fish and poultry, sugar, margarines and stock feed). All activity data are country-specific.

Since unstable gases such as NMVOCs are eventually converted into CO_2 due to chemical reactions in the atmosphere, they were ascribed the same global warming potential/equivalent CO_2 as CO_2 ($CO2_e$), namely unity.

2.2.1 Industrial Sector: NMVOC

NMVOC emissions in the Industrial sector are relatively low, with total NMVOC emissions ranging from 13.78 Gg (1990) to 15.91 Gg (2002) (Table 2.6).

Road Paving with Asphalt

NMVOC emissions from Road Paving with Asphalt were essentially based on the availability of data, which was in fact the year 1994, and this value was used for all other years. **NMVOC** emissions from **road paving with asphalt** were estimated at **9.6 G** (1990-2004) (Table 2.6). Furthermore, NMVOC emissions from road paving with asphalt accounted for over 50 % of all NMVOC emissions in the Industrial sector (Table 2.6 and Fig. 2.11).

Alcoholic Beverage and Food Production

The other two sectors contributing to NMVOC emissions within the Industrial Sector are the manufacture of **alcoholic beverages** and **food production.**

However, NMVOC emissions from these two industrial sources are relatively low, ranging from 1.38 Gg (2000) to 2.54 Gg (1990-1998) for alcoholic beverages, and from 1.64 Gg (1990) to 3.63 Gg (2004) for food production (Table 2.6). These values are converted to percentages for the Reference year (2000) and presented for demonstration of the breakdown of NMVOC source emissions (Fig. 2.11). For the Reference year, emissions from road paving with asphalt dominate with 63.87 % (Fig. 2.11).

Table 2.6. NMVOC emissions for the industrial sector for the period 1990-2004

Industrial Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Road Paving: Asphalt	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Alcoholic Beverages	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.07	1.38	1.98	2.19	1.80	2.40
Food Production	1.64	1.96	2.81	2.80	2.89	2.88	3.14	3.10	2.89	3.60	3.09	3.21	4.12	3.48	3.63
Total	**13.78**	**14.1**	**14.9**	**14.94**	**15.03**	**15.02**	**15.28**	**15.24**	**15.03**	**15.27**	**14.07**	**14.79**	**15.91**	**14.88**	**15.63**

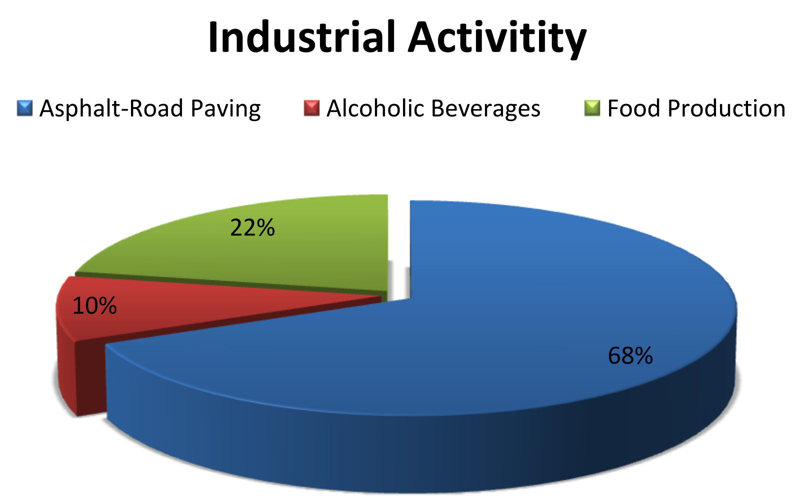


Fig. 2.11. **NMVOC emissions from road paving with asphalt, manufacture of alcoholic beverages and food production for the reference year (2000: %)**

2.2.2 Halocarbon Emissions

Guyana is classified as an Article 5 Country under the Montreal Protocol, meaning that it is a low volume consuming country of ODS, hence is grouped with others and is treated differently from other high volume and producing countries. Guyana neither produces nor exports any of the Kyoto Protocol gases, namely HFC, HCFC, PFC and SF6. It is allowed trade in CFCs, HFCs, HCFCs and blends containing these gases that are controlled under the Protocol. Importers include Dhanson Trading, with 55 % of total importation of the national market, Harvey's Electrical, 24 %, Allied Trading Enterprise, 15 % and Frontier Trading, 6 %, as reported by Guyana Revenue Authority, Customs Department (2007). The gases imported for local use includes CFC 11, CFC 12, CFC 115, HFC 134 a, HCFC 22, HCFC 141b, HCFC 404a.

Agriculture is one of the key sectors of the Guyanese economy, accounting for more than 25 % of GDP in 2009 (Bureau of Statistics, Guyana, 2009). Methane (**CH_4**) is one of the most important non-CO_2 GHG emitted by the Agriculture sector. CH_4 emissions are derived, in order of importance, from **rice cultivation, enteric fermentation and manure management** in the rearing of livestock, **field burning of agricultural residues** and **prescribed burning of savannahs.**

2.3 Agriculture Sector

Carbon Monoxide (**CO)** and Nitrogen Oxides (**NOx)** emissions are derived exclusively from the **field burning of agricultural residues** and to a lesser extent from **prescribed burning of savannahs**.

Nitrous Oxides (**N_2O)** emissions however, which are very small, resulted from a number of sources, including **enteric fermentation and manure management, field burning of agricultural residues, prescribed burning of savannahs** and a variety of soil processes, including synthetic nitrogenous fertilizer application to agricultural fields.

For field burning of crop residues, the most important crops for Guyana are rice and sugar-cane. Other crops, such as maize, are considered insignificant.

For the prescribed burning of savannahs, two categories of savannah lands were identified: dry and wet savannahs. No data on total savannah area burnt annually was available. As such, the default approach was used, of taking total savannah area and a fraction of what is burnt annually to estimate GHG emissions from this source. Discussions with officials revealed that some spontaneous burning occurs annually. There is also some amount of planned burning for agricultural purposes, but monitoring of this situation is inadequate. It was determined that the total area burnt annually however, represents a very small percentage of the total savannah area.

2.3.1 Agriculture Sector: Emissions and Removals

Since methane (CH_4) and nitrous oxide (N_2O) emissions have significant global warming potentials, emissions are calculated for each gas per se, and then for each gas weighted according to its global warming potential or equivalent CO_2 (CO_2e). On the other hand, since carbon monoxide (CO) and nitrogen oxides (NOx) emissions eventually revert to CO_2 in the atmosphere, CO_2e calculations are not done for these gases. CO_2 emissions are negligibly small and are considered to be zero.

Methane (CH_4) Emissions

Methane emissions in the Agriculture sector derive mainly from rice cultivation under flooded conditions, and CH_4 emissions for the period studied ranged from 14.4 Gg (2002) to 29.4 Gg (1999) (Table 2.7).

The other major contributor to CH_4 emissions in the Agriculture sector is Enteric Fermentation from domestic animals with values ranging from 8 Gg (1990) to 16 Gg (2004). Contributions to CH_4 emissions from manure management are minimal and negligible on account of the fact that manure management systems are not prevalent in Guyana. (Table 2.7.)

The next important contributor to CH_4 emissions in the Agriculture sector is Field Burning of Agricultural Residues, mainly sugarcane and rice residues, and values ranged from 4.38 Gg (1990-1998) to 4.73 Gg (1999) (Table 2.7). Prescribed Burning of Savannahs also contributes minimally to CH_4 emissions, being 0.65 Gg for all years. (Table 2.7.)

In all, total CH_4 emissions in the Agriculture sector range from 34.23 Gg (2002) to 57.48 Gg (1999) (Table 2.7).

CH_4 emissions are then converted to CO_2e based on a 100-year global warming potential value of 25 (IPCC, 2007). These results are shown for the three selected years, namely 1994, 1999 and 2004. (Table 2.8.)

Table 2. 7. Methane (CH_4) emissions (Gg) for the agriculture sector (1990-2004)

Activity CH_4	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Enteric Fermentation	8	8.9	9	9.8	10	10	11	11	12	12	13	13	14	15	16
Manure Management	0.5	0.1	0.3	0.2	0.13	0.67	0.3	0.63	0.13	0.7	0.3	1	0.8	0.6	0.4
Rice Cultivation – Flooded	25.9	25.9	25.9	25.9	25.9	25.9	27.1	28.5	25.9	29.4	23.2	24.9	14.4	25.8	23.2
Field Burning of Agricultural Residues	4.38	4.38	4.38	4.38	4.38	4.38	4.38	4.38	4.38	4.73	4.38	4.38	4.38	4.38	4.38
Prescribed Burning of Savannahs	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Total CH_4 Emissions	**39.43**	**39.93**	**40.23**	**40.93**	**41.06**	**40.95**	**43.43**	**45.16**	**43.06**	**47.48**	**41.53**	**43.93**	**34.23**	**46.43**	**44.63**

Methane (CH_4) Emissions as CO_2e

When methane **(CH_4)** emissions are converted to CO_2e, based on a global warming potential of 25 (IPCC, 2007), the values of (CH_4) emissions increase substantially. Emissions of CH_4 from rice cultivation, for the chosen years (1994; 2000; 2004), now range from 575 Gg (2000) to 647.5 Gg (1994) (Table 2.8 and Fig. 2.12; 2.13; 2.14).

Similarly, CH_4 emissions from enteric fermentation, the other major contributor to methane emissions in the agriculture sector, increase in values ranging from 250 Gg (1994) to 400 Gg (2004) (Table 2.8 and Fig. 2.12; 2.13; 2.14).

As to be expected, relatively significant increases in methane emissions are also observed for the other sub-sectors, namely field burning of agricultural residues, prescribed burning of savannahs and manure management (Table 2.8 and Fig. 2.12; 2.13; 2.14).

Table 2. 8. Methane (CH_4) emissions (Gg) as CO2 and CO_{2e} for the agriculture sector for the selected years (1994; 2000; 2004)

Activity	1994 (CO_2)	1994 (CO_2e)	2000 (CO_2e)	2000 (CO2e)	2004 (CO_2)	2004 (CO_2e)
Enteric Fermentation	10	250	13	325	16	400
Manure Management	0.13	3.25	1	25	0.4	10
Rice Cultivation – Flooded	25.9	647.5	23	575	23.2	580
Field Burning of Agricultural Residues	4.38	109.5	4	100	4.38	109.5
Prescribed Burning of Savannahs	0.65	16.25	1	25	0.65	16.25
Total CH_4 Emissions	**41.06**	**1026.5**	**47.48**	**1050**	**44.63**	**1115.7**

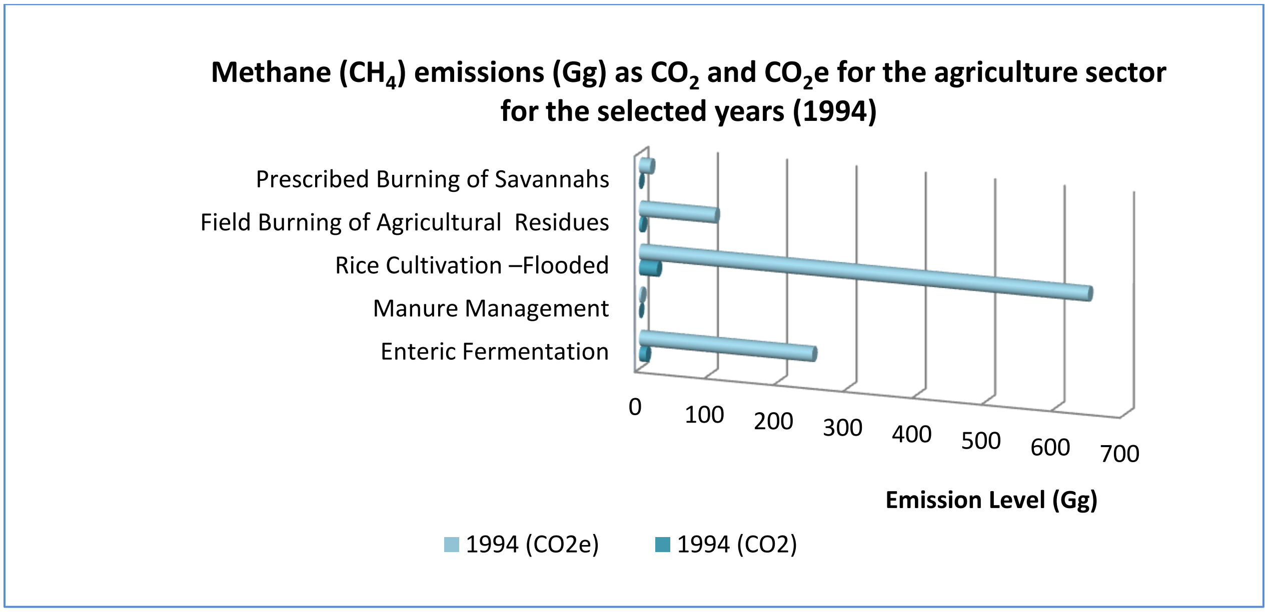


Fig. 2.12. Methane (CH_4) emissions as CO_2 and CO_{2e} for the agriculture sector for the year 1994

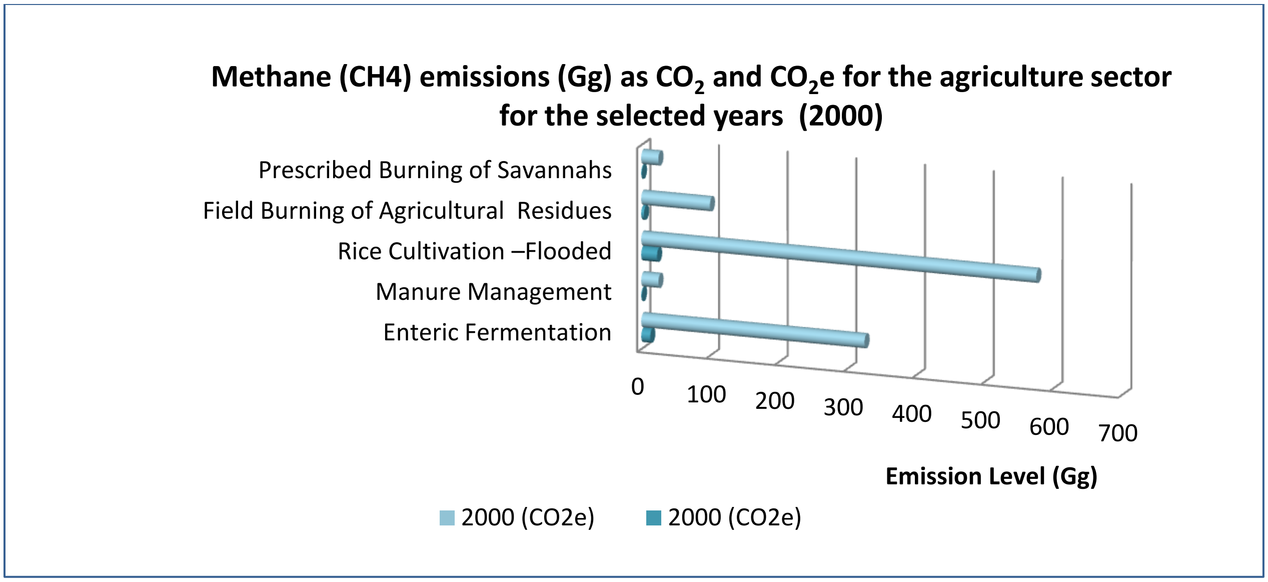


Fig. 2.13. Methane (CH_4) emissions as CO_2 and CO_{2e} for the agriculture sector for the year 2000

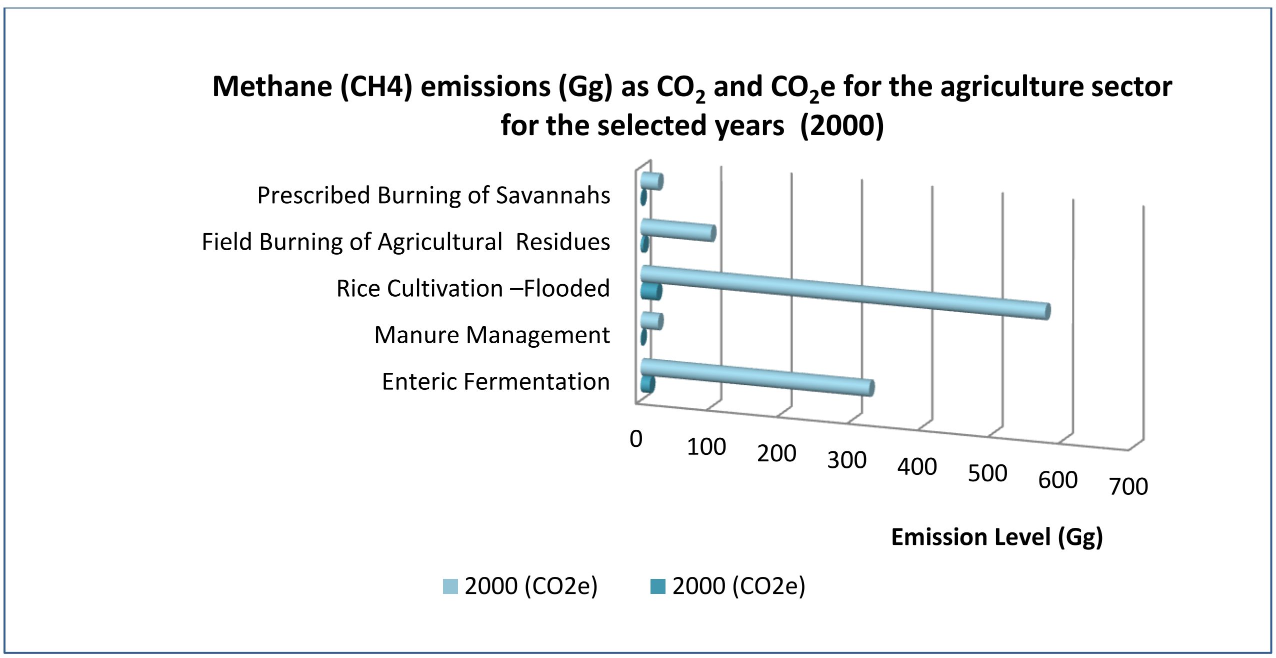


Fig.2.14. Methane (CH_4) emissions as CO_2 and CO_{2e} for the agriculture sector for the year 2004

Nitrous Oxide (N_2O) Emissions as N_2O and CO_2e

Nitrous oxide (**N_2O**), like methane, is also emitted from all agricultural activities examined previously except for rice, namely from **enteric fermentation and manure management** for domestic animals, the **cultivation of histosols**, **prescribed burning of savannahs**, **field burning of agricultural residues** and **atmospheric deposition and leaching of soils**. However, because of the very low values of emissions and rounding errors there is no perceptible change in N_20 emissions from year to year, with total values being 0.72 Gg, of which atmospheric deposition and soil leaching (0.21 Gg) and cultivation of histosols (0.21 Gg) are the most important (Table 2.9).

On account of limited activity data, direct N_2O emissions from grazing animals are negligible and are considered as zero.

Table 2. 9. Nitrous Oxide (N_2O) emissions (Gg) as N_2O (1990-2004)

Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Enteric Fermentation	I/NO*	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO
Manure Management	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO
Direct N_2O Emissions-Histosols	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Prescribed Burning of Savannahs	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Field Burning of Agricultural Residues	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Indirect N_2O Emissions – Atmospheric Deposition and Leaching	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Direct N_2O Emissions – Grazing Animals	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO
Total N_2O Emissions	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**

*I/NO: Insignificantly Small or Not Occurring

Because of the similarity of N_20 emissions from year to year, only one year, the Reference Year (2000), is used to demonstrate N_20 emissions as CO_2e. In order to convert N_20 emissions to CO_2e, a global warming potential of 298, over 100 years, is used (IPCC 2007).

N_20 emissions as CO_2e for the selected year (2000) now range from 2.98 Gg from the prescribed burning of savannahs to 110.26 Gg from the indirect emissions from atmospheric deposition and leaching from soils (Table 2.10 and Fig. 2.15).

Table 2. 10. Nitrous Oxide (N_2O) emissions (Gg) as N_2O and CO_{2e} (2000)

Activity	N_20 (2000)	CO_2e (2000)
Enteric Fermentation	I/NO*	I/NO
Manure Management	I/NO	I/NO
Direct N_2O Emissions- Histosols	0.21	62.58
Prescribed Burning of Savannahs	0.01	2.98
Field Burning of Agricultural Residues	0.13	38.74
Indirect N_2O Emissions – Atmospheric Deposition and Leaching	0.37	110.26
Direct N_2O Emissions – Grazing Animals	I/NO	I/NO
Total N_2O Emissions	**0.72**	**214.56**

*I/NO: Insignificantly Small or Not Occurring

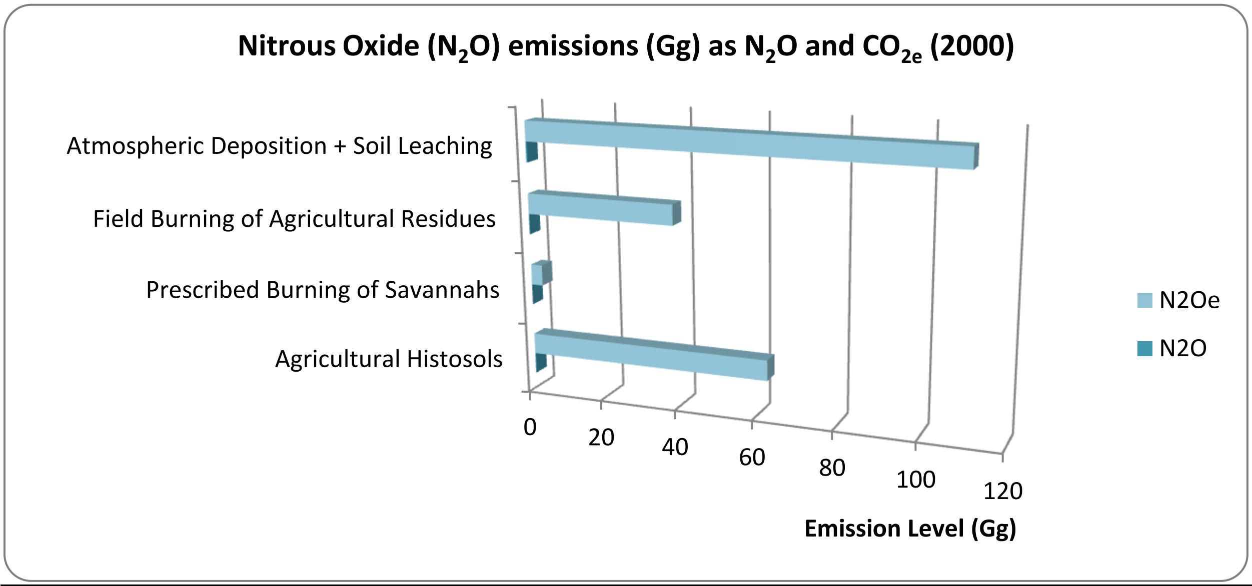


Fig.2.15. Nitrous Oxide (N_2O) emissions as N_2O and CO_{2e} (2000)

Carbon Monoxide (CO) Emissions

Carbon Monoxide (CO) Emissions from the Agriculture sector derive exclusively from the **Prescribed Burning of Savannahs** and from the **Field Burning of Agricultural Residues**. Activity data for both categories were not obtainable. Since burning of sugar-cane and rice residues is common in Guyana, it is necessary nonetheless to incorporate them. The necessary default data are obtained from the FAO Statistical Yearbook (1991; 2009).

Emissions of CO from the Prescribed Burning of Savannahs are calculated as 17 Gg for all years (1990-2004), whereas emissions from the Field Burning of Agricultural Residues are calculated as 92 Gg for all years (1990-2004).

Nitrogen Oxides (NOx) Emissions

Nitrogen Oxides (NOx) Emissions from the Agriculture sector also derive exclusively from the Prescribed Burning of Savannahs and from the Field Burning of Agricultural Residues; total emissions are relatively small, approximately 5 Gg for all years (1990–2004).

Emissions of NOx from the Prescribed Burning of Savannahs are calculated as 0.3 Gg for all years (1990-2004), whereas emissions from the Field Burning of Agricultural Residues are calculated as 4.7 Gg for all years (1990-2004).

2.4 Land Use Change and Forestry Sector

Guyana has a total land area of 21.5 million hectares, out of which three-quarters of this area, representing over 18.39 million hectares, are covered mainly by tropical moist evergreen rainforests, containing over 1,000 known species.

However at the time of this Inventory, the total forested area was estimated at 16.45 million hectares. It is also estimated that the total forest area which is impacted by anthropogenic activities is roughly 2.3 million hectares (~ 14 %) (GFC 1998). This total disturbed forest area is based to a large extent on a percentage of the total forest area that is allocated to logging, an anthropogenic activity that disturbs/impacts on the forest biomass stocks. It includes the following categories of logging activities: Wood Cutting Leases, Timber Sales Agreements (TSA) and State Forest Permission (SFP) conversion areas (2,182,152 ha). There are also disturbed forest areas from mining activities (approximately 40,000 ha), and from land allocation to Amerindian communities (approximately 51,000 ha), which when totalled would amount to 2.273 million hectares or 13.8 % of total forest area.

Other anthropogenic activities include forest-cutting for charcoal production, forest clearing for agriculture and infrastructure such as roads and settlements, and forest fires caused by humans. This would lead to an increase in anthropogenically affected forest area which, when added up and rounded out, would be at 15 %. However, it is difficult to separate natural fires from human-induced forest fires, although the literature points to a greater incidence due to human activities (IPCC 1996).

Changes in Forest and Other Woody Biomass Stocks and Forest Conversion

Activity data on **species and areas** (hectares) of forest/biomass stocks of forests and on **commercial harvest** from the forest (m^3) are country-specific. **Annual growth rate (tdm/ha), conversion** and **emission** factors relating to **carbon fraction**, **biomass conversion/expansion,** and **fraction of biomass oxidized** were taken as **default** values from the **IPCC Guidelines (1996; 2000; 2003; 2006)** and the **EFDB** database. Furthermore, where published data was lacking, as for instance the fraction of biomass burned on-site and off-site, these were estimated, based on expert judgement, from comparisons with other countries in the region (for example Costa Rica).

Owing to a lack of data locally on forest conversion rates, the estimates for the rate of conversion of forest as provided in the Revised (1996) IPCC GHG Inventory Workbook (1980-1990 period) were used in this inventory as default.

Finally, it was assumed that 15 % of forested areas (16.45 million hectares) were in some form or the other affected by human activity and this total forest area was considered in the calculations of GHG removals and emissions.

2.4.1 CO_2 Emissions/ Removals

CO_2 emissions and **removals** from the **Land-Use Change and Forestry** sector are derived mainly from **Changes in Forest and Biomass Stocks (Removals), Forest and Grassland Conversion (Emissions), Forest Soils (Emissions),** and **Abandonment and Regrowth of Managed Lands.** For Changes in Forest and Biomass Stocks (Removals), only moist forest areas are considered since this is where these activities are concentrated. However, for Grassland Conversion (Emissions), Forest Soils (Emissions), and Abandonment and Regrowth of Managed Lands, all three forest categories, namely moist, moist with short dry season, and moist with long dry season are considered. No data is available for the Abandonment of Managed Lands in Guyana. However, based on expert judgement, this value is considered insignificant and placed at zero (Table 2.11 and Figure 2.16).

Changes in Forest and Biomass Stocks provide CO_2 Removals ranging from -65,318 Gg (1990) to -59,333 Gg (2004) (Table 2.11 and Figure 2.16).

Forest and Grassland Conversions result in CO_2 Emissions ranging from 1,025 Gg (2001) to 2,319 Gg (1990-1997 and 2002-2004) (Table 2.11 and Figure 2.16).

CO_2 from Forest Soils also result in emissions that, on account of the use of default data, are constant at 2,180 Gg (1990-2004) (Table 2.11 and Figure 2.16).

Total CO_2 Emissions from the Land Use and Forestry Sector therefore range between (2,575 Gg (1999) to 4,499 Gg (1990-1998 and 2002-2004) (Table 2.11 and Figure 2.16).

Total CO_2 Removals from the Land Use and Forestry Sector range between -65,318 Gg (in 1990) to -59,333 Gg (2004) (Table 2.11 and Figure 2.16).

The Land Use and Forestry Sector provide Net Removals of CO_2 with values ranging from -60,819 Gg (1990) to -54,834 Gg (2004) (Table 2.11 and Figure 2.16).

However, when compared to the Initial National Communication (INC) of Guyana, GHG removals from the LULUCF sector was -29,195 Gg for the baseline year 1994. This change is due to the fact that for the sub-module on Changes in Forests and Other Woody Biomass Stocks, a slightly higher forest area (2.47 million hectares: 15 %) of Guyana's forests is now considered to be anthropogenically impacted, whereas for the INC only part of the forest area (2.273 million hectares: 13.8 %) was considered as being affected by human activities. Also the categorization of forest classes was modified for shifting forest cover acreages from moist short and long dry seasons to mainly moist, because of the changing climate in recent years, hence this would create higher removal rates.

Table 2. 11. CO_2e emissions/removals from land use change and forestry (Gg) (1990 - 2004)

Activity: CO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Changes in Forest and Biomass Stocks	-65318	-64839	-64361	-63882	-64157	-63482	-63037	-62710	-62338	-61678	-61196	-60756	-60306	-59781	-59333
Forest and Grassland Conversion	2319	2319	2319	2319	2319	2319	2319	2319	2319	2319	2319	2319	2319	2319	2319
CO_2 Emissions and Removals from Forest Soils	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180
Abandonment of Managed Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE*
Total Emissions (+)	4499	4499	4499	4499	4499	4499	4499	4499	4499	2575	3921	3205	4499	4499	4499
Total Removals (-)	**-65318**	**-64839**	**-64361**	**-63882**	**-64167**	**-63482**	**-63037**	**-62710**	**-62338**	**-61678**	**-61196**	**-60756**	**-60306**	**-59781**	**-59333**
Net Removals	**-60819**	**-60340**	**-59861**	**-59383**	**-59658**	**-58982**	**-58538**	**-58210**	**-57838**	**-57178**	**-56697**	**-56256**	**-55806**	**-55282**	**-54834**

*NE: Not estimated

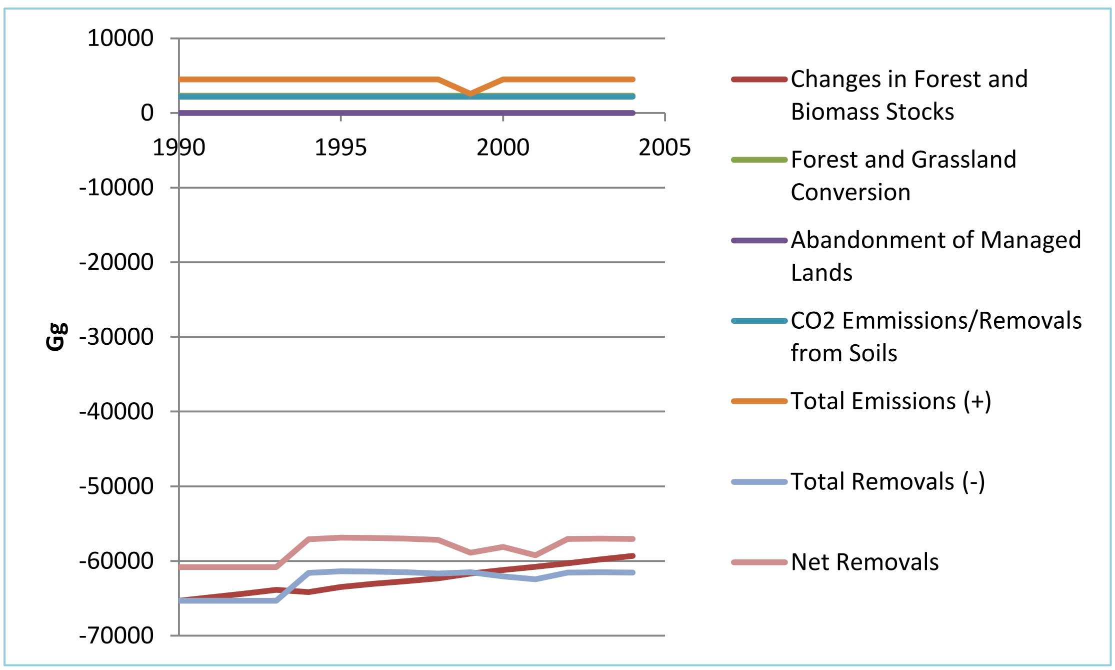


Fig. 2.16. CO_2 emissions/removals from land use change and forestry (1990 - 2004)

Non-CO_2 Emissions

Non-CO_2 trace gases, including **CH_4, N_2O** and **NOx** and **CO,** are also emitted from **Forest and Grassland Conversions** through the burning of cleared forests. The forest areas used to estimate non-CO_2 emissions are the same as in Section 2.4 above.

In the case of **CH_4** and **N_2O**, emissions are also expressed as CO_2e based on their respective radiative forcings over a 100-year period: **CH_4 (25)** and **N_2O (298)** (IPCC 2007).

Methane **(CH_4)** emissions remained constant at 7 Gg (1990-2004) (Table 2.12 and Figure 2.17).

CH_4e emissions remain constant at 175 Gg (19902-2004) (Table 2.12 and Figure 2.17).

Nitrous oxide **(N_2O)** emissions range from 0.03 Gg (2000-2001) to 0.05 Gg (1990-1999 and 2002-2004) (Table 2.12 and Figure 2.17).

However, nitrous oxide **(N_2O)** emissions expressed as **CO_2e** range from 0.8.9 Gg (2000-2001) to 14.9 Gg (1990—1999 and 2002-2004) (Table 2.12 and Figure 2.17).

Nitrogen oxides (**NOx)** emissions vary between 1.1 to 2.0 Gg (Table 2.12 and Figure 2.17).

Though more significant, carbon monoxide (**CO)** emissions range from 39 to 61 Gg (Table 2.12 and Figure 2.17).

Table 2. 12. Non-CO_2 and CO_2e emissions (Gg) from land use change and forestry (1990 - 2004)

Non-CO_2 Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CH_4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
CH_4e	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175
N_2O	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.05	0.05	0.05
N_2Oe	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	8.9	8.9	14.9	14.9	14.9
NOx	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.1	1.1	2	2	2
CO	61	61		61	61	61	61	61	61	61	39	39	61	61	61

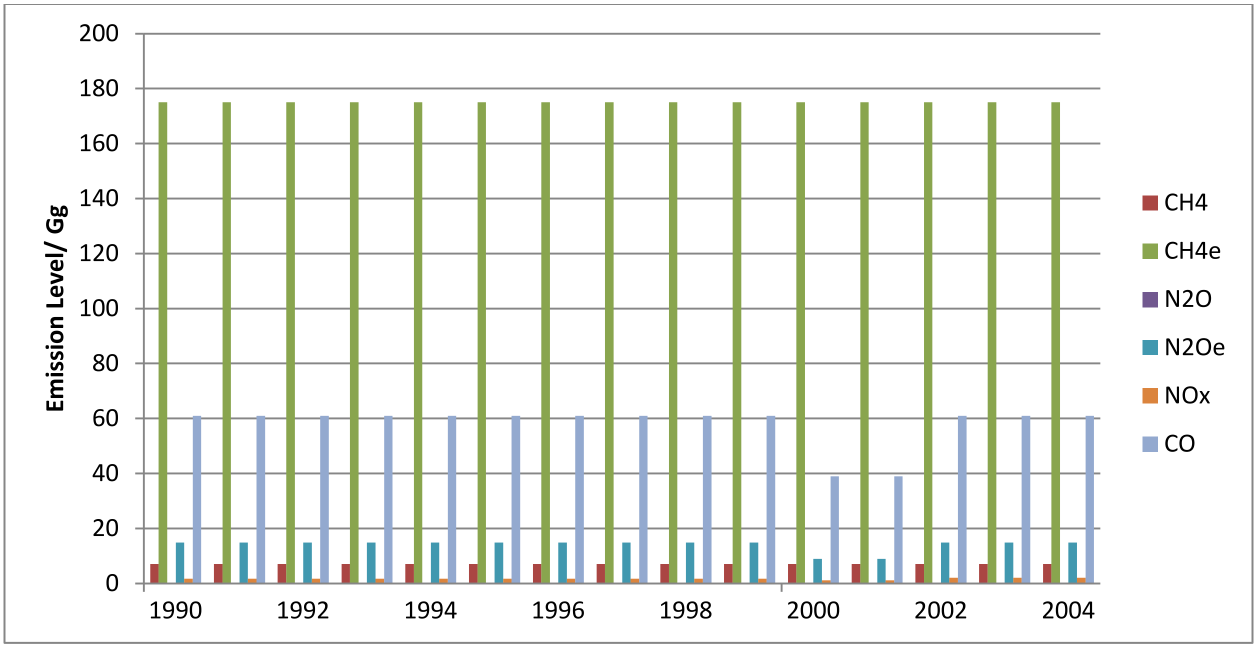


Fig. 2.17. **Non-CO_2 and CO_{2e} emissions from land use change and forestry (1990 - 2004)**

2.5 Waste Sector

For the **Waste** sector, GHG emissions are limited to **Methane (CH_4)** from **Solid Waste Disposal Sites (SWDS)** and to indirect **Nitrous Oxide (N_2O)** emissions from **human sewage**. **Both methane (CH_4) emissions** from **Solid Waste Disposal Sites (SWDS)** and indirect **Nitrous Oxide (N_2O)** emissions from **human sewage** are converted to CO2e values **(CH_4=25 and N_2O= 298)** based on their global warming potentials over a 100-year period (IPCC 2007).

There is no anaerobic treatment of Industrial or Domestic wastewater; hence estimates of methane emissions from domestic wastewater have not been made. The state-owned Guyana Sugar Corporation (GUYSUCO), the privately owned beverages and fish processing factories, and the Omai Gold Mines Limited are essentially the companies where industrial wastewater is produced. However, the wastewater from these sources is discharged into flowing rivers and the ocean, except for Omai Gold Mines Limited where mining wastewater undergoes a treatment process (both naturally and chemically) for the degradation/reduction of cyanide before being discharged into the aquatic systems.

Similarly waste incineration is not included. A Waste Incinerator is located in the capital city, Georgetown. Primarily waste from the abattoir and hospitals is incinerated here. The IPCC Workbook does not have a methodology to estimate emissions from incinerators, so such emissions were not calculated. However, emissions will be negligible since the bulk of solid waste in Guyana is placed in “open dumps/sanitary landfill sites” in the urban centres, and in rural areas where it is scattered on land, and either burned or buried.

Solid Waste Disposal

Solid waste disposal on land falls under the categories ‘open-dump’ and ‘sanitary landfill’. Sanitary landfill (managed site), which is described as the trench-method, is particularly practiced in the capital city, Georgetown. The other urban areas practice ‘open dumping’ (unmanaged sites) where waste is burnt regularly. Activity data was only available for the **Le Repentir** Landfill site in Georgetown for the years 1999-2004.

The rural population, which is about 66 % of the total population of Guyana, have a limited collection and disposal system for solid waste. Collected waste is transported to the dumpsite. It is safe to assume there is little or no methane emission from rural locations.

Activity data pertaining to Municipal Solid Waste (MSW) disposed to Solid Waste Disposal Sites (SWDSs) is country-specific, with the estimate of urban population whose waste is sent to solid waste disposal sites obtained from the **Georgetown Solid Waste Department** of Guyana. However, the **IPCC Default** values for **Methane Correction** factor, **Fraction of Degradable Organic Compounds (DOC)** in MSW, **Fraction of DOC which degrades** and **Fraction of Carbon Released** as methane were used for the estimation of **methane** emissions from solid waste disposal systems. Default values from the EFDB data site for similar countries were used.

2.5.1 CH_4 Emissions from Solid Waste Disposal

Data analyses using the above methodology provide net annual methane emissions from **Solid Waste Disposal Sites,** as both CH_4 and CO_2e. Based on available **Activity Data,** CH_4 emissions range from 2.05 Gg (1999) to 2.78 Gg (2004), and CH_4 emissions expressed as CO2e range from 51.25 Gg (1999) to 69.5 Gg (2004) (Table 2.13 and Figure 2.18).

Only a part of the capital city, Georgetown, and the sub-urban district of Tucville have sewerage treatment facilities in Guyana, representing an estimated 10 % of the population of Guyana. Out of the remaining 90 % of the population, about 20-30 % are estimated to use septic tanks and the remainder use pit latrines (INC 2002).

Nitrous Oxide (N_2O) emissions from **human sewage** were estimated from country-specific data on **population.** The **IPCC default factors** for **fraction of nitrogen in protein** and emission of N_2O were used to estimate emissions from **human sewage**. A factor of 25.8 (EFDB Database for an adjacent country: Brazil) was used for ‘per capita protein consumption’ (protein in kg/person/yr) to estimate N_2O emissions from human sewage.

Nitrous Oxide (N_2O) emissions, as both **N_2O and N_2O_E** are stable and unchanged at 0.05 Gg, on account of minimal activity data and rounding errors, for the period considered (1999-2004) (Table 2.13 and Figure 2.18). This value is relatively small and can be considered insignificant. However **N_2O** emissions expressed as **CO_2e** are significantly higher at 14.19 Gg, but still unchanged for the years considered (1999-2004) (Table 2.13 and Figure 2.18).

Table 2. 13. CH_4 and N_2O emissions from waste sector (1999 - 2004)

Activity: CH_4 and N_2O Emissions (Gg)	1999	2000	2001	2002	2003	2004
Solid Waste Disposal (CH_4)	2.05	2.23	2.41	2.49	2.5	2.78
Solid Waste Disposal (CH_{4e})	51.25	55.75	60.25	62.25	62.5	69.5
Human Sewage (N_2O)	0.05	0.05	0.05	0.05	0.05	0.05
Human Sewage(N_2Oe)	14.19	14.19	14.19	14.19	14.19	14.19

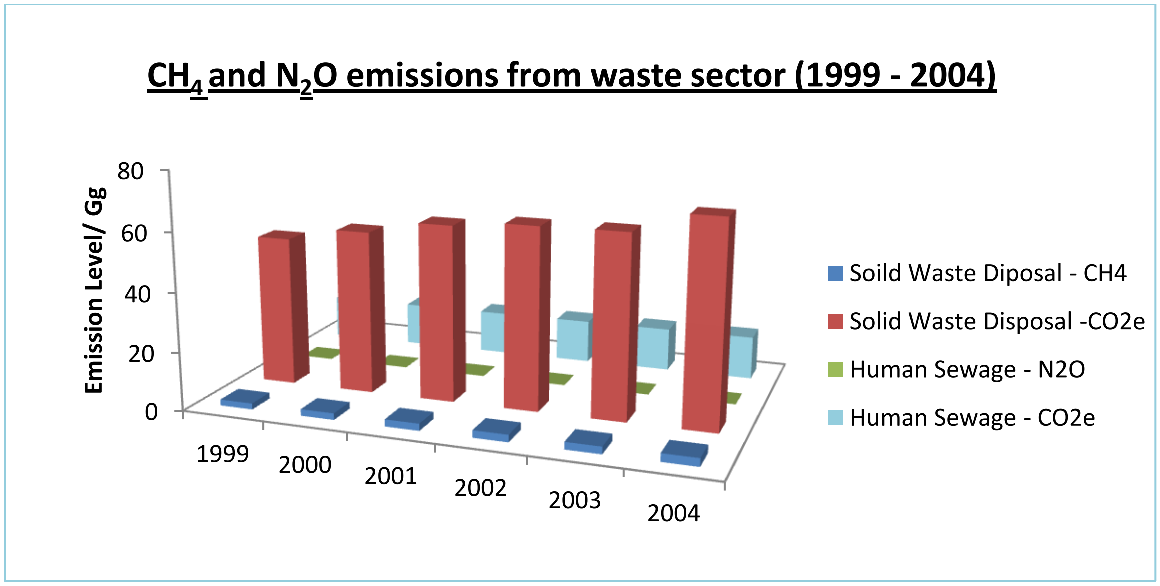


Fig. 2.18. CH_4 and N_2O emissions from waste sector (1999 - 2004)

2.6 Memo Items

Under the IPCC Revised (1996) methodology, countries are required to report **International Aviation Bunkers and International Marine Bunkers** and the **Burning of Biomass** separately as **Memo Items**. This is because it is unclear as to how to allocate responsibilities for CO_2 emissions from International Aviation and Marine Bunkers. In the case of the burning of biomass for energy purposes, the IPCC Revised (1996) methodology assumes that the CO_2 emissions of a particular year are compensated by regrowth of biomass and reabsorption of CO_2 by an equivalent amount the year following.

The Guyana Sugar Corporation uses bagasse for the co-generation of steam and electricity. The emissions deriving from these activities are reported under **Biomass Emissions.**

Carbon Dioxide (CO_2) Emissions from International Aviation Bunkers

Emissions from **International Bunkers** are very minimal. This is because most of the vessels engaged in international air and marine transport in the country purchase their fuel outside of Guyana.

Based on available **Activity Data,** CO_2 emissions Deriving from International Aviation Bunkers range from 11 Gg (1999) to 2.78 Gg (1998 and 200) (Table 2.14).

The decline in emissions Deriving from International Aviation Bunkers beginning in 1996 is due in large measure to the Guyana Airways Corporation that was previously state-owned being the main consumer of bunker fuel (aviation / jet kerosene) prior to this date, before reducing and eventually closing operations.

Carbon Dioxide (CO_2) Emissions from International Marine Bunkers

For **International Marine Bunkers,** CO_2 emissions are constant at 8 Gg for all years (1990-2004). This is mainly attributable to sectoral data not being available for this sector. Expert Estimates of the consumption of Aviation Jet Kerosene and Aviation Gasoline for this sector yielded values that did not vary significantly from year to year, and compounded by rounding errors, CO_2 emissions remained more or less stable at 8 Gg (1990-2004) (Table 2.14).

Table 2. 14. CO_2 emissions from memo items (1990 - 2004)

Memo Items	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
International Aviation Bunkers	22	22	22	22	22	22	20	20	11	15	11	17	13	13	13
International Marine Bunkers	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Burning of Biomass	1,487	1,487	1,487	1,487	1,487	893	959	1,571	716	716	716	716	716	716	716

Carbon Dioxide (CO_2) Emissions from Biomass Fuels

In Guyana the biomass fuels that are burned for energy are primarily firewood, charcoal, bagasse and rice husks.

However, the largest amounts of CO_2 emissions derive from **bagasse** combustion at sugar factories located at Skeldon, Albion, Rosehall, Blairmont, Enmore, LBI, Wales and Uitvlugt. Total **bagasse** consumption and combustion from all factories combined are provided in Table 2.15.

Much smaller amounts of CO_2 emissions derive from the combustion of wood and wood wastes in the **residential** and **manufacturing** sectors. Also minimal amounts of **rice husk** are combusted in the manufacturing sub-sector. Furthermore, **Charcoal** combustion in the **residential** sector also accounts for minimal amounts of CO_2 emissions.

Table 2. 15. Production of bagasse from all sugar factories in Guyana (1990-2004)

Bagasse ('000 tonnes)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total (All Factories)	863.2	965.6	1294.2	1197.7	1157.9	1063.7	1180.6	1137.5	1090.0	1270.8	1081.7	1136.8	1341.3	1248.4	1378.6

2.7 Summary of GHG Emissions and Emissions as CO_2e

Since there are no drastic changes between the years, a summary of GHG emissions for the three selected years (1994, 1999 and 2004) are presented. For CH_4 and N_2O these are also presented as CO_2e. SO_2 emissions are insignificantly small and are not included.

As can be seen, CO_2 emissions derive mainly from the Energy sector, and as shown earlier these come mainly from the energy generation and transport sub-sectors (Tables 2.16, 2.17 and 2.18).

CO_2 removals derive exclusively from the Land-Use Change and Forestry sector, and as shown earlier these come mainly from the forest and grassland conversion sub-sectors (Tables 2.16, 2.17 and 2.18).

CH_4, especially when expressed as CO_2e, derive mainly from the Agriculture sector, and as shown earlier these come mainly from the rice cultivation and domestic animals sub-sectors (Tables 2.16, 2.17 and 2.18).

N_2O emissions are minimal even when expressed as CO_2e and derive mainly from the Agriculture sector, and as shown earlier these come mainly from the domestic animals and manure management sub-sectors (Tables 2.16, 2.17 and 2.18).

NOx emissions are minimal and derive from the Energy and Agriculture sectors (Tables 2.16, 2.17 and 2.18).

CO emissions are slightly higher and derive from the Agriculture, Energy and Land-Use Change and Forestry sectors (Tables 2.16, 2.17 and 2.18).

NMVOC emissions are also minimal and derive from the Energy and Industrial Activities sectors (Tables Tables 2.16, 2.17 and 2.18).

Finally, SO_2 emissions that normally derive from Energy and Industrial Activities sectors, mainly oil refining activities that are non-existent in Guyana, are insignificantly small (Tables 2.16, 2.17 and 2.18).

Table 2. 16. Source/Sink categories and GHG emissions (Em.)/removals (Rem.) (Gg) (1994)

GHG Source/Sink Category (1994)	CO_2 Em. (Gg)	CO_2 Rem. (Gg)	CH_4 Em. (Gg)	CH_4 as CO_2e Em. (Gg)	N_2O Em. (Gg)	N_2O as CO_2e Em. (Gg)	$\Sigma(CO_2+CH_4+N_2O)$ as CO_2e Em. (Gg)	NOx Em. (Gg)	CO Em. (Gg)	NMVOC Em. (Gg)	SO_2 Em. (Gg)
Energy	1,440	I/NO*	3	75	I/NO	I/NO	1, 515	10	84	15	I/NO
Industrial Processes	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	15	I/NO
Agriculture	I/NO	I/NO	41	1,025	0.9	268.2	1, 293.2	5	109	I/NO	I/NO
Land-Use Change and Forestry	I/NO	-64,167	7	175	I/NO	I/NO	175	2	61	I/NO	I/NO
Waste	NE	NE	2	50	0.1	29.8	79.8	NE	NE	NE	I/NO
Totals	**1,440**	**-61,572**	**53**	**1,325**	**1**	**298**	**3, 063**	**17**	**254**	**30**	**I/NO**
International Bunkers	30	NE	NE	NE	NE	NE	NE	NE	NE	NE	I/NO
Biomass	1,487	NE	NE	NE	NE	NE	NE	NE	NE	NE	I/NO

*I/NO: Insignificantly Small or Not Occurring; NE: Not Estimated (by IPCC Methodology)

Table 2. 17. Source/Sink categories and GHG emissions (Em.)/removals (Rem.) (Gg) (2000)

GHG Source/Sink Category (1994)	CO_2 Em. (Gg)	CO_2 Rem. (Gg)	CH_4 Em. (Gg)	CH_4 as CO_2e Em. (Gg)	N_2O Em. (Gg)	N_2O as CO_2e Em. (Gg)	Σ $(CO_2+CH_4+N_2O)$ as CO2e Em. (Gg)	NOx Em. (Gg)	CO Em. (Gg)	NMVOC Em. (Gg)	SO2 Em. (Gg)
Energy	1, 688	I/NO*	I/NO	I/NO	1	298	1, 986	9	40	10	I/NO
Industrial Processes	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	14	I/NO
Agriculture	I/NO	I/NO	42	1,050	5	1,490	2,540	5	109	I/NO	I/NO
Land-Use Change and Forestry	I/NO	-61,196	7	175	2	596	771	2	61	I/NO	I/NO
Waste	NE	NE	2	50	0	0	50	NE	NE	NE	I/NO
Totals	**1,688**	**-61,482**	**51**	**1,275**	**8**	**2,384**	**5,347**	**16**	**210**	**24**	**I/NO**
International Bunkers	23	NE	NE	NE	NE	NE	NE	NE	NE	NE	I/NO
Biomass	716	NE	NE	NE	NE	NE	NE	NE	NE	NE	I/NO

*I/NO: Insignificantly Small or Not Occurring; NE: Not Estimated (by IPCC Methodology)

Table 2. 18. Source/Sink categories and GHG emissions (Em.) /removals (Rem.) (Gg) (2004)

GHG Source/Sink Category (1994)	CO_2 Em.(Gg)	CO_2 Rem.(Gg)	CH_4 Em. (Gg)	CH_4 as CO_2e Em. (Gg)	N_2O Em. (Gg)	N_2O as CO_2e Em. (Gg)	Σ (CO_2+CH_4+N_2O as CO_2e Em. (Gg)	NOx Em. (Gg)	CO Em. (Gg)	NMVOC Em. (Gg)	SO2 Em. (Gg)
Energy	1, 657	I/NO*	I/NO	I/NO	I/NO	I/NO	1, 657	10	41	11	I/NO
Industrial Processes	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	I/NO	16	I/NO
Agriculture	I/NO	I/NO	45	1,125	5	1490	1, 274	5	109	I/NO	I/NO
Land-Use Change and Forestry	I/NO	-59,333	7	175	I/NO	I/NO	175	2	61	I/NO	I/NO
Waste	NE	NE	3	75	0.5	149	224	NE	NE	NE	I/NO
Totals	**1,657**	**-61,533**	**55**	**1,375**	**5.5**	**1,639**	**3, 330**	**17**	**211**	**27**	**I/NO**
International Bunkers	21	NE	NE	NE	NE	NE	NE	NE	NE	NE	I/NO
Biomass	716	NE	NE	NE	NE	NE	NE	NE	NE	NE	I/NO

*I/NO: Insignificantly Small or Not Occurring; NE: Not Estimated (by IPCC Methodology)

2.8 Key Sources

Key Source Categories are individual sectors or sub-sectors from which significant (~ 90 %) GHG emissions derive. Since there are no drastic changes between the years, key source categories for the three selected years (1994, 1999 and 2004) are presented. For CH_4 and N_2O these are also presented as CO_2e.

It is evident that CO_2 removals from the Land-Use Change and Forestry sector, CO_2 emissions from the Energy sector, and CH_4 emissions, expressed as CO_2e, from the Agriculture sector, are the key source sectors (Table 2.19).

2.9 Trends in GHG Emissions/ Removals

For the period examined (1990-2004), there are no real apparent trends in GHG emissions (Table 2.19 and Figures 2.19 and 2.20).

CO_2 emissions (Reference) range between 1,246 Gg (1992) and 1,813 Gg (1998), whereas GHG Removals (Forestry) vary between -65,318 Gg (1990) and -59,333 Gg (2004) (Table 2.19 and Figure 2.20).

However, when compared to the Initial National Communication (INC) of Guyana, GHG removals from the LULUCF sector was -29,195 Gg for the year 1994. This change is due to the fact that for the sub-module on Changes in Forests and Other Woody Biomass Stocks, 15 % of the entire forest area (16.45 million hectares) of Guyana is now considered to be anthropogenically impacted, whereas for the INC only part of the forest area (2.273 million hectares: 13.8 %) was considered as being affected by human activities. Also the categorization of forest classes was changed from moist dry, and moist, to essentially moist.

The non-CO_2 gases emissions are also remarkably stable from year to year. CH_4 emissions vary between 44 Gg (2002) and 56 Gg (2003). N_20 emissions remain stable at around 1 Gg for all years. CO however ranges from 205 Gg (1995) to 254 Gg (1990-1994). Finally, NMVOC emissions vary between 24 Gg (2000) and 30 Gg (1992-1994) (Table 2.19 and Figure 2.19).

Table 2. 19. **Trends in GHG emissions (Gg): 1990-2004**

GHG	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2-Em	1288	1259	1246	1403	1395	1599	1633	1801	1813	1805	1734	1713	1684	1675	1731
CO_2-Rm	-60818	-64839	-64361	-63882	-64167	-63482	-63037	-62710	-62338	-61678	-61196	-60756	-60306	-59781	-59333
CH_4	51	52	52	52	53	51	53	55	53	57	51	54	44	56	55
N_2O	1	1	1	7	1	1	1	1	1	1	1	1	1	1	1
NOx	17	17	17	17	17	17	17	18	17	17	16	17	16	16	16
CO	254	254	254	254	254	205	208	209	209	210	210	211	211	211	211
NMVOC	28	29	30	30	30	26	27	27	26	27	24	26	27	26	27

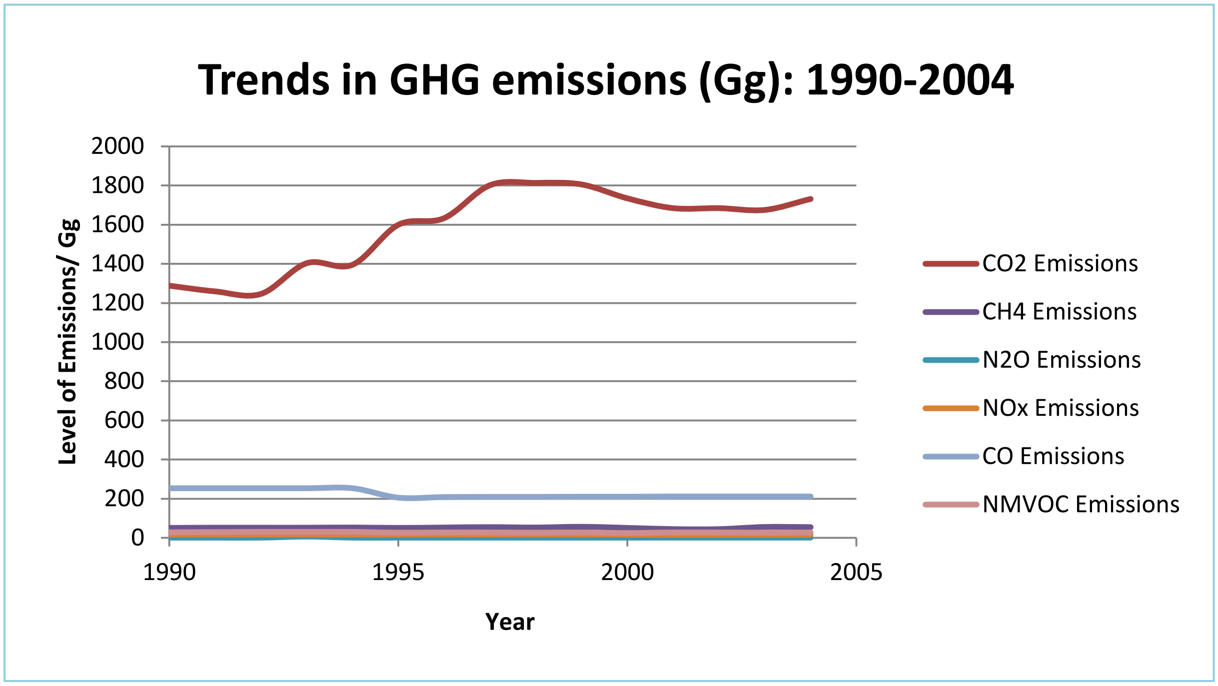


Fig. 2.19. Trends in GHG emissions (Gg): 1990-2004

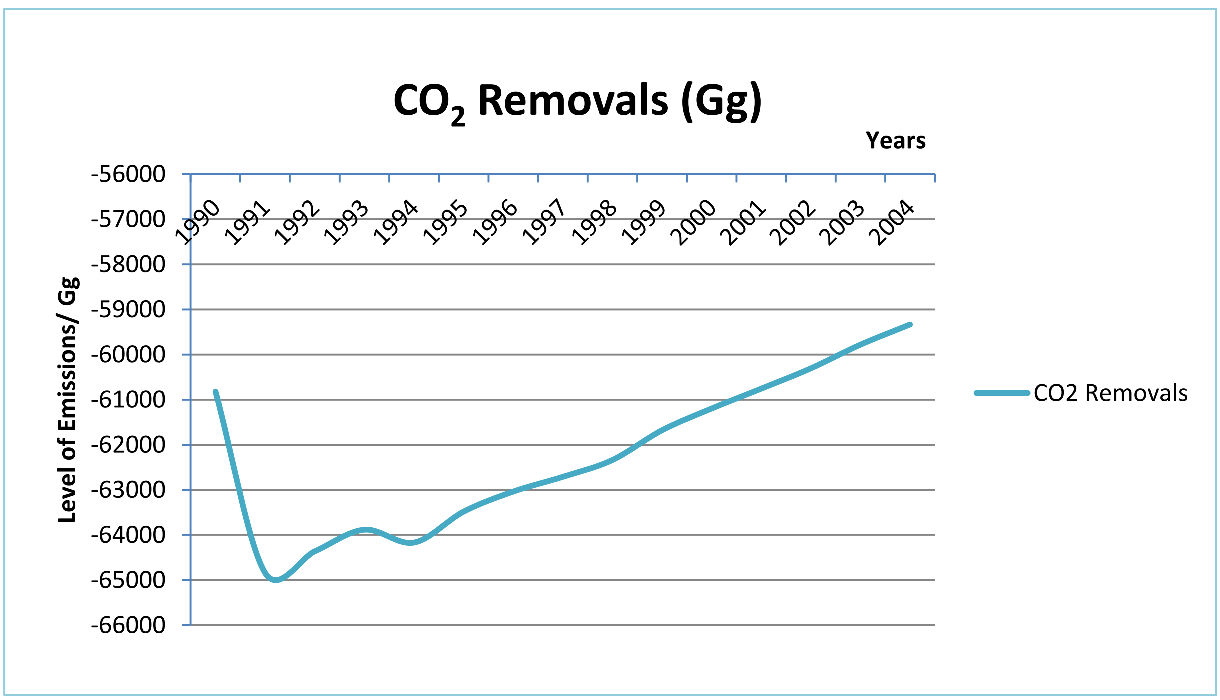


Fig. 2.20. Trends in GHG removals (Gg): 1990-2004

2.10 Uncertainties

There are a number of uncertainties pertaining to the GHG inventory for Guyana for the years 1990-2004. All sectors are plagued by data gaps and almost all conversion and emission factors used were default values extracted from the IPCC (1996; 2000; 2003; 2007) Guidelines and the EFDB database.

In the Energy sector the sectoral breakdown of the activity data by fuel type was not complete for all years and sectors.

For the Industrial sector, though limited in activities, data for road paving with asphalt was inadequate or missing.

For the Agriculture sector, N_2O emissions from soils due to fertilizer use and nitrogen-fixing plants were inadequate or missing.

For the Land-Use Change and Forestry sector, the fact that for Forest and Grassland Conversion 15 % of all forest acreages were considered to be impacted by anthropogenic activities, though realistically close, may not be the case. The fact that all forests are classified as moist raises further doubts. These questions need to be addressed in future National Communications.

Finally, for the Waste sector, activity data is lacking for some years (1990-1998), and no data was available for Commercial and Industrial Wastewater treatments.

2. 11 Abatement Analysis

Based on the Key Sectors discussed previously, it is evident that the major focus of GHG mitigation for Guyana, as part of its Nationally Appropriate Mitigation Actions (NAMAs), should be directed at the Energy (energy industries), Agriculture (rice cultivation) and Land-Use Change and Forestry (forest conversions and soils) sub-sectors. Not being highly industrialized, the Industry sector contributes minimal amounts of NMVOC emissions. Similarly, the Waste sector, on account of the relatively small population and the absence of industrial, commercial and residential wastewater treatment facilities, emits small amounts of N_2O and NOx.

The abatement analysis is done by focusing on the key source sub-sectors responsible for GHG emissions in Guyana, namely energy industries, rice cultivation in the agriculture sector, and forest conversions and soils for the period considered (1990-2004) as baseline. Based on research that used energy alternatives modelling, cost-effectiveness, environmental, social and economic costs, several abatement technologies and policies and measures have been derived for a number of countries with similar concerns as Guyana.

2.11.1 Energy Supply Sub-Sector

Promising approaches for Guyana to abate future GHG emissions from the Energy Supply sub-sector include more efficient conversion of fossil fuels; switching from the petroleum fuels which are currently used to low-carbon fossil fuels such as natural gas, and switching to renewable sources of energy such as small-scale hydro, solar, wind and biomass power. Switching to fuels with a lower carbon-to-hydrogen ratio such as from oil to natural gas can reduce GHG emissions. Natural gas has the lowest CO_2 emissions per unit of energy of all fossil fuels, at about 15 kg C/GJ, compared to oil with about 20 kg C/GJ. Each of these options has its unique characteristics that determine cost-effectiveness, as well as social and political acceptability. Both the costs and the environmental impacts need to be considered.

With Guyana's abundant reserves of forests, biomass for energy production may also be an attractive alternative. On the basis of commercial experience in neighbouring Brazil, an estimated 13 EJ/yr of biomass could be produced at an average cost for delivered woodchips of $1.7/GJ (IPCC 1996; OECD, 2008). However, it must be cautioned that apart from lesser amounts of GHG emissions by using wood as a fuel, biomass also contributes to emissions through harvesting, milling and transport operations, though to a much lesser extent, than fossil fuels.

Studies have shown that intermittent wind power on a large grid can contribute an estimated 15–20 % of annual electricity production for a country like Guyana without special arrangements for storage, backup and load management. The wind potential, if utilized to replace fossil fuels, and irrespective of costs, translates into CO_2 emission reductions of 0.1–0.2 Gt C/yr. The present stock average cost of energy from wind power is approximately 10¢/kWh, although the range is wide. Based on cost effectiveness, wind power is already competitive with fossil-based power. A 1 MW wind turbine plant can reduce CO_2 emissions by roughly 2,873 t CO_2 per unit (Ministry of Environment and Physical Planning, Government of Macedonia: In OECD 2008). However, countries with large numbers of operating wind turbines sometimes experience public resistance to such factors as the noise of turbines, the visual impact on the landscape and the disturbance of wildlife (IPCC 1996; OECD, 2008).

With its location close to the equator, Guyana is well-positioned to exploit solar energy. Direct conversion of sunlight to electricity and heat for water-heating can be achieved by photovoltaic (PV) and solar thermal electric technologies. PV is already competitive as a stand-alone power source in locations remote from electric utility grids, and this could be advantageous for the remote rural areas of Guyana. However it has not been competitive in bulk electric grid-connected applications. The cost-effectiveness of PV systems is nonetheless expected to improve significantly through research and development, as well as with economies of scale (IPCC 1996; OECD 2008).

With its abundance of large rivers, Guyana may also consider hydropower as an alternative energy source. The investment costs for hydro projects in developing countries like Guyana suggest that, on average, the cost of new hydroelectricity delivered to final user is 7.8¢/kWh_e. The actual investment cost can be high, with financing likely to become a barrier due to the long amortization horizons involved. However, small-scale hydro projects, as have been initiated in the hinterlands of Guyana, can be regionally important, especially where cost-effective. A 4 MW micro-hydro plant can reduce CO_2 emissions by roughly 12,425 t CO_2 per unit

(Ministry of Environment and Physical Planning, Government of Macedonia: In OECD 2008). On the other hand, the construction phase of larger hydroelectric plants has social consequences and direct and indirect environmental impacts, such as water diversion and disturbance of aquatic ecosystems, with adverse human health impacts. , Hydropower generation may also lead, though to a much lesser extent, to GHG emissions through destruction of forests and operations such as transport.

Other energy alternatives that may become available in the future, especially along the coastal zone of Guyana, include the total energy flux of tides, waves, and thermal and salinity gradients of the Atlantic Ocean.

2.11.2 Agriculture: Rice Cultivation Sub-Sector

Flooded rice fields in Guyana produce CH_4 emissions, which can be reduced by improved management measures. The ranges of potential reductions shown indicate uncertainty about the effectiveness of mitigation measures and the degree of additivity of effects as, for example, in rice production. Successful implementation of available mitigation technologies will depend on demonstration that: (i) grain yield will not decrease or may increase; (ii) there will be savings in labour, water and other production costs; and (iii) rice cultivars that produce lower CH_4 emissions are acceptable to local consumers.

Although Forests are a net sink for CO_2 in Guyana, certain forest practices can cause CO_2 emissions. Forest management practices that can restrain the rate of CO_2 emissions can be grouped into three categories (IPCC 2007, Vol.3): (i) management for carbon conservation; (ii) management for carbon sequestration and storage; and (iii) management for carbon substitution. Conservation practices include options such as controlling deforestation, protecting forests in reserves, changing harvesting regimes, and controlling other anthropogenic disturbances, such as fire and pest outbreaks. Sequestration and storage practices include expanding forest ecosystems by increasing the area and/or biomass and soil carbon density of natural and plantation forests, and increasing storage in durable wood products. Substitution practices aim at increasing the transfer of forest biomass carbon into products, rather than using fossil-fuel-based energy and products, and other non-wood building materials (IPCC, 1996).

However, these abatement measures for the three key source sectors considered may have further economic and social repercussions for Guyana. On the one hand there may be displacement of peoples and jobs, but on the other hand, in the long run, there would be greener jobs, and local capacity, not to mention greater autonomy, especially in regard to energy supply, especially in the hinterlands. But the initial economic costs may be prohibitive and this may have to be addressed through leveraging funds from international donor agencies.

The Land-Use Change and Forestry sector, as seen previously, is already the largest sink for CO_2 in Guyana. However, this sink capacity for CO_2 removal from the atmosphere can be further enhanced in different ways:

1) Guyana can choose to participate in several UNFCCC mitigation activities, such as the Clean Development Mechanism (CDM), and Reducing Emissions from Deforestation and Forest Degradation (REDD and REDD+), which will not only increase the sink capacity of Guyana's Forests but will also allow for the increased monetization of this sector.
2) Another way in which Guyana's sink capacity may be enhanced is the Carbon Capture and Storage (CCS). The vast tracts

of forest lands in Guyana may well be underlain by geological reservoirs that can be amenable to CCS projects, which will again provide not only environmental but also economic benefits.

However, the Government of Guyana has recently embarked on the economic pathway of the Low Carbon Development Strategy (LCDS), so as to develop local capacity in carbon capture and storage and to exploit and monetize its vast areas of forest lands.

2.11.3 Other Sub-Sectors

Road Transport Sector

As for the mitigation of CO_2 emissions from road transport, this can also be addressed in the following ways:

1) It is evident that most of the emissions from this sub-sector come from vehicular traffic in the large urban centres such as Georgetown. The obvious measures therefore would be to develop an efficient public transport system, using fleets of buses that use less polluting fuels, such as liquefied natural gas (LNG). Again these will incur additional costs during the setting-up phase.
2) Alternatively, Guyana is well-endowed with extensive land space, with fairly good soils, especially in the coastal lowlands, and these can be used to grow crops such as corn and more sugar-cane, from which clean-burning biofuels such as ethanol can be derived for use in road transport. The challenge here however, will be the competition with the agricultural economy (sugar-cane) and food security (corn).

Waste Sector

Though this sector is not a large contributor to total GHG emissions in Guyana, mainly methane (CH_4), and being less than 70 Gg even when expressed as CO_2e, there may be the possibility of leveraging funding under the Programmatic CDM (Clean Development Mechanism) programme.

2. 12 Data Collection (QA/QC)

Controls that ensure the accuracy of the GHG data and information such as Quality Assurance (QA) and Quality Controls (QC) are required to ensure the integrity of data and information. For key sectors, such as LULUCF and Energy, the relevant agencies, namely the Guyana Forestry Commission and the Guyana Energy Agency, should implement data collection and quality control procedures, including sectoral disaggregation of data, as for instance in the Energy Sector. This data collection system for future GHG inventories should include:

- Overall data QA/QC plans, procedures and records; for example, data protection and chain of custody
- Where applicable, meter calibration procedures
- Data error-checking tests on data input, processing and output
- Data reconciliation and periodic comparisons
- Internal audit (i.e. quality assurance) activities
- Management review activities. An example is regular, periodic management meeting minutes which consider results and changes to GHG management activities.

Error checking procedures are an important component of QA/QC plans and operations—checking for errors along the data trail. One should assess error checking procedures that address the following three broad categories of data handling:

1. **Input controls**, or procedures for checking data from measured or quantified values

2. **Process controls**, or error checking during the process of collating, transferring, processing, calculating, estimating, aggregating, or adjusting input data

3. **Output controls**, or controls surrounding the distribution of GHG information and comparisons between input and output information.

As a matter of fact, it is highly recommended that each one of these agencies create a data management division to deal with GHG inventory statistics and controls. Furthermore, the Activity data to be collected, advisedly on at least a monthly basis, and the emission factors to be derived locally, including parameters and units of measurement, should be guided by the completed Worksheets submitted (1990-2004) for all five sectors, namely Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry and Waste.

2. 13 Summary and Conclusions

Based on the inventory of GHG for Guyana for the period 1990-2004, it is evident that in so far as CO_2 Emissions and Removals are concerned, Guyana can be considered as a Net Sink Country. CO_2 removals (~ -61,000.000 Gg) significantly exceed emissions (~1,500 Gg). The bulk of CO_2 emissions derive from the Energy sector, while all of the CO_2 removals are attributable to the Land-Use Change and Forestry sector.

However, CO_2 removals, which derive exclusively from the Land-Use Change and Forestry sector, and which are largely due to absorption of CO_2 by its vast tracts of tropical forests, are calculated based on the fact that only 15 % of its forest area is considered to be anthropogenically-impacted by deforestation activities in the Forest and Grassland Conversion sub-sector.

Guyana can argue to justify its CO_2 sink capacity through consideration of its total forest area, if it can justify that its policies on forest conservation and preservation, whether or not with carbon sequestration in view, are an anthropogenic act.

As shown in earlier sections, CO_2 emissions are derived mainly from fuel combustion activities in the Energy sector. Any mitigation effort by Guyana in this sector can therefore focus on the activities in this sector.

Non-CO_2 emissions in Guyana are relatively small. CH_4 emissions, the only other non-CO_2 gas of note for instance, derive mainly from rice cultivation and enteric fermentation in animals and manure in the Agriculture sector. However when CH_4 emissions are expressed as CO_2e, the emission values increase significantly. Guyana's mitigation efforts can therefore also be directed at activities in these sectors.

One of the largest logging operations at Mabura Hill, Central Guyana

Cattle grazing on rice-lands

Chapter 3

Mitigation and Abatement Analysis

Chapter 3

Mitigation and Abatement Analysis

3.0 Introduction

Although Guyana does not have any specific emissions reduction targets, as a non-Annex I party to the Convention, Guyana has a responsibility under Decision 17.CP.8 (Guidelines for the Preparation of National Communications from Parties not included in Annex I to the Convention) to 'provide information on programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol…' (Paragraph 26).

This chapter documents the progress that Guyana has made to limit emissions of greenhouse gases (GHGs), enhance its carbon sinks, and identify the potential to introduce measures to mitigate climate change.

Guyana's low emissions (relative to international levels), combined with the country's vast forest resources which sequester and store carbon, contribute to Guyana's status as a net carbon sink. According to the Greenhouse Gas Inventory (GHG-I)[9], CO_2 removals (61,533 Gg) significantly exceed emissions (1,657 Gg). Mitigation in this context does not necessarily imply an absolute reduction in emissions in relation to a given base year, but rather it implies a reduction relative to what emissions would otherwise have been in the future in the absence of specific GHG mitigation action.

The scope of the MAA has been limited to the energy, waste, agriculture and forestry sectors, based upon the findings of the GHG-I (see Table 2.3). Energy (including transportation), agriculture and waste are major emitters whereas the forest sector is a significant CO_2 sink.

3.1 Methodology

The timeframe for assessment has been set at thirty years with the base year being 2000. Two scenarios were developed to analyse the mitigation potential within each sector: a baseline scenario and a mitigation scenario.

The baseline scenario is constructed based on the trends, plans and policies prevailing in Guyana at the time the analysis was undertaken. For each sector more than one baseline scenario were defined to reflect the fact that Guyana has committed itself to a number of long term plans, particularly through the Low Carbon Development Strategy (LCDS) which introduces major changes to the existing structure of the economy.

The key policies and initiatives used to develop the scenarios for all sectors are shown in Table 3.1 below.

The scenarios extrapolate the trajectory of activities responsible for generating GHGs (e.g. energy consumption, agricultural production, deforestation and forest degradation, and waste generation) between the baseline year and the end year of the assessment. These projections were based on assumptions of population growth, GDP, and other macroeconomic variables. In selecting the appropriate combination of mitigation technologies, their suitability for the Guyana context were taken into account, using the following criteria:

- potential for large impact on GHGs

[9] Government of Guyana (2010) Greenhouse Gas Inventory. Final Report. December 2010.

- direct and indirect economic impacts
- consistency with national development goals
- potential effectiveness of implementation policies
- sustainability of an option
- data availability for evaluation
- other sector-specific criteria.

Table 3. 1 National and sectoral policies, strategies and initiatives considered in the baseline

Sector	Programmes, Strategies, Policies and Plans[10]
National Development	The Low Carbon Development Strategy (LCDS) [11] The National Development Strategy 2001 - 2010[12]
Energy (including transport)	The Caribbean Renewable Energy Development Programme Guyana Power & Light Inc Development and Expansion Programme 2009 – 2013 Guyana Transport Sector Study (2005)[13] Amaila Falls Hydroelectric Project
Agriculture	Action Plan for Agricultural Diversification in Guyana (2005) Agriculture Sector Development Unit Mangrove Management Project (2010)
Land-Use Change and Forestry	Guyana's REDD-Readiness Preparation Proposal (2010) [14] Guyana REDD+ Monitoring Reporting and Verification System (MRVS)[15]

[10] Guyana Energy Agency website, information extracted at http://www.gea.gov.gy/images/HydropowerSites.jpg and updated with information from the Guyana Energy Agency, Alternative Energy Programmes/Initiatives in Guyana, November 2009.

[11] Government of Guyana (2010) A Low Carbon Development Strategy. Transforming Guyana's Economy While Combating Climate Change, May 2010, Office of the President, Republic of Guyana [online] http://www.lcds.gov.gy/images/stories/Documents/Low%20Carbon%20Development%20Strategy%20-%20May%202010.pdf (accessed 13 August 2010).

[12] Government of Guyana (2000) Guyana National Development Strategy, 2001-2010 [online] available at http://www.sdnp.org.gy/nds/

[13] http://www.gina.gov.gy/guyanatransportstudy/vol4/covervolumeIV.pdf .

[14] Guyana Forestry Commission (2010) Readiness Preparation Proposal (RPP) for Guyana. World Bank Forest Carbon Partnership Facility (FCPF), April 2010 [online] available at: http://www.forestry.gov.gy/Downloads/Readiness_Preparation_Proposal_April_2010_Revised.pdf (accessed 11 August 2010).

[15] GFC and Pöyry (2010) Guyana REDD+ Monitoring Reporting and Verification System (MRVS) Interim Measures Report [online] available at: http://www.forestry.gov.gy/Downloads/Guyana_MRVS_Interim_Measures_Report_2010_Final.pdf

A Technology Needs Assessment (TNA) helped to identify and prioritize a range of technologies (including practices and policy reforms) that may be considered appropriate for Guyana including scenarios and Models

The following tools were used to model emissions and mitigation potential in each sector:

- Energy Industries - LEAP and RETScreen were identified as tools for projecting emissions from energy-intensive industries in Guyana (see Appendix 3.2).
- Forestry - COMAP (Comprehensive Mitigation Analysis Process) was used to analyze the impact of changes in forest cover, product demand and supply, and the costs and benefits of the different mitigation options (see Appendix 3.2 for more information).
- Agriculture - No formal GHG estimation models for mitigation potential for agriculture exist. Therefore a more qualitative approach was used, based on information on the emissions reduction potential of different technologies.
- Waste and Wastewater - approved UNFCCC Clean Development Mechanism (CDM) methodologies were used to assess mitigation potential.

3.2 Energy Sector

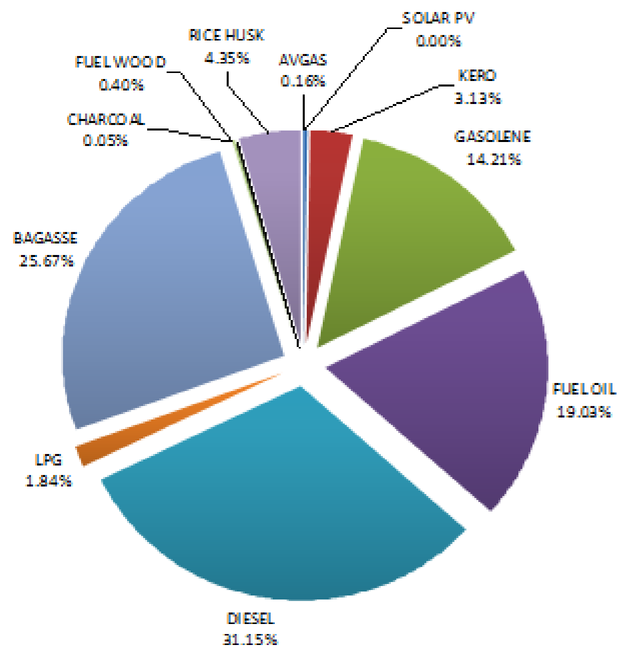
The GHG-I[16] shows that the energy sector is the principal source of GHG emissions in Guyana. Energy supply in Guyana is largely from petroleum products (>90%). Other energy sources include bagasse (about 8%) and fuel-wood. Guyana currently imports all of the petroleum products used in the energy sector. However, there is currently interest in exploration for offshore oil in Guyana's waters. It is speculated that there could be significant oil reserves in this region, but much of this would be exported rather than used for the domestic market. As this exploration is still speculative, these reserves have not been included in the energy analysis.

According to the Guyana Energy Agency (GEA)[17], in 2008 Guyana consumed approximately 5.1 million barrels of oil equivalent (BO_E) from a variety of energy sources: diesel (gasoil), bagasse, fuel oil, gasoline, rice husk, kerosene, liquid petroleum gas (LPG), fuel-wood, charcoal, avgas, solar photovoltaic (PV), solar water heaters, wind turbines and biogas. Table 3.1 and Fig. 3.1[18] below illustrate the respective contribution from the various sources of energy in 2008.

[16] Government of Guyana (2010) Greenhouse Gas Inventory. Final Report. December 2010.
[17] Guyana Energy Agency, Alternative Energy Programmes/Initiatives in Guyana, November 2009.
[18] Guyana Energy Agency, Alternative Energy Programmes/Initiatives in Guyana, November 2009.

Table 3. 2. Respective contribution from the various sources of energy for Guyana energy mix in 2008[19]

	Billion Barrels (BBLs)	Litres	Energy Value (GJ)	Energy Value (BOE)	Installed Capacity (MW)
Avgas	9,988	1,587,962	50,993	8,332	14
Kerosene	171,826	27,318,100	977,658	159,748	272
Gasoline	842,471	133,941,937	4,444,544	726,233	1,235
Fuel oil	1,006,600	160,036,314	5,950,557	972,313	1,653
Diesel	1,675,189	266,333,274	9,739,467	1,591,416	2,705
LPG	133,400	21,208,866	574,654	93,898	160
Bagasse			8,027,524	1,311,687	2,230
Charcoal			17,156	2,803	5
Fuel Wood			124,949	20,417	35
Rice Husk			1,359,694	222,172	378
Solar PV			171	28	0.05
Total	**3,839,474**	**610,426,453**	**31,267,367**	**5,109,047**	**8,685**



1. Bagasse is used for cogeneration to produce process steam and electricity at each of the 8 sugar estates.
2. Rice husk is used by 21 mills to dry paddy and/or parboiling. 3 mills use the husk for electricity generation.
3. Bagasse and rice husk represent estimated total yield based on industry output. Actual energy consumed would be less. Methodologies will be developed in 2009 to more accurately estimate their respective energy contribution.
4. Solar PV is estimated based on currently available data. Actual energy may be closer to 1%. Energy produced from solar water heaters are not yet included.

Fig. 3. 1. Guyana primary energy by source in 2008

[19] Ibid.

According to figures provided by the GEA,

Guyana's energy intensity, measured as units of energy per unit of GDP, has been decreasing since 1994 (except in 1998 where it increased slightly), as shown in Fig. 3.2.[20]

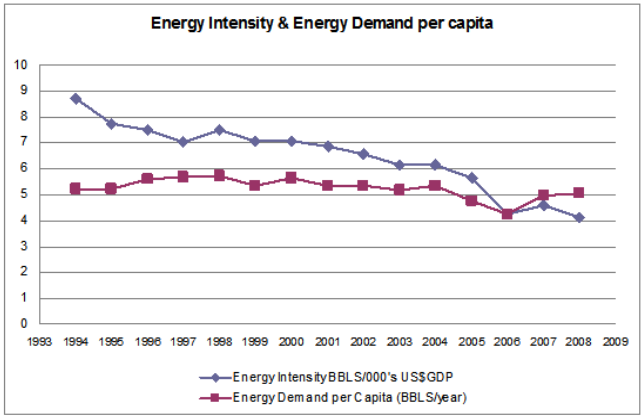


Fig. 3. 2. **Guyana's energy intensity (BBLS/000's US$GDP) and Guyana's energy demand per capita (BBLS/year**

Energy demand per capita in Guyana has been fairly stable, fluctuating between 5 BBLS/year in 1998 and 4.2 BBLS/year in 2006. Energy demand per capita in Guyana can reasonably be expected to increase as a result of climate change, mainly for space cooling due to the warmer climatic conditions in the country.

3.2.1 Renewable Energy

A number of options exist for Guyana to draw upon its natural resources to provide renewable sources of energy. These include:

Hydropower: Guyana has a large hydropower potential of approximately 7,000 MW. An inventory of the hydropower potential in Guyana identified 67 potential hydropower sites across four major river basins: Cuyuni, Mazaruni, Potaro and Essequibo. Tendering procedures have already been completed for some of these and it is expected that construction and operation will commence within the next few years. Appendix 3.1) shows the most promising sites.

Amaila Falls which will be used to generate hydropower

[20] GEA, Guyana Energy Information 1994-2008.

Solar: Guyana's tropical climate and high average daily solar radiation makes the country suitable for solar power (its location ensures an average of about 5 peak sun hours per day). Small-scale solar photovoltaic (PV) systems are already used in health centres, schools, communities and homes for lighting, small appliance loads, water pumping and productive cottage industries. There is also increased use of solar water heating for domestic water. Guyana has around 88 kW of solar power installed primarily in the hinterland regions, where there is no access to the grid, which generates approximately 160 kWh of annual electricity. Guyana Water Incorporated and the Ministry of Local Government have also installed a number of solar well systems. The following table (Table 3.3), extracted from the Alternative Energy Programmes Initiatives in Guyana, shows the locations and annual energy output of these systems as well as their application.

Solar systems were also installed in Guyana as part of several projects which have been carried out in the region:

- **Unserved Areas Electrification Programme**: In 2008, a number of remote areas in the country were benefiting from the installation of solar photovoltaic projects, under the Unserved Areas Electrification Programme (UAEP).[21] The UAEP installed "Solar Home Systems" in four villages where grid power was not available: Yarakita (106 systems), Capoey (68 systems), Kurukabaru (103 systems) and Muritaro (66 systems). Moreover Orealla has also received a 2500 W system to facilitate productive works within that community (namely for the cottage industry).
- **DC Home Solar Light Kit**: this solar project developed by GEA and the Office of the Prime Minister in collaboration with the Ministry of Amerindian Affairs will provide DC Home Solar light kits to hinterland communities. This will provide lighting for the communities without access to electricity. Up to November 2009, 337 systems had been already distributed.
- **CIDA/OLADE/University of Calgary Haskayne School of Business Rural Electrification Project**: This project started in 2007 and was concluded in 2009. In this project 49 households of the Wowetta community benefited from solar-powered home systems. In addition, the village received a solar freezer and a solar water pump.
- **GEA Demonstration Projects**: The Agency installed 4 solar photovoltaic demonstration units within the institution.
- **Japan Cool Earth Partnership**: The Japanese Government has expressed interest in developing a solar photovoltaic plan in Guyana, which would supply the produced electricity to the national grid. The GoG has submitted a proposal to the Japanese Government for developing a 1 MW solar PV farm.

Guyana's Minister of Amerindian Affairs, the Hon. Pauline Sukhai (L) presents a solar panel to a community representative under the UAE programme

[21] Guyana Energy Agency, Energy Development, Solar http://www.sdnp.org.gy/gea/energydev-solar.php

Table 3. 3. Guyana's 88 kW of installed solar power: location, annual energy output, application

Location	Reg.	Year Installed	No. of panels	Solar Cell	Total Rated Power (W)	System Volt (DC)	Status	Application	Annual Energy Estimation (kWh)
Wara Paka	1	2007	2		110		Operational	Health Centre	200.75
Yarakita	1	2008	105	Poly-si	13125	12	Operational	Residents & School	23953.125
Capoey	2	2008	67	Poly-si	8375	12	Operational	Residents & School	15284.375
Karia Karia	3	2007	2		110		Operational	Health Centre	200.75
Swarte Hoek	3	1997	62		11000	120/240	Operational	Lighting and appliances	20075
Guyana Energy Agency	4	2007	3	multicrystalline	110	12	Operational	Lighting and computers	200.75
St. Culbert	5	2006	24	monocrystalline	1800	20	Operational	Well pump	3285
Orealla	6	2009	14	Poly-si	2450	120V	Operations	Lighting and appliances for a Fruit Cheese Factory	4471.25
Imbamadai	7	2007	2		110		Operational	Health Centre	200.75
Kato	7	2005	8	Poly-si	1008	30	Operational	Electricity for clinic	1839.6
Kaieteur	8	2004	10	monocrystalline	1272	24	Operational	Park and Guest House	2321.4
Monkey Mountain	8	2007	2		110		Operational	Health Centre	200.75
Paruima	8	2004	8	Poly-si	1008	30	Operational	Productive works	1839.6
Kurukubaru	8	2008	102	Poly-si	12750	12	Operational	Residents & School	23268.75
Aishalton	9	2006	24	monocrystalline	1800	20	not working	Well pump	3285
Annai	9	2004	24	monocrystalline	1272	20	Operational	Well pump	2321.4
Apoteri	9	2007	2		110		Operational	Health Centre	200.75
Karasabai	9	2004	24	monocrystalline	1272	20	Operational	Well pump	2321.4
Sand Creek	9	2006	24	monocrystalline	1800	20	Operational	Well pump	3285
Yupukari	9	2006	24	monocrystalline	1800	20	not working	Well pump	3285
Wowetta	9	2009	49		1960	12	Operational	Residents	3577
Wowetta	9	2009	2		170		Operational	Solar Freezer	310.25
Wowetta	9	2009	4		340		Operational	Well pump	620.5
Moraikaboi	10	2004	24	monocrystalline	1272	20	Operational	Well pump	2321.4
Muritaro	10	2008	63	Poly-si	7875	12	Operational	Residents & School	14371.875
Hinterland communities		2009	1000		15000	12	Operational	Lighting	27375
TOTAL					**88,009**				**160,616**

Source[22]

[22] Guyana Energy Agency. Alternative Energy Programmes/Initiatives in Guyana. November 2009.

Wind: Guyana has begun to assess the potential for developing wind power in certain locations.

The Government of Guyana and Delta Caribbean signed an MOU (Memorandum of Understanding) in March 2007 for the construction of a 13.5 MW Wind Farm at Hope Beach, on the East Coast of Demerara. This project will supply power to the grid when completed.

Through the UAEP, monitoring activities and recording of wind speeds are being carried out in the following areas: Orealla, Jawalla, Campbelltown and Yupukari.

Biomass: Energy from biomass is also an important source of energy in Guyana. As noted earlier, around 25.67% of the electricity supply in Guyana came from bagasse co-generation in 2008. Bagasse is used in the sugar industry and rice husk in the rice industry for the co-generation of heat and electricity, while wood (fire-wood and charcoal) is used in the residential sector for cooking purposes.

There has been much interest in expanding the production of energy from biomass sources; however to date, few additional biomass plants have materialized.

Modernization of the existing bagasse co-generation facilities with the use of higher pressure boilers could generate more electricity which could be distributed to the grid. The modernized Skeldon sugar factory will be providing approximately 10 MW of electricity to the national grid from 2009.[23]

Methane use for energy production in Guyana is underdeveloped. However, there are opportunities for methane recovery associated with agriculture (e.g. poultry and cattle farms) and potentially also from landfill. In August 2007 a small pilot biogas facility to generate electricity was installed, and is fed with cow manure.[24] There are presently six additional digesters using various feedstocks located throughout Guyana.

Biofuel: A number of proposals have been submitted for the production of biodiesel from ethanol and a variety of feedstocks, and several projects are currently being implemented.

The Government of Guyana will benefit from support to prepare the project Expanding Bio-energy Opportunities in Guyana that will assess the bio-energy potential, provide policy recommendations for bio-energy and support the development of the investment for bio-energy projects.

IAST Biodiesel Project – This is a Pilot project capable of producing 60 x 45 gallon barrels of biodiesel per month using edible oils and waste edible oils as feedstock. Forty-eight (48) barrels of biodiesel were produced by the IAST laboratory in 2008.

Wauna Biodiesel Production - A commercial-scale unit (based on the IAST biodiesel pilot unit) is currently in operation at Wauna. This unit is capable of producing 300 to 600 barrels of biodiesel per month using palm oil as the feedstock. In 2008, 1,076 barrels of biodiesel were produced and sold to the Region 1 Administration for power generation at Mabaruma.

[23] Guyana Energy Agency. Kick the Habit: a presentation that covers the current energy situation and the status of the various energy developments and energy conservation measures in Guyana. [online] available at: http://www.sdnp.org.gy/gea/downloads/Kick%20the%20Habit.pdf (accessed 25 August 2009).

[24] Ibid.

3.2.2 Energy Efficiency

According to the GHG-I, residential, commercial and institutional buildings are responsible for a significant amount of carbon emissions, mainly because of the energy they consume.

The GEA has embarked on public awareness activities, including brochure production, to raise awareness amongst the public about opportunities for improving energy efficiency and reducing energy use. Building codes are being developed for solar panels.

3.2.3 Transport

The transport sector offers significant opportunities for achieving reductions in GHG emissions. The GHG-I indicates that transport is responsible for 18.9% of total CO_2 emissions from the energy sub-sector, or around 9% of total emissions. It is estimated that approximately 20% of all liquid fossil fuels imported into Guyana are for the transportation sector.

Some mitigation measures are already being undertaken in the transport sector, including an analysis of the bio-energy potential in Guyana. The outcomes of the analysis will inform policy and regulations on bio-energy production and support investment for biofuel projects.

Unleaded gasoline has also been introduced into Guyana, and as of January 1999 leaded gasoline was no longer imported. There are no restrictions in terms of vehicle imports in Guyana.[25] However there are restrictions in terms of sales of new and second-hand imported vehicles set out by the Environmental Protection Act.[26]. In terms of mobile sources of emissions, the Environmental Protection (Air Quality) Regulations 2000[27] impose restrictions on the sale of any new or used imported vehicles that do not meet certain exhaust emission standards, and that are not equipped with fully functioning emissions control systems or other diagnostic technologies for monitoring exhaust emissions. The Regulations also stipulate that within three years after the commencement of these Regulations, or such other time as the Environmental Protection Agency (EPA) may determine, EPA shall establish exhaust emission standards with which every motor vehicle shall comply.

Under this Act, the Ambient Air Quality Standards are as shown in Table 3.4 below.

Table 3. 4. Ambient air quality standards for Guyana

Pollutant	World Bank Std.
Nitrogen Dioxide (NO_2) Maximum 24-hour average	150mg/m 3
Particulate Matter (PM10) 24-hour average	70mg/m 3
Sulphur Dioxide (SO_2) 24-hour average	125mg/m 3

As of 2004, Guyana EPA and the Guyana Bureau of Standards are developing emission standards for vehicles in Guyana.[28]

[25] UNEP. Latin America and the Caribbean Passenger Vehicle Standards & Fleets (updated Oct 2009). Extracted at: http://www.unep.org/pcfv/PDF/MatrixLACVEHOct09.pdf, accessed 12 January 2010.

[26] Environmental Protection Act. Environmental Protection (Air Quality) Regulations 2000. http://www.epaguyana.org/index2.php?option=com_docman&task=doc_view&gid=28&Itemid=29.

[27] Environmental Protection Act (Air Quality). Extracted from: http://www.temasactuales.com/assets/pdf/gratis/GUYair.pdf, on 12 January 2010.

[28] UNEP, Latin America and the Caribbean Passenger Vehicle Standards & Fleets (updated Oct 2009). Extracted at: http://www.unep.org/pcfv/PDF/MatrixLACVEHOct09.pdf, accessed on 12 January 2010.

3.3 Existing policies, programmes and practices

Tables 3.5, 3.6 and 3.7 below provide information on the policies, programmes and projects implemented or under implementation in Guyana.

Table 3. 5. Policy developments and other measures for energy industries

Sector	Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation in Guyana
Industry	Retrofit existing power plants with energy efficient technologies / and switch to more efficient fuel use	**Guyana National Development Strategy 2001-2010** ***UAEP – Unserved Areas Electrification Programme:*** Implementation of a cost reduction initiative, which included the modification of generators and upgrade of Low-NOx equipment; identification and removal of illegal connections and replacement of defective meters (8000 meters were installed) ***GPL's Development and Expansion Programme 2009-2013:*** Improve voltage regulation; reduce outages due to trips and planned maintenance activities; improve management when restoring service; and increase capacity to meet growing demand (US$13.91M)
	Reduce transmission losses	***UAEP - Unserved Areas Electrification Programme:*** Implementation of a cost reduction initiative, identification and removal of illegal connections and replacement of defective meters (8000 meters were installed) Further installation of 3000 more meters during 2009 ***GPL's Development and Expansion Programme 2009-2013:*** Between 2009 and 2013 GPL estimates reducing losses by 11.6 %, where 8.25 % will be non-technical and 3.35 % technical. (US$17.4 M)
	Implement demand-side management strategies such as pricing and subsidization of new technologies	**Guyana National Development Strategy 2001-2010** ***GPL's Development and Expansion Programme 2009-2013:*** ▪ Installation of SCADA (Supervisory Control & Data Acquisition) system in a modern Central Control Centre (US$5.538M) ▪ Construction of a fibre optic network between Skeldon and Edinburgh and a new Central Control Centre with SCADA capability (US$5.38M)
	Replace existing oil-fired plants with new natural gas-fired stations and RE sources	**Guyana National Development Strategy 2001-2010** **A Low-Carbon Development Strategy : Draft for Consultation** ***GPL's Development and Expansion Programme 2009-2013:*** ▪ It is expected that generation from RE or HFO sources will increase to 81% in 2009, 98.5% in 2010 and 100% in 2013 (US$72.5 M). ▪ Transmission lines to integrate areas in Demerara and Berbice (US$16.14M) ▪ Substations to provide outlets at seven (7) new locations through 69/13.8KV substations (US$24.27M) ▪ Start of hydropower in 2013, the addition of Linden to the National Grid and the continuous expansion of housing schemes will result in the need for another electrification programme (US$2.3M). Caribbean Renewable Energy Development Programme: more than 16 projects have been identified, of which two have been funded.

		Capacity Building and Demonstration Projects for Electrification of Hinterland and Unserved Areas, Utilizing Renewable Energy: ▪ Share practices related to innovative/alternative financing instruments for sustainable development ▪ Introduction of more efficient stoves ▪ Installation of photovoltaic (PV) systems in the Paruima, Wauna and Kato communities ▪ The development of other sources of energy, such as hydro and wind considered
	Energy conservation in commercial/residential/ public buildings	**UAEP - Unserved Areas Electrification Programme**: replacement of 480,000 incandescent bulbs with free energy-saving bulbs Capacity Building and Demonstration Projects for Electrification of Hinterland and Unserved Areas, Utilizing Renewable Energy: share practices related to innovative/alternative financing instruments for sustainable development Awareness-raising by Guyana's Energy Agency through the distribution of flyers on lighting, appliances and building design
	Energy conservation in transportation	Awareness-raising by Guyana's Energy Agency through flyers on transportation.

Table 3. 6 Measures to reduce greenhouse gas emissions from energy use in buildings

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation in Guyana
Reduce energy consumption – using energy efficient cooling systems, more efficient lighting, cooking appliances, updating building codes	**Guyana Energy Agency** The Guyana Energy Agency has identified ways to save energy and has prepared flyers which show simple ways/measures to save energy in buildings such as the introduction of efficient lighting, efficient appliances, insulation and other activities which can save energies in everyday life.[29] **Guyana Power & Light Inc – Developing an Expansion Programme 2009 – 2013** Guyana Power & Light Inc, the main electricity provider in Guyana, is providing more information on energy efficiency by assisting consumers to calculate the benefits of using energy-efficient lights and appliances. They are also fostering a relationship between consumers and the private sector to ensure energy-efficient appliances are more available, affordable and accessible.[30] **Capacity Building and Demonstration Projects for Electrification of Hinterland and Unserved Areas** More energy efficient stoves were introduced to several hinterland communities which use fire-wood as the main cooking fuel. The design of the stove has been modified using 50% less fuel-wood than the traditional local firesides. All communities have expressed interest in fabricating replica stoves within the villages. Indigenous materials are used where possible; however the fire chamber of the stove poses a difficult challenge.[31] Building codes are being designed for Latrines and Solar Panels and those

[29] http://www.sdnp.org.gy/gea/downloads.php

[30] Guyana Power & Light Inc. Developing an Expansion Programme 2009–2013 [online]. Available at http://www.gplinc.com/files/D&E_Programme_2009_2013_Final.pdf (accessed 24 September 2009).

[31] Capacity Building and Demonstration Projects for Electrification of Hinterland and Unserved Areas, Utilising Renewable Energy [online]. Available at: http://www.undp.org.gy/project00012817.html (accessed 24 September 2009).

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation in Guyana
	are expected to be released in June 2010 and December 2011, respectively. However, these codes do not integrate measures or incentives for the application of energy efficiency measures for new buildings (insulation, HAVAC systems, cooling systems, efficient lighting, and efficient equipment).[32]
Sustainable design – improve insulation/reduce cooling losses, update building codes, use sustainable materials	**Building Design Energy Conservation Tips** Published and distributed by the Guyana Energy Agency.[33] This flyer offers 14 tips for building design that includes energy efficiency and conservation considerations as well as support for deployment of renewable energy technologies when appropriate. This flyer also provides a way for consumers to estimate their energy costs. Duty and tax exemption on selected building materials[34] A Building Application Process has been in action since 2001 To enforce greater adherence to building codes in Guyana, a National Technical Sub-Committee on Regional Building Standards was launched in November 2009.[35] The current Housing Act is dated from 1998. There is a Manual for Building Developers issued in 2008, which does not refer to improvement on isolation nor reduction of cooling losses etc.[36]
Policies – mandatory energy efficiency standards, incentives	No energy efficiency policies, standards nor incentives exist in Guyana.

[32] Information provided by the Guyana Bureau of Standards.
[33] See http://www.gea.gov.gy/downloads/building-design-brochure.pdf.
[34] See http://www.goinvest.gov.gy/incentives.html.
[35] See http://www.stabroeknews.com/2009/stories/11/19/committee-on-regional-building-standards-set-up/.
[36] See http://www.chpa.gov.gy/).

Table 3. 7. Measures to reduce greenhouse gas emissions from transport

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation in Guyana, or recommended
Improvements in energy efficiency of vehicles	Guyana Energy Agency energy-saving campaign GEA published a series of brochures containing energy-saving tips for a number of sectors including car transport.[37]
Shift to less carbon-emitting fuels and in the longer term to hybrid vehicles	Unleaded gasoline has been introduced into the Guyana market. As of January 1999, leaded gasoline was no longer imported. Shift to less carbon-emitting technologies: Analysis of the bio-energy potential in Guyana IAST pilot biodiesel project (that has produced 48 barrels of biodiesel in 2008 as well as a biodiesel commercial scale unit (Wauna Biodiesel Production) that is already operational and has the capacity to produce 300 to 600 barrels of biodiesel per month using palm oil as the feedstock Guyana National Development Strategy 2001-2010: National Transportation strategy should be developed to introduce standards for cleaner fuels to eliminate lead and sulphur emissions
Mandatory installation of pollution removal devices (e.g. catalytic converters)	Stated in the Environmental (Air Quality) Protection Act 2000
Stricter import controls e.g. so that only vehicles meeting minimum environmental standards are brought into the country	Environmental Protection (Air Quality) Regulations 2000: Imposes restrictions on the sale of any new or used imported vehicles that do not meet better exhaust emissions standards or are equipped with a fully functioning emissions control system or some other diagnostic technology for monitoring exhaust emissions Sets out air quality emission standards (for the environment) As of 2004, the Guyana EPA and the Bureau of Standards are developing emission standards for vehicles in Guyana
Measures to encourage modal shifts (e.g. from road to rail transportation)	Guyana National Development Strategy (NDS) 2001-2010: Recommends that a comprehensive National Transportation Strategy should be developed which would include a safety programme, monitoring of programmes, and strategies for long term development of growing areas
Design and introduction of incentives (e.g. using pricing controls) to encourage the use of alternative, less polluting fuels	The National Transportation Development Strategy also incorporates subsidy schemes for social services public transport; road charges, tolls, parking fees, increased vehicle licence fees, and weight charges for heavy duty lorries will be introduced, with the revenue allocated to the provision of alternative transportation - public transportation (bus and rail), and proper paths for cycling and walking, thereby enabling citizens to make a free choice.
Research and Development in vehicle and transport system technologies	None

[37] See http://www.sdnp.org.gy/gea/downloads/autosmart-brochure.pdf.

3.4 SCENARIOS

3.4.1 Energy sector analysis

Baseline Scenario

The results of this scenario show the energy demand, fuel requirements and carbon dioxide emissions of Guyana assuming that no mitigation measures are implemented (See Appendix 3.2). The results in Fig. 3.3 show the total energy demand in Guyana increasing to 4,347 GWh, with the largest requirement for energy in the transport sector. Industrial demand is low compared to household demand. This is due to most industries in Guyana (sugar cane and mining) generating their own energy, which has not been included in this analysis.

The results in Fig. 3.4 show the fuels required to meet this demand. While bagasse, wood and charcoal are all domestically sourced, all oil products are imported. The amount of bagasse required to meet the demand for electricity increases from 81,000 tonnes per annum in 2008 to 260,000 tonnes per annum in 2030. This is well within the production in 2008 of 1,077,520 tonnes per annum. Guyana has a large wood resource and it is assumed that it can sustainably meet all its demand for wood and charcoal for energy generation.

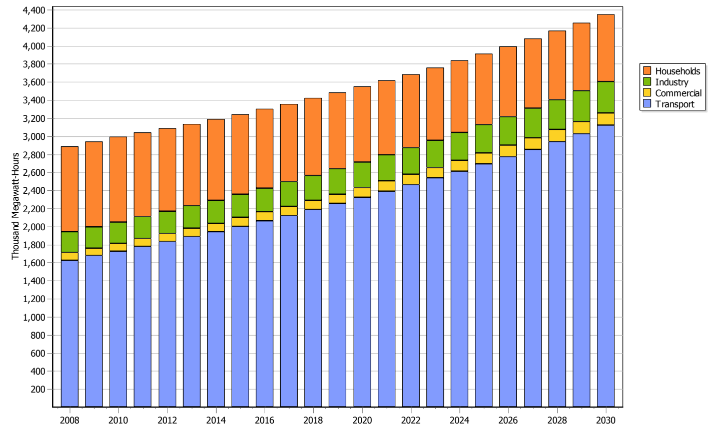


Fig. 3. 3. Baseline energy demand

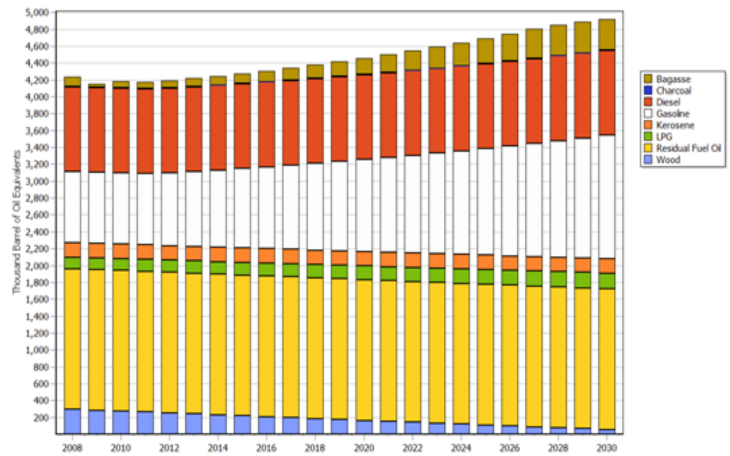


Fig. 3. 4. Reference fuel requirements

Figure 3.5 shows the carbon dioxide emissions for the energy sector in Guyana which are expected to increase from 948,000 tonnes in 2008 to 1,391,000 tonnes in 2030.

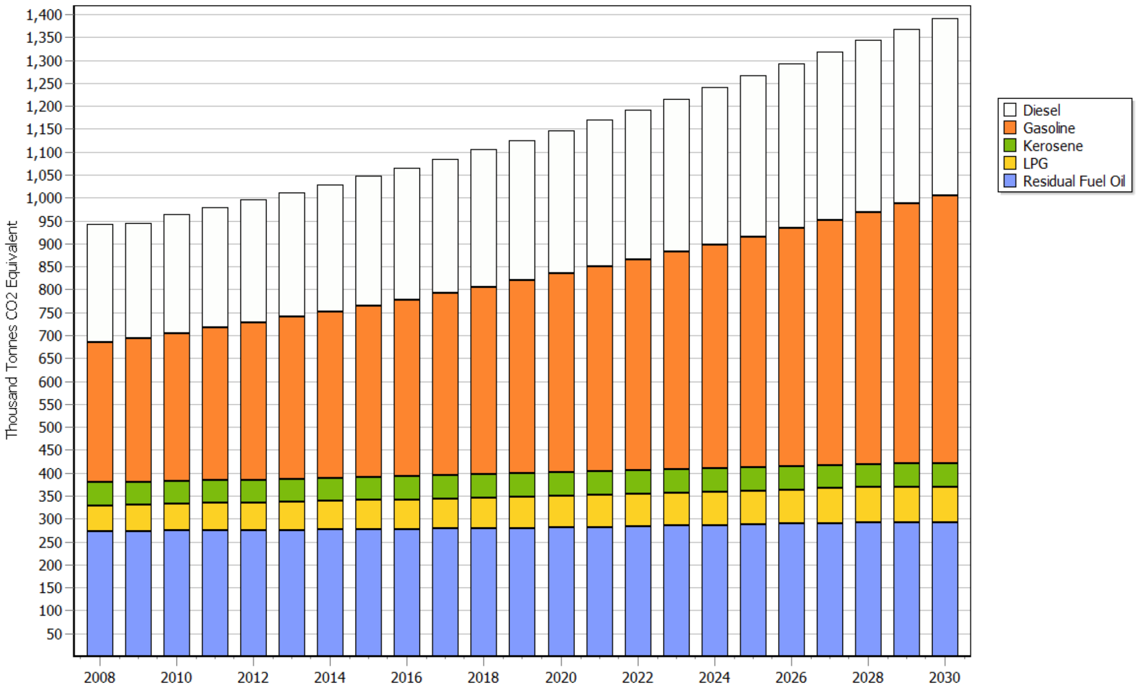


Fig. 3. 5. **Reference carbn dioxide emissions**

Demand-Side Management Scenario

The results of this scenario show the energy demand, fuel requirements and carbon dioxide emissions of Guyana assuming that energy efficiency measures are implemented such as more efficient appliances, lighting, industrial processes, and also a reduction in transmission losses for electricity.

The results in Fig. 3.6 show the total energy demand in Guyana increasing to 4,201 GWh under this scenario, compared to 4,347 GWh in the reference scenario. The dip from 2008 to 2010 is a result of the improvements in transmission losses from 40 % to 15.4 %.

The results in Fig. 3.7 show the fuels required to meet the demand in this scenario and Fig. 3.8 shows the associated carbon dioxide emissions. Implementing demand-side management measures results in a reduction of carbon dioxide emissions in 2030 from 1,391,000 tonnes in the reference scenario to 1,349,000 tonnes, resulting in a saving of 42,000 tonnes.

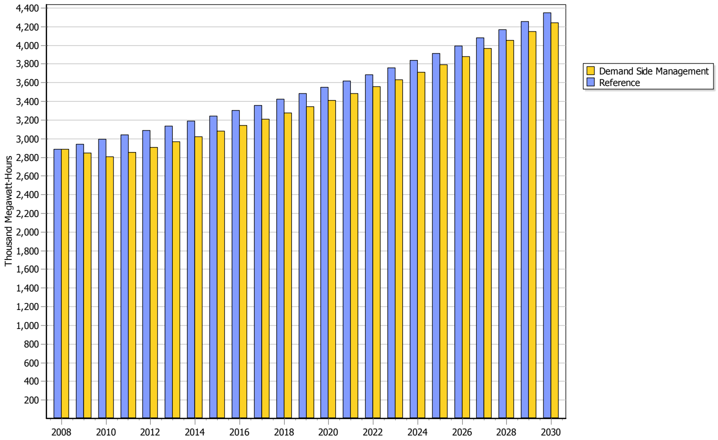


Fig. 3. 6. **Demand-side management energy demand**

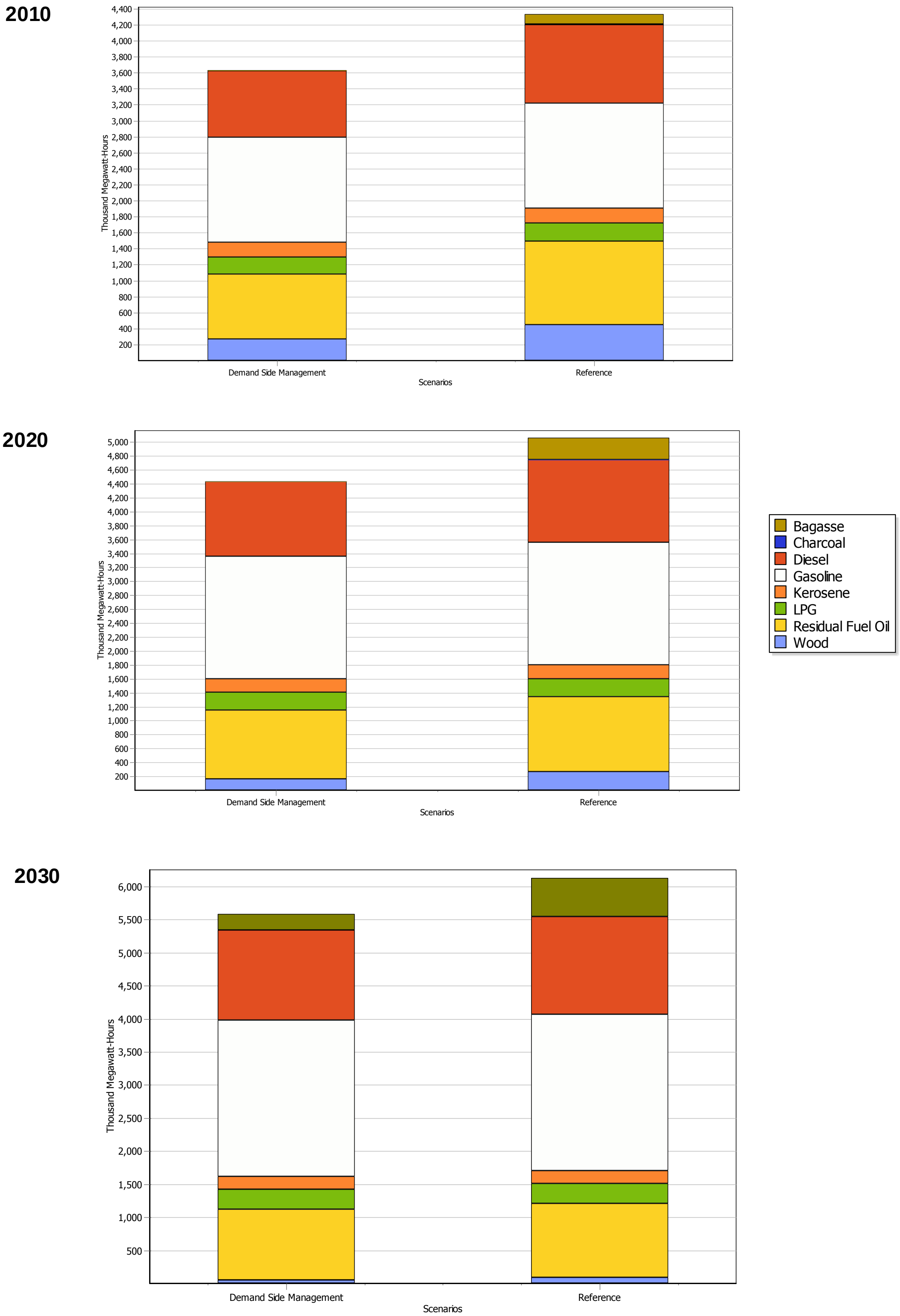


Fig. 3. 7. **Demand-side management fuel requirements**

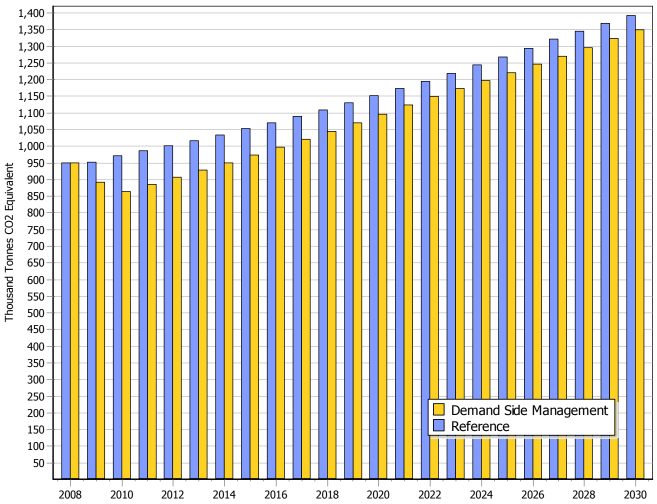


Fig. 3. 8. Demand-side management carbon dioxide emissions

Renewable Energy Scenario

This scenario shows the fuel requirements and carbon dioxide emissions of Guyana assuming that renewable energy systems are installed to generate electricity for Guyana. This would include additional capacity for utilizing bagasse, installing hydropower stations, wind turbines and PV plants.

This scenario assumes the same energy demand as the baseline scenario for households, industry, commercial, and transport sectors; therefore there is neither a change in the results shown in Fig. 3.3 for the baseline scenario, nor in the fuel required to fulfil the demand. The difference between the baseline scenario and the renewable energy scenario is the electricity source. The fuels used to generate electricity compared to the reference scenario are shown in Fig. 3.9. This shows that by 2020 all the electricity in Guyana could be generated from renewable sources, based on the assumptions in this model. The electricity demand could primarily be met using hydropower, with an input from the bagasse generators. The results from the analysis show that the hydropower capacity that would be installed by 2020 would be sufficient to meet the demand even without input from the Mazaruni Falls project. However, in reality there will be

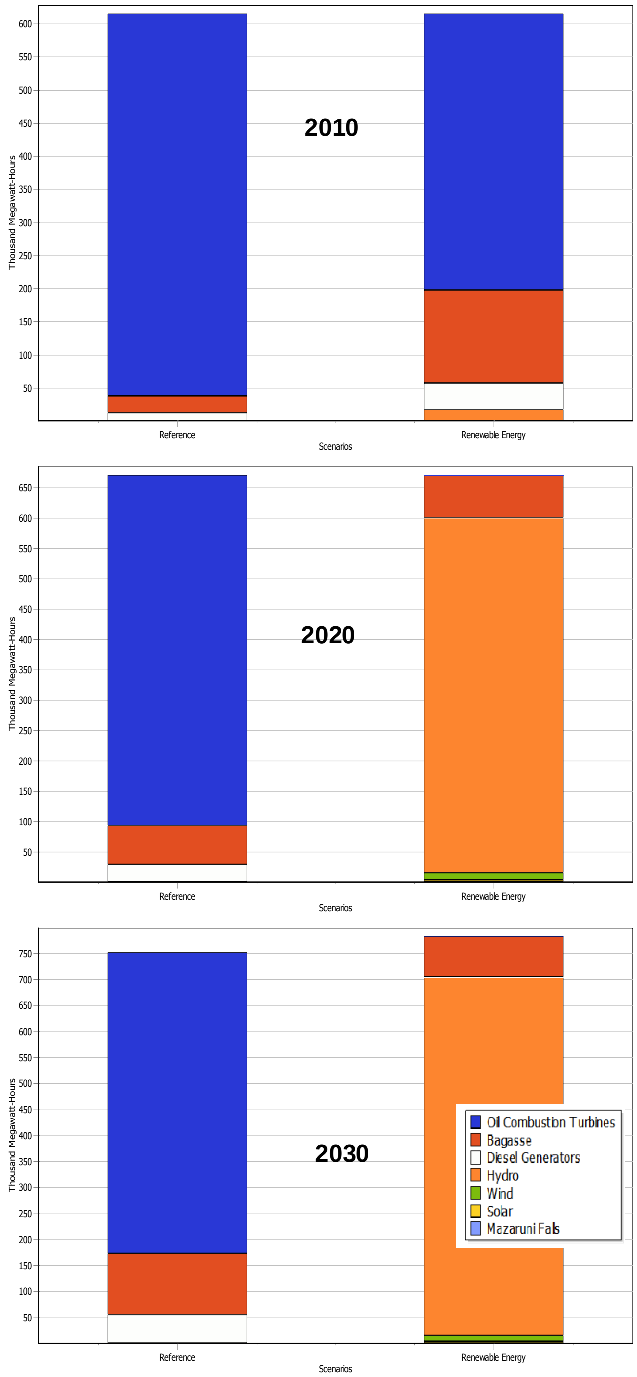


Fig. 3. 9. Renewable energy scenario electricity generation

times when there are lower river flows and less output from the other hydropower plants, and therefore there will be a requirement for electricity generated from the Mazaruni Falls.

The use of renewable energy for electricity generation has a significant effect on the carbon dioxide emissions of Guyana. The results in Fig. 3.10 show a reduction of carbon dioxide emissions in 2030 from 1,391,000 tonnes in the baseline scenario to 912,000 tonnes in the renewable energy scenario, a saving of 479,000 tonnes.

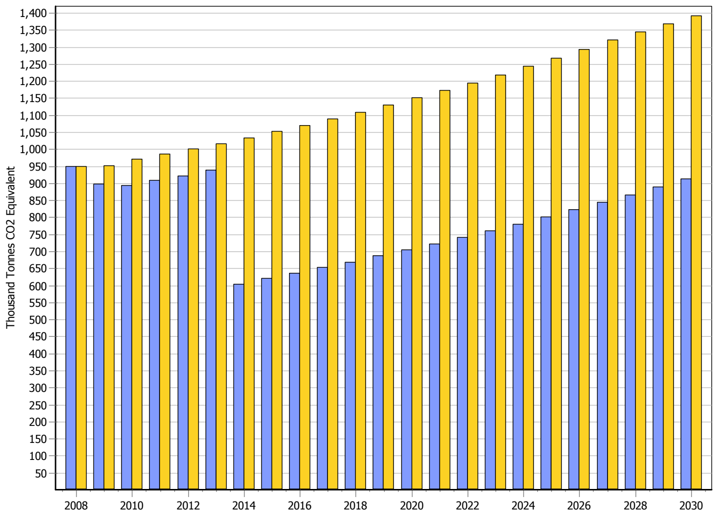


Fig. 3. 10. Renewable energy scenario carbon dioxide emissions

Transportation Scenario

The results of this scenario show the fuel requirements and carbon dioxide emissions of Guyana assuming that mitigation measures in the transport sector are enacted. This would include using more efficient engines, the use of hybrid cars, and B20 biodiesel.

This scenario assumes the same energy demand as the baseline scenario for households, industry and commercial sectors; there is therefore no change in the fuel requirements apart from diesel and gasoline for transport. The fuel requirements for transport compared to the reference scenario are shown in Fig. 3.12. This shows a significant decrease in fuel requirements for the transport sector by 2030. By 2030 the fuel demand would have dropped to a total of 1,410,000 BOE from 1,929,000 BOE in the baseline scenario. In addition to the diesel and gasoline, it is estimated that Guyana would use 67,000 BOE of B20 biodiesel. This would require an increase in the production of biodiesel to 13,400 barrels a year from the current 600 produced in the pilot plant.

This reduction in transport fuel demand also has an effect on the carbon dioxide emissions. In Fig. 3.11 it can be seen that the carbon dioxide emissions in 2030 are reduced from 1,391,000 tonnes in the baseline scenario to 1,152,000 tonnes, a saving of 239,000 tonnes.

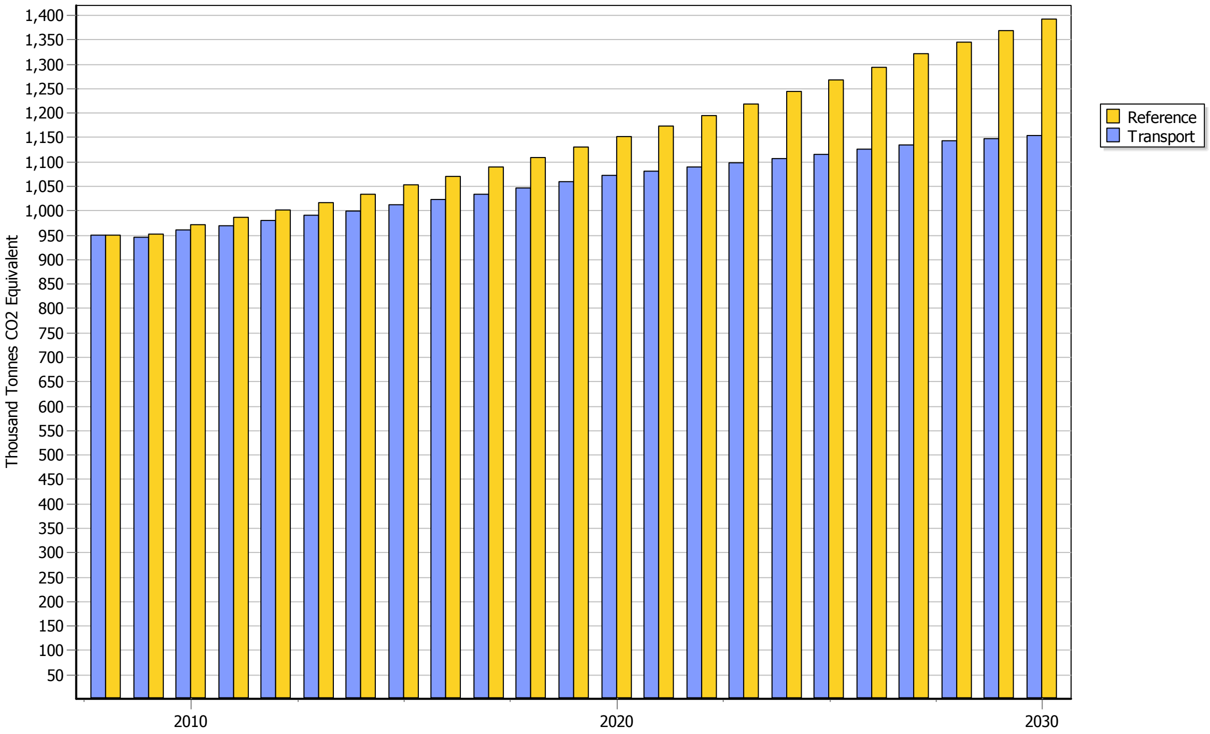


Fig. 3. 11. **Transport scenario carbon dioxide emissions**

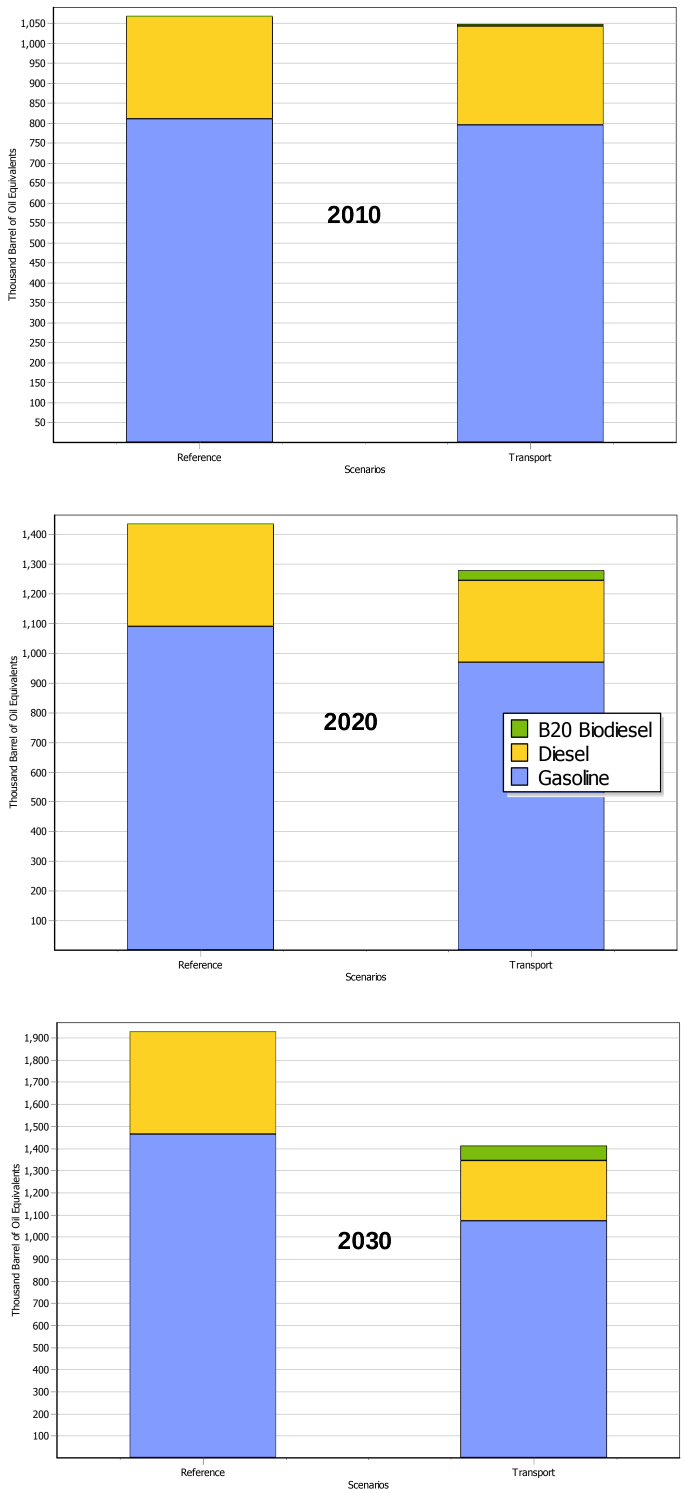


Fig. 3. 12. Transport scenario fuel requirements

The mitigation scenario combines the results of all the above scenarios to produce an overall mitigation scenario. The results show the energy demand, fuel requirements, and carbon dioxide emissions if all the mitigation measures mentioned above were implemented.

Graph 3.13 shows the total energy demand for all the scenarios. This shows that the transport scenario measures have the greatest effect on energy demand, and in combination with the demand-side management measures result in a significant reduction in total energy demand compared to the baseline scenario.

In 2030 the total energy demand in the baseline scenario is 4,347 GWh, reduced to 3,401 GWh in the mitigation scenario. This reduction in total energy demand, plus the use of renewable energy for electricity generation, result in reduction in fuel import requirements. Fig. 3.15 shows a reduction in residual fuel oil imports to zero by 2030, as well as reductions in other fuel demand compared to the reference scenario. Together, these measures result in an overall reduction in carbon dioxide emissions as shown in Fig. 3.14.

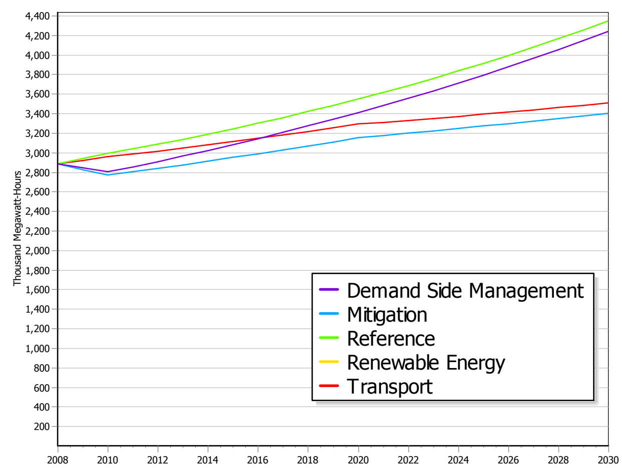


Fig. 3. 13. Mitigation scenario energy demand

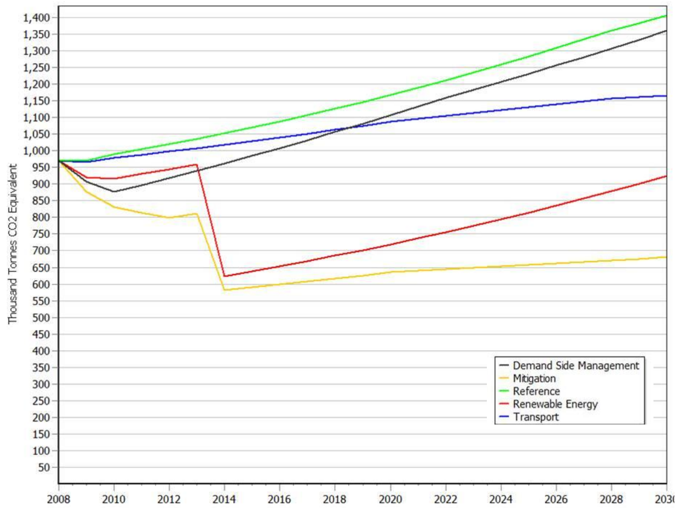


Fig. 3.14. Mitigation scenario CO_{2e} emissions

In 2030 the mitigation scenario has carbon dioxide emissions of 673,000 tonnes compared to the reference scenario emissions of 1,391,000 tonnes; a saving of 719,000 tonnes. In fact the mitigation scenario has lower carbon dioxide emissions than the baseline year of 2008, which has 949,000 tonnes of carbon dioxide emissions. The significant drop in emissions in the graph corresponds to the 165 MW Amaila Falls hydropower project coming online.

3.4.2 Mitigation options and prioritization of measures

Although some advancements have been made since the publication of the INC (especially in terms of renewable energy projects under analysis and in development, as well as in regulations), in terms of mitigation options for the energy, transport and building sectors, these continue to be the same as the ones expressed in the INC.

The following table (Table 3.8) summarizes mitigation options in terms of technology and policy instruments for Guyana's energy, transport and building sectors. A two-pronged approach to mitigation is required that addresses both the way in which energy is generated, and also the efficiency of the use of this energy.

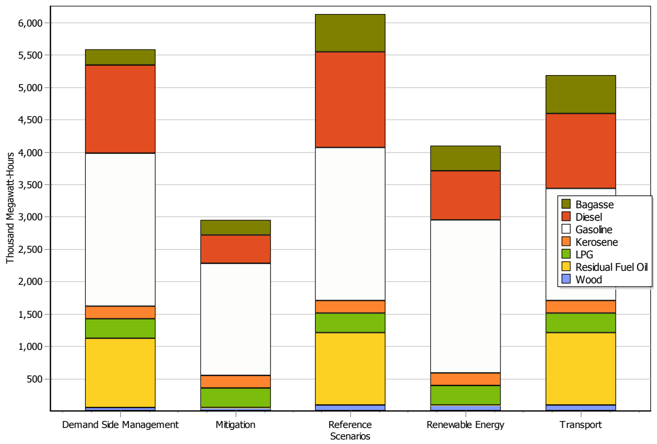


Fig. 3.15. Mitigation scenario fuel requirements in 2030

Table 3. 8. Mitigation options for the energy sector

Sector	Short-Term (2010-2016)	Medium-Term (2016-2020)	Long-Term (2020 onwards)
Energy	Technologies: Modernization of power plants: energy efficiency, retro-fitting, decarbonisation, distribution efficiency Hydropower, wind farms, solar systems Capacity building actions to increase awareness on technologies available, climate change impacts mitigation and unconventional renewable energy sources Policy instruments: Energy conservation (sensitization, transmission losses) Demand-side management (pricing, competition, subsidies)	Technology: Less carbon-intensive fuels Switching to renewable energy Hydropower, wind farms and solar systems Policy instruments: Facilitate less carbon-intensive technologies (accelerated, depreciation, agreement on more efficient equipment) Development of comprehensive energy plan for Guyana	Technology Continue to promote renewable energy Policy instruments: Regulatory programmes Market pull and demonstration (development/application of efficient technologies) Implementation of an energy plan
Transportation	Technologies: Efficiency improvement (less carbon-emitting vehicles; types, and lubricants) Pollution control devices (catalytic converters) Alternative energy: biodiesel, natural gas Policy instruments: Finish the development of the Transportation Strategy for Guyana Legislation to include: speed limiters, reduction of vehicle use, car pooling Development of vehicle emission standards	Technology: More efficient engines (4-stroke, electronic systems) Policy Instruments: Government incentives for licensing (energy-efficient vehicles); for pricing (alternative fuels), and for the use of public transport	Technology: Modern hybrid vehicles Traffic and fleet management systems Policy instruments: Research & Development in vehicle transport system technology
Buildings	Technologies: Reduce energy use: energy-efficient cooling systems; more efficient lighting, more efficient cooking appliances; updating building codes and inclusion on the building codes Regulations on energy conservation labels Policy Instruments: Development of regulations with mandatory energy-efficient standards Voluntary measures (builders/manufacturers)	Technologies: Thermal integrity (cooling losses) Enforcement of the energy conservation labels and building codes Include energy audit specification for new buildings and refurbished ones Policy Instruments: Market-based programmes with incentives for adoption of	Technologies: Choice of materials (wood instead of concrete) Policy Instruments: Research & Development in terms of new energy and efficient building materials and products

Sector	Short-Term (2010-2016)	Medium-Term (2016-2020)	Long-Term (2020 onwards)
		energy-efficient products Procurement programmes (large purchase of energy and efficient products) Development of regulations to include integrated energy supply (heat and/or electricity)	

3.5 Land Use and Forestry

Sector overview

Guyana's pristine forests are its most valuable asset, covering 85 % of the total land area (~18.3 million hectares).[38] Of the total forested area approximately 74 % (~13.3 million hectares) is State Forest Land, while the remaining is under the jurisdiction of Amerindian communities or on private property.[39] As shown in Table 3.9, 50.1 % of the State Forest (~6,682,335 ha) has been allocated for timber harvesting and 7.9 % (~1,050,699ha) is under total or partial conservation activities, including the Iwokrama Forest reserve and research site and the Kaieteur National Park. The remaining 42 % of the State Forest still remains unallocated (~5,606,980 ha).[40]The responsible Government Agency for the management of State Forest Land is the Guyana Forestry Commission (GFC) which was established in 1979 as a semi-autonomous Government organization.[41]

Guyana also has important mangrove forests which play an important role both in protecting the country's estuarine and coastal areas from the effects of sea-level rise, and in the abatement of climate change through carbon sequestration. It is estimated that mangrove forests are capable of fixing up to 17 tonnes of carbon/hectare/year, which is more per unit area than phytoplankton in tropical oceans.[42] Under the Global Climate Change Alliance project, the European Commission is supporting a mangrove management programme, which includes the preparation of a National Mangrove Management Action Plan (NMMAP). The overall objective of the programme is to 'respond to climate change and to mitigate its effects through the protection, rehabilitation and wise use of Guyana's mangrove ecosystems through processes that maintain their protective function, values and biodiversity, while meeting the socio-economic development and environmental protection needs in estuarine and coastal areas.'[43]

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[38] Readiness Preparation Proposal (RPP) Guyana. Forest Carbon Partnership Facility (FCPF). April 2010. [Online.] Available at: http://www.forestry.gov.gy/Downloads/Readiness_Preparation_Proposal_April_2010_Revised.pdf (accessed 11 August 2010).

[39] Ibid.

[40] Ibid.

[41] Ibid.

[42] Guyana Forestry Commission and Integrated Coastal Zone Management (ICZM)–EPA (2001). National Mangrove Management Action Plan.

[43] Guyana Mangrove Action Committee (2010) National Mangrove Management Action Plan 2010-2012. [Online.] Available at http://www.agriculture.gov.gy/NMMAP-Final%20v0.3_7-22-10.pdf (accessed 15 December 2010).

Table 3. 9. State Forest Allocations (as at December 2009). Guyana Forestry Commission.

Classification[44]	Area (Hectares)	% of Area Type	% of Allocated Forests	% of Total State Forest Area
Production Area Allocations	**6,682,335**	**100.0**	**86.4**	**50.1**
State Forest Permissions (SFP)	1,671,369	25.0	21.6	12.5
Wood Cutting Lease (WCL)	30,535	0.5	0.4	0.2
Timber Sales Agreement (TSA)	4,347,939	65.1	56.2	32.6
State Forest Exploratory Permit (SFEP)	632,492	9.5	8.2	4.7
Permanent Research and Reserve Areas	**1,050,699**	**100.0**	**13.6**	**7.9**
GFC Forest Reserves	17,795	1.7	0.2	0.1
Other Research and Reserve Sites	1,032,903	98.3	13.4	7.7
Total Forests Allocated	**7,733,034**		**100.0**	**58.0**
Unallocated Forests	5,606,980	42.0		42.0
Total State Forest Area	**13,340,014**			**100.0**

Guyana is also the first country in the world to attempt national scale action on Reducing Emissions from Deforestation and Forest Degradation (REDD+). In doing this, it is hoping to help other forest countries and the international community resolve many of the technical issues that currently make progress difficult. As part of this effort, interim reference level and payment methodologies have been established, and these are being used in a partnership with Norway (see section on Forest Conservation below).

Guyana's Readiness Preparation Proposal[45] (RPP), prepared for the Forest Carbon Partnership Facility, sets out further detail on how the forest carbon stocks will be managed in a way which aims to achieve carbon neutrality over time. In all sectors, REDD+ will enable greater resources to be devoted to addressing illegal activities, and improving governance where necessary. The specific measures to achieve this are specified in the RPP, and will be further developed in the REDD+ Governance Development Plan.

[44] Readiness Preparation Proposal (RPP) Guyana. Forest Carbon Partnership Facility (FCPF). April 2010. [Online.] Available at: http://www.forestry.gov.gy/Downloads/Readiness_Preparation_Proposal_April_2010_Revised.pdf (accessed 11 August 2010).

[45] See http://www.forestry.gov.gy/Downloads/Readiness_Preparation_Proposal_April_2010_Revised.pdf (accessed 20/06/2010).

Although Guyana has had relatively low historical rates of deforestation, the country's national circumstances clearly indicate that if incentives and governance are not directed to controlling deforestation and degradation, both of these rates and their associated emissions are expected to significantly increase, mainly because of the growing demand for agricultural products (including biofuels) and the international growing demand for tropical timber. Furthermore, Brazil has a very large and dynamic human population that could rapidly move into Guyana for logging and mining activities, particularly via a new major international highway from Brazil which will be built.

Economic value

The value of Guyana's rainforest, if harvested and the land put to the highest value subsequent use, has been estimated to vary between US$4.3 billion and $23.4 billion. The wide range of estimates is driven by fluctuating prices for commodities such as logs, rice and palm oil – but the most likely estimate is US$5.8 billion. This forest value, known as Economic Value to the Nation (EVN), is the equivalent of an annual annuity payment of US$580 million (most likely estimate).[46] Although this option would be economically rational for Guyana, this would have significant negative consequences for the world. The deforestation that would accompany this development path would reduce the critical environmental value which Guyana's forests provide. Conservative valuations of the Economic Value to the World (EVW) provided by Guyana's forests suggest that, left standing, they contribute US$40 billion to the global economy each year.[47] These estimates include the State Forest Lands, and exclude lands under the jurisdiction of Amerindian communities and private property.

Existing policies, programmes and practices

The importance of protecting standing forests for the benefit of the indigenous people, the country, and the wider world has been acknowledged in Guyana through a number of policies, programmes and practices already in place aiming to protect Guyana's forests. The Low Carbon Development Strategy and the Execution of Guyana's Readiness Preparation Proposal (RPP) are setting up the implementation framework for REDD+ activities in Guyana (Tables 3.10 and 3.11).

The health of the fisheries resources used by indigenous communities depends on a healthy rainforest ecosystem

[46] Government of Guyana (2010). Transforming Guyana's Economy While Combating Climate Change: A Low Carbon Development Strategy. Office of the President, May 2010. [Online.] Available at: http://www.lcds.gov.gy/images/stories/Documents/Low%20Carbon%20Development%20Strategy%20-%20May%202010.pdf (accessed 11 August 2010).
[47] Ibid.

Table 3. 10. Existing policies, programmes and practices in the forestry sector

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation in Guyana
Management of forests specifically for carbon conservation, including via introduction of stricter controls on harvesting, deforestation, fires and pest outbreaks	**Code of Practice for harvesting operations** ▪ Allowing for best practices to be implemented for sustainable forest management including maximum allowable cut, harvesting of trees based on proximity limitations and compliance with social and environmental safeguards.[48] **Annual management planning requirement** ▪ The issuance, planning and management of large concession areas are executed in line with GFC guidelines, which themselves lend to the implementation of sustainable forest management.[49] **National log tracking system and legal verification system** ▪ The GFC has implemented a national log tracking system and has developed a legal verification system in forest concessions which have collectively enhanced Guyana's compliance in forest law enforcement, governance, and trade.[50] **Land-cover change monitoring** ▪ The GFC has in place, a Change Detection system for recording and updating roads and forest disturbances from satellite data. Such information will assist GFC in targeting areas of change and mobilizing necessary resources to undertake enforcement measures and to assess rates of forest cover change. **Effective implementation of mining regulations** ▪ A stronger compliance with mining regulations allows for sustainable use of forest resources, thereby decreasing deforestation and forest.[51] **Forestry Training Centre** ▪ The GFC through the Forestry Training Centre has been offering regular training sessions in Reduced- Impact Logging (RIL) practices to loggers, from both private as well as Amerindian communities.[52]
Management of forest resources specifically for the purposes of carbon sequestration, e.g. through measures to expand the area of forest ecosystems and the density of forest biomass, and increasing the absorption capacity of forest	**Biomass estimation in various soil types** ▪ The development of a National Biomass Monitoring System (NBMS) system is intended to provide data for REDD project assessments of current forest biomass, and forest biomass change over time, in response to REDD-oriented government policies relating to forestry and land-use planning. Currently 135 biomass monitoring plots have been

[48] Readiness Preparation Proposal (RPP) Guyana, Forest Carbon Partnership Facility (FCPF), April 2010 [online] available at: http://www.forestry.gov.gy/Downloads/Readiness_Preparation_Proposal_April_2010_Revised.pdf (accessed 11 August 2010).
[48] Guyana Forestry Commission (GFC) questionnaire response.
[49] Ibid.
[50] Ibid.
[51] Ibid.
[52] Ibid.

soils	established.[53] **Forest conservation projects** ▪ The GFC is implementing a project, funded under the KfW Small Grants Component of the Guyana Protected Areas System (GPAS) project, which seeks to enhance forest conservation and monitoring through the improvement of facilities and provision of equipment for the Moraballi Forest Reserve.[54]
Policy and other measures for promoting afforestation, reforestation and forest regeneration	**Revised Forests Bill (2009)** ▪ This revised Forests Bill allows for 'forest conservation activities' which include the preservation of forests for the purpose of carbon sequestration or any other form of environmental services. Investors have the opportunity to invest in this area in accordance with the Government of Guyana guidelines.[55] **Readiness Plan (R-Plan) (2010)** ▪ The World Bank has approved the readiness plan (R-Plan) for Guyana. Guyana is one of 37 countries around the world that stand to benefit from the World Bank's Forest Carbon Partnership Facility (FCPF), a Multi-Donor Trust Fund (MDTF) administered by the World Bank.[56] **Memorandum of Understanding between the Governments of Guyana and Norway (2010)** ▪ The objective of this MoU is to foster partnership between Guyana and Norway on issues of climate change, biodiversity and sustainable, low carbon development. Of particular importance is the establishment of a comprehensive political and policy dialogue on these issues, and close co-operation regarding Guyana's REDD-plus efforts, including the establishment of a framework for result-based Norwegian financial support to Guyana's REDD-plus efforts.[57] **Low-Carbon Development Strategy (2010)** ▪ Guyana launched its Low-Carbon Development Strategy (LCDS) in May 2010. At the Government of Guyana's request, Norway has commissioned an independent assessment of current forest governance and law enforcement standards; an independent assessment of present logging practices and levels of deforestation and forest degradation, including an assessment of their carbon footprints; and the provision of independent advice from an international institution for the consultative process on the LCDS.[58] **National Mangrove Management Action Plan 2010-2012 (2010)** ▪ The overall objective of the National Mangrove Management Action Plan is to respond to climate change and to mitigate its effects through the

[53] Ibid.
[54] Dr Indarjit Ramdass, Executive Director of Guyana Environmental Protection Agency. *Personal Communication (by email),* 5 February 2010.
[55] Ibid.
[56] The FCPF was created in 2007 as a mechanism to support country readiness for 'reducing greenhouse gas emissions from deforestation and forest degradation' (REDD), a mechanism now under negotiation at the United Nations Framework Climate Change Convention.
[57] See http://www.lcds.gov.gy/images/stories/Documents/MOU.pdf (accessed 23 December 2010).
[58] Government of Guyana (2010). Transforming Guyana's Economy While Combating Climate Change: A Low Carbon Development Strategy. Office of the President, May 2010. [Online.] Available at: http://www.lcds.gov.gy/images/stories/Documents/Low%20Carbon%20Development%20Strategy%20-%20May%202010.pdf (accessed 11 August 2010).

protection, rehabilitation and wise use of Guyana's mangrove ecosystems, through processes that maintain their protective function, values and biodiversity while meeting the socio-economic development and environmental protection needs in estuarine and coastal areas.[59]

National Forest Plan (2001)

- The National Forest Plan was produced in 2001 by the GFC after a period of consultation with stakeholders in the sector. The Plan provides a framework, and identifies programmes and activities that must be accomplished, to ensure implementation of the policy and compliance with the law.

National Forest Policy (1997)

- The National Forest Policy addresses key areas of forest sector development in Guyana. The aim is to promote sustainable and efficient forest activities which utilize the broad range of forest resources and contribute to national sustainable development, while allowing fair returns to local and foreign entrepreneurs and investors. The fundamental objective shall be to develop a financially and economically viable forest industry.

Several agencies work in collaboration to address natural resources issues in Guyana:

- Guyana Forestry Commission
- Guyana Lands and Surveys Commission
- Guyana Geology and Mines Commission
- Ministry of Amerindian Affairs
- Environmental Protection Agency

[59] Guyana Mangrove Action Committee (2010). National Mangrove Management Action Plan 2010-2012. [Online.] Available at: http://www.agriculture.gov.gy/NMMAP-Final%20v0.3_7-22-10.pdf (accessed 15 December 2010).

Table 3. 11. Actions to address deforestation and forest degradation (from Guyana's REDD Readiness Proposal to the Forest Carbon Partnership Facility)

Efforts[60]	Outcomes	Gaps /Challenges	Opportunities
Implementation of the Code of Practice for Harvesting Operations that allows for good practices to be implemented in Sustainable Forestry Management (SFM) and legality, including a maximum allowable cut, the harvesting of trees based on proximity limitations, and compliance with the GFC's social & environmental guidelines, annual and management plan requirements, execution of forest inventory, ESIA, national log-tracking system, legal verification system, and strengthened field monitoring	The issuance, planning and management of large concession areas are executed in keeping with GFC's guidelines which themselves lend to the implementation of SFM and legality, which allow for deforestation and degradation to be kept to a minimum. There is managed extraction, control of gaps size openings and improvements in GFC's social and environmental guidelines. Protection of buffer zones in forest areas Progress in compliance with SFM	Community groups require additional capacity to implement all aspects of the CoP In some cases, capacity of institutions needs to be strengthened (GFC, GGMC) New areas allocated would have to undergo capacity building and in some cases commitment of additional resources to enable these to be executed. Implementation of the legality assurance system needs to be advanced. Training in standards of legality needs to be extended in a larger way to forest communities.	With compliance by forest-land holders, deforestation and forest degradation at the national level will be maintained at the existing low rate, and can even be lowered in the future. Maintenance of a high level of legality will foster the maintenance of a low rate of deforestation and degradation.
The GFC community forestry development programme capacity building sessions have been and continue to be held with communities in forest law, forest inventory & management.	A stronger compliance with forest law, forest inventory and forest management allows for sustainable use of forest resources, thereby decreasing deforestation and forest degradation.	More resources needed for additional communities to be targeted	With compliance by both large and small scale operators, deforestation and forest degradation at the national level will be maintained at the existing low rate, and can even be lowered in the future.

[60] Extracted from Guyana Forestry Commission (2009). Guyana REDD Readiness Preparation Proposal. Accessed online at: http://forestcarbonpartnership.org/fcp/sites/forestcarbonpartnership.org/files/Documents/PDF/Sep2009/Readiness_Preparation_Proposal_Revised_September_7_2009.pdf on 04/05/2010.

Land titling	Ninety-six (96) village communities have titles to their lands.	Ten villages do not yet have formal legal title. Some villages currently exist without title because they do not yet fit the criteria for titling.	With the implementation of REDD and the receipt of revenues generated from REDD, the land titling process can be speeded up.
Effective implementation of the mining regulations	A stronger compliance with mining regulations allows for sustainable use of forest resources, thereby decreasing deforestation and forest degradation.	More resources needed for additional communities to be targeted	With compliance by both large and small scale operators, deforestation and forest degradation at the national level will be maintained at the existing low rate, and can even be lowered in the future.
Monitoring of infrastructural development	Conducting of Environmental Impact Assessments (EIAs) for large infrastructural projects & preparation of Environmental Management Plans for smaller scale infrastructural projects Monitoring & oversight by the Ministry of Public Works and Communications (MPW&C), EPA, and other sector agencies such as GL&SC, Ministry of Housing (MoH)	Need for more qualified personnel on staff of both EPA and MPW&C to oversee planning and implementation of projects Greater inter-agency co-ordination can allow for more effective monitoring and oversight of projects.	Capacity building and support to better understand REDD and the implications of infrastructural development on REDD will lead to better monitoring and enforcement.
Efforts have been made to limit the effects of agriculture on the forest resources.	Sustainable agriculture practices have been developed and implemented among operators.	More efficient technologies needed Need for more qualified personnel	Capacity building and support to better understand REDD and implications of agricultural development on REDD More capacity building and support in various areas

Table 3.10 shows that Guyana is already implementing a number of measures to promote conservation and sustainable use of its forest resources. These measures are an integral part of the LCDS which provides the strategic framework for the execution and monitoring of the REDD+ mechanism. Guyana is presently in the process of preparing its detailed REDD+ strategy which involves further developing proposed REDD+ activities, consulting on these, and evaluating them through a series of pilot projects.

3.5.1 Baseline Scenario(s)

As illustrated in the sector overview, Guyana is a country with historically low rates of deforestation and illegal logging activities. The forestry sector's contribution to the economic activity in Guyana has been rather modest. Forest conservation has been rapidly evolving in Guyana, and the implementation of the upcoming REDD+ activities is expected to play a fundamental role in the monitoring and enforcement of sustainable forest management practices and forest conservation.

In view of the above, the most probable baseline scenario is that deforestation would continue with the same low rate in the future. However, Guyana is a developing country with unexploited potential for economic development, including agriculture and valuable natural resources (e.g. mineral deposits). Considerable economic change might occur over the next several decades. The growing national and regional demand for agricultural products, tropical timber, and other forest products, and unexploited mineral deposits increase the pressures on Guyana's forestry resources. Given these uncertainties, it is difficult to predict a single trajectory for changes in forest cover into the future. This is true for any developing country, where considerable economic and social change can be expected, such that the baseline scenario might be quite different from historical trends.[61] Consequently, two baseline scenarios were formulated for the MAA.

Baseline Scenario 1

The major assumption underlying this baseline scenario is that although forest cover is likely to keep decreasing in the future, the rate of forest loss/conversion is expected to remain at its very low current levels, i.e. ranging between 0.1% and 0.3%. Future demand for forest products is expected to be met from existing plantations and managed forests. The implementation of REDD activities is however expected to moderate deforestation and degradation. Thus, under this scenario, it has been assumed that forest cover will be reduced by 0.3% annually until the full implementation of the REDD+ mechanism, which is assumed to be around 2015. Following the implementation of the REDD+ mechanism, it is expected that the rate of deforestation will decrease to 0.1% annually.

Baseline Scenario 2

The major assumption underlying this baseline scenario is that the anticipated economic change and the associated pressure within the designated areas from mining activities and the expectations for growing national and regional demand for agricultural products, tropical timber and other forest products, will put additional pressure on forest lands. Thus under this scenario it has been assumed that there will be no change of the rate of deforestation, and despite the implementation of the REDD mechanism, deforestation would continue at 0.3% annually.

[61] Greenhouse Gas Mitigation Assessment Guidebook (US Country Studies); Chapter 2: Basic Methods and Concepts for Mitigation Assessment. [Online.] Available at: http://unfccc.int/resource/cd_roms/na1/mitigation/Resource_materials/Greenhouse_Gas_Mitigation_Assessment_Guidebook_1995/chap02.pdf (accessed 06 January 2010).

Mitigation Options

Mitigation options for the forestry sector are classified into two broad categories: those that aim at maintaining the existing forest stocks, such as controlled deforestation and more efficient conservation and use of forest products, and those that aim at expanding the pool of carbon in soils, vegetation, and wood products, such as reforestation and afforestation.[62]

With 85 % of its land under forest cover, Guyana is a net sink country, where removals exceed emissions by a factor of 35.[63] As there has not been much deforestation to date in Guyana, mitigation in the forestry sector will focus predominantly on maintaining existing carbon stocks rather than increasing them. The following mitigation options were therefore considered to be the most promising for the forestry sector in Guyana.

3.5.2 Mitigation Scenarios: Abatement Analysis

Approach

The development of the baseline scenario(s) and the evaluation of the GHG mitigation options in the forestry sector were performed using COMAP. This model was used to develop the baseline scenario(s), identify the mitigation options appropriate for carbon sequestration in Guyana, determine the carbon pool and sequestration, and estimate the unit costs and benefits of the suggested mitigation activities.

Under Baseline Scenario 1, forest cover is likely to keep decreasing as a result of land conversion (primarily agriculture and mining). However, as a result of the implementation of REDD and other conservation activities in the country, it is projected there will be an increase in protected land; consequently the rate of deforestation is expected to eventually decrease. Under Baseline Scenario 1, the forest reserve has been assumed to be reduced annually by 0.3 % up to 2015 (at which point it is assumed that REDD+ measures will take effect), and then continue reducing at a lower rate by 0.1 % annually.

Under Baseline Scenario 2, forest cover is also likely to keep decreasing as a result of land conversion to other land-use activities, primarily agriculture and mining. However, under this scenario it is assumed that despite the implementation of REDD activities and other forest protection programmes, forest protection would remain weak. Thus, it has been assumed that the annual rate of loss in the forest reserve will continue at 0.3 %.

Carbon pool and sequestration

In order to determine the carbon pool and sequestration, it is necessary to know the biomass density, the carbon content of biomass and the soil carbon density.

The figures for biomass density, soil carbon density, and carbon density for Guyana were obtained from the Global Forest Resources Assessment Report for Guyana.[64] The report estimates above-ground biomass of between 121 and 230 t/ha for forests in Guyana. A value of 146 t/ha was used which corresponds to the weighted average of 187 tons/ha for above-ground biomass minus the 41 t/ha stored in roots.[65] For below-ground biomass, the total of root biomass production of 41 t/ha was used.[66] In the absence of specific data for Guyana for the carbon density of the wood, a default value of 0.5 tC/ha was used as recommended in the COMAP Description and Instruction Manual.[67]

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[62] Greenhouse Gas Mitigation Assessment Guidebook (US Country Studies). Chapter 11: Forestry Sector. [Online.] Available at: http://unfccc.int/resource/cd_roms/na1/mitigation/Resource_materials/Greenhouse_Gas_Mitigation_Assessment_Guidebook_1995/chap11.pdf (accessed 18 November 2009).

[63] Government of Guyana (2010). Greenhouse Gas Inventory. Final Report. December 2010.

[64] Forestry Department (FAO) (2005). Global Forest Resources Assessment Country Reports, Guyana. [Online.] Available at: ftp://ftp.fao.org/docrep/fao/010/ai858E/ai858E00.pdf (accessed 13/10/2009).

[65] Ibid.

[66] Ibid.

[67] Makundi, W. and Sathaye, J. (1999). Comprehensive Mitigation Assessment Process (COMAP) – Description and Instruction Manual. Lawrence Berkeley National Laboratory. [Online.] Available at: http://ies.lbl.gov/drupal.files/ies.lbl.gov.sandbox/3163.pdf (accessed 2 January 2011).

Economic assessment

The costs of forest protection ($/ha) include the costs of establishment of the forest conservation and forest protection plans, the operating and maintenance costs of the plan such as field patrols, boundary maintenance, administration etc., and the monitoring costs which involve the monitoring of protection arrangements, biomass growth rates and carbon accumulation, remote sensing and satellite photography. Since in the case of Guyana some forest protection has been already in place in the baseline, the cost of these conservation activities should also be considered in the analysis.

The benefits from land conversion ($/ha/yr) under the baseline scenario(s) are estimated as the value of goods and services which are directly obtained from harvesting the forest and converting the cleared area to other land uses. As already illustrated in the forestry sector overview, the most likely estimate of Guyana's State Forest value, if harvested and the land is put to the highest value subsequent use, is US$5.8 billion.[68] This forest value, known as Economic Value to the Nation (EVN), divided by the total hectares of State Forest in the base year (i.e. 13,340,014 ha), gives the economic value per hectare from land conversion as US$435 ha/yr (the value is the same under both baseline scenarios).

Following the implementation of the mitigation plan, some of the goods and services which were obtained from the area prior to the scheme will have to be sourced from other regions; for example timber might need to be imported. Usually this comes with an additional cost unless these products can be imported at a lower price from other markets. The costs or benefits of providing these products ($/ha/yr) from alternative markets/sources should therefore also be included in the assessment. In the case of Guyana, domestic consumption of wood products with population growing at 0.24% per annum is negligible (~270,000 m^3) compared to exports,[69] so for simplicity it has been assumed that the cost of providing alternative products is equal to 0 under the mitigation scenario.

Standing forests generate significant local ecosystem services such as non-timber forest products, biodiversity, flooding control and eco-tourism. These services whose economic benefits accrue primarily to forest users will be lost once forests are cleared. Under the baseline scenario the benefits from forest protection and conservation ($/ha/yr) should include the value of these ecosystem services. The value of the ecosystem services from State Forest Land for Guyana has been estimated at US$0.6 billion.[70] This figure also refers to State Forest. US$0.6 billion divided by 13,340,014 hectares of State Forest Land equals to US$45 ha/yr benefit from ecosystem services under the baseline scenario.

Intact ecosystems generate economic benefits for Guyana. Visitors being shown the Upper Essequibo River.

[68] Government of Guyana (2010). Transforming Guyana's Economy While Combating Climate Change: A Low Carbon Development Strategy. Office of the President. May 2010. [Online.] Available at: http://www.lcds.gov.gy/images/stories/Documents/Low%20Carbon%20Development%20Strategy%20-%20May%202010.pdf (accessed 11 August 2010).

[69] Ibid.

[70] Ibid.

Under the mitigation scenario it has been assumed that there will be additional benefits from more ecosystem services. Thus, a value of US$50 ha/yr benefit from ecosystem services has been applied.

To estimate the net present value of these benefits, discounted over the 20 years that the mitigation activity would last, a 10% discount rate has been used, as in the LCDS for Guyana, based on a review of the existing forest valuation literature.

The analysis yields the results shown in the tables below (3.12 and 3.13).

Table 3. 12. Results of the mitigation analysis for the forestry sector

	Unit	Outcome under Baseline 1	Outcome under Baseline 2
Carbon stock in 2030 (no mitigation)	Tonnes	582,397,210	565,150,787
Total carbon saved (with mitigation) between 2010 and 2030	Tonnes	150,351,918	167,598,340
Total costs of mitigation	US$ (present value)	96,745,077	96,745,077
Total benefits of mitigation	US$ (present value)	2,386,769,075	2,386,769,075
Total marginal net benefits of mitigation[71]	US$ (present value)	261,345,376	252,354,160
Marginal abatement cost	US$/tC	2	2
Marginal abatement cost	US$/ha	47	45

Table 3. 13. Priority mitigation measures for the forestry sector

Short-term (2010 – 2015)	Medium-term (2015-2025)	Longer term (2026 and beyond)
▪ **Build capacity** in sustainable forest management and forest monitoring. This will require investment in staff within GFC, but also improving reporting procedures within the GGMC and accountability amongst mine operators. ▪ Provide **training in reduced impact logging.**	▪ Improve enforcement of the Code for Sustainable Harvesting. ▪ Acquire **more advanced forest mapping and monitoring technologies** such as remote sensing, accompanied by training in their operation and maintenance and interpretation of their outputs. ▪ Implement **fire and pest management** measures to reduce forest degradation.	▪ Continued revision of practices and incentives for sustainable forest management

[71] These represent the additional net benefits from mitigation (i.e. benefits over and above what would have otherwise been achieved in the baseline scenario).

As expected, the modelled outcomes suggest that the benefits of taking action to protect Guyana's forests are high in relation to the costs. Mitigation activities, which are additional to those already planned under the LCDS and REDD+, result in carbon savings of 1.5 million tonnes under a baseline scenario in which incentives from REDD+ outweigh the incentives to log, and savings of 1.67 million tonnes under a baseline scenario where the rate of deforestation continues at existing levels. The cost of saving each additional unit of carbon is estimated to be around US$2, which is consistent with estimates provided in the LCDS. The marginal abatement cost per unit land area is slightly higher under the baseline 1 scenario, as the opportunity costs (or benefits forgone) of forest protection are significantly higher, as a smaller area of forested land is converted to its next best alternative use (likely to be agriculture or mining).

Prioritization Matrix for Land Use and Forestry

The Government of Guyana is already taking significant steps to protect its forest resource to enable it to benefit from REDD+ payments in future. However, funding from REDD+ is not guaranteed, and therefore there are other measures that could be considered that would both complement REDD+ activities as well as provide additional support to safeguard Guyana's forest resource. A list of additional measures, prioritized on the basis of the findings of the mitigation and abatement analysis, are shown in the table above.

3.6 Solid Waste and Wastewater

Considering that the majority of the emissions arise from solid waste disposal, the mitigation analysis was focused on options to reduce GHG emissions from landfill sites.

Sector overview

Despite the relatively small scale of emissions from the waste sector, there are certain mitigation options which can control GHG emissions from waste, while at the same time contributing to wider national objectives, including the protection of the public health and the natural environment.[72]

Based on information contained in the National Inventory of Greenhouse Gases, it is estimated that the waste sector accounts for around 2% of total GHG emissions. GHG emissions are limited to methane, CH_4, (2.78 Gg and expressed as CO_2e 69.5 Gg in 2004) from Solid Waste Disposal Sites (SWDS), due to waste decomposition in anaerobic conditions, and also to indirect nitrous oxide emissions, N_2O, (0.05 Gg and expressed as CO_2e 14.19 Gg, 2004) from human sewage.[73]

The waste sector includes the following three sub-sectors:

- Municipal Solid Waste (MSW)
- Domestic wastewater
- Industrial wastewater

[72] Guyana Initial National Communication in response to its commitment to the UNFCCC. April 2002. [Online.] Available at: http://unfccc.int/resource/docs/natc/guync1.pdf (accessed 27 January 2010). Note: CH_4 emissions from solid waste disposal sites are estimated based on population statistics for urban areas. This figure is uncertain as it is not based on actual waste deposited. N_2O emissions from human sewage were based on IPCC default values.
[73] Government of Guyana (2010). Greenhouse Gas Inventory. Final Report. December 2010.

Municipal solid waste

Georgetown has a solid waste collection system serving approximately 92% of the city's residential population. The collection system is divided into ten zones which are contracted to the private sector. In three of the ten zones collections are made twice a week, and for the remaining seven zones collections are made once a week. It is estimated that approximately 10% of household waste is disposed of informally around Georgetown at around 250 sites.[74] This waste is also periodically collected. In Georgetown, approximately 265 tonnes of waste is deposited daily at Le Repentir landfill on Mandela Avenue. Known waste management sites outside Georgetown include two temporary dump areas at Lusignan and Grove in Region 4.

The Le Repentir landfill site covers approximately 20 acres and began accepting waste in 1993. While the Le Repentir landfill has reached its engineered capacity, it is still being used until a new landfill at Haags Bosch is completed. The Haags Bosch landfill is expected to begin operating in mid 2010.[75] In June 2009, the Government awarded a contract to a company to cap the Le Repentir landfill and install gas vents in preparation for closure. These works are currently ongoing.

The Haags Bosch landfill will be an international standard sanitary landfill covering 100 acres and with a design life of around 20 years. It is being constructed with a loan of $18 million from the Inter-American Development Bank, which was approved in 2006.

[74] Personal communication, Hubert Urlin, Georgetown Solid Waste Management Unit. (28 January 2010.)
[75] Personal communication, Hubert Urlin, Georgetown Solid Waste Management Unit. (28 January 2010.)

Domestic wastewater

Guyana Water Incorporated (GWI) manages two sewerage systems, both located in central Georgetown. The first system, the Central Georgetown and Tucville Sewage system serves approximately 12,000 households, equivalent to around 31% of the city's population. It is a gravity fed system incorporating 24 interlinked sewerage basins draining into a single pumping station. The second, Tucville sewerage system located at Turning Point, serves about 4,000 residents of the Tucville community. It also receives sludge from septic tanks in the Greater Georgetown area and from private waste disposal tankers as part of the public/private partnership with GWI.[76]

Waste from all sewage stations is pumped via the Kingston foreshore where it is then disposed of by dilution approximately 150 metres into the sea at the mouth of the Demerara River. There is no wastewater treatment in Guyana and no plans at present to introduce N_2O reduction activities in current operations. At the time of writing, GWI was, however, in the advanced stages of tendering for a feasibility study for a new wastewater treatment plant.[77]

Industrial wastewater

The Guyana Sugar Corporation, privately owned drinks and processing factories, and the Omai Gold Mines Ltd generate most of the country's wastewater.[78] All wastewater from these industries is discharged into the ocean or flowing rivers, except in the case of Omai Gold Mines Ltd where it undergoes a treatment process – both chemical and natural – before being discharged into the Essequibo River. The treatment process is not anaerobic and hence no methane is emitted.[79]

[76] Personal communication, Rensford Joseph, Guyana Water Incorporated. (29 January 2010.)
[77] Personal communication, Rensford Joseph, Guyana Water Incorporated. (29 January 2010.)
[78] Government of Guyana (2010). Greenhouse Gas Inventory. Final Report. December 2010.
[79] This was also confirmed during interview with an officer from Guyana Water Incorporated in January 2010.

Existing policies, programmes and practices

In 2008, the Ministry of Local Government and Regional Development launched the Georgetown Solid Waste Management Programme, which seeks to improve the life of the residents of Georgetown and the rest of Region Four, through the provision of sustainable solutions for solid waste management. Among its many components, the programme aims to strengthen the capacity of the Municipal Solid Waste Department; raise public awareness of better household management of solid waste within Georgetown and the Neighbourhood Democratic Councils (NDCs); construct and operate the Haags Bosch Sanitary Landfill Facility (HBSLF) on the East Bank; and provide additional resources to rehabilitate and close the Mandela landfill.

Table 3.14 below outlines the range of measures that have been identified and/or implemented that will contribute towards reducing the level of emissions from the waste sector.

Table 3. 14. Existing policies, programmes and practices in the waste sector

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation in Guyana
Reduce the volume of waste produced at source (e.g. demand management techniques including regulatory and incentive measures)	Several proposals for plastics recycling have been developed and there are ongoing studies into their feasibility. However, finance has been a constraint to developing these proposals further.[80]
Improve waste management techniques (waste segregation, waste recovery, and waste recycling) to reduce the volume of waste sent to landfill	The National Development Strategy (1997) notes the following measures to be taken: ▪ Solid waste management programmes will be drawn up by the EPA, made available for comment in draft, and once approved, compliance with their regulations will be mandatory, as in the case of other classes of pollutants. These programmes will also specify measures and investments required to increase waste management capacities. ▪ Improvement in solid waste management to be combined with introduction of collection fees or privatisation of the service
Installation of transfer stations and centralized sanitary landfills in each of the major population centres (Georgetown, Linden, and New Amsterdam)	In 2006, the Inter-American Development Bank approved an $18 million loan for the construction and operation of a sanitary landfill at Haags Bosch, Georgetown, Guyana.
Landfill gas capture (and flaring)	In June 2009, the Government awarded a contract to a company to provide covers and gas vents for the closing of Le Repentir dumpsite. The project will facilitate the installation of clay cover materials to five acres of closed landfill and the installation of landfill gas vents.

[80] Personal communication, Selwin Grenion, Georgetown Solid Waste Management Unit. (November 2010.)

3.6.1 Baseline Scenario(s)

No data was identified regarding projected increases in waste, thus in the absence of data, projections were made on the basis of historical trends and in line with projected population growth. Guyana is a developing country where considerable socio-economic change might occur over the next several decades. Two baseline scenarios were defined in order to deal with uncertainties around the rate and impact of socio-economic development on waste production.

Under both baseline scenario(s):

- Le Repentir will be capped and vented; however, it is assumed this process will not mitigate emissions of methane to the atmosphere.
- The Haags Bosch landfill will be built and operated to international standards with capping and venting; however, it is assumed this process will not mitigate emissions of methane to the atmosphere.
- No other landfill sites will be brought into operation during the next twenty years.

3.6.2 Mitigation Options

There are several technologies suitable for reducing GHG emissions from solid waste disposal sites. Mitigation options for solid waste disposal sites are classified into two broad groups: (i) gas recovery and (ii) waste diversion such as recycling, composting and reducing the waste at source. The following mitigation options were considered to be the most promising for the waste sector in Guyana.

Landfill gas recovery and flaring

Landfill gas recovery and flaring involves the capture and destruction of methane emissions that would otherwise be released into the atmosphere (baseline scenario). The installation of a gas recovery and flaring system requires the piling and sealing of the amassed waste with a suitable landfill cap to facilitate optimal gas recovery and the installation of a gas capture network and flare. Flaring of landfill gas is dependent upon a number of factors such as gas quantity and quality. Engineered and sanitary landfills can achieve landfill gas recovery rates as high as 90%, while recovery rates for open and managed dump sites vary between 30 % and 60 %.[81]

The capacity and the efficiency of a flaring system can vary significantly depending on the specifications and the design. Flaring system capacity rates can vary from 10 m^3/h to 4000 m^3/h.[82] Methane destruction efficiency can also vary significantly. Enclosed flares are capable of achieving minimum destruction efficiency of 90%. Candlestick (open) flare systems might not be as efficient (as external air will be mixed with the methane), thus the achievable destruction efficiency might not be as high.[83] The selection of a flaring system would also depend on the methane content of the landfill gas which would make its operation viable.

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[81] Methane to Markets: Overestimation of Landfill Gas Recovery – Implications and Recommendation for Better Modelling Practices. [Online.] Available at: http://epa.gov/lmop/documents/pdfs/conf/11th/stege_presentation.pdf (accessed 8 September 2009).

[82] See: http://www.uniflare.co.uk/flarestacks.html (accessed 13 August 2010).

[83] See: http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf (accessed 13 August 2010).

Composting

The capital expenditure for composting facilities is significantly lower when compared to landfill gas recovery and flaring systems, as composting requires simple technology. Composting technology is not considered to be feasible in either of the two landfill sites. Capping and venting systems have already been installed in most of the Le Repentir landfill (~10 hectares), thus there is insufficient waste and space in the remaining area for composting (~5 hectares). Similarly, the Haags Bosch landfill is a sanitary landfill, which has been designed to international standards with capping and venting systems in place, thus there is no opportunity for composting. Furthermore there is no market for selling the compost. Although composting would not be viable in a commercial basis in Guyana, the potential may exist for domestic composting.

Other technologies

An alternative to landfill gas flaring is electricity generation from landfill gas. The utilization of landfill gas for electricity generation is however, constrained by a number of technological and legislative barriers, including difficulties with connecting energy supplies to the national grid.

No established and widely used technologies were identified for reducing nitrous oxide emissions from sewage.

3.6.3 Mitigation Scenario

It is proposed that the installation of landfill gas recovery and combustion systems would complement the existing venting systems in the Le Repentir and the newly commissioned Haags Bosch landfills by destroying methane emissions. The capping and venting systems that have already been installed in the two landfill sites would need to be modified and improved to allow for the destruction of the recovered landfill gas through flaring systems. The type and the destruction efficiency of the flaring systems that would be installed cannot be specified without a detailed feasibility study. However, it is envisaged that high efficiency enclosed flares would be optimal for both cases. For the analysis, a high destruction efficiency rate of >90 % has been assumed. It is further assumed that the flaring systems in the two landfills would not be operational until at least 2015, by the time they would have been designed, approved and commissioned.

Further to the emissions reductions delivered by the proposed mitigation scenario, it would also result in non-GHG related environmental benefits such as reduced explosions and air quality risks from uncontrolled landfill gases. There is potential to provide additional on-site employment opportunities, and registration of the projects under the Kyoto Protocol Clean Development Mechanism (CDM) could potentially generate carbon finance.

3.6.4 Abatement Analysis

Greenhouse Gas Abatement Potential

Waste deposition in Le Repentir landfill was expected to cease by the end of 2010. Methane production at the site is therefore expected to decline as the rate of decomposition of existing waste slows. Le Repentir has only fairly recently been rehabilitated with the installation of a capping and venting system. Landfill gas recovery rates from managed dump sites are relatively low, varying between 30 % and 60 %, and therefore the emissions reduction potential from Le Repentir Landfill is expected to be low. It has been estimated that with the installation of a high combustion efficiency system (>90%), emissions reductions could vary between approximately 4,000 and 8,000 tCO_2e per annum for a low and a high gas recovery scenario respectively.

Waste deposition in Haags Bosch is expected to begin within 2011. As Haags Bosch landfill is an engineered facility, landfill gas collection rates can be as high as 90 %. Furthermore, as this will be an operating facility, the continuous deposition of new waste will increase the methane generation potential. It has been estimated that under Baseline Scenario 1, where waste generation rate is expected to increase by 290 t/day by 2030, emissions reductions from Haags Bosch following the installation of a high efficiency destruction system (>90%) could vary between approximately 30,000 and 50,000 tCO_2e per annum for a low and a high gas recovery scenario respectively. Under Baseline Scenario 2, where waste generation rate is expected to increase by 350 t/day by 2030, emissions reductions from Haags Bosch could vary between approximately 35,000 and 55,000 tCO_2e per annum for a low and a high gas recovery scenario respectively.

Economic assessment

Detailed feasibility studies are required to understand the types of options and equipment available before a flaring system can be specified that meets the needs without unnecessary costs.[84] Capital costs for such systems may vary significantly, depending on the type, capacity and the manufacturing of the flaring system, and the nature and extent of earthworks and construction works required. Based on similar projects developed in Europe, America, and Asia, for the range of the emissions reduction potential estimated for the Le Repentir and Haags Bosch landfills, the capital costs of a new flaring system could range between US$200,000 and US$500,000. Similarly, operational costs also vary depending on the specifications of the flaring system, the energy requirements and the maintenance schedule. Based on similar projects, it is envisaged that the annualized costs for the construction and operation of the flaring systems may vary between US$2-5 per tonne of CO_2e saved.

However, there may be opportunities for Guyana to sell Certified Emissions Reductions (CERs) if the landfill gas recovery and flaring project is considered eligible as a CDM project under the Kyoto Protocol. To qualify, it would have to be demonstrated that (a) the carbon savings are additional to what may have been achieved anyway in the absence of the project, and (b) that the level of emissions reductions can be maintained over a period of time (usually 20-30 years) to justify the investment.

[84] John Zink Company LLC (2005). Specifying a cost-effective landfill flare system. [Online.] Available at: http://www.johnzink.com/products/flares/pdfs/tp_cost_effective_landfill_rev.pdf (accessed 13 August 2010).

Prioritization matrix for solid waste and wastewater

Based on the preceding analysis, there appears to be a case for investigating the technical viability and economic feasibility of introducing gas recovery and flaring systems at Le Repentir and Haags Bosch landfill sites.

In the meantime, the Solid Waste Management Programme should focus on capacity building amongst waste management authorities at both the national and local levels, and awareness-raising amongst individuals, households and commercial operations about the need to reduce waste at source, and the opportunities available for waste re-use and recycling. This in turn requires that the infrastructure to support waste recycling and recovery is in place. Markets for recycled materials are limited in Guyana and, combined with the relatively low levels of waste produced at present, the incentives for developing waste recovery and recycling facilities have been largely absent. There may, however, be scope for investigating the potential to develop markets or shared facilities elsewhere (in neighbouring countries or CARICOM states) in order to achieve economies of scale (Table 3.15).

Le Repentir landfill site

Table 3. 15. Prioritization matrix for mitigation activities in the waste sector

Short-Term Measures (2010 – 2015)	Medium-Term Measures (2015-2025)	Long-Term Measures (2026 and beyond)
▪ Develop targeted programmes to **raise awareness** about importance of, and opportunities for, reducing waste at source and recycling ▪ Promote **commercial and household waste recycling** through: ▪ Development of infrastructure (e.g. collection systems, depots, and processing plants, etc.) to support recycling activities ▪ Design of incentives to promote recycling activities ▪ Promote more widespread uptake of on-farm **composting** activities and investigate potential for developing markets for composted material (e.g. for use in combating soil erosion or as a landfill cover) ▪ **Methane recovery** from Le Repentir landfill following decommissioning in 2010	▪ Introduce **targets** for waste reduction (e.g. % of waste sent to landfill) and recycling ▪ Investigate potential for developing **markets for recycled materials** (e.g. through industrial exchange programmes, etc.)	▪ **Methane recovery** from waste biomass (e.g. at Haags Bosch landfill site)

3.7 Agriculture

Overview

Agriculture is the most important sector of the Guyanese economy, accounting for around 25% of the national GDP in 2009.[85] Agriculture in Guyana is also responsible for around 33% of total greenhouse gas emissions, and is the single largest source of methane and nitrous oxide (accounting for around 82% and 94% of total methane and nitrous oxide emissions respectively).[86]

Rice cultivation and enteric fermentation in animals are the two main sources of CH_4 emissions, although field burning of agricultural residues and prescribed burning of savannahs also contribute to this source. N_2O emissions emanate from the use of synthetic nitrogen fertilisers on agricultural soils, manure management, field burning of agricultural residues, and prescribed burning of savannahs.[87] CO_2 emissions are derived exclusively from the field burning of agricultural residues and, to a lesser extent, from prescribed burning of savannahs. Additional emissions in agriculture might occur from energy use. However, as with most developing countries, mechanization of agriculture is rather limited, and thus on-farm energy use is relatively low. Most on-farm energy use is for irrigation, water pumping and the operation of machinery (e.g. tractors) or for the processing of agricultural products (e.g. sugar production from sugar cane).

[85] Bureau of Statistics. Guyana. 2009.
[86] Government of Guyana (2010). Greenhouse Gas Inventory. Final Report. December 2010.
[87] Carbon monoxide (CO) and nitrogen oxides (NOx) emissions are derived exclusively from the field burning of agricultural residues and from prescribed burning of savannahs.

Existing policies, programmes and practices

Short-term mitigation options included direct seeding of rice-fields which minimizes soil disturbance and reduces methane emissions, shifts in cultivation techniques such as modified water regimes involving lesser water requirements and energy demand for short critical periods, and for nitrous oxide emissions mitigation, the use of mineral as opposed to organic fertilizers. For methane emission reduction from enteric fermentation in animals in the short and medium term, it was proposed that low quality forages that produce high methane emissions be upgraded. However this option was considered to be limited by higher costs, more fertilizer use, and hence soil and water pollution. For the medium and long term, methane mitigation in agriculture was proposed through the development and use of hybrids that require less water and energy, and the introduction of other economically feasible crops that emit less methane (Table 3.16).

Table 3.16. Existing policies, programmes and practices in the agriculture sector

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation
Modifications to cultivation regimes (particularly for rice)	The Guyana Rice Development Board (GRDB) has already made significant efforts to support a low carbon growth path in terms of reducing CH_4 and N_2O emissions from rice production.[88, 89] The new cultivation regimes involve water management with occasional drainage of rice-fields during the growing season, and fertiliser application in drained fields. **Water management**: The land is prepared with wet tillage and the water used for tillage is then retained to grow the rice crop. The crop is typically grown through a depth of 5-7.5 cm of water, but the water level may be reduced, or fields may be completely drained for the application of fertilizers or post-emergence herbicides during the early stages of crop development. An adequate water level (7.5 to 10 cm) is subsequently maintained until around 85 to 90 days after sowing, depending on variety. This method reduces the amount of CH_4 emitted, by eliminating the bacteria that survive under the oxygen-free environment and which are responsible for the fermentation process in decomposing organic matter. Shallow flooding provides additional benefits, including water conservation and increased yields. The combination of heavy rain and drought over the last few growing seasons has prevented the implementation of such water management practices. **Fertiliser application to drained fields**: The application of nitrous fertilisers such as urea (organic) and phosphorous (mineral) transform nitrogen into compounds like N_2O. This

[88] Personal communication, Viviane Baharally (Entomologist) Guyana Rice Development Board. (28 January 2010.)
[89] Personal communication, Dr Mahendra Persaud (Plant Breeder), Mr Kuldip Ragnauth (Extension Manager) and Ms Viviane Baharally (Entomologist). Guyana Rice Development Board. (28 January 2010.)

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation
	process is enhanced by moisture in the soil and microbial activity. The amount of N_2O produced and released is therefore more a function of the particular cultivation practices used rather than of the fertiliser itself. Allowing a sufficient drying period (2-3 weeks) after the application of nitrous fertiliser limits N_2O formation. This practice has been already adopted by farmers through the efforts of GRDB, AGRO Services of the USA, and FLAR. **Exclusion of rice straw from rice-fields**: This practice reduces methane emissions from submerged soils and is already practiced in the rice industry. **Post-harvest rice husk management practices**: Approximately 100,000 tonnes of rice husk are produced annually. Burning of rice husk has been a common practice in Guyana, contributing to CO_2 emissions. The GRDB is looking for alternatives to rice husk burning. One option which has been already practiced by one rice-miller is the use of gasification plants to convert husk into high quality combustible fuel for power generation. Furthermore, rice husk has been proven suitable for use in construction with commercial applications. A study undertaken by the Institute of Applied Science and Technology (IAST) in 2008 (funded by the EU) indicated that rice husk can be used as cement binder or in brick production.
More controlled use of fertilisers	The GRDB is exploring the possibility of applying organic fertilisers to rice production as well as the option of deep placement of nitrogen fertilisers. These practices are currently in experimental stage in fields at Burma Rice Research Station. Furthermore, the GRDB is promoting integrated crop management which involves environmentally-friendly practices, sensible use of pesticides, bio-pesticides application, and seed treatment. Such practices have been already adopted by some farmers.
Development and use of hybrid varieties	The GRDB is undertaking research to investigate the potential of developing and introducing new varieties with tolerance to delayed harvesting, saline conditions, increased flooding and pests.
Investigate feasibility of introducing new or alternative crops that emit less methane	The GRDB is working on the development of drought- tolerant strains to encourage upland rice cultivation. Upland rice cultivation significantly contributes to methane emission reduction. So far one variety has been already successfully integrated into the upland cultivation. The Hinterland Rice Project aims to lead the way forward for this strategy.

Mitigation Options	Policies, Programmes and Projects Implemented or under Implementation
Upgrade livestock fodder to reduce emissions from enteric fermentation	No such practices have been developed.[90]
Modernization of agriculture	The installation of biogas collection and combustion systems to reduce emissions from animal waste was introduced in Guyana in August 2007, with a small pilot biogas facility to generate electricity fed with cow manure.[91] Similar facilities are planned for the Canal No.1, La Grange and Kuru Kururu areas. The Skeldon Sugar Modernization Project (SSMP)[92] involves the addition of a more efficient co-generation plant consisting of a combined heat and power (CHP) cycle to allow for the simultaneous production for electrical power for on-site use in the sugar factory, and for the sale of excess power to the Berbice regional grid. The bagasse produced after the extraction of sucrose from the sugar-cane will be used as fuel in the boilers to generate superheated steam to initiate the co-generation process. The project is registered under the Clean Development Mechanism (CDM) of the UNFCCC and will generate GHG emissions reduction by displacing fuel oil used in generators.[93] As a result of the new project, the existing sugar-cane area in the Berbice County and from private holders growing sugar for GUYSUCO will be expanded. Each of the eight estates of sugar production has its own sugar factory. Currently there are plans for implementing another project similar to Skeldon.[94]

[90] Personal communication, Selina Lepps (Technical Projects Office) Ministry of Agriculture - Crops & Livestock. (02 February 2010.)
[91] Guyana Energy Agency, Kick the Habit: a presentation that covers the current energy situation and the status of the various energy developments and energy conservation measures in Guyana. [Online.] Available at: www.gea.gov.gy/downloads/Kick%20th%20Habit.pdf) (accessed 25 August 2009).
[92] See http://cdm.unfccc.int/UserManagement/FileStorage/VSSDFHR8560V4TR0RMYXNTUCO02LMO.
[93] See http://cdm.unfccc.int/UserManagement/FileStorage/VSSDFHR8560V4TR0RMYXNTUCO02LMO.
[94] Personal communication, Lisa Shivraj (Biotechnologist), Guyana Sugar Corporation. (1 February 2010.)

3.7.1 Baseline Scenario(s)

The key assumption underlying the establishment of the baseline scenario(s) for agriculture is that the sector will exhibit continued growth over the next twenty years, with more diversified agricultural products and a significant increase in agricultural trade and exports of fruits and vegetables. The baseline scenarios represent the expected emissions trajectories, taking into account existing practices or likely future developments in rice, sugar, fruit and vegetable, and livestock production.

Baseline Scenario 1 (existing strategies and policies are not implemented)

This scenario assumes that agricultural production practices will continue following historical trends and that, although there are strategies and plans in place (i.e. the LCDS and various farm-level initiatives), these are not actually implemented on the ground, possibly as a result of economic, technical and exogenous (i.e. weather-related) factors.

Baseline scenario 2 (existing strategies and policies are implemented)

This scenario assumes that at least some of the proposed measures set out in national development strategies (specifically the LCDS) and that have been piloted (e.g. improved water management in rice production) are implemented more widely.

3.7.2 Mitigation Options

The GRDB has already begun making efforts towards limiting emissions from rice production and post-harvest management practices. Similar efforts are being made to control emissions from agricultural waste through the installation of biogas collection and combustion systems in several areas. Fertiliser application and research on developing new cultivars is also taking place in Guyana. There are a limited number of additional mitigation measures suitable for Guyana; the focus should therefore be on providing the necessary support to ensure that the available options are effective, sustainable and implemented more widely amongst farmers.

Some of the additional mitigation options that may be considered for the agriculture sector in Guyana are described below.

Biogas systems

The agriculture sector produces a significant amount of waste including animal manure and crop residue. In the absence of waste management practices in agriculture, organic matter decomposes anaerobically, generating methane. This mitigation option involves the installation of biogas collection and combustion systems (with or without energy generation) to effectively manage agricultural waste from small farms and households. Waste can be transferred centrally and treated in biogas systems at the community level in order to reduce the costs of implementing such systems in household or small farm level. A small pilot biogas facility to generate electricity fed with cow manure was introduced in Guyana in August 2007,[95] with similar facilities planned for the Canal No.1, La Grange and Kuru Kururu areas. The main barriers associated with the application of biogas technology in Guyana include the lack of an institutional framework for waste management, the equipment which is not readily available in the country, and the lack of commercial opportunities for electricity generation.

[95] Guyana Energy Agency. Kick the Habit: a presentation that covers the current energy situation and the status of the various energy developments and energy conservation measures in Guyana. [Online.] Available at: www.gea.gov.gy/downloads/Kick%20th%20Habit.pdf) (accessed 25 August 2009).

Livestock nutritional management practices

Effective livestock nutritional management (e.g. processed feed) can significantly reduce both methane and nitrogen emissions from feed fermentation and animal manure. For example:

- Pomar (1998) indicated that about 50 % of the total nitrogen excreted by pigs could be reduced cost-effectively by modifying the composition of the diet without any impairment on performance, by balancing amino acids composition of diets, and phase feeding.[96]

- Other studies have shown that canola oil added to concentrate diet can reduce methane emissions by up to 33 % by reducing the amount of feed fermented,[97] and that improving the ratio of high-quality grain to forage in animal feed can reduce methane to 2-3 % of the gross energy intake. The addition of fats to grain diets is known to reduce the amount of feed fermented.

- Changing liquid or slurry handling systems in poultry barns can also significantly reduce methane emissions. It has been observed that methane emissions are greater when liquid or slurry handling systems, which support anaerobic conditions, are used. In solid manure management, such as poultry systems where broilers are kept on dry bedded manure packs (about 25 % moisture), lower CH_4 emissions have been reported.[98] Patni and Jackson[99] observed that ammonia loss in poultry manure from the high rise, deep pile system was greater (0.8-5.3 kg/h) than the shallow gutter system (0.7-2.4 kg/h).[100]

Effective management of rice paddies

The GRDB has already a mitigation strategy in place involving options such as improved water management and more effective fertiliser application, upland rice cultivation and the introduction of new varieties which can all contribute significantly to reducing CH_4 and N_2O generation. Thus there are not significant changes which can be made to these practices to further reduce the emissions from rice production. Furthermore, the implementation of some of these practices, such as improved water management, has been delayed as a result of unfavourable weather conditions.

Changes in cultivation practices (controlled fertilisers and crop rotation)

The application of nitrous fertilisers such as urea (organic) and phosphorous (mineral) is commonplace in rice production in Guyana. Nitrous fertilisers transform nitrogen into compounds like N_2O. This process is enhanced by moisture in the soil and microbial activity. The amount of N_2O produced and released is

[96] Reducing Greenhouse gas emissions from Livestock Agriculture in Manitoba, Manitoba Climate Change Task Force [online] available at: http://www.iisd.org/taskforce/pdf/dept_animal_sci.pdf (accessed 01 February 2010).
[97] Wittenberg, K. and Boadi, D. (2001) Reducing Greenhouse Gas Emissions from Livestock Agriculture in Manitoba. Report for Manitoba Climate Change Task Force Public Consultation Sessions [online] available at http://www.iisd.org/taskforce/pdf/dept_animal_sci.pdf (accessed 01 February 2010).
[98] Tessier, S.and Marquis, A. 1998. Livestock manure management systems and greenhouse gas production. Agriculture and Agric-Food Table Climate Change Workshop, Montreal. Nov 19-20 1998, cited in Wittenberg, K. and Boadi, D. (2001.) Reducing Greenhouse Gas Emissions from Livestock Agriculture in Manitoba. Report for Manitoba Climate Change Task Force Public Consultation Sessions. [Online.] Available at: http://www.iisd.org/taskforce/pdf/dept_animal_sci.pdf (accessed 01 February 2010).
[99] Patni, N.K. and Jackson, H. A. 1996. Ammonia concentration in, and emissions from commercial high-rise and shallow -gutter caged-layer barns. Paper No. 964092, An ASAE Meeting presentation; cited in Wittenberg, K. and Boadi, D. (2001.) Reducing Greenhouse Gas Emissions from Livestock Agriculture in Manitoba. Report for Manitoba Climate Change Task Force Public Consultation Sessions. [Online.] Available at: http://www.iisd.org/taskforce/pdf/dept_animal_sci.pdf (accessed 01 February 2010).
[100] Wittenberg, K. and Boadi, D. (2001.) Reducing Greenhouse Gas Emissions from Livestock Agriculture in Manitoba. Report for Manitoba Climate Change Task Force Public Consultation Sessions. [Online.] Available at: http://www.iisd.org/taskforce/pdf/dept_animal_sci.pdf (accessed 01 February 2010).

therefore more a function of the particular cultivation practices used rather than of the fertiliser itself. One way of limiting N_2O formation is therefore to apply better water management practices that allow a sufficient drying period (2-3 weeks) after the application of nitrous fertiliser.[101] That way, the loss of nitrogen through dilution and denitrification is minimized, and the release of both N_2O and CH_4 emissions is substantially reduced.

Other possible practices for reducing emissions include crop rotation, as opposed to sequenced cropping of the same species, and employing measures to minimize the disturbance to soils. Crop rotation helps avoid excessive depletion of soil nutrients and can also help improve soil structure. A traditional component of crop rotation is the replenishment of nitrogen through the use of green manure or nitrogen-fixing plants in sequence with cereals and other crops. Replenishing the minerals in the soils reduces the need for nitrous fertilisers. Crop rotation practices are not widespread in Guyana. Although they would be difficult for rice production because of the specific cultivation techniques required,[102] if fruit and vegetable production does expand (as the LCDS suggests it could), then farmers may consider crop rotation to reduce fertiliser use, minimize costs and limit GHG emissions.

3.7.3 Mitigation Scenarios

Under the mitigation scenario, it is proposed that CH_4 emissions are reduced through the introduction of nutritional management practices in cattle farms, and N_2O emissions from atmospheric deposition and leaching from soils are reduced through changes in cultivation practices (e.g. fertiliser applications and crop rotations). The introduction of a nutritional management scheme to cattle farms would involve the addition of fats to grain diets which studies have shown could achieve a reduction of up to 33 % per head in emissions from enteric fermentation. Changes in cultivation practices would be expected to achieve up to a 40% decrease per unit area in emissions from atmospheric deposition and leaching from soils. Total abatement potential therefore depends upon the number of livestock consuming improved feedstock, as well as the total cultivated area over which improved land management practices are implemented. Sufficient data on pig production was not available to allow an assessment of the potential for reducing nitrogen emissions from pigs. Furthermore, the GHG-I suggests that nitrous oxide emissions from agriculture are negligible.

[101] Farming for a better climate, optimise the application of fertilisers and manures, Scottish Agricultural College. Accessed online at: http://www.sac.ac.uk/mainrep/pdfs/pgappnutrients.pdf on28/01/2010.
[102] Personal communication, Jerald Joseph (Technical Projects Officer), Ministry of Agriculture (28 January 2010).

3.7.4 Abatement Analysis

Greenhouse gas abatement potential

Based on the outcome of the Greenhouse Gas Inventory of Guyana for the SNC, emissions from enteric fermentation were estimated at 250 Gg CO_2e for 1995 and 400 Gg CO_2e for 2004. Cattle population growth increased from 186,661 to 299,250 in 2004.[103] Following the above, it has been estimated that each head of cattle produces 1.34 tCO_2e per annum. As indicated in the baseline, cattle growth is expected to continue to increase at the current high rate up to 2012, and then it will decrease by 1-2 % to mirror the projected rate of population growth and associated demand for animal products. Based on this assumption, the total emissions associated with enteric fermentation over the period 2010 to 2030 are estimated to be approximately 17,000 Gg CO_2e. The introduction of a nutrition management plan which would involve the addition of fat to grain diets of cattle would be expected to decrease emissions from enteric fermentation by up to 33% annually. The project would be implemented from 2013, and under the best case scenario (implemented by all farmers), could achieve up to 5,060 Gg CO_2e fewer emissions over the period 2013-2030 (under baseline there would be 15,334 Gg CO_2e over the period 2013-2030). Under a more likely scenario in which improved nutrition is given to only 30 % of the cattle population, this would achieve up to 1,713 Gg CO_2e fewer emissions over the same period.

The Greenhouse Gas Inventory of Guyana shows that annual indirect N_2O emissions from atmospheric deposition and leaching have remained constant (at 110.26 Gg CO2e) over the period 1994 to 2004. In the absence of any mitigation measures it is expected that emissions levels would remain the same over the next 20 years.

Under the mitigation scenario it has been assumed that organic fertilisers would replace synthetic fertilisers over the next 20 years and crop rotation practices would be introduced as a way to increase productivity and reduce emissions. If it is assumed that only 20 % of the total cultivated area of Guyana is put under improved management practices, it is estimated that a reduction of around 22 Gg of CO_2e from 2004 levels could be achieved annually. If a higher proportion of farmers (say 40 %) switch to more environmentally-sensitive farming practices, then it is estimated that savings of around 44 Gg of CO_2e could be achieved annually.

Changes to livestock nutrition are reportedly cost-effective to implement, although a more detailed investigation is required to assess the costs of alternative feedstocks. If improved feedstocks are found to be more expensive than those currently used, then various incentive measures (e.g. subsidies) will need to be introduced to encourage their uptake amongst farmers.

Prioritization matrix for agriculture

The outcomes of the abatement analysis for agriculture suggest that mitigation options should focus around researching and developing and implementing cultivation techniques (e.g. reduced tillage, improved water management techniques) that are suited to the climatic and soil conditions of Guyana. The feasibility (in terms of sourcing supplies and costs) of introducing high quality livestock feed also needs to be investigated, as this offers significant potential for reducing methane emissions with immediate effect. (Table 3.17)

[103] Source: Crops & Livestock Department (2009) Ministry of Agriculture.

Table 3. 17. Priority mitigation measures for the agriculture sector

Short-Term Measures (2010 – 2015)	Medium-Term Measures (2015-2025)	Long-Term Measures (2026 and beyond)
▪ Continued research and establishment of demonstration projects to trial new **water management techniques,** including active irrigation and drainage of rice-fields to reduce both nitrogen dioxide and methane emissions ▪ **Continued research into and development of new cultivars and hybrids** that require less fertiliser and reduce methane emissions ▪ Promote use of **cropping techniques** that minimize soil disturbance and retain soil nutrients ▪ Improve the **quality of feedstock** for cattle and pigs ▪ Investigate potential for introducing **solid manure handling systems** for poultry barns	▪ Promotion uptake of proven water management techniques ▪ Investigation of the feasibility of **expanding commercial fruit and vegetable production** in line with the LCDS ▪ Investigation of the feasibility of crop cultivation in appropriate upland areas (i.e. taking account of soil erosion risk) ▪ **Continued research into and development of new cultivars and hybrids** that require less fertiliser and reduce methane emissions	▪ **Continued research into and development of new cultivars and hybrids** that require less fertiliser and reduce methane emissions

3.8 Mitigation Framework

The framework outlined below presents these developments as part of a broader programme of measures, which include a combination of technological options and enabling activities.

The framework takes account of:

- Guyana's Greenhouse Gas Inventory which shows the sectors and sub-sectors responsible for producing most of Guyana's GHG emissions, and hence where the most significant abatement potential is likely to lie.
- The findings of the mitigation and abatement analysis, which highlight the most cost-effective options for reducing GHG emissions.
- Guyana's national development objectives, as set out in the LCDS, National Development Strategy and National Competitiveness Strategy.

Objectives

The framework is intended to support Guyana's response to Paragraph 1 (b) (ii) of the Bali Action Plan, which calls for 'Nationally Appropriate Mitigation Actions (NAMAs) by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity building, in a measurable, reportable and verifiable manner.' It sets out the structure within which Guyana is focusing both its existing and envisaged future efforts to reduce, limit, or control GHG emissions, and maintain or enhance the country's role as a globally important carbon sink.

Mitigation Framework

The framework considers measures to mitigate climate change under two broad headings:

Technical measures for mitigation of climate change in key sectors

- Energy
- Transport
- Buildings
- Waste
- Agriculture
- Forestry and Land Use

Supporting and enabling measures

- Capacity building and institutional strengthening
- Measures to provide a more supportive policy and regulatory environment
- Education, communication, and public awareness
- Mobilization of financial resources
- Development and transfer of appropriate technology
- Fostering international connections and partnerships
- Measures for participation in global carbon markets

The framework headings and sub-headings are discussed below.

Technical measures for mitigation of climate change

Both the GHG-I and the MAA suggest that the major focus for Guyana's mitigation efforts should be directed at the energy (and particularly energy industries), agriculture, and forestry sectors. Emissions from industry and waste are relatively low at present and are not expected to grow significantly in the future, as a result of both the low rate of population growth (which inhibits demand for industrial outputs and the generation of waste), and the low levels of industrialization.

A prioritized listing of the range of technical mitigation measures that have been considered, or are recommended, is shown in Table 3.18.

Supporting and enabling measures

Guyana recognizes the need to introduce new measures, or enhance existing ones, to enable the successful implementation of mitigation options. These are described in more detail below:

Capacity building and institutional strengthening

Guyana is already taking steps to create and consolidate the necessary capacities for policy development and implementation. To support the implementation of the LCDS, it has developed five new or enhanced institutional capabilities:

- An Office of Climate Change (OCC) which consolidates and streamlines Government efforts on climate change, including the co-ordination of engagement with multilateral processes and UNFCCC negotiations.
- *A Low Carbon Strategy Project Management Office (PMO)* which has been established to drive key projects as part of the Low-Carbon Development Strategy.
- *A Guyana REDD Investment Fund (GRIF)* which is being established to manage forest payments, to reduce the cost of capital on other essential investments, and, over the long term, to act as a permanent investment fund for low carbon investments.
- A strengthened *Environmental Protection Agency* which will ensure that social and environmental safeguards are applied to the appropriate internationally recognized standards for all GRIF investments.
- *The REDD Secretariat at the Guyana Forestry Commission* which will be the implementing agency for implementing REDD readiness' activities, including the development and implementation of a monitoring, reporting, and verification system.

However, it needs to further develop capacity that will allow for the design and implementation of effective policy frameworks across sectors that will support efforts to exploit the country's mitigation potential through both public and private sector projects. This includes development and capacity building for institutions, and fostering the capacity and knowledge of private sector actors, including financial intermediaries.

It may be necessary to formulate a bespoke climate change mitigation capacity-building action plan, in which the specific needs and proposed activities (including supporting activities such as awareness-raising, data collection and management, dissemination of information, and investment in research and development) are identified, together with any barriers, and steps that may be taken to overcome these.

Measures to encourage inter-departmental working and knowledge/data sharing should also be considered. These could include, for example:

- Regular update meetings with stakeholders from relevant departments and ministries, or establishment of a climate change portal with links to relevant activities/services being undertaken by different departments.
- Setting up mechanisms to enable indigenous capacity building in identifying and sourcing climate change technologies, and to provide adequate training for those organizations that will manage and operate the technologies.

Measures to provide a more supportive policy and regulatory environment

An effective policy and regulatory framework is essential to support mitigation activities. It creates an environment conducive to investment and should also provide the options and incentives for taking action to reduce greenhouse gas emissions. Ideally, the policy framework should be:

- Effective – it should result in a reduction in, or at least stabilization of, emissions of GHGs
- Efficient – the benefits of the policy outcomes should outweigh the costs
- Equitable – distributional consequences should be taken into account
- Flexible – to respond to changes in circumstances and to better information

Key areas of focus for strengthening the policy and regulatory framework include:

- Designing and introducing incentive measures (e.g. taxes, subsidies and pricing strategies) that discourage carbon-intensive activities, encourage investment in more energy-efficient or low carbon technologies, and manage the demand for energy.
- Developing, implementing and enforcing standards and codes (e.g. building codes and energy efficiency standards)
- Introducing sustainable procurement guidelines and policies, particularly for the public sector which – as in most countries - is responsible for a significant proportion of GHG emissions through its estate, operational assets, and transport fleet.

Education, communication, and public awareness

Education, training, and public awareness are also critical to the success of any mitigation strategy. Guyana would benefit from the development of a comprehensive public communication strategy to:

- Raise awareness of the actions that can be taken (by individuals, households, businesses, institutions) to reduce greenhouse gas emissions. Initiatives may include raising awareness of measures that may be taken to reduce energy use, or to reduce, re-use and recycle waste. Many such initiatives are already underway in Guyana, but the effectiveness of such campaigns needs to be monitored and, where necessary, improved, using various media and possibly incentives.
- Highlight the benefits (e.g. cost savings) from introducing such measures
- Outline what further information and advice on energy-saving technologies and measures may be available
- There is also a need to better communicate research findings, especially where these may have relevance across sectors or could inform the development of policy. In particular, efforts are needed to:
- Co-ordinate Guyana's mitigation research resources to more effectively support climate change decision-making, including through brokering research partnerships, and providing a vehicle to commission new research.
- Build the capacity of the Guyanese research community to generate information relevant to decision-makers.
- Establish an interface between researchers and decision-makers.
- Promote co-ordinated programmes of work on mitigation across Guyana, working in collaboration with stakeholders and other researchers in national, regional and sectoral contexts.

Mobilization of financial resources

Until recently, one of the most persistent barriers to the implementation of activities to assist Guyana in its efforts to mitigate climate change has been a lack of funding. However, there are now several potential sources of funding for which Guyana is eligible and which could assist in leveraging funds for investment in, and deployment of, low carbon technologies. These include:

- Financial support pledged by the *Government of Norway*, as well other potential interim REDD+ agreements such as the 'Interim REDD+ Partnership' emerging under the Paris-Oslo process (in which Guyana is actively involved). There is also the possibility of further funding in the future should a REDD+ mechanism become operational at the international level.
- *The GEF Trust Fund* – which supports projects and programmes that increase resilience to the adverse impacts of climate change, or that reduce greenhouse gas emissions in the areas of renewable energy, energy efficiency, and sustainable transport.
- *The Clean Technology Fund (CTF)* - a multi-donor Trust Fund within the World Bank's Climate Investment Fund (CIF) which supports the rapid deployment of low-carbon technologies which achieve long-term savings in GHG emissions in a cost-effective way.
- The *Global Energy Efficiency and Renewable Energy Fund (GEEREF)* – a Public-Private Partnership (PPP) under the European Commission, which aims to increase the leverage of public funds for investments in energy efficiency and renewable energy projects in developing countries and economies in transition. Investments eligible for the fund include projects that promote energy efficiency and renewable energy technologies such as small hydro and biomass, manufacturing and energy services, depending on the country context.
- Initiatives arising from the Copenhagen Accord including the *Copenhagen Green Fund* which channels funding from the Fast Start Fund, (a US$10 billion per year fund for the period 2010-2012, which will be made available to developing countries for capacity building, planning, early mitigation actions (including forestry), and adaptation); and a commitment from developed countries to jointly mobilize US$100 billion dollars a year by 2020 to address the needs of developing countries. This funding will come from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources of finance.

Guyana would also benefit from more effective systems to ensure transparency and accountability in the use of funds mobilized for climate change.

Development and transfer of appropriate technology

The development and transfer of technology are critical to the achievement of mitigation programmes in Guyana. Key areas of work in the field of technology include:

- Enhancing technology development and transfer, including hard technologies (e.g. renewable energy technologies, building technologies, etc.) and soft technologies (e.g. knowledge, systems, procedures, best practices)
- Addressing technology transfer barriers, including rules of trade tariffs, intellectual property right-barriers and technical trade barriers (standards, eco-labelling)
- Enhancing and supporting the research and development capacity in Guyana to foster the development and local manufacture of cleaner mitigation technologies
- Enhancing technology co-operation between Guyana and other CARICOM countries and SIDS
- Research and Development Programmes.

A Technology Needs Assessment (TNA) has been completed to identify Guyana's specific technology needs and priorities. The TNA forms the basis for a portfolio of energy-saving technologies (ESTs), projects and programmes, which have the potential to reduce GHG emissions, protect the climate system and contribute to Guyana's sustainable development. TNA is one of five key elements of an overall integrated framework to enhance technology transfer. Other elements include improving access to technology information, creating enabling environments, strengthening local capacity, and instituting technology transfer mechanisms.

A key priority is the creation of an enabling environment for the transfer of new technologies and practices. This requires strengthening environmental policy and regulatory frameworks, enhancing the legal system, designating clear roles and responsibilities for all institutions/organizations concerned, and appointing a single authority with responsibility for co-ordinating activities within each sector, facilitating the development of markets, and providing the necessary funding and technical support for research and technology development. While it is recognized that this is a long-term, ongoing process, it should be possible in the interim to start introducing various 'no regrets' measures[104] that will yield immediate and tangible benefits.

To enable technology transfer, adequate financing must be available. It has been recommended that an indicative financing plan that signposts the financing and funding opportunities for the concerned technologies is formulated. This should cover all available financing and funding opportunities, including commercial bank loans, multilateral co-operation, financing by international organizations like IFC, GEF and DFID, and other climate-change related financing schemes such as CDM.

Fostering international connections and partnerships

Partnerships can provide a valuable channel for sharing information, exploring mutually beneficial mitigation opportunities and leveraging funding for research and development.

Guyana already participates in the Forest Carbon Partnership Facility, which is helping the country to develop its technical and institutional capacity to take advantage of any future system of positive incentives for REDD+. It has also recently signed a Memorandum of Understanding with the Government of Norway through which the two countries have agreed to share knowledge, information, and best practice relating to emissions reductions, biodiversity and climate change.

Further action could be taken to develop relationships with other forest-rich countries – particularly neighbouring countries such as Brazil – to share experiences in REDD preparation and development, as well as with other CARICOM states that may be able to provide data and expertise, but also and perhaps more importantly, markets for low carbon products produced under the LCDS.

Measures for participation in global carbon markets

Guyana is well-positioned to take advantage of developments in global carbon markets, particularly through the emerging REDD+ mechanism, but potentially also through the Clean Development Mechanism. Guyana has already submitted a REDD-Readiness Preparation Proposal to the Forest Carbon Partnership Facility detailing the measures to be taken to manage forest carbon stocks, and efforts are ongoing in the development of a Monitoring, Reporting and Verification (MRV) system and REDD Governance Plan.

Guyana could also investigate the potential for benefiting from CDM projects, particularly waste management using composting or landfill gas capture, hydropower and energy-efficiency projects, and the development of biofuels.

[104] These are measures that contribute to the achievement of the country's socio-economic development objectives regardless of their contribution to climate change mitigation.

Table 3. 18 Overall summary priority measures for mitigation

Sector	Short-Term Measures (2010 – 2015)	Medium-Term Measures (2016-2025)	Long-Term Measures (2026 and beyond)	Potential Funding Sources
Energy	▪ Design and implementation of **demand-side management** techniques to encourage better use of existing distribution infrastructure, and reduce peak demand. This will require a combination of raised public awareness (i.e. what individuals/households/businesses can do to reduce energy demands) as well as (in the longer term) implementation and enforcement of appropriate regulatory and financial incentive mechanisms. ▪ Continued **development of hydropower** resources such as Amaila, particularly in terms of advancing technical design and sourcing funding for development of identified sites ▪ **Modernizing existing power plants** that will remain in operation even once hydropower becomes the main source of energy. Modernization measures include: ▪ Retro-fitting with more energy-efficient machinery and equipment ▪ Introduction of thermal power and heat co-generation techniques ▪ Improving distribution efficiency ▪ Promoting **investment in the development of bio-ethanol production** (particularly in the Canje Basin).	▪ Mandatory **labelling** of all electrical compliances by suppliers to show energy rating ▪ Design and implementation of **regulatory and financial incentive mechanisms** to reduce energy demand. This may include reform of existing tariff structures. ▪ Improving **distribution efficiency** of the power system through measures to reduce transmission and distribution losses ▪ Investigating the feasibility of implementing further **co-generation** activities ▪ Exploring opportunities for generating **energy from waste**, particularly through methane capture from Le Repentir landfill and potentially also from the new Haags Bosch landfill site ▪ Investigating the feasibility of developing **wind and solar power** ▪ Promoting more widespread use of **alternative fuels**	▪ Continuing to develop and promote uptake of **renewable sources** of energy, particularly wind and solar (where feasible)	▪ The Global Energy Efficiency and Renewable Energy Fund (GEEREF) ▪ The Clean Technology Fund (CTF) ▪ The GEF Trust Fund ▪ Multilateral lending agencies (e.g. the World Bank, Inter-American Development Bank) ▪ Private investors ▪ Carbon markets (e.g. the CDM)
Transport	▪ Developing and implementing a **Clean Transportation Programme** ▪ Measures to **reform import controls** in favour of low-emission vehicles	▪ Establishing mandatory **fuel efficiency or emissions standards** for all vehicle imports ▪ Implementing policies to gradually **replace the**	▪ Promote more widespread uptake of **hybrid vehicles** ▪ Improving/introducing **mass transport systems**	▪ The GEF Trust Fund ▪ Multilateral lending agencies (e.g. the World Bank, Inter-American

Sector	Short-Term Measures (2010 – 2015)	Medium-Term Measures (2016-2025)	Long-Term Measures (2026 and beyond)	Potential Funding Sources
	▪ Developing a **'green guide'** to assist consumers in comparing the fuel efficiency of different vehicles	**government fleet** with more fuel-efficient vehicles ▪ Investing in **public transport infrastructure** and awareness (particularly in Georgetown) to support a modal shift ▪ Introduction of **traffic management systems** (e.g. signalling) to reduce congestion during peak hours	(including light rail in urban centres such as Georgetown and rail into the interior) ▪ **Urban planning** to improve accessibility of key services and reduce trip lengths	Development Bank) ▪ Private investors
Buildings	▪ Promoting energy efficiency in buildings through **targeted awareness-raising** programmes that seek to reduce demand in industrial, business, government and residential buildings ▪ Phasing out of incandescent light bulbs ▪ Installation of motion-sensor lights ▪ Installation of variable frequency drives on chillers, pumps and cooling towers ▪ Introduction of more energy-efficient stoves within households	▪ Implementing incentives for **retro-fitting** of existing buildings with more energy-efficient appliances ▪ Designing and implementing **guidelines and/or standards and regulations** for design of new buildings	▪ Use of **passive design and low carbon materials** in building construction	▪ Multilateral lending agencies (e.g. the World Bank, Inter-American Development Bank)
Waste	▪ Developing targeted programmes to **raise awareness** of importance of, and opportunities for, reducing waste at source and recycling ▪ Promoting **commercial and household waste recycling** through: ▪ Development of infrastructure (e.g. collection systems, depots, and processing plants, etc.) to support recycling activities ▪ Design of incentives to promote recycling activities ▪ Promoting more widespread uptake of on-farm **composting** activities and investigating	▪ Introducing **targets** for waste reduction (e.g. % of waste sent to landfill) and recycling ▪ Investigating potential for developing **markets for recycled materials** (e.g. through industrial exchange programmes, etc.)	▪ **Methane recovery** from waste biomass (e.g. at Haags Bosch landfill site)	▪ Multilateral lending agencies ▪ Carbon markets (i.e. through the Clean Development Mechanism)

Sector	Short-Term Measures (2010 – 2015)	Medium-Term Measures (2016-2025)	Long-Term Measures (2026 and beyond)	Potential Funding Sources
	potential for developing markets for composted material (e.g. for use in combating soil erosion or as a landfill cover) ▪ **Methane recovery** from Le Repentir landfill following decommissioning in 2010			
Agriculture	▪ Continued research and establishment of demonstration projects to trial new **water management techniques,** including active irrigation and drainage of rice-fields to reduce both nitrogen dioxide and methane emissions ▪ **Continued research and development into new cultivars and hybrids** that require less fertiliser and reduce methane emissions ▪ Promoting the use of **cropping techniques** that minimize soil disturbance and retain soil nutrients ▪ Improving the **quality of feedstock** for cattle ▪ Investigating the potential for introducing **solid manure handling systems** for poultry barns	▪ Promoting uptake of proven water management techniques ▪ Investigating the feasibility of **expanding commercial fruit and vegetable production** in line with the LCDS ▪ Investigating the feasibility of crop cultivation in upland areas ▪ **Continued research and development into new cultivars and hybrids** that require less fertiliser and reduce methane emissions	▪ **Continued research and development into new cultivars and hybrids** that require less fertiliser and reduce methane emissions	▪ Bilateral development agencies ▪ Multilateral lending agencies (e.g. the World Bank, Inter-American Development Bank) ▪ Specialized agencies such as the Food and Agriculture Organization (FAO)
Forestry and Land Use	▪ Continued efforts to support the **implementation of the REDD+ mechanism** ▪ **Building capacity** in sustainable forest management and forest monitoring. This will require investment in staff within GFC, but also improving reporting procedures within the GGMC, and accountability amongst mine operators. ▪ Providing **training in reduced impact logging**	▪ Improving enforcement of the Code for Sustainable Harvesting ▪ Acquiring **more advanced forest mapping and monitoring technologies** such as remote sensing, accompanied by training in their operation and maintenance and interpretation of their outputs ▪ Implementing **fire and pest management** measures to reduce forest degradation	▪ Continued revision of practices and incentives for sustainable forest management	▪ Bilateral development agencies ▪ Carbon markets (e.g. through the REDD+ mechanism) ▪ NGOs (e.g. Conservation International, WWF)

3.8.1 Project Concepts

Guyana has already set out a proposed programme of measures under its LCDS, and therefore priority is likely to be given to these in the period to 2015. Financing for these measures is expected to come from payments under the REDD+ mechanism. Additional projects may be considered, particularly in the energy sector (and associated sub-sectors), which is the most significant source of GHG emissions.

The mitigation framework and prioritization matrix (see Table 3.18) provide an indication of the types of technological options that Guyana has considered, and the supporting measures it has identified as crucial to the successful transition to a low carbon economy.

Energy Sector

As noted earlier, Guyana has already conducted extensive investigation into its hydropower potential, and with the Amaila Falls hydro-electric project expected to come online in 2014, its dependence on fossil fuels for energy generation should decline significantly. This suggests that any additional projects in the energy sector should focus on improving the energy efficiency of transport and buildings, managing demand, and identifying and beginning to commission other hydropower schemes or other sources of renewable energy (solar and wind), to ensure a reliable and continued supply of renewable energy into the future, beyond the expected lifetime of the Amaila project.

Some of the specific renewable energy projects which Guyana wishes to take forward – and their associated investment costs – are listed in the table below (Table 3.19).

Table 3. 19. Renewable energy sector projects

Project	Abatement Potential	Cost	Funding Source
Turtruba Hydro-electric Project (HEP)	High	Unknown	Multilateral funding agencies (e.g. World Bank, IADB) Private lenders Carbon markets (CDM)
Moco Moco HEP Rehabilitation	High	US$430,000	Multilateral funding agencies (e.g. World Bank, IADB) Private lenders Carbon markets (CDM)
Wamukaru HEP	High	US$12.5-14.6 million	Multilateral funding agencies (e.g. World Bank, IADB) Private lenders Carbon markets (CDM)
Kato Hydroelectric Project (Chiung River)	High	Unknown	Multilateral funding agencies (e.g. World Bank, IADB) Private lenders Carbon markets (CDM)
Devil's Hole HEP	High	US$65.24 million	Multilateral funding agencies (e.g. World Bank, IADB) Private lenders Carbon markets (CDM)

In this light, project concepts have been developed for (i) the development of an energy efficiency improvement programme and (ii) technical assistance to promote the development of hydropower projects. (Table 3.20.)

Table 3. 20. Development of energy efficiency programmes

Project Title	Development of Energy Efficiency Programmes
Sector	Public and private
Technology / Measure	Capacity building
Specific technology needs	None
Specific material / equipment needs	Trainers and international policy expert
Project rationale	The energy sector is the principal source of GHG emissions in Guyana. This is mainly attributed to the fact that energy supply in Guyana is largely from petroleum products (>90%). Guyana lacks institutional capacity to develop energy efficiency programmes, legislation and policy, targeting the energy sector to reduce energy demand.
Project objectives	The short-term objective of the project is to train staff within government departments and electricity providers to design and implement programmes and policy to reduce energy demand through energy efficiency measures in the energy sector. The long-term objective is for these energy efficiency measures to lead to a reduction in demand for energy, leading to a consequent reduction in associated GHG emissions and in a reduction of the dependence on imported fossil fuel products.
Expected project outputs/outcomes	**Output 1: Institutional capacity needs evaluated, training programmes developed, and training conducted** This output aims to strengthen the capacity of institutions in the energy and transport sector. The first stage of this output is to evaluate the current capacity of these institutions in regard to developing energy efficiency programmes, policy and legislation to reduce energy demand. Following this evaluation, a training programme will be developed covering energy efficiency measures and demand-side management as relevant to each organization. It is envisaged that this training will consist of formal training sessions as well as on-the-job training, and will be carried out by an International energy efficiency expert. **Output 2: Development of energy efficiency policy and legislation** This output aims to assist the government department trained in Output 1 to develop policy and legislation regarding energy efficiency measures in the energy sector. International policy experts will review current policy and produce a report with propositions for policy and regulations to encourage the uptake of energy efficiency measures. Following stakeholder consultation with the departments of energy, transport, buildings and electricity providers, the international expert will

	develop policy and legislation measures for submission to the Government of Guyana for approval. **Output 3: Awareness-raising programmes** This output will result in a series of awareness-raising programmes on energy efficiency, targeted to both large energy users, e.g. sugar producers, and smaller users, e.g. residential users. An international expert will work with those trained in Output 1 to develop a series of programmes on energy efficiency. This will consist of both awareness-raising through a comprehensive dissemination programme for low consumers, and workshops targeted at large energy consumers.
Expected project benefits	Reduction of CO_2 emissions by 42,000 tonnes by 2030, compared to business as usual Capacity of government departments and other organizations increased in terms of energy efficiency measures
Total estimated project cost	US$500,000
Possible sources of funding	GEF, Multilateral funding agencies (e.g. World Bank, IADB, UNIDO)
Project stakeholders	Office of the President, Guyana Energy Agency, Guyana Power & Light Inc

It is recommended that feasibility studies are undertaken to establish the technical viability of projects (especially for renewable energy development) before these can be worked up into detailed proposals for funding. The abatement potential and capital costs will necessarily be dependent upon the project design, and while it may be possible to put forward estimates based on similar projects elsewhere, these may bear no relation to the actual costs of implementation in Guyana.

Land Use and Forestry

As noted in section 3.5, Guyana is already implementing a number of measures to promote conservation and sustainable use of its forest resources. These measures are an integral part of the LCDS which provides the strategic framework for the execution and monitoring of the REDD+ mechanism. Guyana is also presently in the process of preparing its detailed REDD strategy, which involves further developing proposed REDD activities, consulting on these, and evaluating them through a series of pilot projects.

It is important that Guyana has the necessary technical and institutional capacity to ensure sustainable conservation and use of its valuable forest resources. This includes having the necessary resources in place to monitor land use and land-use change in forested areas, to enforce harvesting quotas, and to negotiate fair REDD+ agreements with foreign countries.

Wood used as fire-wood

Table 3. 21. Capacity building in sustainable forest management

Project Title:	Capacity Building in Sustainable Forest Management
Sector	Forestry
Technology / Measure	Capacity building and institutional strengthening
Specific technology needs	None
Specific material / equipment needs	Trainers and experts
Project rationale	The GFC has been tasked with the responsibility of overseeing the process to develop and implement the national REDD+ Strategy, including the national Monitoring, Reporting & Verification System (MRVS), as well as readiness activities under the World Bank's Forest Carbon Partnership Facility (FCPF). A REDD Secretariat was established as a new operational unit of GFC but additional specific capabilities are required to fulfil this mandate.
Project objectives	▪ To improve capacity to provide practical support for sustainable forest management and improved forest governance, law enforcement, and regulatory frameworks that assist efforts to reduce emissions from deforestation and forest degradation ▪ To build the institutional and technical capacity needed to deliver sustainable forest management that supports REDD+ ▪ To enhance the capacities of forest-dependent communities (including Amerindian communities) to assess their forest resources and to contribute towards effective sustainable forest management
Project outcomes	Enhanced capacity to implement measures necessary to limit deforestation and forest degradation
Expected project benefits	Improved capacity of GFC to develop and implement a national mechanism and institutional framework for carbon stock measurement, and monitoring activities related to the national Monitoring, Reporting and Verification System (MRVS), and thereby support to the capacity building plan at national and local level as outlined in Guyana's Readiness Preparation Plan (R - PP) and MRV Roadmap
Total estimated project cost	US$1 million
Possible sources of funding	GEF, IADB, FAO, European Commission, Bilateral aid agencies, International NGOs
Project stakeholders	Guyana Forestry Commission, forest-dependent communities

Solid Waste and Wastewater

As noted in section 3.6, there are several technologies available for reducing GHG emissions from solid waste disposal sites. Mitigation options for solid waste disposal sites are classified into two broad groups: (i) gas recovery and (ii) waste diversion such as recycling, composting and reducing the waste at source. The project concepts recommended below therefore identify specific projects that may be undertaken to reduce emissions from solid waste in Guyana (Table 3.22).

Solid waste management is an important issue in Georgetown. The volume of waste generated is growing rapidly in line with both population growth and increased levels of per capita consumption. Opportunities for recycling are limited and, as a result, significant volumes of waste are generated and sent to landfill. By encouraging household and business recycling and providing the necessary infrastructure to support this, the volume of waste sent to landfill may be reduced, thereby also reducing emissions from landfill.

Table 3. 22. Public information and awareness-raising

Project Title	Public Information and Awareness-Raising
Sector	Waste
Technology / Measure	Awareness-raising, capacity building and needs analysis
Specific technology needs	A mechanical waste separation facility
Specific material / equipment needs	Vehicles and equipment for sorting and collection of recyclables
Project rationale	At present, recycling and re-use of household and business waste in Georgetown is very limited. This may be largely attributed to a lack of investment in waste collection and separation facilities, the absence of a domestic market for recyclable materials and lack of awareness on the part of households and industries of the benefits of, and opportunities for, reducing, recycling and re-use of waste.
Project objectives	The objectives of this project are to improve environmental benefits of integrated solid waste management in Georgetown through recovery and reuse of recyclable materials in line with good international standards; and to strengthen national capacities to manage recyclable materials. The proposed project will consist of five components that will cover investments targeting: (1) The construction of a mechanical waste separation facility [MWSF] in Georgetown (2) Improvements to solid waste management in Georgetown including provision of equipment for the collection and separation of waste at source (3) Public information and awareness-raising (4) Assessment of the feasibility of setting up a waste exchange programme, or similar markets for recycled waste (5) Project management.

Project outcomes	Increased awareness amongst households and businesses of the opportunities for, and benefits of, reducing, re-using and recycling solid waste Increased capacity of the waste management authority in Georgetown to collect, sort and recycle municipal solid waste
Expected project benefits	Reduced emissions from landfill as a result of a reduction in the volume of municipal solid waste sent to landfill
Total estimated project cost	US$5 million
Possible sources of funding	World Bank, IADB, GEF, UNDP, local funding
Project stakeholders	Ministry of Local Government and Regional Development, Georgetown Solid Waste Management Unit, Environmental Protection Agency

The installation of landfill gas recovery and combustion systems would complement the existing venting systems in the Le Repentir and the newly commissioned Haags Bosch landfills by destroying methane emissions. The capping and venting systems that have already been installed in the two landfill sites would need to be modified and improved to allow for the destruction of the recovered landfill gas through flaring systems. The feasibility of installing such a system needs to be determined before it can be established whether such a system would result in significant reductions in emissions levels sufficient to attract investment in a Clean Development Mechanism project (Table 2.23).

Table 3. 23. Landfill gas recovery and flaring clean development mechanism (CDM) project

Project Title	Landfill Gas Recovery and Flaring Clean Development Mechanism (CDM) Project
Sector	Waste
Technology / Measure	Gas recovery and flaring system
Specific technology needs	None
Specific material / equipment needs	None
Project rationale	The Le Repentir landfill site covers approximately 20 acres and began accepting waste in 1993. Le Repentir landfill is at capacity. However, it was still being used until a new landfill at Haags Bosch is completed. In June 2009, the Government awarded a contract to a company to cap the Le Repentir landfill and install gas vents in preparation for closure. However, there are no measures in place to capture and destroy methane emissions.

	Landfill gas recovery and flaring involves the capture and destruction of methane emissions that would otherwise be released into the atmosphere (baseline scenario). The installation of a gas recovery and flaring system requires the piling and sealing of the amassed waste with a suitable landfill cap to facilitate the optimal gas recovery, and the installation of a gas capture network and flare. Flaring of landfill gas is dependent upon a number of factors such as gas quantity and quality. Engineered and sanitary landfills can achieve landfill gas recovery rates as high as 90% while recovery rates for open and managed dump sites vary between 30% and 60% .
Project objectives	To assess the feasibility of developing a Clean Development Mechanism project to capture and destroy methane emissions from the Le Repentir landfill site
Project outcomes	A report on the feasibility of developing a CDM project at the Le Repentir Landfill site
Expected project benefits	The study will provide the evidence required by potential investors of the technical feasibility of installing a landfill gas recovery and flaring system that will qualify for Certified Emission Reductions (CERs) under the CDM.
Total estimated project cost	US$15,000
Possible sources of funding	GEF Small Grants Programme
Project stakeholders	Georgetown Solid Waste Management Unit

Agriculture

Table 3. 24. Feasibility study and testing of options for reducing enteric GHG emissions from livestock

Project Title	Feasibility Study and Testing of Options for Reducing Enteric GHG Emissions from Livestock
Sector	Agriculture
Technology / Measure	Research and development
Specific technology needs	None
Specific material / equipment needs	None
Project rationale	Livestock production has grown significantly over the past decade, and enteric fermentation (from livestock digestive processes) has been shown to be a significant contributor to greenhouse gas emissions. There are a number of options for reducing enteric GHG emissions from livestock including: ▪ Promotion of high-quality forages in ruminant feeding and grazing systems ▪ Feed and Animal Management (Improved Animal efficiencies) – which have proven an effective way of reducing GHG from animals, and economically profitable for adoption by producers. In general, when productivity of animal is improved, CH_4 emission per unit of product is reduced, because feed energy associated with maintaining the animal is reduced. ▪ Addition of fats to grain diets ▪ Further research is required to assess the feasibility of introducing such measures in Guyana.
Project objectives	▪ To identify and assess the technical and economic feasibility of options for reducing enteric emissions from livestock ▪ Piloting of options ▪ Development and implementation of a nutrition management plan
Project outcomes	The project will result in: ▪ A comprehensive research study and feasibility assessment ▪ Small scale pilot projects to assess the practicability of options ▪ A livestock nutrition management plan
Expected project benefits	The R&D project will improve understanding of the options available to reduce emissions from livestock. Piloting of feasible options will provide an on-the-ground assessment of the longer-term sustainability of options and the requirements for wider uptake amongst farmers. The evidence generated through the study may also be used to inform agricultural policy around livestock management.
Total estimated project cost	US$200,000
Possible sources of funding	GEF, multilateral funding agencies (e.g. World Bank, IADB)
Project stakeholders	Office of the President, National Agricultural Research Institute, Ministry of Agriculture

Table 3. 25. **Research and development of effective water management techniques in rice paddies**

Project Title	Research and Development of Effective Water Management Techniques in Rice Paddies
Sector	Agriculture
Technology / Measure	Active irrigation and drainage
Specific technology needs	Active irrigation and drainage systems
Specific material / equipment needs	None
Project rationale	The Guyana Rice Development Board (GRDB) has already made significant efforts to support a low carbon growth path in terms of reducing CH_4 and N_2O emissions from rice production, through changes to cultivation regimes and water management practices. However, to date water management techniques have been unsuccessful because they have not been able to adapt to flood and drought conditions. This R&D project will help the GRDB to conduct further research to test more flexible water management regimes that are effective in both wet and dry conditions.
Project objectives	The objective of this R&D project is to investigate options for improving the management of water in paddy fields. This includes developing and piloting active irrigation and drainage systems based on the actual water requirements of rice.
Project outcomes	A comprehensive report that clearly documents the research findings, recommended plan of action, and resources required to implement potential measures more widely amongst rice farmers in Guyana
Expected project benefits	Based on case studies from elsewhere, it is estimated that improved water management techniques may reduce methane emissions by up to 40% and improve yields.
Total estimated project cost	US$50,000
Possible sources of funding	FAO, World Bank, IADB, GEF
Project stakeholders	National Agricultural Research Institute, Ministry of Agriculture, Guyana Rice Development Board

3. 9 Conclusions

Guyana has already made significant progress in identifying and developing options to support a low carbon development trajectory, including:

- The formulation and publication of a **Low Carbon Development Strategy**, which sets out Guyana's approach to forging a new low-carbon, climate-resilient economy over the coming decade, including facilitation of investment in high potential, low carbon sectors, and development of a Clean Transportation Programme
- Developing the institutional capabilities and **Information and Communication Technologies** (ICT) required to support the implementation of the LCDS
- Investigating the potential for **hydropower development** and promoting the construction of the Amaila Falls Hydropower plant which, once online, is expected to enable Guyana to switch from nearly 100% dependence on fossil-fuel based electricity generation to nearly 100% clean, renewable energy supplies
- The signing of a Memorandum of Understanding with the Government of Norway which sets out how the two countries will 'work together to provide the world with a relevant, replicable model for how **REDD+** can align the development objectives of forest countries with the world's need to combat climate change.'
- Preparation of a **REDD-Readiness Proposal** for the Forest Carbon Partnership Facility, which sets out in detail how forest carbon stocks will be managed in a way which aims to achieve carbon neutrality over time. REDD+ will enable greater resources to be devoted to addressing illegal activities, and improving governance where necessary. The specific measures to achieve this are specified in the RPP, and will be further developed in the REDD+ Governance Development Plan, which was due to be finalized by October 2010.

Despite Guyana's progress in developing strategies to address climate change, particularly the LCDS, and in attracting the investment necessary to implement measures to protect its valuable forest resource, several barriers presently exist to the introduction of climate change mitigation measures in Guyana. These include the costs of procuring and maintaining renewable and energy efficiency technologies, the financial feasibility of options, and the limited availability and continuity of technical expertise within relevant institutions to design effective research and development programmes and policies, implement and measure their effectiveness, and operate and maintain mitigation technologies so that they work to their full potential.

Overcoming these barriers requires, in the vast majority of cases, taking steps to create an enabling environment as described earlier in the framework. The draft LCDS is a promising start and has enjoyed strong and widespread support both within Guyana and internationally. However, significant effort and investment in institutional strengthening and reform, technical capacity building, education, and awareness-raising will be required for this model to succeed.

Some of the common barriers to the transfer and implementation of mitigation measures are described below, together with suggestions for how these may be overcome. These suggestions are based on a review of experiences in other countries that are at a similar level of development to Guyana, and on discussions with stakeholders at a mitigation and abatement analysis workshop (Table 3.26).

Table 3. 26. Barriers and suggestions for overcoming these

Types of Barriers	Description of Barriers	Suggestions for Overcoming these
Financial	High costs of new technologies	Give priority to technologies with quick payback periods and guaranteed returns. Adopt a full-cost accounting approach – i.e. see whether high initial costs may be more than offset by the cost savings accrued over the life of the technology; international co-operation and knowledge transfer; international funding
	Limited project finance; restrictions on foreign investment.[105]	Closer collaboration with the private sector; borrowing from multilateral lending institutions (e.g. IADB); regulatory reform
	Lack of financing instruments/systems and difficulties in securing credit and loans from commercial banks, especially for unproven technologies.	Regulatory reform to reduce levels of actual or perceived risk; co-operation with financial institutions such as the Inter-American Development Bank (IADB); purchase of appropriate insurance cover
Economic / Market / Trade Constraints	Weak or absent price signals (e.g. tiered water and energy tariffs that discourage wasteful use) and barriers to introduction of technologies (e.g. energy efficiency options)	Address market failures (e.g. through carbon taxation or other methods that encourage the uptake of more efficient technologies); change pricing policies
	Weak competition (particularly in the energy supply sector) that reduces incentives to innovate and potentially erects barriers to new entrants (e.g. independent electricity producers who wish to sell to the grid have little bargaining power; they are price-takers.	Strategic planning and interventions at appropriate level; regulatory reform to allow and encourage competition
	Limited market size to justify the investment (e.g. in recycling or composting technologies, etc)	Stimulate the creation of markets (e.g. through awareness-raising, incentives, regulation, etc); create linkages with regional markets. Compost may be considered for use as a landfill capping.
	Import tariffs (including import restrictions) and intellectual property issues.	International and bilateral negotiations, research partnerships, etc., to ensure that critical technologies are treated as public goods
	Some unsupportive macro-economic policies, particularly import regulations	Changes in the macro-economic environment; improving financial and administrative efficiencies

[105] The Heritage Foundation (2010). 2010 Index of Economic Freedom. Accessed online at www.heritage.org/Index/Country/Guyana on 29/01/2010.

Types of Barriers	Description of Barriers	Suggestions for Overcoming these
Policy / Institutional	Lack of technical capacity to establish and maintain technologies	Communication and education; development of a critical mass of human capital via appropriate policies; development of adequate support for the national education system; international co-operation and knowledge transfer; technology-related capacity building (e.g. through study tours, short-term exchange studentships, etc)
	Legal/regulatory barriers	Regulatory reform / tightening of regulatory standards
	Lack of a supporting/incentive-based policy framework for technology transfer, research and development, and behavioural change	Policy and regulatory reform – .e.g. development of an explicit national policy supporting technology development. The draft LCDS goes some way to achieving this but regulatory reform (e.g. removal or reduction of import tariffs on ESTs) needs to accompany the policy reform.
	Absence, or weak enforcement, of feasible and appropriate standards (e.g. pollution, fuel efficiency, etc) based on local conditions	Establishing appropriate standards accompanied by effective enforcement measures
	Poor enforcement (e.g. of regulations around polluting activities, unsustainable logging practices, etc) often due to lack of available human resources	Institutional strengthening; dedication of more resources towards monitoring and enforcement; legal reform giving relevant authorities (e.g. EPA, GFC) the 'power to act'
	Perceived lack of transparency[106] which impinges on foreign direct investment	Institutional reform; introduction of measures/incentives to promote good governance and transparency of transactions/agreements, etc.
Technical / Technological	Technology not yet proven for local application	Implementation of small-scale demonstration/trial projects; establishing research partnerships; examining possibility of trialling the technology/practice in other CARICOM countries
	Environmental constraints (e.g. topography, climate, etc.)	Selecting technologies that are suited to the local context
Information	Lack of technical information	Education; international, regional and local research partnerships and knowledge sharing
	Lack of demonstrated track record for	Implementing demonstration projects

[106] See, for example: www.heritage.org/Index/Country/Guyana.

Types of Barriers	Description of Barriers	Suggestions for Overcoming these
	many emerging technologies	
	Lack of awareness of potential sources of funding support and credit	Establishing relationships with relevant regional partners for information sharing; commissioning a review of potential funding sources for priority technologies in different sectors
Social, cultural and behavioural norms and aspirations	Social and cultural preferences impeding the uptake of new technologies	Awareness-raising, education, introduction of incentives to encourage environmentally-sustainable behaviour (e.g. through subsidies or payments for environmental services), or penalties for activities that directly or indirectly contribute to climate change (e.g. taxes, fines, etc)
	Lack of awareness and social acceptance; insufficient understanding of the advantage of new technologies	Education and awareness-raising; implementation of demonstration projects
	Lack of confidence in the economic, commercial and technical viability of technologies and practices	Education and awareness-raising; implementation of demonstration projects

Chapter 4

Vulnerability and Adaptation Assessment

Chapter 4

Vulnerability and Adaptation Assessment

4.0 Introduction

Guyana is particularly vulnerable to climate change impacts because of its extensive low-lying coastal zone that hosts over 90% of the population, as well as the main livelihoods, economic activities and infrastructure of the country. This zone is threatened by sea-level rise, increase in storm surges and changes in rainfall patterns. Any impact on the coastlands will have consequences for the country's economy, basically sustained by the sectors of Agriculture, Forestry, and Fishing, which are economic activities that are highly sensitive to changes in climate.

Climate change has the potential to constrain the ability of a developing country such as Guyana to reduce poverty and reach its sustainable development objectives under the Millennium Development Goals (MDGs). Thus, incorporating concrete adaptation actions in national policies, in order to reduce the vulnerability of the poor and improve their capacity to adapt to climate change, while taking advantage of the opportunities climate change brings, is key. (UNDP 2011).

According to Decision 17/CP8, Paragraph 29 of the UNFCCC (United Nations Framework Convention on Climate Change (UNFCCC), to which Guyana is a signatory Party, 'Non-Annex I Parties should provide information on their vulnerability to the adverse effects of climate change, and on adaptation measures being taken to meet their specific needs and concerns arising from these adverse effects'. The Decision also states that the Vulnerability and Adaptation (V&A) assessments are also expected to incorporate other relevant data and information emanating from other similar studies and assessments.

This Chapter deals with the V&A assessment component of the Second National Communication (SNC) of Guyana and puts the focus on integrated impacts and adaptation assessments for the most vulnerable territory (the coastal zone) and sectors of the country. It is divided into three sections and offers an integrated presentation of Guyana´s vulnerability and adaptation needs. In sum:

Sub-chapter 4.1 presents a panoramic view of Guyana´s economy and social development, in order to contextualize the following description of the country´s main climate-related threats and vulnerabilities, as well as the main cross-cutting and sectoral adaptation needs.

Sub-chapter 4.2 presents the different studied climate and sea-level trends and scenarios, specifying the methodologies applied, as well as the main outputs derived from the scenarios' projections for the sectoral analysis.

Sub-chapter 4.3 presents the vulnerability assessment that was carried out at both territorial and sectoral levels. The first includes a comprehensive quantitative and qualitative assessment of the coastal zone as a territorial system that holds the most vulnerable set of physical features, economic activities and human settlements of Guyana; while the sectoral includes mainly qualitative analysis (except in the case of agriculture where a more quantitative analysis is carried out), and covers the water, agriculture, fisheries, health, energy, forestry and tourism sectors. In every analysis, adaptation proposals are also presented.

Finally, the **conclusion** (**sub-chapter 4.4**) offers a brief summary and description of the main challenges in assessing vulnerability and implementing adaptation, and refers to the main gaps, barriers, needs and priorities.

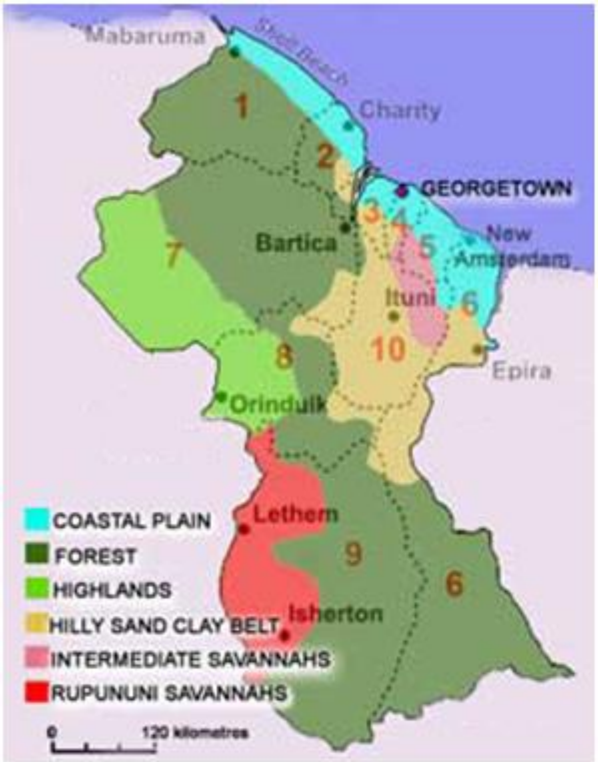

Fig. 4. 1. Administrative and Geographic Regions of Guyana

4.1 Guyana's National Circumstances, Vulnerability and Adaptation Needs

The following section presents an integrated approximation to Guyana´s vulnerability and adaptation needs, summarizing the results of the different sectoral analyses that are developed in the next sub-chapters. The Sub-chapter starts with a summarized description of Guyana´s economy, social development and growth patterns, in order to give context to the following presentation of the main climate-related threats, as well as the activities and population exposed. Finally, a description of Guyana's underlying vulnerabilities and main cross-cutting adaptation needs is presented.

Guyana´s economy and social development

In 1993, Guyana´s Government with assistance from the UNDP and the World Bank carried out the Household Income and Expenditure Survey (HIES) / Living Standards Measurement Survey (LSMS) that revealed that about 43 % of the population lived below the poverty line, with 29 % living in extreme poverty. In 1999, Guyana completed a Living Conditions Survey (LCS) which indicated a decrease in poverty levels. In fact, the proportion of the population living below the poverty line was found to be 35 %, with 19 % living under conditions of extreme poverty (PRSP 2001). Although the poverty indices have decreased, climate change has the potential to negatively impact growth and poverty reduction targets.

Climate change may exacerbate poverty as the country´s economy is highly dependent on climate. Over 90 % of the population of Guyana lives and works in the coastal zone which represents less than 5 % of the country's total land. This coastland is properly called 'the low coastal plain' as most of it is below mean high tide level by more than one metre in some areas (particularly on the East Coast of Demerara), which makes the main livelihoods, economic activities and infrastructure of the country extremely vulnerable to climate change impacts (such as flooding and water intrusion derived from storm surges, sea-level rise, and intense precipitation).

The agricultural sector (which includes fisheries and forestry) is a significant contributor to GDP in Guyana. Actually, between 2004 and 2007 it contributed approximately 35 % of the country's GDP, and employed between 30-35 % of the labour force (Bureau of Statistics 2008). In 2006, fisheries itself accounted for 7 % of Guyana´s GDP. The exports from this sector have consistently surpassed US$50 million since 2004 (Caribbean Community Climate Change Centre 2009) and employs around thirteen thousand people in Guyana in the primary and secondary sector (FAO 2005). The forest sector's contribution to the GDP over the past few years has been around 3.10 %.

Any impact on the coastlands will have consequences for the country's GDP directly related to the Agriculture, Forestry, and Fishing sectors, and will severely affect the population that is mainly employed in these sectors. The agriculture sector, especially sugar-cane, would very likely be negatively affected by climate change through decreasing yields, on account of increasing droughts mainly.

The World Travel and Tourism Council (2001) estimated 12.2 % of GDP as the total contribution from travel and tourism, and 10.6 % total contribution to employment. With most of the tourism infrastructure located on the coastal zone, Guyana´s tourism sector is also very vulnerable to climate change, which may affect the sector´s contribution to the national GDP and employment.

Guyana´s main climate-related threats and impacts

Climate-change related threats to the country are diverse. The main ones consist of increase of heavy rainfalls (possibly leading to flooding); sea-level rise and storm surges especially for the coastal zone; increase in temperature and the decrease of main annual precipitation (possibly deriving from drought episodes). These produce, alone or together, other derived threats that affect several regions and sectors of Guyana. Figure 4.2 shows the multidimensional nature of climate change impacts, and the possible chain of effects derived from these impacts. The derived threats, such as drought, flood and the change in seasonal temperature, may impact on more than one sector in the country, possibly at the same time, thus magnifying the effects. Some of them are explained below.

It is estimated that increase in temperature may affect tropical forests with an increase in fires, affecting wood production that is used for commerce and housing. The increase in temperature would also contribute to the spread of infectious diseases such as malaria and dengue, while precipitation decreases together with temperature increases would affect the evapotranspiration process, causing water deficits for industrial activities (energy generation, fisheries, agriculture) and human consumption. Extreme events (e.g. El Niño Southern Oscillation) (ENSO) would increase in intensity and frequency, causing damage to housing and other infrastructure, and the marine ecosystems would be disrupted, affecting the fish industry, one of the main food sources for Guyanese people.

Severe estimated water deficits, leading to droughts in the south of Guyana, may lead to migration towards the coastal zones, adding pressure to the socio-economic systems already exposed to climate-related threats. On the other hand, changes in precipitation patterns, with intense rainfall, may cause landslides and flooding that may damage coastal infrastructure such as the sea-wall system, housing, the sewage and sanitation system, hotel facilities, roads, energy generation and transmission infrastructure, fishermen's landing sites, and the Demerara River Conservancy, among others.

The IPCC (1996) Guidelines offer a default methodology which includes default emission factors and in some cases default activity data, which is appropriate for Guyana, given the data limitations. The GHG inventory of the SNC of Guyana applied, to the extent possible, the IPCC Good Practice Guidance and Uncertainty Management (2000) in National Greenhouse Gas Inventories, taking into account the need to improve transparency, consistency, comparability, completeness, and accuracy in the GHG inventory. The inventory also included, to the extent possible, a key source analysis as indicated in the IPCC good practice guidance, to assist in developing a GHG inventory that better reflects the national circumstances.

Using the Revised IPCC (1996) guidelines and methodologies, and augmented, where possible, by the IPCC (2000) Good Practice guidelines and the IPCC (2006) guidelines, the Inventory was performed on a sector basis and covered the Energy, Industrial Processes, Agriculture sectors. Floods, as well as landslides, may have an impact on Guyana's aquaculture activities, decreasing fish production. In the year 2005, floods in Guyana affected more than 270,000 persons, and had an economic cost of US $2.68 billion dollars (Table 4.1) See Appendix 4.1. Furthermore, floods due to rainfall and sea-level rise caused the marine water to be contaminated and run-offs to collapse, contaminating drinking water and fresh water for aquaculture. Sea-level rise could also cause saline intrusion that erodes the coast, affecting water resources and agricultural and housing soil, putting these in danger.

The coastal zone is also exposed to storm surges caused by extreme weather events; this phenomenon can be exacerbated by the impending sea-level rise projected. In this likely event of sea-level rise coupled with storm surges, not only would human settlements, infrastructure and persons be at risk to coastal inundation, but also valuable ecosystems and the East Demerara Water Conservancy, agricultural lands and crops, and aquaculture activities, which are the most significant economic sectors of Guyana. Moreover, storm surges would very likely lead to salinization of aquifers and soils, affect the drainage of watercourses, and cause the deterioration of valuable agricultural soils.

These vast climate change threats will very likely create hardships for the economy and livelihoods of the people of Guyana, leading to health and food insecurity, migrations and a decrease in the main sources of income such as tourism, wood, fisheries, and agricultural exports.

Guyana is especially vulnerable because 35% of its population lives below the line of poverty; plus almost 90 % of its population, the majority of the infrastructure, the most fertile agricultural soils and most of its industrial activities and freshwater resources are located in the coastal zone, which is the area most exposed to the climate change threats as described above.

Table 4. 1. **Main recent climate-related disasters (2005 – 2011)**

Disaster	Year	Persons Affected	Persons Killed	Persons Homeless	Economic Cost (USD)
Flood	2005	274.774	37	0	2.68 Billion
Heavy Rainfall	2007	300	0	0	150.000
	2011	8	0	8	15.000

4.1.1 Guyana's main adaptation costs and needs scenarios

Guyana has made an effort to estimate some urgent, near-term investments in the highest priority areas where the population and economic activity are concentrated. According to its Low Carbon Development Strategy (LCDS, Office of the President 2009), these investments include the following:

- Upgrading infrastructure and assets to protect against flooding through urgent, near-term measures (US$225 million). This includes maintaining (US$20 million) and upgrading (US$39 million) drainage systems; maintaining and reinforcing the ocean sea-wall which protects most of the low-lying coastal areas from the Atlantic (US$30 million); and repairing the Conservancy which protects the capital, Georgetown, and most of the East Coast from overflow water (US$123 million).

- In addition, these initiatives include implementation initiatives to improve sanitation and water (US$12 million) and flood-proofing health clinics (US$1 million).

- Addressing systematic and behavioural concerns (US$33 million). These initiatives include strengthening building codes and expanding the early warning system (US$19 million) and building an emergency response system (US$15 million).

- Developing financial and risk/insurance measures to boost post-flooding resiliency (US$10 million).

- Switching to flood-resistant crops (US$10 million).

- Establishing the climate-change adaptation needs of Guyana's hinterland regions, including forest communities. There are also plans to analyze the adaptation of Guyana's hinterland and riverain areas so as to embolden communities, build new river defences, and introduce new seed varieties for crops for agriculture (Office of the President, Republic of Guyana, 2009).

According to the LCDS, by 2030 the annual loss due to flooding in Guyana is projected to be US$150 million (or close to 10 per cent of current GDP). This at-risk value has been estimated by using flood maps that combine an assessment of flood risk, population density, and economic activity. Additionally, an extreme event similar to the serious flooding in 2005, which resulted in losses equivalent to 60 per cent of GDP, could result in some US$0.8 billion in losses and harm to more than 320,000 people, a number that is almost half of Guyana's population. In fact, the total adaptation costs for Guyana are projected to exceed US$1 billion at the national level (Office of the President 2009).

Guyana's main adaptation needs involve the most important economic sectors, considering most climate change impacts affecting the country are cross-cutting, i.e. flooding affecting the coastal plain affects agricultural land and products, human settlements, industrial activities, etc. Therefore, adaptation actions should build on the key adaptation needs identified by each sector, as well as at the territorial level (the coastal plain mainly). The aim is to reduce vulnerability and increase resilience to climate change for the Guyanese society and its development process.

To this end, all adaption actions could be built based on five pillars:

- **Pillar #1: Information, research and systematic observation** in order to reduce uncertainty regarding sectoral and territorial vulnerability, and to provide information for accurate decision-making and early warning systems
- **Pillar #2: Institutional framework and capacity building, education and awareness** for building human and technical resources and increased social awareness to address the impacts of climate change
- **Pillar #3: Policy, legal framework and tools to integrate climate change adaptation into development planning**, relying on tools such as disaster risk reduction and integrated coastal zone management (ICZM)
- **Pillar # 4: Generation and application of technologies**, both for knowledge management and for building infrastructure and service design, including and articulating knowledge and practices from different social groups
- **Pillar #5: Innovative financing instruments,** as a fundamental pillar aimed at introducing financing instruments for the implementation of adaptation measures, and to expand/adjust mechanisms and platforms, including international co-operation and funding, and investments from the private sector and public budget.

Most of the investment on adaptation measures will have an impact on the economic and social activities taking place in the coastal plain, in a cross-cutting manner. By addressing these adaptation measures in regard to coastal protection, the adaptation of sectors such as agriculture, fisheries, water, energy, health, tourism and forestry would be greatly facilitated. The Kyoto Protocol Adaptation Fund can provide a portion of the resources needed to revitalize and upgrade Guyana´s coastal protection, including drainage and irrigation, since these measures will go a long way to promote adaptation in other key sectors. The Government of Guyana should therefore urgently pursue finances from this Fund.

There is also a need to strengthen capacities at the institutional level to create management tools that incorporate climate change as a cross-cutting issue. This involves managing the information generated for decision-making in contexts of uncertainty, as well as effective co-ordination platforms. It is also important to develop a culture of prevention in which concrete actions should be taken such as the promotion of home, health, and agriculture insurance, and raising public awareness, working at community levels.

Table 4.2 presents some of the key information in Sub-chapter 1. It tries to illustrate the process of identifying climate change impacts, analyzing their interaction with vulnerable territories and sectors, and finally, proposing adaptation measures to address impacts and vulnerability.

Table 4. 2. Summary of climate change impacts, derived effects for sectors/ territory and key cross-cutting adaptation measures

Possible Climate Change Impacts Affecting Guyana	Some Derived Effects Affecting Sector/Territory	Key Adaptation Measures
Increase in storm surges, sea-level rise and/or increased rainfall leading to flooding	▪ Coastal protection infrastructure affected (causing impacts on all the systems the coastal plain holds) ▪ Houses in human settlements damaged by soil erosion ▪ Pollution of freshwater for aquaculture ▪ Change in patterns of agricultural yields due to agricultural soil erosion ▪ Saline intrusion affecting water resources- surface and ground water	▪ Developing climate change scenarios and impacts using more accurate data, smaller scales and methodologies (Pillar #1) ▪ Strengthening institutional capacity of the GoG to manage water levels in the East Demerara Water Conservancy (EDWC) and to guide interventions aimed at reducing Guyana's vulnerability to floods (Pillar #2). ▪ Mainstreaming adaptation measures into the integrated coastal zone management plans (ICZM) and urban planning; developing new building codes that include risk assessment; implementation of an emergency response plan and upgrading early warning systems (Pillars #3 and #1) ▪ Construction, maintenance and reinforcement of sea defence and water infrastructure: sea-walls, drainage, upgrading of the East Demerara Water Conservancy (Pillar #4). ▪ Developing indexed insurance products to minimize the risk of crop yield losses, and a project to be financed by the Adaptation Fund (Pillar # 5). ▪ Developing financial and risk/insurance measures to boost resiliency post-flooding (Pillar #5)
More intense and frequent ENSO events, change in rainfall and temperature patterns leading to droughts	▪ Migration of human settlements from the hinterland, increasing the pressure on the coastal zone ▪ Increase in pests and diseases ▪ Increase in infectious vector-transmitted diseases due to temperature rise ▪ Reduction in productivity of crops, especially sugar-cane and rice, leading to effects on exports ▪ Risk to energy security in the future due to water	▪ Developing an integrated system for the development of water availability information and projections (Pillar #1). ▪ Education, training, and participatory processes where dialogue and communication between stakeholders is required to design and implement effective relocation measures (Pillar #2) ▪ Expanding the early warning system and building an emergency response system for droughts (Pillar #3) ▪ Monitoring-systems for infectious diseases; developing drought-resistant crops and efficient technologies and practices for water use in different sectors (Pillar 1 and #4) ▪ Economic incentives to redirect new coastal

	deficit for hydropower stations (possible source to diversify energy matrix currently dependent on fossil fuels). ▪ Increase of forest fires due to temperature rise	settlements to better-protected locations, promoting investments in appropriate infrastructure and effective use of water (Pillar #5). ▪ Developing financial and risk/insurance measures to boost post-flooding resiliency (Pillar #5)

4.2 Climate and Sea-Level Trends and Scenarios

This section looks at observed climate and sea-level change over the past century, and the projected change for the twenty-first century in Guyana. The results reported in this section form the basis for the discussion of climate change impacts on the Coastal Plain and on various sectors of the economy of Guyana, which are elaborated upon in subsequent sections of this Vulnerability and Adaption chapter.

Different scenarios and projections at different scales have been applied for Guyana:

- Climate change scenarios that cover precipitation and temperature changes are national in scope
- Sea-level rise and storm surge projections are focused on the coastal zone
- Rainfall, evapotranspiration and water deficit projections cover regions 4, 5 and 10
- Temperature, rainfall and solar radiation scenarios that are used for crop yields projections cover Regions 5 and 6.

The following table (Table 4.3) shows models and methods used: reference time periods, the analyzed time periods, and IPCC emission scenarios used. A more detailed description of each is presented in the following sections.

Coastal communities and agricultural sectors (e.g. sugar) are extremely vulnerable to climate change.

Table 4. 3. **Climate and sea-level scenarios and projections**

Level	Name	Model Used	Reference Time Periods (Observed climate)	Analyzed Time Periods	Reference Time years	Scale	Methods Used	Study Area	Emissions Scenarios (IPCC)
National	Climate scenarios: temperature, precipitation	A-OGCM	1960 – 2006	1960 – 2100	2030, 2060, 2090	Annual – Seasonal		Guyana (national)	B1, A2, A1B
Coastal Zone	Sea-level rise and storm surges	Digital Elevation Model (DEM) / CGCM2 / HadCM3			2031, 2051, 2071	20 years	Downscaling (ARCGIS) 90m x 90m, downscaled to 25 x 25 m	Coastal Zone of Guyana (5,760km2) Georgetown, Regions 3 and 4; parts of 2 and 5	
Sectoral (Water)	Rainfall, evapotranspiration and water deficit	CGCM1 / HADCM3	1961 - 1990	2040 – 2069	Average 2040 – 2069	Annual and monthly	Downscaling (SDSM)	Timehri (Region 5) New Amsterdam (Region 6) Ebini (Region 10)	
Sectoral Agriculture	Temperature, rainfall and solar radiation for crop yields	CGCM1 / HADCM3 /	1961 – 1990	2040 – 2069	Average 2040 – 2069		Downscaling (SDSM) / Bristol and Campbell model (1984) / Villa model (1993)	Timehri (Region 5) New Amsterdam (Region 6) Ebini (Region 10)	A2
Sectoral (Agriculture)	crop model	DSSAT	1961 – 2008	2040 – 2069	Average 2040 – 2069	Annual	RMSE statistic	Region 5 (rice) and Region 6 (sugar-cane)	A2

4.2.1 Climate and sea-level scenarios

Methodology

The data sets and results reported in this section were extracted from the United Nations Development Programme (UNDP) Climate Change Country Profiles project (McSweeney *et al.* 2008) that provides country-scale data files and easily accessible analyses of up-to-date observed data and multi-model scenario-based projections for fifty-two developing countries in Africa, Asia, South and Central America, including Guyana. The project facilitates the use of observed and modelled climate data in climate impact assessment and exploration, by providing observed data and future climate projections, modelled using the SRES scenarios in the IPCC Fourth Assessment Report for each country, in a standard format that is more manageable than the large global fields which are directly available from the Program for Climate Model Diagnosis and Inter-Comparison (PCMDI) (McSweeney *et al*. 2008, 2009).

McSweeney *et al.* (2009) analyse data on current and future climates and climate scenarios (temperature, rainfall and sea-levels), together with time series climatologies (1960-2100). These were extracted from ensemble coupled Atmosphere-Ocean General Circulation Models (A-OGCMs), forced by three of the Special Report on Emissions Scenarios (SRES) marker scenarios, which were used in the IPCC Fourth Assessment Report (2007); namely a high (A2), a low (B1) and a medium (A1B) emissions scenario, which produce high, low and medium climate forcings and changes.

Current climate and recent observed climate trends

Guyana is located at latitudes of approximately 2° to 8° north of the equator and experiences a typically warm and moist tropical climate. Mean air temperature ranges between 25° to 27.5°C throughout the year in most regions, except the upland regions in the interior/west of the country, where mean temperatures are cooler and range between 20° to 23°C (McSweeney *et al.* 2008, 2009; IPCC 2007; Guyana INC 2002). As for rainfall, most of Guyana receives between 250 to 450 mm of rain per month and during the rainy season. Guyana also experiences two wet or rainy seasons: 1) between May and July that affects more or less the entire country, and 2) between November and January, which second wet season affects mainly the northern coastal regions, which receive around 150 to 300 mm per month of rain during this period (McSweeney *et al*. 2008, 2009; IPCC 2007; Guyana INC 2002).

The climate of Guyana is sensitive to the El Niño Southern Oscillation (ENSO) cycle that leads to significant inter-annual variations in climate. ENSO and El Niño episodes are normally accompanied by dry conditions throughout the year, and generally warmer air temperatures between June and August, whilst the cool phase of ENSO, namely La Niña episodes, are generally accompanied by wetter conditions throughout the year and cooler air temperatures between June and August (McSweeney *et al*. 2008, 2009; IPCC 2007; Guyana INC 2002).

Inter-annual air temperature fluctuations approaching 1°C are also caused by volcanic eruptions globally, as evidenced by temperature fluctuations at the Botanical Gardens station in Georgetown between the years 1880 and 2000 (Guyana INC 2002).

Temperature

The mean annual air temperature of Guyana, overall, has increased by 0.3°C since 1960, which translates into an average rate of ~ 0.07°C per decade; a rate of warming less rapid than the global average of ~ 0.08°C per decade recently, with the highest changes occurring in the August-September dry season (~ 0.10°C per decade) (Table 4.4 and Fig. 4.2) (McSweeney *et al.* 2008). Furthermore, average diurnal temperature variations are generally lower on the coast where the marine influence is most pronounced, and maximum temperatures average 29.6^{0}C, while daily temperatures average 24^{0}C. However, the lowest average daily temperatures occur in the higher interior mountainous regions, where daily maximum temperatures average 28.6^{0}C and daily minimum 19.6^{0}C (Guyana INC 2002).

Precipitation

Mean annual rainfall over Guyana has increased at an average rate of 4.8 mm per month or 2.7 % per decade since 1960. Trends in both annual and seasonal rainfall are minimal and not statistically significant (95 % confidence: McSweeney *et al.* 2008). There also seems to be no evidence of any significant trends in maximum one-day or five-day extreme rainfall events (Table 4.4 and Fig. 4.4).

However, seasonal changes in temperature and especially variability in rainfall, which is very sensitive to the ENSO cycle, have been increasing in recent years. For instance during 1997-98, when there was the existence of the warm phase El Niño mode, drought conditions were persistent. On the other hand, during the cool phase La Niña mode, as in 1996, severe rainfalls accompanied by flooding have occurred (Guyana INC 2002).

A-OGCM projections of future climate

Temperature

For Guyana overall, the mean annual air temperature is projected to increase in the 2030s by 0.4°C to 1.4°C according to the B1 scenario; by 0.6°C to 2.0°C according to the A1B scenario, and by 0.8°C to 1.8°C according to the A2 scenario (Table 4.4 and Figs. 4.2 and 4.3) (McSweeney *et al.* 2008).

In the 2060s, the mean annual air temperature is projected to increase by 0.9°C to 2.3°C according to the B1 scenario; by 1.3°C to 3.2°C according to the A1B scenario, and by 1.7°C to 3.3°C according to the A2 scenario (Table 4.4 and Figs. 4.2 and 4.3) (McSweeney *et al.* 2008).

Initially, by the 2090s, the mean annual air temperature of Guyana is projected to increase by 1.4°C to 3.0°C according to the B1 scenario; by 2.0°C to 4.6°C according to the A1B scenario, and by 2.9°C to 5.0°C according to the A2 scenario (Table 4.4 and Figs. 4.2 and 4.3).

Furthermore, the projected rate of warming is similar in all seasons, but more rapid in the southern, interior regions of the country than in the northern, coastal regions (Table 4.4 and Figs. 4.2 and 4.3) (McSweeney *et al*. 2008).

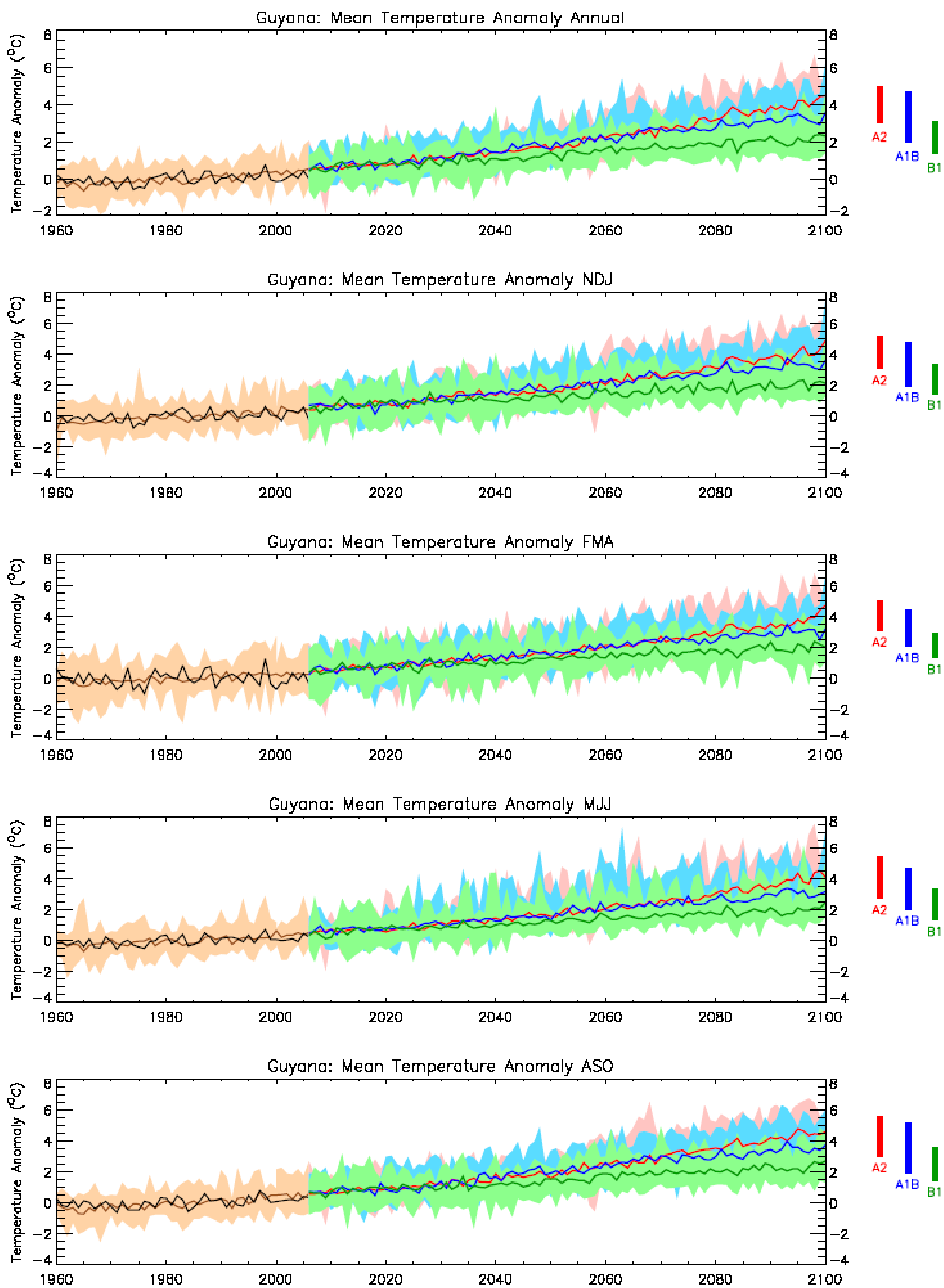

Fig. 4.2. **Observed (1960-2006) and projected (to 2100) annual and seasonal air temperature anomalies for Guyana (referenced to 1970-1999 (McSweeney *et al*. 2008; 2009).**

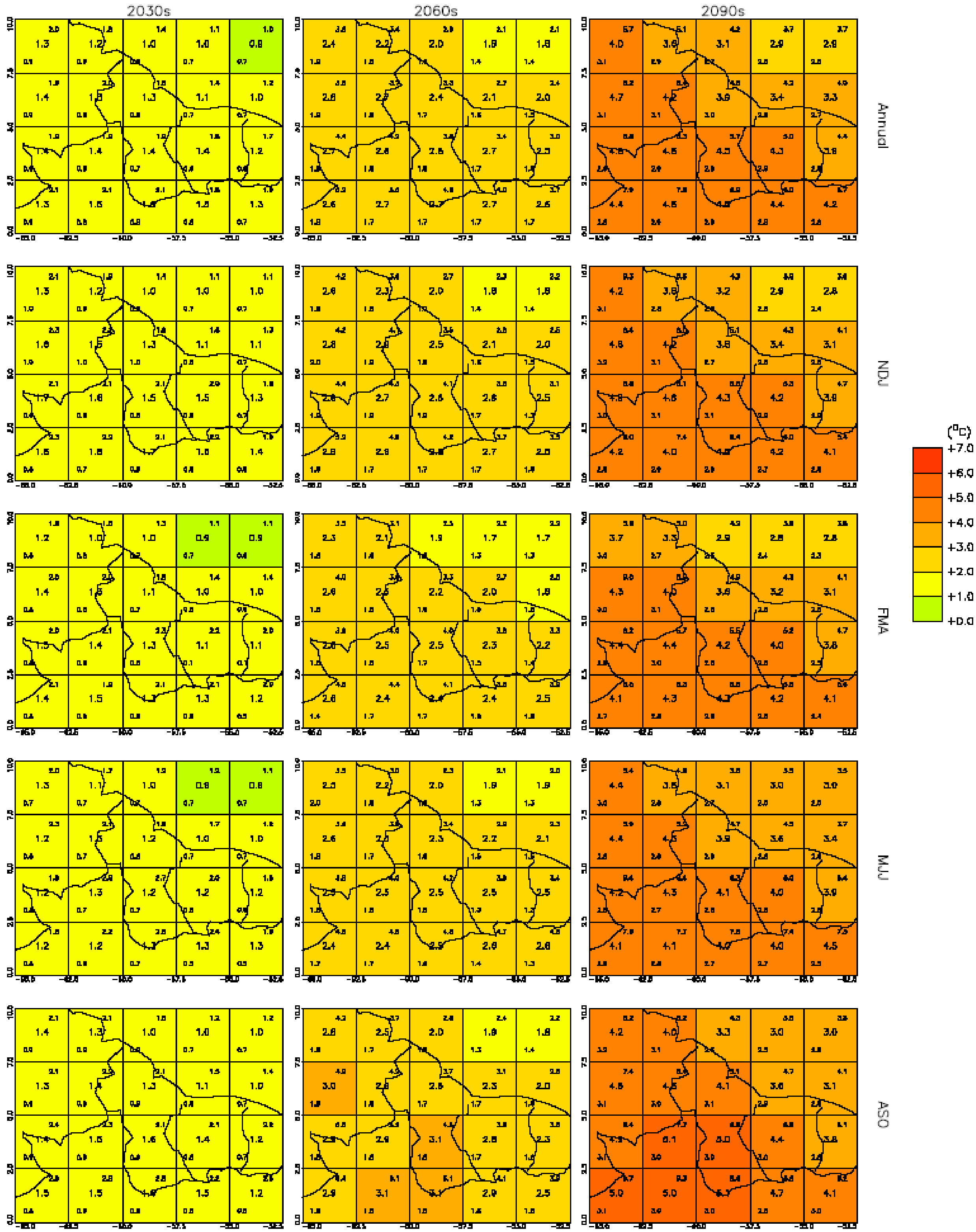

Fig. 4.3. Spatial patterns of area averaged (2.5^0 x 2.5^0) and projected (2030s; 2060s; 2090s) annual and seasonal air temperature anomalies for Guyana (referenced to 1970-1999) according to the A2 scenario. For each grid box the central value and colour give the multi-model ensemble median, and the values in the upper and lower corners give the ensemble maximum and minimum (McSweeney *et al* 2008; 2009).

Precipitation

A-OGCM projections of mean annual rainfall, from different models in the ensemble, project a wide range of changes in precipitation for Guyana. Ensemble median values of rainfall changes by the 2060s are however consistently negative for all seasons and emissions scenarios. Meanwhile, the projections of mean annual rainfall vary between a reduction of 34 % to an increase of 20 % by the 2090s, with median values of -18 (reduction) to -4 % (increase) (Table 4.4 and Fig. 4.4) (McSweeney *et al.* 2008).

Whilst the largest decreases in total rainfall are projected for the wettest season, namely May, June and July (MJJ) (-68 to +21mm per month), relative changes in projected rainfall show the strongest decreases in the dry season of August, September and October (ASO) and in the wet season of November, December and January (NDJ) (-82 to +68 %) (Table 4.4 and Fig. 4.4).

Regarding the changes in the spatial changes in rainfall into the future, according to the A2 scenario it would seem that generally, annual and seasonal rainfall would decrease slightly (~ 10 %), especially in the 2090s, and that these decreases in rainfall would mainly affect the northern half of Guyana, including the critical coastal zone (Table 4.4 and Fig.4.5).

The proportion of total rainfall that would fall in heavy events (maximum one- and five-day rainfalls) in the future (2060s and 2090s) does not show a consistent direction of change, but tends towards positive changes, particularly in the southern parts of the country in the wet season (November, December and January - NDJ) and in the dry season (February, March and April -FMA) (Table 4.4 and Fig. 4.6) (McSweeney *et al.* 2008)

Finally, A-OGCM model simulations show wide disagreement in projected changes in the amplitude or frequency of future El Niño events that have teleconnections to rainfall amounts and distributions for this region of the world (McSweeney *et al.* 2008).

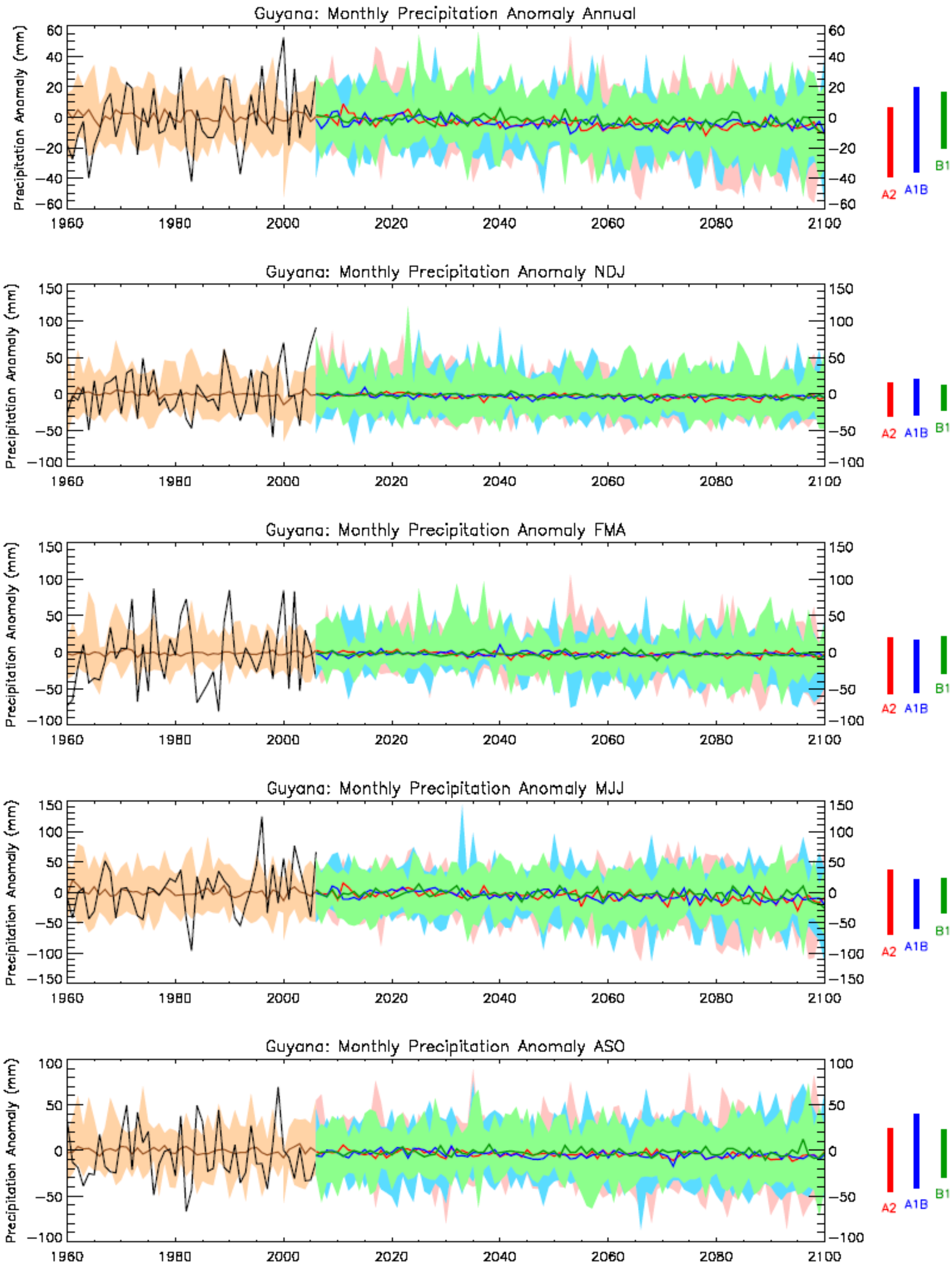

Fig. 4.4. Observed (1960-2006) and projected (to 2100) annual and seasonal air precipitation anomalies for Guyana (referenced to 1970-1999). (McSweeney *et al.* 2008; 2009.)

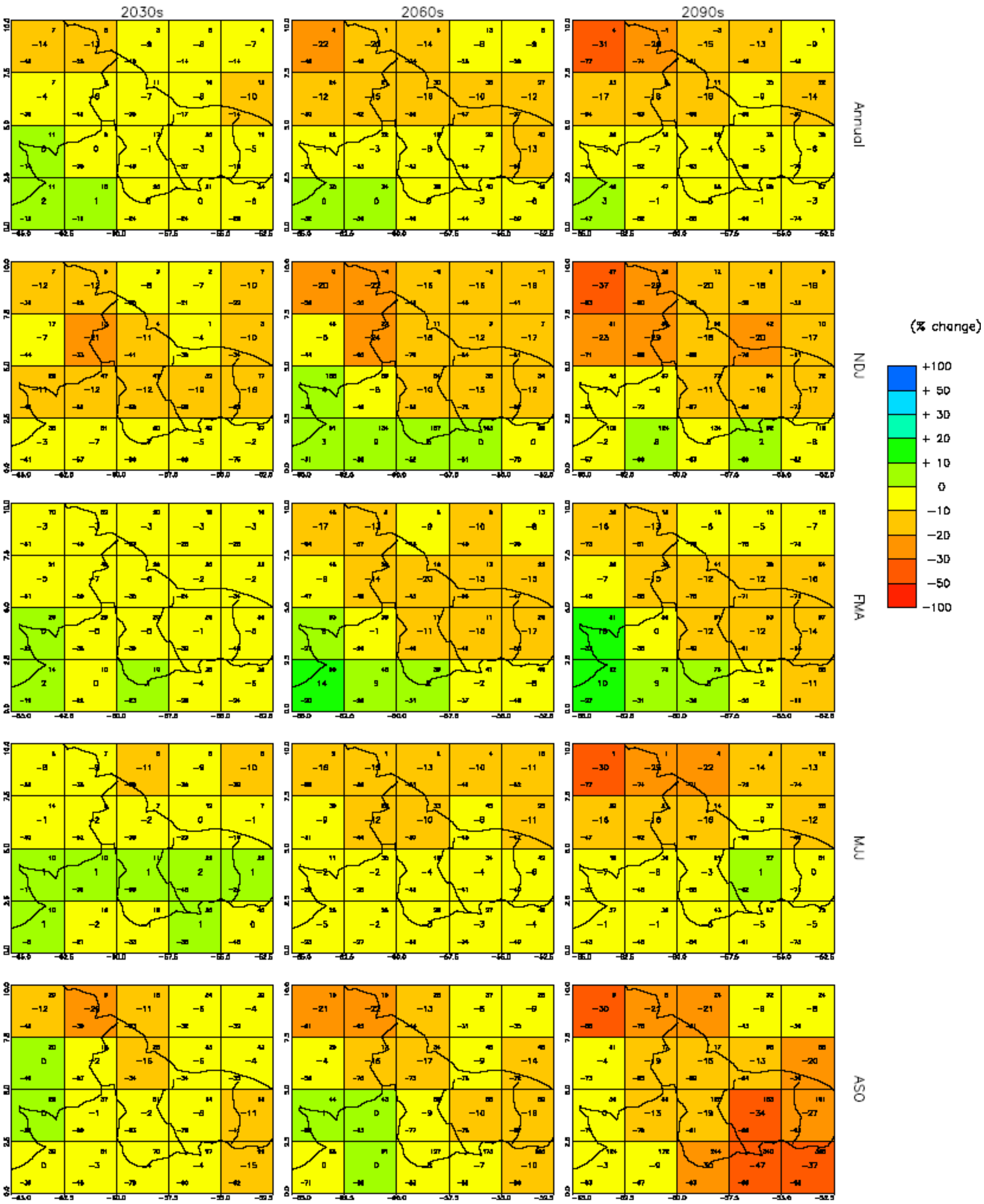

Fig. 4.5. **Spatial patterns of area averaged (2.5^0 x 2.5^0) and projected (2030s; 2060s; 2090s) change in monthly precipitation (%) for Guyana (referenced to 1970-1999) according to the A2 scenario. For each grid box, the central value and colour give the multi-model ensemble median, and the values in the upper and lower corners give the ensemble maximum and minimum. (McSweeney *et al*. 2008; 2009.)**

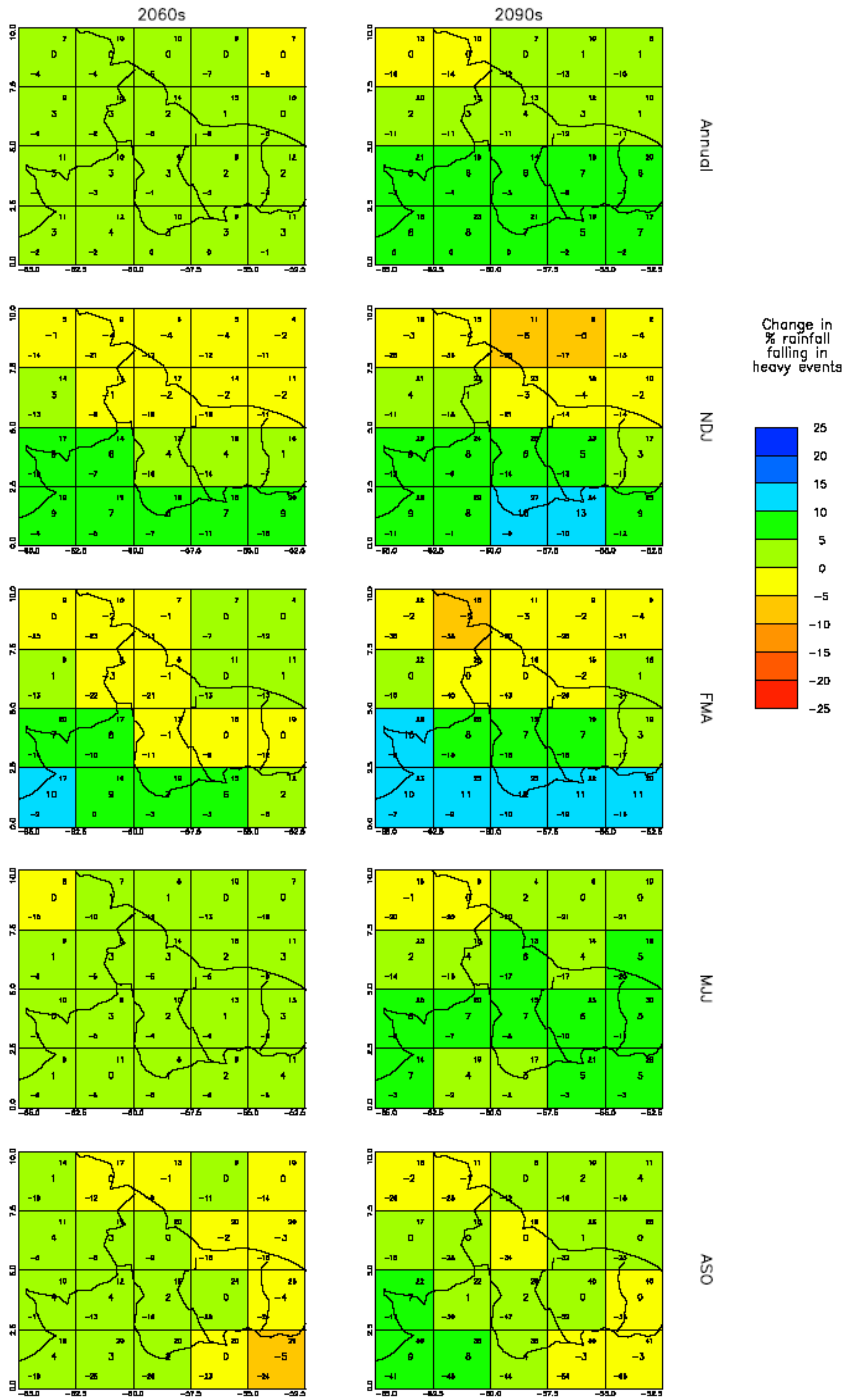

Fig. 4.6. **Spatial patterns of area averaged (2.5^0 x 2.5^0) and projected (2060s; 2090s) change in the proportion of precipitation as 'heavy' events for Guyana (referenced to 1970-1999) according to the A2 scenario. For each grid box, the central value and colour give the multi-model ensemble median, and the values in the upper and lower corners give the ensemble maximum and minimum. (McSweeney *et al* 2008; 2009.)**

The next table (Table 4.4) summarizes the observed mean (1970-1999), observed trend (1960-2006), and projected changes for the 2030s, 2060s and 2090s of air temperature (°C) and precipitation (mm/month and %) on an annual basis and according to season for Guyana.

Table 4. 4. Observed and Projected Changes for the 2030s, 2060s and 2090s of air temperature (°C) and precipitation (mm/month and %). (Source: McSweeney *et al*. 2008; 2009.)

	Observed Mean 1970-99	Observed Trend 1960-2006		*Projected changes by the 2030s* Min	Median	Max	*Projected changes by the 2060s* Min	Median	Max	*Projected changes by the 2090s* Min	Median	Max
Temperature												
	(°C)	(change in °C per decade)		*Change in °C*			*Change in °C*			*Change in °C*		
			A2	0.8	1.3	1.8	1.7	2.5	3.3	2.9	4.0	5.0
Annual	25.2	0.07*	A1B	0.6	1.5	2.0	1.3	2.6	3.2	2.0	3.3	4.6
			B1	0.4	1.1	1.4	0.9	1.7	2.3	1.4	2.2	3.0
			A2	0.9	1.4	1.8	1.8	2.4	3.6	3.1	4.0	5.1
NDJ	25.1	0.09*	A1B	0.3	1.4	2.0	1.3	2.5	3.3	2.0	3.4	4.5
			B1	0.4	1.0	1.8	0.9	1.6	2.4	1.4	2.2	3.2
			A2	0.7	1.2	1.9	1.6	2.4	3.5	2.9	3.8	5.0
FMA	25.2	0.00	A1B	0.7	1.4	2.2	1.3	2.3	3.3	2.1	3.1	4.3
			B1	0.4	0.9	1.3	0.7	1.7	2.1	1.3	2.1	2.8
			A2	0.7	1.2	1.9	1.6	2.4	3.5	2.7	4.0	5.4
MJJ	24.9	0.11*	A1B	0.6	1.3	1.7	1.3	2.4	3.2	2.0	3.3	4.4
			B1	0.3	0.9	1.7	0.8	1.6	2.9	1.3	2.1	3.2
			A2	0.9	1.4	1.8	1.7	2.7	3.7	3.0	4.4	5.6
ASO	25.6	0.10*	A1B	0.6	1.6	2.1	1.4	2.7	3.7	1.9	3.4	5.1
			B1	0.4	1.0	1.6	0.9	2.1	2.6	1.4	2.2	3.5
Precipitation												
	(mm per month)	(change in mm per decade)		*Change in mm per month*			*Change in mm per month*			*Change in mm per month*		
			A2	-12	-2	8	-25	-5	3	-39	-5	6
Annual	178.1	4.8*	A1B	-11	-2	10	-23	-5	4	-33	-4	17
			B1	-7	0	5	-14	-4	4	-21	-4	16
			A2	-15	-3	6	-21	-4	4	-29	-3	19
NDJ	135.7	6.3	A1B	-15	-1	12	-21	-4	5	-28	-5	20
			B1	-15	0	9	-20	-3	7	-23	-6	15
			A2	-8	-1	7	-28	-1	3	-56	-1	20
FMA	142.4	6.3	A1B	-20	-1	10	-40	-3	9	-56	-2	14
			B1	-7	0	13	-20	-3	5	-32	-3	21
			A2	-31	2	9	-36	-9	7	-68	-15	33
MJJ	301.3	8.1	A1B	-16	0	9	-32	-8	7	-54	-8	19
			B1	-16	0	8	-25	-2	7	-30	-6	20
			A2	-18	-2	18	-33	-4	18	-45	-8	26
ASO	132.1	-0.9	A1B	-16	-1	21	-33	-3	18	-39	-6	39
			B1	-18	-1	12	-26	-3	19	-28	-2	25
Precipitation (%)												
	(mm per month)	(change in % per decade)		*% Change*			*% Change*			*% Change*		
			A2	-29	-4	7	-41	-8	13	-63	-4	8
Annual	178.1	2.7*	A1B	-16	-4	14	-37	-8	3	-54	-5	20
			B1	-21	0	9	-26	-4	7	-34	-5	17
			A2	-37	-14	11	-60	-9	29	-82	-17	62
NDJ	135.7	4.6	A1B	-31	-7	15	-59	-13	33	-78	-12	25
			B1	-33	0	10	-42	-8	11	-63	-10	19
			A2	-22	-2	17	-33	-5	28	-45	-6	49
FMA	142.4	4.4	A1B	-26	-8	26	-30	-9	23	-42	-12	34
			B1	-19	-2	33	-28	-11	12	-32	-9	52
			A2	-38	2	5	-39	-6	11	-55	-10	14
MJJ	301.3	2.7	A1B	-10	-1	6	-29	-8	2	-44	-6	15
			B1	-20	0	7	-31	-1	4	-37	-6	15
			A2	-34	-10	22	-69	-9	21	-82	-18	27
ASO	132.1	-0.7	A1B	-32	-4	51	-65	-9	24	-80	-15	54
			B1	-31	-1	21	-48	-9	25	-76	-10	33

The observed climate shows that Guyana has already experienced an increase in air temperature since 1960, and projections of future climate indicate that Guyana will undergo significant changes in climate in future years.

The IPCC marker scenarios (A2; A1B; B1) all project air temperature increases approaching 2° to 4^{0}C by the end of this century. On the other hand, rainfalls would seem to remain unchanged or decrease slightly for all seasons, and the variability of rainfall, both temporal and spatial, is expected to change considerably.

4.2.2 Sea-level rise and storm surges for coastal zone impact assessment

A-OGCM projections for sea-level rise and storm surges

For Guyana, the HadCM3 scenario of relative sea-level rise gives lower estimates of sea-level rise than the CGCM2 for the three time periods (Table 4.5). The sea-level rise projections for 2031 vary from 14 cm (HadCM3) to 26 cm (CGCM2). For 2051 the sea-level rise goes from 21 cm (HadCM3) to 43 cm (CGCM2). Finally, for the year 2071, the scenario of relative sea-level rise goes from 25 cm (HadCM3) to 51 cm (CGCM2).

Given the fact that there is minimal difference in sea-level rise between the two A-OGCMs between the period 2031-2071 compared to the minimum and maximum storm surge, two generalized storm surge scenarios were created by superimposing the minimum storm surge (2 m) and the maximum storm surge (5 m) on the average of sea-level derived from CGCM2 and HadCM3 and averaged over the 2031-2071 time period (Table 4.6).

For the year 2031, according to the minimum storm surge scenario, the final storm surge height varies from 2.82 m (HadCM3) to 2.94 m (CGCM2), whereas in the maximum scenario, the projections vary from 5.82 (HadCM3) to 5.94 (CGCM2).

Nevertheless, in the last period projected, 2071, according to the minimum storm surge scenario, the final storm surge height varies from 2.93 m (HadCM3) to 3.19 m (CGCM2), while in the maximum scenario, it varies from 5.93 (HadCM3) to 6.19 (CGCM2).

Hence, the final storm surge height from the HadCM3 model estimates an increase of 11 cm from 2031 to 2071 for the minimum and maximum scenarios. Conversely, the CGCM2 estimates an increase of 25 cm from 2031 to 2071 for both scenarios.

Outputs of sea-level rise presented in this section are part of the Methodology for Constructing a Digital Elevation Model (DEM) for Sea-Level Rise and Storm Surge for the coastal zone impact assessment, described in Section 4.3.1. This methodology allows for the analysis of intrusions in the coastal zone of Guyana deriving from sea-level rise and storm surges.

Table 4.5. Estimates of future sea-level rise for the area surrounding the coastal zone of Guyana using the CGCM2 and HADCM3 model outputs as a basis

Year	Contribution	HadCM3	CGCM1
2031	Main -thermal expansion (cm)	9.8	18.2
	Other factors (cm) [(a)]	13.5	25.3
	Final value (cm) [(b)]	14	26
2051	Main -thermal expansion (cm)	14.9	24.5
	Other factors (cm) [(a)]	20.5	33.7
	Final value (cm) [(b)]	21	34
2071	Main -thermal expansion (cm)	17.6	36.8
	Other factors (cm) [(a)]	24.2	50.6
	Final value (cm) [(b)]	25	51

(a). Multiply by 1.375; (b). Rounded value.

Table 4.6. Final storm surge heights used to simulate maximum and minimum storm surge impacts according to the CGCM2 scenario and HadCM3 scenario

Year	Scenario	HadCM3	CGCM2
2031	Minimum (m)	2.82	2.94
	Maximum (m)	5.82	5.94
2051	Minimum (m)	2.89	3.02
	Maximum (m)	5.89	6.02
2071	Minimum (m)	2.93	3.19
	Maximum (m)	5.93	6.19

4.2.3 Rainfall patterns and evapotranspiration projections for the water sector

This sub-section presents the projected rainfall patterns and evapotranspiration for the period 2040 – 2069 that would cause water excesses or deficits. The evaluation has been done for three Regions (5, 6 and 10), as detailed below. The results have been used as an input for the vulnerability and adaptation assessment of the water sector. (See section 4.3.3.)

Methodology

The methodology consists in using measured rainfall data and calculated evapotranspiration (ET) for the current period (1961-1990) for three stations within the study area, for which data was available, and which provided an adequate spatial dispersion to allow for downscaling using SDSM; namely the Timehri (Region 5: 6º30' Lat. N and 58º15' Long.W); the New Amsterdam (Region 6: 6º14' Lat. N and 57º31' Long. W) and the Ebini (Region 10: 5º33' Lat. N and 57º46' Long. W) stations. (Fig. 4.7.)

For the future period the downscaled (SDSM: Statistical DownScaling Model) temperature and rainfall data from two A-OGCMs, namely the CGCM1 and the HadCM3 models were used. The calculation of Evapotranspiration (ET) is based on the Thornthwaite equation (Thornthwaite 1948), due to its simplicity, requiring mean monthly temperature (^{0}C) and mean monthly sunshine hours, and its ability to provide reasonable estimates of ET in humid tropical regions (Alkaeed *et al.* 2006). Since sunshine hours are not available for the future period, regression equations were developed between observed evaporation pan data and maximum and minimum temperature, and these were used to estimate ET for the future period (Alkaeed *et al*. 2006).

Precipitation (P) and evapotranspiration (ET) and their differences (P-ET)

At the stations selected within the study zone (Timehri, New Amsterdam and Ebini), the down-scaled CGCM1 and HadCM3 future climate scenarios for the 2040-2069 period, when compared with the current climate generally, show increases in temperature and decreases in rainfall.

These increases in temperature could eventually lead to increases in evapotranspiration (ET), and when combined with decreases in rainfall (P), these would result in increased water deficits (P-ET), and potential shortages of water for agricultural, domestic and industrial purposes.

The projections for the three stations on average changes in temperature show that this increase is superior for the average minimum temperature, in the CGCM1 and HadCM3 models, than for the average maximum temperature. The HadCM3 model appoints lower temperature increase for the Tmin and Tmax than the CGCM1 model at the Timehri and New Amsterdam stations. Conversely, at the Ebini station, the HadCM3 model assigns considerably higher temperature increase for the Tmin (1.50˚C) and Tmax (1.10˚C) than the CGCM1 model (Table 4.7).

Moreover, the average changes in rainfall, for both models, display a decrease that varies between -7˚C to -9.7˚C for the three stations. Both models assign a lower decrease at the Timehri and New Amsterdam Stations in comparison with the Ebini station (Table 4.7).

Fig. 4.7. Stations chosen for the water sector (Source: Google Earth)

Table 4.7. Average changes in temperature and rainfall for Timehri, New Amsterdam and Ebini stations for future climate (2040-2069)

Climate station	Tmin (˚c)		Tmax (˚c)		Rainfall (%)	
	CGCM1	Hadcm3	CGCM1	Hadcm3	CGCM1	Hadcm3
Timehri	1.11	1.1	1.09	0.7	-8	-7
New Amsterdam	1.09	0.9	1.05	0.5	-8.3	-7.4
Ebini	1.04	1.5	1	1.1	-8.9	-9.7

At the Timehri station, Tmin (average monthly minimum temperature) increases by 1.11^{0}C and Tmax (average monthly maximum temperature) increases by 1.09^{0}C according to CGCM1, while Tmin increases by 1.10^{0}C and Tmax increases by 0.70^{0}C according to HadCM3. On the other hand, rainfall decreases by 7 and 8 % according to HadCM3 and CGCM1 (Table 4.7 and Figs. 4.8; 4.9 and 4.10).

For the New Amsterdam station, Tmin increases by 1.09^{0}C and Tmax increases by 1.05^{0}C according to CGCM1, while Tmin increases by 0.90^{0}C and Tmax increases by 0.50^{0}C according to HadCM3. On the other hand, rainfall decreases by 8.3 % according to CGCM1 and by 7.4 % according to HadCM3 (see Figs. 4.11; 4.12 and 4.13).

Finally, for the Ebini station, Tmin increases by 1.04^{0}C and Tmax increases by 1.0^{0}C according to CGCM1, while Tmin increases by 1.5^{0}C and Tmax increases by 1.10 ^{0}C according to HadCM3. On the other hand, rainfall decreases by 8.9 % according to CGCM1 and by 9.7 % according to HadCM3 (see Figs. 4.14, 4.15 and 4.16 below).The high degree of volatility in precipitation and the spikes in evapotranspiration in some sites are very likely due to modelling errors.

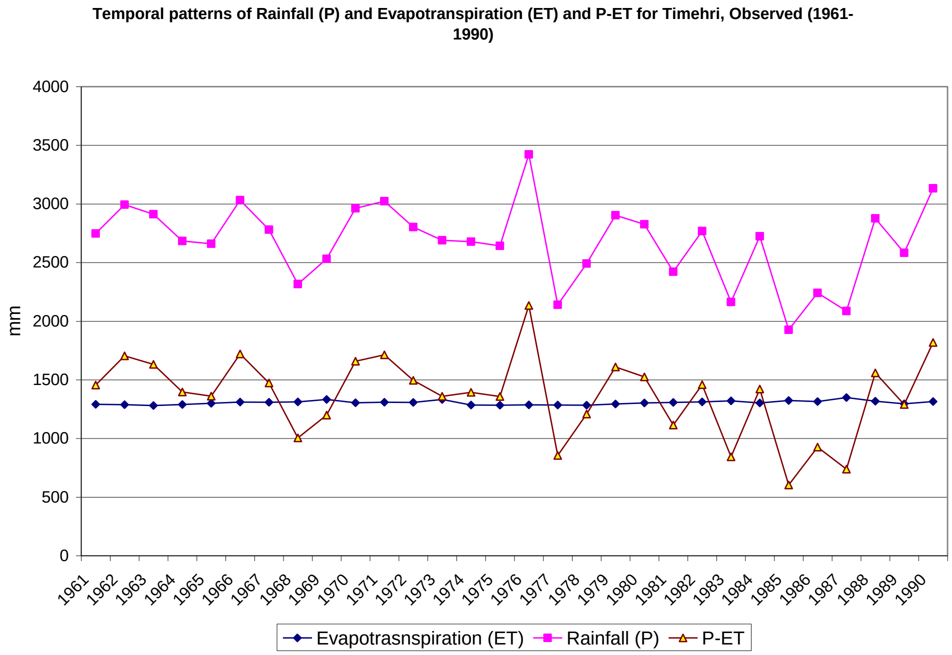

Fig. 4.8. Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for Timehri, observed (1961-1990).

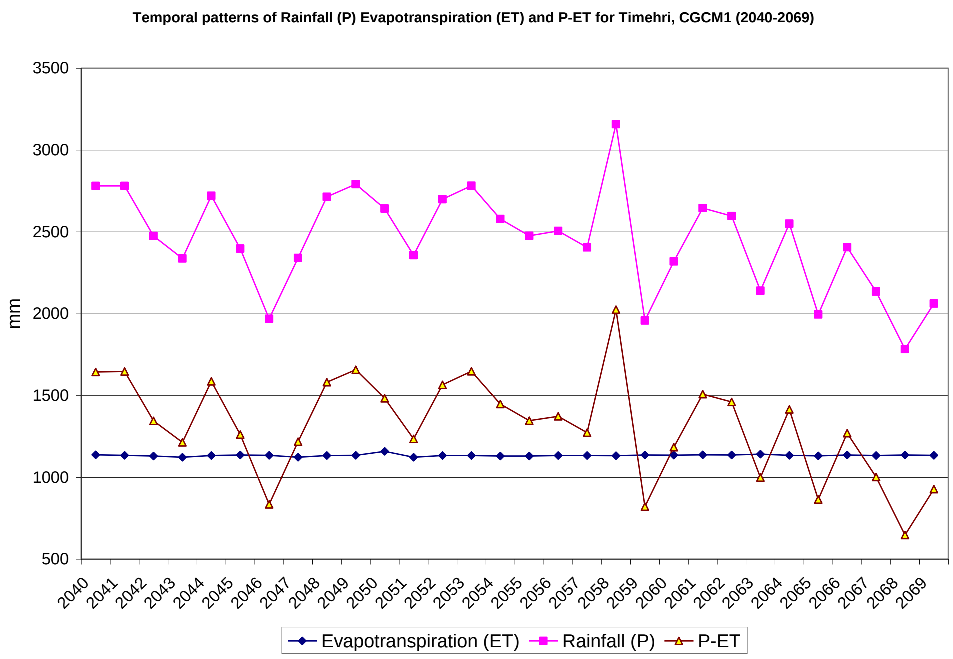

Fig. 4.9. Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for Timehri, CGCM1 (2040-2069).

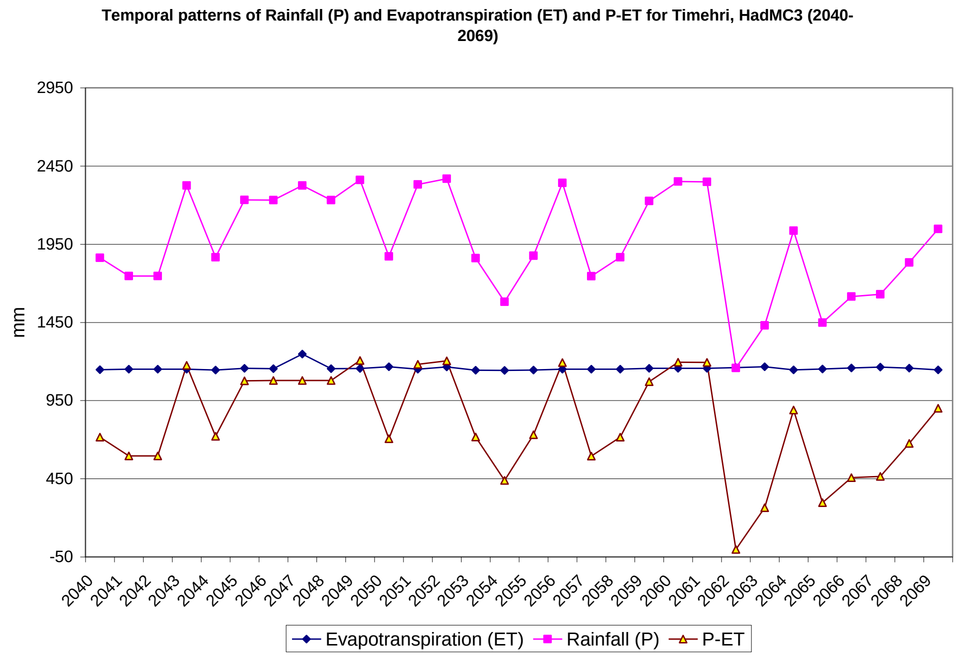

Fig. 4.10. Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for Timehri, HadCM3 (2040-2069).

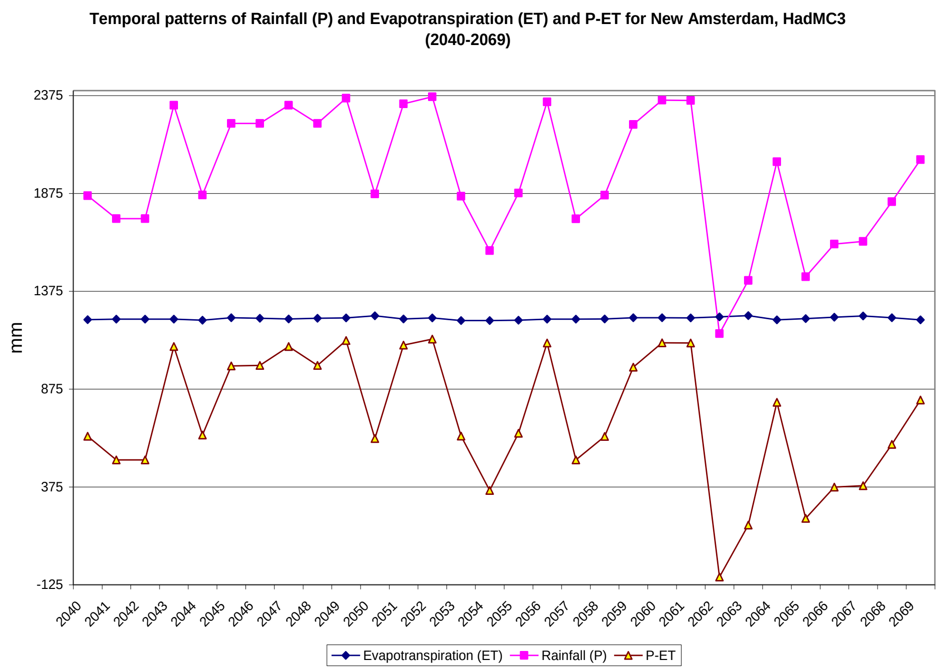

Fig. 4.11. Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for New Amsterdam, HadCM3 (2040-2069).

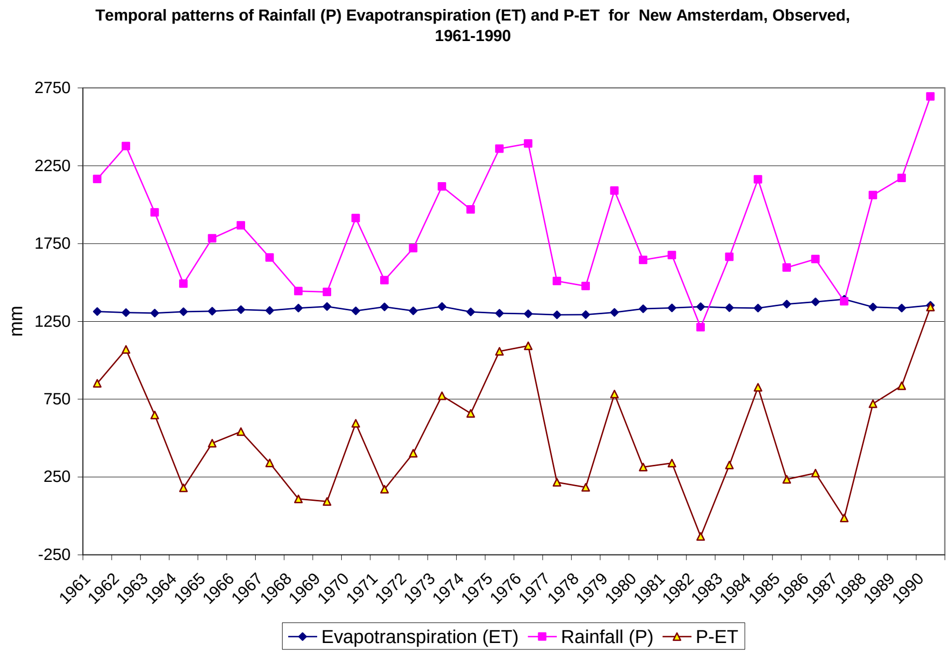

Fig.4.12. Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for New Amsterdam, observed (1961-1990).

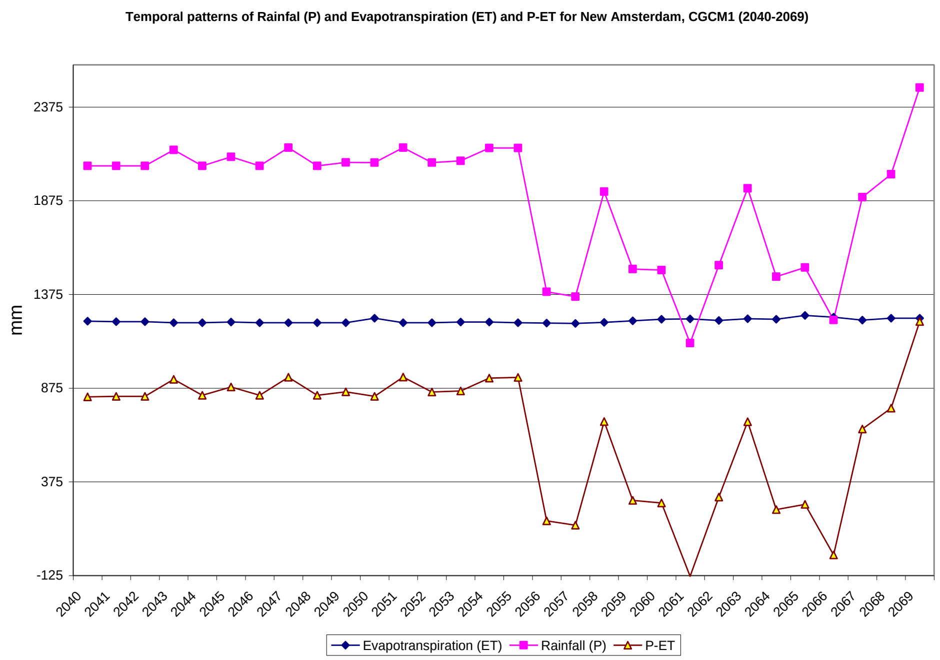

Fig.4.13. Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for New Amsterdam, CGCM1 (2040-2069).

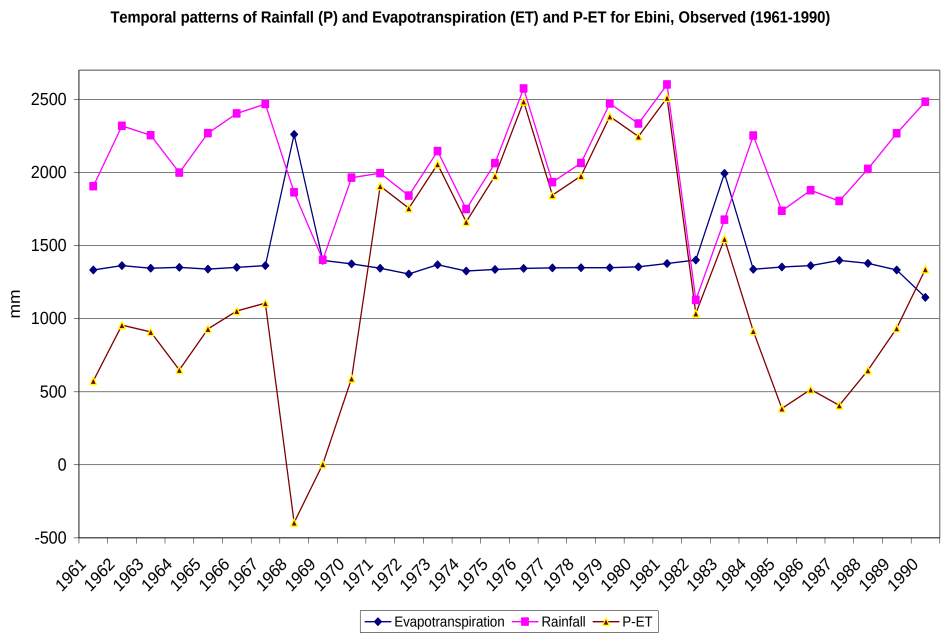

Fig.4.14 **Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for Ebini, observed (1961-1990)**

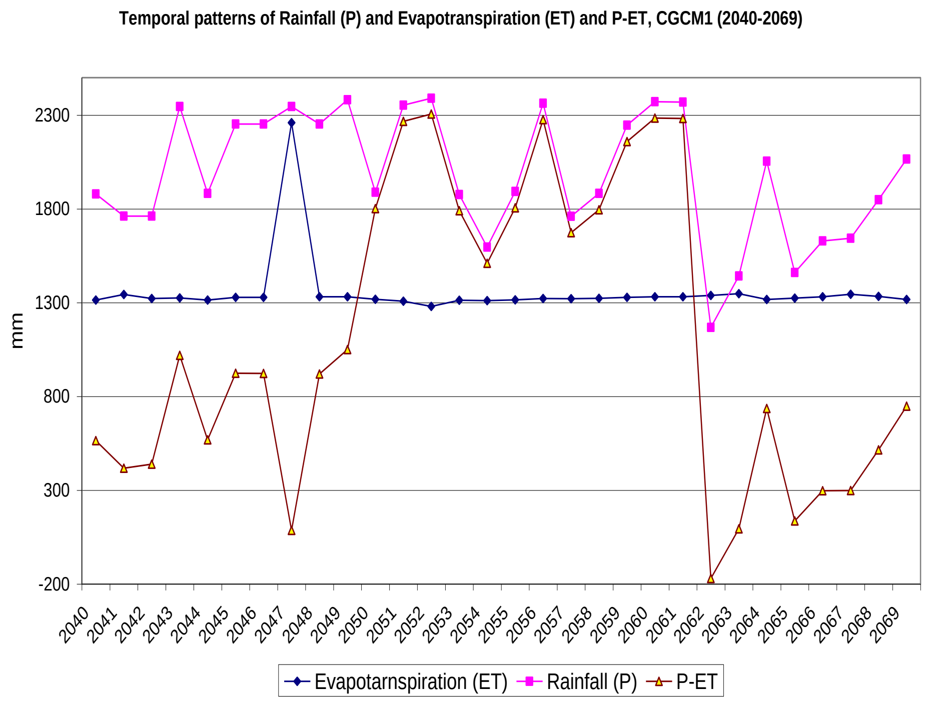

Fig. 4. 15 **Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for Ebini, CGCM1 (2040-2069).**

Temporal patterns of Rainfall (P) and Evapoyranspiration (ET) and P-ET for Ebini, HadMC3 (2040-2069)

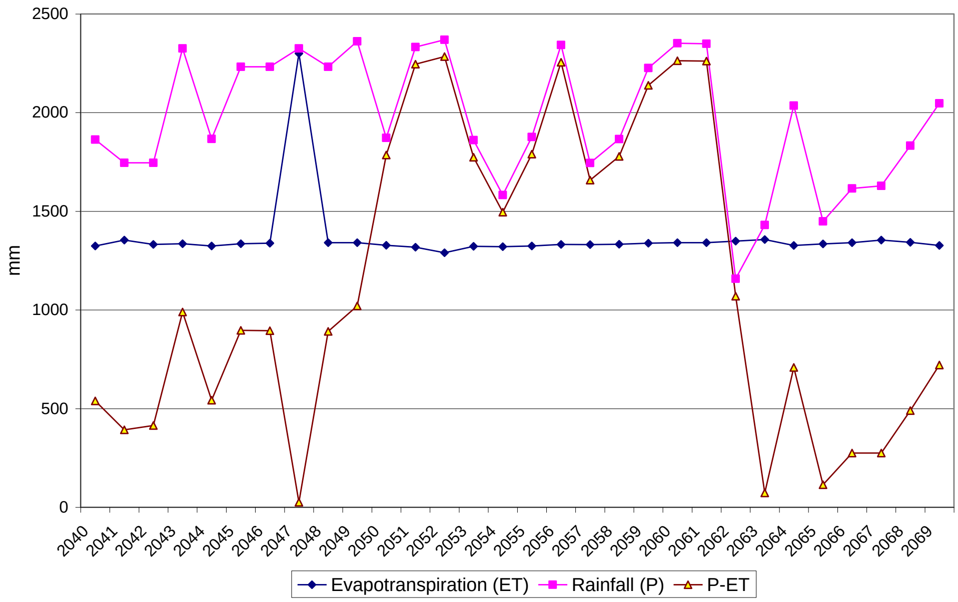

Fig.4.16 Temporal patterns of rainfall (P), evapotranspiration (ET) and P-ET for Ebini, HadCM3 (2040-2069)

Precipitation, evapotranspiration and water deficits

When analyzing monthly patterns, the two down-scaled climate scenarios (CGCM1 and HadCM3) both project significant changes in rainfall (P) and evapotranspiration (ET), and consequently in Water Deficits (P-ET) for all three stations selected, namely Timehri, New Amsterdam and Ebini.

The Timehri station projects an increase in water deficit for all months, whereas New Amsterdam presents a decrease.

For the Timehri station, both the CGCM1 and the HadCM3 project significant changes in monthly rainfall for almost all months of the year. CGCM1 **projects decreases in rainfall for all months, except May (2.47 mm/month) and October (4.82 mm/month)** for the period 2040-2069, with decreases in rainfall ranging from -6.07 mm/month (December) to -40.18 mm/month (January). The HadCM3 projects even greater rainfall decreases and for all months of the year with values ranging from -23.16 mm/month (April) to -95.22 mm/month (November), and thus drier conditions in the dry seasons.

For monthly **evapotranspiration (ET),** as would be expected with the warmer climate, **CGCM1 projects increases for all months,** for the period 2040-2069, with increases ranging from 0.17 mm/month (October) to 4.39 mm/month (January). Similarly, **the HadCM3 also projects increases in ET for all months of the year except January,** with values ranging from 0.93 mm/month (April) to 9.33 mm/month (November), during the dry seasons. (Table 4.8 and Fig. 4.9 and 4.10)

As a consequence, water deficits (P-ET) increase substantially for almost all months. CGCM1 projects increasing water deficits (P-ET) for all months, except May and October, for the period 2040-2069, with increases in P-ET ranging from -7.3 mm/month (August) to -44.57

mm/month (January). However, the HadCM3 projects even greater increases in P-ET for all months of the year, with values ranging from -24.08 mm/month (April) to -104.55 mm/month (November), during the dry seasons. (See Table 4.8 below.)

Table 4.8. **Summary of monthly data for evapotranspiration (ET), rainfall (P) and water deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and HadCM3) for the Timehri station (mm/month)**

EVAPOTRANSPIRATION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET-61_90	83,28	76,78	89,34	93,08	95,65	90,32	93,47	100,35	98,75	104,09	95,76	87,43
ET_40-69-CGCM1	87,67	80,78	92,61	94,43	97,01	92,28	96,29	100,89	100,06	104,26	96,05	91,01
ET_40-69-HadMC3	81,99	78,14	91,08	94,01	98,78	95,6	97,23	104,57	103,88	111,04	105,09	94,37
ET_40-69-CGCM1-ET_61-90	4,39	4	3,27	1,35	1,36	1,96	2,82	0,54	1,31	0,17	0,29	3,58
ET_40-69-HadMC3_ET-61-90	-1,29	1,36	1,74	0,93	3,13	5,28	3,76	4,22	5,13	6,95	9,33	6,94

RAINFALL

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P-61_90	240,34	128,36	145,63	187,78	327,6	334,47	316,9	229	156,47	153,13	182,99	269,68
P_40-69-CGCM1	200,16	94,77	121,51	164,32	330,1	300,36	292,2	222,2	130,31	157,95	172,65	263,61
P_40-69-HadMC3	152,85	84,47	120,75	164,62	243,5	267,11	288,2	180,1	114,73	71,32	87,77	187,96
P_40-69-CGCM1-P_61-90	-40,18	-33,59	-24,12	-23,46	2,47	-34,11	-24,7	-6,76	-26,16	4,82	-10,34	-6,07
P_40-69-HadMC3_P-61-90	-87,49	-43,89	-24,88	-23,16	-84,05	-67,36	-28,7	-48,8	-41,74	-81,81	-95,22	-81,72

PRECIPITATION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P-ET-61_90	157,06	51,57	56,29	94,69	231,93	244,15	223,42	128,59	57,73	49,04	87,23	182,24
P-ET_40-69-CGCM1	112,49	13,99	28,91	69,88	233,1	208,08	195,94	121,29	30,25	53,69	76,59	172,61
P-ET_40-69-HadMC3	70,86	6,33	29,67	70,61	144,8	171,51	190,93	75,54	10,85	-39,72	-17,32	93,59
P-ET_40-69-CGCM1-P-ET_61-90	-44,57	-37,58	-27,38	-24,81	1,12	-36,07	-27,48	-7,3	-27,48	4,65	-10,64	-9,63
P-ET_40-69-HadMC3_P-ET-61-90	-86,2	-45,24	-26,62	-24,08	-87,18	-72,64	-32,49	-53,05	-46,88	-88,76	-104,55	-88,65

WATER DEFICIT (P-ET)

Unlike the Timehri station, for the New Amsterdam station, both the CGCM1 and the HadCM3 project significant positive changes in monthly rainfall for almost all months of the year. CGCM1 projects increase in rainfall for some months, for the period 2040-2069, with increases in rainfall ranging from 21.73 mm/month (March) to 130.19 mm/month (January), and decreases in rainfall for other months, with decreases in rainfall ranging from -12.02 mm/month (December) to -66.4 mm/month (July). The HadCM3 projects even greater rainfall increases and for all months of the year, except for October (-1.88 mm/month), December (-17.12 mm/month), January (-14.23 mm/month), February, (-6.55 mm/month) and April (-2.23 mm/month), with increases in monthly rainfall ranging from 0.27 mm/month (June) to 66.79 mm/month (July), during the wet seasons.

Presumably, on account of the cloudier and wetter climate for the future period (2040-2069), monthly evapotranspiration (ET) decreases for all months according to both down-scaled climate scenarios. CGCM1 projects decreases in ET for all months, with decreases in ET ranging from -2.72 mm/month (January) to -14.73 mm/month (October). Similarly, the HadCM3 projects decreases in ET for all months of the year, with values ranging from -1.19 mm/month (June) to -14.44 mm/month (March). (See table and figure in the Annex to this document.)

In response to cloudier and wetter conditions, water deficits (P-ET) get generally less for the period 2040-2069. CGCM1 projects increasing water deficits (P-ET) for the months of April (-7.36 mm/month), June (-39.4 mm/month), July (-59.6 mm/month), August (-53.15 mm/month), September (-24.78 mm/month), November (-12.12 mm/month) and December (-6.52 mm/month), and decreasing water deficits for the other months, namely January (132.91 mm/month), February (108.77 mm/month), March (28.29 mm/month), May (68.5 mm/month), and October (2.26 mm/month). Similarly, the HadCM3 also projects increases (P-ET) for almost all months of the year, with values ranging from 1.47 mm/month (June) to 72.95 mm/month (July), with only the months of December (-15.61 mm/month) and January

(-3.24 mm/month) projecting decreases in P-ET. (Table A4.4.2 and Figure A4.4.6 in Appendices.)

Finally, **the Ebini station** presents a scenario that is in-between the situations for the Timehri and New Amsterdam stations. **CGCM1 projects decreases in rainfall for all months**, except February (1.61 mm/month), March (12.33 mm/month), April (0.56 mm/month), and December (9.31 mm/month), for the period 2040-2069, with decreases in rainfall ranging from -4.01 mm/month (January) to -26.52 mm/month (June). The HadCM3 also generally projects rainfall decreases for all months of the year, except February (0.86 mm/month), March (11.26 mm/month), and December (7.65 mm/month), for the period 2040-2069, with decreases in rainfall ranging from -0.9 mm/month (April) to -28.89 mm/month (June).

For monthly evapotranspiration (ET), **CGCM1 projects decreases in ET for all months, except January** (1.74 mm/month) and **February** (1.50 mm/month) for the period 2040-2069, with decreases in ET ranging from -0.52 mm/month (June) to -14.26 mm/month (November). Similarly, the HadCM3 also projects decreases in ET for all months, except January (2.47 mm/month), February (2.23 mm/month), and June (0.37 mm/month), for the period 2040-2069, with decreases in ET ranging from -0.24 mm/month (May) to -13.63 mm/month (November).

As a consequence, water deficits (P-ET) generally decrease for almost all months. CGCM1 projects decreasing water deficits (P-ET) for all months, except March (9.23 mm/month) and December (6.14 mm/month), for the period 2040-2069, with decreases in P-ET ranging from -1.79 mm/month (February) to -29.81 mm/month (June). Similarly, the HadCM3 projects decreasing water deficits (P-ET) for all months, except March (11.15 mm/month) and December (7.7 mm/month), for the period 2040-2069, with decreases in P-ET ranging from -0.08 mm/month (February) to -29.0 mm/month (June). (See figures and tables in the Annex.)

4.2.4 Conclusions

According to the results of projections derived from the scenarios, Guyana will experience increases in temperature, increased rainfall in the rainy season and less precipitation in months where there are already water deficits.

Mean annual air temperature in Guyana has increased by 0.3°C since 1960, and projections of future climate indicate that this will have significant consequences for climate in future years, with temperature rising from 2°C to 4^{0}C by the end of this century. It seems that the increase in temperature will be higher for the average monthly minimum temperatures than for the average monthly maximum temperatures.

The climate scenarios show that the country could experience mean annual rainfall decrease. The rainfall patterns would experience considerable temporal and spatial change along the country. Guyana may suffer water deficits in October and November, as projected for the 2040-2069 period.

Furthermore, Guyana's low-lying coastal plains will be under the foremost threat of sea-level rise deriving from climate change. The projections show that by 2031 the increase in sea-level could reach 26 cm, and for 2071 it could be up to 51 cm. In addition, by 2031 storm surges could result in a 2.94 cm sea-level rise (in a moderate scenario), and up to 5.94 cm (in a catastrophic scenario).

As explained in the next Sub-chapter, these changes may translate into ecosystems disruptions, floods, landslides, storm surges and droughts, among other impacts. These threats will impose severe social and economic constraints on Guyana, and will need to be addressed with adaptation policies and measures.

4.3 Vulnerability and Adaptation Assessments

The vulnerability assessments were carried out at two levels: (i) at a territorial level, focusing on the coastal plain as the territory that holds Guyana's main social and economic assets; (ii) at a sectoral level, including: a) agriculture and water, where quantitative and qualitative analyses were carried out, using the information from the scenarios and projections described in Section 4.2; and b) an initial qualitative analysis of prioritized sectors such as fisheries, health, energy, forestry and tourism.

For the territorial analysis, the focus is the coastal plain, vulnerable to sea-level rise and occurrences of flooding. The coastal zone analysis focuses on the susceptibility of this area to the physical and ecological changes imposed by sea-level rise and storm surges, flooding, erosion, saline intrusion into surface and ground water sources, among others. Hence, land loss is assessed according to use. Human settlements are also analyzed as part of this territorial assessment, considering this is the most populated and vulnerable area. Human settlements in Guyana are mainly exposed to rising sea-levels and flooding. Although these are the main threats, climate change would also cause a decrease in annual and seasonal rainfall, possibly leading to seasonal droughts that could force inland farmers to migrate to the coastal zone, which is also analyzed.

The sectoral analysis aims at examining the underlying vulnerabilities and expected climate change impacts for the different scenarios in several sectors of importance to Guyana's economic and social development. This section also includes the main adaptation measures in response to climate change impacts in each sector. For this, the sectoral analysis presents a brief description of the sector; identifies the main climate threats using the climate and sea-level rise projections (Section 4.2) where available and applicable; analyzes Guyana´s exposure to these, and evaluates the sector´s vulnerability in relation to its importance for the population and the economy.

4.3.1 Part 1: Territorial Analysis

Coastal Zone

Description and scope of the analysis

The Second, Third and Fourth Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (IPCC 1990; 2001; 2007) indicate that countries that contain extensive, low-lying coastal zones, such as Guyana, are likely to be among the communities most vulnerable to the adverse impacts of climate change.

Guyana is a country with sparsely inhabited interiors, and populations concentrated on a small coastal strip that constitutes 5 % of its territory. In fact, 90 % of its inhabitants reside on the coastal plain where the main urban centres and assets are located, and where the main industrial and commercial activities take place. Of that percentage, 61 % of the population lives within the low elevation coastal zones of the country (Mason 2011). Coastal assets include major infrastructure (especially crucial drainage and irrigation systems), mangrove ecosystems that stabilize the coast, purify runoff water and serve as an invaluable habitat for various flora and fauna, agriculture (one of the major contributors to GDP), roads and communication networks. 43 % per cent of Guyana's GDP is produced in regions exposed to significant flooding risk (Office of the President, Republic of Guyana, 2009).

Human settlements have long been drawn to coastal zones, because these areas provide land for housing, many resources, and trading opportunities. In the specific case of Guyana, higher population densities are observed in Georgetown, the capital city, and in adjoining areas, due to the proximity and closer links with the important urban centre. Major highways and secondary roads are also concentrated on this narrow coastal strip.

Regarding dwellings conditions, the 2002 census reported that 31.7 % of the houses were built before 1970. Six in every ten households in Guyana used wood to construct the outer wall of their dwellings and the number of households using concrete or a combined use of concrete and wood in construction has increased. It is estimated that the 2005 flooding severely affected 70,000 dwellings located in Regions 3, 4 and 5, which comprise 62 % of the total population (ECLAC 2005). The 2005 disaster costed the housing sector of Guyana almost US$250 million (Trotman, A. and Mehdi, B. 2008).

Past events such as the 2005 flooding show that all resources and activities performed in the coastal plain are extremely sensitive to climate change, because, in the event of a likely sea-level rise, inundation and flooding, erosion, and saline intrusion into surface and ground water sources would very likely occur. Though there is more than ample space in the interior of Guyana, economic resources and poor soils make displacement to the interior difficult.

For the coastal zone vulnerability and adaptation assessment, the study area is centred on and around the capital city of Georgetown, and covers Regions 3 and 4 and parts of Regions 2 and 5, stretching from Spring Garden to New Amsterdam (see Figure 4.17). Focusing on the coastal plain as the territory that holds Guyana's main social and economic assets, the assessment was carried out through a quantitative approach that was based on the calculation of potentially 'lost land' (in Ha) for the different land uses. These were in the categories of mainly residential, of different agricultural crops, and of grazing and uncultivated land, 'lost' due to inundation under different climate change scenarios. Inundation is considered the impact derived from the two main climate change impacts: sea-level rise and storm surges. Although Guyana is located well south of the active hurricane belt in the northern Atlantic, it is not uncommon for swells and storm surges, triggered by these northerly storms, to affect the Atlantic coastal zone of Guyana. Information on projections for these impacts has already been described in Section 4.2.

A qualitative analysis is also made taking into account the main features of human settlements (dwellings, infrastructure, and goods) in the coastal plain, and how these could be affected by climate change.

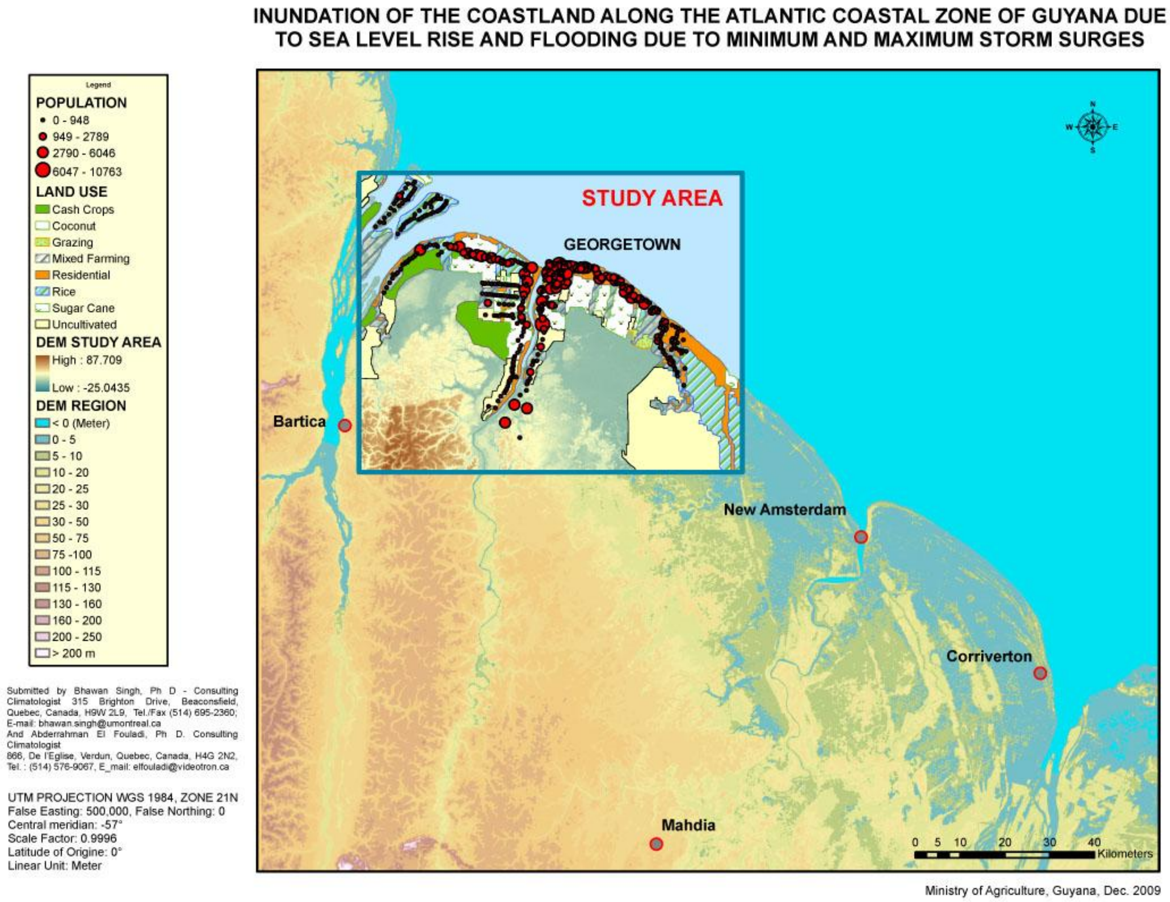

Fig. 4.17. The selected study area on the coastal zone of Guyana

Methodology for constructing DEM for sea-level rise and storm surge for the coastal zone impact assessment

The methodology used for the sea-level rise and storm surge is the Digital Elevation Model (DEM), which is a virtual representation of the topography that allows the analysis and visualization of spatial behaviour, and the evolution of the various physical and land-use phenomena. In this study, the DEM allows for the analysis of intrusions deriving from sea-level rise and storm surges, according to the different scenarios of future sea-levels and wind-driven surges along the Atlantic Ocean coastal zone of Guyana.

Results of the impact analysis of sea-level rise on the coastal zone

Guyana´s coast represents a highly dynamic nexus between land and sea, which is adjusting over time to a range of drivers, including climate change, sea-level rise, and storm surges. Climate change and climate-driven sea-level rise impose additional threats to coastal systems already under pressure from population concentration, and increasing population growth in the future.

In fact, the concept of vulnerability applied to the Coastal Zone comprises:

- The susceptibility of the coastal zone to the physical and ecological changes imposed by sea-level rise
- The potential impacts of this natural system's changes on the socio-economic system
- The capacity to cope with the impacts, including the possibility of preventing or reducing impacts through adaptation measures.

The impact analysis of the coastal zone has been done by estimating how many hectares of different land uses (residential, various crops, grazing land, and uncultivated lands) would be inundated due to sea-level rise, under two A-OGCMs (HadCM3 and CGCM2), and taking into account three scenarios: a) sea-level rise without storm surges; b) sea-level rise with a storm surge of 2 m; c) sea-level rise with a storm surge of 5 m as shown below (Table 4.9) and previously presented in Section 4.2.

Sea-level rises range under different scenarios: in 2031, from 14 cm to 5.94 meters; in 2051, from 21 cm to 6.02 metres; and in 2071, from 25 cm to 6.19 metres.

Results of the impact assessment of the different previously presented scenarios show that a significant portion of hectares would be inundated in the coastal zone, as shown in Table 4.10 below.

Under the most conservative sea-level rises (Scenario **a.** of Table 4.9, that range from 14 cm in 2031 to 51 cm in 2071), the most affected areas would be the residential land and rice cultivation land, with respectively up to 1,347 Ha and 1,068 Ha affected in 2031; and up to 1,854 Ha and 2,674 respectively in 2071 (Table 4.11).

When analysing the impact of sea-level rise scenarios b and c, which consider minimum and maximum storm surges coupled with the two A-OGCM models, it is evident that a far more extensive area of the coastal zone of Guyana is likely to be inundated, even in the scenario of minimum storm surge (HadCM3 scenario for 2031). In the worst case scenario, almost a 25 per cent of the coastal plain territory would be affected (142-480 Ha) (Table 4.12). As can be seen, the uncultivated area will be the most affected, followed by the rice and sugar-cane crops, and the residential zone. Consequently, agricultural production will be endangered, which may affect the income of this sector, as human settlements are located in the coastal zone. Mixed farming, crash crops, coconut and grazing areas will also be affected to a lesser extent, respectively. See Appendix 4.3 for supplementary tables and graphs.

Table 4.9. Sea-level rises for 2031, 2051 and 2071 under three different scenarios (a, b and c) according to the HadCM3 and CGCM2models

Year	Scenario	HadCM3	CGCM2e
2031	a. Sea-level (m)	0.14	0.26
	b. Minimum (m)	2.82	2.94
	c. Maximum (m)	5.82	5.94
2051	a. Sea-level (m)	0.21	0.34
	b. Minimum (m)	2.89	3.02
	c. Maximum (m)	5.89	6.02
2071	a. Sea-level (m)	0.25	0.51
	b. Minimum (m)	2.93	3.19
	c. Maximum (m)	5.93	6.19

Table 4.10. Land coastal area likely to be inundated under three different scenarios by 2031, 2051 and 2071 according to the HadCM3 and CGCM2 models

		Scenario a: Only Sea-level Rise (hectares inundated)		Scenario b: Min Storm Surge (hectares inundated)		Scenario c: Max Storm Surge (hectares inundated)	
	Model	HadCM3	CGCM2	HadCM3	CGCM2	HadCM3	CGCM2
Year	2031	1961	2901	75,578	79,851	139,123	140,245
	2051	2563	3764	78,038	82,881	139,784	140,986
	2071	2901	5645	79,483	88,591	140,152	142,480

Table 4.11. Land coastal area and land use likely to be inundated under scenario a by 2031, 2051 and 2071 according to the HadCM3 and CGCM2 models

Model	Year	Land area in the coastal zone that is likely to be inundated	Most highly impacted areas
CGCM2	2031	2,901 hectares	• Residential: 1,347 hectares • Rice: 1,068 hectares
	2051	5,645 hectares	• Residential: 1,536 hectares • Rice: 1,559 hectares
	2071	3,764 hectares	• Residential: 1,854 hectares • Rice: 2,674 hectares
HadCM3	2031	1,961 hectares	• Residential: 1,066 hectares • Rice: 601 hectares
	2051	2,563 hectares	• Residential: 1,255 hectares • Rice: 890 hectares
	2071	2,901 hectares	• Residential: 1,347 hectares • Rice: 1,068 hectares

Table 4.12. Land area inundated due to storm surges, according to the CGCM2 and HadCM3 scenarios for the selected study area on the coastal zone of Guyana, around the three future reference years

Model	Year	Land area in the coastal zone that is likely to be inundated (minimum-maximum)
CGCM2	2031	79,851- 140,245 hectares
	2051	82,881- 140,986 hectares
	2071	88,591- 142,480 hectares
HadCM3	2031	75,578- 139,123 hectares
	2051	78,038- 139,784 hectares
	2071	79,483- 140,152 hectares

Figure 4.18 shows graphically the extension of different lands that would be inundated for 2051 under scenario a (only sea-level rise) according to the CGCM2 model.

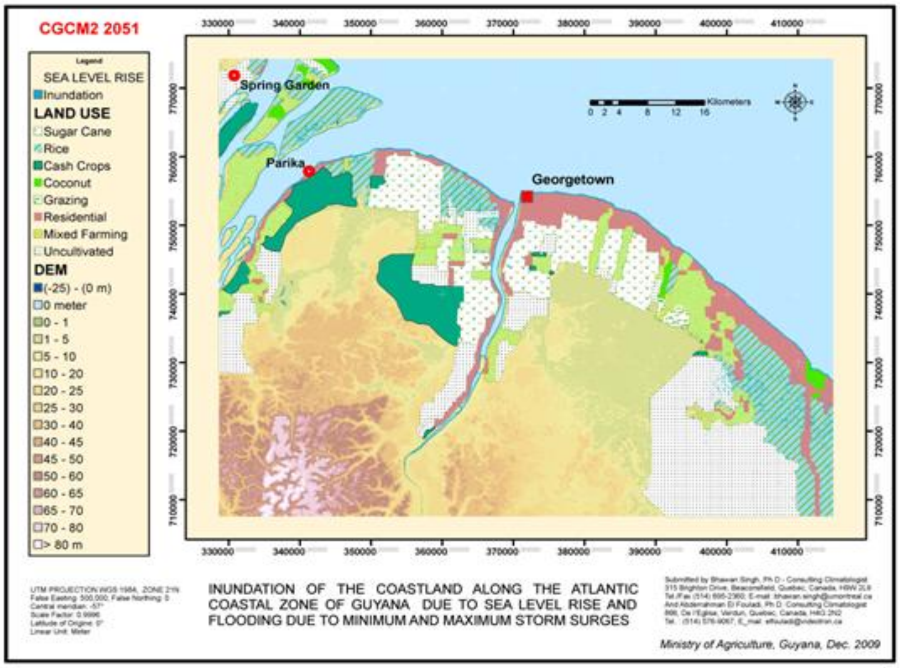

Fig. 4.18. **Inundation due to sea-level rise (scenario a) according to the CGCM2 model for the year 2051 for the selected study area on the coastal zone of Guyana**

The next figure 4.19 shows the worst case scenario analysed by 2071, where more than 142,000 ha would be inundated out of which 29,443 ha would be rice cultivated land; 28,032 sugar-cane and 22,361 residential land.

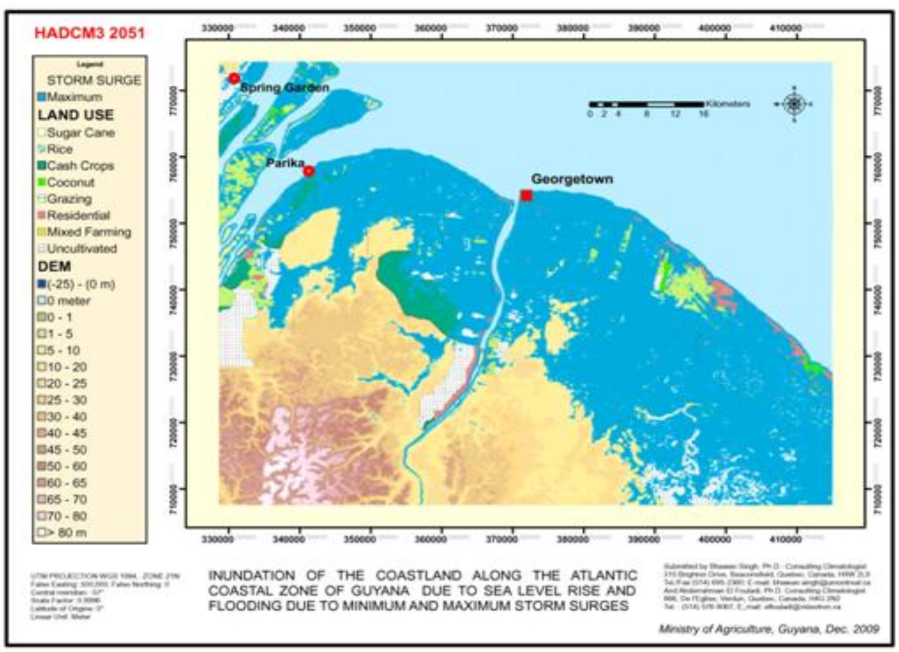

Fig. 4.19. **Inundation due to maximum storm surge (5 m) and sea-level rise according to the HadCM3 for the year 2051 for the selected study area on the coastal zone of Guyana**

In the following Table 4.13 there is a detailed description of the coastal zone area according to land use that is likely to be inundated.

Table 4.13. Land loss (hectares) according to land use categories due to sea-level rise and minimum and maximum storm surge for the coastal zone of Guyana according to the CGCM2 and HadCM3 for the years 2031, 2051 and 2071

		Year								
		2031			2051			2071		
	Category	Max Storm Surge	Min Storm Surge	Sea-level Rise	Max Storm Surge	Min Storm Surge	Sea-level Rise	Max Storm Surge	Min Storm Surge	Sea-level Rise
CGCM2	Rice	29,341	25,195	1,069	29,374	25,495	1,559	29,443	26,028	2,674
	Sugar-Cane	27,949	16,423	76	27,977	17,369	112	28,032	19,016	207
	Residential	22,067	11,325	1,347	22,166	11,872	1,537	22,361	12,947	1,854
	Cash Crops	7,542	1,240	53	7,647	1,387	65	7,848	1,739	83
	Coconut	1,446	621	74	1,472	644	83	1,521	690	95
	Mixed Farming	15,345	6,573	89	15,508	6,858	127	15,854	7,433	229
	Uncultivated	35,593	17,719	191	35,876	18,487	276	36,444	19,944	492
	Grazing	962	755	3	966	770	5	978	794	12
	Total	**140,245**	**79,851**	**2,902**	**140,986**	**82,882**	**3,765**	**142,481**	**88,591**	**5,646**
HadCM3	Rice	29,287	24,687	602	29,319	24,986	890	29,336	25,154	1,069
	Sugar-Cane	27,902	15,152	42	27,929	15,881	63	27,945	16,315	76
	Residential	21,915	10,595	1,066	22,005	11,008	1,256	22,056	11,258	1,347
	Cash Crops	7,391	1,063	38	7,479	1,163	48	7,529	1,224	53
	Coconut	1,415	587	59	1,432	608	69	1,443	619	74
	Mixed Farming	15,105	6,177	52	15,246	6,406	76	15,324	6,539	89
	Uncultivated	35,156	16,590	102	35,416	17,244	159	35,558	17,623	191
	Grazing	954	727	2	959	743	3	961	753	3
	Total	**139,123**	**75,578**	**1,962**	**139,785**	**78,039**	**2,563**	**140,152**	**79,484**	**2,902**

Thereby, in any scenario, the area that is likely to be inundated will severely affect the agricultural sector as well as human settlements in Guyana´s coastal zone. In the Annex to this document, different maps present the inundation of the coastland due to minimum and maximum storm surge and sea-level rise, according to the different models used for the three years selected for the study.

Increased coastal erosion and more extensive inundation are expected from rising sea-levels, and storm surges may flood greater areas than is currently the case, thereby impacting on primary production, and may cause saline intrusion up estuaries and into groundwater aquifers. As mentioned before, these biophysical impacts may cause loss of coastal habitats, property damage, loss of life, as well as having economic consequences for rural production and urban lifestyles. In many cases the effect of a change in climate and in sea-level will exacerbate problems that already exist.

Impacts on human settlements in the coastal plain

Human settlements in Guyana are mainly exposed to rising sea-levels and flooding. Although these are the main threats, climate change would also cause a reduction in annual and seasonal rainfall, possibly leading to seasonal droughts, that could force migration to the coastal zone, which may put further pressure on existing housing, food, water, and health systems.

Sea-levels are projected to increase by 0.18 to 0.56 m by the end of this century, depending on the climate scenario used. However, other estimates suggest that sea-level will rise more than 1 metre by 2100, due to increased mass loss from the ice sheets mainly in the Arctic regions (Meehl *et al*. 2007; Jonathan *et al.* 2004). In addition, it is projected that inundation caused by minimum storm surge (2m) may inundate more than 11,000 hectares of residential areas, whereas maximum storm surge (5m) may affect more than 22,000 hectares for the periods 2031, 2051 and 2071.

Further rise in sea-levels would threaten human lives and destroy livelihood assets which include, besides infrastructure losses, forfeits in stocks of natural resources (natural capital), social relationships (socio-political capital), skills and health (human capital), and financial resources (financial capital). It would also seriously affect communications, medical facilities, and transportation infrastructure, which are the basis for human survival.

In Guyana, about 45 % of the coastline is currently subject to erosion (Maurice 2011); hence, sea-level rise may lead to increased erosion that would cause damage to the foundation upon which houses are built, while salt-water intrusion would affect the soil and it would make lumber rot faster.

A rise in sea-level of 0.6 m can also inundate, weaken, and erode coastal roads. Thus, it can increase bridge structural load, as well as scour bridge foundations. Indirect impacts on industry include those resulting from delays and cancellations due to climate impacts on transportation, communications, and power infrastructure. Similarly, retail and commercial services are vulnerable because of supply chain, network, and transportation.

Floods have proven to be very costly for Guyana and affect largely human settlements. During the 2005 floods, the Government of Guyana provided emergency transfers to affected households and farmers (50,000 and 100,000 G$ respectively), to the amount of G$223.1 million already spent, and G$254.8 million committed, resulting in total transfers of G$477.9 million. Government had also spent G$1.3 billion on income support payments in 2005 to 73,242 households, 1,731 rice farmers, 8,031 other farmers and 1,535 small businesses. Apart from the income support to the affected households, the Government also provided an estimated G$20 million to the Civil Defence Commission for emergency relief and operating shelters (ECLAC 2005).

Adaptation options for the coastal plain and human settlements

Adaptation options, guided by policy changes and legislation, that may warrant immediate short-term consideration would include (Leary *et al.* 2008a; 2008b):

- The formulation and implementation of land-use planning policies to address people and settlements and agricultural lands at risk to inundation, deriving from sea-level rise and storm surges
- Fortification of sea and river defences in accordance with sea-level rise in vulnerable areas
- Implementation of early warning systems in the event of storm surges
- The building of shelters on higher ground either on the coast (Enmore, Mahaicony) or inland (Linden), to house people in the event of inundation due to storm surges.

Longer-term policy changes and adaptation measures to address sea-level rise and storm surges would include:

- Use of building set-backs legislation to limit buildings and other major developmental work on the coast and encourage gradual retreat to higher grounds by making land available in the interior, in an effort to decentralize economic activities and settlement on the coast
- Undertaking detailed surveys to identify most vulnerable areas along the coast, such as the Port of Georgetown, and determining appropriate adaptation strategies
- Undertaking evaluation of agricultural lands, coastal aquifers, and drainage and irrigation systems.

According to Guyana´s climate change adaptation policy and implementation strategy for coastal and low-lying areas (2002), the Government, through the Ministry of Housing and Water, may take the following actions in order to ensure that the impacts of climate change are minimized:

- Developing a land-use plan that will identify areas that are vulnerable to climate change, especially inundation, so as to establish appropriate management mechanisms to regulate physical development, including zoning, land allocation, and regularization of existing settlements
- Enforcing Building Codes and collaborating with the insurance and finance sectors to provide appropriate economic incentives to encourage compliance with such Building Codes
- Promoting social and economic research, environmental education and public awareness, and community involvement programmes that address the complex issues of settlements, with the aim of improving the surroundings and quality of life
- Collaborating with other agencies to promote programmes that address poverty alleviation and stimulate job creation within communities or on their peripheries
- Phasing of housing and related infrastructure out of the vulnerable coastal area.

Other possible adaptation measures following the five adaptation pillars are:

- Pillar # 2: Feeding programmes to alleviate poverty and hunger resulting from drought episodes
- Pillar # 4: Increased sea defence structures and river protection barriers to cope with flooding; the increased use of dykes, levees and floodwalls / flood gates and tidal barriers; **improved residential drainage** to prevent run-off flooding, while providing adequate maintenance to existing drainage.
- Pillar # 4: **Installation of mechanical pumping stations** to aid drainage of water
- Pillar # 4: Agro-pastoral management techniques providing for a more efficient use of reduced rainfall, in order to prevent a decline in the productivity of natural resources, and discourage rural- to-urban migration.

The prevention of consequences due to sea-level rise will demand research and systematic observation of sea-level patterns. It is important to invest in capacity building and awareness education for the population living in the coastal areas, about the threats to which they are exposed. The vulnerability of housing infrastructure also requires the promotion of home insurance.

These adaptation response strategies should also be integrated into economic development policies, disaster mitigation and management plans, and integrated coastal zone management plans (ICZM).

It is important to realize that developing a financial strategy is of pivotal importance. The costs of coastal protection works are enormous, ranging from 0.1 % to 10 % of a country's GDP, depending on the sensitivity of the coastal zone and the extent of sea-level rise and storm surges (IPCC 2007). According to Guyana's Low Carbon Development Strategy (LCDS, Office of the President 2009), the identified portfolio of urgent, near-term investments in the highest priority areas where the population and economic activity are concentrated, (which include upgrading infrastructure and assets to protect against flooding through urgent, near-term measures, strengthening building codes and expanding the early warning system, and building an emergency response system, among other actions), are estimated to be more than US$M290 (see Section 4.1.1)- around 17% of 2009 GDP (Bureau of Statistics 2011).

4.3.2 Main Conclusions and Recommendations

Flooding poses a major adaptation challenge for Guyana. Guyana's coastal regions, including Georgetown, lie below mean high tide level, and a large part of Guyana's population live in regions exposed to significant flooding risk.

According to the scenarios projected, a large area of the coastal zone is likely to be flooded, with rice cultivation, residential areas, sugar-cane, mixed farming, and cash crops being the land-use categories most highly impacted. The results of the preceding section highlighted the vulnerability of the coastal zone to climate-driven sea-level rise, and the potential impacts of extreme events such as storm surges.

For the storm surge categories considered, the minimum (moderate) scenario is very likely, whereas the maximum (catastrophic) scenario is less likely. However, it must be cautioned that these simulations are based on a very coarse resolution (90 m x 90 m) of spot heights for the study area selected. In order to have greater confidence in these results, spot heights distribution with a finer resolution (e.g. 10 m x 10 m) would be required. Nonetheless, these results provide credible scenarios of the vulnerability of the coastal zone of Guyana to future sea-level rise and storm surges. Not only would settlements, infrastructure and people be at risk of coastal inundation, but also the valuable agricultural lands and crops that form part of the most significant economic sector of Guyana. Given these potential losses, investing in the most beneficial adaptation measures would significantly increase estimated national income in Guyana, and would likely be essential to attracting investors.

Guyana's climate change scenarios project changes in rainfall patterns (increases in certain months, and decreases in others), and sea-level rise, which may cause permanent inundation of major parts of the coastline and large economic losses, if no preventive measures are taken. In order to reduce the vulnerability of human settlements, it is necessary to improve building codes and increase coastal planning through Ecological Economic Zoning and Land-Use Planning.

Effective adaptation will require a combination of enforceable regulations and economic incentives to redirect new settlement to better-protected locations, and to promote investments in appropriate infrastructure, all of which require political will as well as financial and human capital. Avoiding policies that favour coastal development and imposing more effective coastal zone management could make a difference in the longer term. It is likely that this process will be easier if action is taken as new areas are settled, rather than after their infrastructure is in place.

The trend in development over the years in the Caribbean and Guyana has been towards the coastline. Given that climate change risk and vulnerability are not reflected in the pricing mechanism for houses along the coast, an increase in infrastructure along the coastline to continue supporting existing coastal settlements should be expected. This would also promote the development of major socio-economic infrastructure along the coast to support existing infrastructure. Due to the high vulnerability of Guyana´s coastline, policies for relocation of inhabitants, infrastructure and services that are placed in highly vulnerable areas will also be needed. Although this is technically possible, the feasibility of such action is complex. Such measure should consider the practical and ethical issues, along with the technical ones.

Climate change may worsen the access to basic urban services and the quality of life in cities. The experience of the 2005 flooding revealed that it is important to organize a unit for disaster preparedness, relief and post-disaster planning. Hence, it is recommended that an inclusive, participatory process be used to conduct vulnerability assessments to identify common and differentiated threats to urban development plans, and decide on objectives and ways to reduce vulnerability.

4.3.3 Part 2: Sectoral Analysis

Water sector

Description of the sector and scope for the analysis

Water is a transversal resource with a direct consumptive use by the population, and also by the most productive sectors of Guyana's economy. Water, on the other hand, is also affected by these sectors' activities, either by an inefficient use and/or by contamination.

Water availability is highly sensitive to climate; rainfall is being altered, triggering drought and floods, and affecting water reservoirs, like the East Demerara Water Conservancy (EDWC), which are threatened by climate variability. El Niño and La Niña affect water supply and resources. During the 2000 El Niño season, the water in Georgetown's Conservancy fell below 52 Georgetown Datum (GD). However, during the La Niña spell, water levels rose above 58 GD, resulting in overtopping along the dams of the conservancies.

Water supply has a domestic, industrial and commercial purpose. Guyana's main industries, namely agriculture, forestry and fishing, and mining are dependent on water. At the same time, these sectors are generating pressure on the availability and quality of this resource. Another contributor to GDP is the service sector, which is almost entirely located on the coastal plain. The sensitivity of the service sector to negative impacts must be taken into consideration, as even a small incident can have multiple consequences for the economy.

In addition, Guyana with its many rivers and waterfalls, has significant hydropower potential, which is estimated to be in the region of 7000 MW and is seen as a potential source of energy in the long run; as is further explained, drought episodes could severely affect the generation of energy, since the country is promoting a complete switch to hydropower by 2015.

The vulnerability of the water sector of Guyana is determined by two climate-related threats: 1) extremes in rainfall, with excess rainfall leading to flooding, and lack of rainfall leading to water deficit; and 2) flooding deriving from sea-level rise and storm surges, as discussed in the coastal zone analysis (Section 4.3.1).

For the water sector, the current assessment focuses on water availability based on the results of the projected rainfall patterns and evapotranspiration for the period 2040 – 2069 presented in Section 2.3.1, limited to three Regions (5, 6 and 10); and on the enhanced stress that sea-level rise and flooding pose on the country's already vulnerable water infrastructure, with a special focus on the East Demerara Water Conservancy and the drainage and flood control systems.

Current condition of water resources and demand

Seventy-five per cent (75 %) of the Guyanese population live in a 30-kilometre band along the Atlantic Coast. This is an area of reclaimed lands, much of it below the regional mean sea-level; it is situated between a water storage basin and a protective sea-wall complex of man-made defences and mangroves.

Guyana is an Amerindian word that means 'Land of Many Waters', because of the many large wetland areas, including ponds, swamps, seasonally flooded forests, lakes, mangroves and conservancies. The major rivers include the Essequibo, Demerara and Berbice; smaller ones include the Mahaica, Mahaicony, Abary and Canje. The rivers of eastern Guyana cut across the coastal zone, but they provide limited water access to the interior. Estimates of surface water resources are not available for over all of Guyana, but there is data available from the main drainage basins, as shown in Table 4.14 below.

Table 4.14. Main river basins in Guyana

Drainage basin	Station	Surface area (km^2)	Discharge (km^3/y)	Specific discharge
				($m^3/s/km^2$)
Essequibo	Plantain Island	66 600	66.96	0.0319
	Apaikwa	14 000	23.98	0.0543
	Kamaria	53 500	35.52	0.0211
Demerara	Great Falls	2 460	2.32	0.0299
Berbice	Itabru	5 100	1.6	0.0099

Source: FAO - AQUASTAT

Water supplies for domestic, industrial and commercial purposes are abstracted from wells drilled mainly from two aquifers known as the ‘A’ and ‘B’ sands. The water is distributed through a network of pipes estimated at about 3000 miles, laid in urban and rural areas along the coastal plain. All residents of the coastal area depend wholly on groundwater supply to meet their domestic needs. One exception is the Georgetown area, which utilizes about 30 % of surface water from the EDWC. Nationwide, water supply facilities include about 178 groundwater wells and eight surface water sources.

Most water demand in Guyana is for irrigation purposes, which is derived from water conservancies (in Regions 2, 3, 4 and 5), and from the rivers through pumping in Region 6. The conservancies are located in the ‘backland’ or upper stream catchment areas. They include: the Essequibo Coast Tapakuma Conservancy in Region 2; Boerasirie - West Demerara in Region 3; East Demerara in Region 4, and the Mahaica/Mahaicony/Abary in Region 5, and comprise water-retaining embankments and structures. The Tapakuma Conservancy has been designed to provide irrigation to about 12,000 ha, Boerasirie 36,000 ha, East Demerara 34,500 ha and MMA 17,500 ha (FAO-AQUASTAT). In the Corentyne, irrigation water for rice, sugar and other crops is extracted by a number of pump stations along the Canje River in its lower 50-km stretch, which is **vulnerable to saline intrusion**. This practice can be found on some of the smaller rivers.

While in most years water supply is ensured throughout the year, if droughts occur during the secondary November-January wet season, these conservancies may have water shortages. Water shortages may also occur in the Tapakuma Conservancy, which is partly supplied by pumping from the Pomeroon River.

The coastal zone is transected by a dense network of drainage and irrigation canals. This network of canals links up with the East Demerara Water Conservancy (EDWC), a water storage system that provides regional agricultural lands and urban areas with irrigation and drinking water. During times of heavy rainfall this system functions as a regional drainage and flood control mechanism (Guyana Water Conservancy GEF/PAD 2006).

Guyana’s coastal drainage and flood control

Guyana’s drainage and irrigation system is over 150 years old. The country’s coastal zone consists of a low-lying system of marine and riverine deposits which formerly comprised an extensive network of tidal deltas. Much of the land now in use in northern Guyana lies in this coastal zone below the mean high tide level of around 54 ft Georgetown Datum (GD). This land is protected by an intricate network of seawalls, dykes, polders and drainage structures, including the EDWC system. Guyana’s agrarian economy, which accounts for over 35 per cent of GDP, is highly dependent on this coastal drainage and irrigation system that, among other benefits, provides flood control and allows for bi-annual harvests of their main crops (rice and sugar).

The drainage system is natural (i.e. a gravity-based system augmented by pumps) and depends on the main rivers, which extend beyond the coast. The major and smaller rivers are also part of the drainage network. All these rivers are within tidal influences of the Atlantic Ocean, and this effect is noticeable for some distance upstream.

Guyana’s drainage system is currently under stress; **sea-level** change will exacerbate this condition, considering the discharge window from low tide to mean tide is shrinking. As sea-level continues to rise and the discharge window to shrink, the ability to manage water levels will be further compromised, reducing the system's ability to release excess water.

The East Demerara Water Conservancy (EDWC)

The EDWC is one of the major water conservancy systems in Guyana; it is a freshwater impoundment located in Region 4, fifteen miles south of the most densely populated sector of the Guyana coast. It is bounded to the north by a forty-mile earthen dam structure built some 150 years ago, and to the south by the natural topographic rise composed largely of ancient coastal dune formations. Guyana typically has two rainy seasons; these two periods are separated by dry periods with little or no rainfall. Recently however, the 'winter' rainy season has become more intense and has caused severe flooding. On account of this semi-annual cycle of rainfall the EDWC was constructed so as to capture seasonal rains and provide irrigation water during the dry season. (Figure 4.20.) (Guyana Water Conservancy GEF/PAD 2006.)

The area consists of an impoundment of approximately 550 hectares. This water management system located across Region 4 is composed of two separate elements: drinking and irrigation water, which is collected and stored within the conservancy behind the EDWC dam. In the coastal lowlands, between the dam and the sea defences, an intricate network of canals manages water for drainage and irrigation.

A series of drainage relief structures were constructed to protect the EDWC dam from overtopping and collapse during rainy seasons. Relief canals were constructed from the EDWC west towards the Demerara River, and north towards the Atlantic Ocean. A network of creeks was also created within the Conservancy to conduct water from east to west, in order to increase discharge flows to the Demerara River. Canals connecting eastwards to the Mahaica River were constructed to conduct water from the river into the conservancy during periods of extreme low water. However, when these canals are used for emergency drainage relief, the inhabited downstream lands invariably flood – this is a direct consequence of the sea-level rise that has occurred over the past 50 years.

Conservancy relief canals are currently operating with limitations, as changes in land-use and local increases in sea-level have greatly limited their effectiveness. The degradation of the EDWC system has been compounded by a number of recent severe weather events, such as the floods of 2004-2005. Overtopping of the dam during these rains, in addition to significant dam creeping, has weakened the integrity of an already vulnerable system.

The EDWC dam was structurally weakened by both flood events, but the integrity of the system remained intact. Yet, due to the pressure on the dam over the past years, the system is weaker now than it was prior to 2005 – leaving the EDWC system more vulnerable to collapse. If similar rains occur in the future, it is increasingly likely that the dam will collapse and flood Regions 4 and 5. Based on the partial flooding of Region 4 in 2005, it is estimated that the economic loss resulting from a system breach could be between three and four times Guyana's annual GDP. In addition, replacement costs for the EDWC are estimated between US$200-300 million (Guyana Water Conservancy GEF/PAD 2006). While the EDWC is being reconstructed, it would be incapable of holding irrigation water necessary for agricultural production. As a result, agricultural production could fall by over twenty per cent annually until a new dam is constructed.

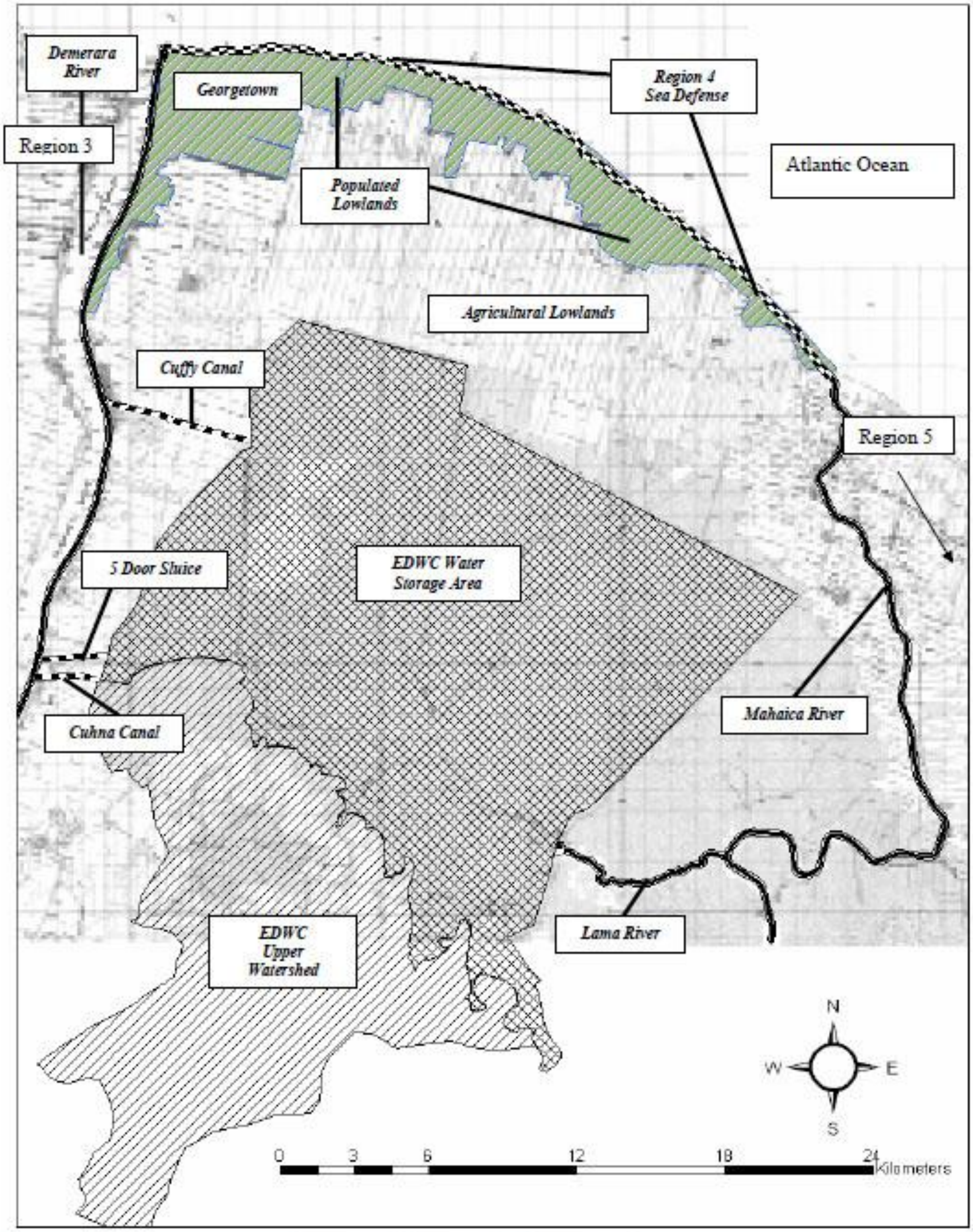

Fig. 4.20. **The East Demerara Water Conservancy (EDWC) and surrounding regions**

Water sector: vulnerability to climate change and adaptation options

Climate change is very likely to have a significant impact on the water sector of Guyana:

- Present rates of **sea-level rise** and projected environmental impacts associated with global climate change, including increased rainfall intensities, pose a significant threat to the water resources sector of the coastal zone of Guyana and other major components of its economy, mainly agriculture.
- **Rainfall** is projected to decrease and become more variable, adding to intense rains and flooding on the one hand, and droughts on the other. **Warmer temperatures** would also exacerbate drought conditions (McSweeney *et al.* 2008, 2009; IPCC 2007; Guyana INC 2002) leading to **water deficits** for domestic, industrial and commercial purposes.
- Rainfall amounts and variability are critical to Guyana's economy. Not only would there be risks of flooding from excessive rainfall in the low-lying coastlands, but agricultural production, a key contributor to GDP, would also be subject to the alternating conditions of excessive rainfall, flooding and drought.
- **Sea-level rise and storm surges**, by-products of climate change, will also affect the water sector through: (i) saline intrusions into aquifers and soils; and (ii) flooding of coastal lowlands, where the bulk of Guyana's population is located (Singh and El Fouladi 2007). These will have consequences for quality of drinking water, erosion of agricultural land, and impacts on livelihoods of people affected by flooding. Sea-water intrusion is a common phenomenon today in coastal aquifers. Although Guyana's coastal aquifer is characterized by some favourable conditions, such as the fact that the clay percentage increases gradually northwards, possibly sealing the aquifer from the sea, the risk of salinization due to sea-water intrusion should not be ignored.

Recent flooding (2005) demonstrates the immediate vulnerability of Guyana to climate-driven events and shortcomings in the current infrastructure (Guyana Water Conservancy GEF/PAD 2006); Guyana's coastal drainage system is insufficient to discharge excess water due to heavy rainfall.

Coastal lowlands, particularly in Region 4, lie below mean sea-level. They are protected by a sea defence barrier and were historically drained using a gravity-based system augmented with pumps. Changes in land use and the replacement of gravity drainage with pumps have modified the coastal flood control systems to the point where the integrated flood control and drainage regime is no longer well understood.

The expected climatic changes will place **additional stresses on the flood control and drainage network**. Without the ability to effectively manage water levels during times of heavy rain, drainage ditches and lowland basins will fill more quickly, increasing the amount of water that must be purged from low-lying areas. While the system historically functioned as a gravity-based system, sea-level rise places additional constraints on the opportunity to discharge to the sea. As the mean sea-level rises, the effective discharge window becomes smaller, with a reduction in the time available to operate gravity-based systems. Understanding these impacts, coupled with the behaviour of the current drainage system and future drainage demands in light of current land-use, are critical to protecting the inhabited coastal lowlands from recurrent flooding.

Impacts on the water sector also affect other related sectors, especially human health, which can be directly affected, through water deficits, or indirectly, through the impacts on food supply and the proliferation of disease-spreading vectors.

Impacts of climate change on water availability: precipitation, evapotranspiration and water deficit

According to projections presented in Section 4.2.2, rainfall and temperature projections (2040-2069) show an increase in max temperature (by between 0.50°C and 1.10°C), an increase in min temperature (by between 0.90°C and 1.5°C) and a decrease in rainfall (by between -7 and -9.7 %). These increases in temperature will eventually lead to increases in evapotranspiration (ET) and when combined with decreases in rainfall (P) will result in increased water deficits (P-ET) and shortages of water for agricultural, domestic and industrial purposes.

Guyana typically has two rainy seasons, the heaviest in the 'summer' season of June-July, and the weaker in the 'winter' season of December-January, these following the delayed passage of the sun and the Inter-Tropical Convergence Zone (ITCZ). These two periods are separated by dry periods with little or no rainfall. Models project great rainfall decreases for all months of the year, thus even drier conditions in the dry seasons. Of special concern, projections show a decrease in precipitation during the rainy season, which will affect mostly rain-fed crops and other industrial activities reliant on the resource.

The two down-scaled climate scenarios (CGCM1 and HadCM3) both project significant changes in rainfall (P) and evapotranspiration (ET) and consequently on water deficits (P-ET) for all three stations selected (Timehri, New Amsterdam, and Ebini).[107] Water deficits will have an effect all year round, for the period 2040-2069, but will be critical during the rainy season (June and July), due to dependence on water availability during those months, and during the dry season (October-November), considering that water availability during that period is already critical.

The meteorological by-product of climate change that will put the most strain on Guyana's water conservancy and flood control systems is the anticipated change in rainfall patterns. While annual rainfall is expected to decrease, these models also estimate that the intensity of precipitation events may increase. Storms will likely become more intense, placing increased demands on the national drainage infrastructure.

Estimates from Atmosphere-Ocean General Circulation Models (A-OGCMs) support the projection that Guyana will be confronted with a general drying trend. In fact these models demonstrate that Guyana will be affected, with average precipitation decreasing by roughly 5 mm/month by the 2060s.

Impacts of climate change on the EDWC and the coastal lowlands

According to the Climate and Sea-level projections presented in Section 4.2, global warming is likely to cause temperature to increase by 2°C to 4° C in Guyana by the end of this century. The projections show that by 2031 the increase in sea-level could reach 26 cm and for 2071 it could be up to 51 cm. According to Meehl *et al.* (2007) and Jonathan *et al.* (2004), sea-level would rise more than 1 metre by 2100, due to increased mass loss from the ice sheets

[107] Water deficit is defined as the difference between rainfall and evaporation; as a consequence of increased evapotranspiration, water deficits increases substantially for almost all months. A positive value indicates that rainfall exceeds evaporation while a negative value indicates that rainfall is insufficient to meet the loss of water due to evaporation.

mainly in the Arctic regions. Projections presented in Section 2 that include scenarios of storm surge occurrence estimate that by 2031 sea-level could reach 2.94 cm (in a moderate scenario) and up to 5.94 cm (in a catastrophic scenario).

While sea-levels are rising on a global scale at a rate of 2-4 mm/year (IPCC 2007), this trend in sea-level is consistent with the work conducted by Douglas (1995) and Smith *et al.* (1999) which indicate that sea-level in the region of Guyana is increasing at a rate in excess of 10 mm/year - or 2 to 5 times faster than the global estimate.

As sea-level rises, the drainage relief capacity of the EDWC is compromised, placing the dams, particularly the EDWC dam, at increased risk of failure. Because drainage infrastructure is principally gravity based, the drainage relief capacity is dependent on the difference in height between water in the system and the sea-level. Therefore, release of water from the conservancies is possible only when the water in the system is higher than the sea. As sea-levels rise, the hydraulic head difference between the EDWC water control structures and sea outlets is expected to be significantly reduced. This effectively reduces both the flow rate and the discharge window available for water level management.

Changes in sea-level, increases in the severity of individual rainfall events, and variations in annual rainfall levels pose significant threats to the EDWC system, future agricultural production, and the overall welfare of inhabitants of the low-lying coastal zone of Guyana. The occurrence of these events limits the effective management of the EDWC water levels and compromises the system's ability to safely discharge water during the rainy seasons. To protect the integrity of the system, the water levels must be lowered to take into account decreased capacity to drain increasing amounts of water. Yet if annual rainfall decreases, water levels within the EDWC must be increased to capture enough rain to ensure water availability during the dry season. Recent flood experience demonstrates that there is a clear need to improve the capacity for the timely management of water levels from both a flood control and resource management perspective.

Adaptation options for the water sector

The projected increase in temperature and the possibility of more frequent and intense droughts, which could lead to water scarcity, as well as the risk of flooding, due to sea-level rise and storm surge intrusions combined with excessive rainfall, will most likely affect the water resource sector of Guyana.

Adaptation measures against flooding are the most urgent for reducing the vulnerability in the water sector. According to Guyana's Low Carbon Development Strategy (LCDS, Office of the President 2009), adaptation measures include the following investments:

- Upgrading infrastructure and assets to protect against flooding through urgent, near-term measures (US$225 million):
  - maintaining (US$20 million) and upgrading (US$39 million) drainage systems
  - maintaining and reinforcing the ocean sea-wall which protects most of the low-lying coastal areas from the Atlantic (US$30 million)
  - repairing the Conservancy which protects Georgetown and most of the East Coast from overflow water (US$123 million).

Climate change impacts will also likely reduce the availability and quality of water resources for industrial, residential and agricultural use. Guyana's GoG, through the Water Authority or responsible agency, will:

- Develop and promote long-term studies of ground water aquifers, to determine resource capability, capacities and exploitation potential, and identify likely impacts from climate change
- Develop and co-ordinate action programmes for watershed management, water conservation, and land use in recharge areas
- Co-ordinate action programmes for improved testing and monitoring of water quality
- Apply information technology towards the improvement of hydrological and hydro-geological data collection, compilation, and database systems, and co-ordinate the effective dissemination and exchange of information
- Collaborate with the Ministry of Health and the EPA to execute action programmes for national Environmental Public Health and Education Awareness especially as it relates to water conservation
- Initiate oceanographic monitoring of water quality and dynamics.

Other adaptation options and response strategies that may be considered appropriate for the water sector of Guyana, under the five pillars, would include:

- Pillar #1: Detailed analysis of climate change impacts on water infrastructure system
- Pillar #2: Water conservation measures, supported by government policies and public awareness campaigns, including metering, the use of time-runs where the water supply may be staggered according to regions or sectors in the domestic/industrial sector
- Pillar #5: The development of new measures to access fresh water resources such as ground water from artesian wells and conservancies in the interior regions and water desalinization plants along the coast
- Pillar #4: The introduction of efficiency control and management practice for water reservoirs networks, especially in the case of agricultural use (efficient irrigation systems such as drip as opposed to centre pivot systems)
- Pillar #4: The use of alternative fresh water collection systems such as rain-water collection
- Pillar #1: The application of scientific monitoring and management of irrigation and drainage systems, such as the use of trickle irrigation systems and the detection and repairing of leaks in the water supply systems.

However, these measures would call for the sensitization of water managers on the potential threats of climate change to the water sector of Guyana, through training and awareness measures.

Main conclusions and recommendations

The water sector would very likely suffer the adverse effects of climate change, through changes in rainfall patterns, increasing droughts and increasing floods. These changes would not only affect water supply and distribution for the domestic and industrial sectors, but also other key sectors such as irrigation water use for agriculture and health.

Sea-level rise and storm surges on the other hand would very likely lead to salinization of aquifers and soils and to impediments to drainage of water courses, not to mention deterioration of valuable agricultural soils.

Since the vast majority of the population and the practice of agriculture are concentrated on the coastal zone of Guyana, the impacts on the water sector will very likely create hardships for the economy and livelihoods of the people of Guyana.

In regard to gaps and barriers, there is a need for the GoG to increase its understanding of the EDWC system and coastal lowland regimes, in order to reduce the vulnerability of extreme flooding in the country's low-lying coastal areas. There is also a need to strengthen the institutional capacity of the GoG to manage water levels in the EDWC, and to guide interventions aimed at reducing Guyana's vulnerability to floods. With regard to information, there is a need for detailed topographic and land-use mapping, hydrologic modelling of coastal lowlands, assessment of EDWC system integrity, EDWC hydraulic modelling, and pre-feasibility studies for coastal lowland interventions.

4.3.4 Agricultural Sector

Description of the sector and scope for the analysis

Guyana has a rich and productive agriculture sector that contributes in a significant way to the economy. The agricultural sector (inclusive of fisheries and forestry) remains one of the most important sectors in the economy; between 2004 and 2007 it contributed approximately 35 % of the country's GDP and employed between 30-35 % of the labour force (Bureau of Statistics 2008).

The main agricultural crops are sugar and rice, which together with shrimp make up the bulk of agricultural exports. The sugar and rice industries, cultivated commercially exclusively along the coast, have remained dominant, contributing a combined total of 14.6 % of GDP in 2007 (Caribbean Community Climate Change Centre 2010).

In recent times, the government has made a conscious effort to diversify the agricultural base, placing greater emphasis on non-traditional crops and the fisheries and forestry industries. Further measures to support 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, 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 plant and animal species adaptive to climatological changes (Caribbean Community Climate Change Centre 2010).

Most of the sugar production is mainly a plantation activity, and is exported to Europe under the Lomé Convention (an agreement by the European Union under which preferential trade terms are offered to certain developing countries). Sugar accounts for nearly 12 per cent of GDP, and over 20 per cent of Guyana's exports (2005). The CARICOM region, which is protected by the common external tariff (CET), is also an important market for Guyanese sugar. Sugar is produced by the state-owned Guyana Sugar Corporation (Guysuco). In 2005, production amounted to nearly 259,000 metric tons.

Unlike sugar production, most of the rice is produced by small-scale farmers. Droughts and heavy rains have an adverse effect on rice crops because the irrigation and drainage systems in rice-growing areas are poorly maintained (Guyana Ministry of Agriculture 2010). As an example, in 1996 the sugar production reached 280,066 metric tons and approximately 255,655 metric tons of sugar were produced in 1998 despite the severe drought. Instead rice production in Guyana declined to 349,890 tonnes in 1998 due to the inconsistent weather, and reached a high of over 365,469 tonnes in 1999. Rice accounted for nearly 9 per cent of Guyana's exports in 2005. Like sugar, Guyana exports rice primarily to Europe and the CARICOM region.

Crops and livestock production (with the exception of sugar-cane) are characterized by the predominance of small farmers, farming less than 15 hectares of land. 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 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 already mentioned Guyana Sugar Corporation (GuySuCo).

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, GuySuCo alone reports employing approximately 18,500 persons at all levels, with most of these employees coming from the rural areas of Guyana where poverty is greatest. It has also provided 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. 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 on 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 (Caribbean Community Climate Change Centre 2010).

The agriculture sector is also a vital source for nutritious agricultural output in the fight against food insecurity in 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 and hinterland households. Particularly, 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 vegetables being cultivated along the embankment of rice fields, as rural families seek to bolster their incomes and diversify their production base, thus spreading their risks.

In order to assess the vulnerability of the agricultural sector of Guyana to climate change, the administrative Region 5 was chosen for rice cultivation and Region 6 for sugar-cane production, which is the main crop in Guyana. The evaluation of the potential crop yield changes were simulated for both sugar-cane (Region 6) and rice (Region 5) for the current climate (1961-1990) and for the future climate (2040-2069). Changes in air temperature and rainfall, flooding from sea-level rise and storm surges, are considered the main climate change threats for the sector and are used for a qualitative analysis of the sector.

Temperature, rainfall and solar radiation for crop modelling

As previously noted, a part of the agricultural sector vulnerability analysis focuses on the impact of climate change on two crop yields, rice and sugar, based in Regions 5 and 6 respectively. For that analysis, data was downscaled to the regions where the analysis was done. This section describes the methodology for developing that input data, coupled with a crop model (see Section 4.2).

The chosen methodology was to couple downscaled A-OGCM data with a crop model so as to examine potential crop yield changes for the two major crops of Guyana, sugar-cane and rice.

Based on research experience and availability of observed and A-OGCM data sets, downscaled A-OGCM data was used, namely the HadCM3 and the CGCM1 data sets, both forced by the A2 scenario. The Statistical Downscaling Model (SDSM: Wilbey *et al* 2001) was used as the downscaling method to derive maximum and minimum daily temperatures and daily rainfall at the station level, for both the HadCM3 and CGCM1 models for the future climate period (2040-2069).

This process involved statistical analyses so as to derive the best set of predictands, using observed data for the current period (1961-1990). SDSM was then calibrated based on regression equations between the chosen predictands and the required climate variables and this for one-half of the data set (1961-1975). The choice of predictands within SDSM was then validated using the observed data for the other half (1976-1990) of the data set.

The focus of the scenarios was on Region 5 for rice cultivation and Region 6 for sugar-cane production. To this end, observed and simulated downscaled A-OGCM data was used on daily maximum and minimum air temperature and rainfall for three stations within and adjacent to the study area, namely the Timehri (Region 4 & 5), New Amsterdam (Region 6), and Ebini (Region 10) stations. For both the current and future climates the daily solar radiation required by the crop model is derived from daily maximum and minimum air temperatures using the method of Bristol and Campbell (1984) and Villa (1993).

Crop Modelling

In order to evaluate the potential impacts of climate change on the potential yields, namely yields limited by soil water, of sugar-cane (Region 6) and rice (Region 5), the climate data was coupled for both the current climate (1961-1990) and the future climate (2040-2069) to a crop model (DSSAT: Decision Support System for Agrotechnology Transfer) so as to derive potential yield changes for these two major crops of Guyana.

DSSAT is calibrated for each crop by choosing a cultivar within DSSAT that best matches the cultivars used in Guyana. Crop yields of both sugar-cane and rice are then simulated using one-half (1961-1975) of the daily climate data set and are then compared against observed yields for validation. The validation criteria used is the RMSE (Root Mean Square Estimate) statistic. The appropriate genetic coefficients for both crops are then chosen based on the lowest RSME between observed and simulated yields. The chosen cultivar that best reproduces the observed yields (1961-1975) for both crops is then used to complete the yields simulations for the entire observed (1961-1990) period.

For the future climate (2040-2069), the same cultivars as previously for both sugar-cane and rice were then simulated by DSSAT by both ignoring and integrating the fertilization effect of ambient CO_2. The yield changes between the current (1961-1990) and future (2040-2069) climate are then used to gauge the impacts of climate change on potential crop yields for both sugar-cane and rice in Guyana.

Projections for Crop Yields

Observed Rice Yields

Observed rice yields in Guyana increased steadily from about 1.5 tonne per hectare (t/ha) in 1968 to about 4.5 tonne per hectare (t/ha) in 2008. This may well be on account of improved agricultural practices and better cultivar selection (see Fig. 4.22).

Simulated Rice Yields: Current and Future

DSSAT-simulated rice yields are compared to observed rice yields for the period 1968 to 1990 (Figure 4.22). The agreement between observed and simulated rice yields is close, especially for the years 1974 to 1990. For the years 1968 to 1974, the poor agreement between observed and simulated data could well be attributed to the rice cultivar used, and therefore the genetic coefficient, at the time being different from the cultivar selected from the DSSAT library (Fig. 4.22)

Observed Sugar-Cane Yields

Observed sugar-cane yields in Guyana fluctuated from year to year, most likely due to fluctuations in rainfall conditions. Sugar-cane yields for the period 1980-2008 fluctuated between 53.37 tonnes per hectare (t/ha) (1990) and 80.73 (t/ha) (1981) with a mean value of 69.43 (t/ha) (Fig. 4.21).

Simulated Sugar-Cane Yields: Current and Future

DSSAT-simulated sugar-cane yields are compared to observed rice yields for the period 1980 to 1990 (Fig. 4.23). The agreement between observed and simulated sugar-cane yields is very close for all years considered (1980 to 1990). The very close agreement between observed and simulated sugar-cane yield data could well be attributed to the sugar-cane cultivar used, and therefore the genetic coefficient, being appropriate with the cultivar selected from the DSSAT library.

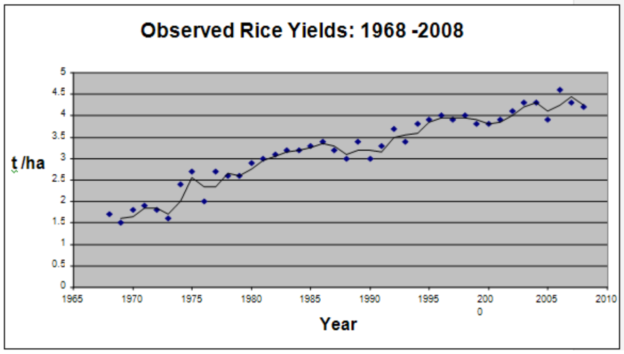

Fig. 4.22. Observed sugar-cane yields for Guyana: 1980-2008

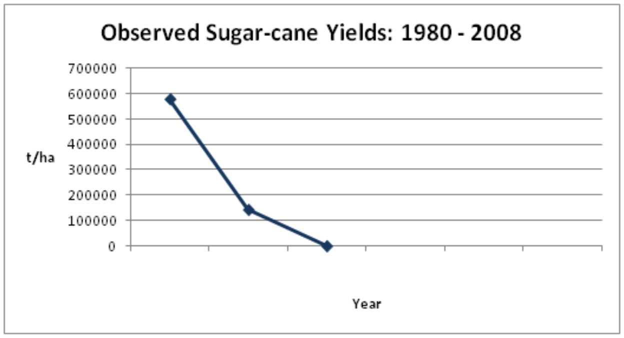

Fig. 4.21. Observed sugar-cane yields for Guyana: 1980-2008

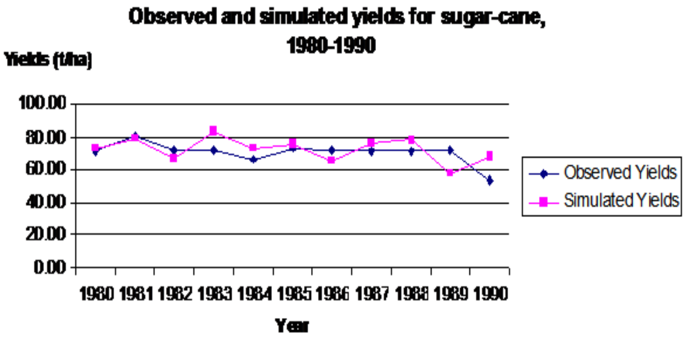

Fig. 4.23. Comparison between observed and simulated sugar-cane yields for the period 1980-1990

Rice and sugar crop: Vulnerability to temperature, rainfall and evotranspiration changes

For sugar-cane and rice production, the temperature, rainfall and evotranspiration projections for 2040-2069 (see Section 4.2.2) indicate the following:

- Observed **rice yields** in Guyana increased steadily from about 1.5 tonnes per hectare (t/ha) in 1968 to about 4.5 tonnes per hectare (t/ha) in 2008. This may well be on account of improved agricultural practices and better cultivar selection. The changes between the current climate (1968-1990) and the future climate (2040-2069) demonstrate that the yield changes are minimal, in view of the fact that in the simulations it is assumed that there is no water limitation, and that rice continues to be cultivated under irrigated/flooded conditions. Also the minimal yields decreases may be because the cultivar selected will provide lower yields under the warmer climate. Rice yields (t/ha) for Guyana under the future climate (2040-2069) according to both the CGCM1 and HadCM3 scenarios, with and without the CO_2 fertilization effect, are presented in Table 4.15.
- The change in mean yield is -2.56 % (with CO_2 fertilization) and -4.17 % (without CO_2 fertilization) according to CGCM1, and -2.04 % (with CO_2 fertilization) and -3.20 % (without CO_2 fertilization) according to HadCM3 (see Table 4.16). The CO_2 fertilization effect therefore reduces the yield losses for the future climate.
- Observed **sugar-cane yields** in Guyana fluctuated from year to year, most likely because of fluctuations in rainfall conditions. Sugar-cane yields for the period 1980-2008 fluctuated between 53.37 tonnes per hectare (t/ha) (1990) and 80.73 (t/ha) (1981) with a mean value of 69.43 (t/ha). These future (2040-2069) changes in the mean yields for sugar-cane are significant, and this could most likely be attributed to increasing moisture stress under the future warmer climate and to the poor performance of the sugar-cane cultivar selected under the warmer and drier future climate (Singh and El Maaya, 1998). [108]

Sugar-cane yields (t/ha) for Guyana under the future climate (2040-2069) according to both the CGCM1 and HadCM3 scenarios, with and without the CO_2 fertilization effect, are presented in Table 4.16.

Yield changes, unlike rice, are significant: a change in mean yield of -40.85 % (with CO_2 fertilization) and of -47.06 % (without CO_2 fertilization) according to CGCM1, and of -33.33 % (with CO_2 fertilization) and of -38.89 % (without CO_2 fertilization) according to HadCM3 (see Table 4.17 below). The CO_2 fertilization effect therefore reduces the sugar-cane yield losses for the future climate.

[108] Similar results were found for Trinidad (Singh and El Maayar 1998).

Table 4.15. Rice yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO2 fertilization (t/ha)

Year	CGCM1-with CO2 (t/ha)	CGCM1- without CO2 (t/ha)	HadCM3-with CO2 (t/ha)	HadCM3-without CO2 (t/ha)
2040	3.71	3.65	3.72	3.68
2045	3.12	3.07	3.14	3.10
2050	2.05	2.02	2.06	2.03
2055	2.34	2.30	2.35	2.33
2060	3.32	3.26	3.33	3.29
2065	2.44	2.40	2.45	2.42
2069	1.46	1.44	1.47	1.45

(For the annual numbers of rice yields, see the Appendix 4.3)

Table 4.16. Summary of rice yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO2 fertilization (t/ha)

Climate Scenario	CGCM1-with CO2 (t/ha)	CGCM1- without CO2 (t/ha)	HadCM3-with CO2 (t/ha)	HadCM3-without CO2 (t/ha)
Mean Yield (t/ha)	2.64	2.60	2.65	2.62
Yield Change (%)	-2.56	-4.17	-2.04	-3.20

Table 4.17. Sugar-cane yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO2 fertilization (t/ha)

Year	CGCM1-with CO2 (t/ha)	CGCM1- without CO2 (t/ha)	HadCM3-with CO2 (t/ha)	HadCM3-without CO2 (t/ha)
2040	48.12	46.09	50.84	48.80
2045	53.31	51.06	56.32	54.06
2050	51.48	49.30	54.38	52.20
2055	51.52	49.34	54.42	52.24
2060	51.05	48.90	53.93	51.77
2065	51.87	49.67	54.79	52.60
2069	52.37	50.16	55.32	53.11

(For the annual numbers of sugar yields, see Appendix 4.3)

Table 4.18. Summary of sugar-cane yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO2 fertilization (t/ha)

Climate Scenario	CGCM1-with CO2 (t/ha)	CGCM1- without CO2 (t/ha)	HadCM3-with CO2 (t/ha)	HadCM3-without CO2 (t/ha)
Mean Yield (t/ha)	51.28	49.11	54.17	52.00
Yield Change (%)	-40.85	-47.06	-33.33	-38.89

Agriculture sector: vulnerability to floods due to sea-level rise and storm surges

Forests cover around 76 % of Guyana. Therefore, large areas are inaccessible and agricultural development in this area is hindered by the lack of electricity and economic transport (Guyana, Ministry of Agriculture). Most agricultural output is derived from a thin belt of land close to the sea (the coastal plain), most of which is below mean high tide level and vulnerable to sea-level rise.

The projections of the sea-level rise and storm surge scenarios estimate that under different scenarios, crops located in the coastal zone would be affected, specially sugar-cane, rice and mixed farming. Under conservative conditions, up to 1364 ha in 2031 could be flooded, while under catastrophic conditions (sea-level rise plus a 5 metre storm surge), up to 82.585 ha could be affected (see Table 4.19 below, data derived from Section 4.3).

Table 4.19. Agricultural land loss (hectares) due to sea-level rise and minimum and maximum storm surge for the coastal zone of Guyana according to the CGCM2 and HadCM3 for the years 2031, 2051 and 2071

		Year								
		2031			2051			2071		
	Category	Max Storm Surge	Min Storm Surge	Sea-level Rise	**Max Storm Surge**	**Min Storm Surge**	**Sea-level Rise**	**Max Storm Surge**	**Min Storm Surge**	**Sea-level Rise**
CGCM2	Rice	29,341	25,195	1,069	29,374	25,495	1,559	29,443	26,028	2,674
	Sugar-Cane	27,949	16,423	76	27,977	17,369	112	28,032	19,016	207
	Cash Crops	7,542	1,240	53	7,647	1,387	65	7,848	1,739	83
	Coconut	1,446	621	74	1,472	644	83	1,521	690	95
	Mixed Farming	15,345	6,573	89	15,508	6,858	127	15,854	7,433	229
	Grazing	962	755	3	966	770	5	978	794	12
	Total	**82,585**	**50,808**	**1,364**	**82,943**	**52,523**	**1,952**	**83,676**	**55,700**	**3,300**
HadCM3	Rice	29,287	24,687	602	29,319	24,986	890	29,336	25,154	1,069
	Sugar-Cane	27,902	15,152	42	27,929	15,881	63	27,945	16,315	76
	Cash Crops	7,391	1,063	38	7,479	1,163	48	7,529	1,224	53
	Coconut	1,415	587	59	1,432	608	69	1,443	619	74
	Mixed Farming	15,105	6,177	52	15,246	6,406	76	15,324	6,539	89
	Grazing	954	727	2	959	743	3	961	753	3
	Total	**82,053**	**48,393**	**794**	**82,364**	**49,787**	**1,149**	**82,538**	**50,603**	**1,364**

Adaptation options

In order to respond to the vulnerability of the sector, some adaptation options that may be considered for the agriculture sector, following the five pillars, include:

- Pillar #1: Substitution and exploration of new crop varieties more suited to the future climate: undertaking the requisite research to identify suitable crops that will withstand the effects of climate change, such as increased temperature, increased droughtiness, salinity incursions and flooding, especially along the coast

- Pillar #2: Development of a Land-use Management Plan, including measures to minimize land degradation and improve soil conservation, while preventing water contamination from the use of fertilizers and pesticides

- Pillar #2: Informing stakeholders of the consequences and possible solutions to the effects of climate change through public awareness and education programmes

- Pillar #2: Collaboration with the National Drainage and Irrigation Authority in order to make effective the rehabilitation and maintenance of drainage and irrigation systems to aid sustainable agriculture

- Pillar #4: Switching to flood-resistant crops (LCDS 2009. Investment estimated: US$10 million)

- Pillar #4: The sea-wall system, which prevents inundation at high tide, is in danger of collapse due to lack of maintenance and wave damage during storms. Repairs to the sea-wall are critical, and immediate protection measures are required. Although there has been ongoing maintenance since 1998, it is estimated that Guyana would need US$4.4 to 6.5 M per kilometre to fortify its sea defences (Guyana Sea Defence Department).

- Pillar #4: Promotion of the change of land use or activities in the most vulnerable areas, if necessary. It is important to explore the possibilities of identifying suitable inland and interior areas for the promotion and development of large-scale agriculture in the medium to long term, due to the seriousness of the impacts of sea-level rise on the coast. Emphasis should also be placed on the impacts of climate change in the interior locations as well, examining such factors as rainfall changes, and soil fertility and suitability.

- Pillar # 4: Repairing of EDWC and drainage systems

- Pillar #4: Improvements in farm-level management

- Pillar #5: Establishing a crop insurance programme to compensate farmers for losses due to these climate and sea-level changes in the long term.

Most of the adaptation measures identified in the water sector related to improvement, repairing, and/or maintenance of the water infrastructure system, also reduce vulnerability in the agricultural sector.

Therefore, it is important to evaluate the adaptive capacity of the agricultural sector to threats being posed by climate change. The frequency and intensity of flooding, on one hand, and seasonal droughts on the other, call for government policies and legislations that should include education and awareness programmes for farmers and farmer's groups in the short term.

Other adaptation options that may be of relevance would include: an evaluation of the adaptive capacity of the farming community in response to climate change and other stressors in the agriculture sector.

However, these measures will incur additional costs of production, and will call for the sensitization and retraining of the farming community in these alternative agricultural practices.

Main conclusions and recommendations

Climate change and variability will very likely bring about more extreme weather conditions ranging from excessive high intensity rainfall and flooding to protracted droughts, both of which would have damaging effects on Guyanese agriculture. Furthermore, since the bulk of agricultural activities are practised in the coastal zone, there is the added threat of saline water intrusion through inundation and intrusions.

The agriculture sector, especially sugar-cane, would very likely be negatively affected by climate change through decreasing yields, mainly on account of greater droughtiness. Rice production would be less impacted, since it relies heavily on irrigation. Impacts on the water sector, through increasing drought conditions, or salinization from sea-level rise and storm surges, may indirectly impact upon the agriculture sector.

Other sub-sectors of agriculture, such as livestock and fisheries, may also be subject to similar types of climate and sea-level risks, e.g. livestock depend on the availability of grazing pastures which are at risk of being subjected to drought and flooding along the coast. In the case of freshwater fisheries and shrimp farms, saline intrusions and inundations deriving from sea-level rise and storm surges may also impact negatively on this sub-sector.

It is evident that climate change and sea-level rise will pose serious threats to agriculture in the future, and the Government of Guyana would need to put in place policies and measures to address these issues, especially in view of the fact that agriculture is a significant contributor to GDP. The economic challenge for Guyana therefore is to identify specific agricultural and rural development needs and opportunities, and to focus investment in those areas where the greatest impact from adaptation, on food security and poverty, will be achieved. (Caribbean Community Climate Change Centre 2010.)

It is furthermore important to develop a land-use plan (land-zoning strategy) in order to identify the best-suited land for sustainable agriculture expansion and diversification, so as to undertake climate change vulnerability studies on all the major crops that are threatened, and identify suitable alternative varieties where feasible. (The National Climate Committee 2002.)

4.3.5 Fisheries Sector

Description of the sector and scope for the analysis

The fisheries sector is of high socio-economic importance for Guyana. In recent years the government has been promoting a policy to diversify the agricultural base, placing greater emphasis on non-traditional crops such as fisheries. The country has established a fisheries zone of 200 n.mi which is recognized as an Exclusive Economic Zone (EEZ). The country´s coastline is 432 km long and the EEZ is 138 240 km^2.

Fish is a major source of animal protein in Guyana. It is estimated that the per capita annual consumption is 88.4 kg. In 2006, Fisheries accounted for 7 % of Guyana´s GDP, while exports from this sector have consistently surpassed US$50 million since 2004 (Caribbean Community Climate Change Centre 2009). Fisheries employ around thirteen thousand persons in Guyana, in the primary and secondary sector (FAO 2005). These jobs include people in harvesting, in processing and in marketing, and from fishing-related occupations, such as boat-building, supply, and repair. Moreover, the fishery sector is a significant net contributor to Guyana through taxes (export and fuel consumption) and license fees.

The fishery sector has three categories, depending on source of production: (i) Marine fishery which includes industrial trawler fishery, deep-slope fishery and small-scale artisanal fishery; (ii) inland fishery consisting of subsistence activities and an ornamental fish industry, which are conducted in rivers, lakes, swamps and flooded plains; (iii) Aquaculture, which is pursued on a small scale on the coast in polder areas and in ponds.

The main export of the industry is shrimp, including prawn (*Penaeus spp.*), seabob (*Xiphopenaeus kroyeri)* and whitebelly (*Nematopalaemon schmitti*). The main fin fish catches are bangamary (*Macrodon ancylodon*), butterfish (*Nebris microps*), red snapper (*Lutjanus campechanus*), grey snapper (*Lutjanus griseus*), trout (*Cynoscion virescens*) and gillbacker (*Arius parkeri*). The main crab species taken are the blue sheriga (*Callinectes bocourti*), the bunderi (*Cardiosoma guanhami*) and the red sheriga (*Portunus rufiremus*). There is also a shark fishery. Conversely, Guyana´s fishery sector has overexploited the prawn, and there is concern that seabob and sharks are showing signs of overexploitation. Moreover, penaeid shrimp tails have had a 36 % reduction by volume over a ten-year period.

Guyana's fishing fleet consists of around 120 trawlers based in Port Georgetown. The industry exploits the waters in the continental shelf aiming to obtain small shrimp and fin fish. There is also a fleet of some 1,200 artisanal boats that fish in river mouths, and near the shore at shallow depths. However, studies have shown that “the effort (vessels) in this industry is three times that which was registered” (FAO 2005).

On the other hand, aquaculture is a new activity with potential for strong growth, and significant for job creation. Hence, the government is promoting freshwater aquaculture development by providing on-site training of farmers. In 2006, the production value was US$1.2 million, with an average annual growth of 14.4 % since 1995.Guyana´s aquaculture ventures breed the tilapia (*Oreochromis sp*.), hassar (*Hoplosternum littorale*), freshwater pacu (*Colossoma macropomum*), and swamp shrimp (*Mesopenaeus tropicales)* (Caribbean Community Climate Change Centre 2009).It is estimated that some 2,000 hectares are used for aquaculture. Areas identified as suitable are the North and Central Rupununi (Region 9), Monkey Mountain and Taruka (Region 8), Mabaruma and Moruca sub-district (Region 1), Region 2 and Upper Mazaruni (Region 7).

It is important to highlight that Guyana has already taken the following steps regarding fisheries:

- Development of the fisheries sector is part of Guyana's agriculture diversification drive
- Guyana's Low Carbon Development Strategy identified aquaculture as a key area for expansion
- A Fisheries Management Plan was finalized.

For the fisheries sector, the qualitative assessment takes into account the impacts of climate change on the marine ecosystems and aquaculture activities, from expected changes in the spawning of fish to the threats to the fishing infrastructure.

Fisheries sector: vulnerability to climate change and adaptation options

With the expected increase of temperature and change in rainfall patterns in Guyana, the main threats to fisheries are the decrease in water quality for fish, and the disruption of ecosystem dynamics. Hence, the main expected impacts of climate change in fisheries are the change of species distribution, species abundances, and the productivity of the marine ecosystems.

The changes in water properties, circulation patterns and enrichment processes will affect the production of plankton and disrupt the marine ecosystems dynamics, which will change the distribution and production of fish. In addition, the change in seasons will affect the migratory patterns of fish.

In Guyana the changing rainfall patterns that will increase the intensity of rainfall will lead to a change in conductivity of the water, and thus probably, an increased rate of spawning. For example, the high temperature and increased rainfall will dilute the brackish water where swamp shrimp (*Mesopenaeus tropicales*) are reared, resulting in faster rates of growth. However, with an increase in rainfall there will be more severe and recurrent flooding that could affect aquaculture activities; pond banks could be eroded and cultured fish could escape. Through flooding predacious species could be introduced in culture operations, affecting the production. In the same way, the soil of ponds could leach away nutrients, and coastal water could be contaminated because of bacteria from urban and agricultural runoff and municipal wastewater.

The increasing water flow from extreme events may lead to increases in sedimentation impacting the rivers, and dilution of the saltwater which will affect the fishing industry by decreasing the number of fish populations. Conversely, there is threat of saltwater intrusion in Guyana that can have a debilitating effect on freshwater aquaculture production, since certain species such as hassar *(Hoplosternum littorale*) and pacu (*Colossoma macropomum*) will not be expected to survive under saline conditions. Other fishes, such as the tilapia, can live with salinity levels of up to 28 parts per thousand; however, these fish need freshwater for reproduction and for survival of the fries (Caribbean Community Climate Change Centre 2009).

Moreover, fishery resources are vulnerable to climate change. Events such as extreme flooding will cause the potential destruction of landing sites and co-operative buildings that are situated along the coast of Guyana, where fishers land their catch for market purposes. Sea-level rise will threaten landing sites, co-operative buildings, fishers and mangroves.

The economic effects of climate change impacts on the fisheries would be significant in Guyana because of the high level of dependence on the resource, in terms of fishing for subsistence, and the contribution of the fishing industry to the national GDP and employment. Climate change may have an impact on the four key dimensions of food security in the fisheries sector: availability, stability, access, and utilization. In Guyana, people living in rural areas depend heavily on fish as their source of protein, especially because other alternatives are too expensive.

Marine ecosystems have the capacity to adapt to the uncertain impacts of environmental variability, which can be enhanced or suppressed by management and policy actions (Perry 2010). However, this adaptive capacity can be affected by human actions such as over-fishing that makes for shorter life spans and the loss of marine populations. For that reason, adaptation policies and measures should integrate responses to climate change threats with the inherent problems of the sector, such as win-win adaptation measures that will also respond to the socio-economic drivers for fishing.

It is also crucial to adopt an ecosystem approach that ensures intersectoral co-ordination and co-operation for effective climate change responses. It is required that the differences, if any, on the biology of the fisheries, checking for growth patterns with the rise of temperature and salinity, be assessed. This will enable the government to take policy decisions on what to promote for aquaculture activities, for example.

Other adaptation measures include intensifying mechanisms to monitor and regulate the fisheries sector. In this way, fishing that is illegal, unregistered and unreported has to be eliminated. For this, it is required that the quality control for fishing activities through improved port-state control of fishing fleets, improving monitoring control and surveillance, and improving systems of traceability of fish products at all levels of the supply chain be increased (IPSO 2010).

In order to address these issues, the GoG, through the Ministry of Fisheries, Crops and Livestock, will:

1. Develop and implement national policies, legal and institutional frameworks, databases, and technical capacity building and operational standards for the national fisheries sector
2. Establish strict mechanisms and procedures for patrolling, monitoring and protecting Guyana's Atlantic Exclusive Economic fisheries Zone
3. Explore the potential for aquaculture and mariculture and implement such programmes where feasible
4. Collaborate with sector agencies to minimize the effects and impact of air, soil and water pollution and contamination on the marine/fisheries ecosystems and biodiversity of Guyana
5. Collaborate with sector agencies to develop and promote public education and awareness programmes relative and important to the fisheries sector, including protection of mangroves.

For the flood impacts, sedimentation traps in some parts of the rivers could decrease the amount of sedimentation reaching the fish grounds. In addition, aquaculture activities should be protected with barriers to avoid the several impacts mentioned above.

Main conclusions and recommendations

Guyana is expected to have an important change in the species distribution, species abundances, and the productivity of the marine ecosystems, as a result of the projected increase of temperature and change in rainfall that threaten fisheries by decreasing water quality and disrupting the ecosystems dynamics.

Even though the main climate change impacts are identified, several factors limit the analysis of climate change impacts on fisheries, such as the uncertainties about how nutrient inputs and productivity will respond to warmer conditions, and how the species will respond at different levels of temperature (Perry 2010).

Moreover, the lack of professional scientists, management and data collection needs to be addressed in order to develop research that will allow the taking of adaptation policies and measures according to the country's needs.

4.3.6 Forestry Sector

Description of the sector and scope for the analysis

As of 30 September 2009, Guyana's total forest area has been estimated at 18.39 million hectares, of which 15.5 million ha are administered by the State. This area is greater than the previous forest estimates as reported by FAO's Global Forest Resources Assessment (FRA 2010), which is 15.2 million ha. According to Guyana's submission to the FAO (FRA 2010), a total of 3.58 million ha have been classified as other wooded land, and an additional 0.9 million ha as other lands (Guyana's Forestry Commission 2011). The remaining forests are classified as state lands, amerindian lands, and private property (Khan 2001). The different categories of forests present in Guyana include rain forest, seasonal forest, dry evergreen forest, marsh forest, swamp forest, montane forest, and mangrove forest (Khan 2001).

Only 10 % of the population live and work in the hinterland, the majority of which are Amerindians. Amerindians total approximately 9.2 % of Guyana's population, and currently own approximately 13.9 % of the land- which is a very significant increase from 6% in the early 1990s (GFC 2010a). Amerindians use the forest resources as a source of food, medicine, building materials, fibres, tannins and dyes (GFC 2007). Main economic activities in the hinterland vary from region to region, and include mixed subsistence farming, mining, or forestry operations, depending on the location. Forest resources are basically used for agriculture, harvesting of forest produce, ecotourism, research, conservation and Amerindian reservations (GFC 2007).

Guyana contributes significantly to the biodiversity of the wider Amazon Region, both in terms of total number of species, and number of endemic species. Mainly due to low population pressure and to limited commercial activity in the forest areas, its natural ecosystems are relatively intact (Khan 2001). Forest ecosystems provide a large number of services in addition to commercial timber goods, such as habitat for biodiversity, soil and water protection or purification, carbon sequestration and storage, climate regulation, and recreational, cultural and spiritual benefits (Fischlin *et al*. 2007).

It is important to mention mangrove forest ecosystems,[109] since they are an important coastal resource, and they have a variety of functions and uses (Khan 2001), such as:

- Coastal protection and sea defence: acting as barriers to diminish or buffer wave action, protecting the sea-wall or embankment, and reducing the damage to the sea defence system

[109] Mangrove forests are found at the interface between the terrestrial and marine ecosystems. They are also found in estuarine wetlands and in tidal reaches of riverine areas (Khan. M. 2001).

- Bee-keeping: around 75 % of the honey produced is from mangrove areas
- Fisheries: natural breeding and nursery grounds for brackish-water shrimp and fin-fish species
- Wood: one of the most important uses because it provides an easy source of fuel-wood, and is used domestically for cooking, making fences, tents, and arbours for gardens.

According to Guyana´s Mangrove Restoration Project, by 2010 the Mangrove Forests in Guyana were estimated to be 80,432 hectares. Mangroves are found along the sea-coast and those riversides closer to the sea in Regions 1 to 6; the most are located in Region 1, followed by Region 2.

The Forest Sector´s contribution to GDP over the past few years has been around 3.10 %, with a contribution of 3.11 % for 2010. Products include logs, round-wood, lumber, split-wood, plywood, fuel-wood, and non-timber forest products such as wattles, manicole palm, and mangrove bark (GFC 2010b). According to the Guyana Forestry Commission (2007), 27,000 people are directly employed in the forestry sector, including furniture manufacturing, craft, utensils, charcoal, fire-wood and conservation, with more than half involved in logging activity (GFC 2010c). Regarding exports, the total export value for 2010 was US$49.1 M, representing an increase of 7.9 % over 2009 (GFC 2010c).

For the forestry sector, the qualitative assessment developed takes into account the impacts of climate change not only on the forest itself and forest-related industries, but also on forest-dependent activities, such as ecotourism, and the people that live in and depend on them. The analysis considers forest fires, the decrease in ecotourism and the loss of mangroves. The latter have particular importance not only because of their ecological value, but also because they serve as natural barriers for the coastal zone.

Forest sector: vulnerability to climate change and adaptation options

According to climate change scenarios (see Section 4.2), there will be temperature increases and variations in the precipitation patterns throughout the country: median annual increase of 4.5ºC in the southern hinterland regions for the 2090s, with +5.0ºC for the ASO season; and annual median precipitation changes of -4 %, with variations of -19 % and -30 % for the ASO season (McSweeney *et al.* 2008). These variations will bring severe consequences to forests, activities and people that depend on them (Spittlehouse *et al.* 2003).

Potential threats of climate change on forests as a result of these and other variations (such as an increase in CO_2 concentrations), are forest fires,[110] invasive species and pathogens (due to climate variability) which can modify the structure and composition of the forest, and changes in the phenology (the time of flowering and fruiting of the forest), which can affect species growth or survival (CIFOR 2009). These threats affect not only the forest itself, including its biodiversity and inhabitants, but they also create disturbances in the local and national economy.

Climate change is likely to become one of the most significant drivers of biodiversity loss[111] by the end of the century, already forcing

[110] Although rainforests are not easy to penetrate by fires, when droughts occur there is leaf litter accumulation, which becomes drier because of an increase in canopy openness and understory insolation, increasing the likelihood of fires (Lawrence *et al.* 2001). An example of forest fires originating from extreme droughts is the 1997/1998 El Niño event, which produced a widespread drought with accompanying forest fires (Khan 2001).

[111] In Guyana there are over thirty animals listed on the IUCN Red List for endangered species (McSweeney *et al* 2008), a number that could increase due to habitat loss or variations in the local ecosystems.

biodiversity to adapt through shifting habitat, changing life cycles, or the development of new physical traits (CBD 2011). The loss or degradation of forests can generate a number of impacts on its inhabitants, such as a reduction in water availability due to soil erosion and salinization; scarcity of basic supplies needed to subsist, such as food and shelter; a reduction to their income due to a loss of resources, or changes in the surroundings that disrupt operations; and it may even force migrations, both out and into the forest.

Mangrove ecosystems are threatened by climate change, especially by sea-level rise (Gilman *et al*. 2008). Some regional studies suggest that sea-level may rise more than 1 m. by 2100, due to increased mass loss from the ice sheets mainly in the Arctic regions (Meehl *et al.* 2007; Jonathan et al. 2004). The coastal zone analysis in Section 4.2, project different sea-levels. The more conservative scenario, according to the CGCM2 and HadCM3 models developed for the coastal zone, estimate a sea-level rise of 25 to 51 cm by 2071, while the catastrophic one (allowing for a storm surge of 5 metres) projects a 5.93 to 6.19 m sea-level rise. This, combined with a wide range of changes in precipitation projected for Guyana, exposes the coastal zone of Guyana to particular risk.

If the water level rises due to climate change, or there are floods due to heavy rain, these natural defence systems will be destroyed or severely damaged (Khan 2001). Other threats that affect mangroves due to climate change are an increase in temperature generating changes in species composition, phenology patterns and landward migration; a decrease in precipitation together with an increase in evaporation increasing salinity, decreasing productivity, growth and seedling survival, among others. (Gilman *et al*. 2008).

A reduction in mangrove area and health will increase the threat to human safety and shoreline development as a consequence of coastal hazards such as storm surges, flooding, and erosion. Mangrove losses would also reduce coastal water quality, reduce biodiversity, eliminate fish nursery habitats, and eliminate a major resource for human communities that traditionally rely on mangroves for numerous products and services (Gilman *et al*. 2008).

An important factor to be considered when dealing with forests and climate change is that forests play a crucial role in climate change mitigation when developing adaptation measures. Forests act as carbon sinks, so when they are destroyed the carbon stored in them is released into the atmosphere, increasing CO_2 concentrations, thus aggravating climate change (FAO 2011). Even though Guyana has had relatively low historical rates of deforestation (0.1% to 0.3%), if incentives and governance are not directed to controlling deforestation and degradation, both of these rates and their associated emissions are expected to significantly increase (GFC 2010a).

In order to address anticipated impacts from climate change on forestry resources, and to protect this resource, the Government, through the Guyana Forestry Commission, has envisaged the following measures (National Climate Committee 2002):

1. Collaboration with the Environmental Protection Agency (EPA) for the use of environmentally sound technologies within the forest sector, for the protection and conservation of biodiversity and biological resources

2. Promotion and encouragement of local communities and indigenous people’s participation in forest use, protection, conservation and management, and the utilization of non-timber forest products

3. Promotion of increased domestic use of a wider range of timber species

4. Implementation of efficient Management Plans for primary and secondary forest, and degraded forest lands

5. Collaboration with research and development institutions to promote species enrichment of degraded forests and forests lands with economically valuable species which are resilient to the impacts of climate change, where possible

6. Finalization of all pending Forest Management Legislation. Taking advantage of the new trading opportunities available under the new positions adopted in the Land Use, Land-Use Change and Forestry (LULUCF) sector to enhance conservation and sustainable management.

Other possible adaptation measures, mostly linked to good forest management which were identified by CIFOR (2009) include:

- Promotion of ecosystem integrity: reduction of the vulnerability of forests by reducing present threats, maintaining genetic diversity or promoting ecosystem health via restoration
- Promotion of landscape management: adaptation should be implemented at the landscape level to avoid fragmentation and provide connectivity. This maximises the size of land management units and enables decision-making on a larger, biogeographic scale. It also provides buffer zones and flexibility of land uses, and conserves forest types across environmental gradients.
- Expansion of the reserve system and protection of key species and ecosystems: protected areas may be designed taking into consideration long-term shifts in plant and animal distributions and natural disturbance regimes. A primary adaptation strategy to climate change and current climate variability is to reduce and manage the other stresses on species and ecosystems, such as habitat fragmentation, destruction and over-exploitation.
- Promotion of active management: refers to pest management, prevention of fires and maintenance of natural fire regimes, techniques to promote forest productivity, and assisted migration with species introductions to new areas
- Promotion of community-based forest management: this could be established as a national policy. It enhances the resilience of natural ecosystems through forest protection and the establishing of new forests, while enhancing soil conservation and social inclusion.

In respect to mangroves, there are a number of adaptation measures that could be implemented. In 2010, the EU-funded Guyana Mangrove Restoration Project was launched in order to implement the National Mangrove Management Action Plan of the National Agricultural Research Extension Institute. The total EU programme funding is €4,165,000 with a programme implementation period of four years. The specific objectives of the MAC project are: (a) to establish the administrative capacity for the management of mangroves in Guyana; (b) to promote sustainable management of mangrove forests; (c) to establish and complete a legal framework for mangrove ecosystem management which encourages community-based participation; (d) to support research and development of Guyana's mangrove forests; (e) to develop effective protection and/or rehabilitation of mangrove ecosystems; and, (f) to increase public awareness and education about the benefits of the mangrove forests (GMRP 2011).
Other adaptation measures for mangroves include (Gilman *et al* 2008):

- Elimination of non-climate stresses on mangroves in order to increase overall ecosystem health to reduce vulnerability and increase resilience to stresses from climate change
- Management of catchment activities that affect mangrove sediment elevation, in order to minimize long-term reductions in mangrove sediment elevation, or enhance sediment elevation
- Mangrove rehabilitation: mangrove enhancement can increase resistance and resilience to climate change, and mangrove restoration can offset anticipated losses.
- Regional monitoring network: establishing baselines and monitoring gradual changes through regional networks using standardized techniques will allow for a better understanding of mangrove response to sea-level and global climate change, and alternatives for reducing adverse effects.

Important adaptation options that should be mentioned are those related to capacity building, education and awareness, both at local levels (e.g. with Amerindian communities that depend on the forests, people that live near mangroves, people related to logging industries, conservationists, park rangers, local authorities, etc.) and national levels (policy-makers, industries, decision-makers, etc.). The *National Climate Change Adaptation Policy and Implementation Plan* mentions the need to promote research to develop technologies and improve data collection, which is crucial in acquiring a better understanding of the coming changes, and therefore, being better prepared to handle them. This, however, can only be done if there is adequate financing, and if the appropriate legal framework and instruments are in place.

Main conclusions and recommendations

Climate change has the potential to affect forest ecosystems including mangroves in Guyana, according to some scenarios that indicate changes of a median increase of 4.5°C in temperature by 2100, and a reduction of median precipitation of -4 %, and sea-level rises of up to 6 metres by 2071.

Forests are of significant importance for Guyana, not only because they form more than 75 % of the country's territory, but because they provide a large number of environmental and commercial services (including those from mangroves), and represent at least 3 % of the GDP.

Nowadays forest management is mainly based on how forests developed under past climatic conditions, but it is time for forest managers and policy-makers to accept that climate change is a reality, and that forests and forest communities face significant changes. Adaptation requires planning for change so that a suite of options is available whenever needed. And so, in order to face these changes, it is crucial to incorporate the concept of climate change in every area that relates to forests, including land-use planning, the elaboration and review of national policies, and the implementation of local planning processes.

This also applies to mangroves. The use of these ecosystems is now being monitored and regulated, and the implementation of the GMRP in 2010 has had an important positive impact in the protection and restoration of mangrove ecosystems. Lack of public awareness regarding the importance of mangroves has been one of the reasons why these fragile ecosystems are currently at risk, and this is why the Project has a very strong public awareness component, which deals with education and community involvement. Much of the destruction resulted from conversion of these ecosystems to other uses, which can be attributed to mangroves being viewed as wastelands. For example, mangroves are cut for fuel-wood, even though it is an offence under the Sea Defence Act of 1998 to cut mangroves.

Both technical and financial capacities are currently being built in areas such as forest carbon and monitoring of forest carbon fluxes, as well as in the use of GIS and Remote Sensing. It will not be an easy task to face all of the impacts that will emerge due to a continuously changing climate that affects structure, composition and processes that occur in the forests. Forest managers will have to do their best to achieve realistic results, given the necessary tools to do so, such as training, financial support, adequate technological resources as well as infrastructure, and a regulatory framework that allows them to adapt to the changes (Blake *et al.* 2008).

Guyana is cognizant of the role of forests in climate change and is currently engaging in efforts towards entering into a forest carbon financing mechanism, specifically that of REDD+, that will help to reduce deforestation and degradation and lead to a sustainable management of forests. Even though created mainly by a mitigation incentive, this financial mechanism will enable forest adaptation (since conservation and sustainable management are basic adaptation measures). Guyana is entitled to receive a total of US$3.6 million over a 36-month period to implement readiness activities, including the development of a Monitoring, Reporting and Verification System (MRVS) that will prepare Guyana to enter into a forest carbon financing mechanism. It is important then, that the adaptation needs are clearly identified and incorporated where possible, as part of these readiness activities.

4.3.7 Tourism Sector

Description of the sector and scope for the analysis

The tourism industry in Guyana is centred mainly on ecotourism in the hinterland area, with untouched and diverse forests, as well as a large number of waterfalls, including the Kaieteur Falls that have a sheer-drop height of 225 metres.[112] Another important attraction is the Savannah plain of the Rupununi, where riding, hunting, fishing and swimming are available (Khan 2001). Other tourism market niches are sport fishing, yachting (GOI 2010), and bird-watching with over one thousand species of birds to see.

Tourist attractions on the coast of Guyana include the city of Georgetown, and a few beaches like the Shell Beach, which is located in Region One and stretches from Waini Point to the mouth of the Pomeroon River. This is the only beach in the world where four species of sea turtles nest (the Leatherback, Green, Olive Ridley and Hawksbills), and is also an important habitat for a number of other animal species, some of which are now endangered (Khan 2001). Other beaches include those located on the coast, namely, Number 63 Beach in Corentyne, Berbice; Hope Beach; Bushy Park; Parika, and Unity Beach. These latter beaches are more readily accessible and lie just outside the boundary of coastal communities. The beaches are the sites for cultural and recreational activities. Currently, there are three major cremation facilities constructed along the foreshores at Babu John, Hope, and Ruimzigt.

Even though most of the tourism in the country takes place in the hinterland, all the main executive hotels are located on the coastland, within a half mile from the sea defences.

[112] The Kaieteur Falls are located in thick jungle in the hinterland, easily reached by a small aircraft, chartered by travel agencies.

Guyana has some 60 hotels (half of them in Georgetown and its vicinity) with 1,133 rooms or 2,623 beds in the entire country (World Bank 2007). As a result, while tourism in Guyana is mainly centred on the hinterland, most of the industry support services, including offices, hotels, major roadways, hospitals, a new convention centre (built in 2005), and the airport, are located on the coast (Khan 2001).

The National Tourism Policy Document (1998) sets out the guidelines for a national tourism policy, and it suggests and supports the development of a national system of protected areas as an essential step in the development of a national eco-tourism industry (Atkins 2006). In 1999, the National Development Strategy (NDS) included a chapter on tourism and recommended the establishment of a statutory body -the Guyana Tourism Authority (GTA) - to align public and private sector interests in the management and marketing of the sector. The GTA´s main function is to assist in the formulation and implementation of policies for the tourism sector, and to liaise with stakeholders. The GTA is responsible for research and statistics, marketing and product development, and sector-related information technology (World Bank 2007).

There have been a number of developments in the tourism sector in Guyana, such as the National Plan for Eco-Tourism Development as part of the technical assistance programme (OAS 1997); A Tourism Policy document; an Eco-tourism Plan and a Kaieteur Park Master Plan (1998); and Training and Capacity Building for the Tourism Sector in 2001 (Atkins 2006).

According to the World Travel and Tourism Council, estimated key statistics for tourism in Guyana for 2011 are (WTTC 2011):

- Direct contribution of travel and tourism to GDP: 4.8 % of total GDP
- Total contribution of travel and tourism to GDP: 12.2 % of GDP
- Direct contribution of employment: 13,000 jobs, 4.1 % of total employment
- Total contribution of employment: 33,000 jobs, 10.6 % of total employment
- Visitor exports form travel and tourism: 5.4 % of total exports
- Travel and tourism investment: 3.5 % of total investment.

For the tourism sector, the qualitative assessment developed under this sub-chapter considers the impacts on tourism infrastructure and tourist flow changes due to climate-related factors that could affect the sector, such as extreme events and increase of diseases. It also considers its relation to Guyana´s economy and local employment importance.

Tourism sector: vulnerability to climate change and adaptation options

Due to its close connections to the environment and to climate itself, the tourism sector is considered to be a highly climate-sensitive economic sector, similar to energy, agriculture, and transportation. Changes in the weather could affect the tourism industry through increased infrastructure damage, higher operating expenses (e.g. insurance, backup water and power systems, and evacuations), additional emergency preparedness requirements, and business interruptions (Simpson *et al.* 2008). If tourism in Guyana decreases, the national and local economies will undoubtedly be affected, considering the sector´s contribution to the GDP and the number of people employed directly and indirectly by the sector.

With most of the tourism infrastructure on the coast, Guyana´s tourism sector is extremely vulnerable to climate change (Khan 2001). Guyana´s coast is exposed to rising sea-levels and flooding, which will be exacerbated with climate change (Khan 2001; Atkins 2006). The sea-levels estimated in Section 4.2 would affect the eco-resorts that have been established along creeks and inland waterways in recent years, constituting one of the primary destinations for vacationing, water-sports, weddings, parties, fashion shows, and other social events.

Another threat that could affect the tourism sector is the increase of diseases such as malaria, dengue fever, and others, due to an increase in the geographical ranges and seasons of vector organisms (Simpson *et al.* 2008; Khan 2001), which will have an impact on the number of tourists coming to the country.

Even though most of the tourism in Guyana takes place in the hinterland not under direct threat due to sea-level rise or flooding, there are other threats due to an increase in temperature and a decrease in precipitation, such as forest fires and biodiversity loss, which could affect the eco-tourism industry. Another important issue to consider is that one of Guyana´s main touristic attractions are its waterfalls, with Kaieteur Falls as the main attraction. If precipitation decreases, the water flow could be diminished, thus having an impact on the magnificence of the waterfall.

In order to prepare for and address the impacts of climate change, the Government, through the Ministry of Trade and Tourism and Industry, may (National Climate Committee 2002):

1. Undertake the preparedness of civil society and all those with a stake (e.g. forestry), or whose communities will be affected by the influx and impact of tourists, to make the necessary accommodation and/or adjustments that have to be made

2. Define, develop and enact a clear national policy and strategy for eco-tourism product development and promotion, and establish the legal and institutional frameworks for an effective tourism sector, which recognize potential impacts on tourism development arising from climate change

3. Address the issues of the likely impacts of eco-tourism on the environment, protected areas, the management of natural, cultural and heritage sites, and the protection and conservation of biodiversity and biological resources

4. Determine the economic implications of tourism, particularly nature-based tourism, on the different sectors

5. Develop institutional and human resources capacity to service the needs of a tourism industry

6. Promote public education, training of hospitality workers, and develop community awareness of the needs of the tourism industry, especially those relating to nature-based tourism.

It is also important to have building codes in place in the coastal areas in order to prevent damage from storm surges and sea-level rise. For example, hotels should be built at a safe distance from the high tide mark and above mean sea-level. Other adaptation options to have in hotel areas are evacuation plans, insurance coverage, staff training, first aid kits, food and water storage, as well as early warning systems in place (Simpson *et al*. 2008).

Main conclusions and recommendations

The tourism industry, and especially the eco-tourism sector, present a strong economic opportunity for Guyana and, if carried out appropriately, can contribute to the conservation of the largely intact hinterland, bringing development to the local people. It is important to consider that the success of eco-tourism depends on the state of the surrounding ecosystem, creating an incentive for the stakeholders involved to preserve their physical environment (Atkins 2006).

Even though tourism in centred in the hinterland, it is important to emphasize that most of the tourism infrastructure (i.e. hotel accommodation) is found on the coast, which is extremely vulnerable to the impacts of climate change, especially to floods and storm surges, and this has to be considered when evaluating and implementing adaptation measures.

Available studies that have examined the climate change risk appraisal of tourism operators have consistently found low awareness of climate change and little evidence of long-term strategic planning in anticipation of future changes in climate (Simpson *et al.* 2008), an issue that has to be dealt with at the national and local levels.

4.3.8 Energy Sector

Description of the sector and scope for the analysis

Guyana´s energy sector has traditionally been reliant on imported petroleum-based fuels as its primary source of energy. Historically, the energy sector was characterized by a lack of a reliable supply of electricity: by continuous load discharges, voltage variations, shortfalls because of periodic fuel shortages, and lack of funds to replace aging generators and to build new power plants. Nowadays, the energy system is more stable and the Government continues to take steps to diversify the country´s energy matrix. In order to reverse Guyana´s dependence on fossil fuels, the country has started a process to switch from nearly 100 % dependence on fossil fuel-based electricity generation to nearly 100 % clean and renewable energy supplies. In the medium term, electricity supply based on the renewable energy projects will add up to 150 MW; 140 MW coming from hydropower and 10 MW from bagasse (GPL 2011). This future dependence on hydropower makes it of high importance to consider possible effects of climate change on water availability.

Energy situation

Guyana’s energy supply in 2008 was approximately 5 million barrels of oil equivalent (BOE) from a variety of energy sources: diesel (gasoil), bagasse, fuel oil, gasoline, rice husk, kerosene, LPG, fuel-wood, charcoal, avgas, solar photovoltaics and biodiesel. The value of petroleum product imports represented however 31.3 % of the value of Guyana’s merchandise imports, while the value of petroleum imports represented 43 % of Guyana’s GDP (US Embassy 2009).

With over 7000 MW of hydropower potential in the country, Guyana continues to study and analyze various options, as part of the effort to diversify its energy matrix. The Amaila Falls **Hydroelectric** Project has most recently been revised to a 165 MW hydropower plant. The plant will deliver electricity to Guyana's capital (Georgetown) and its second largest town (Linden) by an electric transmission line. Construction of the hydro facility and electrical interconnection is anticipated to begin in late 2011 and will take approximately four years to complete. Since the demand of Guyana's electric utility, which averages a total of about 100 MW, is presently dependent on fossil-based imports for all of its energy generation, a 165 MW plant will meet all of Guyana's electricity needs from renewable energy when the plant commences commercial operation. During its four years of construction, the project will provide employment opportunities and increased economic activities in Guyana. The plant will provide power reliability, greater security and protection against oil price rises above about US$72 per barrel of crude. Over time, the project will prevent the average wholesale energy cost from rising, and will spur additional economic investment resulting in more jobs and stronger infrastructure. After twenty years of operation, the Project will be transferred to the state electric power company at no cost.

It is important to mention that a 30 MW **bagasse**-based generation plant was installed in 2009 and is currently supplying power to the electric power company through a power purchase agreement. Renewable energy has begun to make a contribution to the national energy matrix with the commissioning of the Skeldon 30 MW co-generation facility. While operational and other difficulties since its commissioning in 2008 have severely limited the dispatch of power from the co-generation facility, GuySuCo is guaranteeing twenty-six weeks of co-generation operation from 2012.

Likewise, Guyana has been actively installing **solar photovoltaic** systems in remote hinterland communities and schools that do not have access to grid power. To date, more than 203.85 kW of solar photovoltaic systems have been installed, and the installed capacity of solar power will soon be boosted with a massive programme to promote renewable solar energy (0.715 MW) in Guyana.

Under the Unserved Areas Electrification Programme (UAEP), four solar energy demonstration projects were originally planned to be implemented in Kurukabaru, Yarikita, Capoey, and Muritaro. However, due to the positive responses and the obvious need, the project was extended to other remote hinterland communities. In fact, a total of 1,750 solar systems were installed under the UAEP, in homes, schools and other community buildings, across twenty-one hinterland villages.

On the other hand, GPL and Delta Caribbean signed a MOU, in March 2007, for the construction of a 13.5 MW Wind Farm at Hope beach on the East Coast of Demerara. High equipment prices, due largely to the strength of the Euro and the worldwide demand for wind turbines, required a complete project review. The feasibility study has been completed and the company has submitted an updated commercial proposal which proposes a tariff of US$0.105/kWh based on a delivery point at Hope Beach for an 18 MW wind farm. The proposal indicates that financing is being pursued by the investor.

The Government of Guyana continues to receive proposals for the production of **biofuels**. The Ministry of Agriculture, with funds from the Special Japanese Fund of the Inter-American Development Bank, has procured consulting services to:

a. Improve the capacity of the GoG to identify and evaluate viable investment opportunities in the bioenergy production chain
b. Develop a financial vehicle or instrument to promote investment opportunities and develop a strategy to harness Guyana's potential for bioenergy production
c. Increase capacity building and the transfer of technology to build a critical mass of bioenergy technicians, operators, and demonstration programmes, and for
d. Institutional strengthening to support Agro-energy policy of Guyana, support for small scale bioenergy demonstration programmes and dissemination of results.

The Institute of Applied Sciences and Technology (IAST) research facility produced almost 40 x 45-gal barrels of biodiesel using edible oils and waste edible oils as feedstock during 2010. The commercial unit operating at Wauna, Region 1, produced 1,076 barrels of biodiesel using palm oil as the feedstock during 2010. Of this amount, 60 % was used for power generation while 40 % was used for transportation.

Guyana continued its public awareness campaign to sensitize the public on energy efficiency and conservation programmes. A total of 14,000 brochures with energy-saving tips on transportation, lighting, appliances and building designs were printed and distributed to various sector agencies, key stakeholders and the general public during 2010. A week of energy-related activities including a seven-day radio quiz, a live panel discussion on energy-related matters, a three-day energy exhibition and an architecture seminar to promote energy-efficient building designs were held during 2010 to promote energy awareness. Information is continually uploaded to the GEA website at www.gea.gov.gy.

Finally, it is important to mention that the Guyana Energy Agency will soon be publishing a Guide for the Design and Construction of Low-cost Bio-digesters which can be used by small scale farmers to convert animal waste to energy in the form of biogas for cooking, lighting and electricity generation.

Electricity Situation

The principal public supplier of electricity in the country is Guyana Power and Light, Inc. (GPL). GPL is a government-owned utility with exclusive rights for the transmission, distribution and sale of electricity, and non-exclusive rights for generating electricity in Guyana. GPL supplies over 150,000 residential, commercial, industrial and government customers. In 2010 GPL's customer base expanded to 151,288 customers, a net increase of 4,253 (2.89 %) customers over 2009. Gross generation for 2010 totalled 626 GWh representing an increase of 6.84 % over 2009. Gross generation has been rising steadily over the last four years.

Increasing peak demands and energy demands require that reliable generation capacity be available to ensure the continuous supply of electricity. The acquisition of additional generation capacity is therefore necessary due to the following circumstances:

- Faster than expected growth in demand
- Increase in unreliability and availability of the installed capacity, due to many of the engines being well beyond their useful life
- Provision of a stock that will provide an improved margin of capacity, given the rising demand and the level of unreliable engines.

GPL's total installed capacity is 163.5 MW, of which 109.3 MW relates to Demerara, but only 73.7 MW was considered reliable (2009 Annual Report). The options available to respond to rapid demand growth are generally limited to off-the-shelf technologies such as fossil-based technologies.

The co-generation plant would be complemented in 2015 with about 140 MW of power from the Amaila Falls Hydroelectric Project. These projects, with adequate compensation in the GPL network, should provide over 99 % of all GPL's energy requirements by 2015. The contribution of hydropower and bagasse-based co-generation will transform Guyana's electricity sector from dependence on fossil-based energy to a diversified low-carbon renewable energy matrix.

The Unserved Areas Electrification Programme extended the access to electricity supply to households and house lots of Regions 2, 3, 4, 5, 6, 7 and 10, which resulted in 22,000 more households receiving access to electricity supply. With respect to loss reduction, through the initiatives of the UAEP, GPL's losses were reduced from 40 % in 2006 to 31.3 % by the end of 2010. For the year 2010, losses were reduced by 3 %, which translates to savings of approximately US$4M for the period. This was achieved through aggressive loss reduction initiatives including the introduction of iron meters, prepaid meters, a new customer billing system, installation of new interfaces, replacement of defective meters, and actively pursuing illegal connections.

GPL's strategic long-term generation plan is premised on the continued use of renewable sources of power to meet base-load generation needs. The development of a large hydropower facility by the Brazilians at Turtruba would assist GPL to meet its incremental power needs when the capacity at Amaila becomes inadequate by 2018.

It will be recognized that the changes in global weather patterns would impact water availability for any hydro development, both positively and negatively. GPL would therefore continue to maintain its fossil fuel capacity to fill capacity gaps and maintenance requirements for the hydropower plants.

It is important to mention that, due to concerns about the reliability of electricity supply in the past, some companies (such as sugar and the mining industry) opted for self-generation, which is estimated to be 42 MW throughout the country (GPL 2011). But, as was noted before, the energy sector is also receiving extensive focus from the government because energy is seen as an important driving force for growth and development.

Energy demand per capita in Guyana can reasonably be expected to increase as a result of climate change, mainly for cooling buildings due to the warmer climatic conditions in the country. According to the Mitigation Assessment Energy Analysis, the total energy demand in Guyana will increase to 4,347 GWh by 2030 with the largest requirement for energy being in the transport sector and household. In that sense, Guyana's Energy Policy aims to provide energy at the lowest possible sustainable cost, with adequate energy security. In order to achieve this, it encourages the effective and efficient use of energy and considers the utilization of indigenous renewable energy sources.

For the energy sector, the qualitative assessment considers climate change impacts on the generation and transmission of electricity, focusing on the transformational change that is currently ongoing in Guyana from oil to the hydroelectricity-based sector. Therefore, exposure to water deficits, drought, and extreme events such as heavy rainfall and landslides are analysed.

Energy sector: vulnerability to climate change and adaptation options

Considering the energy supply in the mid-term will come mainly from hydropower, Guyana's dependence on water availability makes it vulnerable to possible effects of climate change, such as the increase in seasonal droughts as the result of change in precipitation patterns and warmer temperatures. Projections of mean annual rainfall vary between reductions of 34 %, to an increase of 20 % by the 2090s, with median values of -18 (reduction) to -4 % (increase). Therefore, drought episodes could severely affect the generation of energy, since the country is promoting a complete switch to hydropower by 2014.

Secondly, while water deficits would increase substantially for almost all months, it is also projected that there will be intense rains and flooding that could impact on the energy infrastructure for generation and transmission. Heavy rainfall and landslides have already damaged a hydropower plant (Moco Moco plant in the Upper Takutu – Upper Essequibo region) making it inoperable. Regarding infrastructure, deep risk analysis should be performed if power stations or transmission lines are to be installed in the coastal zone, since climate change threats and sea-level rise could harm them. Further pressure on the energy system could also be a consequence of drought seasons caused by climate change, since such episodes may force farmers to migrate to the coastal zone.

The vulnerability of the energy system is of considerable importance for Guyana´s development, since the energy sector of a country is indispensable for the well-being of its economy. The energy supply allows industries to expand and the national economy to grow. Energy supply rests on a governmental company, so governmental capacity to deal with climate-related issues needs to be greatly strengthened.

This adds to the fragility of the energy sector that is in the process of change, coupled with the fact that it has already been estimated that with energy demand growth, the national energy sector will not be able to supply sufficient energy. Even if, as planned, the development of a large hydropower facility by the Brazilians would assist GPL to meet its incremental power needs when the capacity at Amaila becomes inadequate by 2018, Guyana needs to ensure itself energy security. In that sense, GPL has considered continuing to maintain a minimum of 50 MW of fossil fuel capacity to fill capacity gaps in response to weather threats. Energy efficiency measures play a crucial role for reducing energy demand and can also be seen as adaptation measures under stringent energy supply conditions.

Diversification of energy sources is the main adaptation policy that would help Guyana cope with climate change. This policy goal should be accompanied by strengthened climate change related risk analysis for the design and construction of energy infrastructure, so as to ensure resilience to the different impacts of climate change. Guyana´s Low Carbon Development Strategy states that investments in priority climate adaptation infrastructure can reduce by ten per cent the current GDP which is estimated to be lost each year as a result of flooding.

According to *Guyana´s Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-lying Areas* (2002), in order to address anticipated impacts from climate change on energy resources, and to give effect to commitments under the UNFCCC, the Government through the Guyana Energy Authority, may:

1. Promote investment to continue development of renewable energy sources and to encourage the upgrading of generation facilities using cleaner fuel and possibly natural gas

2. Promote public awareness programmes that focus on alternative, renewable, environmentally-friendly, energy technologies

3. Promote and widen incentive mechanisms, which are in place to improve energy production efficiency and efficient use of energy.

In addition, energy efficiency adaptation measures have been considered by Guyana´s National Energy Efficiency Programme (i.e. energy efficient lighting for government and public buildings, home energy audits, financing energy-efficient appliances, etc).

Another important issue to consider is to study the climate scenarios to determine the best locations for power plants, whether they are hydropower, solar, wind, etc. This will help ensure that the power plants will have a longer life span and that they will be used efficiently.

Main conclusions and recommendations

Guyana has started a whole change process in its energy sector, switching from total dependence on imported oil to energy generation with renewable sources, mainly hydropower. However, climate change threats, specifically drought, could be a serious set-back for its energy stability. Therefore, the principal adaptation policy is the diversification of energy sources in the country. In addition, the energy sector is vulnerable because of its inefficiency and its exposure to extreme events that could damage its infrastructure.

For the development and stability of the energy sector under a climate change scenario, it is necessary to include climate change variables in energy planning, and reverse the lack of knowledge on climate change issues by government officials. Energy efficiency can also play an effective role in adapting to climate change.

Additionally, research is needed to develop energy policies and strategies, mainly on:

- Climate change risk analysis and adaptation measures for hydropower infrastructure
- Potential use of indigenous energy sources as a means of diversifying the energy matrix
- The potential of wind energy and the viability of wind farms as a means of diversifying the energy matrix
- Future water availability for the Amaila Hydropower project
- The potential for hydroelectric power generation in the hinterland and projection of water availability.

4.3.9 Health Sector

The information presented for the health sector is based on available secondary qualitative data, contrasted with some international studies on climate change and human health. Due to a lack of data, the methodology and findings for the health sector of Guyana rely heavily on the published literature for the region (MoH, Amarakoon *et al.* 2003; Chen and Taylor 2002). There is no scientific/quantitative data on effects and impacts of climate change on Guyana's population health. Nevertheless, the projections on climate and sea-level rise help in understanding the urgency of improving Guyana's health system, and the necessity for scientific evidence for this sector, as is further explained.

Description of the sector and scope of the analysis

The health of millions of people is affected each year by both the acute and long-term effects of climate. It is expected that climate change will impact on ecosystem services, in ways that increase vulnerabilities regarding food security, water supply, natural disasters and human health, and which will in turn affect socio-economic development (IPCC 2007b; Stern 2006; WHO 2003; 2008). As shown in the chart below, some of the direct impacts of climate change include changes in exposure to weather extremes (e.g. heat waves), and increases in other extreme events (e.g. floods, storm surges, droughts), with several health effects.

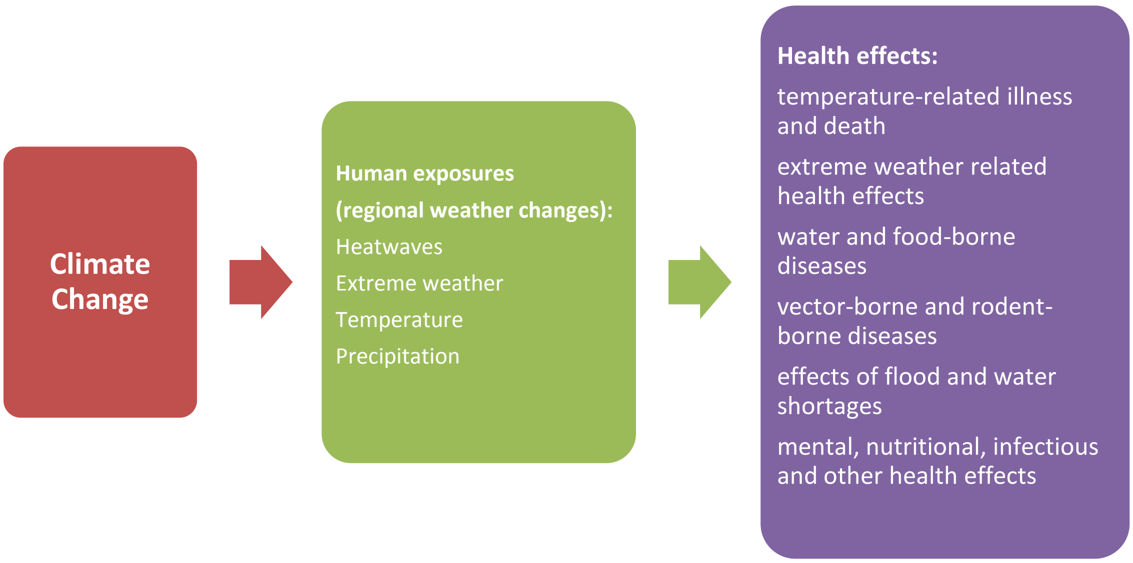

Fig. 4. 24 **Climate change and derived health effects**

Source: Adapted from Climate Change and Human Health, Risks and Responses. WMO, WHO, UNEP – 2003.

Yet, as will be explained further, health outcomes are influenced by other factors besides those imposed by climate change. In addition, climate change will lead to higher levels of some air pollutants, sea-level rise, increased outbreaks and transmission of diseases through unclean water and through contaminated food, and will threaten agricultural production in some of the poorest countries.

Climate change also brings new challenges in the control of infectious diseases. Many of the major killers in Guyana are highly linked to temperature and rainfall, including cholera and diarrhoeal diseases (water-borne diseases), as well as vector-borne diseases including malaria, dengue, leptospirosis and schistosomiasis (WHO 2010).

According to Guyana's Ministry of Health's statistics (2007), the most prevalent diseases recorded nationally among all ages are respiratory tract infections and malaria. Malaria and dengue fever, both highly climate-sensitive diseases as regards temperature and rainfall, have become major public health problems in Guyana in the recent past. *Plasmodium falciparum*, one of the species that causes malaria, is the main infectious agent. New cases represent over 90 % of the cases detected each year. Figure 4.25 shows that malaria has been, by far, the most disease that has most characterized the Guyanese health sector.

Variations in Guyana's climate are also attributed to the El Niño-Southern Oscillation (ENSO). This event is one of the most prominent known sources of inter-annual variability in Guyana's weather and climate. This phenomenon has two phases: a warm phase known as El Niño where Guyana experiences reduced rainfall, sometimes leading to droughts; and a wet phase where heavy rainfall and flooding occurs (MoH 2008). Excessive rain and droughts are factors that can contribute to increased malaria mortality. In this regard, the impacts of major vector-borne diseases and disasters can have a negative influence over Guyana's social development, threatening to slow, halt or reverse the progress that the global public health community has made against many of these diseases.[113]

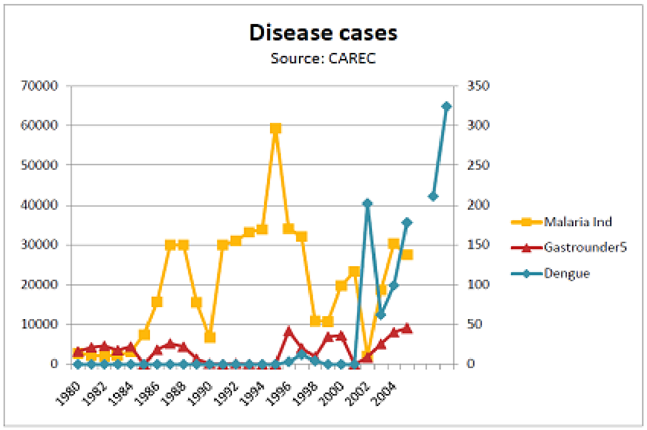

Fig. 4.25. Disease cases 1980 - 2004

Health Sector in Guyana

The health of the population is given priority, as the government increases its spending in this sector with every budget. In Guyana, 4.4 % of the GDP goes to health issues[114] (Table 4.21). In addition, the sector benefits by receiving grants from donors in the fight against HIV/Aids, Tuberculosis, Malaria, other illnesses and diseases. Guyana boasts a sizeable health infrastructure for its population, with 379 related centres providing some level of health care. For the six coastal Regional Democratic Councils (RDC) a total of 243 centres are found (Table 4.20).

Nonetheless, acute shocks such as extreme weather events and outbreaks of disease epidemics can overload the capacities of health systems in Guyana. The 2005 Flood is a perfect example of this.

[113] From: Economic Assessment on the Impacts of Climate Change on Human Health in Guyana. Second Draft, 2011.
[114] Source missing.

Table 4.20. Health facilities per RDC

	RDC 1	RDC 2	RDC 3	RDC 4	RDC 5	RDC 6	Total
Health Posts	41	21	26	12	14	20	**134**
Health Centres	3	13	13	38	17	28	**112**
District Hospitals	3	1	3	0	2	3	**12**
Regional Hospitals	1	0	1	0	0	0	**2**
Specialist Hospitals	0	0	0	1	0	1	**2**
Private Hospitals	0	0	0	7	0	0	**7**
National Hospitals	0	0	0	1	0	0	
Company Hospitals	0	0	0	0	0	0	**0**
Rehabilitation Centres	0	0	0	1	0	0	**1**
Geriatric Hospitals	0	0	0	1	0	0	**1**
Total	**48**	**35**	**43**	**61**	**20**	**36**	**243**

Source: Statistical Bulletin, December 2009.

Table 4.21. Public expenditure for selected sectors (G$ Billions)

Sector /Year	2009	2010	2011 (Budgeted)
Health	12.8	13.4	14
Education	20.3	21.8	24.3
Bridges & Roads	8.1	7.9	10.1
D&I	4.9	5.1	6.6
Sea & River Defence	2.7	2.6	3.0

Source: GoG. Budgets 2010; 2011. Ministry of Finance. January 2010 & 2011

Health impacts of climate-related diseases

According to the Lancet Commission's 2009 report,[115] **climate change is the biggest global health threat** of the twenty-first century, and will affect the key determinants of human health. Currently, there is growing evidence that climate change will have profound effects on the health and well-being of citizens in countries throughout the world, and will affect countries such as Guyana, exposed to climate events, and with a high rate of poor population. Table 4.22 below shows different health determinants due to climate change that have a health impact. Most of those determinants are and will be present in Guyana because of climate change.

[115] *Managing the Health Effects of Climate Change.*

Table 4.22. **Health determinants and health outcomes**

Health Determinant due to Climate Change[116]	Health Outcome
Direct impact of heat and cold	Cardiovascular disease deaths
Temperature effects on food-borne diseases	Increased cases of diarrhoea, gastro-enteritis
Temperature effects on water-borne diseases	Increased cases of diarrhoea, gastro-enteritis
Temperature, humidity, rainfall effects on vector-borne (and rodent-borne) diseases	Increased incidence of malaria, dengue fever, leptospirosis
Effects of extreme rainfall and sea-level rise on flooding [(a)]	Fatal injuries; non-fatal injuries and mental health effects
Changing patterns of agricultural yield	Malnutrition
Effect of flooding and drought on food and water-borne diseases	Increased incidence of cholera, diarrhoea, gastro-enteritis
Sea-level rise and reduced snowmelt impacts on freshwater availability	Drought and flooding, pests, diseases, biodiversity loss, economic disruption
Drought and flooding, pests, diseases, biodiversity loss, economic disruption	Malnutrition
Destruction of health infrastructure in floods and storms	Increases in mortality and morbidity in affected areas
Temperature and precipitation effects on incidence and intensity of forest fires	Fatal and non-fatal injuries
Temperature and precipitation effects on incidence of dust storms	Fatal and non-fatal injuries
Emergence or spread of pathogens via climate-change-driven biodiversity loss	New cases of infectious diseases

In Guyana, the following projections have been estimated:

- Sea-level will rise more than 1 metre by 2100, due to increased mass loss from the ice sheets mainly in the Arctic regions (Meehl *et al.* 2007; Jonathan *et al.* 2004); different sea-level scenarios estimate an increase of at least 25 to 51cm by 2071 (see Section 4.2).
- In the 2060s, the mean annual air temperature is projected to increase between 0.9°C to 3.3°C, according to the B1, A1B and A2 (McSweeney *et al*. 2008).
- A-OGCM projections of mean annual rainfall vary between a reduction of 34 % to an increase of 20 % by the 2090s, with median values of -18 (reduction) to -4 % (increase) (McSweeney *et al.* 2008).

Some effects of climate change, such as changes in precipitation (rainfall), temperature patterns, and sea-level rise, will potentially result in a number of changed health outcomes. Some of these outcomes include increased death and injuries, and higher incidence of vector-borne (i.e. malaria and cholera) and water-borne (i.e. dengue and diarrhoea) diseases. Climate change also affects health indirectly through the disruption of agricultural systems due to drought or excess rain, leading to malnutrition or famine.

Much of what is known concerning how climate change might affect human health has been inferred from correlation of health conditions with climate variability (weather variables or seasonability). Studies have focused on the possible impact that changing climate, season, and weather variables might have on the incidence of disease.

With an increase in temperature, there may be migration of vectors up to higher elevations, and not just horizontal migration. Climate-induced effects on other sectors such as agriculture,

[116] (a) Separately attributed to coastal floods, or inland floods and landslides. Source: adapted from Campbell-Lendgrum and Woodruff (2007)

fisheries, water and coastal resources, and social and economic conditions might also affect human health.

Scope of the Analysis

Regardless of the theoretical relationships between environmental health and hazard, which are well known (WHO 2003; WHO 2008; IPCC 2007), and some modelling studies undertaken, there has been little empirical research on these linkages carried out in Guyana. Recently a study was done in Guyana (Emmanuel 2011), utilizing the predictive/statistical model to extrapolate the temporal climate/disease relationship to estimate change in temperature and/or rainfall-related cases under future climate change.[117] The focus of the study was to estimate the impact of climate change on the four communicable diseases of most significance for Guyana: malaria, dengue, gastroenteritis and leptospirosis, all of which are expected to be associated with the flood events that are anticipated to impact the country with increasing likelihood and intensity as a result of climate change.[118]

The aim of the modelling approach is to estimate the impact of climate change on human health to 2050 in Guyana under the A2 and B2 scenarios prescribed by the Inter-governmental Panel on Climate Change (IPCC).

A predictive empirical statistical modelling is used in this study to estimate the relationship between climate and disease. This involves the estimation of an econometric model using Ordinary Least Squares (OLS) regression in order to obtain the historical relationship between each disease and rainfall and temperature for the period 1980–2005, and then to forecast the number of disease cases that could be anticipated between 2011 and 2050 under the A2, B2 and BAU scenarios. The results have not yet been validated, so they cannot be presented in this chapter.

The assessment developed in this section takes into consideration, qualitatively, the potential impacts of climate change such as changes in exposure to weather extremes (T, P) and increases in other extremes events (e.g. floods, storm surges, droughts) that can result in several health effects. It also evaluates the infectious diseases that may appear because of the changing climate patterns.

Health sector: vulnerability to climate change and adaptation options

Vulnerability of human populations to health outcomes vary, taking into consideration the extent to which a particular health outcome is climate-sensitive, and the population's capacity to adapt to climate changes. Some factors that influence vulnerability are (WHO 2003): (i) population density; (ii) level of economic development; (iii) food availability; (iv) income level and distribution; (v) local environmental conditions; (vi) pre-existing health status; and (vii) quality and availability of public health care.

Furthermore, climate change impacts on human health are affected by factors prevailing within a country, which include: effectiveness of the public health system, demographic structure and location, and national disaster preparedness and response.

[117] The relationship between climate and disease is estimated using econometric methods largely.

[118] The results on leptospirosis have not been included here since historical data indicates it is not a major disease in terms of the number of cases that have been recorded since 1980.

In Guyana, the most vulnerable groups of people are the poor, including Amerindians (of whom more than 90 per cent of those in the rural interior live below the poverty line); rural coastal villagers (36.7 per cent of whom live below the poverty line); small children who constitute a significant proportion of the populace, and the elderly (MoH 2008).

Initial health risks are crucial to determine vulnerability of population. In the case of Guyana, 19 % of the population is extremely poor, 90 % resides in localities below mean high tide level, and 39 % of the population (and 43 % of its GDP) are located in areas exposed to significant flooding risks. The country is rich in natural resources, yet still faces considerable challenges in terms of overcoming poverty and providing for the equitable development of its people. In addition, Guyana lacks a national health insurance system, though there is a National Insurance Scheme which offers limited health-related compensation, but the public health system of the country may not always be adequate to face the greater demands posed by climate change.

Other problems affecting Guyana are the following:

- Malnutrition among children
- High mortality and morbidity rate, due to non-communicable diseases and communicable diseases such as malaria, acute gastroenteritis, acute respiratory infections, tuberculosis and HIV
- Polluted potable and irrigation water coming from the coastal plain's supply, which can increase cases of diarrhoea
- Migration of health care professionals and geographical imbalance of professionals
- Challenge of provision of health care services consistently to the entire population due to geography and distribution of the population
- Significant inequities existing regarding urban versus rural access to adequate water and sanitation facilities: for every urban dweller without water coverage there are 1.7 rural dwellers; in the case of sanitation, for every urban dweller without sanitation, there are 4.9 rural dwellers.

Table 4.23 shows examples of factors that affect vulnerability at different levels, namely, individual, community and geographical, and how these factors have an influence on vulnerability. As shown, Guyana presents most of these factors which make its population vulnerable to possible climate change impacts.

Table 4.23. **Examples of factors affecting health vulnerability**

Level	Influence on vulnerability	Description	Applies to Guyana?
Individual	Disease status	Those with pre-existing cardiovascular disease, for example, may be more vulnerable to direct effects such as heat waves.	N/A
	Socio-economic factors	Poor in general are more vulnerable.	✓
	Demographic factors	Elderly are more vulnerable to heat waves, infants to diarrhoeal diseases.	✓
Community	Integrity of water and sanitation systems and their capacity to resist extreme events Local food supplies and distribution systems Access to information Local disease vector distribution and control programmes	Lack of early warnings of extreme events	✓
Geographical	Exposure to extreme events	Influence of El Niño cycle or occurrence of extreme weather events more common in some parts of the world	✓
	Altitude	Low-lying coastal populations more vulnerable to the effects of sea-level rise	✓
	Proximity to high-risk disease areas	Populations bordering current distributions of vector-borne disease may be particularly vulnerable to changes in distribution	✓
	Rurality	Rural residents often have less access to adequate health care; urban residents more vulnerable to air pollution and heat island effects	✓
	Ecological integrity	Environmentally degraded and deforested areas more vulnerable to extreme weather events	✓

Source: Adapted from WHO 2003.

In addition, some empirical evidence of climatic change in Guyana shows that:

- Mean annual temperature Georgetown increased by 1.0°C over the period 1909 to 1998, with the mean maximum temperature increasing by 0.8°C and the mean minimum temperature increasing by 1.2°C during this time period (UNFCCC 2002).
- The hottest days and nights showed a systematic and statistically significant increase during 1954 -2005 (Seulall 2005).
- The hottest day-time temperatures is increasing at a rate of 0.25°C per decade and the hottest night time temperature is increasing at a rate of 0.43°C per decade (Seulall 2005).

Considering these facts, if current climatic trends continue in Guyana (which according to future climate projection is most likely to happen), there will be an increased intensity of rainfall over shorter periods and longer periods of dry spells. This will have numerous health outcomes for the Guyanese population.

The key impacts of climate change on health at the national and regional levels follow.

Effects of weather and climate on vector-borne diseases

Infections caused by pathogens that are transmitted by insect vectors are strongly affected by climatic conditions such as temperature, rainfall and humidity. These diseases include some of the most prevalent current killers in Guyana: malaria, dengue and other infections carried by insect vectors, and diarrhoea, transmitted mainly through contaminated water.

a) Malaria

Malaria transmission is strongly affected by climate and is transmitted by *Anopheles* mosquitoes. The number of mosquito vectors depends on the availability of freshwater breeding sites. Warmer temperatures, higher humidity and more places where water can collect also favour malaria transmission. Malaria is present throughout Guyana, including urban areas; the risk is present at all altitudes, and is especially high in all rural areas (only the city centres of Georgetown and New Amsterdam are risk free); the risk of contracting malaria is all year round, from January to December. It particularly affects the Amerindians.

Malaria incidence is influenced by a number of factors, among which climate factors are major drivers. Other factors are effectiveness of public health infrastructure, insecticide and drug resistance, human population growth, immunity, travel, and land-use change. According to WHO (2003),[119] malaria's sensitivity to climate is illustrated in desert and highland fringe areas where rainfall and temperature, respectively, are critical parameters for disease transmission. Some statistical evidence shows a relationship between El Niño and malaria epidemics in Guyana (Gagnon 2002); however the casual mechanisms have not been understood completely. Also, drought has been identified as a factor that can contribute to increased malaria-related deaths.

Therefore, countries such as Guyana may be at risk of increased transmission of malaria, considering: (i) Malaria has been a major health problem and remains endemic in the interior regions; (ii) evidence of increasing temperatures and varying rainfall patterns associated with El Niño. This is especially the case in Guyana, which has particular constraints in relation to the speed and ease of runoff water during periods of heavy rainfall. Slow runoff is likely to increase the prevalence of vector breeding sites if there are inadequate or inadequately targeted vector control programmes.

[119] Climate Change and Human Health, Risks and Responses. WMO, WHO, UNEP – 2003.

In addition, Guyana's population lacks protective immunity, therefore could be prone to epidemics when weather conditions facilitate transmission.

As shown in Fig. 4.26 (Malaria cases 1980-2005), the average number of malaria cases in Guyana annually between 1991 and 1998 was approximately 48,805. In 2005, a total of 38,984 new cases were reported, of which *Plasmodium falciparum*[120] represented 39 % and *P. vivax* 54 %. The average annual parasite index in 2005 was 173.95 (number of malaria cases per 1,000 persons per year), while the percentage of malaria risk areas stood at 21.5 %. Prevalence of malaria is higher in hinterland regions (especially Regions 1, 7 and 8, as shown in the graph 4.27), where there is less access to appropriate health infrastructure.

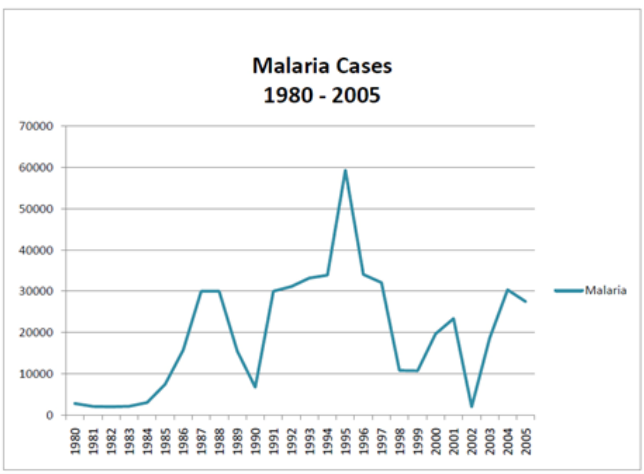

Fig. 4.26. **Malaria cases 1980 – 2005**

Source: Economic Assessment on the Impacts of Climate Change on Human Health in Guyana. Second Draft, 2011.

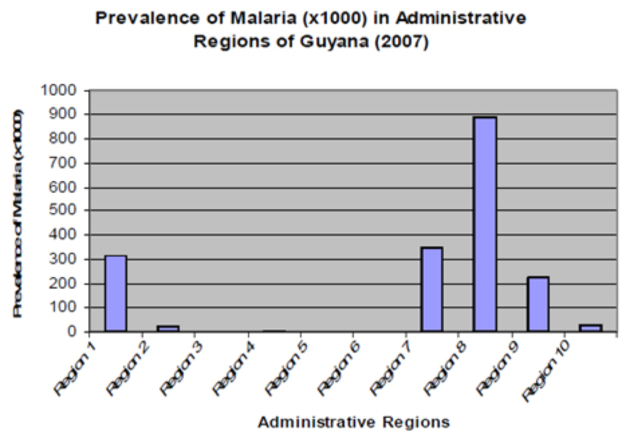

Fig. 4.27. **Prevalence (number of reported cases) of malaria (x1, 000) according to administrative regions of Guyana (MoH 2008)**

Figure 4.27 shows prevalence of Malaria is especially high in hinterland regions 7 and 8. According to the Ministry of Health (2008), correlation analysis supports the contention that 'decreased rainfall can increase the prevalence of malaria', especially for Regions 7 and 8, where these results reveal a strong and statistically significant association.

b) Dengue

Dengue prevalence is increasing rapidly. Transmitted by Aedes mosquitoes, dengue is a fast growing health challenge, particularly in tropical cities in developing countries such as Guyana. Cases have risen dramatically in the last forty or so years, as unplanned urbanization, with consequences such as standing water in waste and other receptacles, have created mosquito breeding sites, and movement of people and goods has spread both mosquito vectors and infections. Future climate trends are also expected to play a role, since the distribution of dengue is also highly dependent on climate.

Dengue is seasonal and usually associated with warmer, more humid weather. The vector density and transmission potential can be affected by increased rainfall (WHO 2003).

[120] *Plasmodium falciparum* (also known as malignant) is the most dangerous of these infections; it has the highest rates of complications and mortality.

For the first ten months of 2010, the Ministry of Health reported that there were 1000 cases of dengue fever compared to 760 for the same period in 2009. The increase in the prevalence rate is thought by the Ministry of Health to be a consequence of climate change. Over the years, statistics have shown that the figures for dengue fever have risen (Ministry of Health 2010). Furthermore, several studies (Ministry of Health 2008; Amarakoon *et al.* 2003) have pointed to a link between El Niño-Southern Oscillation (ENSO) and the incidence of dengue fever. ENSO is known to have a significant influence on Caribbean countries, including Guyana. During the warm phase of El Niño, the rainy seasons are generally drier and hotter, with warmer temperature continuing into the El Niño + 1 year when the rainy season is generally wetter (Chen and Taylor 2002). These climate conditions create environments that are conducive to the propagation of the dengue virus.

Comparatively, between 1980 and 2005, the number of cases of dengue is lower than the number of malaria cases. Nonetheless, given the expected changes in rainfall pattern (projections of mean annual rainfall vary between a reduction of 34 % to an increase of 20 % by the 2090s), there is potential for the increased occurrence of vector-borne diseases such as dengue, as well as the associated dengue hemorrhagic fever (DHF).

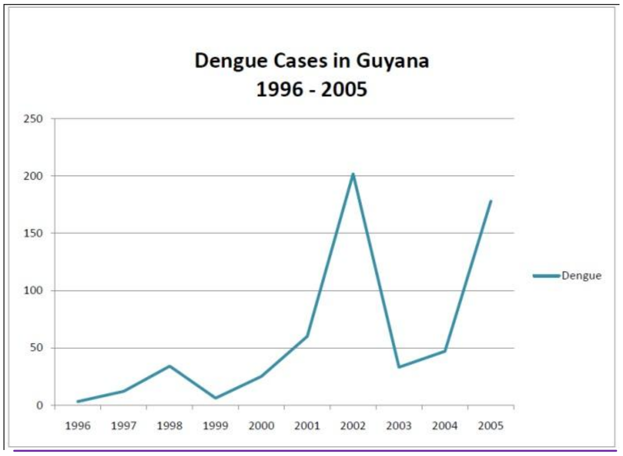

Fig. 4.28. Dengue cases 1996 – 2005

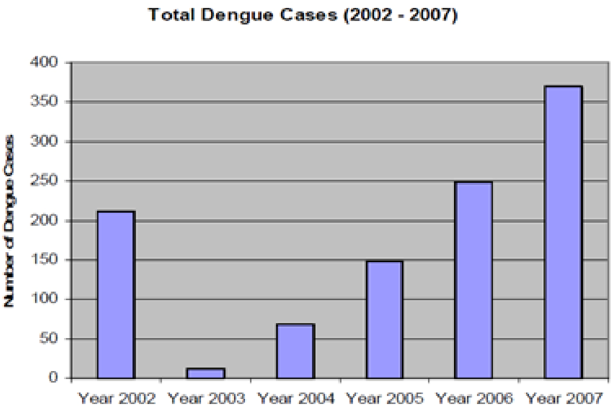

Fig. 4.29. **Prevalence (number of reported cases) of dengue cases for the years 2002-2007 (Ministry of Health 2008)**

As shown in figures 4.28 and 4.29, Dengue cases are prevalent in Guyana; thus, starting 2004, the number of cases showed a significant progressive increase. Figure 4.29 shows that the rate of dengue cases continued to grow, probably as a consequence of the 2005 flooding and ineffective vector and disease surveillance.

Since 2000, surveillance of dengue fever has improved, although weaknesses remain in overall case reporting and in reporting of circulating serotypes.

Effects of weather and climate on water-borne, food-borne and rodent-borne diseases

c. Diarrhoea

The Ministry of Health (MOH) considers gastroenteritis a major public health problem and reports that, for every 10,000 of the population in Guyana, approximately 800 instances of the illness occur each year. The rate in children under five is about 1,200 episodes for every 10,000. Almost 30 per cent of deaths of children under five are caused by diarrhoeal illnesses. Gastroenteritis occurs in every geographic region of the country. However, the disease‘s occurrence is seasonal, with the highest incidence occurring in the months of December, January, February and March (MOH 2010).

Guyana recorded a total of 60,246 diarrhoeal cases in 2009. In this year, children under one year old accounted for 5,673 (9.4 per cent) of cases; children between one year and under five years old accounted for 17,059 (28.3 per cent) of diarrhoeal cases, for the age group five to fourteen years old, there were 15,325 (25.4 per cent) cases of diarrhoeal illnesses, and for the age group older than fifteen years, there were 22,191 (36.8 per cent) cases.

As figures 4.30 and 4.31 show, gastroenteritis cases (which include diarrhoea) are prevalent in Guyana; nonetheless, some years which showed a growth in number were 1996, 1999-2000, and 2004-2005, the latter probably as a consequence of the 2005 flooding. Fig. 4.31

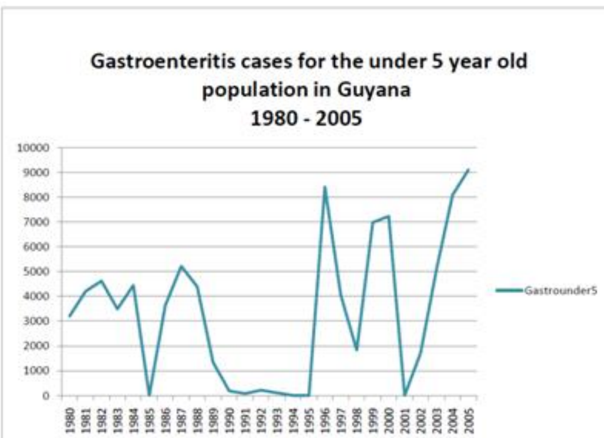

Fig. 4.30. **Gastroenteritis cases for the under 5 year old population in Guyana 1980-2005**

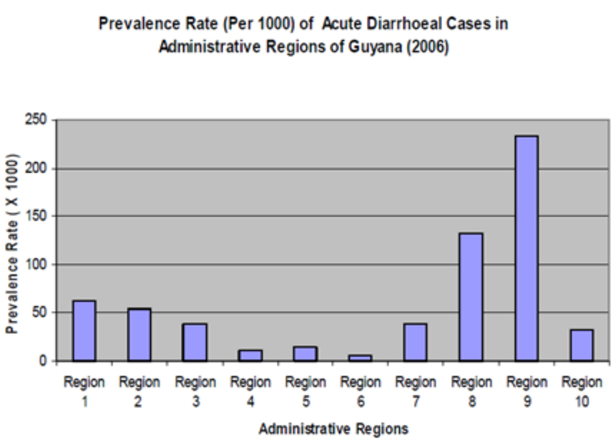

Fig.4.31. **Prevalence (number of reported cases) rate of acute diarrhoeal cases in the Administrative Regions of Guyana in 2006 (Ministry of Health 2008)**

shows prevalence of diarrhoea is especially high in Regions 8 and 9. Viruses and bacteria transmitted through water and contaminated food can cause severe diarrhoea in children, often locking them into a vicious cycle of undernourishment, susceptibility to other infectious diseases, and eventually death. Higher temperatures and too much or too little water can each facilitate transmission of this disease. In tropical countries with inadequate water and sanitation services, diarrhoea is much more common when temperatures are high. For example, studies have shown that the rates of diarrhoeal disease increase by about 8 % for every 1°C increase in temperature (Lindsay and Birley 1996; Martens 1996). In Guyana, a warming of 1.4 to 5°C is projected by the end of the century, which could lead to a significant increase in the incidence of diarrhoeal disease.

Both flooding and unusually low levels of water, as in the coastal zone of Guyana, can also lead to water contamination and trigger higher rates of illness and death from diarrhoea. Global warming and greater variability in precipitation threaten to increase the burden of this disease.

There is some concern that gastrointestinal-related illnesses, such as diarrhoea, may become a major health concern associated with climate change in Guyana, considering that experts anticipate an increase in the number and intensity of flood events which have serious negative implications for the quality of potable water, based on the reported inadequacy of the country's sanitation infrastructure. Compounding this is the fact that since a substantial portion of the country's population and economic activity is located along the coast, this may imply increased risk of the flooding of pit latrines and, in turn, a reduction in the availability of potable water sources.

Mounting water stress fosters a range of long-term public health challenges. Lack of access to clean water supply and sanitation, along with poor hygiene, is already the main contributor to the burden of diarrhoeal disease. Climate change in Guyana is projected to bring changing rainfall patterns, increased temperatures and evaporation, and salinization of water sources through rising sea-levels.

d) Cholera

Other indirect effects of climate change would result from flooding of the low-lying coastal zone of Guyana, where the bulk of the population reside, deriving from excess rainfall or sea-level rise and storm surges. These in turn would lead to losses and reductions in food supply which would trigger hunger and malnutrition, and the proliferation of diseases such as cholera.

e) Leptospirosis

Humans become infected through contact (ingestion and dermal) with water, food, or soil containing urine from animals infected by Leptospira bacteria. The number of human cases worldwide is not well documented, as leptospirosis is under-reported in many areas of the world, including the Caribbean (Fig. 4.32).

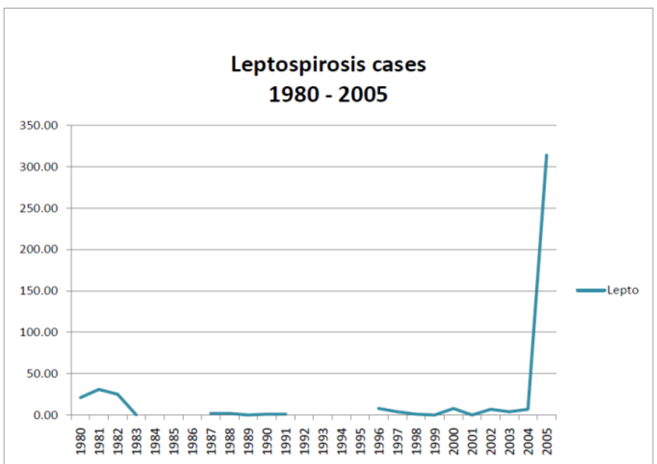

Fig. 4.32. Leptospirosis cases 1980 - 2005

In Guyana, the historical data for leptospirosis is very patchy, as shown in Figure 4.32, due to missing data during the period 1980 to 2005. A major widespread outbreak of leptospirosis occurred during the extensive flooding in 2005. Based on daily field surveillance by some forty Ministry of Health mobile medical teams and hospital surveillance, 87 leptospirosis cases were reported.

To prevent the disease's further spread, the Ministry provided weekly doxycycline prophylaxis for three weeks to the entire age-appropriate population. There were 23 confirmed leptospirosis deaths registered during the flood disaster. There were 12 other deaths due to the flooding (PAHO 2007).

Health effects related to temperature

a) Impacts of heat waves

Studies have shown that daily temperatures above a locally specific threshold result in higher mortality rates (Lindsay and Birley 1996; Martens 1996). The hot summer of 2003 in Europe produced sustained high record temperatures which resulted in markedly higher death rates, particularly among the elderly population. Continuing global warming and possible increases in temperature variability will make such events more frequent and more severe. Mean annual temperature in Guyana is expected to increase by between 1.4°C and 5°C by the end of the century (see chapter on climate change and sea-level rise), and this may place more and more people at risk of heat-related mortalities. Heat stress and cardio- and cerebro-vascular conditions resulting from extreme temperature are therefore likely to increase in the future (Ministry of Health 2008).

b) Effects produced by food shortages (i.e. malnutrition)

Pressures on agriculture threaten to increase the burden of malnutrition. Under-nutrition and related diseases are currently the greatest contributor to the global burden of disease, killing millions of people every year, mostly children in developing countries. Projections indicate that climate change will cause decreases in agricultural production in many tropical developing regions such as Guyana.

Currently, the agricultural sector in Guyana (which includes fisheries and forestry) is a vital source for nutritious agricultural output in the fight against food insecurity in Guyana. In particular, Amerindian communities remain heavily dependent on the sector to provide cassava, their main staple, which is then converted into various food items. A vast majority of agricultural activities take place on the coastal plain of Guyana, which is likely to be affected by climate variability (unless appropriate actions are taken), and in the interior locations, which are likely to suffer even more severely from a sociological standpoint. At the same time, coastal soils are fertile but extremely vulnerable to flooding due to their low-lying nature. As such, drainage and water control remain major challenges.

Increased frequency of El Niño events and future changes to the ocean ecology also have the potential to substantially alter fish breeding habitats and food supply for fish, and ultimately abundance of fish populations, increasing the risk of food insecurity and the health consequences of malnutrition.

These impacts on agriculture and fisheries are of special concern, considering Guyana has a high rate of population at risk, especially among the children. According to PAHO (2007), the following risk groups have been identified in Guyana, in terms of food security: low-income families, the indigent and homeless population, children 0–5 years of age, adults over age 65, and those infected with communicable diseases or affected by one or more non-communicable chronic diseases. A 2003 nutrition and anthropometric survey conducted in nursery schools showed that 9.7 % of children ages 3–4 were underweight for their age; for the 5–6-year-old age group, 14 % were underweight, and 27 % presented anaemia.

c) Mental illness and other diseases

In the long run, the greatest health impacts may not be from acute shocks such as disasters or epidemics, but from the gradual increases in pressure on the natural, economic, and social systems that sustain health, and which are already under stress. These gradual stresses include reductions and seasonal changes in the availability of fresh water, regional drops in food production, and rising sea-levels, as in Guyana.

Studies have shown that, for tropical climates, as temperature rises above the comfort level (~ 27°C in Guyana, there is an estimated 1.4 % increase in mortality (Martens 1998).

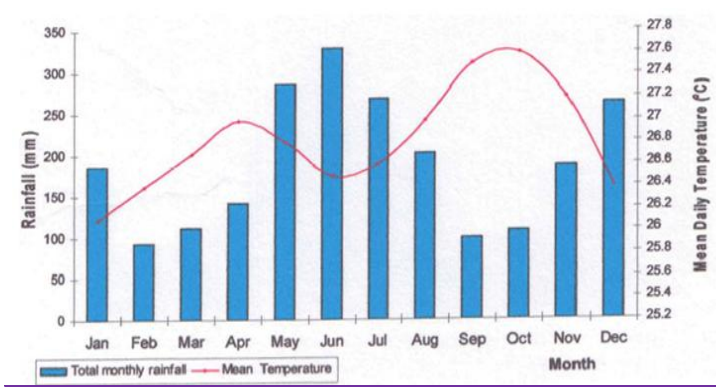

Fig. 4.33. **Mean monthly temperature and total monthly rainfall in the coastal region of Guyana (Ministry of Health 2008)**

For instance, in the case of cardiovascular mortality among those aged over 65 years, a unit increase in temperature in hot climates increases mortality by 1.6 %. Similarly, deaths attributable to respiratory causes in warm climates increase by 10.4 % with a unit increase in temperature (Gatrell and Elliot 2009). It would appear then that mortality deriving from respiratory ailments is particularly sensitive to temperature increase and this may be of concern to Guyana.

The Guyana Ministry of Health (2008) identified further health problems that are likely to occur in Guyana as a result of climate change, including tick-borne diseases, such as encephalitis and Lyme disease; premature birth; respiratory conditions such as bronchitis; leptospirosis and several types of diseases transmitted by animals.

Health effects related to extreme events

Floods and Droughts

The major hazards which affect Guyana are flooding and drought (see Figure 4.34[121].). The country is prone to both coastal and riverine flooding. Drought is a recurrent feature of the environment because of the El Niño factor. Guyana's coastal regions, including Georgetown, lie below sea-level, and a large part of Guyana's population live in regions exposed to significant flooding risk. As such, flooding poses the major adaptation challenge for Guyana.

Although total annual and seasonal rainfalls are not projected to change significantly, extremes of rainfall events that cause either flooding or drought, both of which can impact upon human health either directly or indirectly, are expected to increase in occurrence (see Sub-chapter 2 and Section 4.3.1).

[121] Source of data: EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium.

For instance, floods can cause drowning and physical injuries; heighten the risk of diseases transmitted through water, insect vectors and rodents; damage homes and infrastructure; and disrupt the supply of essential medical and health services. On the other hand, droughts can increase the risk of water and food shortages and malnutrition, necessitate greater reliance on contaminated water, and lead to diminished health among vulnerable members of the population. Droughts and floods also increase the risk of diseases spread by contaminated food and water. The combination of extreme heat and drought are also important risk factors for causing wildfires, resulting in direct health and economic losses, and increased risk of respiratory illnesses due to smoke pollution.

Affected People

Disaster	Date	Affected (no. of people)
Drought	1997	607,200
Flood	2005	274,774
Flood	2008	100,000
Flood	1996	38,000
Flood	2006	35,000
Drought	1988	0
Flood	1989	0
Mass mov. wet	2000	0

Killed People

Disaster	Date	Killed (no. of people)
Flood	2005	34
Mass mov. wet	2000	10
Drought	1988	0
Flood	1989	0
Flood	1996	0
Drought	1997	0
Flood	2006	0
Flood	2008	0

Economic Damages

Disaster	Date	Cost (US$ X 1,000)
Flood	2005	465,100
Flood	2006	169,000
Drought	1997	29,000
Drought	1988	0
Flood	1989	0
Flood	1996	0
Mass mov. wet	2000	0
Flood	2008	0

Fig. 4.34. Types of disasters occurring in Guyana, and their effects -1996-2008

Extreme events effects on health infrastructure

Flooding is the major climate change related threat for Health Infrastructure and the Health System as a whole, due to sea-level rise projections and current vulnerability of the coastal zone. In the 2005 flood, health facilities were severely affected; most septic tanks and latrines were flooded and unusable. As of 30 January 2005, the floods had impacted on the health facilities of Regions 3 and 4. Surveys conducted by PAHO revealed that in Region 3, 25 % of the 12 health centres were closed and had some damage; Region 4 (population of 75,000) was the most affected, where 22 of the 36 health centres (61 %) were flooded, 12 health care facilities (33 %) were out of operation, 3 (8 %) had limited functional capacity, and 7 (19 %) were fully functioning. The damage reported included loss of supplies (needles, drugs, vaccines, cotton, bandages, etc), and damage to water pumps, refrigeration units (Cold Chain), furniture, and electrical wiring. The damage from the 2005 flood cost the health sector G$173.4 million.

Adaptation measures for the health sector

In order to develop policy options to reduce a country's vulnerability, it is critical to understand and identify the scope of the risk from climate change on the human health of the population.

The global public health community has a wealth of experience in protecting people from climate-sensitive hazards. Many of the necessary preventive actions to deal with the additional risks of climate change are already clear. Widening the coverage of proven, effective health interventions will be critical to the global effort to adapt to climate change. As a matter of fact, health impacts of climate change will be determined by both climate change and non-climatic factors such as health care and the health condition of the population (Fig. 4.35).

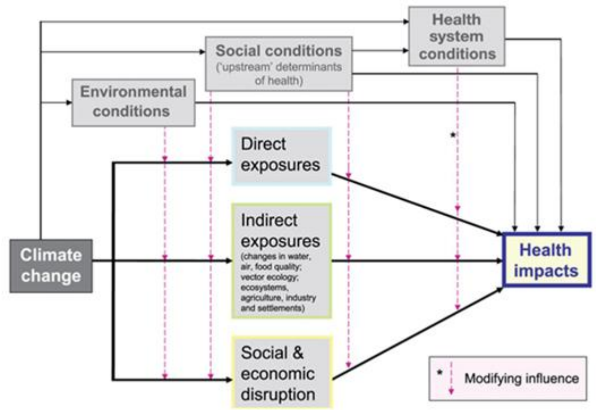

Fig.4.35. **Climate and non-climate determinants of health impacts**

Some urgent needs for adaptation have been identified as laid out in Table 4.24:

Table 4.24. Adaptation needs in the health sector

CLIMATE ELEMENT	LIKELY IMPACT	POSSIBLE INTERVENTION OPTION (PLANNING OR MANAGEMENT OPTION)
Less Rain, Drought	The timings and amount of precipitation may change areas with less precipitation; salt concentrations in water may increase greatly. High salt concentration in water and reduction of water supply may directly affect the health of the population in that area, and the precipitation/ food production could also be reduced	Increasing and securing fresh water supply
	Increased burden of diarrhoeal disease caused by water scarcities (drought)	Strengthening surveillance and control of infectious disease
	Low food supply will increase shortages and incidence of malnutrition	Improving feeding programmes
Increased Rain/ Flooding	Some increases in non vector-borne infectious diseases could occur from increased flooding	Increasing health care Monitoring
	Increased burden of diarrhoeal disease caused by excess water	Increasing health care Monitoring
	Potential for increased injuries, and death resulting; Increased flooding can be followed by outbreaks of diseases, such as cholera, especially when water and sanitation services are damaged or destroyed.	Building community resilience; investment in hospitals, health facilities and other infrastructure protected from the long-term effects of climate change
Change in Season (e.g. El Niño)	Increases in potential transmission of vector-borne infectious diseases (e.g. malaria, dengue fever, yellow fever, and some viral encephalitis) from an expansion in the geographical ranges and seasons of vector organisms	Increasing health care
	The seasonal and geographical abundance of the major vector species, such as mosquitoes, could change	Mosquito eradication programmes, e.g. spraying
Increase in Temperature	Direct health impacts include increases in mortality and illness due to anticipated increases in the intensity and duration of heat waves	Enhancing health care system
	An increase in extreme weather would cause a higher incidence of death, injury, psychological disorders, and exposure to contaminated water supplies.	Improving social welfare in emergency situations; reinforcing health vulnerability and risk assessment, multi-sectoral disaster risk reduction, health emergency preparedness, early warning, and health action in emergencies
	Some increases in non vector-borne infectious diseases could occur from elevated temperature; respiratory and allergic disorders could result from climate-enhanced increases in some air pollutants, pollens, and mould spores.	Strengthening surveillance and control of infectious disease; improving pest control and introducing new policies by the Government
	Increased morbidity and mortality, especially in older persons who already suffer from cardiovascular and/or respiratory diseases due to high temperatures and heat waves	Improving social welfare in emergency situations

In order to address anticipated impacts from climate change on human health, the GoG, through the Ministry of Health, will:

1. Improve the provision of health services to cater for increased illness by acquiring, where feasible, the relevant treatment for the many anticipated illnesses as a result of climate change

2. Collaborate with relevant agencies to improve health statistics and develop programmes aimed at instituting early warning systems for climate change impacts on health

3. Collaborate with relevant agencies nationally and internationally to promote research and development of treatment for illnesses due to the impacts of climate change

4. Develop emergency response programmes to deal with illnesses following drought conditions and shortage of food for vulnerable sectors of the population

5. Embark on a massive public education and awareness programme on the importance of maintaining good health in light of the anticipated health impacts of climate change.

<u>Adaptation policies</u> and forward planning will be required to assess and cope with the threats posed by climate change, and enhance capacity to deal with public health emergencies. This approach will need to strengthen health co-ordination, health emergency management systems, early warning systems related to the health consequences of climate change, and interventions to control tropical diseases.

For the successful implementation of any Climate Change Adaptation Plan, all anticipated changes to local climate patterns must be known. The most vulnerable areas for possible climate change impacts must be identified and possible mitigation measures, appropriate planning and management strategies be implemented for the protection of the selected areas.

<u>Health Care Policies</u>

Guyana has developed and implemented (1995-2000) national policies that relate to the prevention of climate-related diseases such as malaria and malnutrition. The plan sought to incorporate the work of both private and public health sectors, with the objectives of strengthening and expanding primary health care; improving secondary care in the hospitals; improving tertiary care at the Georgetown Public Hospital, and strengthening the general management of the health sector.

The Global Fund is a critical part of Guyana's response to malaria. Guyana currently has two malaria grants worth approximately $3.9 million. The grants focus primarily on strengthening and expanding health services in the rural interior in order to ensure early diagnosis and correct malaria treatment.

Guyana has also embarked on its Health Sector Reform Programme, which proposes the separation of institutional direction and regulatory functions for health care provision. A restructured Ministry will emphasize policy development; allocation of resources and developing sustainable financing; performance evaluation; regulation; research and development; and setting of objectives. In 1998, the Government initiated the Health Sector Policy and Institutional Development Programme.

In addition, Guyana updated the Health Sector Strategy for 2008-2012, with the following five components: (i) decentralization of health service providers; (ii) strengthening the skilled workforce and human resources systems; (iii) strengthening government capacity for sector leadership and regulation; (iv) strengthening sector financing and performance management systems; (v) strengthening strategic information in terms of improved health impact and outcomes.

It is expected that the NHSS 2008-12 will result in, among others:

- Reduction of malaria by 5,000 cases per year
- Prevention and reduction of health, social and economic burdens associated with communicable diseases, including malaria, and neglected and emerging diseases
- Improved capacity to respond to emergencies, disasters, climate change and environmental health risks.

There is also a National Malaria Plan and a new impetus to pass legislation to support health reforms, the decentralization of health services, and the provision of health insurance; all these are with a view to addressing future health issues that may be exacerbated by climate change (WHO 2010). Guyana's national malaria control plan outlines a number of activities to combat the disease, including increasing access to prompt diagnosis and treatment, the effective use of insecticide-treated nets and the creation of a network of community health centres.

Main conclusions and recommendations

Key priorities for Guyana are the following: (i) mainstreaming climate change into all policies, programmes and health plans; (ii) capacity-building in climate change around the national health system; (iii) strengthening the scientific research on the epidemiological profile of Guyana; (iv) increasing public awareness on climate change and health issues among the population.

According to the Guyana Ministry of Health (2008), one of the strengths of Guyana's response to the threat of climate change is the development of policy documents (National Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-Lying Areas; National Health Sector Strategy); however implementation of these policies is low due to human and financial resource constraints. Guyana's capacity to respond to climate change and in particular to protect health from this phenomenon therefore needs buttressing.

Strengthening of the public health system is necessary with or without climate change; climate change makes this need even more critical and urgent. There is a need for additional investment to strengthen key health functions, and for forward planning to address the new challenges posed by climate change. This additional investment should include an increase in the capacity of the health system to extend services and continuity of care to both mobile and remote populations.

Some measures that Guyana could undertake are:

- Research on climate and its influence and impact on the various sectors
- Health facilities risk-analysis, especially against floods
- Improving data collection and dissemination of climate-related data

- Training personnel in each of the important agencies on climate change issues
- Establishing correlations with climate change related variables and diseases, for example:
    - More in-depth analysis of relationships between trends in climate and indicators of altered health risk (e.g. mosquito range) or health status (e.g. heat-attributable mortality)
    - An analysis of basic climate/health relationship, e.g. correlation of increased occurrences of dengue fever in the warmer drier period of the first and second years of El Niño events
    - Extrapolation of mapped climate/disease (or vector) relationship in time and space to estimate change of distribution of disease (or vector) with future change in climate (e.g. increase in diarrhoeal diseases in the rainy season in the tropics)
- Establish more data on how droughts and floods affect agriculture production, and have consequences for food insecurity and malnutrition.

4.4 Conclusions

Guyana is a vulnerable country due to the dependence of the population on the very important coastal plain, which, according to projections, will be affected by sea-level rise, storm surges and increase in precipitation leading to flooding, and other climate-related events.

In recent years, Guyana has come to recognize its vulnerability to climate change, and has moved forward in identifying vulnerable areas and populations, as well as infrastructure and social and economic activities at risk, through the construction of scenarios at different levels (national, coastal and sectoral level), and developing vulnerability assessments at a territorial and sectoral level. As a result, Guyana currently acknowledges the country's vulnerable sectors and regions, and has identified preliminary adaptation needs. These analyses have also allowed the assessing of the vulnerability of the coastal area, its population, infrastructure, facilities and services, and activities carried out there.

There is nonetheless still a long way to go for Guyana to deal with climate change. Among the gaps identified, the following can be mentioned among the main ones:

- The information generated is not representative of the complexity and diversity of Guyana and carries significant uncertainty.
- Climate change is not yet considered a development issue; it is not a priority for the country’s development.

Under both premises, a series of activities are required aimed at reducing vulnerability and applying effective and sustainable adaptation measures. All adaptation actions should be built based on five pillars: (1) information, research and systematic observation; (2) institutional framework and capacity building, education and awareness; (3) policy, legal framework and tools to integrate climate change adaptation into development planning; (4) generation and application of technologies; (5) innovative financing instruments.

Following the five pillars, it will be required that the consolidation and complementing of the progress achieved so far by Guyana be continued, and therefore the succeeding actions and plans may be developed:

a. Planning and implementing an updated Climate Change Adaptation Policy and Implementation Strategy for Coastal and Low-Lying Areas, to prioritize adaptation needs and actions for the implementation of measures in the short and medium term, linked to already existing development plans (Pillar #3)
b. Estimating the investment and financing required for the implementation of adaptation policies and the development of innovative financial instruments that promote private sector participation (Pillar #5)
c. Undertaking cost analysis/feasibility of those adaptation measures identified, and prioritizing the adaptation measures in co-ordination with sectors and regions (Pillar #1)
d. Development of climate scenarios using smaller scales, other methodologies, and prioritizing different regions and sectors (Pillar #1)
e. Undertaking vulnerability and adaptation assessments in sectors and regions not yet studied (Pillar #1).

In addition, it is also required to have: (i) solid base information and applied research to guide the development process, including both the challenges and the opportunities of climate change; (ii) to expand the research approach so that vulnerability to climate change is considered in policies and development actions; (iii) to develop an integrated system for the development of climate information and climate projections, allowing for sizing the impacts of climate change and for more accurate analysis of vulnerability, leading to systemic and sustainable adaptation options at national, regional and local level.

In regard to the flooding event of 2005, lessons learnt show investing in disaster preparedness, improving early warning systems, maintenance of drainage and irrigation systems and the conservancy of dams, revising and upgrading building codes, and establishing and strengthening disaster management systems to reduce the impact of future disasters, is important to avoid losses in GDP and disruption in economic activities and dislocation of people. The GoG has acknowledged that the geographic distribution of the population, particularly as related to access to social services and the generation of opportunity in rural and isolated communities, is one of the main factors shaping their vulnerability to floods, in addition to differences in social structures, cultural patterns and livelihoods, both within regions and between them.

Regarding the sectors analyzed, some gaps and barriers have also been identified. The key findings are the following:

- For the **coastal plain**: The lack of building codes and more effective coastal planning and management that consider climate change impacts make the infrastructure, economic activities and population along the coast vulnerable to sea-level rise, flooding and droughts, as a result of changing rainfall and temperature patterns. In order to have greater confidence in the results of the storm surge and sea-level rise projections that will most likely affect the coastal plain, spot heights distribution with a finer resolution (e.g. 10 m x 10 m) would be required, in order to have a more precise perspective of the economic and social actions required to face such events.

- For **human settlements:** Due to lack of effective coastal planning and management that consider climate change impacts, progressive abandonment of land and structures in highly vulnerable areas and resettlement of inhabitants away from the coastline is needed, following adequate coastal planning and building codes. Effective adaptation will require a combination of enforceable regulations and economic incentives to redirect new settlement to better-protected locations and to promote investments in appropriate infrastructure, all of which require political will as well as financial and human capital. Avoiding policies that favour coastal development and imposing more effective coastal zone management could make a difference in the longer term.

- For the **water sector**: There is a need to increase the GoG's understanding of the EDWC system and coastal lowland regimes, in order to reduce the vulnerability of extreme flooding in the country's low-lying coastal areas. There is also a need to strengthen institutional capacity of the GoG to manage water levels in the EDWC and to guide interventions aimed at reducing Guyana's vulnerability to floods. With regard to information, detailed topographic and land-use mapping, hydrologic modelling of coastal lowlands, assessment of EDWC system integrity, EDWC hydraulic modelling and pre-feasibility studies for coastal lowland interventions are needed.

- For the **agriculture sector**: Guyana lacks an adequate land-use plan (land zoning strategy) in order to identify the best-suited land for sustainable agriculture expansion and diversification, so as to undertake climate change vulnerability studies on all the major crops that are threatened. Land-use planning may allow the identification of suitable alternatives for crop varieties where feasible, and the development of policies and measures to address the threats posed by climate change, specifically sea-level rise. The economic challenge for Guyana is to identify specific agricultural and rural development needs and opportunities, and to focus investment in areas where the greatest impact on adaptation, food security and poverty will be achieved (Caribbean Community Climate Change Centre 2010).

- For the **fisheries sector**: Even though the main climate change impacts are identified, several factors limit the analysis of climate change impacts in fisheries, such as the uncertainties about how nutrient inputs and productivity will respond to warmer conditions, and how the species will respond to changing temperatures (Perry 2010). Moreover, the lack of professional scientists, management and data collection needs to be addressed and upgraded, in order to develop research that will allow the taking of adaptation policies and measures, considering the projected increase of temperature and change in rainfall, which threaten fisheries by decreasing water quality and disrupting the ecosystem's dynamics.

- For the **health sector**: Strengthening of the public health system is necessary with or without climate change; climate change makes this need even more critical and urgent. There is a need for additional investment to strengthen key health functions, and for forward planning to address the new challenges posed by climate change. This additional investment should include increase in capacity of the health system to extend services and continuity of care to both mobile and remote populations. Also, more in-depth analysis of relationships between trends in climate and indicators of altered health risk (e.g. mosquito range) or health status (e.g. heat-attributable mortality) are needed.

- For the **energy sector**: Guyana has started a process to switch from total dependence on imported oil to energy generation with renewable sources, mainly hydropower. However, climate change threats, specifically drought caused by an increase in temperature and a decrease in rainfall, could be a serious setback for its energy stability, yet this vulnerability analysis has not been developed. For the development and stability of the energy sector under a climate change scenario, it is necessary to include climate variables in the energy planning and reverse the lack of knowledge on climate change issues by the GoG.

- For the **forestry sector:** Nowadays forest utilization and preservation are mainly based on how forests developed under past climatic conditions; yet it is time for forest managers and policy-makers to accept that climate change is a reality and that forests and forest communities face significant changes. Adaptation requires planning for change so that a suite of options is available whenever needed. And so, in order to face these changes, it is crucial to incorporate the concept of climate change in every area that relates to forests, including land-use planning, the elaboration and review of national policies, and the implementation of local planning processes.
- For the **tourism sector**: most of the tourism infrastructure is found on the coast, which is extremely vulnerable to the impacts of climate change, especially to floods and storm surges, which has to be considered in the sector's planning. Available studies that have examined the climate change risk appraisal of tourism operators have consistently found low awareness of climate change, and little evidence of long-term strategic planning in anticipation of future changes in climate (Simpson *et al.* 2008), an issue that has to be dealt with at the national and local levels.

Guyana must take action to integrate these considerations into planning and development processes, prioritizing certain actions to be implemented in the short term.

Chapter 5

Research and Systematic Observation (RSO)

Chapter 5

Research and Systematic Observation (RSO)

5.0 Introduction

As a non-Annex I Party, Guyana is encouraged to provide information on:

- Activities relating to the transfer of, and access to, environmentally sound technologies and know-how, the development and enhancement of endogenous capacities, technologies and know-how, and measures relating to enhancing the enabling environment for development and transfer of technologies; and

- Climate change research and systematic observation, including their participation in and contribution to activities and programmes of national, regional, and global research networks and observing systems.

Purpose and Objectives

To effect such a significant change will require support from a wide range of stakeholders and from the Guyanese people as a whole. Not least of all, it will require significant investment in mitigation and adaptation technologies and practices, research and development, and changes in behaviour through education, awareness-raising and appropriate incentives.

This chapter charts Guyana's progress in implementing measures to address climate change since the publication of the INC and National Climate Change Action Plan, and also identifies those areas where further action and research is needed.

More specifically, the objectives of this chapter are to:

- Present the findings of a detailed assessment of the technology needs and priorities of key sectors including energy, transport, industry, waste, agriculture and forestry with respect to climate change adaptation and mitigation

- Identify the research and systematic observation (RSO) activities in which Guyana is already engaged

- Provide recommendations for strengthening scientific research and climate change observation and monitoring systems, including compilation of greenhouse gas inventories, and design and implementation of programmes for climate change adaptation and mitigation.

Ultimately, the Technology Needs Assessment (TNA) and RSO analyses should identify the specific measures needed to strengthen Guyana's capacity to monitor and address the causes and consequences of climate change, and enhance research relating to programmes containing measures to mitigate and/or to adapt to climate change.

The chapter is structured as follows:

- Section 5.1 reports on the findings of a Technology Needs Assessment (TNA) and as such, identifies, assesses and prioritizes those technologies, practices and policy reforms that may be implemented in different sectors of Guyana's economy to reduce GHG emissions and/or adapt to the impacts of climate change, which are in accordance with the national development objectives and which can contribute towards reducing the impacts of climate change in Guyana

- Section 5.2 describes the status of national programmes for research and systematic observation (RSO) relating to the climate change system, including participation in global RSO systems, and identifies the needs, constraints and gaps in climate change research and systematic observation.

5.1 Technology Needs Assessment

5.1.1 Background

Article 4.5 of the UNFCCC identifies technology transfer as a key mechanism for addressing climate change, and requires developed countries to promote, facilitate and finance transfer of, or access to, appropriate technologies and know-how in developing countries. Technology Needs Assessment for climate change enables countries to identify the most appropriate technology options for controlling, reducing or preventing GHG emissions and/or adapting to the impacts of climate change. The TNA[122] process helps to prioritize technologies, practices and policy reforms that can be implemented in different sectors (e.g. energy, transport, waste, agriculture and forestry) for mitigating or adapting to climate change, whilst simultaneously contributing to wider national sustainable development goals.[123]

5.1.2 Key sectors and technologies

The key sectors for mitigation were selected based on their contribution to Guyana's GHG emissions as indicated in the GHG Inventory for Guyana over the period 1990 to 2004,[124] as well as on the mitigation opportunities that are available (or emerging) and suited to the Guyanese context.

Most mitigation opportunities are to be found in the energy sector, which is also the single largest contributor to net GHG emissions. The electricity generation sub-sector is presently responsible for most of these emissions, but this could change rapidly in future as Guyana actively develops its renewable energy sources. There are also important mitigation opportunities in the agriculture, transport, forestry, buildings and waste sectors.

The Vulnerability and Adaptation assessment highlights the vulnerability of Guyana's coastal zone to the impacts of climate change. The agriculture, water resources and human health sectors are particularly vulnerable as a result of predicted increases in temperature, sea-level rise and flooding from excessive rainfall. These are therefore the priority sectors for which adaptation technologies and activities have been identified.

A list of possible mitigation and adaptation technologies for each of the key sectors is shown in Table 5.1.

[122] UNFCCC (2002). Methods for Climate Change Technology Transfer Needs Assessments and Implementing Activities, Developing and Transition Country Approaches and Experiences, Climate Technology Initiative. March 2002. Accessed online at: http://unfccc.int/ttclear/pdf/TNA/CTI/Tech%20Transfer%20Guidelines-12%20_final_.pdf on 15/08/2009.

[123] Gross, R., Dougherty, W., and Kumarsingh, K. (2004). 'Conducting Technology Needs Assessments for Climate Change' UNDP, New York, UA, 26pp. Accessed online at: http://unfccc.int/ttclear/pdf/TNA/UNDP/TNA%20Handbook_Final%20version.pdf on 14/08/2009.

[124] Greenhouse Gas Inventory of Guyana (1990-2004). Draft chapter. (March 2010).

Table 5.1. Key sectors for mitigation and adaptation and associated technologies

Sector		Technology Options
Mitigation	Energy	Hydropower
		Solar power
		Wind power
		Co-generation
		Energy from waste
		Fuel switching (biofuels)
		Distribution efficiency
		Hybrid vehicles
		Fuel-efficient vehicles
		Improved mass-transport systems
	Buildings sector	Energy-efficiency (including technologies, incentives/subsidies to encourage uptake of energy-saving and renewable energy technologies) and implementation of building codes
		Insulation
	Waste sector	Recycling
		Composting
		Biogas
	Agriculture sector	Improved water management
		Minimal soil disturbance
		Crop rotation
		Controlled fertilisers
	Forestry sector	Forest conservation
		Sustainable logging
		Fire and pest management
Adaptation	Agriculture sector	New crop species and cultivars/ substitution of crops
		Pest management
		Changes in cultivation practices, including improved water management techniques
	Buildings sector	Enforcement of existing building codes and development controls and introduction of new building codes where necessary
	Coastal sector	Structural options
		Early warning systems
		Stringent planning controls in susceptible areas
	Water resources sector	Rain-water collection
		Improved water efficiency
		Improved drainage/irrigation /re-use

5.1.3 Priority sectors for mitigation and key technologies for preliminary

Energy Sector

The energy sector is the principal source of GHG emissions in Guyana. This is attributed to the fact that Guyana has traditionally been reliant on imported petroleum-based fuels as its primary energy source. Other energy sources include bagasse (25.67 %), rice husk (4.35 %), fuel-wood (0.40 %) and solar photovoltaics (~1 %).[125]

In 2008, Guyana consumed approximately 5.1 million barrels of oil equivalent.[126] Energy demand per capita in Guyana can reasonably be expected to increase as a result of climate change, mainly for space cooling due to the warmer climatic conditions in the country.

Secure and stable energy supply is essential for achieving economic and social development in Guyana.

Mitigation technology needs in the energy sector involve a combination of renewable technologies and energy efficiency measures. Some of these technologies have already been implemented in Guyana, which is expected to help their application on a larger scale. Significant efforts have already been directed towards assessing opportunities for the development of Guyana's vast water resources into a sustainable source of energy.[127] It is understood that around 67 potential hydropower sites have already been identified. The greatest potential lies in the upper reaches of the Cuyuni, Mazaruni, Potaro and Essequibo river basins. In recent years the Government of Guyana has implemented a number of solar energy initiatives, including:[128]

Solar power

- ***The Unserved Areas Electrification Programme (UAEP)***, which provided a total of 343 solar home systems to four indigenous communities (Yarikita, Capoey, Kurukabaru and Muritaro). Orealla also received a 2500 W system to facilitate cottage industries (cheese and cassareep production) within that community (See Appendix 5.3).

- ***Solar power demonstration projects*** within the Guyana Energy Agency (GEA). GEA installed four PV units to power lights, laptops, a DSL modem and router. While the cost of the solar units is not competitive with conventional electricity (at least in the short- to medium-term), it has allowed GEA staff to continue operation as usual during power outages.

- ***Installation of DC Home Solar Light Kits*** in hinterland communities without access to electricity. GEA, together with the Office of the Prime Minister and the Ministry of Amerindian Affairs, has provided solar light kits, together with installation instructions, to 337 households across six communities in Region 9.

- ***The CIDA/OLADE/University of Calgary-Haskayne School of Business Rural Electrification Project*** in the Woweta community in Region 9 participated in a solar power pilot project which ran from 2007-2009. Under the project, solar power systems were installed in 49 households. The systems were designed to provide lighting for up to six hours a day. The

[125] Alternative Energy Programmes in Guyana. November 2009, Guyana Energy Agency.
[126] Ibid.
[127] Monenco (date unknown) Hydroelectric Power Survey of Guyana Final Report.
[128] Guyana Energy Agency (2009) Alternative Energy Programmes in Guyana. November 2009.

community also received a solar-powered freezer and a solar water pump system.

- ***The Japan Cool Earth Partnership*** is a Japanese initiative through which the Japanese Government has expressed interest in developing a solar photovoltaic farm in Guyana. The aim of the project is to diversify Guyana's energy supply to the national grid. A proposal was submitted by the Government of Guyana to the Japanese Government for the development of a 1 MW solar PV farm to be located behind Eccles Industrial Site, East Bank Demerara.

Current use of solar power in Guyana is low, considering the country's potential. However, with PV panel installation costs presently ranging between G$2,300 to G$3,300 (US$11.5 to US$16.5) per watt installed, cost remains a significant barrier. There is therefore a need to identify more cost-effective solar power technologies which are currently under development in other countries, and, once these become available, to develop incentive and support mechanisms (e.g. subsidies and credit facilities) to encourage their uptake in Guyana.

Wind power

Wind energy electricity generation is a relatively new technology in Guyana. The technology for generating energy from wind is reliable and efficient; it requires minimal maintenance and operational requirements, and the turbines used to convert wind to a more useful form of energy may directly feed local or national grids. Wind farms may be suitable for the electrification of rural and/or remote areas, where distribution networks already exist or can easily be installed, while individual wind turbines can also be used to supply electricity to individual buildings or properties. While the technology for wind power generation is readily available, implementation is limited by local wind conditions and cost.

The Government of Guyana and a private Dutch company (Delta Caribbean N.V) signed a Memorandum of Understanding (MOU) in March 2007 for the construction of a 13.5 MW Wind Farm at Hope Beach in the East Coast Demerara district. This project was expected to be commissioned in 2010[129] and to supply around 4 MW of firm power to Guyana Power and Light (GPL). However, in July 2009 President Bharrat Jagdeo announced[130] that the wind farm was not considered feasible due to the low wind speeds and high investment costs. In November 2009, GEA reported that the Power Purchase Agreement (PPA) relating to this development was still under review.[131]

Wind speeds are being monitored and recorded in four other locations (Orealla, Jawalla, Campbelltown and Yupukari) under the Unserved Areas Electrification Project of the Office of the Prime Minister. However, the data collected so far suggests that the wind speeds are not sufficiently attractive.[132] This suggests that the development of wind power is not really a viable option in Guyana at this time.

Co-generation[133]

Co-generation plants simultaneously generate electric power and heat energy by making use of waste heat (thermal energy) that would otherwise have been released to the environment through cooling towers, flue gas or other means. While Guyana has little need for district heating systems, co-generation from bagasse produces process-steam and electricity at each of Guyana's eight sugar estates.[134]

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[129] Guyana Energy Agency. Energy Development, Wind. Accessed online at: http://www.sdnp.org.gy/gea/energydev-wind.php, on 8/11/2009.

[130] 'US$26M Hope Beach wind farm no longer feasible', Kaieteur News, 23 July 2009. Accessed online at: http://www.kaieteurnewsonline.com/2009/07/23/us26m-hope-beach-wind-farm-no-longer-feasible/ on 28/01/2010.

[131] GEA (2009) Alternative Energy Programmes in Guyana.

[132] Ibid.

[133] Also known as Combined Heat and Power.

[134] GEA (2009). Alternative Energy in Guyana.

The Guyana Skeldon Bagasse Co-generation Clean Development Project (CDM)[135] consists of the addition of a more efficient co-generation plant to the ongoing Skeldon Sugar Modernization Project (SSMP).[136] The CDM project activity consists of a combined heat and power (CHP) cycle to allow the simultaneous production of electrical power for on-site use in the sugar factory, and for the sale of excess power to the Berbice regional grid. The bagasse produced after the extraction of sucrose from the sugar-cane will be used as fuel in the boilers to generate superheated steam to initiate the co-generation process.

The project will generate GHG emissions reduction by displacing the fuel oil used in the generators operated by GPL in the Berbice grid. Furthermore, it is expected that by increasing the capacity of the regional grid and providing a more reliable power supply, a significant proportion of unregulated and inefficient self-generation by industries and households in the region may be displaced.

Co-generation from bagasse clearly makes an important contribution to Guyana's energy security. It allows postponement of the installation and/or dispatch of thermal energy generation utilities and therefore reduces the country's dependence on imported petroleum products. It was estimated in 2008 that bagasse provided more than a quarter (25.67 %) of Guyana's primary energy.[137] The Skeldon Bagasse Co-generation CDM project may serve as a useful model for demonstrating the potential range and value of benefits (in terms of energy cost savings and wider sustainable development benefits) that similar bagasse co-generation projects may deliver at other appropriate locations in Guyana.

[135] See: http://cdm.unfccc.int/UserManagement/FileStorage/VSSDFHR8560V4TR0RMYXNTUCO02LMO.

[136] A modern sugar factory that will manufacture Very High Pol (VHP) raw sugar.

[137] GEA (2009). Alternative Energy in Guyana.

Energy from waste

Energy from waste represents an increasingly important fuel source in both developed and developing countries.

Landfill gas contains up to 60 % methane, a potent GHG with global warming potential 21 times higher than that of carbon dioxide. By capturing and combusting the landfill gas, GHG emissions from the landfills are significantly reduced.

Waste-to-energy conversion resolves two important issues: waste management and sustainable energy supply. Landfill gas recovery projects improve landfill operations because adequate cover materials are required to minimize the intrusion of air during gas extraction in order to prevent uncontrolled explosions and reduce fire risk. Not only does this improve health and safety for those working on the site, but also has wider environmental benefits for neighbouring communities by reducing odour, vermin and air and smoke pollution.[138]

In cases where significant amounts of landfill gas can be recovered, it may be used to generate electricity for on-site use and/or to supply the grid. Landfill sites can generate commercial quantities of landfill gas for up to thirty years after waste has been deposited. Recovering this gas and using it as a fuel not only ensures the continued safety of the site after landfilling has finished, but also provides a significant long-term source of income from sales of power.

The Clean Development Mechanism (CDM) under the Kyoto Protocol recognises the sustainable development benefits that landfill gas recovery projects may deliver in developing

[138] In November 2009 residents near the Le Repentir landfill were affected by smoke emanating from the landfill following a fire. Some residents reported respiratory problems (Stabroek News, 2 December 2009).

countries, whilst at the same time helping industrialized countries to offset their emissions. There are presently no landfill gas recovery projects in operation in Guyana, but opportunities may exist for developing CDM projects at both the existing Le Repentir landfill site in Georgetown and the new sanitary landfill site in Eccles.

There are also opportunities in the agricultural sector for methane recovery from biomass residue and livestock manure (see biogas under **Waste** below).

One of the main barriers limiting the implementation of this technological option is the monopolistic nature of the electricity supply market in Guyana. Although independent power producers (IPPs) are legally entitled to generate energy to meet their own requirements, they have to obtain licences from GPL before they can sell any surplus electricity.[139]

Distribution efficiency

Reduction of transmission and distribution losses improves the overall efficiency of the power system, lowers the costs to electricity suppliers, reduces energy prices and secures the stability of power supply. Additional benefits include resource savings and environmental protection.

Guyana Power and Light (GPL) is currently in the advanced stages of designing a US$39.6 million project to finance upgrading of substations and transmission lines. This project is expected to facilitate the construction of 110 kilometres of single circuit 69 KV overhead transmission lines and 1.8 km of 69 KV submarine cable, seven new substations and the expansion and upgrading of two existing substations, installation of a fibre optic network and Supervisory Control and Data Acquisition (SCADA) system for tele-metering and protection.[140]

The GPL project should substantially reduce transmission losses, and the most cost-effective opportunities for improving supply-side distribution efficiency are already most likely to have been exploited. However, there is a need to design and implement measures to improve the management of demand. Effective demand-side management (DSM) should help encourage better use of the existing distribution infrastructure and reduce peak demand, thereby reducing the load and the amount of heat produced. This in turn requires the design and enforcement of appropriate regulatory and financial incentive mechanisms.

Fuel switching (Biofuels)

Switching to cleaner burning liquid fuels such as biogas, natural gas and biomass/biofuels, reduces GHG emissions from power generation. Furthermore, some of these alternative fuels are also less expensive than conventional fuel sources. Potential feedstock includes sugar-cane, coconut oil, palm oil and sweet potatoes. Poultry and cattle farms may also offer a viable source of biogas production. (See section on biogas under **Waste** below.)

Switching existing power plants to cleaner burning fuels such as diesel rather than fuel oils by installing appropriate equipment may not be cost-effective for older power plants. Lack of local knowledge and expertise and the limited remaining productive lifespan of existing power plants might not justify such investment. However, as existing power plants are decommissioned, the scope for replacing these with gas-fired power stations and

[139] Personal communication, Sandra Britton, Guyana Energy Agency. (28 January 2010.)

[140] Guyana On-line: http://www.guyanaonline.net/news/index.php?view=read&id=245&cat=1

biomass/biofuel power plants needs to be investigated.

The Institute of Applied Sciences and Technology (IAST) has already piloted a unit capable of producing 60 x 45-gal barrels of biodiesel per month, using edible oils and waste edible oils as feedstock. Forty-eight barrels of biodiesel was produced by the IAST laboratory in 2008. Based on the design of the IAST biodiesel pilot unit, a commercial scale unit is currently in operation at Wauna, Region 1. This unit is capable of producing 300 to 600 barrels of biodiesel per month using palm oil as the feedstock. In 2008 1,076 barrels of biodiesel were produced and these were sold to the Region 1 Administration for power generation at Mabaruma.[141] Small-scale production of biodiesel from coconut oil and recycled vegetable oil is also being done in Georgetown.

The Ministry of Agriculture (MoA) has recently secured a loan from the Inter-American Development Bank (IDB) to investigate the potential for expanding bio-energy opportunities in Guyana. This forms part of the IDB's Sustainable Energy and Climate Change Initiative as well as the initiative of the Government of Guyana (GoG) to prepare an Agro-energy policy for the country. With the phased reduction of the EU's preferential price for sugar from African, Caribbean and Pacific (ACP) countries, Guyana is seeking alternative ways of supporting its valuable sugar industry. Among those alternatives, bioethanol production from sugar cane appears to have good prospects, particularly as the US is likely to vastly expand imports of ethanol in order to meet its gasoline consumption reduction targets.

The MoA recognises that a competitive agro-industry sector in Guyana gives rise to the possibility of increased financial returns on investments related to the sugar-cane industry, through the sale of carbon credits derived from reductions in GHG emissions. These reductions can be obtained, directly or indirectly, through the use of bioethanol and biodiesel substituting for gasoline and diesel respectively, co-generation with bagasse, and methane abatement from biofuel wastewater treatment processes. Introducing new crops such as oil palm and jatropha could produce very similar benefits, although the social and environmental impacts of such actions need to be thoroughly assessed. The Government of Guyana has, however, made it clear that no land presently used for food production will be given over to biofuel production.

Work is presently being undertaken to (i) improve the capacity of the GoG to identify and evaluate viable investment opportunities in the bioenergy production chain; (ii) develop a financial vehicle or instrument to promote investment opportunities and develop a strategy to harness Guyana's potential for bioenergy production; (iii) increase capacity building and the transfer of technology in order to build a critical mass of bioenergy technicians, operators, and demonstration programmes; and (iv) strengthen institutional capacity to support the implementation of agro-energy policy in Guyana, including the provision of support for small scale bioenergy demonstration programmes and dissemination of results.

Once the opportunities for biofuel generation have been identified, efficient conversion technologies will be required to ensure that the price of biofuels in Guyana is competitive in both local and regional markets.

[141] GEA (2009). Alternative Energy Programmes in Guyana. November 2009.

5.1.4 Transport

The complete dependence of Guyana's transport sector on fossil fuels at present indicates that there may be considerable potential for achieving GHG emissions in this sector through the phasing in of more fuel-efficient vehicles or alternative energy vehicles. The transport sector consists mainly of road transport, and to a much lesser extent inland marine transport and inland aviation. Transport CO_2 emissions range from 210 Gg (14.6 %: 1990-1994) to 335 Gg (19.8 %: 2000).[142]

GHG emissions from both aviation and marine transport in Guyana are minimal, contributing less than 1 % of total GHG emissions.[143] That is mainly due to the fact that most of the vessels engaged in international air and marine transport in Guyana purchase their fuel from other countries. Based on available activity data, total CO_2 emissions from international bunkers are around 21 Gg (2002-2004). CO_2 emissions from international aviation bunkers fell from 22 Gg in 1990 to 13 Gg in 2004, primarily as a result of reduced operations by the national airline (Guyana Airways Corporation). However, CO_2 emissions from international marine bunkers doubled (from 4 Gg to 8 Gg) between 1994 and 1995, and remained at that level over the period 1995 to 2004.[144] Since marine and aviation transport are not significant emission sources in Guyana, the analysis was focused on road transport where the most emission savings can be achieved.

Presently there are no import controls allowing only fuel-efficient vehicles into the country. Additional challenges faced by the transport sector in Guyana include shortage of funding for road maintenance, lack of appropriate design standards and maintenance monitoring, and insufficient local resources for road construction and maintenance.[145]

Mitigation options in the transport sector should be aligned with the wider national goals for reducing reliance on fuel imports, promoting economic development, and generally helping to achieve the objectives of Guyana's Low Carbon Development Strategy (LCDS).[146]

Hybrid vehicles

Hybrid cars are not presently available in Guyana, mainly because of the high cost of the technology. While this is not considered a priority technology for Guyana in the short-term, it may prove to be a more cost-effective option in the medium- to longer-term (10-20 years), as the technology becomes more widespread globally.

Fuel-efficient vehicles

Fuel efficiency in vehicles is typically measured as the ratio of fuel consumed per unit distance travelled and is principally a function of vehicle age (and hence technology), as well as size. Older and large vehicles tend to generate more CO_2 emissions compared with the newer and the smaller ones.

Vehicle technology plays a key role in reducing vehicle CO_2 emissions. Such technologies are capable of widespread deployment in the short term (5–10 years) but significant policy and regulatory reform, particularly around vehicle imports, will be necessary to support their uptake. Such reforms may include:

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[142] Greenhouse Gas Inventory of Guyana (1990-2004). Draft chapter. (March 2010.)

[143] Greenhouse Gas Inventory of Guyana (1990-2004). Draft chapter (March 2010).

[144] Greenhouse Gas Inventory of Guyana (1990-2004) – Draft Chapter. (March 2010).

[145] Ministry of Public Works and Communications (2005). Guyana Transport Sector Study, Final Report, Administrative Appendix I, Study Methodology. December 2005.

[146] Government of Guyana (2009). Transforming Guyana's Economy While Combating Climate Change: A Low Carbon Development Strategy. Draft for Consultation. Office of the President, June 2009.

- Establishing and enforcing mandatory vehicle fuel efficiency or CO_2 emission standards for all vehicle imports
- Providing exemptions or concessions for vehicle imports that meet or exceed these emission standards
- Developing and promoting a 'green guide' that allows consumers to compare the fuel economy (and hence lifetime costs) of different vehicles
- Introducing government fleet procurement policies
- Differential government taxes and charges based on fuel efficiency or greenhouse gas emissions (or proxies such as engine size or vehicle weight), e.g. vehicle registration, stamp duty, import duties, and
- Subsidies for purchase or conversion of alternative-fuelled vehicles.

Consideration should also be given to implementing travel demand and other measures that contribute towards reduced emissions, including:

- Changing road conditions (including signalling) to reduce congestion during peak hours
- Encouraging more efficient organization of trips to reduce total vehicle mileage
- Investing in, and promoting, alternative modes of transport to reduce the total number of vehicles on the road
- Urban planning to reduce trip lengths.

Improved mass-transport systems

Guyana has a poor mass-transport system, with the public transport system being dominated by privately-owned buses and mini-buses in urban areas. Taxis are used to connect urban centres with rural areas. Rail lines are no longer in operation. Improvement in mass-transport systems can be achieved via the introduction of safe, efficient and reliable means of transport, including railway systems, public buses (preferably fuel-efficient) and through the use of incentives (e.g. low fares, safety, frequency of services) to encourage people to make better use of public transport.

Furthermore upgrading the existing public transport fleet by introducing more fuel-efficient vehicles, and the use of lower-carbon fuels including liquefied petroleum gas (LPG), natural gas, and biodiesel could offer significant advantages in terms of reduced GHG emissions and other environmental benefits.

Possible barriers towards an enhanced mass-transport system in Guyana include the topography, the cost-effectiveness of introducing such a system (very limited population to serve) and commuter preferences, particularly in Georgetown where urban commuters have become accustomed to the convenience of travelling by private car. New public transport systems will require major improvements in road and communication infrastructure, and developing this infrastructure will entail significant investment. The LCDS recognises too the importance of investment in low-carbon economic infrastructure, particularly to improve access to non-forested lands in order to reduce pressures on forest resources.

Buildings

Buildings are generally responsible for a large percentage of CO_2 emissions, largely because of their significant energy demands (for lighting, heating and cooling) and poor energy efficiency.

There are several easily attainable options for reducing GHG emissions from buildings, including the use of more efficient lighting and cooking appliances, and energy-efficient cooling systems. The Guyana Energy Agency has already initiated a public awareness campaign to sensitize the public to the benefits (in terms of cost-savings) of implementing energy-efficiency and energy conservation measures in buildings.

Energy efficiency

Energy efficiency measures are one of the most effective ways to reduce GHG emissions from buildings and thus reduce energy supply and consumption costs. There are a number of ways of improving energy efficiency within buildings. These include:

- Replacing incandescent bulbs with energy-efficient ones (this can achieve up to 80 % energy savings)
- Installing motion-sensor lights to reduce unnecessary electricity consumption
- Installing variable-frequency drives on chillers, pumps and cooling towers to improve cooling system efficiency, by cleaning or changing filters to ensure maximum operational efficiency, and by installing thermostats to control temperature levels
- Introducing more energy-efficient stoves, particularly among those communities that use firewood as the main cooking fuel. The design of the existing stoves can be modified to use less fuel-wood than the traditional local firesides, and thus reduce the GHG from their operation.
- Longer-term measures may focus on the use of low carbon materials in building construction and on passive design (i.e. maximizing use of natural sunlight for lighting, positioning buildings to benefit from natural airflows, etc).

For any of these measures to be successful will, however, require a supportive regulatory and policy environment. To this end, Guyana may consider strengthening enforcement of regulations around the use of energy-efficient equipment and appliances by, for example, requiring suppliers to make the energy rating of light bulbs and electrical appliances clear to consumers.

Insulation

Insulation prevents outdoor air from infiltrating enclosed spaces and thus reduces the need for the use of indoor air-conditioning. Better insulation is achieved by repairing any leaks in seals and insulation around building partitions and ductwork in the air-conditioning systems, by fitting cool roofs (i.e. special coatings on the roof to reflect the heat) and by installing high-efficiency doors and windows (e.g. glazing or films for windows).

5.1.5 Waste

The waste sector accounts for only a small percentage (±1.39 %) of total emissions[147] in Guyana. GHG emissions are limited to methane (CH_4) from Solid Waste Disposal Sites (SWDS), and to indirect nitrous oxide (N_2O) emissions

[147] Estimated based on GWP of each of methane and nitrous oxide emissions as a proportion of GWP of total emissions expressed in CO_2e.

from human sewage.[148] Despite the small scale of the emissions from the waste sector, there are certain mitigation options which can control GHG emissions from waste, while at the same time these can contribute to wider national objectives including the protection of the public health and the natural environment.

Georgetown has a solid waste collection system serving approximately 90 % of the city's residential population. The collection system is divided into ten zones which are contracted to the private sector. In three of the ten zones collections are made twice a week, and for the remaining seven zones, collections are made once a week.[149] Approximately 10 % of waste is disposed of informally around Georgetown, although this is also periodically collected. In Georgetown, approximately 110 tonnes of waste are collected daily and taken to the Le Repentir landfill site on Mandela Avenue.[150]

In June 2009, the Government awarded a contract to a company to close the Le Repentir landfill by capping and installing gas vents. These works are currently ongoing. Le Repentir landfill is at capacity; however, it is still being used until the new Haags Bosch landfill is completed, planned to be opened in July 2010.

The Haags Bosch landfill will be an international standard sanitary landfill of 100 acres with a design life of around 20 years. It is being constructed with a loan of $18 million from the Inter-American Development Bank, awarded in 2006.[151]

In Georgetown, the transportation and disposal of industrial and commercial waste is the responsibility of the individual companies. Hospital waste and abattoir waste is burned in a waste incinerator sited at Princess Street.

Composting

Composting practice is easy to apply with minimal capital expenditure and low operation and maintenance costs, and is therefore considered to be appropriate for Guyana. It is a well-known practice, applicable at a wide range of scales and using a wide variety of substrates. Some research has already been conducted at the University of Guyana to produce compost by recycling grass, water hyacinth, and cattle dung.[152] Recently, NAREI has started promoting composting with a few farmers who are now actively engaged in such activity. However, commercial facilities do not currently exist in Guyana. Possible barriers towards the application of composting in Guyana include the lack of adequate previous experience in similar projects, and the lack of a market for the compost. However, compost has applications other than as a fertilizer. It can, for example, be used as a covering for landfill waste, where research has indicated that it could significantly reduce methane emissions.[153] Compost has also been successfully used as an erosion control technique.[154]

Biogas

Biogas is not widely generated or used in Guyana despite its potential. Guyana's considerable forest resources support a number of logging and sawmilling industries which generate significant amounts of waste which

[148] Guyana Initial National Communication in response to its commitment to the UNFCCC, April 2002. Accessed online at: http://unfccc.int/resource/docs/natc/guync1.pdf on 19/08/2009.

[149] IDB (date unknown). Georgetown Solid Waste Management Programme Environmental Impact Assessment.

[150] Personal communication, Hubert Urlin, Georgetown Solid Waste Management Unit (28 January 2009).

[151] See: http://www.gina.gov.gy/archive/daily/b090617.html

[152] Ansari, A .A. (2009) *'Indigenous Approach in Organic Solid Waste Management in Guyana (South America)'*. Global Journal of Environmental Research 3 (1): 26-28. Accessed online at: http://www.idosi.org/gjer/gjer3(1)09/5.pdf on 16/04/2010.

[153] See, for example: www.epa.gov/waste/nonhaz/municipal/pubs/ghg/f02022.pdf (Accessed 28/01/2010.)

[154] See, for example: www.docstoc.com/docs/21078196/Controlling-Soil-Erosion-on-Construction-Sites-Using-Compost-Blankets (Accessed 29/01/2010.)

can be converted to energy. Traditionally, wood was used to generate electricity by direct combustion and steam generation, and also in feeding gas producers fuelling modified diesel engines. Waste from the timber industry is believed to be particularly suitable for fuelling machinery used for cereal production.

In August 2007 a small pilot biogas facility to generate electricity was installed and fed with cow manure,[155] and similar facilities are planned for Canal No.1, La Grange and Kuru Kururu. The main barriers associated with the application of biogas technology in Guyana include the lack of an institutional framework for waste management, equipment which is not readily available in the country, and the lack of competitive prices and commercial opportunities for electricity generation, due to the monopolistic supply of electricity in Guyana.

The development of biogas in Guyana will require significant investment in creating awareness of the technology and its benefits, and training in the use of the technology. The efficiency and reliability of electricity from biogas would also need to be carefully evaluated against the costs of more conventional sources of energy, and appropriate incentive measures designed to encourage uptake where necessary.

Recycling

There are presently no formal recycling facilities in Guyana, nor any measures to limit the amount of waste produced. Throughout Guyana there is a problem with littering, with a significant part of the garbage comprising plastic bottles. Possible barriers towards the development of recycling in Guyana include a weak institutional framework for waste management, poor enforcement of environmental law, limited knowledge about recycling practices, and the lack of an adequate market (size of population) to justify the development of recycling plants.

5.1.6 Agriculture

Agriculture is the most important sector of the Guyanese economy, both in terms of foreign exchange generation and employment. The agricultural sector is responsible for over a fifth (22 %)[156] of total CO_2 emissions and is the principal source of non-CO_2 emissions in Guyana.[157] That percentage includes the emissions from the energy requirements for agriculture as well as from livestock (e.g. manure and enteric fermentation), crop production (e.g. rice cultivation), and field burning of agricultural residues.

Improved water management, including improved drainage and irrigation practices

Improved water management systems, including active irrigation and drainage of rice fields, can significantly reduce CH_4 emissions. Mid-season drainage and intermittent irrigation reduce CH_4 emissions by over 40 per cent. Shallow flooding provides additional benefits, including water conservation and increased yields.[158]

The Guyana Rice Development Board has already developed a mitigation strategy for rice production using a new water management regime to reduce CH_4 emissions. Under the new management regime, land is prepared with wet tillage and the water used for tillage is then retained to grow the rice crop. The crop is typically grown through a depth of 5-7.5 cm of water, but the water level may be reduced or

[155] Guyana Energy Agency. Kick the Habit: a presentation that covers the current energy situation and the status of the various energy developments and energy conservation measures in Guyana. Accessed online at: www.gea.gov.gy/downloads/Kick%20th%20Habit.pdf on 25/08/2009.

[156] Greenhouse Gas Inventory of Guyana (1990-2004). Draft chapter (March 2010).

[157] Greenhouse Gas Inventory of Guyana (1990-2004) – Draft chapter (March 2010).

[158] Ibid.

fields may be completely drained for the application of fertilizers or post-emergence herbicides during the early stages of crop development. An adequate water level (7.5 to 10 cm) is subsequently maintained until around 85 to 90 days after sowing, depending on variety.[159] This process allows for good aeration of the rooting system; less than half the amount of water is used compared to traditional techniques, and, importantly for climate change mitigation, nitrogen in the soil is prevented from forming N_2O compounds and escaping into the atmosphere.

A combination of heavy rain and drought over the last few growing seasons has, however, prevented such water management practices. So although this water management process is part of the Guyana Rice Development Board's mitigation strategy, this has not yet been successfully implemented.[160]

Diesel-fuelled pumps are often used to power water pumps where it is not possible to connect these to the main electricity grid. As well as being more costly to run and maintain, diesel pumps also emit CO_2. A number of more sustainable energy solutions such as treadle pumps and ram pumps have been trialled in other developing countries, and could be investigated for use in Guyana.

Changes in cultivation practices

Changes in cultivation techniques can significantly reduce GHG emissions, increase soil organic content and nutrient availability, and result in higher yields.

In Guyana, organic fertilisers are used on crops other than rice and sugar. The application of nitrous fertilisers such as urea (organic) and phosphorous (mineral) is commonplace in rice production in Guyana. One way of limiting N_2O formation is therefore to apply better water management pracices that allow a sufficient drying period (2-3 weeks) after the application of nitrous fertiliser.[161] That way, the loss of nitrogen through dilution and denitrification is minimized, and the release of both N_2O and CH_4 emissions is substantially reduced.

Other possible practices for reducing emissions include crop rotation, as opposed to sequenced cropping of the same species, and employing measures to minimize the disturbance to soils. Crop rotation practices are not widespread in Guyana. Although it would be difficult for rice production because of the specific cultivation techniques required,[162] if fruit and vegetable production does expand (as the LCDS suggests it could), then farmers may consider crop rotation to reduce fertiliser use, minimize costs and limit GHG emissions.

Damage or removal of vegetation, erosion and soil compaction may release the stock of carbon stored in underlying soils. Reducing tillage and the recycling of organic materials to land minimizes soil disturbance and is therefore promoted[163] as a means of increasing the storage of carbon in agricultural soils. Reduced tillage has many benefits besides protecting, or potentially increasing, existing soil organic carbon levels: it can increase soil water infiltration rates and reduce water erosion, enhance soil water retention, and decrease production costs and fossil-fuel consumption.[164] Opportunities exist to introduce reduced tilling

[159] Personal communication, Viviane Baharally (Entomologist), Guyana Rice Development Board (28 January 2010).
[160] Personal communication, Viviane Baharally (Entomologist), Guyana Rice Development Board (28 January 2010).

[161] *Farming for a better climate, optimise the application of fertilisers and manures*. Scottish Agricultural College. Accessed online at: http://www.sac.ac.uk/mainrep/pdfs/pgappnutrients.pdf on28/01/2010.
[162] Personal communication, Jerald Joseph (Technical Projects Officer), Ministry of Agriculture (28 January 2010).
[163] See, for example: Stern, N. (2006). *The Stern Review on the Economics of Climate Change*. HM Treasury: London.
[164] Bhogal, A, Chambers, B., Whitmore, A. and Powlson, D. (2007). *The effects of reduced tillage practices and organic material additions on the carbon content of arable soils.* Report for Defra (Project SP0561). Accessed online at http://randd.defra.gov.uk/Document.aspx?Document=SP0561_6893_ABS.doc on 29/01/2010.

practices in Guyana, particularly in light of the proposed expansion of the fruit and vegetable sector in support of the LCDS.

5.1.7 Forestry

There have already been many direct and indirect efforts by the GoG to reduce deforestation and forest degradation and to identify where particular challenges and opportunities may lie, as outlined in the Table 5.2[165] below:

Table 5.2. Actions to address deforestation and forest degradation

Efforts	Outcomes	Gaps /Challenges	Opportunities
Implementation of the Code of Practice for Harvesting Operations that allows for good practices to be implemented in Sustainable Forestry Management (SFM) and legality, including a maximum allowable cut; the harvesting of trees based on proximity limitations; compliance with the GFC's social & environmental guidelines; annual and management plan requirements; execution of forest inventory; ESIA; national log-tracking system; legal verification system; and strengthened field monitoring	The issuance, planning and management of large concession areas are executed in keeping with GFC's guidelines, which themselves lend to the implementation of SFM and legality which allow for deforestation and degradation to be kept to a minimum. There is managed extraction, control of gaps size openings and improvements in GFC's social and environmental guidelines. Protection of buffer zones in forest areas Progress in compliance with SFM	Community groups require additional capacity to implement all aspects of the CoP. In some cases capacity of institutions needs to be strengthened (GFC, GGMC). New areas allocated would have to undergo capacity building and in some cases commitment of additional resources to enable these to be executed. Implementation of the legality assurance system needs to be advanced. Training in standards of legality needs to be extended in a larger way to forest communities.	**With compliance by forest land holders, deforestation and forest degradation at the national level will be maintained at the existing low rate and can even be lowered in the future.** **Maintenance of a high level of legality will foster the maintenance of a low rate of deforestation and degradation.**
The GFC community forestry development programme capacity building sessions have been and continue to be held with communities in forest law, forest inventory & management.	A stronger compliance with forest law, forest inventory and forest management allows for sustainable use of forest resources, thereby decreasing deforestation and forest degradation.	More resources needed for additional communities to be targeted	**With compliance by both large and small-scale operators, deforestation and forest degradation at the national level will be maintained at the existing low rate and can even be lowered in the future.**

[165] Extracted from Guyana Forestry Commission (2009). *Guyana REDD Readiness Preparation Proposal.* Accessed online at http://forestcarbonpartnership.org/fcp/sites/forestcarbonpartnership.org/files/Documents/PDF/Sep2009/Readiness_Preparation_Proposal_Revised_September_7_2009.pdf on 04/05/2010.

Land titling	96 indigenous village communities have title over their lands.	10 villages do not yet have formal legal title. Some villages currently exist without title because they do not yet fit the criteria for titling.	**With the implementation of REDD and the receipt of revenues generated from REDD, the land titling process can be speeded up.**
Effective implementation of the mining regulations	A stronger compliance with mining regulations allows for sustainable use of forest resources, thereby decreasing deforestation and forest degradation.	More resources needed for additional communities to be targeted	**With compliance by both large and small scale operators, deforestation and forest degradation at the national level will be maintained at the existing low rate and can even be lowered in the future.**
Monitoring of infrastructural development	Conducting of Environmental Impact Assessments (EIAs) for large infrastructural projects & preparation of Environmental Management Plans for smaller scale infrastructural projects Monitoring & oversight by the Ministry of Public Works & Communications (MPW&C), the EPA and other sector agencies such as GL&SC & Ministry of Housing (MoH)	Need for more qualified personnel on staff of both the EPA & MPW&C to oversee planning & implementation of projects Greater inter-agency co-ordination can allow for more effective monitoring and oversight of projects	**Capacity building and support to better understand REDD & implications of infrastructural development on REDD will lead to better M&E.**
Efforts have been made to limit the effects of agriculture on the forest resources.	Sustainable agricultural practices have been developed and implemented among operators.	More efficient technologies needed Need for more qualified personnel	**Capacity building and support to better understand REDD & implications of agricultural development on REDD** **More capacity building & support in various areas**

It is clear from the above Table 5.2 that Guyana is already implementing a number of measures to promote conservation and sustainable use of its forest resources. These measures are an integral part of the LCDS which provides the strategic framework for the execution and monitoring of the REDD+ mechanism. Guyana is presently in the process of preparing its detailed REDD strategy which involves further developing proposed REDD activities, consulting on these and evaluating them through a series of pilot projects.

Forest Conservation

Forest management and forest conservation are mitigation options that are already practiced in Guyana, and which aim to protect forest reserves from uncontrolled deforestation. However, as noted in Guyana's REDD+ Readiness Preparation Proposal, forest-cover monitoring needs to be substantially strengthened through the adoption of more advanced land-cover change monitoring and imaging technologies such as remote sensing and satellite photography. Forest conservation activities in Guyana are expected to increase with the execution of Guyana's REDD+ plan and Memorandum of Understanding (MOU) between the Governments of Guyana and Norway. Alongside technology for forest-cover monitoring, the country also needs significant investment in human resources. This means not only building capacity in forest management but also ensuring that sufficient resources (and supported by an effective regulatory and legal system) are available to enforce sustainable forest management practices on the ground in remote locations.

The passage of the Forests Act in January 2009 now provides the GFC with a broader range of powers to regulate enhanced forest practices, including conservation operations for purposes of carbon sequestration and environmental services, and as such, the GFC is therefore expected to play an increasingly pivotal role in implementation, monitoring, and enforcement of REDD+ activities.

Sustainable logging

Existing harvesting regimes in Guyana are managed according to National Forest Policy, Forest Management Plans and a Code of Practice for Harvesting Operations.[166] Forest Management Plans cover the issuance, planning, and management of large concession areas in line with GFC guidelines. The Code of Practice for harvesting operations allows for best practices to be implemented for sustainable forest management, including maximum allowable cut, harvesting of trees based on proximity limitations, and compliance with social and environmental safeguards.

[166] See: http://www.forestry.gov.gy/Downloads/Readiness_Preparation_Proposal_April_2010_Revised.pdf (Accessed 20/06/2010.)

The aim is to improve the existing harvesting regimes through changes in the cutting cycles and annual allowable cut, selective cutting, harvesting for multiple end-uses, residue utilization for fuel and tertiary products, and increased conversion efficiency, possibly involving technological intervention. Measures are needed to help monitor and ensure compliance with the Code of Practice. Through the process of preparing its REDD+ Readiness Preparation Proposal, Guyana has already identified key requirements for capacity building.

Fire and pest management

There is no significant record of forest pests in Guyana. According to the GFC, the Dakama forest is the only forest type prone to fires. While this type of forest can regenerate naturally by coppicing, there are measures that could be introduced to help prevent the outbreak of forest fires. These include the introduction of fire hindrance barriers such as observation towers, fire lines, channels and water reservoirs, and the establishment of a network of forest fire warning.

5.1.8 Priority sectors for adaptation and key technologies for preliminary action

Adapting to climate change means making adjustments in response to the likely threats as well as opportunities arising from climatic variability and change.

Climate change adaptation therefore requires action across a range of sectors in order to increase the ability of communities and the environment to withstand the impacts of climate change and minimize their consequences. However, because of the often very localized impacts of climate change and the large number of uncertainties in climate forecasting, the identification and evaluation of climate change adaptation technologies is inherently complex.

Although engineering responses such as construction of structural defences can provide part of the solution, adaptation also requires behavioural change which must be both encouraged and enforced by policy and other regulatory and legislative measures. For these measures to be effective, institutional strengthening and capacity building amongst planners, policy-makers and decision-makers is required.

This section provides an overview of the priority sectors in Guyana for adaptation, and the types of policy and technological interventions required for Guyana to adapt and reduce its vulnerability to the impacts of climate change (See Appendix 5.1).

Agriculture

New crop species and cultivars/substitution of crops

To improve the resilience of agricultural production to abiotic stresses brought on by climate change (i.e. higher temperatures, more variable rainfall patterns, drought, flooding, high salt content in soil, pests and diseases) requires the selection of more resistant cultivars, and potentially, substitution of existing crops with varieties more resilient to new climatic conditions.

Since rice is one of the main products grown in Guyana, the Rice Development Board has already considered the introduction of new cultivars and is working on the development of new varieties able to withstand extreme climatic conditions such as extended drought and flooding.[167]

The proposed expansion in fruit and vegetable production on previously unused lands, under the LCDS, provides Guyana with a good opportunity to opt, right from the start, for crops and cultivars that will be able to withstand the changes in climatic conditions. This requires further research to identify the most suitable crops and cultivars, to learn the appropriate cultivation techniques, and to evaluate market demand.

Pest management

Climate change is expected to bring more frequent and more intense pest and disease outbreaks as a result of increased drought or flooding events. A study[168] on the impacts of climate change on Surama, an indigenous Amerindian community, indicated that droughts and floods have severely affected the production of cassava, a key staple food, in the past. Extended droughts caused damage to cassava crops as well as infestation of pests. To overcome the threat of pest infestation, it is necessary for Guyana to identify appropriate pest management approaches, and a plan of action for implementing these approaches, as some crops will be adaptive while others may be more responsive to particular infestations (i.e. dependent on the type and severity of infestation). Adaptive measures include identifying and/or developing pest-resistant crops and implementing farming practices such as intercropping, which help protect vulnerable crops.

According to the Rice Development Board, farmers are becoming increasingly aware of the threats of climate change to agriculture, and are gradually adopting new practices such as treating croplands with pesticides. However, given the costs and environmental impacts of pesticide use, further efforts could be directed towards raising awareness of alternative approaches such as intercropping to protect yields.

[167] Personal communication, Viviane Baharally (Entomologist), Guyana Rice Development Board. (28 January 2010).

[168] UNDP (2009). *Case Study on the Impact of Climate Change on Agriculture on an Indigenous Community in Guyana*. UNDP. Accessed online at: http://www.undp.org.cu/crmi/docs/crmi-gttfcstguyana-bp-2009-en.pdf on 28/01/2010.

Changes in cultivation practices, including improved irrigation and drainage practices

Changes in cultivation practices such as minimum or zero tillage, crop rotation, and changes in sowing dates also enable adaptation of agriculture to the impacts of climate change. Other practices already considered in Guyana work towards adapting to the forthcoming climate change impacts. These practices range from changing the sowing dates, which can reduce the impacts of drought during warmer periods, to promoting upland cultivation to avoid flooding both along the coastline and the floodplains, and delaying harvesting.[169]

Further measures to be considered include improving the efficiency of water use in agriculture and access to irrigation. Drip irrigation is widely promoted in other developing countries as a means of improving water productivity in agricultural regions expected to be affected by a decline in average annual rainfall, but this also requires investment and capacity in maintaining and operating canals and sluices.[170]

Buildings

It is not only the structure of buildings that needs to be considered, but also their location and design. Buildings located in floodplains are more vulnerable to flooding, and those with poor insulation and/or airflow may also impact upon the buildings' inhabitants during periods of high temperature. There are measures that can be adopted to ensure that new construction is specifically designed to take account of the likely impacts of climate change, particularly when considering that many of the buildings that are constructed now will probably still be in use after 50 years. It is also important to consider retrofitting the existing building stock to ensure that it remains resilient to climate change impacts.

Adaptation measures for buildings to withstand climate change will depend upon the age, construction and type of building, and different solutions will be applicable to different types of property.

Revision, refinement and enforcement of building codes

The imminent changes in climate require the introduction of new building codes to promote the use of new and innovative materials and technologies in buildings to reduce vulnerability and adapt to the impacts of climate change. While Guyana has a number of building codes, these are not actively enforced. The existing building codes need to be revised and refined, and new ones may need to be developed, in light of the predictions of the likely impacts of climate change on Guyana. These should focus on locating new development away from flood-prone areas and/or adopting designs that are able to withstand the impacts of flooding. Further incentives may be developed and introduced to encourage designs that:

- have effective ventilation strategies making best use of natural airflows
- minimize penetration of direct light and heat (e.g. through glazing, careful selection of building materials, and orientation of buildings)
- use efficient lighting and air-conditioning to minimize waste heat
- enable future adaptability
- are able to withstand flooding (e.g. by raising homes, agricultural outbuildings and other buildings above ground level).

[169] Personal communication, Viviane Baharally (Entomologist), Guyana Rice Development Board. (28 January 2010).

[170] ITCSD (2010) *Agricultural Technologies for Climate Change Mitigation and Adaptation in Developing Countries: Policy Options for Innovation and Technology Diffusion. Issue Brief No. 6*. Accessed online at http://ictsd.org/downloads/2010/06/agricultural-technologies-for-climate-change-mitigation-and-adaptation-in-developing-countries_web.pdf on 21/06/2010.

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5.1.9 Coastal Zones

Structural options

As shown in Fig. 5.1, the coastal zone is divided into two vulnerable zones: Impact Zone I, which is not currently protected by man-made structures, and Impact Zone II, which comprises the densely populated regions and is protected by a combination of concrete and earthen sea defences. Approximately 110 km of the Guyanese coastline is protected by concrete sea defences, 250 km by a mangrove belt backed up by an earth embankment, and 70 km by natural sand banks.[171]

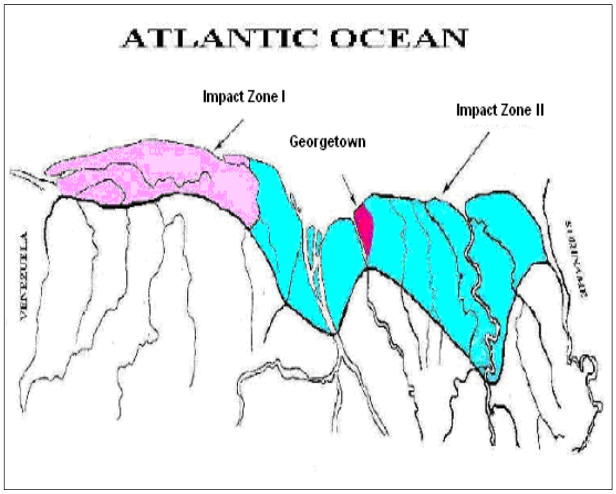

Fig. 5.1. Vulnerable coastal zones[172]

Modern construction and environmental engineering tools and techniques allow for more durable sea and river defences which last for longer periods of time (30 years design lifetime) without suffering significant damage.[173] Since 1990, new structures or reinforcement works in the coastal zone have used 'rip-rap' construction.[174] Guyana is also testing the potential of introducing HESCO barriers[175] as opposed to the traditional gabion baskets.[176] However, the costs of such structures are high, and additional precautions need to be taken to minimize their potential impacts on the marine environment.

In recent years, a number of rehabilitation and reconstruction programmes have been funded both by the Government of Guyana and international donor agencies, such as the European Commission and the Inter-American Development Bank. The Sea and River Defence Division (SRDD) of the Ministry of Public Works and Communications has the responsibility for the maintenance and new construction of sea and river defences. The SRDD is being supported in the managing of new capital construction works through technical assistance programmes funded by the international agencies. The Emergency Repair Unit which operates under the SRDD is the responsible unit for monitoring the condition of the sea defences and ensuring that emergency repairs are completed.

Following the severe floods of 2005, the Government of Guyana has taken very seriously measures to address coastal flooding. Since 2005, it has approved contracts valued close to GY$1 billion (US$5 million) for works to be undertaken in the sea and river defence sector in several regions. The works to be undertaken include both 'rip-rap' structures and gabion baskets along the coast and rivers. Some of these works include construction and installation of gabion baskets at Riverview, on the Essequibo River, construction of 600 metres of

[171] *Guyana Initial National Communication in response to its commitment to the UNFCCC*, April 2002. Accessed online at: http://unfccc.int/resource/docs/natc/guync1.pdf on 19/08/2009.

[172] *Guyana Initial National Communication in response to its commitment to the UNFCCC*, April 2002. Accessed online at: http://unfccc.int/resource/docs/natc/guync1.pdf on 19/08/2009.

[173] *Government continues to invest in sea, river defence* (April 2008). Guyana Government Information Agency. Accessed online at: http://www.gina.gov.gy/archive/daily/b080414.html on28/01/2010.

[174] Personal Communication, Geoffrey Vaughn (Engineer), SRDD. (27 January 2010.)

[175] The HESCO barrier or HESCO bastion is a modern gabion used for flood control and military fortification. It is made of a collapsible wire mesh container and heavy duty fabric liner.

[176] Personal Communication, Geoffrey Vaughn (Engineer), SRDD. (27 January 2010.)

rip-rap sea defence at Sea Spray, Leonora, West Coast Demerara, and 120 metres of rip-rap river defence at Toevlugt, West Bank Demerara.

In 2007 the European Commission allocated approximately €18 million towards the rehabilitation and reinforcement of Guyana's sea defences. The funds are going towards works, preventative maintenance and reconstruction, as well as institutional capacity building. The institutional capacity building component includes further development of the existing Shore Zone Management System and the formulation of a Sea Defence Sector Policy to provide a comprehensive framework under which co-ordinated actions can take place, and to ensure that adequate funding is allocated for rehabilitation works and maintenance. This programme aims to preserve existing mangroves and to evaluate the possibility of restoring the mangroves that once formed a natural defence against the sea.[177]

Geographic Information Systems (GIS) also help improve the effective management of sea defences. The EPA, in collaboration with the Guyana Sea Defence Project Execution Unit of the Ministry of Public Works and Communications, has already developed a Sea Defence Management Information System (SDMIS). This is a pilot project that focuses on the island of Leguan and which vuses GIS for the effective management of sea defences. SDMIS uses a GIS/database approach to store attributes or characteristics of the sea defence structures, including their condition, structure type, construction year, length, and residual life. SDMIS displays visually the sea defence outline and photographs of any segment.[178]

As can be seen from the above, Guyana has already directed significant resources towards improving its flood defences. Further effort is required to ensure co-ordinated actions amongst the different agencies involved, and to develop the capacity required to routinely inspect and maintain the condition of these defences.

Monitoring and early warning systems

Monitoring the frequency and severity of extreme events is an important component in ensuring protection of the coastal zones. It is essential to monitor the hydrodynamics (storm surges, tides, currents) and establish a morphological monitoring system using advanced technology such as satellite imaging and GIS. Furthermore, using pilot zones to model the real impacts of sea-level rise would enable Guyana to reduce disaster risk in the face of a changing climate.

The establishment of disaster early warning systems and the development of preparedness and response plans, including promoting public awareness, can play a significant role in reducing vulnerability.

The Civil Defence Commission (CDC) has already taken action in this regard. It has already prepared and proposed a flood plain mapping system which is currently awaiting approval.[179] A GIS system has also been in place since 2005, after the devastating January 2005 floods, to monitor water levels on a daily basis.[180] However, official hazard and vulnerability mapping, *ad hoc* monitoring or

[177] European Union, Delegation of the European Commission to Guyana, Suriname, Trinidad & Tobago, Aruba and the Netherlands Antilles – Press Release Guyana, December 19, 2007. Accessed online at: http://www.delguy.ec.europa.eu/en/Press%20Releases/9th%20EDF%20Sea%20Defences%20Press%20Release.pdf on 27/01/2010.

[178] *Managing the Sea Defences along Guyana's Coast: A GIS/RDBMS Approach*. Acccessd online at: http://www.caribbeangis.com/SDMIS_Summary.pdf on 28/01/2010.

[179] Personal Communication, Bruce Munro (Engineer), CDC (27 January 2010).

[180] Personal Communication, Karen Anthony (Senior GIS Analyst), LSD (27 January 2010).

plans for relocation of population are not readily available. While some mapping and planning work has been done, such information is scattered throughout a number of different departments, e.g. Guyana Lands and Surveys Commission (GL&SC), Guyana Environmental Protection Agency (EPA), and the National Drainage and Irrigation Authority (NDIA).[181]

Representatives of several ministries also meet regularly with the National Steering Committee (NSC), which reports to the Natural Resources and Environment Advisory Committee (NREAC) and the Integrated Coastal Zone Management Committee, to exchange information, alert the public and share collaboration to respond to natural disasters.[182,183] Hydromet is responsible for monitoring weather and climate, and is able to provide national and local weather and precipitation forecasts for both the short- and longer-term. They are thus able to warn against the onset of floods and droughts. These warnings are particularly useful for farmers. However, Hydromet suffers from limited human resources and skills, and, despite the fact that capacity has recently been developed in using hydrological models, these are not systematically used for early warning purposes.[184]

The importance of early warning is emphasized in several strategy and action plan documents, while many institutions are already involved, or recognize the need to be involved (NDIA, Hydromet, GLSC) in these efforts. A number of initiatives include the following.[185]

- Over the last decade UNDP has constantly supported Guyana's efforts to reduce the risks of natural disasters. In 2008 a four-year project was launched, Strengthening National and Local Capacities for Disaster Response and Risk Reduction. This initiative, jointly funded by UNDP, GoG and IADB, and implemented by the Office of the President, aims at helping Guyana to increase its preparedness for the risks of disasters at the national and local levels.

- Japan International Co-operation Agency (JICA) is funding a pilot project in the heavily vulnerable Mahaica-Mahaicony area, which includes an early warning system for flooding (including flash floods).[186,187]

- Capacity Development and Mainstreaming for Sustainable Land Management Project (SLM) (2008-2011) UNDP – GEF (Guyana Lands and Surveys Commission)

- Integrated Disaster Risk Management Plan Project (2009-2011) IDB (Civil Defence Commission)

- The United States Southern Command (USSouthCom) has partnered with the CDC to help in the area of Flood Hazard Mapping. Currently the equipment and software are tested in the Mahaicony region, while staff are trained in the operation of the software.[188]

Although some efforts have been put into improving preparedness (particularly in the development and use of early warning systems), the high costs of establishing such systems, in combination with the limited technical capabilities in place, means that they fall short of their full potential in terms of

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[181] Flasse Consulting (2009). *Early Warning System Study Situation Report*. Prepared by Flasse Consulting for GLSC, UNDP and GEF.

[182] Ibid.

[183] Personal Communication, Bruce Munro (Engineer), CDC (27 January 2010).

[184] Ibid.

[185] Ibid.

[186] Flasse Consulting (2009). *Early Warning System Study Situation Report*. Prepared by Flasse Consulting for GLSC, UNDP and GEF.

[187] Personal Communication, Bruce Munro (Engineer), CDC (27 January 2010).

[188] http://www.stabroeknews.com/2009/stories/05/20/cdc-prepared-to-minimise-any-rainy-season-disaster-ramsarup/ .

protecting communities and industries from severe weather events.

Stringent planning controls in susceptible areas

Many of the areas that are developed now will still be in use after 50 years. For this reason, spatial development plans should take into account the projected changes in land morphology as a result of erosion and flooding, in order to reduce the vulnerability of future developments to these changes.

In the case of Guyana, vulnerability mapping (including flood risk mapping) would play a vital role in helping the planning and development authorities to assess the suitability of locations for new development, accounting for the impacts of future climate change. Such information can then inform planning policy and development control measures to prevent, or at least limit, inappropriate development in vulnerable areas such as floodplains and areas subject to coastal erosion. This will in turn require institutional strengthening and capacity building to promote effective policy- and decision-making and to enforce development controls.

Water resources

Adaptation measures for freshwater sources are critical to the viability of agriculture and for maintaining human health and well-being.

Measures that may be implemented over the short term are likely to be the design and introduction of water conservation measures, including metering, the more efficient use of irrigation water, and the rationing of water during extremely dry years. As for the medium to long term, adaptation measures may include stricter water conservation techniques, collection of rain-water for potable and non-potable use, stricter control and management of the supply network in agriculture, and keeping reservoirs at lower head to reduce evaporation at hydropower sites. Barriers to transfer and use of these technologies include the financial costs involved, as well as a poor appreciation by water managers of the potential impacts of climate change on the availability of freshwater resources in future.

Rain-water collection

There is little information on the current extent of rain-water harvesting in Guyana.[189] The 2002 census indicates that rain-water provides around 15 % of the country's drinking-water supply.

Recent research[190] examined the feasibility of installing domestic rain-water harvesting systems (DRWH) to improve household water security in St Cuthbert's Mission. DRWH systems were shown to be a relatively low-cost option for universally improving a household's geographical and temporal access to a water source, and that the water quality was of sufficient standard. These findings suggest that encouraging the use of DRWH systems more widely throughout Guyana could help reduce vulnerability to the impacts of climate change. However, given predictions for increased rainfall variability, further research is needed to improve the design of systems so that the water collected can be hygienically stored (or treated before use) for use in drier seasons.

Promote water efficiency

Guyana Water Incorporated (GWI) provides water to around 145,000 homes, offices and schools across Guyana, and supplies over 300,000,000 litres of water daily.[191] Drinking water is sourced from underground aquifers,

[189] Personal communication, Rensford Joseph, Guyana Water Incorporated. (29 January 2010.)

[190] Intven, L. (2009*). Scaling up domestic rain-water harvesting, St. Cuthbert's Mission, Guyana*. Research on behalf of McGill University and the Caribbean Water Initiative.

[191] Personal communication, Rensford Joseph, Guyana Water Incorporated. (29 January 2010.)

boreholes, and rivers including the Demerara and Mazaruni.

With a predicted increase in the prevalence of drought in Guyana, the conservation of water is going to be a key adaptation measure. More efficient use of freshwater resources is an important element of water conservation. Water efficiency practices can be practised by agricultural, residential, and commercial water users.

Improved irrigation systems and stricter water management practices in agriculture can reduce the amount of water required to irrigate a crop effectively, by supplying water when most needed and in the best suited manner to irrigate plants. Controlling the rate and the timing of irrigation can significantly reduce water losses.

The CDC already operates a drainage management system using canals to control the amount of water entering and/or leaving flood-prone areas.[192] Sluice gates are closed during high tide to prevent salt-water intrusion, and opened during periods of intense rainfall to channel excess water out to sea. These operating rules may be reviewed in light of the expected increase in the occurrence and intensity of flooding events in Guyana, to ensure that cultivated areas and communities are protected from severe flooding. For example, the FAO has issued guidelines on the management of flood control, and drainage and irrigation (FCDI) sluice gates[193] which could be adapted for use in Guyana.

Low-flow plumbing fixtures are usually low cost and can significantly reduce water loss from residential use and also save residents money in the long term. Some low-flow plumbing fixtures include pressure reduction devices, low-flush systems in toilets and low-flow showerheads.[194]

Finally, water supply utilities can ensure efficient use of water by installing metering devices, early-leak-detection systems and replacement of water pipes. Pricing systems could also be considered as part of water management.

The advantage of all these water efficiency measures is the low cost and the simple application and operation of these technologies. Furthermore, while it is relatively straightforward to design incentives for encouraging more efficient use, or discouraging wasteful use of water, such incentives need to be supported by effective water use monitoring (e.g. metering), equitable tariffs and efficient administration and payment collection mechanisms.

Water drainage / reuse

Freshwater that has been used in a process (e.g. industrial, home use) is usually discarded as waste. Wastewater is usually discharged into natural watercourses where it is subjected to natural purification processes (where the assimilative capacity of the fluvial ecosystem has not already been exceeded) so that it becomes available for reuse. Similarly, technologies that reclaim and purify wastewater may enable its reuse several times. Wastewater treatment and its subsequent reuse within a water process for industry or agriculture allows for optimum use of limited resources.[195]

Wastewater treatment at public water works is undertaken primarily to protect public health and the environment by eliminating any infectious agents or pathogenic organisms that may be present in the wastewater. The costs for wastewater treatment and reuse vary,

[192] Personal communication, Bruce Munro, Guyana Civil Defence Commission. (29 January 2010.)

[193] See: http://www.fao.org/teca/content/management-flood-control-drainage-and-irrigation-fcdi-sluice-gates. Accessed online on 21/06/2010.

[194] *Guyana Initial National Communication in response to its commitment to the UNFCCC, April 2002*.
Accessed online at:
http://unfccc.int/resource/docs/natc/guync1.pdf on 19/08/2009.

[195] Ibid.

depending on the type and the level of the treatment, the location and the amount of wastewater that needs to be treated, yet the benefits to public health and economic productivity are substantial.

GWI manages two sewer systems, both located in central Georgetown. They serve approximately 12,000 households; equivalent to around 31 % of the city's population. Both sewers are gravity-fed systems and serve 24 sewage stations within Georgetown. Another larger sewage station is located at Turning Point, Tucville. This station serves about 4,000 residents of the Tucville community and also receives sludge from septic tanks in the Greater Georgetown area and from private waste disposal tankers as part of the public/private partnership with GWI.[196]

Waste from all sewage stations is pumped via the Kingston foreshore where it is then disposed of by dilution approximately 150 metres into the sea at the mouth of the Demerara River. There is presently no wastewater treatment in Guyana, GWI relying instead on the assimilative capacity of Guyana's vast network of waterways, and no plans at present to introduce N_2O reduction activities in current operations. At the time of writing, GWI was, however, in the advanced stages of tendering for a feasibility study for a new wastewater treatment plant.[197]

5.1.10 Overarching Issues

In addition to the sector-specific technologies and practices that may be implemented to help combat the threat of climate change, there are a number of other overarching challenges that need to be addressed. These are closely related to research and systematic observation systems (see Section 5.2) and include:

- Improving climate models and scenarios at a detailed regional level, especially for extreme weather events, to reduce high levels of uncertainty
- Advancing understanding of 'good practice' adaptation measures through knowledge-sharing and sharing of information on feasibility, costs and benefits
- Involving both the public and private sectors and the general public at both local and national level. Awareness-raising is a fundamental prerequisite for changing behaviours and encouraging the uptake of new technologies or more environmentally sustainable practices.
- Enhancing co-ordination and collaboration both within and between countries (particularly amongst the small island developing states in the Caribbean region) to ensure the coherence of adaptation measures with other policy objectives and the appropriate allocation of resources.

Addressing these challenges will require institutional strengthening, improved data collection, sharing and integration, enhanced communication and the implementation of financial incentive (or disincentive) mechanisms to encourage the implementation of more energy-efficient, low carbon technologies and to discourage wasteful use of resources.

[196] Personal communication, Rensford Joseph, Guyana Water Incorporated. (29 January 2010.)
[197] Ibid.

5.1.11 Barriers to technology

Despite Guyana's progress in developing strategies to address climate change in a number of areas and in attracting the investment necessary to implement those strategies, several barriers presently exist to the introduction of climate change mitigation and adaptation technologies in Guyana. These include the costs of procuring and maintaining technologies, the financial feasibility of options, uncertainties regarding the possible nature and significance of climate change impacts and, most significantly, limited availability and continuity of technical expertise within relevant institutions to both operate new technologies to their full potential and to maintain these technologies.

Overcoming these barriers requires, in the vast majority of cases, taking steps to create an enabling environment. The draft LCDS is a promising start and has enjoyed strong and widespread support both within Guyana and internationally. However, significant effort and investment in institutional strengthening and reform, technical capacity building, education, and awareness-raising will be required for this model to succeed.

Some of the common barriers to the transfer and implementation of technologies are described below in Table 5.3, together with suggestions for how these may be overcome.

Table 5.3. Barriers and suggestions for overcoming these

Types of barriers	Description of barriers	Suggestions for overcoming
Financial	High costs of new technologies	Giving priority to technologies with quick payback periods and guaranteed returns. Adopting a full-cost accounting approach – i.e. seeing whether high initial costs may be more than offset by the cost savings accrued over the life of the technology); international co-operation and knowledge transfer; international funding
	Limited project finance; restrictions on foreign investment[198]	Closer collaboration with the private sector; borrowing from multi-lateral lending institutions (e.g. IADB); regulatory reform
	Lack of financing instruments/systems and difficulties in securing credit and loans from commercial banks, especially for unproven technologies	Regulatory reform to reduce levels of actual or perceived risk; co-operation with financial institutions such as the Inter-American Development Bank (IADB); purchase of appropriate insurance cover
Economic / Market / Trade Constraints	Weak or absent price signals (e.g. tiered water and energy tariffs that discourage wasteful use) and barriers to introduction of technologies (e.g. energy efficiency options)	Addressing market failures (e.g. through carbon taxation or other methods that encourage the uptake of more efficient technologies); changing pricing policies
	Weak competition (particularly in the energy supply sector) that reduces incentives to innovate, and potentially erects barriers to new entrants (e.g. independent electricity	Strategic planning and interventions at appropriate level; regulatory reform to allow and encourage competition

[198] The Heritage Foundation. 2010. *Index of Economic Freedom.* Accessed online at: www.heritage.org/Index/Country/Guyana on 29/01/2010.

	producers who wish to sell to the grid have little bargaining power; they are price-takers)	
	Limited market size to justify the investment (e.g. in recycling or composting technologies, etc.)	Stimulating the creation of markets (e.g. through awareness-raising, incentives, regulation, etc); creating linkages with regional markets. Compost may be considered for use as a landfill capping.
	Import tariffs (including import restrictions) and intellectual property issues	International and bilateral negotiations, research partnerships, etc., to ensure that critical technologies are treated as public goods
	Some unsupportive macro-economic policies, particularly import regulations	Changes in the macro-economic environment; improving financial and administrative efficiencies
Policy / Institutional	Lack of technical capacity to establish and maintain technologies	Communication and education; development of a critical mass of human capital via appropriate policies; development of adequate support for the national education system; international co-operation and knowledge transfer; technology-related capacity building (e.g. through study tours, short-term exchange studentships, etc)
	Legal/regulatory barriers	Regulatory reform / tightening of regulatory standards
	Lack of a supporting/incentive-based policy framework for technology transfer	Policy and regulatory reform –.e.g. development of an explicit national policy supporting technology development. The draft LCDS goes some way to achieving this but regulatory reform (e.g. removal or reduction of import tariffs on ESTs) needs to accompany the policy reform.
	Absence, or weak enforcement, of feasible and appropriate standards (e.g. pollution, fuel efficiency, etc.) based on local conditions	Establishing appropriate standards accompanied by effective enforcement measures
	Poor enforcement (e.g. of regulations around polluting activities, unsustainable logging practices, etc.) often due to lack of available human resources	Institutional strengthening; dedication of more resources towards monitoring and enforcement; legal reform giving relevant authorities (e.g. EPA, GFC) the 'power to act'
	Perceived lack of transparency[199]	Institutional reform; introduction of measures/incentives to promote good governance and transparency of transactions/agreements, etc
Technical / Technological	Technology not yet proven for local application	Implementation of small scale demonstration/trial projects; establishing research partnerships; examining possibility of trialling the technology/practice in other CARICOM countries
	Environmental constraints (e.g. topography, climate, etc.)	Selecting technologies that are suited to the local context
Information	Lack of technical information	Education; international, regional and local research partnerships and

[199] See, for example: www.heritage.org/Index/Country/Guyana

		knowledge sharing
	Lack of demonstrated track record for many emerging technologies	Implementing demonstration projects
	Lack of awareness of potential sources of funding support and credit	Establishing relationships with relevant regional partners for information sharing; commissioning a review of potential funding sources for priority technologies in different sectors
Social, cultural and behavioural norms and aspirations	Social and cultural preferences impeding the uptake of new technologies	Awareness-raising, education, introduction of incentives to encourage environmentally-sustainable behaviour (e.g. through subsidies or payments for environmental services) or penalties for activities that directly or indirectly contribute to climate change (e.g. taxes, fines, etc)
	Lack of awareness and social acceptance; insufficient understanding of the advantage of new technologies	Education and awareness-raising; implementation of demonstration projects
	Lack of confidence in the economic, commercial and technical viability of technologies and practices	Education and awareness-raising; implementation of demonstration projects

5.1.12 Conclusions and Recommendations

The findings of the TNA and barrier analysis suggest that:

- The priority sectors for mitigation are **forestry and energy with forest conservation, hydropower development, and implementation of energy efficiency measures identified as the priority technologies within these sectors.**
- Guyana is at the forefront of REDD+ negotiations and was the first country to sign an agreement with the World Bank's Forest Carbon Partnership Facility. Furthermore, a recent agreement with Norway (worth up to US$250 million over five years) provides a substantial incentive for Guyana to avoid emissions from deforestation and forest degradation as a result of proposed development projects that could lead to an increase in logging and conversion of forest for large-scale agriculture and plantations. In order to gain the maximum benefits from REDD+ investments and the Norwegian pledge, the relevant authorities within Guyana will need to put in place **a strong and effective forest monitoring and enforcement network** and will also need to demonstrate good governance and transparency in order to attract responsible investment in REDD+-related initiatives.
- Priority measures for adaptation are the implementation of **engineering measures (such as rehabilitation of existing sea defences) to protect the coastline from the impacts of flooding, development of early warning systems to protect both communities and agriculture, and the introduction of building codes**.
- There are a number of relatively cost-effective measures that could be introduced in the transport sector that would not only contribute to GHG emission reductions but

also result in improved air quality and reduced congestion, particularly in Georgetown. Such measures include **improving the existing public transportation network in a move to encourage more people to travel by public transport, replacing the existing bus fleet with more fuel-efficient vehicles or switching to LPG, and making improvements to traffic management systems (e.g. signalling) to reduce congestion during peak travel times** within Georgetown to support more fuel-efficient driving. Of course these measures will need to be accompanied by changes in public attitudes (possibly through a combination of education and incentives) to promote use of public transport rather than the private car, removal of import barriers, and the necessary support systems, to ensure that new vehicles can be effectively operated and maintained.

- Since agricultural performance – a cornerstone of the Guyanese economy – is particularly susceptible to extreme weather events and the longer-term impacts of climate change, this should also be considered as a priority sector for action. The LCDS highlights the potential for Guyana to become a competitive global producer of tropical fruits and vegetables, but this will require substantial **investment in measures to protect productive land from floods, as well as support for farmers to switch to suitable flood-resistant crops**. From the mitigation perspective, **changes to the water management regime** (particularly for irrigated crops) could reduce methane emissions from rice which, according to the INC, are responsible for most of the greenhouse gases from the agricultural sector.

- Plans for hydropower development and forest conservation activities are already fairly advanced in Guyana. The Amaila Falls Hydropower project, which is expected to start supplying energy in 2014, should supply enough power to meet the country's known demand for electricity (i.e. predicted growth including latent demand). Once Amaila comes online, all Guyana's electricity will come from renewables, and all thermal power plants will be reduced to standby (*Pers Comm, Mr Mahender Sharma, GEA CEO, 13 Nov 2009)*. However, hydropower is also vulnerable to the impacts of climate change, and therefore **steps also need to be taken to encourage energy efficiency both through retro-fitting and through demand-side management. This will require significant investment in public education, changes to planning policy, tariff reform, and introduction of widespread metering of urban households, businesses, and industries.**

- Many households and businesses will require substantial support and encouragement to implement energy-efficient measures, particularly where these are likely to incur costs. It will therefore be important for the responsible authorities to be **able to demonstrate the level of benefits (in the form of cost savings) that may be achieved as a result of energy efficiency measures, and also to provide financial support (e.g. subsidies, favourable lending rates) to those households and businesses wishing to invest in energy-saving technologies.**

- **Further emissions savings may be achieved through encouraging investment in CDM projects,** particularly through the capture and flaring of emissions from agricultural and landfill waste.[200]

- **An enabling environment for technology transfer needs to be created**. The barrier analysis suggests that a key priority should lie in first creating an enabling environment for the transfer of new technologies and practices. This requires strengthening environmental policy and regulatory frameworks, enhancing the legal system, designating clear roles and responsibilities for all institutions/organizations concerned, and appointing a single authority with responsibility for co-ordinating activities within each sector, facilitating the development of markets, and providing the necessary funding and technical support for research and technology development. This is, however, a long-term, ongoing process, but in the interim it should be possible to start introducing various 'no regrets' measures that will yield immediate and tangible benefits.

- **It is also necessary to formulate an implementation or action plan for capacity building** in which the specific needs and proposed activities (including supporting activities such as awareness-raising, dissemination of information and investment in R&D) are identified, together with any barriers and steps that may be taken to overcome these.

- Many of the technologies/proposed activities fall within the remit of several different government departments, and therefore it may be useful to **appoint an overseeing body (possibly the Office for Climate Change) with the responsibility for co-ordinating and disseminating information about mitigation and adaptation activities (including information about technologies acquired, activities ongoing/completed, etc). Measures to encourage inter-departmental working and knowledge/data sharing** should also be considered. These could include, for example, regular update meetings with stakeholders from relevant departments and ministries, or establishment of a climate change portal with links to relevant activities/services being undertaken by different departments.

- **Formulation of an indicative financing plan that signposts the financing and funding opportunities for the concerned technologies.** To enable technology transfer, adequate financing must be available. All available financing and funding opportunities should be explored, including commercial bank loans, multilateral co-operation, financing by international organisations like IFC, GEF and DFID, and other climate-change related financing schemes such as CDM. (See also Section 2.11 for some examples.)

- **Establishment of an appropriate legal and regulatory framework** imposing appropriate standards and codes for the various technologies to ensure that they are harmonized with existing legislation, and that environmental risks and social norms are considered.

- **Setting up mechanisms to enable indigenous capacity building** in identifying and sourcing climate change technologies and providing adequate training for those organizations that will manage and operate the technologies.

- Finally, **the TNA should be treated as a 'live' document**. Ideally, it should be

[200] Note that there are several UNFCCC-approved small-scale CDM methodologies for capturing emissions from agricultural and landfill waste that may be applicable in the Guyana context. These will be explored in more detail in the Mitigation and Abatement component of the SNC.

informed by, and respond to, other components of the SNC, particularly the national circumstances, mitigation and abatement analysis, and vulnerability and adaptation assessment. It is therefore recommended that this chapter is updated to take account of the key conclusions and recommendations of those components. The TNA should also be regularly updated (in collaboration with relevant stakeholders) to reflect the increasingly rapid pace of technological development on a global scale as well as the emergence of indigenous technologies and practices.

- Tables 5.4 and 5.5 present a priority-listing of the short-, medium–, and longer-term mitigation and adaptation technologies and other interventions for Guyana on a sector-by-sector basis. Priority was determined on the basis of the scores attached to each of the technologies identified above, which in turn reflect Guyana's overall development priorities, the suitability of technology possibilities to the Guyanese context (i.e. climate, capacity, etc) and the ease with which barriers to implementation may be overcome. (See Appendix 5.1 for more information.)

Table 5. 4. Mitigation priorities

Sector	Short-Term Measures (2010 – 2015)	Medium-Term Measures (2015-2025)	Long-Term Measures (2026 and beyond)
Energy	▪ Design and implementation of **demand-side management** techniques to encourage better use of existing distribution infrastructure, and reduce peak demand. This will require a combination of raised public awareness (i.e. what individuals/households/businesses can do to reduce energy demands), as well as (in the longer term) implementation and enforcement of appropriate regulatory and financial incentive mechanisms. ▪ Continued **development of hydropower** resources such as Amaila, particularly in terms of advancing technical design and sourcing funding for development of identified sites ▪ **Modernizing existing power plants** that will remain in operation even once hydropower becomes the main source of energy. Modernization measures include: ▪ Retro-fitting with more energy-efficient machinery and equipment ▪ Introduction of thermal power and heat co-generation techniques ▪ Improving distribution efficiency	▪ Mandatory **labelling** of all electrical compliances by suppliers to show energy rating ▪ Design and implementation of **regulatory and financial incentive mechanisms** to reduce energy demand. This may include reform of existing tariff structures. ▪ Improving **distribution efficiency** of the power system through measures to reduce transmission and distribution losses ▪ Investigating the feasibility of implementing further **co-generation** activities ▪ Exploring opportunities for	▪ Continuing to develop and promote uptake of **renewable sources** of energy, particularly wind and solar (where feasible)

		generating **energy from waste**, particularly through methane capture from Le Repentir landfill and potentially also from the new Haags Bosch landfill site ▪ Investigating the feasibility of developing **wind and solar power** ▪ Promoting more widespread use of **alternative fuels**, especially locally-produced biofuels ▪ Promoting investment in the development of bio-ethanol production (particularly in the Canje Basin). Financing required for development of technology and transport infrastructure	
Transport	▪ Measures to **reform import controls** in favour of low-emission vehicles ▪ Developing a **'green guide'** to assist consumers in comparing the fuel efficiency of different vehicles	▪ Establishing mandatory **fuel efficiency or emissions standards** for all vehicle imports ▪ Implementing policies to gradually **replace the government fleet** with more fuel-efficient vehicles ▪ Investing in **public transport infrastructure** and awareness (particularly in Georgetown) to support a modal shift ▪ Introduction of **traffic management systems** (e.g. signalling) to reduce congestion during peak hours	▪ Promoting more widespread uptake of **hybrid vehicles** ▪ Improving **mass transport systems** (including light rail in urban centres such as Georgetown and rail into the interior) ▪ **Urban planning** to improve accessibility to key services and reduce trip lengths
Buildings	▪ Promoting energy efficiency in buildings through **targeted awareness-raising** programmes that seek to reduce demand in industrial, business, government and residential buildings ▪ Phasing out of incandescent light	▪ Implementing incentives for **retro-fitting** of existing buildings with more energy-efficient appliances	▪ Use of **passive design and low carbon materials** in building construction

	bulbs ▪ Installation of motion-sensor lights ▪ Installation of variable frequency drives on chillers, pumps and cooling towers ▪ Introducing more energy-efficient stoves within households	▪ Design and implementation **guidelines and/or standards and regulations** for design of new buildings	
Waste	▪ Developing targeted programmes to **raise awareness** of importance of, and opportunities for, reducing waste at source and recycling ▪ Promoting **commercial and household waste recycling** through: ▪ Development of infrastructure (e.g. collection systems, depots, and processing plants, etc.) to support recycling activities ▪ Design of incentives to promote recycling activities ▪ Promoting more widespread uptake of on-farm **composting** activities and investigating potential for developing markets for composted material (e.g. for use in combating soil erosion or as a landfill cover) ▪ **Methane recovery** from Le Repentir landfill following decommissioning in 2010	▪ Introducing **targets** for waste reduction (e.g. % of waste sent to landfill) and recycling ▪ Investigating potential for developing **markets for recycled materials** (e.g. through industrial exchange programmes, etc)	▪ **Methane recovery** from waste biomass (e.g. at Haags Bosch landfill site)
Agriculture	▪ Continued research and establishment of demonstration projects to trial new **water management techniques,** including active irrigation and drainage of rice fields to reduce both nitrogen dioxide and methane emissions ▪ Promoting use of **cropping techniques** that minimize soil disturbance and retain soil nutrients ▪ Improve the **quality of feedstock** for cattle	▪ Promoting uptake of proven water management techniques ▪ Investigating the feasibility of **expanding commercial fruit and vegetable production** in line with the LCDS ▪ Investigating the feasibility of crop cultivation in upland areas	▪ **Continued research and development into new cultivars and hybrids** that require less fertiliser and reduce methane emissions
Forestry and Land Use	▪ **Building capacity** in sustainable forest management and forest monitoring. This will require investment in staff within GFC, but also improving reporting procedures within the GGMC, and accountability amongst mine operators. ▪ Providing **training in reduced impact logging**	▪ Improving enforcement of the Code for Sustainable Harvesting ▪ Acquiring **more advanced forest mapping and monitoring technologies** such as remote sensing,	▪ Continued revision of practices and incentives for sustainable forest management

		accompanied by training in their operation and maintenance, and interpretation of their outputs. ▪ Implementing **fire and pest management** measures to reduce forest degradation	

Table 5. 5. Adaptation priorities

Sector	Short-Term Measures (2010 – 2015)	Medium-Term Measures (2015-2025)	Long-Term Measures (2026 and beyond)
Agriculture	▪ **Mapping and assessing vulnerability** of existing agricultural lands to impacts of climate change ▪ Revisiting and where necessary **updating the adaptation in agriculture study undertaken in 2007 on behalf of the Caribbean Community Climate Change Centre,** in light of more recent climate change projections and vulnerability assessments	▪ Undertaking **research to identify climate-proof crop types** (resilient to drought, high temperatures, saline soils, etc.), suitable for cultivation in Guyana ▪ Assessing the **feasibility of large-scale agriculture in inland areas** (soil conditions, access, etc) and identifying suitable crop types and investment needs in infrastructure, etc. ▪ Creating **awareness** amongst farmers of the impacts of climate change on agricultural production	▪ Promoting large-scale **farming in inland areas** ▪ **Crop substitution** (hybrid or replacement varieties) that are tolerant to drought, salinity, and pests
Buildings	▪ Revising, refining and updating existing **building codes** and designating overall responsibility for their enforcement	▪ Introduction of **planning and policy measures** to locate new development away from flood-prone areas ▪ **Devising guidelines, standards or incentives for passive design principles** (e.g. ventilation, minimizing direct sunlight) to be incorporated into all new building designs	▪ Implementation and enforcement of regulations for climate-proof buildings
Coastal Zone	▪ **Rehabilitation/strengthening of sea defences**, particularly in most vulnerable areas (Impact Zones I and II). Some work is already underway in this regard. ▪ Rolling out, monitoring and maintaining the **Sea Defence**	▪ Developing a **flood preparedness and response strategy** with clearly defined roles and responsibilities that cover all vulnerable sectors, including health	▪ Where necessary, **managed retreat** of populations most vulnerable to the impacts of sea-level rise and coastal flooding

	Management Information System (SDMIS) ▪ **Community awareness** programmes ▪ Deployment and ongoing maintenance of **early warning systems** in vulnerable areas. ▪ **Designating a single authority in charge of storing official hazard and vulnerability mapping**	▪ **Wetland/mangrove restoration** as a natural sea defence ▪ **Institutional strengthening and capacity building** to ensure continued and effective coastal zone monitoring and management, including maintenance of sea defences and early warning systems	
Water Resources	▪ Introducing **water conservation measures** (metering, low-flow plumbing fixtures, options for tariff reform, leak detection and monitoring) ▪ **Education and awareness-raising** on the need for water conservation and types of measures that can be adopted by industry, business, households and individuals	▪ Introducing **standards to ensure that all new buildings are furnished with water-saving technologies** (e.g. low flow plumbing fixtures) ▪ **Improving wastewater management** facilities ▪ Developing **storage facilities** (reservoirs/conservancies) to allow for seasonal transfers of water resources ▪ Promoting more widespread uptake of **rain-water harvesting** ▪ Implementing **efficiency measures** for agricultural water storage and distribution networks ▪ Encouraging use of **more efficient irrigation systems** for agriculture ▪ Creating an **inventory of freshwater resources** including surface water and groundwater	▪ Water **desalinization plants** along the coast ▪ Development of **groundwater resources**

5.2 Systematic Observation

5.2.1 Background

Research and systematic observations provide information and tools for better understanding of the climate system at various scales. Non-Annex I Parties are encouraged to provide information on their participation in, and contribution to, activities undertaken on a global, national, regional and sub-regional basis in the areas of climate change research and systematic observations, as well as in global change research networks.[201] By identifying the needs, constraints and gaps in climate change research and systematic observation, and communicating this to the parties of the UNFCCC, Guyana's capacity to monitor and address climate-change-related impacts may be strengthened through knowledge and data sharing.

5.2.2 The observation network

Weather and climate

Weather observations in Guyana started in the 1800s but systematic record-keeping only began in October 1965 when the Hydrometeorological Service was established. Much of the Hydromet Service data has been digitized from about 1974 onwards, but there is still a significant amount of data that needs to be retrieved and digitized. Due to a combination of equipment failure (largely as a result of high temperatures and humidity), data losses, and temporary closure of stations, some recent records are not continuous.

[201] UNFCCC (2003). *Reporting on Climate Change: User Manual for the Guidelines on National Communications from Non-Annex I Parties.* Accessed online at: http://unfccc.int/resource/docs/publications/userman_nainc_en.pdf on 19/08/2009.

The Hydrometeorological Service (Hydromet) within the Ministry of Agriculture is the official provider of weather, water, and climate information for Guyana. Hydromet's mission is to observe, archive, and understand Guyana's weather and climate, and provide meteorological, hydrological, and oceanographic services in support of Guyana's national needs and international obligations.[202]

Precedence (in terms of allocation of resources) is given to providing real-time information to the National Weather Watch Centre in order to comply with International Civil Aviation Organization requirements. Duties performed by the National Weather Watch Centre include providing forecasts for aviation activities, general public weather forecasts (daily and seven days), and disseminating hourly meteorological data which is put into code form and transmitted to the Aeronautical Section main office. From there this is re-transmitted to the Global Telecommunication System in Washington and then relayed to other regional and world meteorological centres.[203]

A national 24-hour Weatherwatch Service is operated out of the National Weather Watch Centre at Hyde Park, Timehri. As part of this service, the public can phone in to request forecasts. This is especially useful for farmers. A text service is also available during extreme weather events.

The Climatological Section is responsible for archiving all meteorological and climate data. The Climate Section collects data from the meteorological network and processes, quality controls, and digitizes Guyana's entire climate and meteorological data.

The Agrometeorological Section provides weather services to support food production and food security services in Guyana. Services include generating agrometeorological products to support farming, land management, and the

[202] http://www.hydromet.gov.gy/.
[203] Ministry of Agriculture Hydrometeorological Service Guyana [online] at: www.hydromet.gov.gy. (Accessed 29/09/09.)

selection of improved varieties of plant and breed of animals which are adaptable to different climatological conditions and climate variability. There are two agrometeorological stations. One is located at Mon Repos (near Georgetown) and the other is located at Ebini (in the Upper Demerara-Berbice region). This Section is still in its infancy and currently works concurrently with the Climatological Section to meet some of its objectives.

Weather monitoring is also undertaken by the Guyana Sugar Corporation (although only on its eight estates and primarily for its own use), and the Caribbean Adaptation to Climate Change (CPACC) project. Table 5.6 identifies the weather and climate observation stations included within the INC, and the extent to which these observation stations continue to provide these services.

Table 5.6. Weather and climate observation stations

Observation Facility	Observation Stations	
	INC (2002)	SNC (2009)
Ministry of Agriculture Hydrometeorological Service – Hydromet	- Network of 8 synoptic climatological stations on the coast, in the savannahs and in the rainforest region - 90 rainfall stations around the country	- **8 synoptic stations, 5 climate stations, and 110 rainfall stations throughout Guyana** - **New Doppler radar installed at Hyde Park Timehri (opposite Cheddi Jagan International airport) in October 2009**
Guyana Sugar Corporation	- 73 rainfall stations and 6 climatological stations on the coast in the sugar estates	- **6 automated weather stations and 8 manual meteorological stations** - **Numerous rain gauges**
Linden Mining Company	- Human resource provision at a climatological station in the inland region	
Caribbean Adaptation to Climate Change (CPACC) project	- 2 tide gauges installed at Parika on the Essequibo River, and Rosignol on the Berbice River. Climatological data are transmitted to a regional centre at the University of the West Indies in Trinidad	- **These gauges are not operational and have been decommissioned due to constant vandalism**
Mainstreaming Adaptation to Climate Change (MACC) Project	-	- **New gauge installed at Georgetown**

The monitoring network is concentrated in the north and east of the country with relatively few inland monitoring stations and especially sparse coverage in the southern part of the country. To increase the accuracy of forecasts, a representative network across the country is needed. However, significant resource constraints (including lack of funding for field staff and installation of automated weather stations) limit the extent to which the network may be extended.

Recorded data is captured electronically and stored in a central database. However, the format in which this data is captured makes it unsuitable for public access. A process of transforming records into more user-friendly formats is currently being undertaken, but this is a lengthy process and there are insufficient resources available to make this a priority. Access to weather data can be made available upon request, on the understanding that the processed data (including copies of research outputs) are made available to Hydromet.

In 2003, the European Commission approved a 13.2 million Euro regional project to construct and install four new digital weather radars in the Caribbean to replace an old and obsolete radar network installed by the Caribbean Meteorological Organization (CMO) in the late sixties and early seventies. The CMO Member States operated the old radars since the early seventies, with some units lasting for over 30 years, more than twice the expected lifetime of the radars, before the entire network was surpassed by new technology.

This new CMO Radar Project, which began full implementation in 2005, involves the construction and installation of four new Doppler radars in Barbados, Belize, Guyana, and Trinidad & Tobago. The project will link the new radars with others already in place in the region, to form a modern network of nine radars as part of the Caribbean Early Warning System (EWS) for severe weather conditions.[204]

The Caribbean Forum of ACP States (CARIFORUM) in Guyana has overall responsibility for the project, and is supported by funding from the Ninth European Development Fund (EDF). Project implementation is overseen by a high-level Administrative Steering Committee, with membership from the European Commission as the Funding Agency, CARIFORUM as the Contracting Authority, and the CMO as the Project's Implementing Agency/Supervisor. The overall management of the Project is being carried out in a centralized manner through the Headquarters of the CMO in Trinidad & Tobago.

The Project Management Unit (PMU), made up of a Project Manager and a team of engineering and radar experts, has been provided by a consortium of the United Kingdom's Met Office and Royal Haskoning (Netherlands-UK).

[204] Caribbean Meteorological Organization (2009). [Online.] Available at: www.cmo.org.tt/Radar.htm (accessed 03/09/09).

The model (METEOR 600 S-Band) of Doppler radars being introduced is particularly suited to tropical regions with high rainfall and severe thunderstorm activity. The Doppler radar in Guyana, located near Cheddi Jagan International Airport, was officially handed over on 5 October 2009. Training was provided in Germany for three radar technicians from Guyana.

The new Weather Watch Centre will help the Government be better prepared for extreme weather conditions.

Hydrological monitoring

Hydrological monitoring includes measurements of hydrological parameters; permanent monitoring of surface and groundwater levels; monitoring of sediment in rivers and lakes; monitoring of water temperature in rivers and lakes; data control, updating and archiving in hydrological databases; public information and warning on development and appearance of hazardous hydrological phenomena such as flood risk, etc. Water quality (including chemical, biological and ecological) monitoring is another important aspect of hydrological monitoring.

Hydromet has overall responsibility for hydrological (surface water and groundwater) monitoring on a national scale. Fig. 5.2 shows the location of hydrological and rainfall monitoring stations across the country, and Table 5.7 identifies the hydrological observation stations included within the INC and the extent to which these observation stations continue to provide these services.

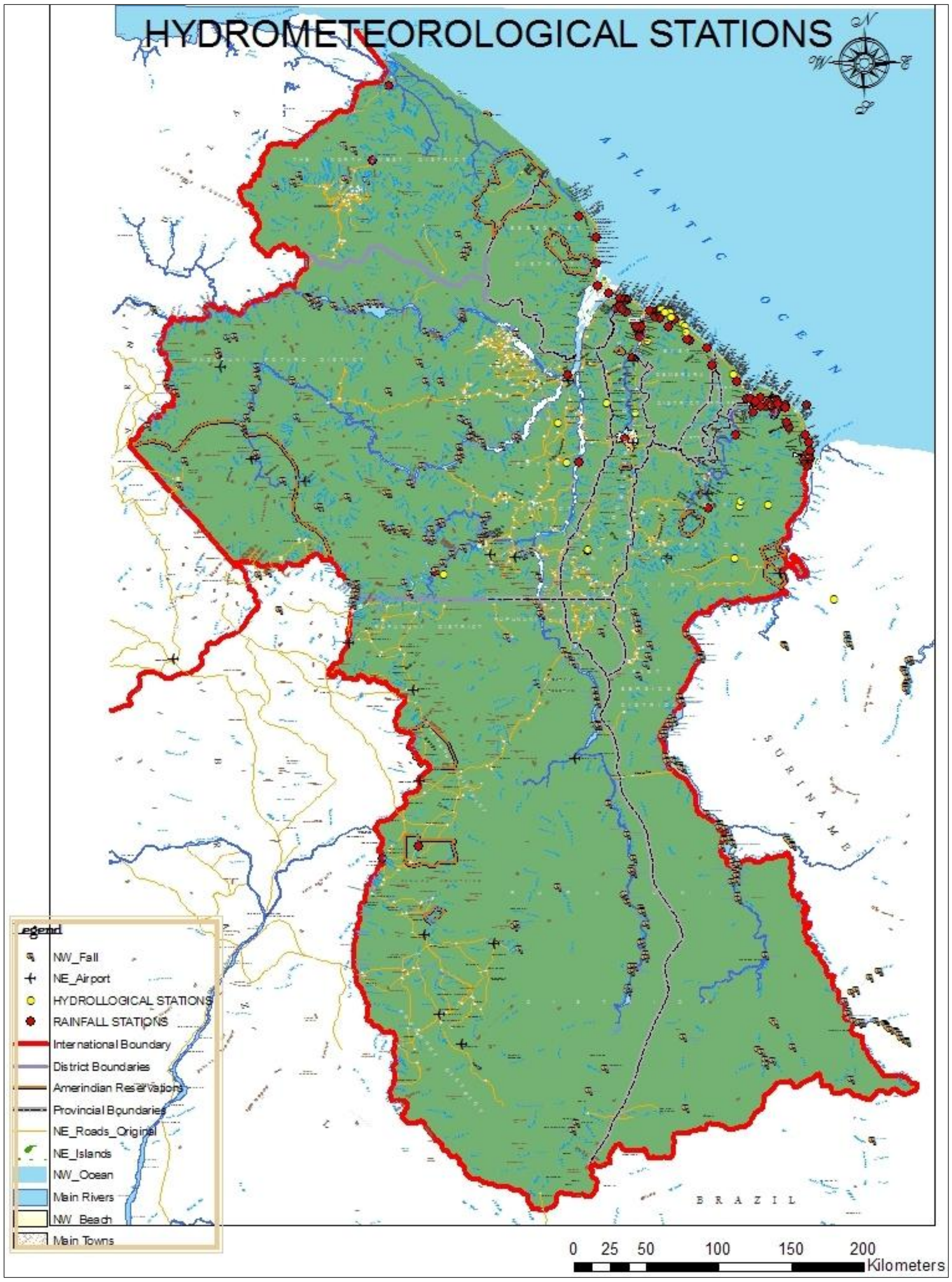

Fig. 5. 2. **Location of hydrological and rainfall stations (image courtesy of Hydromet)**

Based on the map, it is evident that coverage is concentrated in the north and east of the country (which is also where most of the population resides).

Table 5. 7 Hydrological observation stations

Observation Facility	Observation Stations	
	INC (2002)	SNC (2009)
Ministry of Agriculture Hydrometeorological Service – Hydromet	- Hydrology - 15 surface, 1 A-sand aquifer and 2 shallow-well stations – their efficient operation hindered by inadequate staff to undertake timely maintenance	- Surface water - 27 surface water stations of which 16 monitor water levels continuously via water level recorders. 14 have Hydromet personnel at location
	- Hydromet maintains a hydrological database and climatological database using HYDATA 3.0 and CLICOM v3.1 Software	Currently, the Hydrometeorological Service is working with the Caribbean Institute for Meteorology and Hydrology (CIMH) and the World Meteorological Organisation (WMO) to migrate to a new database (CLIDATA)

Guysuco conducts rainfall and runoff monitoring and undertakes routine sampling and analysis of water quality on estate locations. The main users of this data are research and managerial staff on the estates who use it to inform decisions. A central database (containing both meteorological and hydrological data) is maintained within the statistical department at the Guysuco head office, and is accessible to other institutions. The meteorological data collected by Guysuco is incorporated into the Hydromet Service database.

5.2.3 Monitoring and early warning systems

Monitoring the frequency and severity of these extreme events is an important component in ensuring protection of the coastal zones. Monitoring provides information for policy makers, increases public awareness, and contributes to the global research on climate change. It is essential to monitor the hydrodynamics (storm surges, tides, currents) and establish a morphological monitoring system using advanced technology such as satellite imaging and GIS. Furthermore, using pilot zones to model the real impacts of sea-level rise would enable Guyana to reduce disaster risk in the face of a changing climate.

To date, most actions have been in response to natural disasters rather than proactive, evidence-based preparedness planning and action.[205,206] The establishment of disaster early warning systems and the development of preparedness and response plans, including promoting public awareness, can play a significant role in reducing vulnerability.

The Civil Defence Commission (CDC) has already taken action in this regard. It has already prepared and proposed a flood plain mapping system which is currently awaiting approval.[207] A GIS system has also been in place since 2005, after the devastating January 2005 floods, to monitor water levels on a daily basis.[208] However, official hazard and vulnerability mapping, *ad hoc* monitoring, or plans for relocation of population are not readily available. While some mapping and planning

[205] Personal communication, Karen Anthony (Senior GIS Analyst), LSD (27 January 2010).

[206] Flasse Consulting (2009) Early Warning System Study Situation Report. Prepared by Flasse Consulting for GLSC, UNDP and GEF

[207] Personal Communication, Bruce Munro (Engineer), CDC (27 January 2010)

[208] Personal communication, Karen Anthony (Senior GIS Analyst), LSD (27 January 2010).

work has been done, such information is scattered throughout a number of different departments (e.g. GLSC, GINRIS, EPA, NDIA).[209]

Representatives of several ministries also meet regularly with the National Steering Committee (NSC – reporting to the Natural Resources and Environment Advisory Committee - NREAC) and the Integrated Coastal Zone Management Committee, to exchange information, alert the public, and share collaboration to respond to natural disasters.[210],[211] However, a recent report suggested that despite the participation of different ministers and stakeholders in these meetings, there does not seem to be official structured targeted warnings to specific ministries, local communities or the public[212].

Land Use, Land-Use Change and Forestry

There have been some attempts to assess land cover and land-cover change through remote sensing imagery analyses and forest inventory assessment. The Guyana Forestry Commission has in place a Change Detection system for recording and updating roads and forest disturbances from satellite data.

A series of tools have been developed that run within the ArcGIS 9.2 framework and which assist with the detection process and management of the workflow. A key aspect of the system is that GFC takes control of the process and maintains and updates the datasets on an ongoing basis. Using medium-scale imagery, change detection is possible for new forest roads and canopy cleari ngs of around 1ha (100m x 100m) or more in extent.[213]

However, it is sometimes difficult to determine from images of this resolution, the underlying causes of such changes; i.e. whether the canopy disturbances are due to forestry activities or are related to other causes such as mining or agriculture.[214] In cases where change is detected, further investigations can be made using other GIS data such as active forestry concessions, mining properties and agricultural leases to more accurately identify the direct drivers of change. The use of medium resolution images for change detection can therefore serve as a mechanism to alert GFC to possible forestry activities and to justify more targeted ground-truthing activities or the use of higher-resolution satellite imagery. Where higher resolution images are available, these should allow for more definitive and accurate assessments of the causes and nature of the change (i.e. forestry, mining, agriculture, residential).

[209] Flasse Consulting (2009). Early Warning System Study Situation Report. Prepared by Flasse Consulting for GLSC, UNDP and GEF.

[210] Ibid.

[211] Personal Communication, Bruce Munro (Engineer), CDC (27 January 2010).

[212] Flasse Consulting (2009). Early Warning System Study Situation Report. Prepared by Flasse Consulting for GLSC, UNDP and GEF.

[213] GFC (2009*)* Quick Assessment Paper – Deforestation and Forest Degradation in Guyana – 2009. Accessed online at: http://www.forestry.gov.gy/Downloads/Quick_Assessment_Report_September_7_2009.pdf on 24/09/2009.

[214] Ibid.

Table 5.8 summarizes the progress that has been made in land use and land cover monitoring since the publication of the INC.

Table 5.8. **Land use, land-use change and forestry monitoring**

Observation Facility	SNC (2009)
Guyana Forestry Commission	**- The GFC has in place a Change Detection system for recording and updating roads and forest disturbances from satellite data. Such information will assist GFC in targeting areas of change and mobilizing necessary resources to undertake enforcement measures and to assess rates of forest cover change.**
	- The GFC has implemented a national log-tracking system and has developed a legal verification system in forest concessions which have collectively enhanced Guyana's compliance in forest law enforcement, governance and trade.[215]
Iwokrama - International Centre for Rain Forest Conservation and Development	**- Iwokrama is using verifiable indicators at all levels of decision-making which include regional, landscape and ecosystem indicators, species and population indicators, and community, socioeconomic and management-effectiveness indicators. Iwokrama monitoring is primarily focused on: Iwokrama Forest, Iwokrama portion of the Georgetown-Lethem Road and River Systems/Rupununi Wetlands** [216]

Forest monitoring has also benefited from innovation in satellite technology over the last half century. Satellites like NASA's MODIS, the Brazilian Space Agency and China's CBERS, the Japanese ALOS, and French SPOT are actively and accurately monitoring the world's forests—and new, more advanced satellites are launched regularly.

Furthermore, access to satellite imagery is becoming increasingly easy. Applications such as Google Earth allow people to 'monitor' deforestation for them. Google has partnered with a variety of groups in the Amazon, including indigenous tribes, to monitor deforestation and allow individuals to protest and point out illegal and unwanted activities.

Agriculture and soils

Some work has also begun in Guyana in terms of biomass estimation in various soil types. The National Biomass Monitoring System (NBMS) is intended to provide data for REDD+ project assessments of current forest biomass, and forest biomass change over time in response to REDD+-oriented government policies relating to forestry and land-use planning. A system of permanent monitoring plots is proposed to measure and detect changes in forest biomass.[217]

Hydromet also undertakes research activities in support of the agricultural sector. Services include generating agrometeorological products in aid of farming, land management, selection of improved varieties of plants and breed of animals that are adaptable to different climatological conditions and climate variability.

[215] *Guyana FCPF Readiness Plan, Revised June 1st 2009.* Accessed online at: http://www.forestry.gov.gy/Downloads/Guyana_R_Plan_Revised_June_%201_2009.pdf on 25/08/2009.

[216] The Iwokrama International Centre for Rain Forest Conservation and Development [online] available at: http://www.iwokrama.org/home.htm (accessed 30/09/09).

[217] *Guyana FCPF Readiness Plan, Revised June 1st 2009*. Accessed online at: http://www.forestry.gov.gy/Downloads/Guyana_R_Plan_Revised_June_%201_2009.pdf on 25/08/2009.

Table 5.9 shows the improvements in agricultural and soil monitoring since the publication of the INC in 2002.

Table 5.9. Agriculture and soil monitoring

	Observation Station
Observation Facility	SNC (2009)
Ministry of Agriculture Hydrometeor-ological Service – Hydromet – Agrometeor-ological Section	- Operating 2 agrometeorological stations. One is located at Mon Repos and the other is located Ebini.
National Biomass Monitoring System (NBMS)	- A National Forest Biomass Monitoring System in Guyana has been proposed for establishment. A system of permanent monitoring plots is proposed to measure and detect changes in forest biomass. It is proposed that 900 plots, grouped as 180 clusters and 60 transects be established nationally in all major forest types. This will include non-productive Muri and Dakama scrub forests, and sensitive savannah-hill forest mosaics, as these constitute important areas for biomass sequestration and potential forest loss, in addition to the sampling of productive forest.[218]

[218] Ibid.

Energy efficiency

The Energy and Energy Statistics Division of the Guyana Energy Agency (GEA) is responsible for regular analysis and reporting of petroleum imports, energy database management and energy and economic activities within the energy sector. Amongst its activities are monitoring the importation of petroleum products within and outside the PetroCaribe Agreement, and monitoring the renewable energy projects/activities for optimum use, efficiency, and cost-effectiveness. The Division also liaises with the Latin American Energy Information System (SIEE) and the Caribbean Energy Information System (CEIS) on energy-related issues.[219]

5.2.4 Observation data exchange

Guyana is now a member of several international climate-related research and monitoring organizations including the World Meteorological Organisation (WMO), the Intergovernmental Panel on Climate Change (IPCC) and the World Climate Programme. Membership provides several important benefits to Guyana, including access to the most current scientific knowledge and data and opportunities to exchange information and best practice with both developed and developing countries.

Hydromet contributes to the World Weather Watch (WWW) and World Climate Programmes and is also linked with two regional institutions and one international organisation: the Caribbean Meteorological Organisation (CMO), the Caribbean Institute for Meteorology and Hydrology (CIMH) and the World Meteorological Organisation (WMO) respectively. It also reports to the International Civil Aviation Organization (ICAO) on matters relating to operational

[219] Guyana Energy Agency: http://www.gea.gov.gy/divisions.php.

meteorology for aviation. Furthermore Hydromet is the focal point for the Montreal Protocol and Vienna Convention, the Amazon Co-operation Treaty Organization (ACTO) and the Caribbean Water Initiative Project,[220] all of which require at least periodic communication of observation data.

The Office of Climate Change within the Office of the President is the focal point for matters pertaining to the UNFCCC, the Clean Development Mechanism (CDM), and the Low Carbon Development Strategy. It also co-ordinates Government engagements with international forestry programmes such as the World Bank's Forest Carbon Partnership Fund (FCPF), the Forestry Investment Program (FIP), and the United Nations' UN-REDD fund.

Guyana also works closely with regional centres including the Caribbean Community Climate Change Centre (CCCCC) and the Alliance of Small Island States (AOSIS).[221] The CCCCC co-ordinates the Caribbean region's responses to climate change. It is the official repository and clearing house for regional climate change data, providing climate-change-related policy advice and guidelines to the Caribbean Community (CARICOM) Member States through the CARICOM Secretariat. In this role, the Centre is recognized by the UNFCCC, the United Nations Environment Programme (UNEP) and other international agencies, as the focal point for climate change issues in the Caribbean.

Local weather and monthly climatology are also made available internationally through the Global Telecommunication System (GTS) and the AFTN world networks co-ordinated by the World Meteorological Organization and the ICAO.

5.2.5 Barriers

The operation of systematic observation systems in Guyana is presently constrained by a number of factors including:

- Lack of technical capacity to operate and maintain equipment
- A lack of strong analytical skills or interpretative capacity to make use of the models and data that is generated
- Outdated and/or obsolete equipment and inadequate resolution of models
- Incomplete coverage of the observation network due largely to a lack of funding for staff to operate and maintain recording stations in remote locations
- Lack of financial resources to upgrade existing technologies and to provide specialized training in the use of new tech nologies
- The length of time it takes to repair or receive spare parts for faulty or damaged equipment.

[220] Ministry of Agriculture Hydrometeorological Service Guyana [online] at: www.hydromet.gov.gy (accessed 29/09/09).

[221] The Alliance of Small Island States (AOSIS) is a coalition of small island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of global climate change. It functions primarily as an ad hoc lobby and negotiating voice for small island developing States (SIDS) within the United Nations system. Member States of AOSIS work together primarily through their New York diplomatic Missions to the United Nations. AOSIS functions on the basis of consultation and consensus. Major policy decisions are taken at ambassadorial-level plenary sessions. The Alliance does not have a formal charter. There is no regular budget, nor a secretariat.

5.2.6 Recommendations

A number of areas where improvements in research and observation systems are necessary have been identified. These include:

- The need for a co-ordinated approach towards addressing detection of climate change and the impacts resulting from global warming. Ideally, one key department or institution should be tasked with the overall responsibility for co-ordinating information relating to the causes and consequences of climate change across all relevant sectors. This includes working with relevant departments and research institutions to identify where existing gaps in knowledge lie, and how these may be overcome. While the OCC largely covers this role, more is needed to ensure that relevant government departments and research institutions recognize the purpose and objectives of the OCC, and that an effective two-way exchange of information between OCC and these departments is facilitated, so that all parties are kept informed of the various activities being implemented to mitigate and adapt to climate change.

- The need for improved and more systematic monitoring of impacts of climate change on different sectors in order to obtain a better understanding of Guyana's vulnerability to climate change and the resilience and/or responsiveness of different sectors, and to identify where priority actions for adaptation should lie and/or where new opportunities should be exploited.

- Modernization of equipment and development of higher-resolution climate models in order to obtain a clearer picture of how Guyana's climate is expected to change in the future, and what the impacts are likely to be at a much more localized level.

- Acquiring the resources (staff, equipment, and training) needed to digitize climatic/weather data

- Institutional strengthening and capacity building to support research and dissemination of information about the causes and consequences of climate change. This includes developing the necessary skills and capacity to develop and interpret climate models, install and maintain monitoring equipment, collect and analyse data, report findings and identify future research and observation needs.

- While Guyana has made some progress in recent years, many of the above requirements still apply. The Office of Climate Change is charged with the co-ordination of all national climate change activities and therefore an important role for this unit will be to stimulate cross-departmental working and data/knowledge sharing.

The LCDS provides an important framework for directing investments towards low carbon development, but the training and retention of suitably qualified staff within the departments responsible for systematic observation will be crucial to the realization of the strategy's objectives.

Taking into account the large surface area and diverse environments of Guyana, much better physical coverage is needed for most observations (particularly meteorology and hydrology) in order to generate spatially and temporally reliable information. Greater capacity is also required to capture, process, and interpret these data. Capacity-building initiatives should involve Guyanese educational institutions (i.e. the University of Guyana) as well as specialized institutes such as IAST.

Where possible, linkages should also be forged with regional and international institutions to provide opportunities for postgraduate students to acquire the relevant skills, but then also to apply them in a professional capacity in Guyana.

5.3 National Research Programmes and Projects

5.3.1 Background

The publication of the draft LCDS in June 2009 and subsequent release of the second draft in December 2009, and Guyana's entry into a formal partnership with the World Bank's Forest Carbon Partnership Facility are likely to stimulate interest in undertaking the necessary research, development and monitoring activities to support proposed LCDS and REDD+ initiatives. Guyana's agreement with Norway, and the payments that will accrue to Guyana beginning in 2010, will enable implementation of priority actions identified in the LCDS. In particular:

- The key focus areas of the LCDS are on investments in low carbon economic infrastructure, high-potential low-carbon sectors, and climate change adaptation. These will need to be supported by the necessary research, development and monitoring.

- The President of Guyana has established a specialist team (the Office of Climate Change) within the Office of the President to co-ordinate activities relating to climate change. The Low Carbon Strategy Project Management Office was established to drive major low-carbon programme priorities. The REDD Secretariat at the Guyana Forestry Commission will be the implementing agency for 'REDD readiness' activities, including the development and implementation of a monitoring, reporting and verification system. The Guyana REDD+ Investment Fund (GRIF) will be set up to manage forest payments and to reduce the cost of capital on other essential investments.

- Guyana's REDD-Readiness Preparation Proposal sets out the measures to be taken to reduce emissions from deforestation and degradation and highlights the research and observation requirements necessary to support REDD+ activities.

5.3.2 Climate change research

Institutional activities

There are a number of institutions in Guyana that are involved in climate-related research (encompassing climate science and options for mitigation and adaptation). These include:

- The Hydrometeorological Service (climate science) within the Ministry of Agriculture

- Guyana Forestry Commission (forest carbon stocks, forest conservation, and monitoring)

- Guyana Lands and Surveys Commission (flood risk hazard, vulnerability)

- Civil Defence Commission (flood risk hazard, vulnerability)

- The Iwokrama Rainforest Project (forest carbon stocks, forest conservation, and monitoring)

- The Guyana Rice Development Board (development/introduction of new cultivars; rice-growing techniques for reduced emissions)

- The Office of Climate Change (climate change policy, climate change impacts, mitigation and adaptation options, negotiations, climate change financing options)

- The Ministry of Agriculture (opportunities for biofuel expansion and soil management techniques)
- Other government departments and/or institutions that are capable of contributing to, or commissioning new, research include:
- University of Guyana
- National Agricultural Research Extension Institute
- The Institute of Applied Science and Technology
- Guysuco
- The Environmental Protection Agency
- Guyana Energy Agency (renewable energy technologies; energy-saving technologies)
- Ministry of Agriculture (agricultural adaptation)
- Various international organisations based in Guyana including Conservation International (CI), the World Wildlife Fund (WWF), UNDP, UNEP, UNICEF and the Pan American Health Organization (PAHO) amongst others.

Climate change studies and programmes

Climate change has become one of the most pressing issues on the international development agenda. It is therefore unsurprising that recent years have seen significant resources being directed towards addressing issues related to climate change. While globally the main focus of climate change programmes has been on identifying and implementing appropriate mitigation measures, in least developed countries (or countries with low levels of industrialization) the focus has been on adaptation measures.

Some of the research activities that have been, or are currently being, undertaken in Guyana are outlined below.

Weather and climate research and projects (including Early Warning Systems)

As a member of the WMO, Hydromet receives assistance in its efforts to contribute to national development plans and to become a full partner in global collaborative efforts. For example, the WMO is presently working with National Meteorological or Hydrometeorological Services (NMHSs), including Hydromet in Guyana, to implement the WMO Multi-Hazard Prevention Strategy, which aims to reduce by 50 per cent over the decade 2010-2019 the number of fatalities caused by meteorological-, hydrological- and climate-related natural disasters, as compared with the 10-year average fatalities of 1995-2004. The World Bank El Niño Emergency Assistance Project was initiated in 1998 and ended in 2002. The aim of the project was to help to restore the country's agricultural capacity in drought-stricken areas through vulnerability reduction measures in the areas of hydrologic extremes; provide safe and reliable potable water service to marginal urban and remote hinterland and river communities affected by drought; and restore flood protection in low-lying areas of the city of Georgetown. The project supported the upgrading of facilities in selected stations nationwide of the hydrometeorological network managed by the Hydrometeorological Division (HD) of the Ministry of Agriculture.

The Guyana Lands and Surveys Commission is currently undertaking an Early Warning System Study to examine short-term climatic risks (extreme weather events) such as high tides, rising flood waters, forest fires, and drought. The study will identify and appraise several options for Early Warning Systems suited specifically to the types of weather events that occur in Guyana. The research is being conducted over a period of four months between September 2009 and January 2010, and involves a wide range of stakeholders including the Civil Defence Commission, the Red Cross, the Guyana Defence Force, the UNDP, Hydromet, PAHO, NARI and the Guyana Forestry Commission.

Flooding and coastal research

The following projects have been initiated and implemented in order to build capacity in flood management, flood protection, and enable climate change adaptation.

- *The World Bank Conservancy Adaptation Project (CAP)* was initiated in 2007 with the aim of reducing the vulnerability to catastrophic flooding of the Guyana low-lying coastal area, which is currently threatened by sea-level rise resulting from global climate change. This project has been developed to guide a comprehensive upgrading programme of the East Demerara Water Conservancy (EDWC) and lowland drainage system, aimed at increasing discharge capacity and improving water level management. The project will also include some small infrastructure improvements to help cope with the immediate threats to the drainage system. The tools developed under the analytical component of the CAP will be used by the Government of the Republic of Guyana (GoG) and donor agencies to guide future investments.[222]

- ***The Institutional Capacity Building Project (ICB)*** (full name Institutional Capacity Building Activities on Guyana Sea Defences within the Framework of a Shore Zone Management System Project) which ran between 2003 and 2005, aimed at the installation of a database to allow for instantaneous and up-to-date information on the condition of the sea and river defences, including sluices and dams.

- ***Design and Implementation of an Integrated Disaster Risk Management Plan.*** In 2009 the Inter-American Development Bank (IDB) approved a non-reimbursable technical co-operation loan to the Government of Guyana to design and implement a disaster risk management plan. The objectives of the technical co-operation are to support GOG with the *Design and Implementation of an Integrated Disaster Risk Management (IDRM) Plan, within the framework of comprehensive disaster management*. The project has three components: (1) Country Risk Indicators and Flood Risk Evaluation; (2) Strengthening National and Local Capacity for Integrated Disaster Risk Management; and (3) Design of an Investment Programme in Flood Prevention and Mitigation.

- ***Early Warning for Natural Disasters***. The Japan International Co-operation Agency (JICA) is funding a pilot project which includes early warning systems for flooding of the Mahaica River.[223]

[222] The World Bank – Projects and Operations – Conservancy Adaptation Project [online] available at: web.worldbank.org (accessed 29/09/09).
[223] No further details about this project could be found.

Forestry research

The Iwokrama International Centre for Rain Forest Conservation and Development is an autonomous non-profit institution established by Guyana and the Commonwealth. The focus of research is on conservation and business development of the complex Iwokrama ecosystem. The Iwokrama project uses spatial information systems to combine spatial data with data generated through socioeconomic, bio-physical and other studies, and traditional knowledge. The Iwokrama GIS team has research interests in the application of spatial models and satellite remote sensing to forest resource management, and also in the development of GIS in Guyana.[224] Recent studies have included:

- zoning plan for the Iwokrama Forest using linear programming
- predictive spatial model of Greenheart distribution using logistic regression
- delineation of the seasonal flooding with satellite radar.

Other activities of the Iwokrama research project include trials and demonstrations of timber and non-timber plant products production systems, and the understanding of issues with global implications, such as carbon sequestration.

The GFC is also actively in the process of developing a national Monitoring, Reporting and Verification System (MRVS) to support REDD+ implementation in Guyana. A road-map and draft Terms of Reference for Developing Capacities[225] for a national MRVS have already been developed.

[224] The Iwokrama International Centre for Rain Forest Conservation and Development [online] available at: http://www.iwokrama.org/home.htm (accessed 30/09/09).

[225] See: http://www.forestry.gov.gy/Downloads/Terms_of_%20Reference_for_Guyana's_MRVS_Draft.pdf (accessed on 20/06/2010).

Agricultural and soils research

There have been a number of research initiatives undertaken. These include two projects undertaken on behalf of the Caribbean Community Climate Change Centre (CCCC):

- An assessment of the vulnerability and capacity of Guyana's agricultural sector to respond to the impacts of climate change under the Mainstreaming Adaptation to Climate Change (MACC) project[226] (2007).
- The preparation of a national adaptation strategy to address climate change in the agricultural sector[227] (2009).

The National Agricultural Research Extension Institute aims to plan, develop and implement research to maintain national self-sufficiency and export capacity; however, it does not extend to climate change research.

As noted in Section 5.2, the Agrometeorological Section of Hydromet undertakes research aimed at generating agrometeorological products in support of farming, land management, selection of improved varieties of plants and breed of animals which are adaptable to different climatological conditions and climate variability.

Hydromet is currently partnering with the CIMH and a number of other Caribbean countries on the Caribbean Agrometeorological Initiative Project (funded by the EU). Hydromet is also a member of the Caribbean Agrometeorology Network.[228]

[226] Caribbean Community Climate Change Centre (CCCCC) & Government of Guyana (2007). *Vulnerability and Capacity Assessment: Impacts of Climate Change on Guyana's Agriculture Sector*. Prepared by Guysuco for the CCCC, Belmopan, Belize.

[227] Caribbean Community Climate Change Centre (2009). *National Adaptation Strategy to address Climate Change in the Agriculture Sector of Guyana.* Prepared by Development Policy and Management Consultants for the CCCC, Belmopan, Belize.

[228] See: http://63.175.159.26/~monthly/CarAgMet2/aboutus.htm

5.3.3 Recommendations

There are clearly a number of ongoing areas of research within Guyana, yet further effort is required to improve understanding and monitoring of the impacts of climate change on key sectors and communities within Guyana, as well as on appropriate responses to address vulnerability and improve resilience to the effects of climate change. A number of research needs are identified and described in Section 5.1 (Technology Needs Assessment) and include:

- Assessment of the vulnerability of different sectors to climate change, not just in terms of the physical impacts of change but also institutional preparedness and capacity to respond to change
- Development of indicators and climate-impact monitoring systems that can be used to systematically monitor and detect changes in the functioning of forest, freshwater, coastal and other ecosystems
- Preparation of detailed flood risk assessments for both coastal zones and river floodplains
- Development of a better understanding of Guyana's forest carbon stocks (for the purposes of REDD+).

A strategic planning process is needed to reaffirm these needs, identify others, prioritize activities, and initiate implementation of these activities.

A co-ordinated approach between government departments and research institutes is needed to ensure that there is no duplication of efforts, that key research gaps are covered, and that the knowledge generated can be shared and used as inputs into other areas of research (i.e. research on climate impact predictions should inform research into the development of appropriate responses). Opportunities for sharing resources (e.g. climate models, data, and technologies) with other CARICOM countries may also be explored.

Furthermore, support (in the form of funding and availability of time) should be provided for researchers to participate more actively in regional research programmes, such as those co-ordinated by the Caribbean Community Climate Change Centre. This will allow sharing of knowledge and information from which Guyana could significantly benefit. More formal linkages may also be established with research institutions in developed countries in order to provide opportunities for student/research exchanges.

More specific research needs are likely to be identified through the Mitigation and Abatement Analysis (MAA) and Vulnerability and Adaptation Assessment components of the SNC. However, given Guyana's susceptibility to the impacts of sea-level rise and severe flooding, one particular priority area of research might be on compiling a comprehensive database of flood risk and vulnerability maps which could help guide future adaptation and planning efforts. It is understood that there are several ongoing initiatives in this area, but these need to be co-ordinated and the information made easily accessible for use by planners, policy-makers and decision-makers.

Chapter 6

Public Education, Training, and Capacity Building

Public Education, Training, and Capacity Building

Educating the public- brochures on Climate Change produced by Guyana's Ministry of Agriculture

6.0 Progress since INC

Building on the recommendations of the INC, as well as on specific institutional mandates, several ministries, agencies, institutions, and non-governmental organizations undertook training and public awareness programmes and related activities to address climate change impacts. These bodies included the initially established National Climate Unit (2007-2009); the Guyana Energy Authority (GEA), the Environmental Protection Agency (EPA); the School of Earth and Environmental Sciences of the University of Guyana (SEES); the Pan American Health Organization (PAHO); Conservation International Foundation (Guyana) Inc. (CI (Guyana); and the Iwokrama International Centre for Rainforest Conservation and Preservation (IICC). Principal activities which benefited the nation as a whole may be summarized as follows:

- Development of educational materials such as booklets for schools and farmers; and brochures on topics such as: greenhouse gases and climate change, climate change adaptation and mitigation, and energy conservation with reference to appliances, lighting, motor vehicles, and building designs
- Climate change workshops and seminars particularly for persons who reside outside of the urban capital centre, Georgetown, and the immediate coastland of Guyana. For example: public outreach programmes have targeted Regional Officers, health workers, public sector workers and other members of the community in the various coastal Regions.
- Mounting of billboards at strategic locations, and poster exhibitions at the National Library and the University of Guyana campus
- Panel discussions and development of Public Service Announcements on national television to promote climate change awareness and Guyana's Low Carbon Development Strategy
- Publication of newspaper articles and special supplements that focus on the science of climate change, the need for adaptation and mitigation, and the involvement of the public in finding solutions
- Broadcasting of climate change videos and films on national television
- Climate change and flood symposia in observance of international environmental events such as Earth Day, Guyana Environment Week, and World Environment Day.

Several workshops and public awareness booths played an important role in raising the interest and awareness of the Guyanese public on issues related to climate change.

- Establishment of special climate change booths at national exhibitions such as Fisherman's Day, the Grow More Food Campaign, and the Hydro-Meteorological Office Open Day
- Public lectures and presentation of specific papers at special events such as a workshop by the National Agriculture Research Extension Institute (NAREI) on 'Enhancing Food Security and Mitigating Climate Change'
- Several high level engagements between civil societies, the academic community and political figures to discuss climate change issues have been facilitated over the past four years, and intensified with the May 2009 launch of the Low Carbon Development Strategy (LCDS).
- Nationwide active engagement with all stakeholders and persons during a three-month consultation and awareness phase on Guyana's Low Carbon Development Strategy. Several awareness sessions were organized nationally, and activities were held overseas to present and discuss the Strategy to a wide international audience. Special considerations were given to the engagement of Amerindians, Guyana's indigenous population, to ensure their free, prior and informed consent, to have the choice to be active participants in the LCDS if they so determined.

Training is facilitated mainly through targeted workshops locally, and specialized programmes/courses regionally and internationally. Some examples are:

i. A workshop on "Adaptation to Climate Change in the Agriculture sector" held jointly by the CARICOM Climate Change Centre, the National Climate Unit and the School of Earth and Environmental Sciences for key governmental officials representing nineteen Caribbean countries

ii. Watershed Modelling and Management for key environment and natural resource agencies

iii. Greenhouse Gas Inventory, Vulnerability Adaptation Assessment and Mitigation Assessment Tools training workshops for key sector agencies through the Second National Communication Project

iv. Persons from hinterland villages and community-based organizations, the Guyana Forestry Commission, the Ministry of Amerindian Affairs, and Amerindian non-governmental organizations were also trained on topics such as the science of climate change, climate-change mitigation, the role of forests in climate, REDD, and sustainable forestry management. This training was organized by the Iwokrama International Centre for Rainforest Conservation and Development (IICC) and Conservation International Foundation (Guyana) Inc.

v. Skills Enhancement and Training Programme by the Sea and River Defence, Work Services Group, with specific focus on climate-change monitoring and evaluation of sea-level rise, and wave intensity on the coast.

vi. Over the past two years, officers of the Hydrometeorological Service have benefited from weather forecast training that has been facilitated by the Caribbean Institute for Hydrology and Meteorology.

vii. Training has been done for air-conditioning and refrigeration technicians to develop the skills to avoid the use of virgin CFCs through better servicing techniques, recovery, and re-use of refrigerants and the retrofitting of CFC-based equipment.

viii. The University of Guyana, through the School of Earth and Environmental Sciences, has begun the process of course design and development of training materials on climate change issues.

ix. Scholarships are now offered to eligible Guyanese citizens to pursue studies in Forestry and Climate Change. This initiative is aimed at building institutional capacity at the national level.

x. Guyana has also benefited from the activities under the Global Environment Facility (GEF); Caribbean: Planning for Adaption to Climate Change (CPACC); and the Mainstreaming Adaption to Climate Change (MACC) projects, which were aimed at addressing the training needs related to the UNFCCC, and promoting public awareness of the tasks that CARICOM countries are obliged to undertake.

6.1 Assessment of Level of Public Awareness

A survey was done in 2009, in order to better inform public awareness and education activities for the development of a public education strategy. The survey aimed at specific target groups: farmers, students and businesses, parliamentarians and media personnel. The general view is that public awareness, education, and training are critical tools for empowering the Guyana society to play a critical role in climate change adaptation, as well as to support Guyana's Low Carbon Development Strategy as a climate change mitigation measure.

The general findings of the survey suggested that the targeted groups had shown a basic level of understanding and knowledge of climate change issues, although the more detailed science of the global phenomenon seemed to be less understood. Additionally, the majority were aware of the problem, expressed deep concern and interest, and could have identified possible solutions and actions that could be taken to address the global phenomenon. However, they were less inclined to commit financially to help reduce climate change effects. This suggests that there is need for more emphasis on attitudinal changes and personal responsibility, both of which are long-term objectives of a public awareness and education programme. Importantly, the survey results provided a useful point of reference for the design and implementation of a National Environmental Education Programme and Implementation Strategy for Climate Change, which aims to help Guyana to continue to meet its obligations under the Convention.

6.2 Initiatives for Climate Change Integration into National Development Plans, Policies, and Programmes

Guyana recognizes the need to have in place a policy framework that will inform the development planning processes and complement national public awareness, education, and training initiatives to address climate change. While Guyana does not have (as yet) any comprehensive climate change policy document that addresses the totality of issues, at the strategic level, there are a few documents that are recognized as national policy initiatives. These relate directly to climate change adaptation and mitigation measures.

6.2.1 National Capacity Self-Assessment

In 2006, Guyana undertook a Stock-Taking and Thematic Assessment of the UNFCCC. That assessment produced a report that effectively informed policy-makers of the key issues/problems that the country has to address in order to fulfil its obligations under the Convention, and in so doing, adopt a more pro-active approach to the threats of climate change.

6.2.2 National Development Strategy

While the National Development Strategy (NDS 2001-2010) does not directly integrate climate change, there are clear statements on measures to be taken to build capacity in the areas of water management and flood control, sea defence management, and to promote the use of renewable energy. Such interventions will strengthen Guyana's efforts to mitigate and adapt to climate change.

Other national policy documents that have implications for national response to climate change are the National Environmental Action Plan (2001-2005), the Integrated Coastal Zone Management Plan (2000), and the Mangrove Action Plan (2001).

6.2.3 Recent Strategic Developments

Guyana's Low-Carbon Development Strategy

A development strategy for the country, the **Low Carbon Development Strategy (LCDS)** was launched 8 June 2009. This strategy examines how Guyana can deploy its forests in mitigating climate change, while also gaining financial and other support for so doing, and it sets out Guyana's view on how such a platform for partnership can be created, and affirms Guyana's commitment to combating global climate change. It further seeks to provide insights on how to stimulate the creation of a low-deforestation, low-carbon, climate-resilient economy, outlines how Guyana's forests help the world, and how transitional payments from Guyana's climate change partnership with Norway and others, followed in the longer term by payments under the REDD mechanism (Reducing Emissions from Deforestation and Forest Degradation), can create the platform for an effective strategy to avoid deforestation. Further, the Strategy outlines how transitional payments and REDD can enable Guyana's economy to be realigned onto a low-carbon development trajectory, and at the same time grow at, or in excess of, projected Latin American growth rates over the coming decade, while simultaneously eliminating approximately thirty per cent of its non-forestry emissions, through the use of clean energy.

Reducing Emissions from Deforestation and Forest Degradation (REDD)

Under the REDD initiative the following was implemented:

- Establishment of a REDD Secretariat as an Operational Unit in the Guyana Forestry Commission in September 2008. This Secretariat will help to strengthen Guyana's case for the development of a new arrangement to provide positive financial incentives for developing countries that voluntarily reduce or maintain their lower than average historical greenhouse gas emissions from deforestation, and for the inclusion of forest protection under the carbon trading mechanism. Collaborating parties include the Office of the President, the Ministry of Education, the Ministry of Amerindian Affairs, the Ministry of Local Government (Regional Planning), Indigenous Communities and leaders, private sector organizations (FPA, GMSA, PSC); academic institutions (UG, GSA), NGOs (CI-G, WWF, Iwokrama International Centre for Rainforest Conservation and Development), the Guyana Lands and Surveys Commission, and the Guyana Geology and Mines Commission, among others.
- Carbon sequestration studies have been conducted by the Guyana Forestry Commission, the Iwokrama International Centre for Forest Conservation and Development, and other local bodies, with financial support provided by the World Wildlife Fund-Guyana, the Inter-American Development Bank, and the World Bank. These studies include: the Development of a National Forest Biomass Monitoring System for Guyana; Assessment of Historical Baseline of Forest Carbon Stock; Assessment of Projected Emissions of REDD Reference Scenarios; and Field Procedures addressing issues of Co-ordination and Networking for a Monitoring System. Further, as a component of the Guiana Shield Initiative project, studies on biomass monitoring and environmental services have been conducted with the application of Geographic Information Systems (GIS).
- Through the World Bank, a Forest Carbon Partnership Facility (FCPF), a REDD initiative, was established. Based on technical capacity building and baseline research (particularly carbon stock), as well as demonstration activities to facilitate the transmission of knowledge, the FCPF also includes ensuring that governance and administrative institutional arrangements are appropriate. To date, Guyana's Readiness Plan Idea Note (RPIN) and R Plan have been submitted to and accepted by the FCPF.
- The new Forests Act (passed in 2009) provides for 'the integrated and comprehensive regulation of the multiple and complementary functions and uses of the forests of Guyana, including traditional uses'. The provision made for multiple uses allows for actions/decisions to address climate change through avoided deforestation.

National Climate Committee (NCC)

The National Climate Committee (NCC), which was initially established in 1995 and recently re-organized, has wide representation of about twenty-eight stakeholder groups in society. The objectives of the Committee are to:

i. Examine national conditions as they relate to climate change and make recommendations to the relevant authorities on appropriate national measures to address these conditions

ii. Advise the relevant committees and policy-makers on developments and the need for policies and regulations in relation to activities responding to climate change

iii. Advise the Climate Change Unit of the Ministry of Agriculture

iv. Promote technical, scientific, technological and financial co-operation among agencies, institutions, and organizations in Guyana with responsibilities related to climate activities

v. Analyse global developments and the work of Global Conventions and International Organizations dealing with climate issues, and advice on the approach to fulfilling implementation of action programmes related to the national obligations under the climate-related conventions and associated protocols

vi. Promote co-operation with relevant national, regional and international bodies involved in activities responding to climate change

vii. Advise the relevant Ministers on proposals and negotiating positions to promote Guyana's interest in relation to climate change issues at appropriate global and regional forums.

viii. Monitor the implementation of National Policies, Programmes, and Action Plans related to climate, and make recommendations for appropriate changes and revisions.

Recognizing the need to co-ordinate public awareness and education activities, the National Climate Committee also established an Education Sub-Committee tasked with identifying priority issues to be addressed.

6.3 Public Education Programme and Implementation Strategy

The aim of the Public Education Programme and Implementation Strategy is to build the capacity of the citizens of Guyana to take actions (individually and collectively) to mitigate and adapt to climate change.

A stakeholder workshop was held in August 2009 with the aim of promoting public 'buy in' and engaging the public and private sector, community organizations, and non-governmental organizations in the process of finalizing the national strategy document. It is envisaged that networking among key stakeholders will be strengthened and synergies between public education activities will be forged to avoid duplication and to optimize the net effects.

6.3.1 Strategic Goals, Major Target Groups and Activities

The strategic goals of the Public Education and Implementation Strategy are:

- Enhanced awareness and understanding by all social groups (in Guyana) of climate change causes, impacts and solutions
- Empowerment of every citizen of Guyana to make lifestyle decisions and take individual actions that will seek to strengthen and/or support national and international efforts to avert the grave consequences of climate change
- Practice of Corporate Social Responsibility in the private sector in the context of Guyana's Low Carbon Development Strategy (LCDS) and general sustainability
- Increased public access to information on climate change
- Increased opportunities for training of scientific, technical and managerial personnel to address climate change issues at the strategic level.

The major target groups are identified as: households; children and youth; teachers and teacher trainers; policy and decision-makers (including Parliamentarians); consumers; religious groups; mothers unions; indigenous peoples; tradesmen and technicians; private sector; media personnel; resource users (farmers, fishermen, miners and loggers); professionals from various sectors; and the scientific and academic community.

Some of the key activities are: television documentaries; live radio and television programmes; public exhibitions; curriculum development through integration and infusion; formation of Environmental Clubs in schools and communities; science fairs focusing on climate change; quizzes and debates; regional training seminars and workshops; jingles for radio and television; awareness seminars; media symposia; demonstration projects, and short professional training courses.

Promoting awareness - members of a Wildlife Club in the North Rupununi, Guyana, examine termite mounds.

The lead facilitators for these activities are sourced from governmental ministries and agencies, academia, and non-governmental organizations. In addition, a number of regional and international institutions are identified as partners to provide: technical advice to facilitators on specific project activities, financial support for education activities, as well as education materials that can be used immediately or contextualized for local use. They are also expected to participate in education and training, where necessary and practicable.

The Strategy calls for the resuscitation of the National Environmental Education and Advisory Committee to ensure institutional collaboration and co-ordination, and to monitor and evaluate the implementation of the Strategy.

The summary matrix (Table 6.1) indicates proposed time-frame (medium-term and long-term), and activities. The medium term is considered to be between two to three years, and long term four to five years.

Table 6. 1. **Summary matrix indicates proposed time-frame (medium-term and long-term), and activities.**

TARGET GROUP	OBJECTIVES	ACTIVITIES	TIME-FRAME
Households	To disseminate climate change information in order to enhance public awareness and to encourage responsible actions To provide opportunities for self-reflection on individual lifestyles and how these contribute to the climate change problem, with a view to changing attitudes and values To provide a forum for national discourse on climate change issues (example, national obligations and initiatives taken), and to correct possible 'misconceptions'	-Bi-monthly feature articles in each major national newspaper -Billboards in each of the ten administrative regions -Signage -Television documentaries on coastal vulnerability to climate change and the role of Guyana's forests in climate mitigation -Live radio and television programmes that allow for interaction -Radio announcements, jingles -Observance of international events (Earth Day and World Environment Day, World Water Day, etc.) -Public exhibitions -Plays, poetry, songs, dances, short stories -Public forums, panel discussions	Medium- and long-term
Children and Youth	To increase knowledge of climate change issues through integration To provide opportunities for local actions (in a local environmental setting) that address climate change To develop in youths skills to discern the causal relationships between lifestyle choices and climate change impacts, and to promote opportunities for critical thinking and problem-solving	-Audit of present school curricula at nursery, primary, secondary, and technical level -Infusion/integration of climate change issues in existing curricula, using pilot subject initially (e.g. Integrated Science, Geography, Social Studies, Agricultural Science, and English) -Magazines and comic books -Formation of Environmental Clubs in schools and communities -Hosting of youth camps during summer breaks, hikes, tours -Science Fairs focusing on Climate Change -Essay, poster and painting competitions	Long-term

		-Preparation of booklets, pamphlets and workbooks -Production of bi-annual newsletters which can be produced by Environmental Clubs -Integration of climate change in the Adult Education Curricula -Quizzes and debates	
Teachers and Teacher Trainers	To train and retrain teachers and teacher trainers to deliver environmental education lessons which address aspects of climate change at the nursery, primary, secondary, and technical levels	-Curriculum audits -Development of training curricula/teachers manuals for colleges -Regional training seminars and workshops	Medium-term
Policy- and Decision-Makers	To promote an understanding of the causes and consequences of climate change and the importance of 'right' decision-making To improve the capacity of policy- and decision-makers to integrate climate change into social and economic planning, and to plan for mitigation and adaptation, using the INC, the National Climate Change Action Plan, and the National Climate Change Adaptation Plan as key points of reference	-Short training programmes (two to three days) -Partnership demonstration programmes with government agencies and the private sector, as well as communities. This is particularly relevant to adaptation. -Television programmes -Panel discussions -Guest lectures -Summary reports	Medium-term
Consumers	To educate consumers about the climate change impact resulting from their choices To create an awareness of the link between consumerism and climate change To empower consumers to make informed decisions in regard to purchases and to support environmentally friendly products (for example, low carbon emission products)	-Flyers, stickers -Signage -Jingles for radio and television -Green products	Medium-term
Religious Groups and Mothers Unions	To promote awareness and understanding on the part of religious leaders on issues related to climate change, and to encourage them to include 'caring for the earth' in their sermons	-Seminars -Workshops -Panel discussions	Medium-term

Indigenous Peoples	To enhance awareness on the part of indigenous peoples of climate change, its causes and consequences, and to empower them to take further actions to mitigate and adapt to climate change	-Workshops -Awareness Seminars -Preparation of special booklet -Community meetings	Medium- and long-term
Tradesmen and Technicians	To disseminate climate change information in order to enhance public awareness, and to encourage responsible actions	-Training workshops -Awareness Seminars -Brochures	Medium-term
Private Sector	To create and enhance awareness of the causes and consequences of climate change, and the role of the private sector in addressing the global problem To encourage the private sector to adopt appropriate measures to adapt to and mitigate climate change To promote Corporate Social Responsibility	-Television programmes -Workshops -Awareness Seminars -Short training programmes (two to three days)	Medium-term and long-term
Media Personnel	To enhance awareness and understanding of climate change and its impacts To impart skills in disseminating information on climate change	- Press conferences - Two-day training workshops -Media symposia -Organization of biennial media awards for best article on climate change	Medium-term
Resource Users (Farmers, Miners, Fishermen, Loggers)	To enhance awareness of and sensitivity to climate change issues which are related to livelihood activities within natural resource sectors To encourage these user groups to adopt practices that are more sustainable and to support climate change mitigation and adaptation: for example, Guyana's Low Carbon Development Strategy	-Newsletters -Demonstration projects -Radio programmes -Sensitization Seminars or outreaches -Paraphernalia	Medium-term and long-term Medium-term and long-term

		-Stickers/labels	
Professionals	To facilitate the process of decision-making on climate change issues To formulate and review existing policies that will give structural support to the implementation of public education on climate change issues To equip planners, economists, engineers, local government personnel and others with appropriate knowledge and skills that will enable them to incorporate climate change issues in their planning and decision-making.	- Short professional training courses (two to three days) -Workshops -Seminars -On-the-job training	Medium-term
Scientific and Academic Community	To enhance the technical knowledge of the scientific and academic community (university students and lecturers, engineers, researchers, as well as others) on climate change issues and adaptation and mitigation options for Guyana, and to promote networking between this group and other sectors of the broader community To provide opportunities for on-going robust research on climate change (for example, vulnerability studies, carbon sequestration etc.)	Workshops -Symposia -Infusion of climate change into existing University of Guyana curricula -Development of special modularized course on Climate Change, to be offered by the University of Guyana	Medium- and long-term

6.4 Capacity Building

Capacity building, which cuts across many of the issues under consideration in the climate change process, is continuous, progressive and iterative. Key institutional, technical, and financial capacity building activities that have been undertaken by Government of Guyana include the following:

i. National Capacity Self Assessment Studies (2007) in respect to the UNCBD, the UNCCD and the UNFCCC
ii. Establishment of the Office of Climate Change (OCC) at the Office of the President in 2009 for the implementation of the Low Carbon Development Strategy
iii. Re-organization of the National Climate Committee, which was initially established in 1995, and currently has wide-representation of about twenty-eight stakeholder groups in society
iv. Establishment of a REDD Secretariat within the Guyana Forestry Commission.

6.4.1 Technical

There is now improved capacity to disseminate climate-related information on Guyana through two main websites, namely:

- Government of Guyana - Climate Change: www.guyanaclimatechange.gov.gy and
- Low Carbon Development Strategy: www.lcds.gov.gy

There is no specific legislation governing climate change in Guyana. Activities which contribute to climate change are controlled and managed through the Environmental Protection Act of 1996.

Climate change issues have also been integrated in sector-specific policies. For example, by means of the MACC Project, a National Adaptation Strategy to address Climate Change in the Agriculture Sector of Guyana was prepared in February 2009. This strategy identifies and explains ways in which climate change is integrated into agricultural development practices and decision-making in Guyana. Importantly, it draws attention to adaptation responses of the agriculture and allied sectors, and further discusses the potential impacts and challenges of climate change and the opportunities that can be optimized. The strategy concludes with concrete recommendations using a thematic approach: mainstreaming adaptation, research and development, awareness and communication, policy co-ordination, and public-private sector partnership.

In December 2010, with support from the European Commission, Guyana benefited from a land-use project that provided technical assistance to the Guyana Lands and Surveys Commission (GLSC) in the areas of regional planning, mapping and database management, improvement of interaction and linkages between the GLSC, external agencies and stakeholders, and which also facilitated the harmonization of planning legislation.

Guyana has already begun the preliminary stages of developing and implementing a Monitoring, Reporting and Verification System (MRV) for REDD+ participation for Guyana. To date, the following progress has been achieved:

- MRV capacity gap assessment for national requirements (forest change processes/drivers) and International requirements, including IPCC requirements

- Development of an MRV roadmap (see Table 6.2 below) to build sustained in-country capacities, based on current understanding and emphasizing the national REDD implementation opportunities

- Specification for a number of key activities that should be tackled in the near term, including the work on terms of reference to soon start activities, while maintaining flexibility to speed up things if desired by Guyana.

Table 6. 2. MRV Road Map – objectives and expected key results

	National strategy (2010) ➔	Country readiness (2011/12) ➔	Implementation (post 2012)➔
Objectives	Gather and integrate information & fill data gaps for national REDD opportunities, scoping and policy development	Develop capacities, conduct historical monitoring, and implement a (minimum) IPCC Tier 2 national forest carbon monitoring; establish the reference level and report on interim performance	Establish consistent and continuous MRV supporting national REDD+ actions and international IPCC GPG-based reporting and verification
Key results and national capacities developed	1. Comprehensive MRV roadmap developed and national MRV steering body operational 2. Improved national capacities on LCDS, REDD, IPCC-LULUCF, and carbon dynamics 3. Framework and capacities to demonstrate REDD implementation and interim performance 4. All data available and accessible (including acquisition of new forest carbon data) on drivers and processes needed for developing a national REDD policy and interim implementation plan 5. Established communication and participation mechanism to involve relevant stakeholders nationally and internationally 6. Approaches for setting reference levels, linking MRV and policy, and MRV co-benefits and synergies are explored and defined	1. Capacities in place for consistent and continuous acquisition and analysis of key data for Tier 2 nationally and Tier 3 for demonstration/activity sites including international reporting using IPCC LULUCF; uncertainty assessment MRV improvement plan developed 2. Reference level established based on historical data, and future developments using internationally accepted methods 3. All data available and accessible for an updated national REDD implementation plan 4. Regular reporting on REDD demonstrations and interim performance 5. Continued engagement with key national stakeholders for REDD implementation and assuring long-term sustainability of MRV capacities (i.e. universities) 6. Monitoring system explored to cover key variables for other ecosystem services	1. IPCC key category analysis and assessment for Tier 3 approaches completed and implemented (if desired) 2. Independent international review of full MRV system completed 3. Capacity in place and implementation to deliver verification and compliance assessment for REDD results-based compensation 4. National data infrastructure of forest greenhouse gas inventory and assessment in place for regular reporting 5. Implementation plan to use new and proven technologies to reduce uncertainties and increase efficiency of MRV system 6. Framework developed that links REDD into LCDS monitoring, reporting and verification system

Source: Preparing Guyana's REDD+ participation: Developing Capacities for Monitoring, Reporting and Verification Report and Summary of a Workshop and Consultation held 27 – 29 October 2009 in Georgetown, Guyana.

Moreover, in recognition of the need to apprise decision-makers of early warning options that are relevant and appropriate to the Guyana situation, the Guyana Lands and Surveys Commission, with support from GEF, has embarked on an Early Warning System Project. The aim of this project is to provide decision-makers with a comprehensive analysis-based set of options for the introduction of appropriate early warning systems, while enhancing the local knowledge base in such systems.

6.4.2 Institutional

Currently, climate change research activities are undertaken by several institutions, with some degree of institutional collaboration, in the absence of a more co-ordinated approach that could be facilitated by a National Climate Change Research Action Plan. Chief among these institutions are: the Hydrometeorological Service, the University of Guyana, the National Agriculture Research Institute, the Institute of Applied Science and Technology, the Guyana Energy Authority, the Guyana Forestry Commission, and the Iwokrama International Centre. Some of the broad research topics and issues related to climate change being carried out are:

- Estimate of carbon stock in soils (carbon sequestration) in the tropical rainforests
- Impacts of El Niño and La Niña weather phenomena on a hinterland community, and local coping and adaptation strategies
- Renewable energy sources, especially hydroelectric power, bio-fuels, wind, and solar energy
- The role of forests in mitigating climate change

Turtle Mountain located within the Iwokrama Protected Area is part of 371,000 hectares of land managed as a living laboratory to demonstrate sustainable use of natural resources.

Guyana has also commenced implementation of climate change adaptation measures as best as the national economy can support, given other pressing socio-economic issues. Sectors in which notable initiatives have been/are currently being undertaken are:

- Agriculture and Sea Defence
- Energy
- Forestry and Land Use
- Health.

Several national initiatives based on sectoral policy measures have been developed and implemented. These are particularly evident in the areas of agriculture, forestry and energy. Guyana has in place most of the necessary policy measures which provide an enabling environment for climate change to be effectively addressed. With respect to those initiatives that have not yet been undertaken, there are proposals to assure their development and successful implementation.

The country's ability to demonstrate fully its commitment to the obligations to the UNFCCC cannot be divorced from its financial capabilities, in the light of grave socio-economic challenges. However, over the years, its capacity has been enhanced significantly with financial and technical assistance provided by the international community. Moreover, Guyana's advantage lies in the country's vast forests that are still untapped. This provides the global platform for the President's initiative on 'Avoided Deforestation', which offers a range of opportunities- financial, human and technical enhancement. Such opportunities are further enhanced by the range of alliances Guyana has joined at both the regional and international levels. The implication is that the country is well positioned to negotiate resources for climate change adaptation and mitigation. Outstanding examples of the outcome of negotiation processes are the IADB and UNDP Disaster Risk Reduction and Management Projects to be soon implemented. In both cases, the capacity of the Guyana Civil Defence Commission which organizes national response to natural disasters will be improved.

There has been notable improvement in the areas of public education and awareness and the engagement of stakeholders. These measures have enhanced the capacity both of individuals and specific social groups such as the private sector, to take responsible action to help address the impacts of climate change.

6. 4.3 Financial Groups and Activities

Guyana has signed an historic agreement with the Government of Norway which paves the way for Guyana to benefit from the sum of US$250 million over a five-year period to finance the Low Carbon Development Strategy. Under the terms of the agreement with Norway, Guyana will accelerate its efforts to limit forest-based greenhouse gas emissions and protect its rainforest as an asset for the world.

6.4.4 Public Awareness

The Government of Guyana, recognizing the need for the public to better understand their roles and responsibilities in the fight against climate change, made a concerted effort to ensure that education and public awareness were integrated into the national response to climate change. This was manifested in the national efforts that were mobilized specifically in relation to the Second National Communication (SNC) Project, and in relation to Guyana's Low Carbon Development Strategy. In keeping with the commitments under Article 6 of the UNFCCC, Guyana is ensuring that education and public awareness remain an area of key focus. The Second National Communication Project placed emphasis on public awareness and education, and defined specific objectives in this area:

- To enhance public awareness on climate change and strategies for addressing its associated impacts in Guyana
- To encourage active participation in mitigation and adaptation measures
- To encourage integration of climate change issues into future developmental projects/actions/decisions through increased public awareness.

Consistent with Article 6 of the Convention, on public education and awareness, Guyana adopted a multi-faceted approach which included public outreach seminars, brochures and newspaper articles, and thirty-second public service advertisements.

These activities were promoted at the national level within the administrative regions, to ensure maximum reach.

The Government of Guyana continues to promote awareness of climate change, especially in the coastal regions. The efforts so far have ensured that people now have, at least, a basic understanding of climate change. However the fact remains that much more has to be done. Information on more specific issues and concepts relating to climate change has to, both now and in future engagements, make up the majority of the messaging of climate change in Guyana.

The work being done on promoting the Low Carbon Development Strategy, nationally, has served an important function in raising interest and awareness on issues related to climate change. This work on the LCDS has indubitably heightened public interest in climate change, and helped many citizens to relate to the consequences of climate change and to the mitigation and adaptation efforts necessary for the planet to address this issue. The momentum gained from the LCDS initiative and from the countrywide public consultations which were held on this Strategy should be utilized to maintain interest in the issue of climate change. In addition it can be used to help the citizenry to embrace national efforts, and engender an understanding of personal responsibility as well as knowledge of the personal efforts really necessary for addressing climate change.

Across Guyana, the issue of climate change received great focus, largely through the efforts of the Office of Climate Change, the Office of the President, and the SNC project. This increased the public's awareness, and generated products that will lend to long- term sustainability in raising awareness about climate change. The establishment of a climate change website, the development of public service advertisements, and the production of brochures can all be used long-term, which allows for a level of continuity in the public awareness component.

Overall the SNC project targeted the public using the mainstream media, but also new areas such as that of an online presence. However the reach needs to be expanded in light of the needs identified in the public awareness and education survey. Most of the recommendations highlighted in the National Climate Change Action Plan were implemented. However some areas remain critically important and implementation needs to continue. Specifically the incorporation of studies on climate change and the general environment into the curricula of schools must be made a priority.

The Office of National Climate Change has been re-established within the office of the President to co-ordinate national climate change efforts; however, there is no singular national plan which specifically addresses Climate Change Awareness and Education. While a lot of work has been done so far, national co-ordination in this area will help enhance delivery and maximize resources to increase and deepen awareness in Guyana. This is an area that needs to be strengthened and expanded immediately.

6.5 Challenges

Despite the creditable efforts made by Guyana to integrate climate change policy into development plans, there are still challenges to be overcome. These may be articulated as:

- The lack of adequate technical and financial resources for implementation of mitigation and adaptation measures
- The need for a higher level of public awareness and understanding of climate change issues to assure civil society's involvement in efforts to address climate change; for example, by protecting coastal ecosystems (such as mangrove vegetation) that protect the land from sea-level rise, relocating from low-lying areas (including government reserves), and by not dumping garbage indiscriminately into waterways
- Inadequate training to inform appropriate response, particularly at the municipal levels
- Inadequate amount of research to meet the current challenges posed by climate change
- Mobilization of the international donor community to act decisively on climate change issues that transcend national, regional, and international boundaries
- The slow response of the private sector to take on the challenge of new areas of investment that will lead ultimately to effective climate change adaptation measures

6.6 Recommendations

i. There is need for greater collaboration among agencies that address climate change issues. Work programme and capacity enhancement initiatives should be extended always to key stakeholders, in view of the fact that capacity building is a cross-cutting theme. The National Climate Committee will be able to address this issue.

ii. There is the need for research on how the climate is expected to change in the future. The resources for these studies will have to be provided from external assistance since global and regional models will have to be accessed and professional and academic resources will be needed.

iii. Relevant training in various agencies for these to be better equipped to monitor impacts such as erosion, inundation, along with changes in pest abundance, health signals, changes in fisheries, rice and sugar yields.

iv. Development of a policy paper that will outline an agenda for climate research in Guyana; this initiative should be carefully co-ordinated to ensure that the information generated from the research activities are available to government agencies to inform climate change policy development and review.

v. The University of Guyana needs to respond urgently to the human resource gap in regard to climate change by developing and offering short professional courses aimed at enhancing the capacity of key agencies which operate at the national and community levels.

vi. Further strengthening of the Hydrometeorological Services for improved climatological monitoring and forecasting, and capacity building in the area of climate change modelling. This will help national agencies with their climate and climate-change predictions, and provide invaluable data for decision-making.

vii. A long-term National Public Awareness and Education Strategy for Climate Change, beyond the 1999 National Environmental Education and Public Awareness Strategy (NEEPAS) has to be designed, implemented, and co-ordinated by the Office of Climate Change, Office of the President.

viii. Incorporation of studies on climate change and the general environment into the curricula of schools

ix. National Co-ordination of Public Awareness and Education efforts need to be streamlined, and the Office of Climate Change in the Office of the President needs to ensure inter-agency collaboration on awareness efforts to maximize effectiveness and use of resources.

x. A national Climate Change website needs to be developed and promoted as a portal for information on climate change, and its use as a “central clearing house” for information needs to be highlighted.

xi. Public Awareness and Education efforts need to be ‘scaled up’ to address climate change issues in-depth, and to highlight scientific concepts.

xii. Issues related to climate change and its consequences need to be more clearly articulated to reduce misconceptions about the issues directly related to climate change.

xiii. Public Awareness efforts need to highlight ‘personal responsibility’ as a critical component for mitigating climate change. Citizens need to better recognize the connection between their actions and the consequences on the environment.

xiv. Public Awareness and Education efforts need to target hinterland regions, and materials designed that are cognizant of language and socio-economic barriers.

xv. The Office of Climate Change, Office of the President, needs to conduct more outreach activities, especially in the remote areas of Guyana, to raise awareness, and to establish the office as a national co-ordinating point for climate change in Guyana.

xvi. Messages need to be tailored in order to reach specific audiences.

xvii. The Regional Democratic Councils can be used to help disseminate messages and facilitate training of village officers to help reduce 'ignorance' about climate change mitigation and adaptation actions.

Chapter 7

Gaps, Constraints and Financial Capacity

Chapter 7

Gaps, Constraints and Financial Capacity

7.0 Introduction

Guyana, like other developing countries, faces a number of challenges in implementing its obligations under the UNFCCC. These challenges include the lack of resources - technical, physical and financial - to put in place adequate measures to mitigate the causes and, more importantly for Guyana, the consequences of climate change.

This chapter sets out the constraints and gaps, and related financial, technical, and capacity needs, as well as proposed and/or implemented activities for overcoming these gaps and constraints associated with the implementation of activities, measures and programmes implemented under the Convention, and with the preparation and improvement of national communications on a continuous basis. It also provides information on the financial resources and technical support provided by the Government of Guyana, and by the GEF, Annex II Parties, or bilateral and multilateral institutions, for both the preparation of the National Communication and for activities relating to climate change more generally.

7.1 General constraints

General constraints, gaps, and needs for implementation of the UNFCCC were identified as part of the National Capacity Self-Assessment (NCSA) process undertaken between 2005 and 2007.[229] The NCSA report[230] examined the capacity constraints, priorities, and needs in relation to the UN Convention on Biological Diversity (UNCBD), the UN Convention to Combat Desertification (UNCCD) and the UN Framework Convention on Climate Change (UNFCCC), and also identified a number of cross-cutting issues relating to the policy, regulatory, legislative, and institutional frameworks.

Some of the key gaps identified by the NCSA in relation to Guyana's ability to meet its obligations under the UNFCCC and the Kyoto Protocol are summarized in Table 7.1 below.[231]

While some progress has been made in addressing at least some of these constraints (e.g. the establishment of the Office of Climate Change), many of the gaps remain and are symptomatic of a broader range of issues, principal among which is a lack of funding and the technical capacity to harmonize policy and legislative frameworks, enforce regulation and ensure that climate change mitigation and adaptation is more effectively mainstreamed into policies, plans and programmes.

Some of the general and cross-cutting gaps and constraints in Guyana's implementation of the

[229] The NCSA was an UNDP/GEF Enabling Activity Project in the three thematic areas of Biodiversity, Climate Change and Desertification/Land Degradation. Guyana published its NCSA Report in March 2007.

[230] Environmental Protection Agency (2007). Guyana National Capacity Self-Assessment Report. Part I. PIMS 2864.

[231] Environmental Protection Agency (2006). Stock-Taking and Thematic Assessment United Nations Framework Convention on Climate Change. National Capacity Self-Assessment Project prepared for Environmental Protection Agency, Guyana 5 July 2006.

Revised Final [online] available at http://ncsa.undp.org/docs/337.pdf (accessed 30 October 2011).

UNFCCC that were identified during the process of preparing the SNC are set out below in Table 7.1.

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Table 7. 1. Gaps and constraints to implementation of the UNFCCC as identified in the NCSA

Convention Article	Gaps
Article 4.1(a): National Inventories	National greenhouse gas inventory not regularly updated
Article 4.1(b): National and Regional Mitigation Programmes and Adaptation Measures	Absence of a national mitigation programme and national adaptation measures
Article 4.1(c): Mitigation Projects	Climate change mitigation not sufficiently mainstreamed into key sectors such as the industrial, mining and agricultural ones
Article 4.1(d): Promotion of Sustainable Management	Project-based implementation of study findings is lacking
Article 4.1(e): Preparing for Adaptation	Plans not widely implemented
Article 4.1(f): Climate Change Considerations in National Planning	Absence of a programme for placing climate change considerations into socio-economic policies and actions
Article 4.1(g): Promotion and Co-operation in Research	No agency/institution has been tasked with the responsibility for research co-ordination. Insufficient coverage of meteorological stations to monitor the climate system Lack of a Climate System Data Archive
Article 4.1(h): Exchange of Information	Absence of a clearing-house mechanism to facilitate the exchange of information on climate change, and the implementation of laws and regulations
Article 4.1 (i): Education, Training and Public Awareness	A plan to execute an education programme needs to be acted on. Limited participation in training opportunities and public awareness activities
Article 4.5: Development and Enhancement of Endogenous Capacities	Information availability to Guyanese not adequate Policy in seeking developed country assistance not in place
Article 4.8: Consideration of Necessary Actions	Programme of actions related to funding, insurance, and transfer of technology not available
Article 5: Research and Systematic Observation	International and intergovernmental efforts to strengthen national scientific and technical research capacities and capabilities very limited Knowledge of weaknesses in the Guyanese capacity and capability areas not documented
Article 6: Education, Training and Public Awareness.	A co-ordinated programme is not available Low rates of staff retention and institutional memory
Article 12: Communication of Information related to Implementation	Projects for financing not submitted to the UNFCCC COP

7.1.2 Policy

Recent strategic developments to integrate climate change into national policies, plans, and programmes include the National Development Strategy 2001-2010, the Low Carbon Development Strategy (2010), and the establishment of the Office of Climate Change, National Climate Committee, and a REDD Secretariat. While these developments have significantly strengthened the climate change policy context in Guyana, a number of important national policies with a strong bearing on climate change are absent. These include a National Risk Management Plan, a National Land-Use Policy and Plan,[232] a National Transportation Strategy, and a comprehensive Energy Plan, which builds on the Energy Policy of 1994. Furthermore, with the vast renewable energy potential of the country, there is scope for developing a policy aimed at increasing the competitiveness of renewable energy through, for example, feed-in tariffs and portfolio standards, etc.

While the national policy context has been strengthened, a serious gap has been the **failure to establish mechanisms for successfully implementing many of the objectives**. There is a need to develop additional revenue streams for ensuring the measures can be implemented.

One of the key underlying issues is the **lack of a co-ordinated policy framework** to ensure that climate change considerations are mainstreamed into sectoral and national development policies. While the LCDS provides an overarching framework for low carbon development, more effort is required to ensure that climate change risks are fully understood and routinely accounted for in decision-making. Furthermore, insufficient harmonization of policies leads to overlapping mandates among institutions, and limited understanding of roles and responsibilities and stakeholder involvement as these relate to achieving the overall objectives of the UNFCCC.

There is a need to develop sector-specific and site-specific mitigation and adaptation plans, which take into account bio-physical and economic vulnerabilities and opportunities. The need is especially pronounced where communities are facing increasing vulnerability as a result of climate change.

Where sector-specific or site-specific adaptation and mitigation action plans have been developed, these have often not been implemented due to a lack of human resources and financial capital. As a result there are important mitigation and adaptation strategies, which have been identified for over a decade, but have not been implemented.

7.1.3 Institutional

The creation of the Office of Climate Change (OCC) within the Office of the President has strengthened Guyana's institutional capacity to address climate change. However, the **institutional framework remains fragmented,** and its capacity to address an inherently cross-sectoral issue remains a significant barrier.

While the Office of Climate Change (OCC) has been established to support activities relating to climate change, including climate change adaptation, mitigation and forest conservation, the remit of many other agencies with a responsibility for environmental and natural resource management does not presently extend to climate change. This means that many of the opportunities for mobilizing

[232] A national Land Use Policy has been drafted but is yet to be approved by Cabinet, and a National Land-Use Plan is presently being formulated.

resources for mitigation and/or adaptation measures are overlooked (e.g. sharing of data on climate and flood risk), as the linkages between activities are not recognized. Ultimately, a lack of joined-up thinking results in higher costs of management and communication, in an already financially deficient institutional network.

Capacity constraints within agencies also present a significant barrier. There is limited availability of the skilled staff necessary to undertake and communicate research, implement policy actions, and monitor progress. These issues are especially pronounced at the municipal level in Guyana.

7.1.4 Technical

Guyana has limited human resources and technical capacity for climate change management.

Energy demand per capita in Guyana can reasonably be expected to increase as the economy grows. There is therefore a need to decarbonize the energy infrastructure and to significantly increase renewable energy capacity. Significant barriers exist in Guyana to realizing this goal, such as:

- An absence of technical expertise for developing, operating and maintaining renewable energy from sources such as hydropower, and an absence of technologies to mitigate emissions from the energy, transport, waste, and agricultural sectors
- Difficulty in accessing renewable energy and mitigation technologies due to their high cost
- Insufficient access to monitoring technologies, such as GIS mapping, and technical expertise; and
- lack of technical expertise and necessary technologies for compiling GHG inventories.

Similar issues exist with regard to adaptation. More specifically, there is limited technical capacity to:

- Undertake and interpret regional climate change projections
- Conduct research on the vulnerability of key sectors and regions to the impacts of climate change
- Implement and maintain the technologies and equipment necessary to monitor climate and climate-related impacts
- Develop technologies, such as sea defences, irrigation systems, and early warning systems, which are critical to successful climate change adaptation.

7.1.5 Financial

Addressing climate change issues requires significant financial resources. National financial support for climate change related activities is currently insufficient. Agency budgets do not contain direct allocations for climate change issues, so these projects are mainly financed/co-financed by donors and multi-lateral lending agencies such as the World Bank, Inter-American Development Bank (IDB), UNDP and GEF.

The absence of adequate financial resources is cited as one of the major barriers to implementing climate change mitigation and adaptation policies. Financial barriers include the following:

- High costs of new technologies
- Limited concessional project finance
- Restrictions on foreign investment

- Lack of financing instruments/systems and difficulties in securing credit and loans from commercial banks, especially for unproven technologies

- Weak or absent price signals (e.g. tiered water and energy tariffs that discourage wasteful use), and barriers to introduction of technologies (e.g. energy efficiency options)

- Weak competition (particularly in the energy supply sector) that reduces incentives to innovate, and potentially erects barriers to new entrants (e.g. independent electricity producers who wish to sell to the grid have little bargaining power; they are price-takers)

- Limited market size to justify investment (e.g. in recycling or composting technologies, etc.)

- Import tariffs (including import restrictions) and intellectual property issues; and

- Some unsupportive macroeconomic policies, particularly import regulations.

A further significant constraint to the implementation of the Convention is a lack of public awareness of the threat of climate change and the actions that may be taken to mitigate the adverse impacts of change, particularly as these affect vulnerable coastal communities and agricultural land.

7.2 Sectoral Gaps and Constraints

7.2.1 GHG Inventory

There are a number of uncertainties pertaining to the GHG inventory (GHG-I) for Guyana. All sectors have a paucity of activity data and almost all conversion and emission factors used in the GHG-I are default values extracted from the IPCC guidelines and the EFDB database.

The main constraints are related to lack of quality data and information, and the lack of expertise in the respective sectors. Due to the unavailability of relevant data, assumptions were made and data obtained from secondary sources.

Some of the key challenges encountered in preparing the GHG-I include:

- Data limitations, including lack of disaggregation into categories consistent with the IPCC 2006 GHG Inventory methodology, and unavailability of activity data for certain years

- Lack of local emission factors (hence the default values from the IPCC (1996; 2000; 2006) Guidelines and the IPCC Emission Factors Data Base (EFDB) were used

- Gaps in knowledge and skill in understanding the relationship between processes or activities and emissions released

- Lack of centralized activity data collection and compilation in all key sectors

- Lack of consistent historical data for relevant sectors such as forestry, agriculture and waste

- Financial constraints for the task of inventory preparation.

Guyana needs to develop the capacity to develop local emission factors for each of the relevant sectors and related activities, so that uncertainties in future inventories can be reduced. To do this, Guyana requires access to knowledge and best practice in collecting and verifying GHG emission data.

Controls that ensure the accuracy of the GHG data and information such as Quality Assurance (QA) and Quality Controls (QC) are required to ensure the integrity of data and information. For key sectors, such as LULUCF and energy, the relevant agencies should implement data collection and quality control procedures, including sectoral disaggregation of data.

It is recommended that each one of these agencies create a data management division to deal with GHG inventory statistics and controls. Furthermore, the Activity data to be collected, advisedly on at least a monthly basis, and the emission factors to be derived locally, including parameters and units of measurement, should be guided by the completed Worksheets submitted for all sectors, namely Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry and Waste.

7.2.2 Vulnerability and Adaptation

Climate modelling and weather forecasting

Guyana has limited capacity to undertake sophisticated climate modelling, particularly with regard to downscaling global and regional models, in order to develop a more detailed understanding of the likely impacts of climate change on different regions and sectors.

Furthermore, the hydrometeorological monitoring network is concentrated in the north and east of the country with relatively few inland monitoring stations, and especially sparse coverage in the southern part of the country. To increase the accuracy of forecasts, a representative network across the country is needed. However, significant resource constraints (including lack of funding for field staff and installation of automated weather stations) limit the extent to which the network may be extended.

Water resources

There is a need to increase understanding of the East Demerara Water Conservancy (EDWC) system and coastal lowland regimes, in order to reduce the vulnerability of extreme flooding in the country's low-lying coastal areas. There is also a need to strengthen the institutional capacity of the Government of Guyana (GoG) to manage water levels in the EDWC and to guide interventions aimed at reducing Guyana's vulnerability to floods. In regard to information, detailed topographic and land-use mapping, hydrologic modelling of coastal lowlands and assessment of EDWC system integrity, EDWC hydraulic modelling and pre-feasibility studies for coastal lowland interventions are needed.

Energy

Guyana has started a process to switch from total dependence on imported oil to energy generation with renewable sources, mainly hydropower. However, climate change threats, specifically droughts caused by an increase in temperature and a decrease in rainfall, could be a serious overturn for its energy stability, yet this vulnerability analysis has not been developed. For the development and stability of the energy sector under a climate change scenario, it is necessary to include climate variables in energy planning.

Agriculture and fisheries

Guyana lacks an adequate land-use plan (land-zoning strategy) in order to identify the best-suited land for sustainable agricultural expansion and diversification, so as to undertake climate change vulnerability studies on all the major crops that are threatened. Land-use planning may allow the identification of suitable alternatives for crop varieties where feasible, and the development of policies and measures to address the threats posed by climate change, specifically sea-level rise. The economic challenge for Guyana is to identify specific agricultural and rural development needs and opportunities, and to focus investment in areas where the greatest impact on adaptation, food security and poverty will be achieved (Caribbean Community Climate Change Centre, 2010).

Even though the main climate change impacts are identified, several factors limit the analysis of climate change impacts in fisheries, such as the uncertainties about how nutrient inputs and productivity will respond to warmer conditions, and how the species will respond to changing temperatures. Moreover, the lack of professional scientists, management, and data collection needs to be attended to in order to develop research that will allow the taking of adaptation policies and measures, considering the projected increase of temperature and change in rainfall that threaten fisheries by decreasing water quality and disrupting the ecosystem's dynamics.

Forestry

Data and information on the impact of climate change on forests is at present very limited. Further research needs to be undertaken to gather more information to enable decision-making in the future.

Coastal and marine

The lack of building codes and more effective coastal planning and management which consider climate change impacts, make the infrastructure, economic activities, and population along the coast vulnerable to sea-level rise and flooding. In order to have greater confidence in the results of the storm surge and sea-level rise projections that will most likely affect the coastal plain, a finer mapping resolution for modelling would be required, in order to have a more precise perspective of the economic and social actions required to face such events.

Human settlements

Due to this lack of effective coastal planning and management which consider climate change impacts, progressive abandonment of land and structures in highly vulnerable areas, and resettlement of inhabitants away from the coastline will be eventually needed, following adequate coastal planning and building codes. Effective adaptation will require a combination of enforceable regulations and economic incentives to redirect new settlement to better-protected locations and to promote investments in appropriate infrastructure, all of which require political will as well as financial and human capital. Avoiding policies that favour coastal development and imposing more effective coastal zone management could make a difference in the longer term.

Public Health

Strengthening of the public health system is necessary, particularly in light of climate change. There is a need for additional investment to strengthen key health functions and for forward planning to address the new challenges posed by climate change. This additional investment should include capacity building in the health system to extend services, and continuity of care to both mobile and remote populations. Also, more in-depth analysis of relationships between trends in climate and indicators of altered health risk (e.g. mosquito range) or health status (e.g. heat-attributable mortality) are needed.

The potential extension of brackish water ecosystems as a result of sea-level rise that could increase the spatial distribution of malaria is not known. Relationships between climatic factors and disease transmission, particularly dengue, need to be further investigated.

Updated vector distribution maps are important in assessing vulnerability and designing adaptation measures to address the spread of vector-borne diseases.

Tourism

Most of the tourism infrastructure is found on the coast, which is extremely vulnerable to the impacts of climate change, specifically from floods and storm surges. This must be considered in future planning decisions for the sector. Available studies that have examined climate change risk appraisal in tourism operators have consistently found low awareness of climate change and little evidence of long-term strategic planning in anticipation of future changes in climate (Simpson *et al* 2008); an issue that has to be dealt with at the national and local levels.

7.2.3 Mitigation

Despite Guyana's progress in developing strategies to address climate change, particularly the LCDS, and in attracting the investment necessary to implement measures to protect its valuable forest resource, several barriers exist to the introduction of climate change mitigation measures in Guyana. These include the costs of procuring and maintaining renewable and energy efficiency technologies, the financial feasibility of options, and limited availability and continuity of technical expertise within relevant institutions to design effective research and development programmes and policies, implement and measure their effectiveness, and operate and maintain mitigation technologies so that they work to their full potential.

Overcoming these barriers requires, in the vast majority of cases, taking steps to create an enabling policy environment. The draft LCDS is a promising start and has enjoyed strong and widespread support both within Guyana and internationally. However, significant effort and investment in institutional strengthening and reform, technical capacity building, education, and awareness-raising will be required for this model to succeed.

The barriers to the implementation of specific mitigation technologies and measures in each of the key sectors are highlighted in Table 7.2 below and described more fully in Chapter 3 (Mitigation and Abatement Analysis).

Table 7. 2. Barriers to implementation of mitigation and abatement initiatives

Sector	Suitable Technologies	Barriers to Implementing Technology
Renewable Energy	The most promising renewable technologies are hydropower, solar, and possibly wind.	Insufficient access to funds for project finance and the lack of adequate local capacity for establishing and maintaining the technologies. Lack of an enabling policy environment (e.g. use of feed-in tariffs) that encourages investment in renewable technologies .
Transport	The phasing-in of more fuel-efficient vehicles and improvements in the mass transport system	Barriers to an enhanced mass-public transport system include the topography, the cost-effectiveness of introducing such a system (limited population to serve), and commuter preferences. Additionally, significant investment would be required to improve road and communications infrastructure.
The Built Environment	Energy-efficient building codes and retrofitting guidance	Current proposed building codes do not incorporate energy efficiency measures and solely cover the integration of latrine and solar panels.
Agriculture Sector	Improved water management systems, including active irrigation and drainage of rice fields	Sea-level rise and changing climatic conditions are likely to result in salt-water intrusion and inundation of agricultural lands, putting additional stress on coastal defences and the irrigation and drainage systems. Financial and technical barriers exist to improving drainage and irrigation systems.
Waste	Composting, biogas, gas recovery systems Recycling	Inexperience and lack of technical knowledge regarding these technologies Possible barriers towards the development of recycling in Guyana include a weak institutional framework for waste management, poor enforcement of environmental law, limited knowledge about recycling practices and the lack of an adequate market (size of population) to justify the development of recycling plants. Absence of a dedicated technical and strategic advisory body on waste management to guide target achievements and advance GHG mitigation concerns
Land Use and Forestry	Sustainable Land Management Enforcement of mining, forestry and EIA regulations Land titling Forest monitoring	There is a need to increase institutional and community capacity to ensure compliance with the relevant legislation. Guyana lacks the necessary resources to monitor logging activities, especially where logging is conducted in remote areas that are difficult to access. Measures are therefore needed to help monitor and ensure compliance with the Code of Practice for Harvesting Operations. There is also an urgent need for implementation of a land-use plan for the country to act as a rational and transparent basis to designate areas for agricultural development, conservation, carbon sequestration and economic and urban development.

7.2.4 Public Education and Capacity Building

Awareness-raising is a fundamental pre-requisite for changing behaviours and encouraging the uptake of new technologies or more environmentally sustainable practices. There has been a drive over the years to provide training for various government ministries, agencies and institutions through workshops and regional and national courses. In addition, there has been a drive to raise public awareness of the climate change issue. A 2009 survey showed that general public awareness of the issue of climate change is relatively good. However, it also revealed that there is little public support for committing financial resources to help mitigate climate change impacts.

In addition, the Capacity Development and Mainstreaming for Sustainable Land Management Project has produced an Early Warning System (EWS) Study. The aim of the study was to provide training, conduct analyses of climatic vulnerabilities and conduct a situation analysis of early warning systems in Guyana. As part of the study, thirty four (34) stakeholders participated in a two-day EWS Training Workshop with three additional representatives from relevant agencies and one NGO representative. This workshop aimed to promote awareness of stakeholders' functions and mandates, and roles in one or more of the four early warning system components.

The Early Warning System (EWS) components are: monitoring and warning, communication and dissemination, response and knowledge. The Situation Report detailed the key vulnerabilities in Guyana and their priorities for further disaster response and preparedness; the gaps in data for hazard mapping and analysis; and the current status of the Agencies in regard to their roles, past impacts from disasters, and the degree of importance for an EWS to prevent and reduce impacts in the future.

There is a need to have more intense training in implementation of the EWS. The workshop raised the profile of the EWS but there is need to set up the EWS, enhance capacity, and develop an emergency response plan with stakeholders.

Despite the commendable efforts made by Guyana to disseminate information on climate change, several key barriers remain. These include:

- A general lack of public awareness and understanding of the consequences of climate change and, more specifically, of the important contribution that civil society action can make to mitigate the impacts of change. More effort needs to be placed on informing the public of climate change risks (including the costs of inaction) and the specific actions that may be taken to mitigate those risks.

- Inadequate training to inform appropriate responses to climate change, particularly at the municipal levels

- Limited research to meet both current and future challenges posed by climate change

- High rates of staff turnover within agencies and institutions.

7.2.5 Research and Systematic Observation

There are a number of ongoing areas of climate-related research within Guyana, yet further effort is required to improve understanding and monitoring of the impacts of climate change on key sectors and communities within Guyana, as well as on appropriate responses to address vulnerability and improve resilience to the effects of climate change. In addition to the sector-specific technologies and practices that may be implemented to help combat the threat of climate change, there are a number of other overarching research challenges that need to be addressed. These include:

- Improving climate models and scenarios at a detailed regional level, especially for extreme weather events, to reduce high levels of uncertainty
- Advancing understanding of 'good practice' adaptation measures through knowledge-sharing and sharing of information on feasibility, costs and benefits
- Enhancing co-ordination and collaboration on research efforts, both within and between countries (particularly amongst the small island developing states in the Caribbean region), to ensure the coherence of adaptation measures with other policy objectives and the appropriate allocation of resources.

Addressing these challenges will require institutional strengthening, improved data collection, sharing and integration, enhanced communication and the implementation of financial incentive (or disincentive) mechanisms to encourage the implementation of more energy-efficient, low carbon technologies, and to discourage wasteful use of resources.

The operation of systematic observation systems in Guyana is presently constrained by a number of factors including:

- Lack of technical capacity to operate and maintain equipment
- A lack of strong analytical skills or interpretative capacity to make use of the models and data that are generated
- Outdated and/or obsolete equipment and inadequate resolution of models
- Incomplete coverage of the observation network due largely to a lack of funding for staff to operate and maintain recording stations in remote locations
- Lack of financial resources to upgrade existing technologies and to provide specialized training in the use of new technologies
- The length of time it takes to repair or receive spare parts for faulty or damaged equipment.

7.2.6 Technology Transfer

The ability of the country to address the impacts of climate change in line with commitments under the UNFCCC depends on access to and availability of appropriate technologies. Most of these technologies require significant upfront investment and/or need to be accompanied by appropriate capacity enhancement.

Some of the common barriers to the transfer and implementation of technologies are described below in Table 7.3 together with suggestions for how these may be overcome.

Table 7. 3. Barriers and suggestions for overcoming barriers to technology transfer

Types of Barriers	Description of barriers	Suggestions for overcoming
Financial	High costs of new technologies	Giving priority to technologies with quick payback periods and guaranteed returns. Adopting a full-cost accounting approach – i.e. seeing whether high initial costs may be more than offset by the cost savings accrued over the life of the technology); international co-operation and knowledge transfer; international funding. Applications for concessional climate finance through Nationally Appropriate Mitigation Actions (NAMA), National Adaption Programmes of Action (NAPA), REDD technology transfer and other mechanisms
	Limited project finance; restrictions on foreign investment[233]	Closer collaboration with the private sector; borrowing from multi-lateral lending institutions (e.g. IDB); regulatory reform
	Lack of financing instruments/systems and difficulties in securing credit and loans from commercial banks, especially for unproven technologies	Regulatory reform to reduce levels of actual or perceived risk; co-operation with financial institutions such as the Inter-American Development Bank (IDB) on concessional finance; purchase of appropriate insurance cover
Economic / Market / Trade Constraints	Weak policy framework and consequently absent price signals (e.g. tiered water and energy tariffs that discourage wasteful use) and barriers to introduction of technologies (e.g. energy efficiency options)	Addressing market failures (e.g. through carbon taxation or other methods that encourage the uptake of more efficient technologies); changing pricing policies
	Weak competition (particularly in the energy supply sector) that reduces incentives to innovate, and potentially erects barriers to new entrants (e.g. independent electricity producers who wish to sell to the grid have little bargaining power; they are price-takers).	Strategic planning and interventions at appropriate level; regulatory reform to allow and encourage competition, e.g. Feed-in Tariffs (FiTs),[234] portfolio standards, auctions, and credits
	Limited market size to justify the investment (e.g. in recycling or composting technologies, etc)	Stimulating the creation of markets (e.g. through awareness-raising, incentives, regulation, etc); create

[233] The Heritage Foundation (2010). Index of Economic Freedom. Accessed online at www.heritage.org/Index/Country/Guyana on 29/01/2010.

[234] A feed-in tariff is a policy mechanism designed to encourage investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each different technology. Technologies such as wind power, for instance, are awarded a lower per-kWh price, while technologies such as solar PV and tidal power are currently offered a higher price, reflecting their higher costs.

		linkages with regional markets. Compost may be considered for use as a landfill capping.
	Import tariffs (including import restrictions) and intellectual property issues	International and bilateral negotiations, research partnerships etc., to ensure that critical technologies are treated as public goods
	Some unsupportive macro-economic policies, particularly import regulations	Changes in the macro-economic environment; improving financial and administrative efficiencies
Policy / Institutional	Lack of technical capacity to establish and maintain technologies	Communication and education; development of a critical mass of human capital via appropriate policies; development of adequate support for the national education system; international co-operation and knowledge transfer; technology-related capacity building (e.g. through study tours, short-term exchange studentships, etc.)
	Legal/regulatory barriers	Regulatory reform / tightening of regulatory standards
	Lack of a supporting/incentive-based policy framework for technology transfer	Policy and regulatory reform –.e.g. development of an explicit national policy supporting technology development. The draft LCDS goes some way to achieving this but regulatory reform (e.g. removal or reduction of import tariffs on ESTs) is needed to accompany the policy reform
	Absence, or weak enforcement, of feasible and appropriate standards (e.g. pollution, fuel efficiency, etc) based on local conditions	Establishing appropriate standards accompanied by effective enforcement measures
	Poor enforcement (e.g. of regulations around polluting activities, unsustainable logging practices, etc.) often due to lack of available human resources	Institutional strengthening; dedication of more resources towards monitoring and enforcement; legal reform giving relevant authorities (e.g. EPA, GFC) the 'power to act'
	Perceived lack of transparency[235]	Institutional reform; introduction of measures/incentives to promote good governance and transparency of transactions/agreements, etc
Technical / Technological	Technology not yet proven for local application	Implementation of small scale demonstration/trial projects; establishing research partnerships; examining possibility of trialling the technology/practice in other CARICOM countries Use of GIS for mapping of spatial/ geographic information and demonstration areas

[235] See, for example, www.heritage.org/Index/Country/Guyana

	Environmental constraints (e.g. topography, climate, etc.)	Selecting technologies that are suited to the local context
Information	Lack of technical information	Education; international, regional and local research partnerships and knowledge-sharing
	Lack of demonstrated track record for many emerging technologies	Implementing demonstration projects
	Lack of awareness of potential sources of funding support and credit	Establishing relationships with relevant regional partners for information sharing; commissioning a review of potential funding sources for priority technologies in different sectors
Social, Cultural, and Behavioural Norms and Aspirations	Social and cultural preferences impeding the uptake of new technologies	Awareness-raising, education, introduction of incentives to encourage environmentally-sustainable behaviour (e.g. through subsidies or payments for environmental services) or penalties for activities that directly or indirectly contribute to climate change (e.g. taxes, fines, etc.)
	Lack of awareness and social acceptance; insufficient understanding of the advantage of new technologies	Education and awareness-raising; implementation of demonstration projects
	Lack of confidence in the economic, commercial and technical viability of technologies and practices	Education and awareness-raising; implementation of demonstration projects

7. 3 Actions to Address Gaps and Constraints

Table 7. 4. Actions to address gaps and constraints

Priority Area	Existing Initiatives	Proposed Initiatives	Needs
Greenhouse Gas Inventory			
Improve the Quality and Consistency of Data	In preparation of the SNC, Guyana has produced a GHG inventory. CO_2, CH_4 and N_2O emissions from the energy, agricultural, industrial, land-use change and forestry, transport, and waste sector have been compiled. Nevertheless, a range of uncertainties and data gaps need to be addressed.	Introducing quality control and quality assurance measures More regular (monthly) and systematic collection of activity data Establishing data management divisions within GFC and GEA to deal with GHG inventory statistics and controls	**Technical:** Developing a GHG inventory data system aiming at collecting data in the required quality and format **Institutional: Encouragement of** data collection and sharing among the various national institutions and agencies. Specifically, the establishment of data management divisions within GFC, GEA, and the Ministry of Agriculture is necessary. Training of staff in data collection, data entry and implementation of quality control measures, and developing local capacities in using the new guidelines, methodologies, tools and software **Policy: Introducing** a legislative framework to obligate the private sector to report GHG emissions in the required format
Derivation of Local Emissions Factors for Key Sectors and Activities	While an emissions inventory has been compiled for the SNC, all sectors are plagued by the lack of activity data in some cases, and almost all conversion and emission factors used were default values extracted from the IPCC (1996; 2000; 2003; 2007) Guidelines and the EFDB database.	Training of staff within relevant agencies to allow them to develop local emissions factors for key emitting activities within each sector Conducting surveys, studies and scientific research aimed at developing disaggregated activity data and emission factors needed	**Technical:** Technical knowledge in developing disaggregated activity data for priority sectors to facilitate the derivation of local emission factors

		for the GHG inventory estimation, with special focus on key emission sources and sectors with high uncertainty Conducting studies with regional co-operation aiming at developing regional emission factors	
Climate Change Mitigation			
Reduce Emissions from the Power Generation Sector	The IDB provided a $5 million loan aimed at increasing the energy efficiency of Guyana's power sector and reducing distribution losses. The following RE projects are being developed/ have been implemented: A pre-feasibility study was completed in August 2001 for the Turtruba Rapids 760 MW hydro-power project. Optimization studies for Amaila Falls 100 MW hydro-project are presently in progress. PPA negotiations are currently in progress for an 11.4 MW wind farm	Increasing efficiency of the power generation sector and modernizing existing power plants and distribution networks Diversifying power supply through the development of renewable energy technologies Encouraging demand-side management through measures such as pricing, competition and subsidies	**Financial:** Funding required for undertaking feasibility studies, for developing RE technologies, and for increasing efficiency in existing power generation systems and distribution networks **Technical:** Transfer of renewable energy technologies and technical expertise **Policy:** Developing a comprehensive Energy Plan for Guyana which sets more ambitious goals, targets and measures in terms of renewable energy generation and demand reduction **Institutional:** Improving co-ordination between different administrative units and defining roles and scope of powers. The Guyana Energy Agency needs assistance to develop hydropower sites as well as to identify potential project developers and funding to take the projects forward from the feasibility stage. **Public awareness**: Increasing public awareness of the

	at Hope Beach. A number of small scale solar PV projects have been undertaken to provide health centres and hinterland communities with access to electricity. A Bagasse Co-generation Project		opportunities to reduce emissions and energy costs through demand-side management. Consideration of incentivizing demand-side management.
Reduce Emissions from the Transport Sector	No existing initiatives have been identified	Phase-in of more fuel-efficient vehicles Improvements in the public transport system	**Policy:** Change of import policies to encourage the importation of fuel-efficient vehicles. There is a need to develop a National Transportation Strategy, as well as Vehicle Emission Standards and other legislation that will contribute to the reduction of emissions from transport. **Financial:** Significant investment is required to upgrade the road and communication infrastructure, as well as the public transport sector. **Technical:** Access to new fuel-efficient vehicles and technical expertise to maintain these vehicles **Behavioural change**: Changing patterns of driving and attitudes towards the public transport system
Reduce Emissions from the Building Sector	New building codes are being developed, but they only cover the integration of latrine and solar panel into buildings, rather than developing a comprehensive energy conservation, efficiency and renewable energy framework for the built environment.	Developing energy efficiency building codes and energy-efficient retrofitting guidelines Ensuring access to appropriate technologies, such as energy-efficient cooling devices, more efficient lighting and cooking appliances	**Technical:** Best practice technical expertise in energy efficient design, specific to the Guyana climate **Policy:** Producing energy-efficient building codes and retrofitting guidelines, and guidelines for the incorporation of on-site renewable energy systems **Institutional:** Identifying a single authority that will be

		Developing guidelines on the incorporation of appropriate renewable energy technologies into buildings	responsible for enforcing the building codes
Reduce Emissions from Agriculture	The Guyana Rice Development Board has developed a mitigation strategy for rice production using a new water management regime. The Agricultural Support Services Programme is rehabilitating the drainage and irrigation system in nine key areas in Guyana.	Encouragement of Sustainable Land Management Selection of more resistant cultivars and substitution of existing crops with varieties more resilient to new climatic conditions Implementing the mitigation strategy for rice production and improving water management systems	**Financial:** Financial assistance is required to ensure adequate drainage of agricultural lands and to implement soil and water conservation farming techniques. **Technical:** Access to technical best practice and technologies for improving irrigation, drainage, and sea defences, as well as new climate-change-tolerant food crops **Policy:** Finalizing the Draft National Land-Use Policy and the National Land-Use Plan, for Cabinet Approval Developing a framework to support sustainable land management at the farm and landscape level, which includes opportunities to leverage additional revenue streams **Knowledge transfer:** Providing farmers with best practice approach to soil and water conservation farming techniques
Reduce Emissions from Waste	No existing initiatives have been identified.	Composting, biogas and landfill gas recovery systems Recycling	**Financial:** Funding is required to develop mitigation technologies. Consideration of application for funds through the CDM. **Technical:** Access to relevant technologies and expertise in operating and maintaining technologies. **Policy:** Developing a strategy for minimizing emissions

			from waste and for safeguarding human and environmental health **Behavioural change**: Encouraging recycling and re-use in the residential and non-residential sectors
Land-Use Change and Forestry	Funding through the MOU with Norway to protect forest ecosystem services Efforts have been made to provide hinterland communities with legal ownership over certain areas of forest. Code of Practice for Harvesting Operations encourages good practice in Sustainable Forestry Management (SFM) and legality The GFC community forestry development programme capacity building sessions have been and continue to be held with communities in forest law, forest inventory, and management.. Mining regulations have been developed, which afford some level of protection to the forest. Deforestation due to agricultural expansion has been maintained at a low level. Carbon sequestration studies have	Sustainable Land Management Enforcement of the mining, forestry and EIA regulations Continued efforts relating to land titling Forest monitoring, reporting and verification (MRV) system Finalizing the Land-Use Policy and Plan	**Financial:** Guyana lacks the necessary resources to monitor logging activities, especially where logging is conducted in remote areas that are difficult to access. Measures are therefore needed to help monitor and ensure compliance with the Code of Practice for Harvesting Operations. Funding is required to maintain low degradation to forest services and to eventually enhance forest ecosystem services. **Technical:** Acquiring more advanced forest mapping and monitoring technologies such as remote sensing, accompanied by training in their operation and maintenance, and interpretation of their outputs. **Policy:** Finalizing the Draft National Land-Use Policy and the National Land-Use Plan, for Cabinet Approval . Developing a framework to support sustainable land management at the farm and landscape level **Institutional:** Institutional and community capacity needs to be built so that the existing forestry, mining and EIA policies are properly enforced.

	been undertaken.		
Climate Change Adaptation			
Climate Modelling and Weather Forecasting	A hydrometeorological monitoring network exists, but is concentrated in the north and east of the country, with relatively few inland monitoring systems, especially in the southern part of the country.	Developing a representative hydrometeorological monitoring network across the country Developing climate change projections at the local level	**Financial:** Funding is required for automated weather stations and field staff. **Technical: T**echnical expertise in downscaling global and regional climate models to specific regions and sectors within Guyana
Water Resources	The Conservancy Adaptation Project (CAP) aims to help protect the coastal population currently vulnerable to annual flooding. The Agricultural Support Services Programme provides support to rehabilitate and expand the present drainage and irrigation network in nine project areas, covering an area of over 40,000 hectares in the agricultural belt.	Maintaining and upgrading drainage systems Maintaining and reinforcing the ocean sea-wall which protects most of the low-lying coastal areas from the Atlantic Repairing the Conservancy which protects Georgetown and most of the East Coast from overflow water	**Institutional:** There is a need to strengthen institutional capacity of the GoG to manage water levels in the EDWC and to guide interventions aimed at reducing Guyana's vulnerability to floods. **Financial:** Funds for upgrading the irrigation and drainage system and improving sea defences **Research:** Detailed topographic and land-use mapping, hydrological mapping of coastal lowlands, assessment of EDWC system integrity, EDWC hydraulic modelling and pre-feasibility studies for coastal lowland interventions are necessary.
Energy	No existing initiative on assessing and reducing the vulnerability of the energy sector to the impacts of climate change has been identified.	Assessing the impact of climate variability and extremes on energy infrastructure and incorporating this into planning. Assessing the impact of climate change, specifically drought, on proposed hydropower schemes	**Institutional:** Improving climate change knowledge within relevant institutions **Research**: Understanding climate change risks to existing energy infrastructure and future renewable energy infrastructure, particularly hydropower. **Financial:** Funds are required to undertake the relevant assessments.

Agriculture and Fisheries	The Agricultural Support Services Programme provides support to rehabilitate and expand the present drainage and irrigation network in nine project areas, covering an area of over 40,000 hectares in the agricultural belt. The Agricultural Diversification Programme aims at creating a three-commodity chain: fruits and vegetables, aquaculture, and beef to ensure food security. Establishment of a Climate Change and Agricultural Adaptation Unit (linked to the LCDS)	Protecting agricultural lands from the impacts of climate change Developing climate-resilient cultivars and crops Encouraging sustainable agricultural practices to conserve water and soil resources Detailed assessment and modelling of the impacts of climate change on fisheries, and the development of adaptation measures	**Policy:** Finalizing the Draft National Land-Use Policy and the National Land-Use Plan, for Cabinet Approval **Technical:** Access to climate-resilient agricultural crops and implementation of measures to protect agricultural lands **Financial:** Funds to undertake climate change assessments and to develop resilience in the agriculture and fisheries sector
Forestry	The use of forestry ecosystems is now being monitored and regulated, and the implementation of the Guyana Mangrove Restoration Project has had an important positive impact in the protection and restoration of mangrove ecosystems. Funding secured for reducing emissions from deforestation and degradation will benefit adaptation as well as mitigation efforts.	Undertaking research and monitoring of the impacts of climate change on forests to inform decision-making.	**Financial**: The period of EU funding for the Mangrove Restoration Project ends in 2012. Further funding needs to be secured to ensure implementation of the action plan post-2012. **Technical:** Data and information on the impacts of climate change on forests need to be developed. **Policy:** Incorporating climate change impacts into decision-making
Coastal and Marine	Vulnerability assessments of the coast were undertaken through the Caribbean Planning for Adaptation to Climate Change (CPACC) Project.	Development of higher resolution climate models and impact assessments to inform coastal planning and management	**Financial**: Funding is required to improve sea defences and irrigation and drainage infrastructure. **Technical:** Construction, maintenance and reinforcement of sea defence and water infrastructure:

	More recently, the IDB and UNDP funded a project to strengthen the national and local capacities for disaster response and risk reduction. The project seeks to develop capacities of the national emergency management agencies (Civil Defence Commission and line ministries) to co-ordinate disaster response effectively. Furthermore, it aims to strengthen communities' capacities in disaster risk assessment and response planning. The Guyana Mangrove Restoration project aims to restore coastal mangroves.	Maintaining and improving both natural and artificial sea defences to protect coastal areas	sea-walls, drainage, upgrading of the East Demerara Water Conservancy **Policy:** The formulation and implementation of land-use planning policies to address the location of infrastructure, housing schemes, agricultural development schemes and other land uses such as commercial and industrial, to reduce risk of inundation deriving from sea-level rise and storm surges, and to strengthen resilience. Mainstreaming adaptation measures into the integrated coastal zone management plans (ICZM) and urban planning; developing new building codes that include risk assessment; implementing of an emergency response plan and upgrading early warning systems A Coastal Zone Management System needs to be developed to monitor and create an inventory of coastal resources to determine risk, and to monitor development in the vulnerable coastal plain. **Research:** Developing climate change scenarios and impacts using more accurate data, smaller scales and methodologies
Human Settlements	No specific initiatives have been identified. However, projects to improve sea defences will also protect human settlements.	Developing building codes, which encourage the design of a robustly built environment Development of an early warning system and evacuation procedures	**Policy**: Use of building set-backs legislation to limit buildings and other major developmental work on the coast and encourage gradual retreat to higher grounds **Research**: Undertaking detailed surveys to identify most vulnerable areas along the coast, such as the Port of Georgetown There is a lack of a hazard map for flooding, erosion, etc. for vulnerable areas in Guyana, but SIDS and other countries prepare hazard maps for risk analysis.

			Technical: Development of a comprehensive early warning system and technical expertise to maintain and operate it **Policy:** A National Land-Use Policy and the National Land-Use Plan which stipulates the most appropriate area for new buildings, taking into account climate change predictions Incorporation of measures into building codes to encourage climate-resilient design and construction **Financial**: Funds for the formal early warning system and for running an EWS awareness programme with the general public for disaster planning and response
Public Health	No initiatives that relate specifically to climate change and public health have been identified.	Undertaking research into the impact of climate change on public health and developing appropriate adaptation plans Extending medical care to mobile and remote populations	**Financial**: Additional investment is necessary to strengthen key health functions and to undertake research. **Research:** Undertaking research into the relationship between climate change and health risk, especially relating to the threat of malaria **Institutional**: Improving medical care facilities for remote and mobile populations
Tourism	No existing initiatives have been identified	Improving awareness within the tourism sector of the implications of climate change on their sector	**Capacity building**: Enabling the tourism sector to respond to the threats posed by climate change

Capacity building and public education			
Capacity Building	There has been a drive since the publication of the INC to provide training for various government ministries, agencies and institutions through workshops and regional and national courses.	Improving knowledge within the relevant public sector departments on the impacts of climate change and on potential adaptation and mitigation strategies	**Institutional:** There is need for greater collaboration among agencies that address climate change issues. There is a need to enhance the capacity of key agencies operating at the national and community levels. Further strengthening of the Hydrometeorological Services Department for improved climatological monitoring and forecasting, and capacity building in the area of climate change modelling **Technical:** Technical and academic support in developing climate change projections for the national and sub-national level. Training in various agencies, so these are better equipped to monitor the impacts such as erosion, inundation, along with changes in pest abundance, health signals, changes in fisheries, rice and sugar yields **Policy:** Developing a policy paper that will outline an agenda for climate research in Guyana, which will inform policy development and review
Public Education	The Public Education Programme and Implementation Strategy aims to build the capacity of the citizens of Guyana to take actions (individually and collectively) to mitigate and adapt to climate change.	Creating a higher level of public awareness and understanding of climate change issues	**Financial:** Economic resources are needed to support a wider public education programme.

7.4 Financial Resources and Technical Support

Until recently, one of the most persistent barriers to the implementation of activities to assist Guyana in its efforts to mitigate and adapt to climate change has been a lack of funding. However, there are now several potential sources of funding for which Guyana is eligible, and which could assist in leveraging funds for investment in, and deployment of, low carbon technologies and adaptation measures.

These include financial support pledged by the Government of Norway, as well other potential interim REDD+ agreements, the GEF Trust Fund, the Clean Technology Fund (CTF), the Global Energy Efficiency and Renewable Energy Fund (GEEREF), and initiatives arising from the Copenhagen Accord including the Copenhagen Green Fund. However, Guyana would benefit from more effective systems to ensure transparency and accountability in the use of funds mobilized from these, and other, sources. The UNDP and the World Bank have set up a website[236] to help navigate the different multilateral climate finance funds that are currently available. Eventually, once the Green Climate Fund[237] is set up in a few years' time, it is likely that many of the available funds will be bought under its umbrella.

[236] See http://www.climatefinanceoptions.org/cfo/index.php

[237] At COP 16 held in Cancun, Mexico, the COP adopted decision 1/CP.16 in which it decided to establish a Green Climate Fund, to be designated as an operating entity of the financial mechanism of the Convention. The Green Climate Fund will support projects, programmes, policies and other activities in developing country Parties using thematic funding windows. See http://unfccc.int/cooperation_and_support/financial_mechanism/green_climate_fund/items/5869.php

7.4.1 Existing Financial Assistance

Guyana has received funding from various sources to support activities relating to climate change mitigation and adaptation. As stated in the LCDS, Guyana will continue to seek funding from the international community and will particularly target funding for climate change adaptation.

The GEF has supported Guyana in implementing the following climate change activities:

- Preparation of its Initial National Communication to the UNFCCC (US$196,700 from the GEF Trust Fund, 1997)
- Preparation of the Second National Communication to the UNFCC (US$455,000)
- National Capacity Self-Assessment for Global Environmental Management, including climate change (US$200,000 from the GEF Trust Fund, 2004)
- Conservancy Adaptation Project (US$3.8 million from the Special Climate Fund, 2008)

The GEF also funded the Early Warning System Study (see Section 3.4), the objective of which was to provide decision-makers with a comprehensive analysis-based set of options for the introduction of early warning systems appropriate to the Guyana situation, while enhancing the local knowledge base in such systems. A subsequent project funded by the IDB and UNDP sought to strengthen the national and local capacities for disaster response and risk reduction through capacity building in the national emergency management agencies, and through strengthening resilience in communities. The Capacity Development and Mainstreaming for Sustainable Land

Management Project also provided approximately US$46,000 for the EWS Study, with support from the Guyana Lands and Surveys Commission.

The Guyana REDD+ Investment Fund

The Guyana REDD+ Investment Fund (GRIF) is a multi-contributor trust fund for the financing of activities identified under the LCDS. Pending the creation of an international REDD+ mechanism, the GRIF represents an effort to create an innovative climate finance mechanism which balances national sovereignty over investment priorities while ensuring that REDD+ funds adhere to the highest internationally recognised standards for financial, environmental and social safeguards. The GRIF was established in October 2010, with the World Bank as Trustee, following the agreement signed between Guyana and Norway in November 2009.

The World Bank

The World Bank Country Assistance Strategy (CAS)[238] lays out the financial support the World Bank provides to Guyana. In relation to climate change, the Bank is presently supporting the Conservancy Adaptation Project (funded by a US$3.8 million grant from the Global Environment Facility –see above), which seeks to reduce the vulnerability to catastrophic flooding in low-lying coastal areas that are threatened by sea-level rise. In addition, the Bagasse Co-generation Project (US$2.6 million) is helping mitigate global climate change by facilitating the use of market-based mechanisms sanctioned under the Kyoto Protocol that support clean energy projects in Guyana. The Bank has also outlined in its CAS, its intention to assist Guyana's efforts to protect forests (mitigation) and prevent natural disasters (adaptation). On the mitigation side, the Bank will accompany the country's efforts to reduce carbon emissions from deforestation and help negotiate external resources in return. (Readiness Grant from the FCPF currently being processed -US$2 million). The Bank believes that an IDA project supporting sustainable forest management would complement Guyana's participation in the FCPF. This IDA project would: (i) help strengthen the capacities of national institutions in charge of forest protection and management; and (ii) support community-based forest management initiatives undertaken by local and indigenous communities. Overall, the project would promote multipurpose forest management, including new systems of payments for carbon and other environmental services (water regulation and biodiversity conservation). Given the size of the challenges and budget limitations, this project would work on a pilot scale and help develop methodologies that can later be replicated and scaled-up. The FCPF and IDA support might also be complemented by a possible grant from the Japanese Social Development Fund (JSDF) to promote community-driven enterprises in Guyana, and, possibly, by a grant from the Global Environment Facility (GEF) to protect forests and biodiversity and mitigate climate change.

[238] World Bank (2009). International Development Association Country Assistance Strategy for Guyana for the Period FY 2009-2012. Caribbean Country Management Unit Latin America and Caribbean Region. [Online.] Available at http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2009/05/22/000350881_20090522101401/Rendered/PDF/479830CAS0P106101Official0Use0Only1.pdf?bcsi_scan_AB11CAA0E2721250=ANIErUk3cxYr5cen9D6Sua2VSYscAAAAZ4O+FQ==:1&bcsi_scan_E956BCBE8ADBC89F=8FZxJ1kZ5oSRMeveWRvnrbrRc3s6AAAAKRJ4Jw==&bcsi_scan_filename=479830CAS0P106101Official0Use0Only1.pdf (accessed 30 October 2011).

Inter-American Development Bank (IDB)

The IDB provides a range of financial assistance to Guyana. Guyana has registered two relevant projects for financial assistance from the IDB, including the proposal to build and operate a hydropower project at Amaila Falls, and Institutional Strengthening in support of the LCDS. The IDB has approved a number of other projects which contribute to efforts to address climate change. These are summarized in Table 7.5 below.

Bilateral donors

The most important bilateral donor to Guyana is Norway, with which it signed a Memorandum of Understanding that set out how the two countries will 'work together to provide the world with a relevant, replicable model for how REDD+ can align the development objectives of forest countries with the world's need to combat climate change.' The agreement is worth up to $250 million over the period up to 2015, and will be based on achieving specific goals.

The Country Strategy Paper for Guyana (2008-2013)[239] presents the strategic framework for co-operation between the European Commission (EC) and Guyana under the Tenth European Development Fund (EDF). EC assistance under the Tenth EDF concentrates on macro-economic support as well as continued support to the Guyana sea defence and coastal management programme. The EC's total allocation (2008-2013) foreseen for Guyana to address these priorities amounts to €55.4 million. This includes funding for the Guyana Mangrove Restoration Project[240] which commenced in February 2010 and is expected to run for a duration of 48 months, depending on the availability of alternative funding sources once the EU funds expire in 2012. The overall objective of the mangrove restoration project is to respond to climate change and to mitigate its effects through the protection, rehabilitation, and wise use of Guyana's mangrove ecosystems, through processes that maintain their protective function, values and biodiversity, while meeting the socio-economic development and environmental protection needs in estuarine and coastal areas.

7.4.2 Financial needs

In order to implement priority adaptation and mitigation strategies, further financial resources and access to technologies are required.

It has recommended that an indicative financing plan that signposts the financing and funding opportunities for climate change priorities be formulated. This should cover all available financing and funding opportunities including commercial bank loans, multilateral co-operation, financing by international organizations such as the World Bank, IDB, GEF and other climate-change related financing schemes such as the Clean Development Mechanism (CDM). In the first instance, Guyana needs to focus on creating an enabling environment for investment in climate change. This requires actions to strengthen the policy and regulatory framework (i.e. one that clearly sets the targets and intentions of the government and lays the groundwork for necessary policy instruments e.g. FiTs), build capacity within agencies to routinely evaluate and mitigate climate risks as part of decision-making, and provide the necessary incentives for private sector investment in mitigation and adaptation measures.

[239] See http://ec.europa.eu/development/icenter/repository/scanned_gy_csp10_en.pdf.
[240] See http://www.mangrovesgy.org/.

It is also increasingly recognized that *ad hoc*, project-based approaches to mobilizing resources will continue to yield insufficient results, and therefore a more comprehensive approach is advocated. One such approach is the development of strategies designed to mobilize a more diversified array of funding sources and mechanisms, along a longer-term time-line.

A more co-ordinated approach to policies, programmes and projects will also help ensure that available resources (internal and external) are used more efficiently and can be channelled towards achieving Guyana's UNFCCC implementation priorities. This requires that national action plans (including National Adaptation and Mitigation Plans) are grounded in broader country frameworks so that they are adequately considered in both the public budgeting process and in donor assistance strategies.

7.5 Conclusion

Like many developing countries, Guyana faces a number of challenges in implementing the requirements of the Convention. One of the most significant constraints is the lack of an overarching policy and institutional framework that ensures that climate change considerations are mainstreamed into both national and sectoral development plans and programmes, and which clearly defines the responsibilities of the various agencies in this regard. A harmonized policy and institutional framework should also help in identifying synergies between programmes and projects which in turn will facilitate resource mobilization and result in more efficient use of available resources.

The following are therefore the priority needs for implementation of the UNFCCC:

- **Improved co-ordination among various ministries and departments** in terms of addressing climate change. As climate change matters are being mainstreamed into national and state co-ordination and policy planning, the roles and mandates of respective agencies in addressing climate change will need to be more clearly defined.
- There is a lack of technical capacity/ scientific information/research and development to carry out vulnerability assessments and also implement mitigation options. One of the reasons is that there are insufficient **dedicated research programmes and funding to support decision-making** relating to addressing climate change.
- Eventually, the implementation of a strategy and action plan on climate change will require **an overall and comprehensive monitoring mechanism**. Information may lie with many implementing agencies. It is important to **share relevant information for decision-making** and mechanisms to do so are required. **Development of an integrated financing strategy or investment plan** that sets out the priorities for mitigation and adaptation, identifies existing resources (internal and external) and the ways in which these may be mobilized through, for example, policy and institutional reforms that result in a more co-ordinated approach to accessing public and private sources of finance.

Table 7. 5. Approved projects which address climate change

Project	Project Description	Funding Amount	Duration of Funding	Financing Type
Strengthening of Iwokrama Phase II	This project is designed to continue the Iwokrama Rainforest International Centre for Rainforest Conservation and Development (IICC) climate change science programme, together with the extension of IICC's core businesses, such as ecotourism, sustainable forest management, development of forests' natural services and the advancement of local community programmes.	US$500,000	Execution period: 12 months from 14 June 2011	Non-Reimbursable Technical Co-operation
Developing Capacities in Implementing REDD+	Developing capacity of the Guyana Forestry Commission, forestry-dependent communities, and other forest users in implementing REDD+	US$ 735,000	Execution period: 24 months from 8 December 2010	Non-Reimbursable Technical Co-operation
Amaila Falls Hydroelectric Project Preparation Studies	The Technical Co-operation is intended to partially cover the project preparation cost of the Amaila Falls Hydroelectric Project.	US$ 1,210,000	Not stated, approved 7 July 2010 and in the implementatio n phase	Technical Co-operation
Shadehouse Vegetable Production and Marketing	The broad objective is to provide rural households and the disadvantaged with the know-how, guidance, and support mechanisms to be self-employed entrepreneurs with sustainable low-cost shadehouse vegetable production facilities, as well as home-based vegetable production for the family.	US$ 101,500	Not stated, approved 9 October 2009 and in the implementatio n phase	Non-Reimbursable Technical Co-operation
Supporting Guyana's LCDS	Institutional strengthening of the three key institutions involved in the implementation of the LCDS: the Office of Climate Change, the Project Management Office, and the Guyana Forestry Commission.	US$ 5,940,000	Execution period: 12 months from 17 September 2009	Grant
Preparation of an Integrated Management Plan for Natural Disasters	The general objective of this TC is to provide support to the Government of the Co-operative Republic of Guyana for the design and implementation of a National Integrated Disaster Risk Management Plan, within the framework of comprehensive disaster management.	US$ 1,000,000	Not stated Approved 4 August 2009 and in the implementatio n phase	Non-Reimbursable Technical Co-operation

Measurement of Climate Change Impacts and Ecosystem Services in Iwokrama	This project is designed to formulate a new science programme at Iwokrama which will provide a series of studies, co-ordinated by a new resident scientist. The project will contribute to the provision of eco-system services, including carbon, watershed service, and biodiversity. A key element of the project is to implement field works and carry out the analysis and modelling of climate change.	US$ 229,500	Execution period: 12 months from 2 April, 2009 but still in implementation phase	Non-Reimbursable Technical Co-operation
Expanding Bio-energy Opportunities in Guyana	The Office of the President of Guyana has requested that the Bank provide it with assistance to improve the capacity of the Government to better respond to project proposals related to non-traditional energy sources, with particular emphasis on bio-energy, and to increase capacity within the Government in relation to bio-energy technology and research. The proposed TC addresses this request through complementary components that include (1) knowledge transfer; (2) design of a financial vehicle or instrument to develop viable investment opportunities; (3) dissemination of information related to the recommended financial vehicle or instrument and the identification of sources of funding for a pilot operation; and (4) capacity building and the transfer of technology.	US$ 675,500	Execution period: 36 months from 1 April 2008	Non-Reimbursable Technical Co-operation
Sustainable Forestry in Protected Areas	The goal of the project is to develop Iwokrama's timber operation as a successful pilot project for the development of a model of sustainable forestry for the region which is economically viable, whilst being socially responsible and environmentally friendly, thus providing revenues to ensure the financial sustainability of Iwokrama. The model can also apply to other similar protected areas interested in pursuing business development activities in order to achieve financial sustainability.	US$ 150,000	Execution period 12 months from 28 February 2008. The project has been completed.	Non-Reimbursable Technical Co-operation
Climate Change and Biodiversity Mainstreaming through Avoided Deforestation	This technical co-operation will contribute to enhancing knowledge regarding climate change on the basis of avoided deforestation, and its link to biodiversity.	US$ 150,000	Not stated	Technical Co-operation

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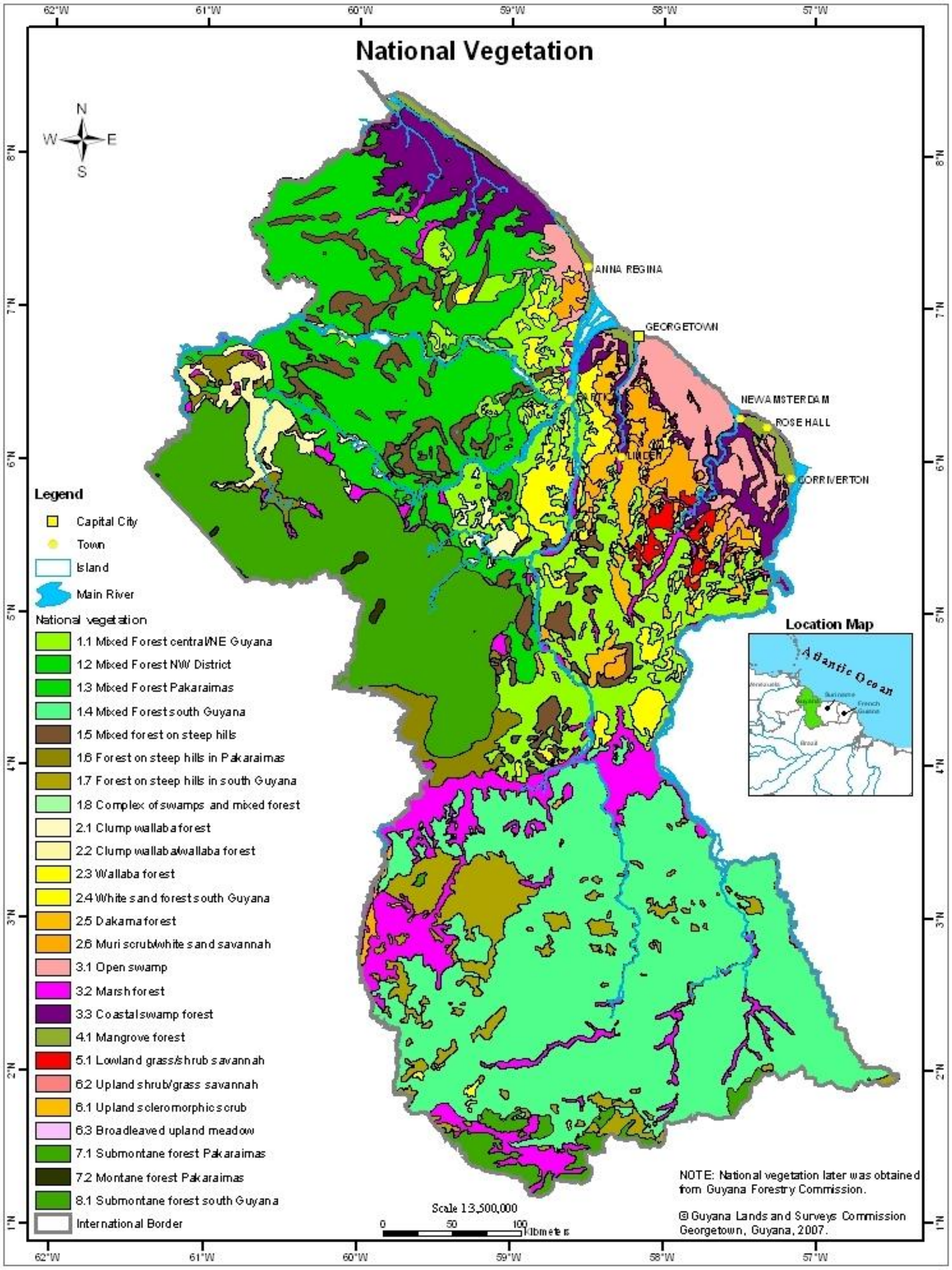
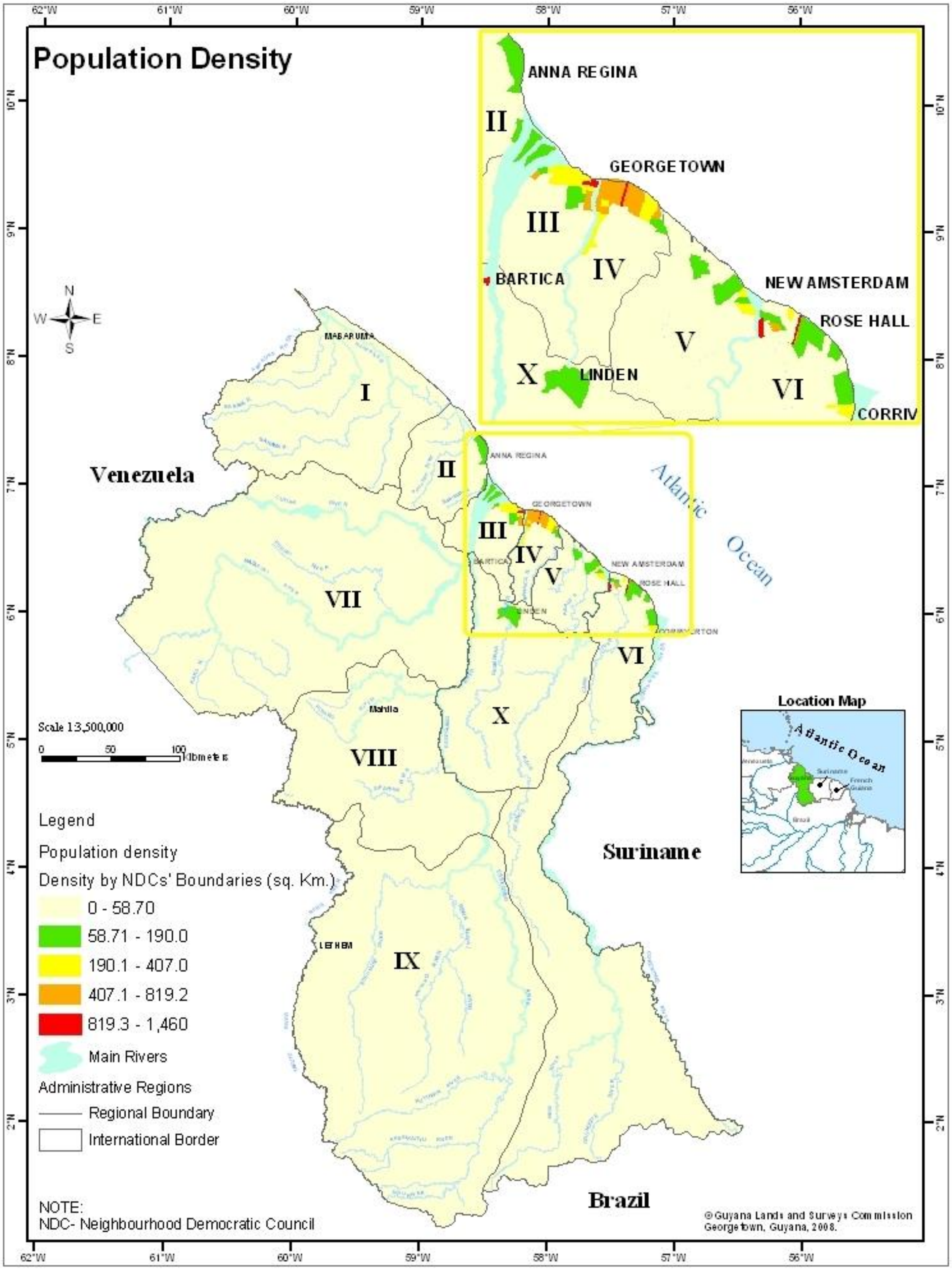
Appendices

Chapter 1. National Circumstances

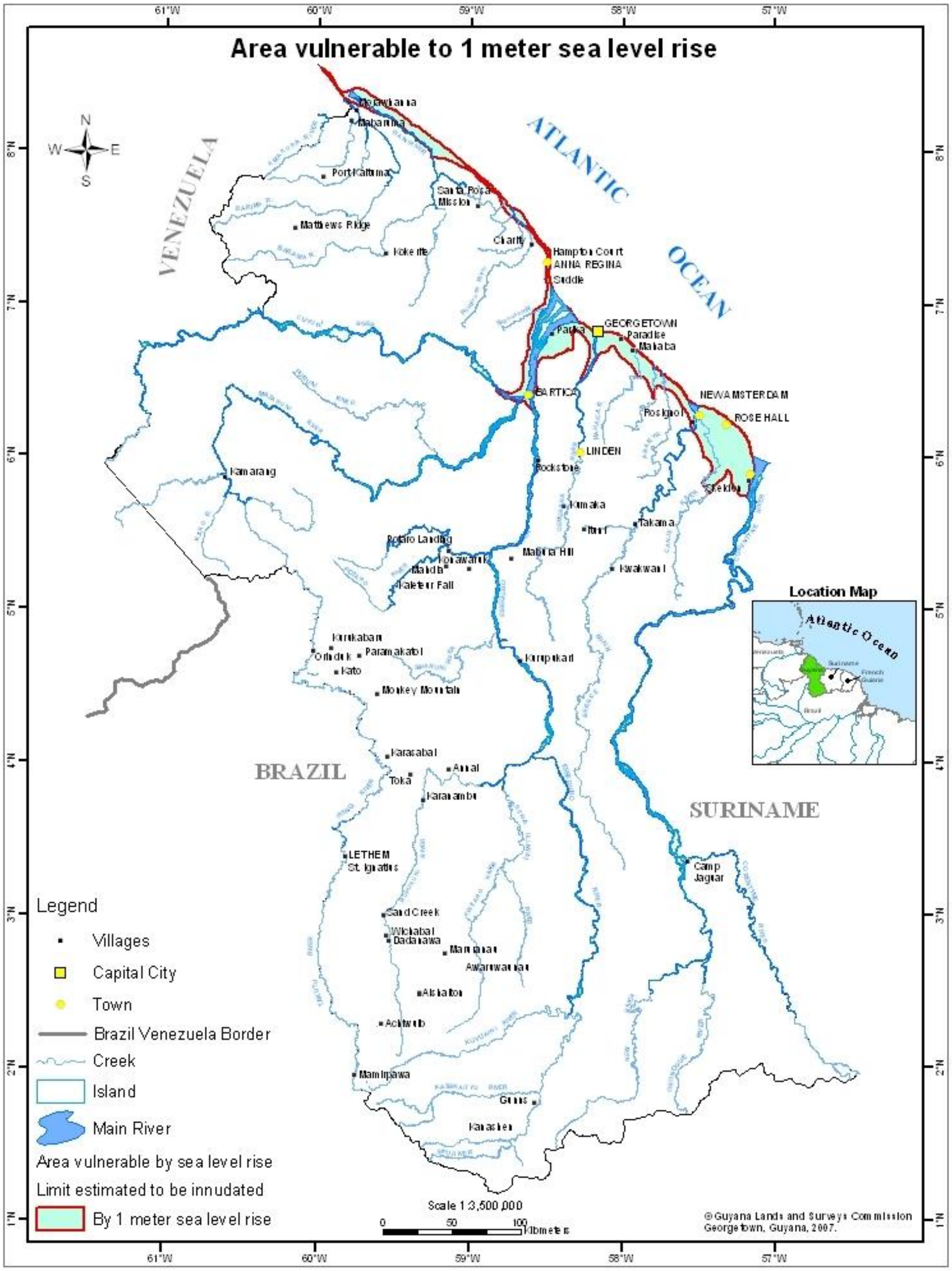
Appendix 1.1 National Vegetation Map



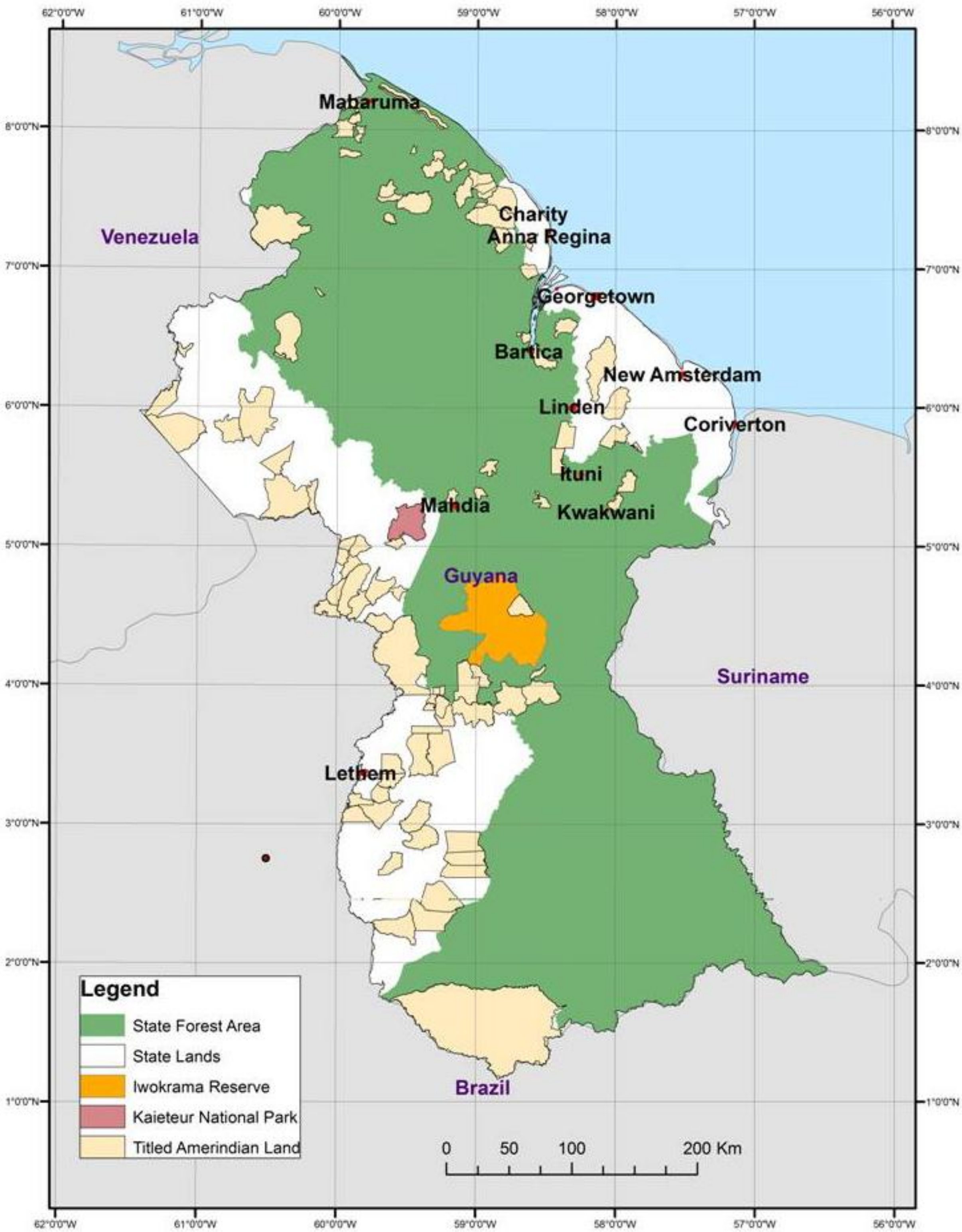
Appendix 1.2. Population Density Map



Appendix 1.3. Sea-Level Rise Vulnerability Map



Appendix 1.4. Land Classification Map



Appendix 1.5. Extract from the LCDS

Major benefits that Guyana can obtain if there is a favourable value placed on Guyana's Forests

Guyana will be able to invest in creating a low deforestation, low carbon, climate-resilient economy where:

- Guyana can avoid cumulative forest-based emissions of 1.5 gigatons of CO_2e (carbon dioxide equivalent which includes other greenhouse gases) by 2020, that would have been produced by an otherwise economically rational development path.
- REDD+ payments can enable Guyana's economy to be realigned onto a low-carbon development trajectory. Guyana can generate economic growth at or in excess of projected Latin American growth rates over the coming decade, while simultaneously eliminating approximately 30 per cent of non-forestry emissions through the use of clean energy.

To achieve this, Guyana must:

- Invest in strategic low carbon economic infrastructure, such as: a hydroelectricity plant at Amaila Falls; improved access to arable, non-forested land; and improved fibre optic bandwidth to facilitate the development of low-carbon business activities.
- Nurture investment in high-potential low-carbon sectors, such as fruits and vegetables, aquaculture, business process outsourcing and ecotourism.
- Reform existing forest-dependent sectors, including forestry and mining, where necessary, so that these sectors can operate at the standards necessary to sustainably protect Guyana's forest.
- Expand access to services, and create new economic opportunities for Amerindian communities through improved social services (including health and education), low-carbon energy sources, clean water, and employment which does not threaten the forest.
- Improve services to the broader Guyana citizenry, including improving and expanding job prospects, promoting private sector entrepreneurship, and improving social services with a particular focus on health and education.

- Guyana's people and productive land can be protected from changing weather patterns. Investments in priority climate adaptation infrastructure can reduce the 10 per cent of current GDP which is estimated to be lost each year as a result of flooding.

Main areas on which resources will be spent in the 2010-2011: Indicative Investment Plan (US$ millions)

	2010		2011	
	Min	Max	Min	Max
Amaila Falls Equity[50]	19	20	20	35
Amerindian Development Fund	4	8.2	4	12.3[51]
Amerindian Land Titling	3	3	3	3
Fibre Optic Cable	0	4.5	0	6.5
SME and Vulnerable Groups' Alternative Livelhihoods	1.5	3	1.5	5
International Centre for Bio-Diversity Research, Low Carbon Curriculum Development and IT Training	1	2	0	2
MRV and Other Support for LCDS[52]	1.5	3.2	1.5	3.7
TOTAL	30	43.9	30	67.9

Priorities for Adaptation

Total adaptation costs for Guyana are projected to exceed US$1 billion at the national level. While all of these adaptation needs must eventually be met, the Office of the President has identified a portfolio of urgent, near-term investments in the highest priority areas where the population and economic activity are concentrated. These are detailed in Section 9, and include:

- Upgrading infrastructure and assets to protect against flooding through urgent, near-term measures (US$225 million)
- Hinterland Adaptation Measures (US$10 million)
- Addressing systematic and behavioural concerns(US$33 million)
- Developing innovative financial risk management and insurance measures to resiliency (US$10 million).
- Switching to flood-resistant crops (US$10 million).

In addition to these urgent near-term measures, an additional US$500 million to $600 million of long-term adaptation measures have been identified, including:

- Upgrading the Conservancy to recognized engineered standards (US$410 million)
- Expanding beyond the priority regions in upgrading the seawall (US$15 million to $60 million); and
- Expanding the drainage and irrigation programme (US$30 million to $119 million).

Appendix 2.1. Tables for graphs.

Table A2. 1. Fuel imports and consumption and stock change ('000 bbls) for 1994

Year: 1994 FUEL	Imports ('000 bbls)	Consump-tion ('000 bbls)	Stock Change ('000 bbls)
Aviation Gasoline	18	16.5	1.5
Kerosene	239	211.4	27.6
Gasoline	547	576.3	-29.3
Fuel Oil	1095	1166.3	-71.3
Gas Diesel Oil	1125	1302.1	-177.1
LPG	71	68.6	2.4
Total	**3095**	**3341.2**	**-246.2**

Table A2. 2. Fuel imports and consumption and stock change ('000 bbls) for 2000

Year: 2000 FUEL	Imports ('000 bbls)	Consumption ('000 bbls)	Stock Change ('000 bbls)
Aviation gasoline	14	13.3	0.7
Kerosene	241	255.3	-14.3
Gasoline	708	722	-14
Fuel oil	943	944.5	-1.5
Gas diesel oil	1946	1950.9	-4.9
LPG	73	75.7	-2.7
Total	**3925**	**3961.7**	**-36.7**

Table A2. 3. Fuel imports and consumption and stock change ('000 bbls) for 2004

Year: 2004 FUEL	Imports ('000 bbls)	Consumption ('000 bbls)	Stock Change ('000 bbls)
Aviation Gasoline	8	8.3	-0.3
Kerosene	186	192.5	-6.5
Gasoline	748	748.4	-0.4
Fuel Oil	901	946.7	-45.7
Gas Diesel Oil	1927	1965.2	-38.2
LPG	131	130.6	0.4
Total	**3901**	**3991.7**	**-90.7**

Table A2. 4. CO_2 Emissions (Gg) from biomass using the reference approach: 1990 – 2004

Memo Item	1990 (Gg)	1991 (Gg)	1992 (Gg)	1993 (Gg)	1994 (Gg)	1995 (Gg)	1996 (Gg)	1997 (Gg)	1998 (Gg)	1999 (Gg)	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)
Total Biomass	1,487	1,487	1,487	1,487	1,487	893	959	1,571	716	716	716	716	716	716	716

Table A2. 5. CO_2 emissions by major source categories according to the sectoral approach (Gg and %) from biomass: 1994 – 1998 (Source: INC 2002)

Biomass Fuel	1994 (Gg)	1994 (%)	1995 (Gg)	1995 (%)	1996 (Gg)	1996 (%)	1997 (Gg)	1997 (%)	1998 (Gg)	1998 (%)
Firewood	82.44	6.6	83.20	5.4	85.59	6.4	87.35	5.3	87.01	7.0
Charcoal	1.69	0.13	1.45	0.09	1.08	0.01	0.59	0.04	0.60	0.05
Bagasse	1,132.94	90.1	1,418.43	91.9	1,199.59	90.1	1,516.68	91.4	1,090.08	88.1
Rice Husk	40.00	3.2	40.00	2.6	45.00	3.3	54.00	3.3	60.00	4.8
Total	**1,257.07**	**100**	**1,543.08**	**100**	**1,331.26**	**100**	**1,658.62**	**100**	**1,237.69**	**100**

Table A2. 6. CO_2 Emissions (Gg) from Memo Items: 1990 – 2004 CO2 Emissions from Biomass Fuels

Memo Items	1990 (Gg)	1991 (Gg)	1992 (Gg)	1993 (Gg)	1994 (Gg)	1995 (Gg)	1996 (Gg)	1997 (Gg)	1998 (Gg)	1999 (Gg)	2000 (Gg)	2001 (Gg)	2002 (Gg)	2003 (Gg)	2004 (Gg)
Internat. Aviation Bunkers	22	22	22	22	22	22	20	20	11	15	11	17	13	13	13
Internat. Marine Bunkers	4	4	4	4	4	8	8	8	8	8	8	8	8	8	8
Total	**26**	**26**	**26**	**26**	**26**	**30**	**28**	**28**	**19**	**23**	**19**	**25**	**21**	**21**	**21**

Appendix 3.1. Most promising hydropower sites, status, average power capacity

Most promising hydropower sites, status, average power capacity

Sites	Status	Av. Cont. Power (MW)[241]	Observations
Hosororo	Feasibility Study	0.015	
Eclipse Falls	Feasibility Study	4	
Tiboku	Feasibility Study	40	
Ikuribisi	Feasibility Study	0.7	
Tipuru	Tender Documents & Final Design	0.1	
Turtruba	Pre-feasibility Study Completed in 2005	320 – 800 MW	MOU was signed by GoG and ENMAN Services Ltd to conduct studies on the feasibility up to July 2010. Based on preliminary investigations, the Turtruba Rapids Hydro Project is feasible and can provide a maximum peak power of 1100 MW and confirmed reliable power of 650 MW. A preliminary optimization also indicated that an installation of about 800 MW is possible.
Kamaria	Pre-Feasibility Level	103	
Oko-Blue	Pre-Feasibility Level	162	
Chi-Chi Div.	Pre-Feasibility Level	96	
Sand Landing	Pre-Feasibility Level	650	
Kaieteur	Pre-Feasibility Level	216	
Amaila Falls Hydroelectric Project	Pre-Construction Level	100 -154	Presently the most advanced project with a proposed capacity of about 100 MW. It is envisaged that this hydroelectric station will be commissioned by 2014.[242]
Tumatumari	Feasibility Study completed. This project has been dormant for a period of time.	34	It is envisaged that this project will seek to provide stable and reliable power for the Guyana economy and the excess will be exported.
Mocomoco	Existing 0.5MW	0.1 – 0.5	The Government of Guyana and

[241] Guyana Energy Agency website; information extracted at http://www.gea.gov.gy/images/HydropowerSites.jpg and updated with information from the Guyana Energy Agency, Alternative Energy Programmes/Initiatives in Guyana. November 2009.
[242] Guyana Energy Agency. Energy Development, Hydro http://www.sdnp.org.gy/gea/energydev-hydropower.php

Sites	Status	Av. Cont. Power (MW)[241]	Observations
	Station (under Repair)		INCOMEX are presently negotiating the rehabilitation of this hydropower station and have estimated the cost of repair to be approximately US$ 430,000.00. A full assessment of the site has to be completed to determine the precise sum for the completion of the project.
Wamukaru	Feasibility Level	First Phase: 2.75 MW Second Phase: 3.5 MW	The feasibility study presented two main alternatives for the development of the site using a phased approach: Alternative I: Serving the Rupununi area only with up to 2.75 MW (1985 to 1993), US$12.5 million Alternative II: Serving the Rupununi area and Bom Fim, Brazil with up to 3.5 MW (1985 to 1996), US$14.6 million.
Tiger Hill	Feasibility Level	15	
Kato	Feasibility level	0.3	Under the Unserved Areas Electrification Programme, Hinterland Electrification component, the Government of Guyana is currently seeking funding to conduct a feasibility study for the Kato site on the Chiung River.
Devil's Hole	Feasibility Study Completed (October 2008). On-hold for future considerations	16	Three alternatives were studied and it was recommended that alternative 3 which has a proposed installed capacity of 16 MW with an estimated cost of investment of US$65.24 million might be the best option
Upper Mazaruni	Feasibility Study - Due to the world financial crisis and the reduced demand for bauxite, this project may no longer be attractive to RUSAL	1500-3000 First 1000 MW: Supply to Brazil and Guyana Second 1000 MW: Supply to smelting plant Third 1000 MW: Supply to Brazil	RUSAL approached the GoG expressing an interest in the development of this project. RUSAL was granted exclusive rights for an initial three (3) years to conduct a feasibility study of the site, in 2007. It is estimated that the cost of construction will be approximately US$2.7-2.9 billion (2007 estimates).
All other sites	Inventory Level		

Appendix 3.2. Energy Assessment Models

LEAP

Description / purpose of the model

LEAP is an integrated energy-environment, scenario-based modelling system, which utilizes relatively simple accounting and simulation modelling approaches. It accounts for flows of energy in a system based on simple engineering relationships (e.g. conservation of energy). Rather than simulating decisions made by energy consumers and producers, LEAP accounts explicitly for their decisions. The model includes demand, supply, resource extraction, GHG emissions and local air pollutants, full system cost-benefit analysis and non-energy sector sources and sinks.

LEAP requires lower initial data (e.g. costs are not required for simple energy and GHG assessments) than other software tools, and is more user-friendly for those with limited experience of energy and GHG modelling. The model also emphasizes other aspects of mitigation assessment by providing flexible and intuitive data management, and advances reporting capacities. LEAP tends to be simple, transparent, intuitive and easy to parameterize.

LEAP includes a Technology and Environmental Database (TED) which is a repository of energy technology data containing technical data, costs, and emission factors for over 1,000 energy technologies.

Data inputs

The following table shows the input data necessary to run LEAP:

Table A3.3 1. Input data necessary to run LEAP

Data type	Examples
Macro-economic Variables Sectoral driving variables More detailed driving variables	GDP/value added, population, household size Production of energy-intensive materials (tonnes or $ steel); transport needs (pass-km, tonne-km); income distribution, etc.
Energy Demand Data Sector and subsector totals End-use and technology characteristics by sector/subsector Price and income response (optional)	Fuel use by sector/subsector a) Usage breakdown by end-use/device: new vs. existing buildings; vehicle stock by type, vintage; or simpler breakdowns; b) Technology cost and performance Price and income elasticities
Energy Supply Data Characteristics of energy supply, transport, and conversion facilities Energy supply plans Energy resources and prices	Capital and O&M costs, performance (efficiencies, capacity factors, etc.) New capacity on-line dates, costs, characteristics Reserves of fossil fuels; potential for renewable resources
Technology Options Technology costs and performance Penetration rates Administrative and program costs Emission Factors	Capital and O&M costs, foreign exchange, performance (efficiency, unit usage, capacity factor, etc.) Per cent of new or existing stock replaced per year Emissions per unit energy consumed, produced, or transported

To build up a good model of Guyana's energy system, it is important to have up-to-date data that can be used broken down by sector, end-use device, technology adopted, as well as information on the policies, projects and programmes planned for the future. Since we still do not have the LEAP licence, data inputs cannot be all specified.

RETScreen

Description / purpose of the model

RETScreen, unlike LEAP that is an integrated model of a complete energy system, is structured as a collection of more specialized spreadsheet-based tools, each of which can be used for screening potential options before they are included in integrated mitigation assessments. It is intended primarily for project-level analysis (screening and feasibility). Therefore RETScreen is a complement of LEAP that helps develop the technical, cost, and performance variables necessary for other models.

RETScreen can be utilized worldwide for assessing energy production and savings, financial viability, life-cycle costs and GHG emissions from a wide range of renewable energy and energy-efficient technologies, including solar photovoltaic, solar hot water, wind, combined heat and power, small hydro, biomass and ground-source heat pump technologies, as well as other energy efficiency measures.

RETScreen is also an accounting framework that is simple, transparent, intuitive and easy to parameterize. The software includes products, project, hydrology, and climate databases. The climate database covers the entire surface of the planet, including central grid, isolated grid, and off-grid areas.

Data inputs

The RETScreen data requirements are those needed for a technical and financial assessment of any clean energy project. This includes location data, meteorological data, equipment data, cost data, and financial data.

RETScreen includes:

- both meteorological and product cost and performance databases which help determine the amount of clean energy that can be delivered (or saved) by a project, and help calculate parameters such as heating loads.
- The weather database has data from 4,720 meteorological stations around the world.
- The product database is linked online to continuously updated data.

COMAP

COMAP is a bottom-up methodological framework which was used in the assessment of carbon sequestration potential by the F7 countries, and is recommended in the Intergovernmental Panel on Climate Change (IPCC) 1995 Working Group II chapter. COMAP helps to account for carbon and monetary flows, and to develop scenarios and cost-effectiveness indicators of alternative mitigation options for the forestry sector.[243] The COMAP approach is mainly dependent on finding the least expensive way of providing forest products and services while reducing the most amount of carbon emitted from the forestry and land-use sector.[244] COMAP is the most widely applied model for the purposes of national mitigation and abatement analyses and has been employed by many countries in the preparation of their National Communications. The COMAP framework was thus recommended as the most appropriate approach to assessing the mitigation potential of the forestry sector in Guyana

[243] Greenhouse gas mitigation assessment guidebook (US Country Studies), Chapter 11 Forestry Sector [online]. Available at: http://unfccc.int/resource/cd_roms/na1/mitigation/Resource_materials/Greenhouse_Gas_Mitigation_Assessment_Guidebook_1995/chap11.pdf (accessed 18 November 2009).
[244] Ibid.

Appendix 3.3 Energy Baseline Scenario

Baseline in the near future until 2012:

- The 10 MW Skeldon factory started to operate, increasing the bagasse electricity produced, and displacing electricity from fossil fuels. According to the Guyana Energy Agency Report: *Alternative Energy Programmes/Initiatives in Guyana,* the Skeldon Sugar Modernization Project will generate 55 GWh per year that will be fed to the regional grid and 58.8 GWh per year to be used at the sugar mill.
- The first phase (2.75 MW) of the Wamukaru Hydro power station was installed by mid-September 2009. Assuming a capacity factor of 50 %, this hydro power project is going to generate around 12 GWh per year, and this electricity is going to be used to supply electricity to the grid (and not for replacing electricity produced from fossil fuels).
- PV systems continue to be implemented in areas with no access to electricity, thus combating poverty alleviation by providing electricity to populations with no access to it.

Baseline from 2012 until 2016:

- In 2012 the hydro Amaila Falls project will be commissioned and a 165 MW hydro power plant will be installed. This hydro power plant will contribute to the Guyana power grid with 983 GWh [245] that will be fed into the national grid and will be used to displace electricity from fossil fuels.
- The Mocomoco hydropower station has been rehabilitated and has a capacity installed of 0.5 MW. Assuming a capacity factor of 50 %, this hydro power project is going to generate around 2 GWh per year, and this electricity is going to be used to replace electricity produced from fossil fuels.
- The 34 MW Tumatumari hydropower station that has been dormant is installed. Assuming a capacity factor of 50%, this hydropower station will produce around 149 GWh per year, that will replace energy produced from fossil fuels.
- The 13.5 wind project is installed, of which a firm capacity of 4 MW is expected to be utilized by GPL. Assuming an 18 % capacity factor, this wind project is expected to generate around 22 GWh per year of electricity that will be used to displace fossil fuels.
- In terms of biomass we will assume that it will increase 1 % a year (in terms of the capacity already installed in previous years, 2005-2008), due to improvements in existing biomass co-generation plants. This electricity will be used to supply the grid-connected populations.

Baseline from 2016 to 2030:

- 30 % of all hydropower stations currently undergoing feasibility and pre-feasibility studies (0.015 MW Hosororo; 4 MW Eclipse Falls; 40 MW Tiboku, 0,7 MW Ikuribisi, 800 MW Turtruba; 103 MW Kamaria; 162 MW Oko-Blue; 96 MW Chi-Chi Div; 650 MW Sand Landing; 216 MW Kaieteur; 15 MW Tiger Hill; 0.3 MW Kato hydropower; the 3rd alternative of the 16 MW Devil's Hole hydro power project; and the 1500-3000 MW Upper Mazaruni (1500 MW considered here for this calculation) are going to be installed. Thus within this a total capacity of 1800 MW 246 will be installed. Assuming a capacity factor of 50 % for all hydropower stations, they will produce together 7884 GWh per year that will be used to displace fossil fuel electricity generation.
- Solar PV continues to be installed in Hinterland regions, providing access to electricity to populations that currently do not have, thus contributing to poverty reduction in these areas.
- 1 MW Solar PV farm is going to be installed to produce electricity to be supplied to the grid, and this electricity will be used to replace electricity produced from fossil fuels.
- In terms of biomass we will assume that it will increase 1 % a year (in terms of the capacity already installed) due to improvements in existing biomass co-generation plants. This electricity will be

[245] Guyana Energy Agency. Alternative Energy Programmes/ Initiatives in Guyana, November 2009.
[246] This calculation assumes that half of the total capacity undergoing feasibility and pre-feasibility studies is installed.

used to supply the grid-connected populations and not to replace electricity produced from fossil fuels.

Moreover, this baseline scenario assumes:

- The need for fossil fuel consumption will continue to grow. It will grow at the same rate as it has grown in previous years (this growth rate was calculated by linear regression of the fossil fuel consumption in the previous years of 2006 and 2009).
- That PV is installed in areas that do not have access to electricity, thus alleviating poverty in Guyana.
- The electricity produced from hydropower projects will be connected to the grid and will be used to replace existing electricity produced from fossil fuels. This was considered as an assumption since the population in Guyana is quite steady. (From 1994 to 2008 it has been around 763 thousand habitants).[247]
- Only the projects referred to in the analysis/consideration are installed.
- When an installed RE project comes to the end of its operating life, it is substituted by an equal one, that generates exactly the same quantity of energy.

Hydro Developments

Table A3.3 2. Energy Baseline Scenario - Hydro Developments

Hydro	2006 (GWh/year)	2007 (GWh/year)	2008 (GWh/year)	2012 (GWh/year)	2016 (GWh/year)	2030 (GWh/year)
2.75 MW Wamakaru	0	0	0	1.00	12.00	12.00
Amalia Falls					983.00	983.00
Mocomoco (0.5 MW)					2.00	2.00
24 MW Tumatumari					149.00	149.00
0.015 MW Hosororo						0.02
4 MW Eclipse Falls						5.26
40 MW Tiboku						52.56
103 MW Kamaria						135.34
162 MW Oko-Blue						212.87
96 MW Chi-Chi Div;						126.14
650 MW Sand Landing						854.10

[247] According to the Guyana Energy Agency Energy Information Spread Sheet.

216 MW Kaieteur;						283.82
15 MW Tiger Hill						19.71
0.3 MW Kato hydropower						0.39
The 3rd alternative of the 16 MW Devil's Hole hydro power project						21.02
1500-3000 MW Mazaruni (1500 MW considered for this calculation)						197.00
Total	**0**	**0**	**0**	**12.00**	**1146.00**	**4828.24**

Biomass

In Biomass estimation the following was considered:

- the total electricity produced by Skeldon (77 GWh/year that will be exported to the grid and the 58 GWh per year produced for internal use at the sugar mill)
- 1 % growth rate per year of energy produced from biomass.

Table A3.3 3. Energy Baseline Scenario -Biomass

Biomass	2006 (GWh/year)	2007 (GWh/year)	2008 (GWh/year)	2012 (GWh/year)	2016 (GWh/year)	2030 (GWh/year)
Skeldon				135.00	135.00	135.00
Other biomass	4800.84	4833.87	2647.03	2648.25	2754.18	3139.76
Total	4800.84	4833.87	2647.03	2783.25	2889.18	3274.76

Wind

Table A3.3 4. Energy Baseline Scenario -Wind

Wind	2006 (GWh/year)	2007 (GWh/year)	2008 (GWh/year)	2012 (GWh/year)	2016 (GWh/year)	2030 (GWh/year)
13.5 MW Wind Project					21,88	21,88.

Photovoltaic (PV)

In this calculation the following was considered:

- The PV installed in Guyana (according to the Guyana Energy Agency) will continue to be installed at the same rate of 2009 (30.44 %) in the following years.
- That no more programmes are going to take place in the future to install PV (since there is no reference for it in terms of the projected projects)

In terms of the energy production from the programmes implemented and under implementation, the calculation was made taking into account:

- The PV panels installed
- The Guyana solar energy resource (for which the data correspondent to Georgetown was the one used)
- The solar yield at 10 % from the horizontal (due to the proximity of the equator)
- 6 % of panel efficiency
- 30 % of losses (battery, wiring, aging etc.)
- Isolated systems / grid-connected system (the only grid-connected system is the Japan Cool Earth Partnership 1 MW Solar PV Farm)

Table A3.3 5. Energy Baseline Scenario – PV System

PV	2006 (kWh/year)	2007 (kWh/year)	2008 (kWh/year)	2009 (kWh/year)	2012 (kWh/year)	2016 (kWh/year)	2030 (kWh/year)
PV installed in Guyana GEA	44781.30	45785.05	122661.18	159999.93	306114,55	1424310,39	74263747,18
DC Home Solar Light Kit			9816.81	9816.81	9816.81	9816.81	9816.81
Unserved Areas Electrification Programme			32475.24	32475.24	32475.24	32475.24	32475.24
Orealla 2500 M W System			3170.00	3170.00	3170.00	3170.00	3170.00
CIDA/OLADE/ University of Calgary-Haskayne School of Business Rural Electrification Project				2821.42	2821.42	2821.42	2821.42
Japan Cool Earth Partnership 1 MW Solar PV Farm (proposed)							1268000.00

Total	44781.30	45785.05	168123.23	208283.40	354398,02	1472593,86	75580030,65

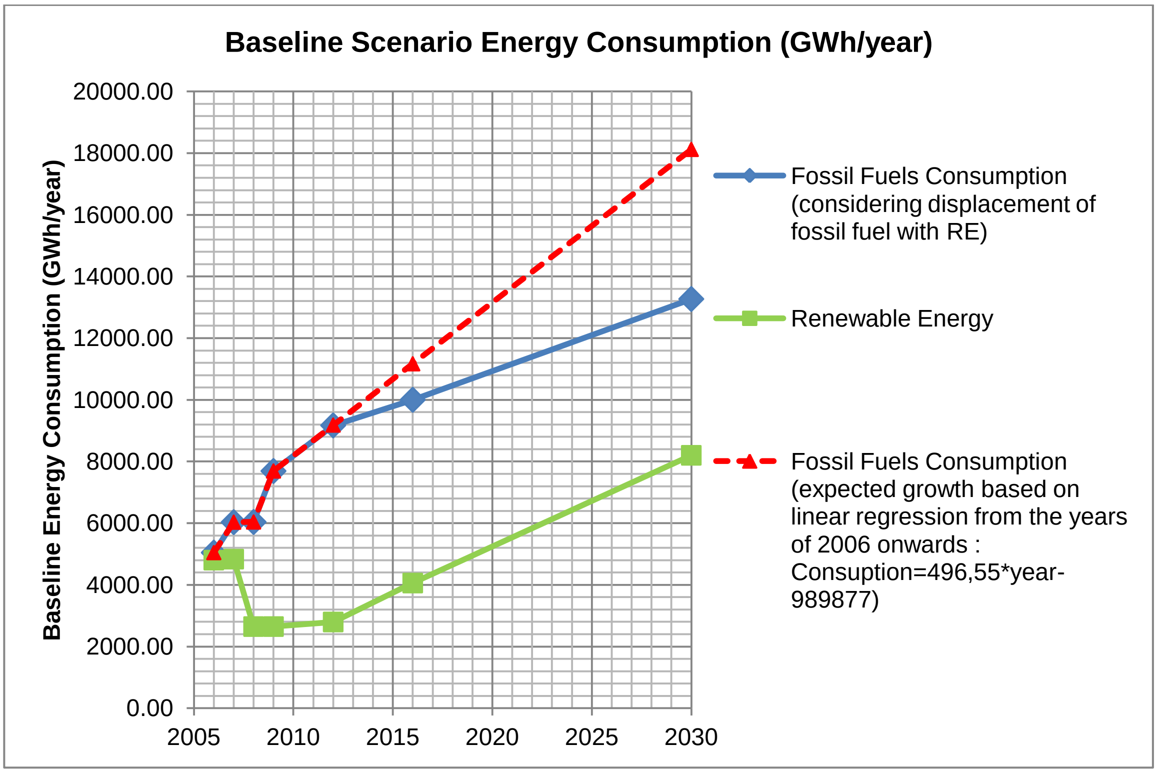
Renewable Energy in Guyana's Energy Mix

The renewable energy within Guyana's energy mix was calculated taking into account:

- Guyana's population maintains itself at a constant (as has been since 1994-2008)
- There is an increasing need for fossil fuel consumption associated with Guyana's development. Guyana's fossil fuel consumption was estimated based on the linear regression of the actual fossil fuel consumption over the last years (2006-2008). This was the period considered because it was the period where there was a growth in fossil fuel consumption (in the previous years there was a decrease in terms of fossil fuel consumption).
- That the renewable energy predicted to be produced from Hydro, Wind and the 1 MW PV farm in Guyana is used to displace fossil fuel (except the PV connected to isolated systems and the biomass which is currently used to supply electricity to the grid).

Table A3.3 6. Renewable Energy in Guyana's Energy Mix

	2006 (GWh/year)	2007 (GWh/year)	2008 (GWh/year)	2009 (GWh/year)	2012 (GWh/year)	2016 (GWh/year)	2030 (GWh/year)
Fossil Fuels Consumption (expected growth based on linear regression from the years of 2006 onwards : Consumption= 496,55*year - 989877)	5045.20	6033.15	6038.30	7691.95	9181.60	11167.80	18119.50
Fossil Fuels Consumption (considering displacement of fossil fuel with RE)	5045,.0	6033.15	6038.30	7691.95	9169.60	10000.51	13268.70
Renewable Energy	480.89	4833.92	2647.20	2647.24	2795.60	4057.94	8199.87
Total (Fossil Fuel with displacement from RE + RE)	**9846.09**	**10867.07**	**8685.50**	**10339.19**	**11965.20**	**14058.45**	**21468.58**



Projected emission reduction in the energy sector taking into account the baseline scenario

The projected emissions reduction in the baseline scenario were calculated for the period under analysis by multiplying Guyana's electricity emission factor by the amount of electricity produced from fossil fuels that will be displaced due to the introduction of the referred RE projects.

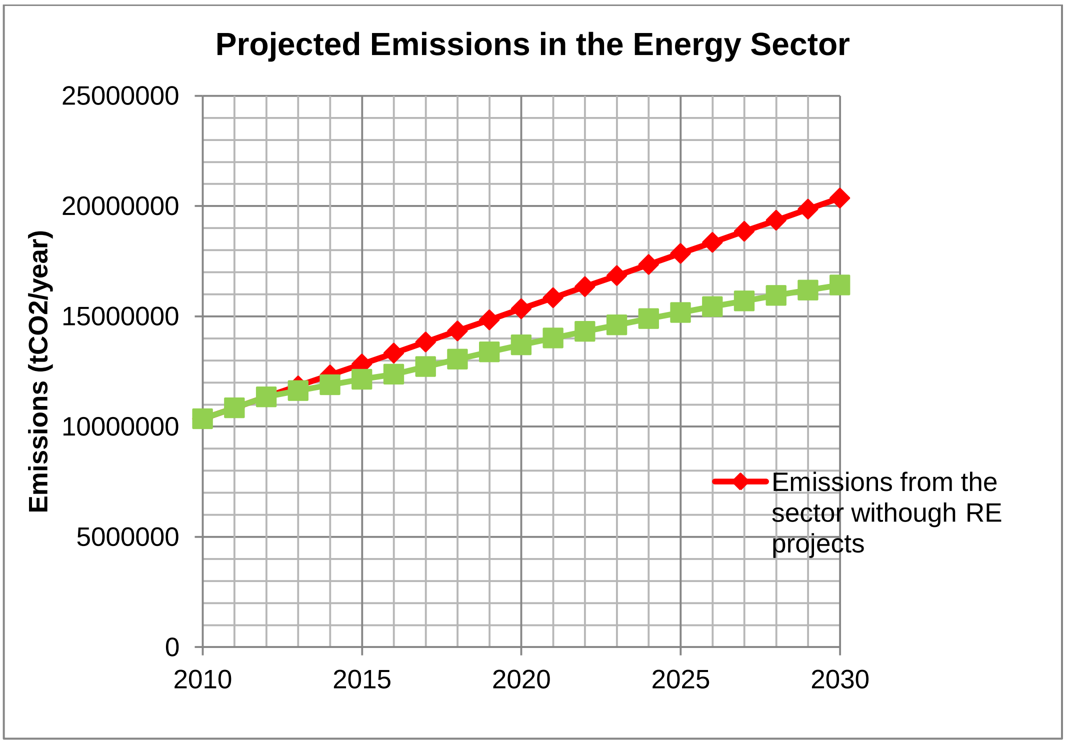
Guyana's electricity system is divided into two regional systems: the Demerara Interconnected System (DIS) and the Berbice Interconnected System (BIS). Although DIS and BIS are linked, the energy flow between them is severely constrained by poor transmission lines capacity and does not account for any significant amount of each regional system's electricity demand. Since at this point the information was lacking concerning which system each project is or is going to be connected to, and since the only electricity emission factor found was the one for the BIS, this is the one used as a base for this assessment. The emission factor of Guyana's grid considered as a base for this calculation is: 0.9485tCO_2/MWh.[248]

Other considerations were also taken into account:

- The fact that emission factors depend on the percentage of renewable energy installed, and decrease with the increase of the RE percentage in the energy mix
- That between the periods of the analysis, the RE % increases at the same rate. (Between 2010 2016, the RE share increases 1.4 % per year, and between 2016 and 2030 increases 0.7 % per year.)

Thus the following figure illustrates the emissions expected in the energy sector: with and without the introduction of the renewable energy projects.

[248] This value was taken out from the Project Design Document of the Guyana Skeldon Bagasse Co-generation Project, consulted at: http://cdm.unfccc.int/UserManagement/FileStorage/VSSDFHR8560V4TR0RMYXNTUCO02LMO, on 3/02/2010.



As can be seen in the baseline scenario (with the introduction of the renewable energy projects), emissions will continue to increase, but at a smaller rate than without the introduction of the renewable energy projects. This is mainly due to the fact that energy demand grows at a higher rate than the renewable energy projects/technologies are installed. Thus in 2016 and 2030, due to the introduction of the RE projects, 957,044 tCO_2 and 3,940,507tCO_2 are projected to be avoided, respectively.

Table A3.3 7. Summary of energy demand assumptions

Sector	Variable	Fuel	Initial Values			Scenarios				
			Activity Level	Energy Demand		Reference	DSM	Renewable	Transport	Mitigation
Urban Households	Percentage of households		28 %			No change	No change	No change	No change	No change
	Percentage of households electrified		100 %			No change	No change	No change	No change	No change
	Fuel used for lighting	Electricity	100 %	240	kWh	No change	Decrease in demand by 0.5 % per annum	No change	No change	Decrease in demand by 0.5 % per annum
	Percentage of households using fuel type for cooking	Electric Stoves	8.75 %	400	kWh	Increase to 10 % by 2030	Increase to 10 % by 2030 and reduction in energy demand by 1 % per annum	Increase to 10 % by 2030	Increase to 10 % by 2030	Increase to 10 % by 2030 and reduction in energy demand by 1 % per annum
		LPG	39.90 %	156	kg	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030
		Coal	0.80 %	876	kg	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030
		Wood	2.95 %	1800	kg	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030
		Kerosene	47.10 %	180	kg	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030
		Charcoal	0.50%	888	kg	Reduction to	Reduction to	Reduction to	Reduction to	Reduction to

						0 % by 2030	0 % by 2030	0 % by 2030	0 % by 2030	0 % by 2030
		Efficient Wood Stoves	0.00 %	900	kWh	None	50 % of all wood stoves from 2010 - 2030	None	None	50 % of all wood stoves from 2010 - 2030
	Other demand	Electricity	100 %	1530	kWh	Increase in demand by 2.5 % per annum	Increase in demand by 2.0 % per annum	Increase in demand by 2.5 % per annum	Increase in demand by 2.5 % per annum	Increase in demand by 2.0 % per annum
Rural Households	Percentage of households	Activity Level	72.00 %			No change	No change	No change	No change	No change
	Percentage of households electrified	Activity Level	45.00 %			2010 – 65 %, then 1 % growth per annum	2010 – 65 %, then 1 % growth per annum	2010 - 65 %, then 1 % growth per annum	2010 – 65 %, then 1 % growth per annum	2010 – 65 %, then 1 % growth per annum
	Percentage of households using fuel type for cooking in electrified households	Electric Stoves	0.40 %	300	kWh	Increase to 10 % by 2030	Increase to 10 % by 2030 and reduction in energy demand by 1 % per annum	Increase to 10 % by 2030	Increase to 10 % by 2030	Increase to 10 % by 2030 and reduction in energy demand by 1 % per annum
		Coal	1.40 %	876	kg	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030
		Charcoal	0.20 %	888	kg	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030
		Efficient Wood Stoves	0.00 %	900	kWh	None	50 % of all wood stoves from 2010 - 2030	None	None	50 % of all wood stoves from 2010 - 2030
		Wood	41.10 %	1800	kg	Reduction to	Reduction to	Reduction to	Reduction to	Reduction to

						10 % by 2030	10 % by 2030	10 % by 2030	10 % by 2030	10 % by 2030
		LPG	22.00 %	156	kg	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030
		Kerosene	34.90 %	180	kg	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030
	Fuel used for lighting in electrified households	Electricity	100.00 %	144	kWh	Increase in demand by 1 % per annum	Increase in demand by 0.5 % per annum	Increase in demand by 1 % per annum	Increase in demand by 1 % per annum	Increase in demand by 0.5 % per annum
	Other electricity demand		100.00 %	520	kWh	Increase in demand by 2.5 % per annum	Increase in demand by 2.0 % per annum	Increase in demand by 2.5 % per annum	Increase in demand by 2.5 % per annum	Increase in demand by 2.0 % per annum
	Percentage of households non-electrified	Activity Level	55.00 %			Reduction to 20 % by 2030	Reduction to 20 % by 2030	Reduction to 20 % by 2030	Reduction to 20 % by 2030	Reduction to 20 % by 2030
	Fuel used for lighting in non-electrified households	Kerosene	100.00 %	30	Litre	No change	No change	No change	No change	No change
	Percentage of households using fuel type for cooking in non-electrified households	Coal	1.40 %	876	kg	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030
		Kerosene	35.00 %	180	kg	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030	Reduction to 0 % by 2030
		Charcoal	0.40 %	888	kg	None	50 % of all wood stoves from 2010	None	None	50 % of all wood stoves from 2010
		Wood	41.10 %	1800	kg	Reduction to 10 % by 2030	Reduction to 10 % by 2030	Reduction to 10 % by 2030	Reduction to 10 % by 2030	Reduction to 10 % by 2030

		Efficient Wood Stoves	0.00 %	900	kWh	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030
		LPG	22.10 %	156	kg	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030	40 % by 2030
Industry	Fuel used	Electricity	100.00 %	124311	MWh	2.5 % per annum growth in demand	2.0 % per annum growth in demand	2.5 % per annum growth in demand	2.5 % per annum growth in demand	2.0 % per annum growth in demand
		LPG	100.00 %	64400	BOE	1.0 % per annum growth in demand	1.0 % per annum growth in demand	1.0 % per annum growth in demand	1.0 % per annum growth in demand	1.0 % per annum growth in demand
Commercial	Fuel used	Electricity	100.00 %	80891	MWh	2.5 % per annum growth in demand	2.0 % per annum growth in demand	2.5 % per annum growth in demand	2.5 % per annum growth in demand	2.0 % per annum growth in demand
Transport	Fuel used	Gasoline	100.00 %	842500	Barrel	3 % per annum growth in demand	3 % per annum growth in demand	3 % per annum growth in demand	2 % per annum growth until 2020, then 1 % per annum growth	2 % per annum growth until 2020, then 1 % per annum growth
		Diesel	100.00 %	236000	Barrel	3 % per annum growth in demand	3 % per annum growth in demand	3 % per annum growth in demand	2 % per annum growth until 2020, then 1 % per annum growth	2 % per annum growth until 2020, then 1 % per annum growth
		Biodiesel	100.00 %	0	Barrel	0	0	0	Linear growth to 20 % of	Linear growth to 20 % of

									vehicles by 2030	vehicles by 2031

Table A3.3 8 Electricity generation assumptions

System	Capacity		Reference	DSM	Renewable	Transport	Mitigation
Small Solar	88	kW	0	0	3 % per annum growth in capacity	0	3 % per annum growth in capacity
Oil Combustion Turbines	132	MW	No change	No change	No change	No change	No change
Bagasse	54	MW	No change	No change	2016 – 64 MW then 1 % growth per annum	No change	2016 – 64 MW then 1 % growth per annum
Diesel Generators	25	MW	No change	No change	No change	No change	No change
Hydro	0	MW	0	0	2010 - 2.75 MW 2012 - 3.25 MW 2014 – 191 MW 2014 to 2030 – 1 % growth per annum	0	2010 - 2.75 MW 2012 - 3.25 MW 2014 – 191 MW 2014 to 2030 – 1 % growth per annum
Wind	0	MW	0	0	2016 – 4 MW	0	2016 – 4 MW
Solar	0	MW	0	0	2016 – 1 MW	0	2016 – 1 MW
Mazaruni Falls	0	MW	0	0	Installation of 1000 MW in 2020	0	Installation of 1000 MW in 2020
Transmission Losses	40 %		3.7 % reduction per year	Reduction to 15.4 % by 2010	3.7 % reduction per annum	3.7 % reduction per annum	Reduction to 15.4 % by 2010

Chapter 4. Vulnerability and Adaptation

Appendix 4.1. Box 1 Guyana Flood 2005

Box 1 Guyana Flood 2005

January-February 2005 had the highest rainfall record since 1888, which resulted in the most severe flooding in the history of Guyana. A combination of extended heavy rainfall, malfunctioning drainage structures, and high tides contributed to the accumulation of between three and five feet of water in some areas. The disaster primarily affected Regions 3, 4, and 5, from West Demerara to Mahaica and Berbice. It is estimated that **the floods affected 62 % of the total population**, Region 4 being the worst hit (ECLAC, 2005). In Georgetown alone, UNICEF believes that **almost 120,000 people** were affected, and that at least 40 % were children.

The Economic Commission for Latin America and the Caribbean (ECLAC) prepared a Report at the request of the Government of Guyana, following the torrential rains and subsequent flooding of January- February 2005. The Socio-Economic Assessment reported the following damage and losses:

- Guyana´s residents were unprepared for the disaster leaving over 70,000 dwellings severely affected.
- The flood had a cost of about **G$93 billion**. Severe damages were estimated at **60 % of the GDP** of 2004.
- The effects amounted to G$55,120.80 million in the housing sector, G$794 million in the health sector, and G$371.70 million in the education sector.
- There was also an important impact on infrastructure, basically concentrated in the water supply and sewerage (G$3.9 billion), roads and transport sectors (G$3.5 billion).
- The tourism sector also had an impact of G$1.1 billion, and many small businesses lost assets (working capital) because their establishments were largely affected and uninsured.
- The GDP for the agricultural sector decreased 2.3 %, compared to 2004's GDP, due mainly to the negative impact on the sector of the flood.
- The sugar industry registered damage equivalent to 16 % of GDP; commerce and small manufacturing lost G$14.5 billion.

The Government acknowledges that the geographic distribution of the population, particularly as relates to access to social services and the generation of opportunity in isolated and in rural communities, is one of the main factors shaping their vulnerability to floods. The differences in social structures, cultural patterns, and livelihoods both within regions and between them, are also factors explaining the differences in their susceptibility to natural hazards.

Additional significant factors affecting the vulnerability of these communities are the operation and management of the waterways, drainage, and irrigation infrastructure, and their financing, factors on which these communities are dependent, and their livelihoods embedded.

Guyana´s Poverty Reduction Strategy Paper -Progress Report (2005), therefore states that: 'The disruption of economic activities and dislocation of people as a result of the recent flooding has brought into sharp focus the challenges of increasing public and private resources for routine and regular maintenance of roads, for drainage and irrigation systems and the conservancy dams, for designing and implementing improved standards in roads, for revising and upgrading building codes and for establishing and strengthening disaster management systems to mitigate the impact of future disasters'.

The 2005 flood disaster also leaves some important lessons that need to be considered in order to face the changes in the rainfall patterns which the scenarios project. In that sense, efforts should concentrate on building resilience in people, especially in women and children. It is essential to promote greater awareness of the risk of flooding and water-borne diseases, as well as social protection programmes targeted to the poor in response to disasters. It is important to promote income-generating programmes and innovative financing mechanisms to strengthen the productive sectors. The maintenance of infrastructure, mainly coastal dikes and barriers, is also pivotal.

Appendix 4.2. The cross-cutting nature of Climate Change in Guyana.

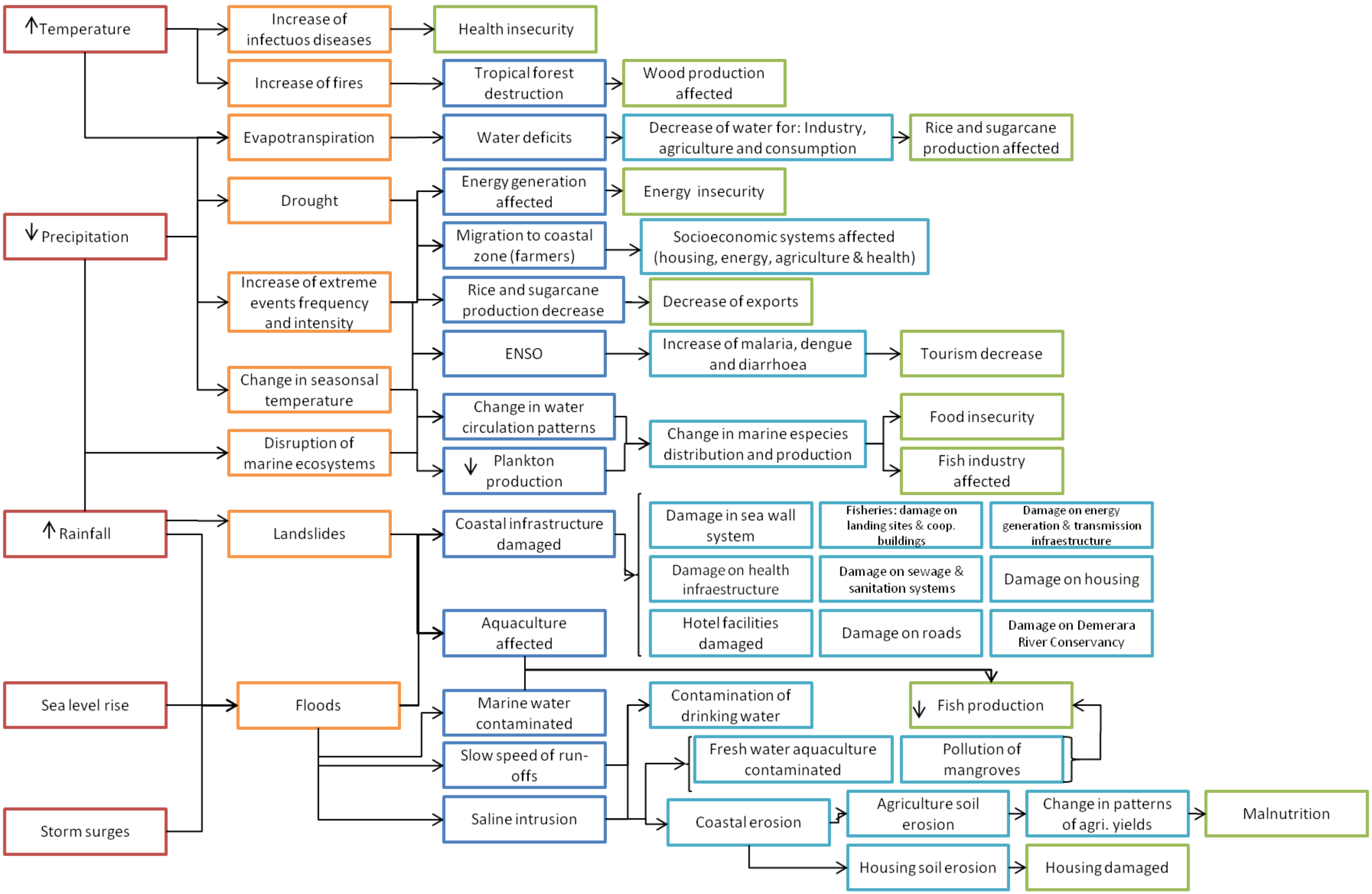


Fig. A4.2.1. The cross-cutting nature of Climate Change in Guyana. The chain firstly shows some of the main climate change threats (red) and the derived threats (orange), then the primary impacts (blue) and the derived impacts in the different sectors (light blue) and finally the main socioeconomic activities and livelihoods affected (green)

Appendix 4.3. Coastal Zone: Complementary Figures

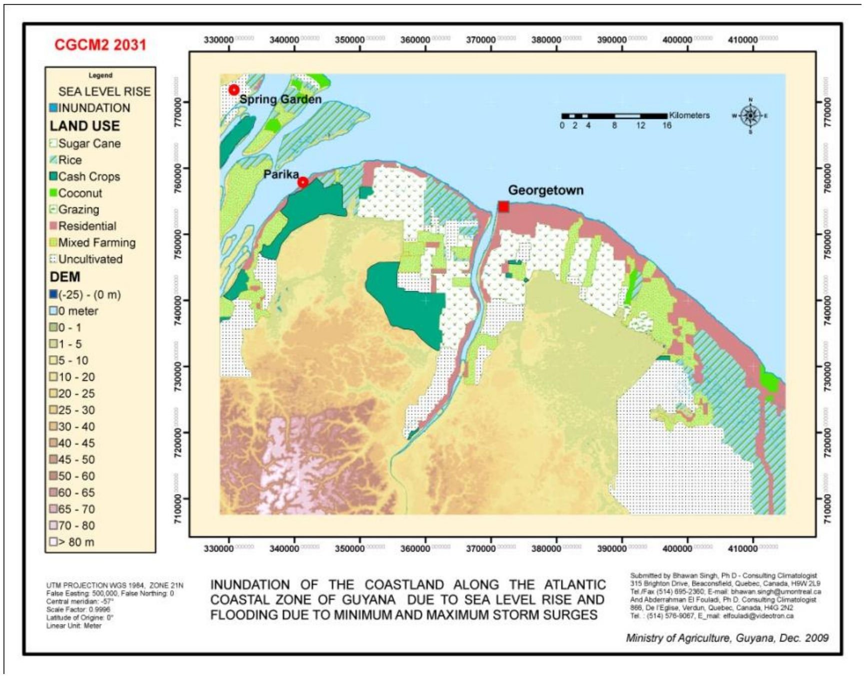


Fig. A4.3. 1. Inundation due to sea level rise according to the CGCM2 scenario for the year 2031 for the selected study area on the coastal zone of Guyana

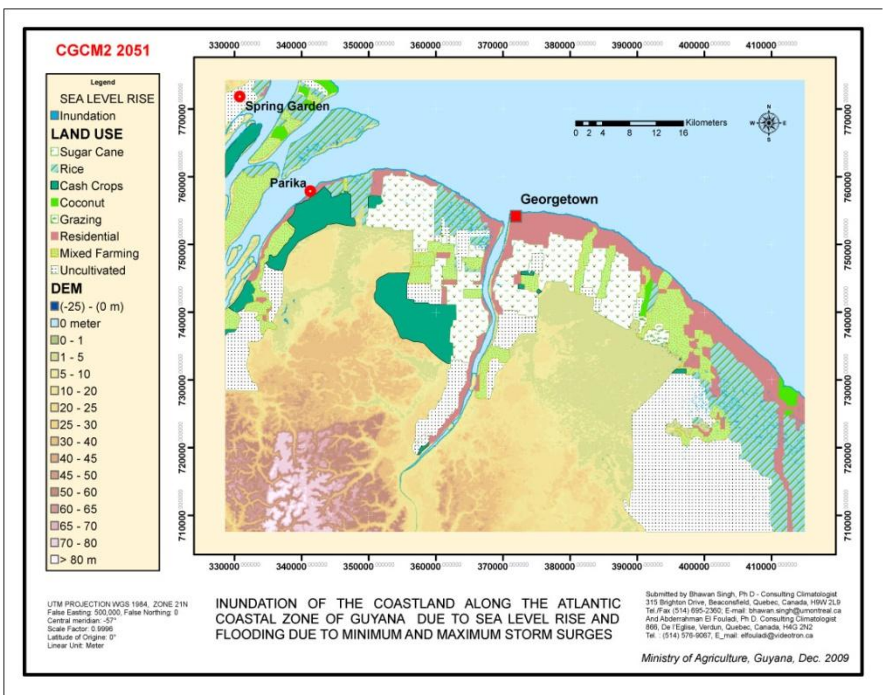


Fig. A4.3. 2. Inundation due to sea-level rise according to the CGCM2 scenario for the year 2051 for the selected study area on the coastal zone of Guyana

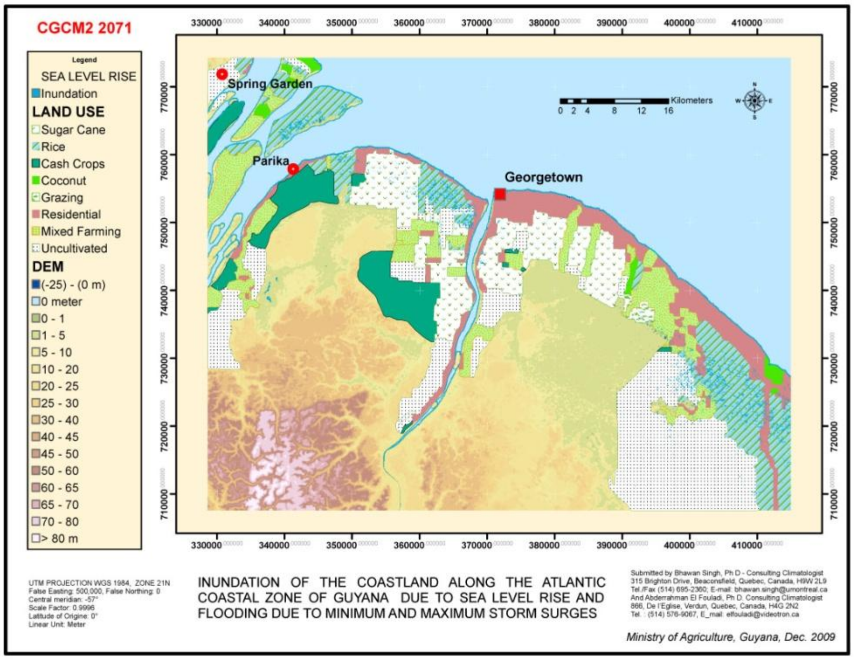


Fig. A4.3. 3. Inundation due to sea-level rise according to the CGCM2 scenario for the year 2071 for the selected study area on the coastal zone of Guyana

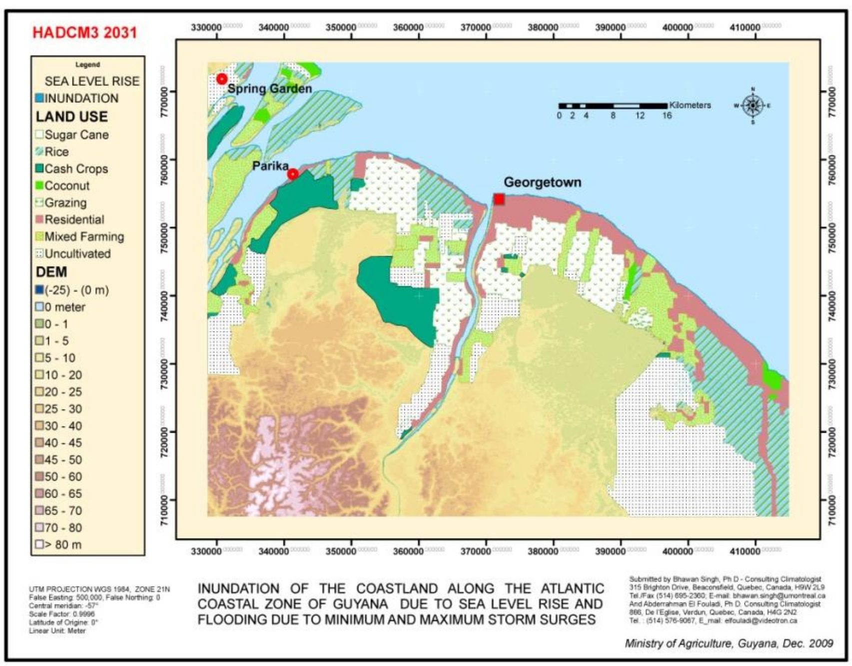


Fig. A4.3. 4. Inundation due to sea-level rise according to the HadCM3 scenario for the year 2031 for the selected study area on the coastal zone of Guyana

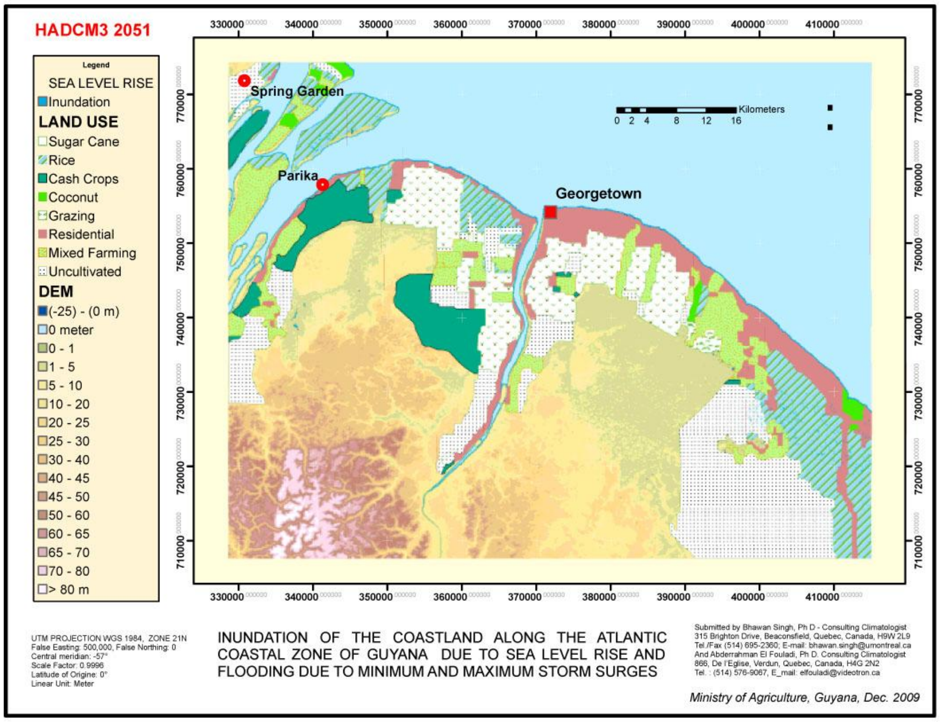


Fig. A4.3. 5. Inundation due to sea-level rise according to the HadCM3 scenario for the year 2051 for the selected study area on the coastal zone of Guyana

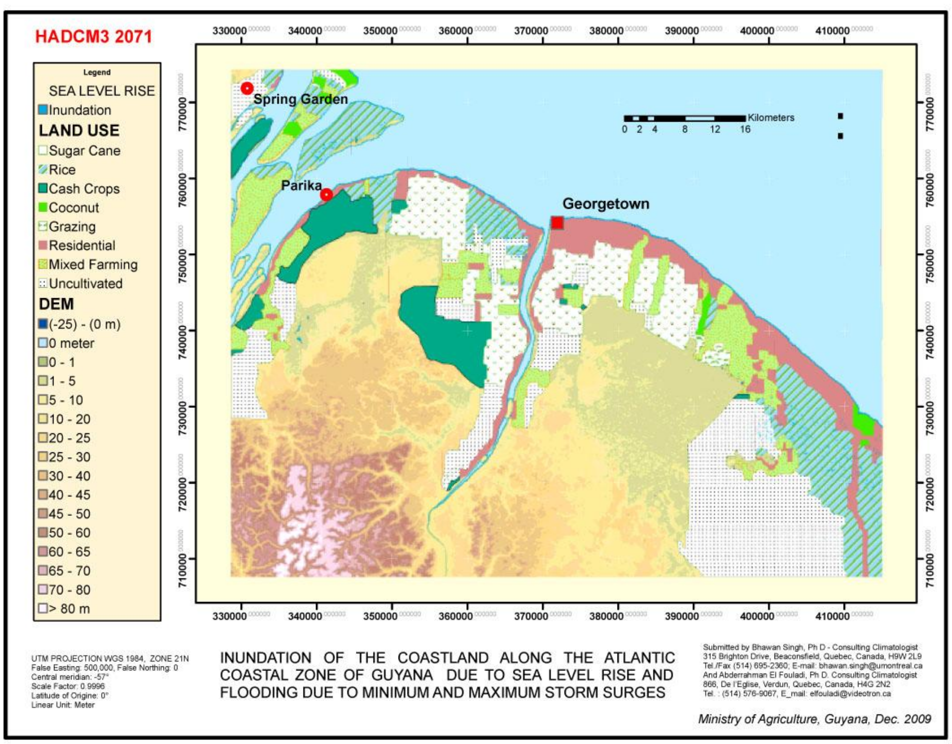


Fig. A4.3. 6. Inundation due to sea-level rise according to the HadCM3 scenario for the year 2071 for the selected study area on the coastal zone of Guyana

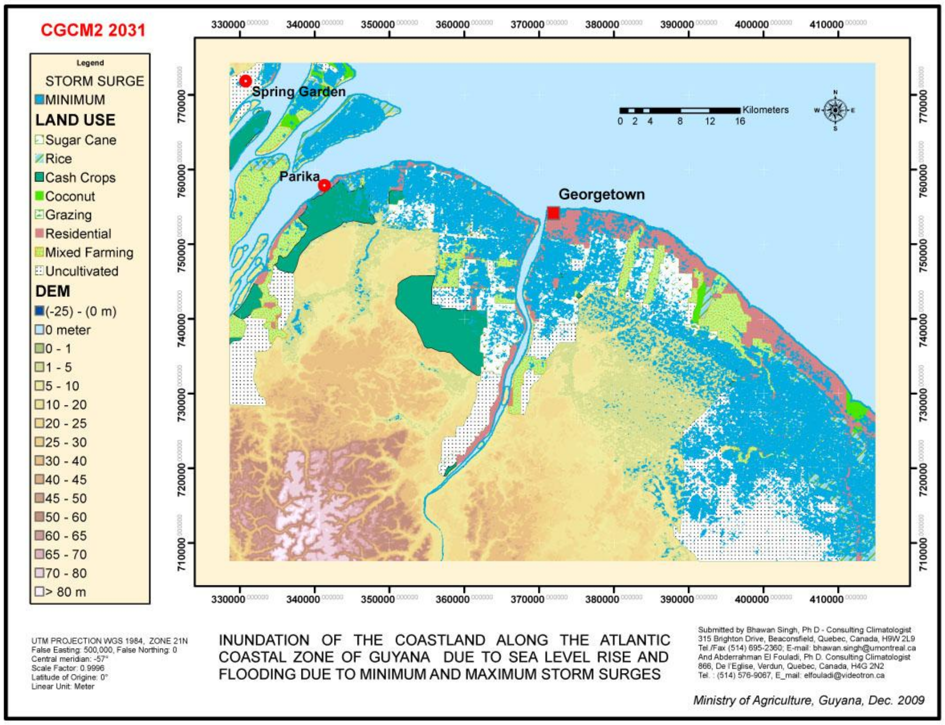


Fig. A4.3. 7. Inundation due to minimum storm surge (2 m) and sea-level rise according to the CGCM2 scenario for the year 2031 for the selected study area on the coastal zone of Guyana

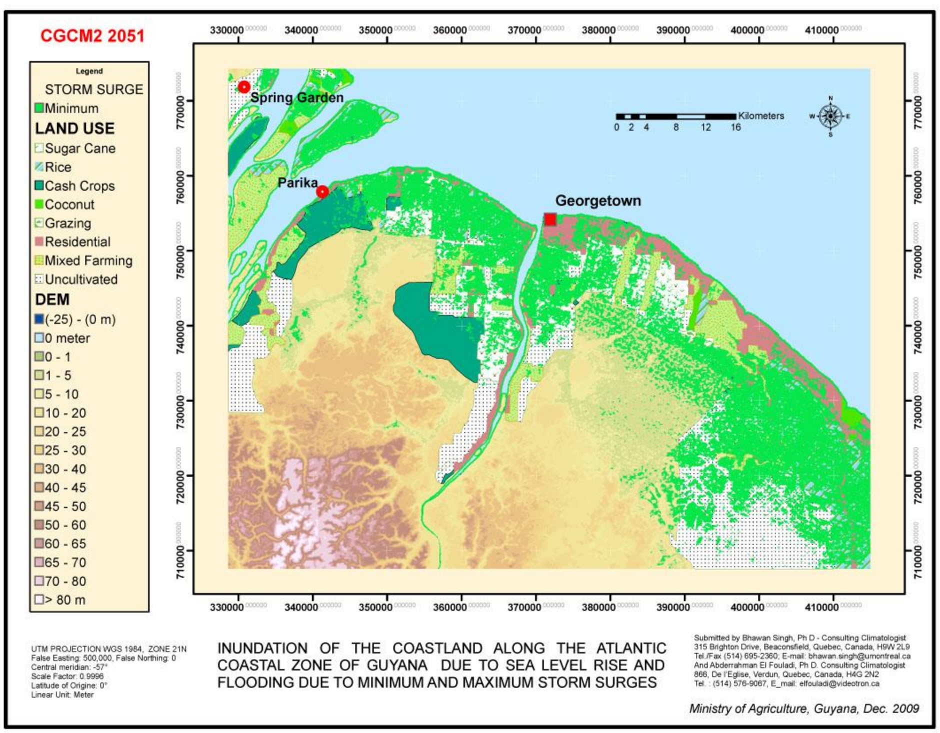


Fig. A4.3. 8. Inundation due to minimum storm surge (2 m) and sea-level rise according to the CGCM2 scenario for the year 2051 for the selected study area on the coastal zone of Guyana

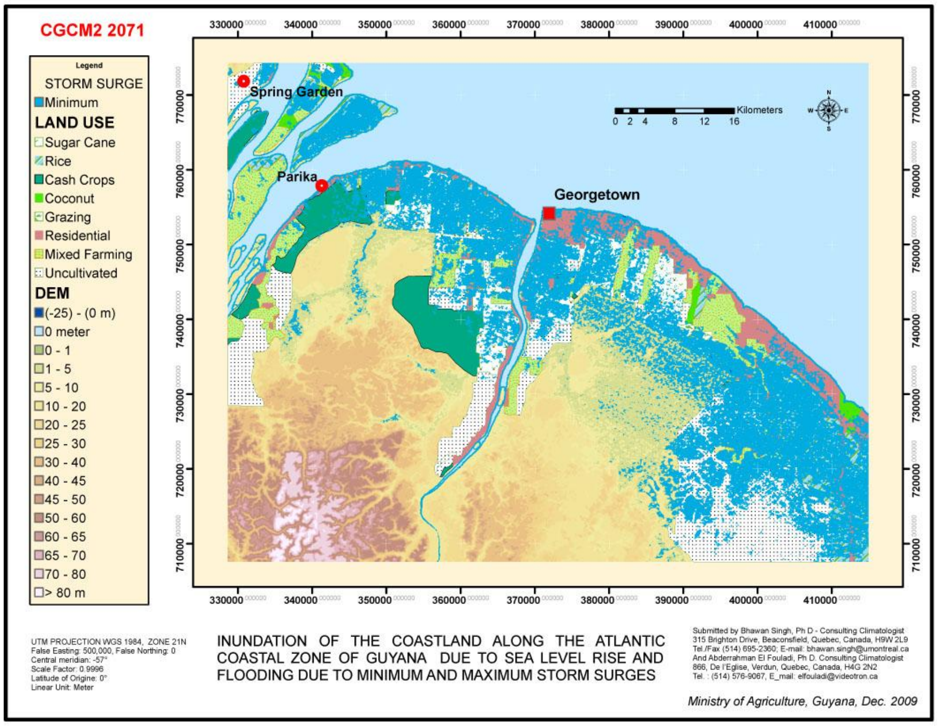


Fig. A4.3. 9. Inundation due to minimum storm surge (2 m) and sea-level rise according to the CGCM2 scenario for the year 2071 for the selected study area on the coastal zone of Guyana

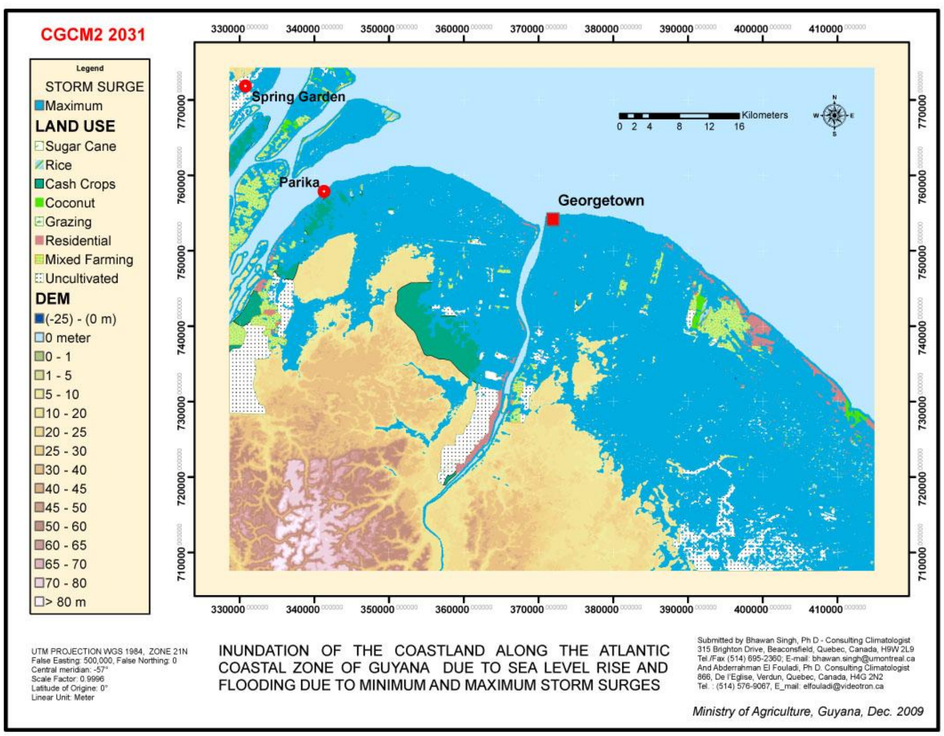


Fig. A4.3. 10. Inundation due to maximum storm surge (5 m) and sea-level rise according to the CGCM2 scenario for the year 2031 for the selected study area on the coastal zone of Guyana

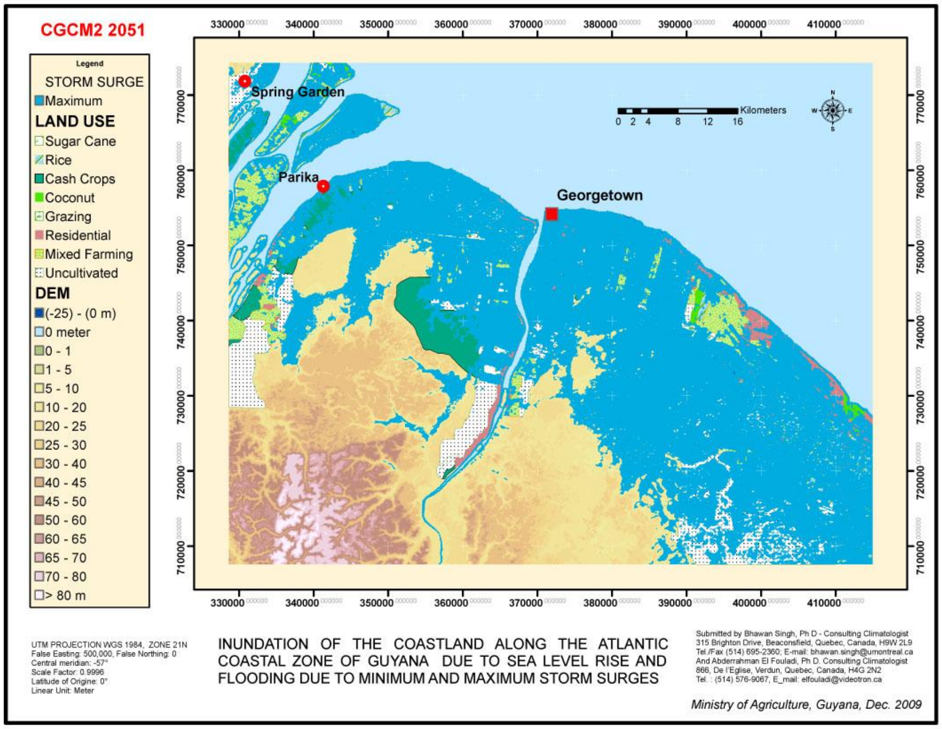


Fig. A4.3. 11. Inundation due to maximum storm surge (5 m) and sea-level rise according to the CGCM2 scenario for the year 2051 for the selected study area on the coastal zone of Guyana

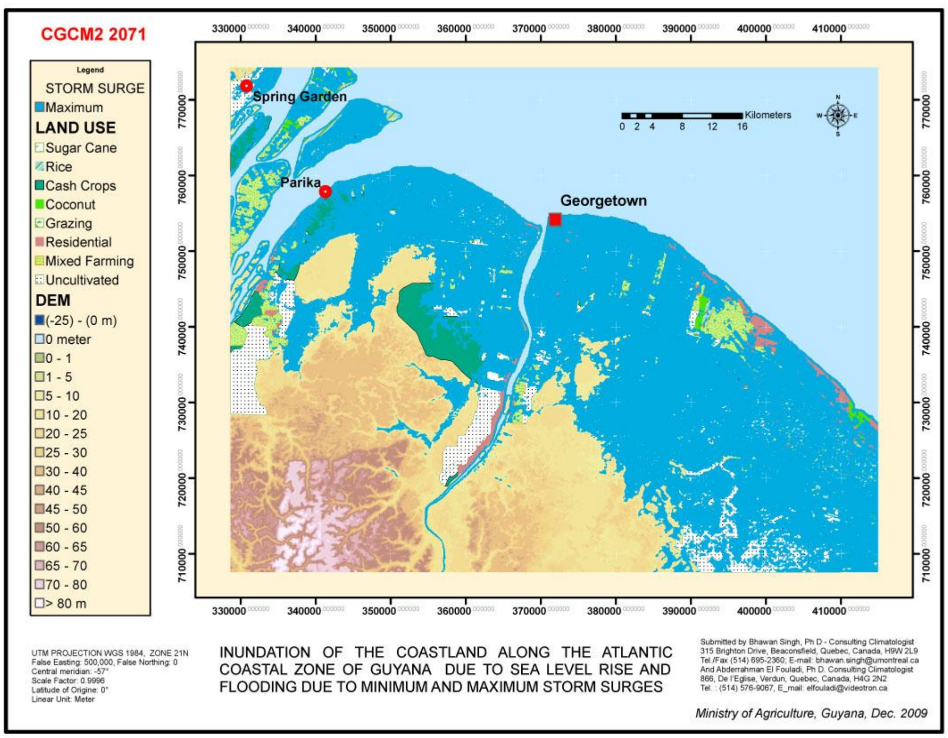


Fig. A4.3. 12. Inundation due to maximum storm surge (5 m) and sea-level rise according to the CGCM2 scenario for the year 2071 for the selected study area on the coastal zone of Guyana

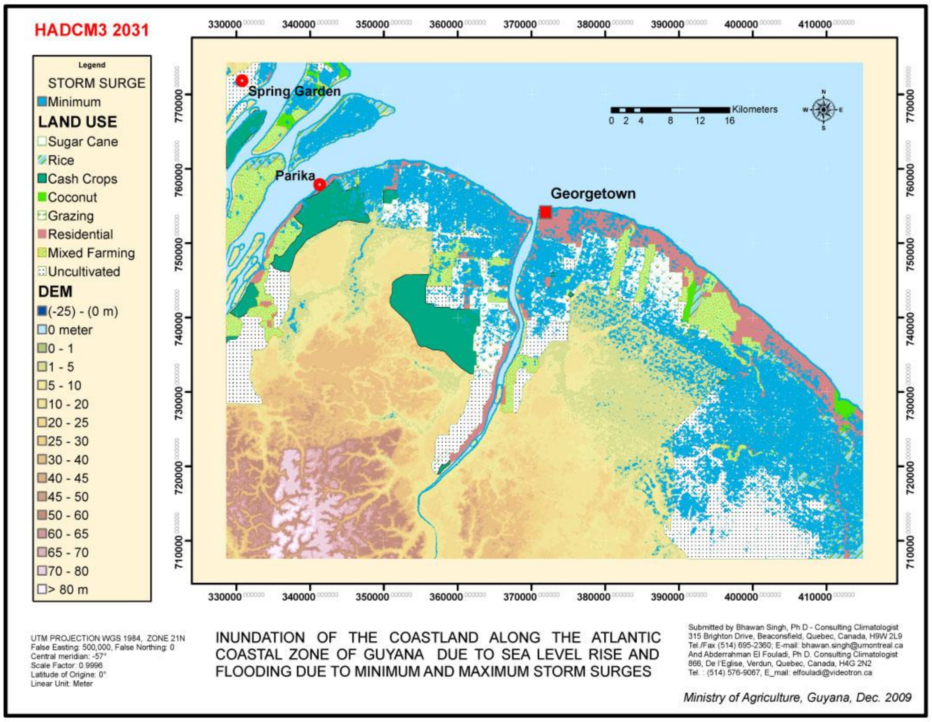


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Fig. A4.3. 13. Inundation due to minimum storm surge (2 m) and sea-level rise according to the HadCM3 scenario for the year 2031 for the selected study area on the coastal zone of Guyana

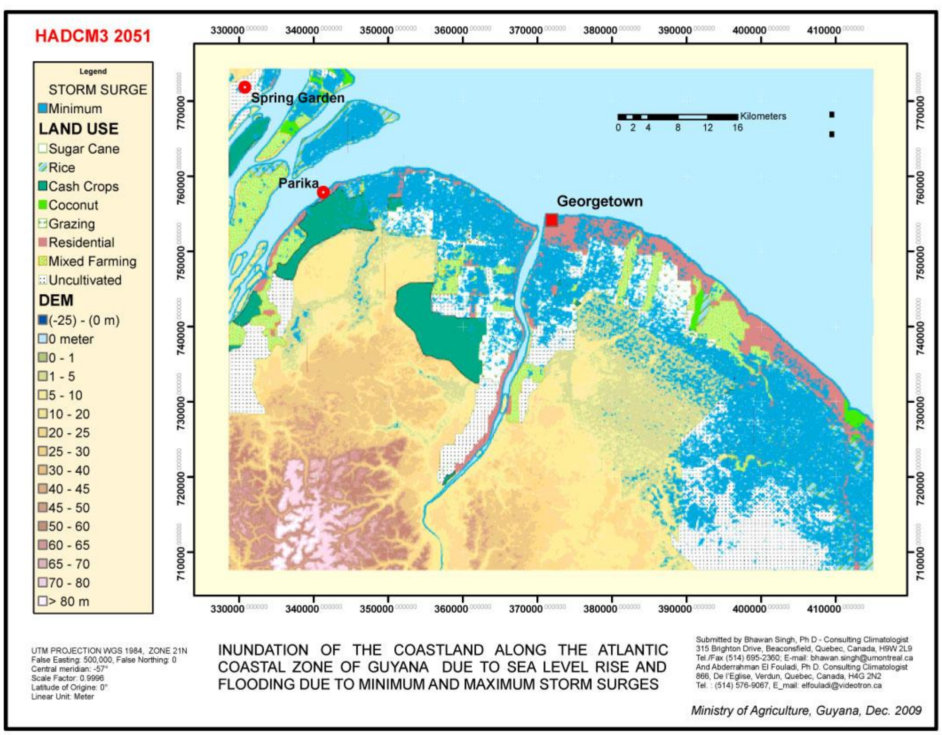

Fig. A4.3. 14 Inundation due to minimum storm surge (2 m) and sea-level rise according to the HadCM3 scenario for the year 2051 for the selected study area on the coastal zone of Guyana

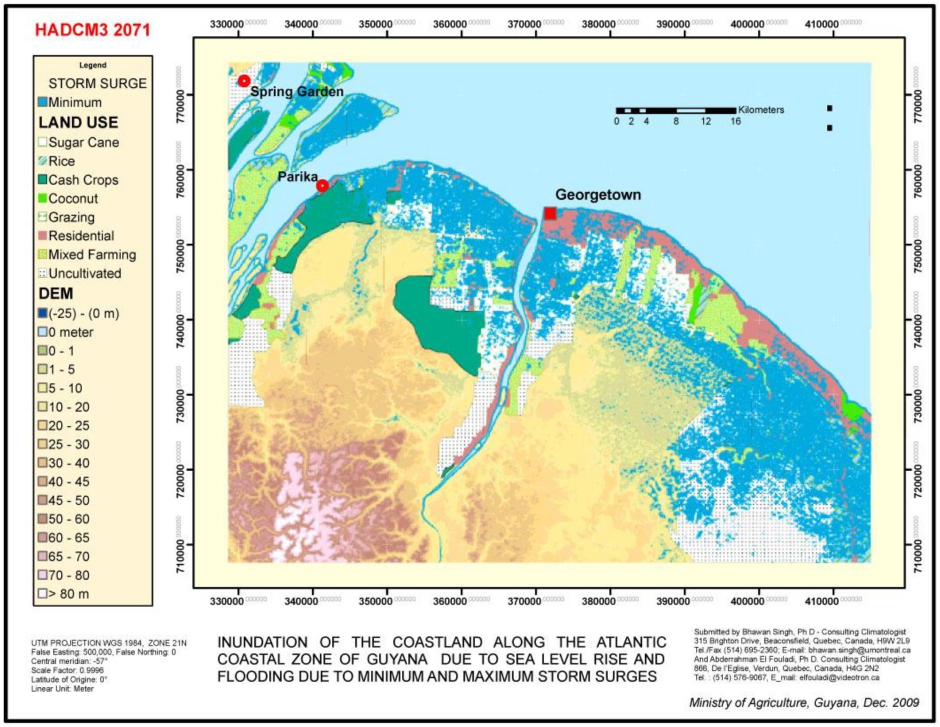

Fig. A4.3. 15. Inundation due to minimum storm surge (2 m) and sea-level rise according to the HadCM3 scenario for the year 2071 for the selected study area on the coastal zone of Guyana

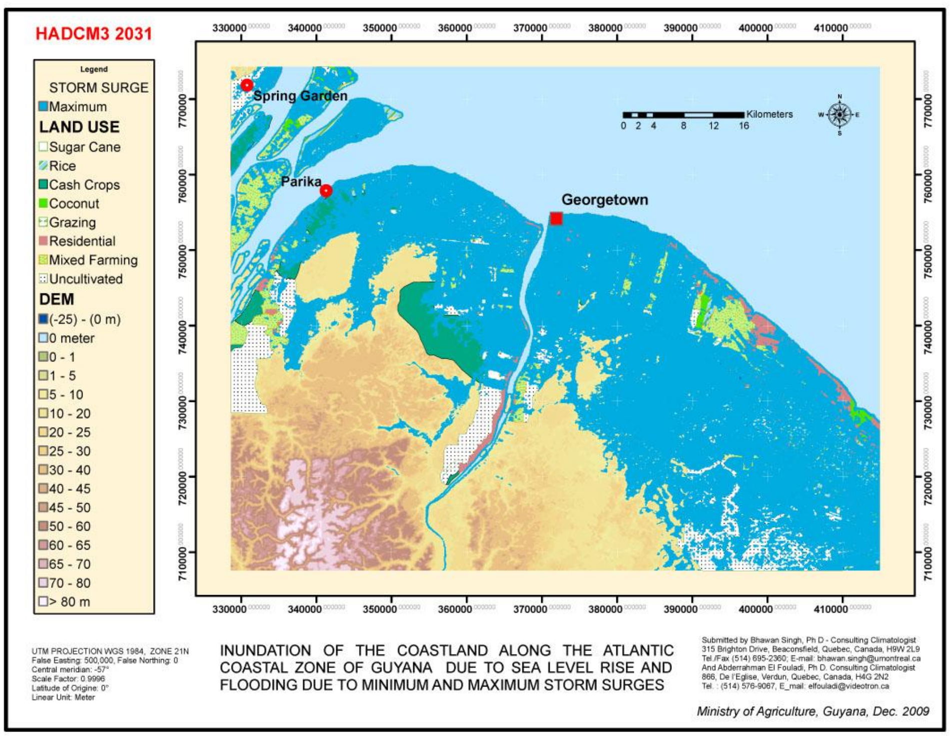

Fig. A4.3. 16. Inundation due to maximum storm surge (5 m) and sea-level rise according to the HadCM3 scenario for the year 2031 for the selected study area on the coastal zone of Guyana

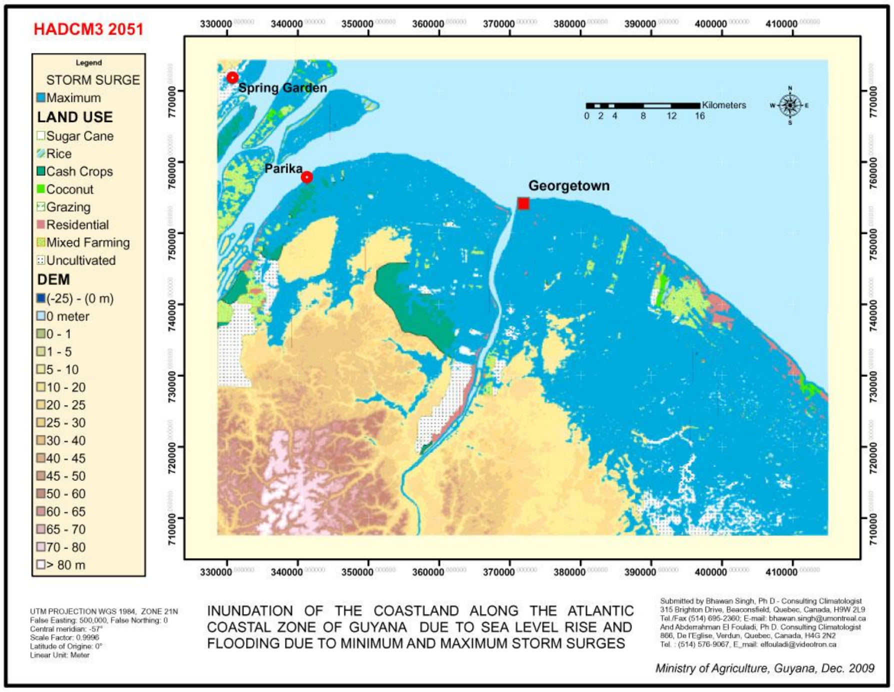

Fig. A4.3. 17. Inundation due to maximum storm surge (5 m) and sea-level rise according to the HadCM3 scenario for the year 2051 for the selected study area on the coastal zone of Guyana

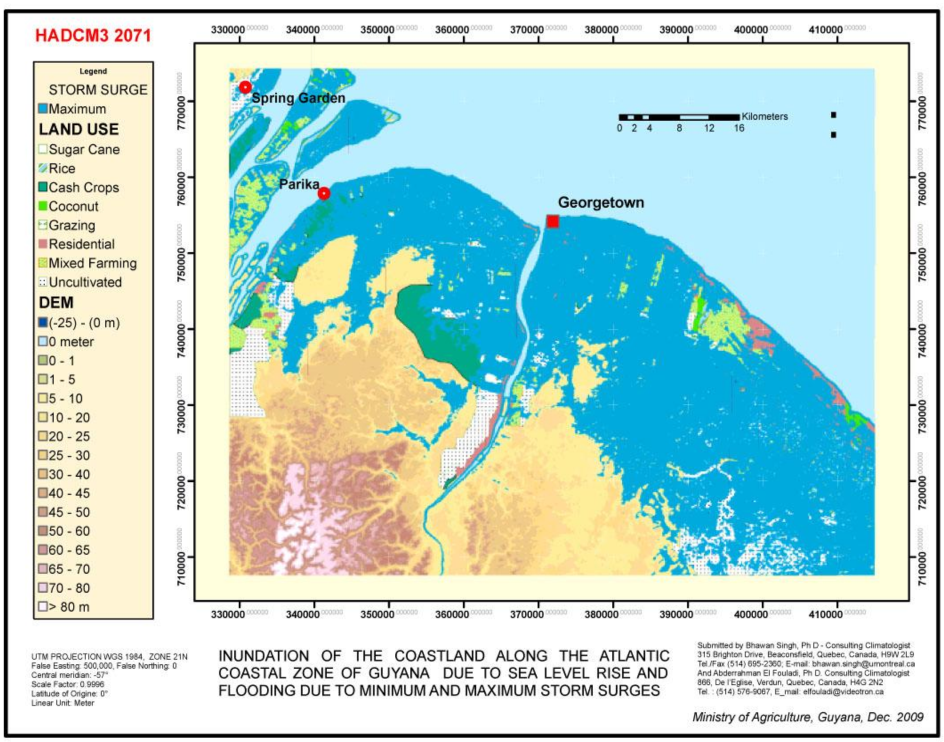

Fig. A4.3. 18. Inundation due to maximum storm surge (5 m) and sea-level rise according to the HadCM3 scenario for the year 2071 for the selected study area on the coastal zone of Guyana

Appendix 4.4. Water Sector: Complementary Tables and Figures for monthly rainfall, evapotranspiration, and water deficits for three stations

Table A4.4. 1. Summary of monthly data for Evapotranspiration (ET), Rainfall (P) and Water Deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and HadCM3) for the Timehri station (mm/month)

EVAPOTRANSPIRATION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET-61_90	83,28	76,78	89,34	93,08	95,65	90,32	93,47	100,35	98,75	104,09	95,76	87,43
ET_40-69-CGCM1	87,67	80,78	92,61	94,43	97,01	92,28	96,29	100,89	100,06	104,26	96,05	91,01
ET_40-69-HadMC3	81,99	78,14	91,08	94,01	98,78	95,6	97,23	104,57	103,88	111,04	105,09	94,37
ET_40-69-CGCM1-ET_61-90	4,39	4	3,27	1,35	1,36	1,96	2,82	0,54	1,31	0,17	0,29	3,58
ET_40-69-HadMC3_ET-61-90	-1,29	1,36	1,74	0,93	3,13	5,28	3,76	4,22	5,13	6,95	9,33	6,94

PRECIPITATION

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P-61_90	240,34	128,36	145,63	187,78	327,6	334,47	316,9	229	156,47	153,13	182,99	269,68
P_40-69-CGCM1	200,16	94,77	121,51	164,32	330,1	300,36	292,2	222,2	130,31	157,95	172,65	263,61
P_40-69-HadMC3	152,85	84,47	120,75	164,62	243,5	267,11	288,2	180,1	114,73	71,32	87,77	187,96
P_40-69-CGCM1-P_61-90	-40,18	-33,59	-24,12	-23,46	2,47	-34,11	-24,7	-6,76	-26,16	4,82	-10,34	-6,07
P_40-69-HadMC3_P-61-90	-87,49	-43,89	-24,88	-23,16	-84,05	-67,36	-28,7	-48,8	-41,74	-81,81	-95,22	-81,72

WATER DEFICIT (P-ET)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P-ET-61_90	157,06	51,57	56,29	94,69	231,93	244,15	223,42	128,59	57,73	49,04	87,23	182,24
P-ET_40-69-CGCM1	112,49	13,99	28,91	69,88	233,1	208,08	195,94	121,29	30,25	53,69	76,59	172,61
P-ET_40-69-HadMC3	70,86	6,33	29,67	70,61	144,8	171,51	190,93	75,54	10,85	-39,72	-17,32	93,59
P-ET_40-69-CGCM1-P-ET_61-90	-44,57	-37,58	-27,38	-24,81	1,12	-36,07	-27,48	-7,3	-27,48	4,65	-10,64	-9,63
P-ET_40-69-HadMC3_P-ET-61-90	-86,2	-45,24	-26,62	-24,08	-87,18	-72,64	-32,49	-53,05	-46,88	-88,76	-104,55	-88,65

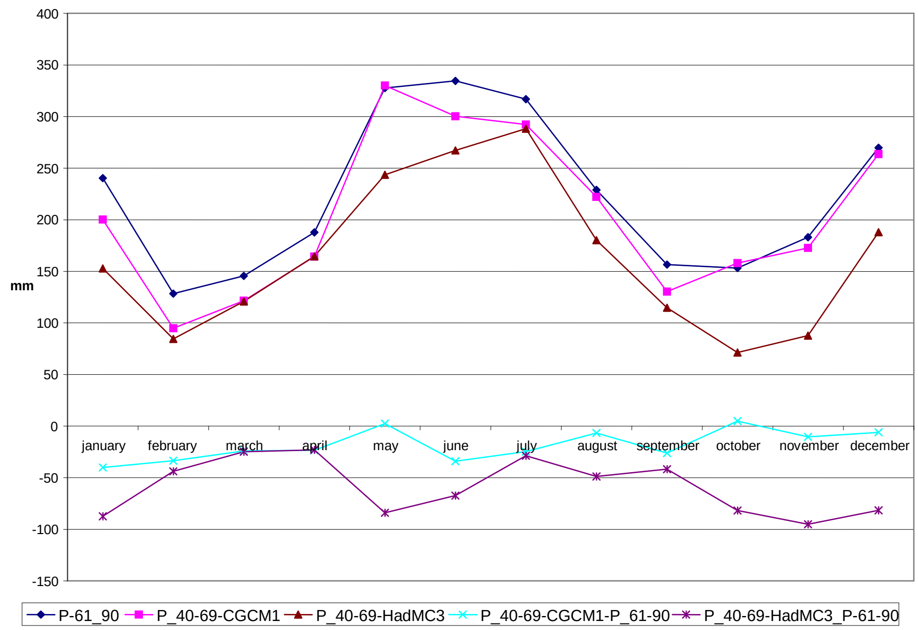

Fig. A4.4. 1. Summary of monthly data for Rainfall (P) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Timehri station

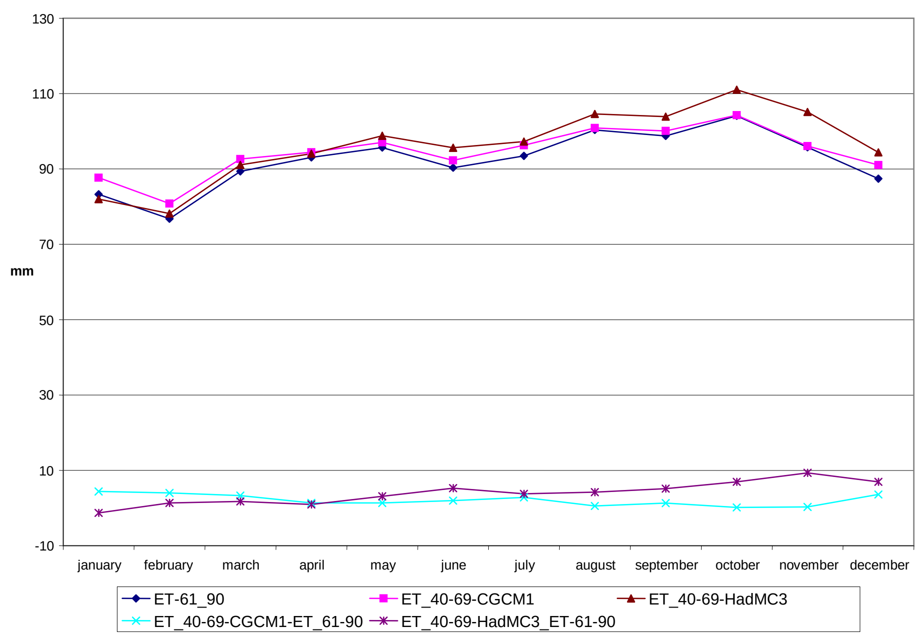

Fig. A4.4. 2. Summary of monthly data for Evapotranspiration (ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Timehri station

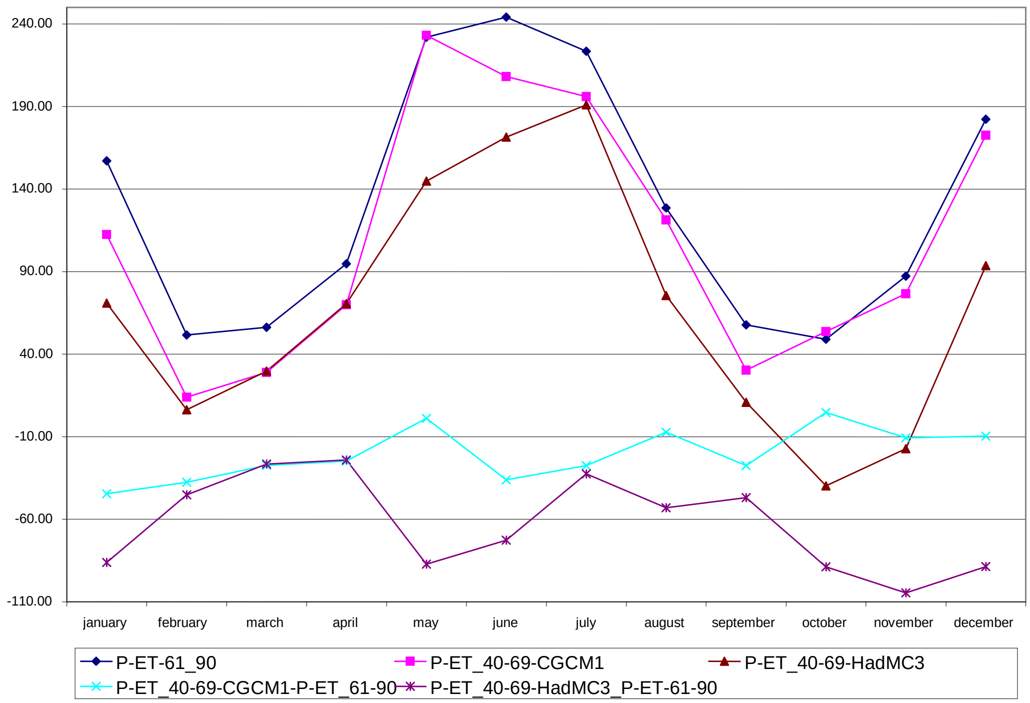

Fig. A4.4. 3. Summary of monthly data for Water Deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Timehri station

Table A4.4. 2. Summary of monthly data for Evapotranspiration (ET), Rainfall (P) and water deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the New Amsterdam station

Evapotranspiration

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_1961-90	98,77	94,02	111,71	107,3	112	103,3	110	121,22	122,33	128,7	116,18	101,97
ET_40_69_CGCM1	96,05	89,75	105,15	100,6	104	97,71	103,2	110,06	110,85	113,97	104,6	96,46
ET_40_69_HadMC3	87,79	83,41	97,27	100,5	106	102,2	103,9	111,78	111,06	118,74	112,36	100,46
ET_40-69-CGCM1-ET_61-90	-2,72	-4,27	-6,56	-6,71	-7,18	-5,63	-6,82	-11,16	-11,48	-14,73	-11,58	-5,51
ET_40-69-HadMC3_ET_61-90	-10,98	-10,61	-14,44	-6,87	-6,12	-1,19	-6,16	-9,44	-11,27	-9,96	-3,82	-1,51

Precipitation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P_1961-1990	167,08	91,02	105,55	166,9	231	266,8	221,4	155,78	71,26	73,2	83,07	205,08
P_40-69_CGCM1	297,27	195,51	127,28	152,8	292	222,8	155	91,47	35,01	60,72	59,37	193,06
P_40-69_HadMC3	152,85	84,47	120,75	164,6	244	267,1	288,2	180,12	114,73	71,32	87,77	187,96
P_40-69-CGCM1-P_61-90	130,19	104,49	21,73	-14,06	61,3	-44	-66,4	-64,31	-36,25	-12,48	-23,7	-12,02
P_40-69-HadMC3_P_61-90	-14,23	-6,55	15,2	-2,23	12,8	0,27	66,79	24,34	43,47	-1,88	4,7	-17,12

Water Deficit (P-ET)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P-ET_1961-1990	68,31	-3,01	-6,16	59,53	119	163,5	111,3	34,56	-51,06	-55,5	-33,11	103,11
P-ET_40-69_CGCM1	201,22	105,76	22,13	52,17	188	125,1	51,76	-18,59	-75,84	-53,24	-45,23	96,59
P-ET_40-69_HadMC3	65,07	1,06	23,48	64,17	138	165	184,3	68,33	3,67	-47,43	-24,59	87,5
P-ET_40-69-CGCM1-P-ET_61-90	132,91	108,77	28,29	-7,36	68,5	-38,4	-59,6	-53,15	-24,78	2,26	-12,12	-6,52
P-ET_40-69-HadMC3_P-ET_61-90	-3,24	4,07	29,64	4,64	18,9	1,47	72,95	33,77	54,73	8,07	8,52	-15,61

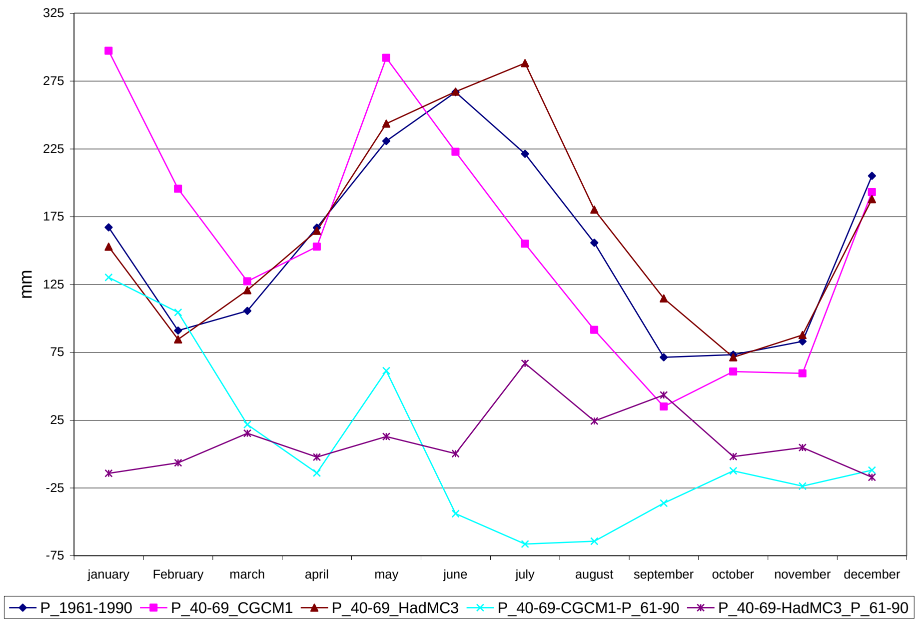

Fig. A4.4. 4. Summary of monthly data for Rainfall (P) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the New Amsterdam station

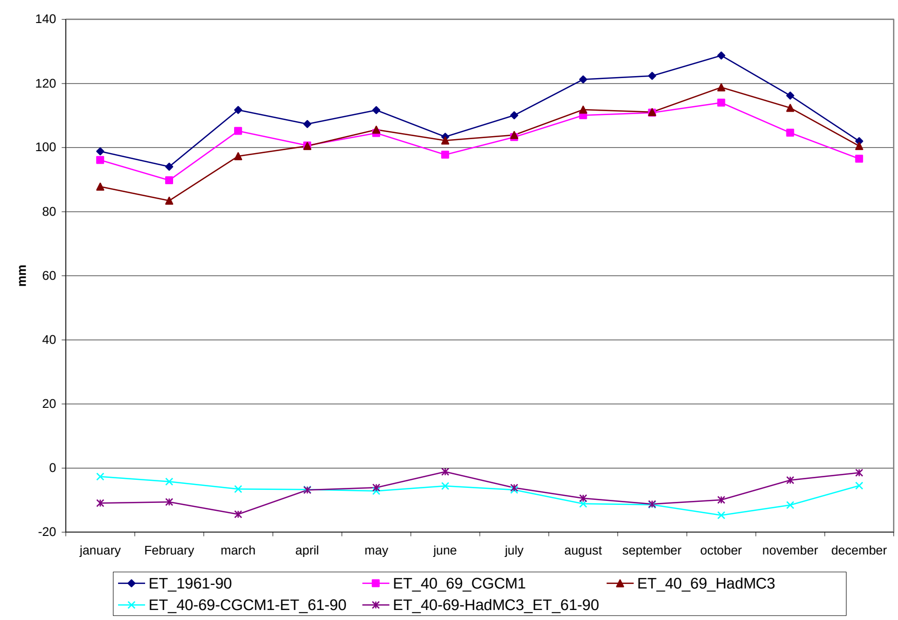

Fig. A4.4. 5. Summary of monthly data for Evapotranspiration (ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the New Amsterdam station

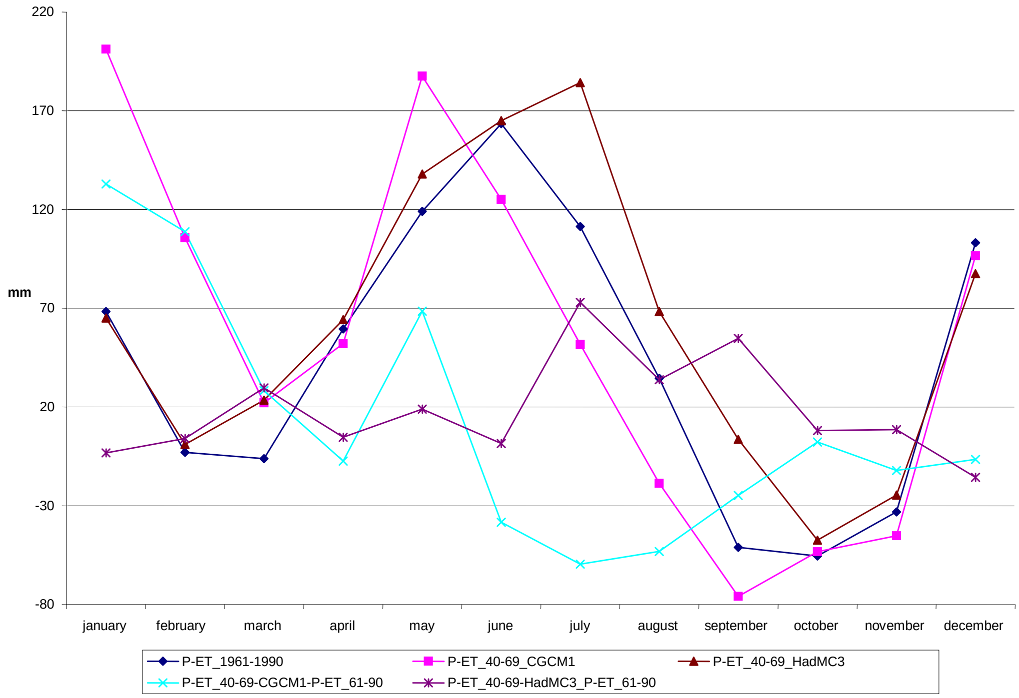

Fig. A4.4. 6. Summary of monthly data for Water Deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the New Amsterdam station

Table A4.4. 3. Summary of monthly data for Evapotranspiration (ET), Rainfall (P) and water deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Ebini station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_CGCM1_40-69	95,83	92,70	106,35	110,00	115,65	111,93	113,78	122,66	121,96	130,52	123,42	110,67
ET_HadMC3_40-69	96,56	93,43	107,18	110,87	116,57	112,82	114,68	123,65	122,95	131,59	124,05	111,53
ET_1961-90	94,09	91,20	107,64	112,36	116,81	112,45	115,54	128,13	127,23	137,04	137,68	119,16
ET_CGCM1_40-69/ET_61_90	1,74	1,50	-1,29	-2,36	-1,16	-0,52	-1,76	-5,47	-5,27	-6,52	-14,26	-8,49
ET_HadMC3_40-69/ET_61_90	2,47	2,23	-0,46	-1,49	-0,24	0,37	-0,86	-4,48	-4,28	-5,45	-13,63	-7,63

Evapotranspiration

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P_CGCM1_40-69	154,2	85,22	121,8	166,08	245,69	269,5	290,71	181,71	115,74	71,95	88,55	189,62
P_HadMC3_40-69	152,85	84,47	120,8	164,62	243,53	267,1	288,16	180,12	114,73	71,32	87,77	187,96
P_1961-90	158,21	83,61	109,5	165,52	251,88	296	295,15	188,63	130,22	96,06	107,58	180,31
P_CGCM1_40-69/P_61_90	-4,01	1,61	12,33	0,56	-6,19	-26,52	-4,44	-6,92	-14,48	-24,11	-19,03	9,31
P_HadMC3_40-69/P_61_90	-5,36	0,86	11,26	-0,9	-8,35	-28,89	-6,99	-8,51	-15,49	-24,74	-19,81	7,65

Precipitation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P-ET_CGCM1_40-69	114,95	44,69	77,1	119,95	197,36	221,9	242,99	129,74	64,12	16,95	35,86	142,13
P-ET_HadMC3_40-69	116,24	46,4	79,02	121,54	197,93	222,7	243,56	131,49	66,48	19,61	38,8	143,69
P-ET_1961-90	122,43	46,48	67,87	122,13	206,42	251,7	249,84	138,2	80,12	42,24	56,48	135,99
P_CGCM1_40-69/P_61_90	-7,48	-1,79	9,23	-2,18	-9,06	-29,81	-6,85	-8,46	-16	-25,29	-20,62	6,14
P_HadMC3_40-69/P_61_90	-6,19	-0,08	11,15	-0,59	-8,49	-29	-6,28	-6,71	-13,64	-22,63	-17,68	7,7

Water Deficit (P-ET)

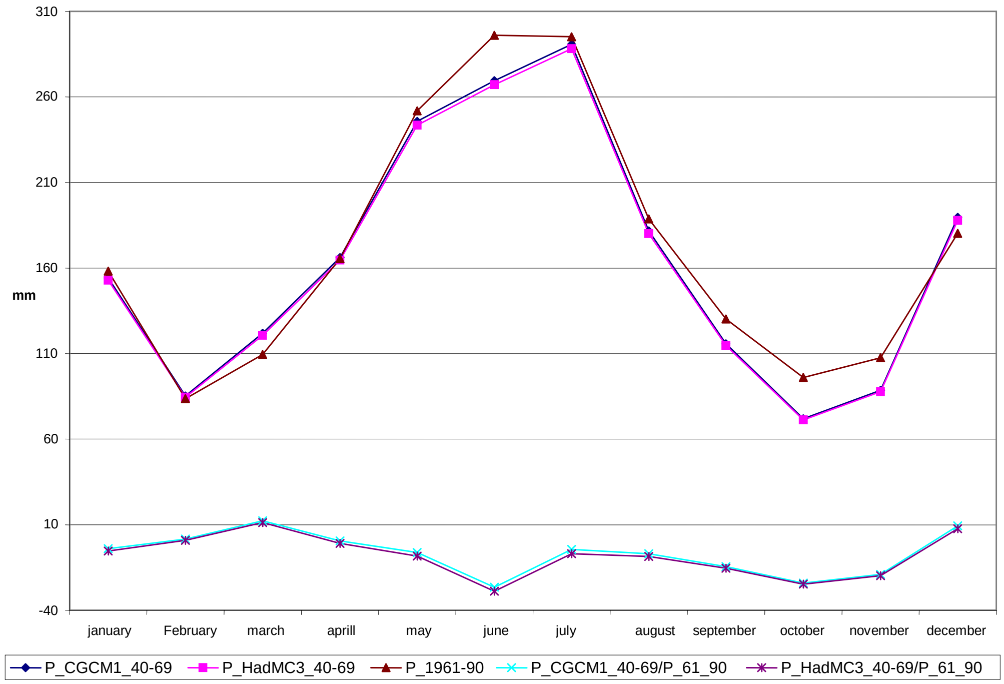

Fig. A4.4. 7. Summary of monthly data for Rainfall (P) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Ebini station

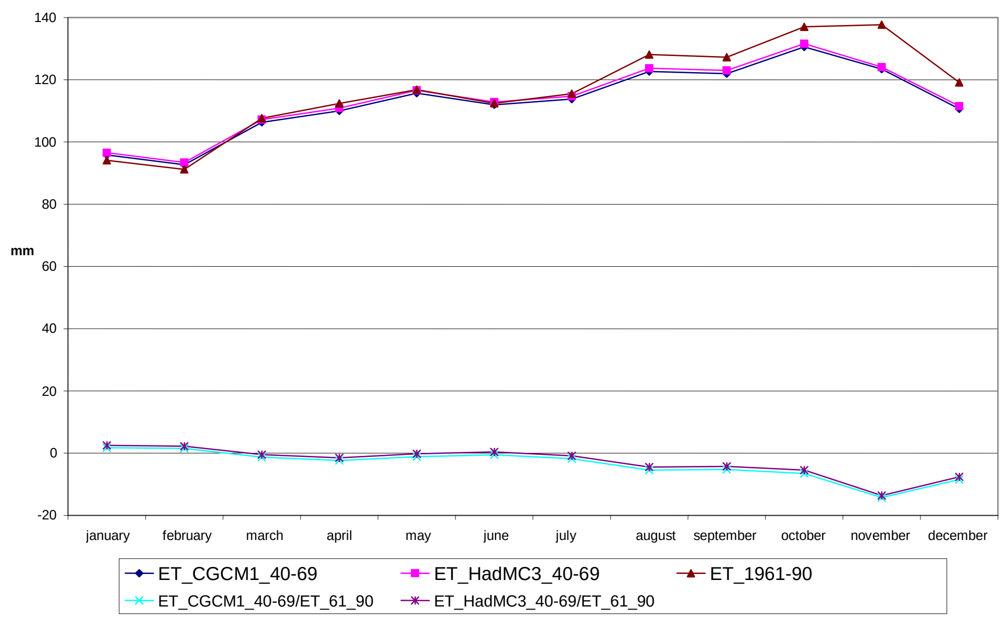

Fig. A4.4. 8. Summary of monthly data for Evapotranspiration (ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Ebini station

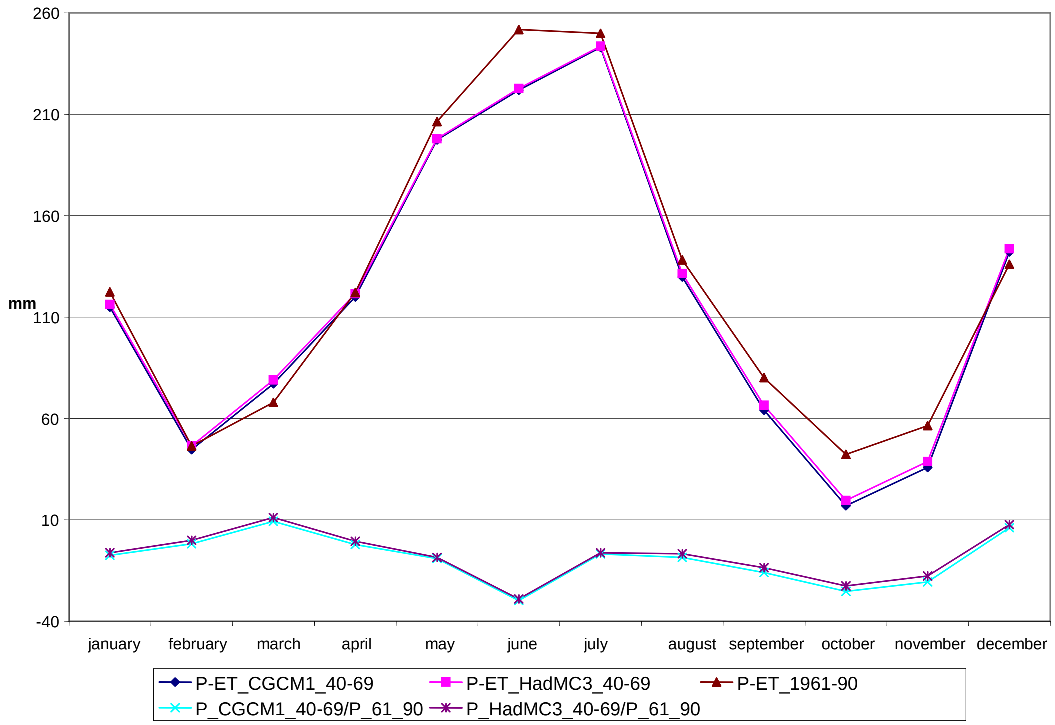

Fig. A4.4. 9. Summary of monthly data for Water Deficits (P-ET) and their changes between current (1961-1990) and future (2040-2069) climate scenarios (CGCM1 and Had CM3) for the Ebini station

Appendix 4.5. Agriculture Sector: Complementary Figures and Tables

Table A4.5. 1. Observed rice yields for Guyana: 1968-2008

Year	Rice Yields (t/ha)
1968	1.7
1969	1.5
1970	1.8
1971	1.9
1972	1.8
1973	1.6
1974	2.4
1975	2.7
1976	2
1977	2.7
1978	2.6
1979	2.6
1980	2.9
1981	3
1982	3.1
1983	3.2
1984	3.2
1985	3.3
1986	3.4
1987	3.2
1988	3
1989	3.4
1990	3
1991	3.3
1992	3.7
1993	3.4
1994	3.8
1995	3.9
1996	4
1997	3.9
1998	4
1999	3.8
2000	3.8
2001	3.9
2002	4.1
2003	4.3
2004	4.3
2005	3.9
2006	4.6
2007	4.3
2008	4.2

Table A4.5. 2. Rice yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO_2 fertilization (t/ha)

Year	CGCM1-with CO_2 (t/ha)	CGCM1- without CO_2 (t/ha)	HadCM3-with CO_2 (t/ha)	HadCM3-without CO_2 (t/ha)
2040	3.71	3.65	3.72	3.68
2041	3.32	3.26	3.33	3.29
2042	3.02	2.98	3.04	3.00
2043	3.02	2.98	3.04	3.00
2044	3.32	3.26	3.33	3.29
2045	3.12	3.07	3.14	3.10
2046	3.02	2.98	3.04	3.00
2047	3.12	3.07	3.14	3.10
2048	3.71	3.65	3.72	3.68
2049	3.22	3.17	3.23	3.20
2050	2.05	2.02	2.06	2.03
2051	2.54	2.50	2.55	2.52
2052	2.54	2.50	2.55	2.52
2053	3.32	3.26	3.33	3.29
2054	2.44	2.40	2.45	2.42
2055	2.34	2.30	2.35	2.33
2056	2.05	2.02	2.06	2.03
2057	3.02	2.98	3.04	3.00
2058	3.71	3.65	3.72	3.68
2059	2.73	2.69	2.74	2.71
2060	3.32	3.26	3.33	3.29
2061	2.73	2.69	2.74	2.71
2062	1.56	1.54	1.57	1.55
2063	1.66	1.63	1.67	1.65
2064	1.37	1.34	1.37	1.36
2065	2.44	2.40	2.45	2.42
2066	2.24	2.21	2.25	2.23
2067	1.85	1.82	1.86	1.84
2068	1.27	1.25	1.27	1.26
2069	1.46	1.44	1.47	1.45

Table A4.5. 3. Summary of Rice yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO_2 fertilization (t/ha)

Climate Scenario	CGCM1-with CO_2 (t/ha)	CGCM1- without CO_2 (t/ha)	HadCM3-with CO_2 (t/ha)	HadCM3-without CO_2 (t/ha)
Mean Yield (t/ha)	**2.64**	**2.60**	**2.65**	**2.62**
Yield Change (%)	**-2.56**	**-4.17**	**-2.04**	**-3.20**

Table A4.5. 4. Sugar-cane yields for Guyana for the period 1980-2008 (t/ha)

Year	Sugarcane Yield (t/ha)
1980	71.11
1981	80.73
1982	72.01
1983	71.96
1984	66.49
1985	72.95
1986	72.19
1987	70.87
1988	70.98
1989	71.91
1990	53.37
1991	58.78
1992	71.66
1993	75.23
1994	72.83
1995	66.68
1996	71.23
1997	66.85
1998	67.00
1999	72.51
2000	61.55
2001	66.97
2002	80.45
2003	72.66
2004	75.09
2005	65.37
2006	64.48
2007	71.97
2008	57.71
Mean	**69.43**

Table A4.5. 5. Sugar-cane yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO_2 fertilization (t/ha)

Year	CGCM1-with CO_2 (t/ha)	CGCM1- without CO_2 (t/ha)	HadCM3-with CO_2 (t/ha)	HadCM3-without CO_2 (t/ha)
2040	48.12	46.09	50.84	48.80
2041	40.97	39.24	43.28	41.55
2042	55.24	52.90	58.35	56.02
2043	54.02	51.73	57.06	54.78
2044	46.41	44.45	49.03	47.07
2045	53.31	51.06	56.32	54.06
2046	51.59	49.41	54.49	52.31
2047	59.25	56.75	62.59	60.08
2048	47.55	45.54	50.23	48.22
2049	56.13	53.76	59.30	56.92
2050	51.48	49.30	54.38	52.20
2051	53.73	51.46	56.75	54.48
2052	47.46	45.46	50.14	48.13
2053	50.58	48.44	53.43	51.29
2054	48.66	46.61	51.41	49.35
2055	51.52	49.34	54.42	52.24
2056	53.42	51.16	56.42	54.17
2057	50.88	48.73	53.75	51.60
2058	47.41	45.41	50.09	48.08
2059	55.29	52.95	58.40	56.07
2060	51.05	48.90	53.93	51.77
2061	50.40	48.27	53.24	51.11
2062	50.32	48.19	53.16	51.03
2063	47.95	45.93	50.66	48.63
2064	51.79	49.60	54.71	52.52
2065	51.87	49.67	54.79	52.60
2066	51.09	48.93	53.97	51.81
2067	51.13	48.97	54.01	51.85
2068	57.32	54.90	60.55	58.12
2069	52.37	50.16	55.32	53.11

Table A4.5. 6. Summary of Sugar-cane yields for Guyana under the future climate (2040-2069) according to the CGCM1 and HadCM3 scenarios, with and without CO_2 fertilization (t/ha)

Climate Scenario	CGCM1-with CO_2 (t/ha)	CGCM1- without CO_2 (t/ha)	HadCM3-with CO_2 (t/ha)	HadCM3-without CO_2 (t/ha)
Mean Yield (t/ha)	**51.28**	**49.11**	**54.17**	**52.00**
Yield Change (%)	**-40.85**	**-47.06**	**-33.33**	**-38.89**

Chapter 5. Research and Systematic Observation (RSO)

Appendix 5.1. Prioritization matrix

Sector		Technology options	Mitigation potential	Vulnerability	Strategies and targets	Sustainability	Costs / Benefits	Utilization	Technology maturity	Funding potential	Support systems	User understanding	Total score
		Weighting	3	4	4	3	4	2	3	4	4	4	**105**
Mitigation	Energy	Hydropower	3		3	2	2	3	2	3	3	3	**79.05**
		Solar power	2		2	2	1	2	2	2	3	2	**59.05**
		Wind power	2		1	2	1	1	2	1	1	2	**41.90**
		Co-generation	2		2	2	2	1	1	2	2	2	**54.29**
		Energy from waste	3		2	1	1	1	1	2	2	2	**50.48**
		Fuel switching (biofuels)	1		1	1	2	2	1	2	2	1	**42.86**
		Distribution efficiency	1		2	2	1	2	1	2	1	1	**41.90**
	Transport Sector	Hybrid vehicles	3		1	2	1	2	2	2	1	2	**50.48**
		Fuel-efficient vehicles	3		2	2	3	3	4	3	2	4	**84.76**
		Improved mass-transport systems	1		1	2	2	3	2	3	2	1	**54.29**
	Buildings sector	Energy-efficiency	3		3	3	3	3	3	3	2	2	**80.95**
		Insulation	1		1	2	2	2	2	1	1	2	**44.76**
	Waste sector	Recycling	1		2	2	2	3	3	2	2	2	**60.95**
		Composting	1		2	2	3	3	3	3	2	2	**68.57**
		Biogas	2		2	1	3	1	2	3	2	1	**58.10**
	Agriculture sector	Improved water management	3		3	3	2	2	2	3	2	2	**72.38**
		Minimal soil disturbance	1		1	2	3	2	1	1	1	1	**41.90**
		Crop rotation	1		1	2	2	2	2	1	1	1	**40.95**
		Controlled fertilisers	1		2	2	2	2	2	2	2	2	**56.19**
	Forestry	Forest conservation	3		3	3	3	3	2	3	3	3	**85.71**

		Sustainable logging	2		3	3	2	3	3	2	2	3	**74.29**
		Fire and pest management	2		2	3	2	3	2	1	2	3	**63.81**
Vulnerability	**Agriculture sector**	New crop species and cultivars/ substitution of crops		2	3	2	2	3	2	3	2	2	**70.48**
		Pest management		1	1	1	2	3	2	1	2	2	**48.57**
		Changes in cultivation practices, including improved water management techniques		2	3	2	1	1	1	2	2	2	**56.19**
	Buildings sector	Introduction of new building codes		3	2	3	2	3	2	2	2	3	**73.33**
	Coastal sector	Hard structural options		2	3	3	2	3	3	3	3	3	**83.81**
		Monitoring and warning systems		3	2	3	3	3	2	3	2	2	**77.14**
		Stringent planning controls in susceptible areas		3	2	3	3	3	3	3	2	1	**76.19**
	Water resources sector	Rain-water collection		2	1	1	3	3	3	1	2	3	**62.86**
		Promotion of water efficiency		2	2	2	2	3	2	2	2	2	**62.86**
		Drainage/re-use		**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**1**	**62.86**

Appendix 5.2. Methodology for establishing criteria and weightings for assessing technology needs

The TNA was conducted in accordance with the following guidelines:

- The Handbook for Conducting Technology Needs Assessment for Climate Change (UNDP/UNFCCC, 2009)
- Conducting Technology Needs Assessments for Climate Change (UNDP/GEF 2004)
- Methods for Climate Change Technology Transfer Needs Assessments and Implementing Activities: Experiences of Developing and Transition Countries (CTI 2002)
- Technologies, Policies and Measures for Mitigating Climate Change (IPCC 2006)

During the course of the assessment, reference was also made to the published TNAs of other developing countries, as these provide useful information on good practice and lessons learnt.

A simplified overview of the approach adopted for conducting Guyana's TNA is presented in Figure A5.2.1 below.

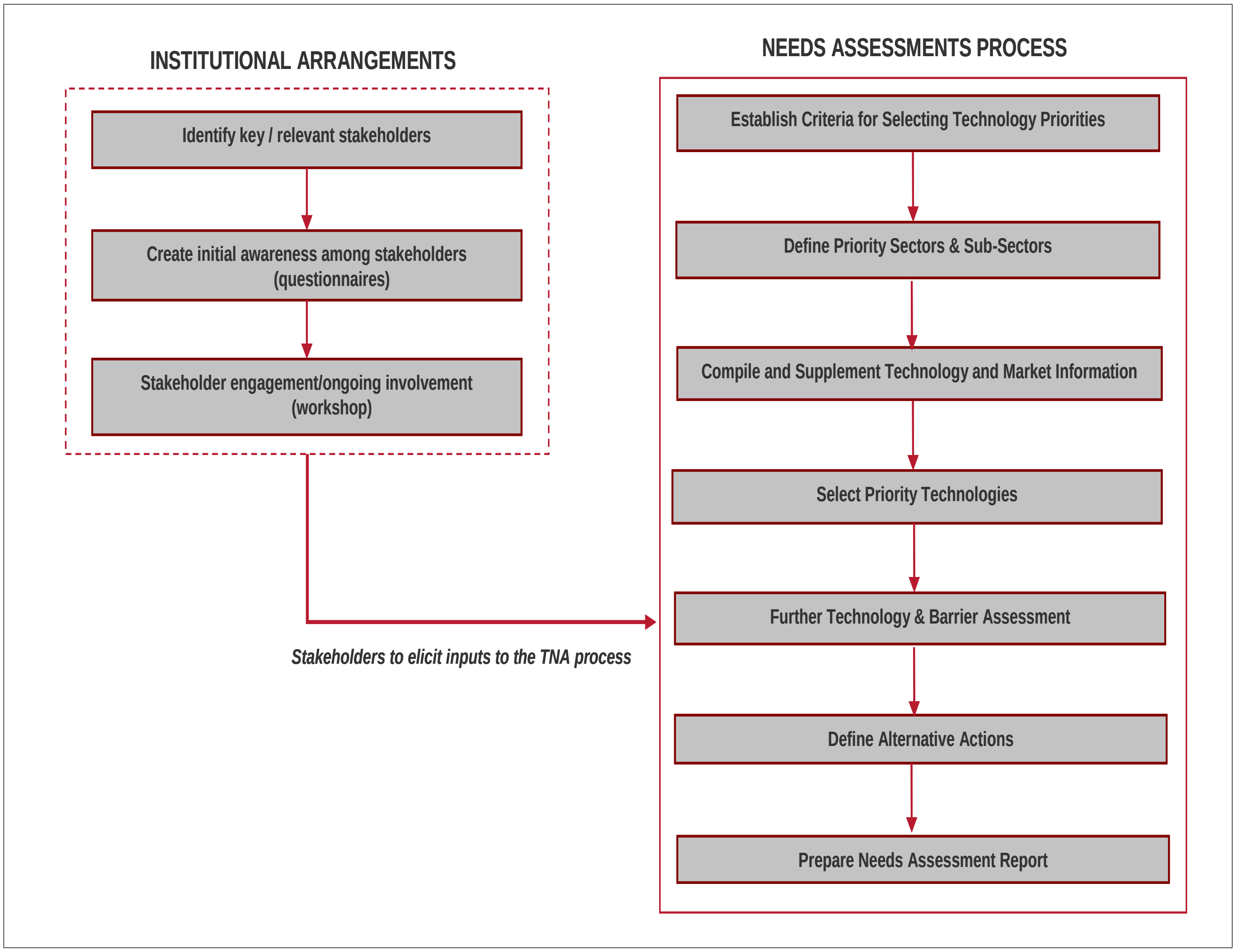

Fig. A5.2. 1. Summary overview of the approach to conducting the TNA (based on CTI, 2002)

Preliminary Assessment

A preliminary assessment was undertaken to identify the priority sectors, as well as data sources, information sources and data gaps. This was based largely on the content of the INC as well as a review of relevant development strategies (specifically the National Development Strategy and the Draft Low Carbon Development Strategy), and available information on sectoral development objectives.

Institutional Arrangements and Stakeholder Engagement

The TNA was undertaken in consultation with sector experts and other relevant national and regional stakeholders. Relevant stakeholders were identified following a review of the INC and in consultation with the SNC Project Office within the Ministry of Agriculture.

In particular, stakeholders contributed towards:

- The identification and weighting of appropriate technology selection criteria
- Identifying the technologies and strategies that are already in place or under discussion in Guyana

- Identifying technology gaps and priority needs
- Describing the constraints to technology transfer and implementation, including the policy environment, technical barriers, costs and other capacity constraints.

An extensive list of technologies with mitigation and/or adaptation potential was developed for a range of sectors. Criteria for the prioritization of technologies were developed by the project team and then discussed, further refined, and agreed with stakeholders at a workshop held in Georgetown, Guyana, in November 2009. The range of potential mitigation and adaptation technology options, as well as potential barriers to their implementation, was also discussed at the workshop.

Establishing Criteria for Selection of Priority Measures

Well-defined criteria for selecting priority measures create a common framework for systematically identifying the highest priority measures and future technology transfer activities. This process also requires an understanding of the impacts or contribution of these measures to the wider environmental, social, and economic development goals of the country. While there are a number of analytical approaches that could be employed, the approach that was adopted in this TNA takes account of the specific circumstances within Guyana, as well as the time and resources available for conducting the assessment.

Generally, the criteria for selecting sectors and technologies for TNA depend on four, often inter-related, factors:

- Contribution to climate change mitigation or adaptation, i.e. how effective is the technology in reducing GHG emissions and/or increasing resilience to the impacts of climate change?
- Contribution to development goals and consistency with national policy and institutional objectives, i.e. how much overlap exists between the technology and previously identified technology needs?
- Market potential, i.e. is there a ready niche for the technology?
- Costs, i.e. how affordable is the technology and what is its profitability or payback potential?

These criteria are in turn defined by a number of indicators which will help identify those technologies that:

- offer significant advantages in terms of contributing towards national and sectoral climate change mitigation and adaptation objectives and which are fit-for-purpose
- are also consistent with and/or contribute towards wider sustainable development goals
- are appropriate for Guyana in terms of capacity/skill requirements, cost and funding opportunities
- are cost-effective to implement.

Determining the importance of each of these indicators is partly a policy decision, and as such is affected by Guyana's development priorities and circumstances.[249] Based on their in-depth knowledge and understanding of the Guyanese context, stakeholders therefore played a crucial role in identifying the relative importance of each of these indicators. Using a pre-defined scoring system, stakeholders

[249] Gross, R., Dougherty, W., and Kumarsingh, K. (2004). "Conducting Technology Needs Assessments for Climate Change". UNDP, New York, UA, 26pp [online]. Available at: http://unfccc.int/ttclear/pdf/TNA/UNDP/TNA%20Handbook_Final%20version.pdf (accessed 14 August 2009).

individually assigned scores or weights to each of the indicators. These were then discussed during a workshop and consensus reached on the final score to be assigned to each indicator. The selected criteria were applied to both mitigation and adaptation technologies.

A description of the criteria and indicators is provided in Table A5.2.1 below.

Table A5.2. 1. TNA criteria

Criteria Groups	Indicators	Short Description
Relevance to climate change	Mitigation potential	**Contribution towards controlling, reducing, or preventing GHG emissions**
	Vulnerability	**Reduced vulnerability and strengthened resilience. Improves the capacity of Guyana to respond to the impacts of climate change including sea-level rise, flooding, rainfall variability, and prolonged periods of high temperature**
Alignment with national goals	Strategies and targets	**Consistent with existing and emerging national policy objectives in the areas of environmental management, poverty alleviation, economic development, and social development**
	Sustainability	**Support Guyana's sustainable development objectives as set out in the National Development Strategy and Low Carbon Development Strategy. 'No regret' solutions that will help achieve sustainable development objectives regardless of climate change.**
Cost and market potential	Costs / Benefits	**Full economic costs and benefits (including capital, operating, and ongoing maintenance costs, as well as any externalities)**
	Utilization	**Potential scale of utilization (i.e. small group of specialist users or larger group of more general users)**
	Maturity	**Commercial availability, ease of use, proven results**
	Funding potential	**Eligibility for funding from commercial bank loans, public sector funds, multi-lateral lending institutions (e.g. the World Bank, IFC, Inter-American Development Bank, etc.), donor organizations, or other funding mechanisms (e.g. under the UNFCCC or GEF)**
Skills and capacity building	Support systems	**Systems in place to support transfer/implementation**
	User understanding	**Capacity of intended users to implement, operate, and maintain the technology**

Each of the mitigation and adaptation technologies and measures considered were then scored according to how closely they matched each criterion, and each score multiplied by the relevant weightings to arrive at a total score for each technology or measure.

Once the scores had been calculated for each technology or measure, all the technology options relevant to each climate change mitigation and adaptation were arranged (in descending order) into a prioritization matrix. Any options containing a score of 0 or 1 for more than one criterion were removed from the prioritization matrix. The resulting prioritization matrix is presented in Appendix 5.1.

Using the scoring system shown in Table A5.2.2 below, stakeholders individually assigned scores or weights to each of the indicators. These were then discussed during a workshop and consensus reached on the final score to be assigned to each indicator. The selected criteria were applied to both mitigation and adaptation technologies. Although most criteria apply to both groups of technologies, in some cases, a particular criterion might be relevant only to one. For example, 'contribution towards controlling, reducing or preventing GHG emissions' applies only to mitigation technologies.

Table A5.2. 2. Indicator scoring system

Scoring system
0 – No importance/makes no contribution, not applicable, or has a negative ranking
1 – Low importance, i.e. of limited importance in terms of Guyana's circumstances and development priorities
2 – Medium importance, i.e. relevant to national circumstances and makes a positive contribution to achieving Guyana's development priorities
3 – High importance, i.e. highly relevant to Guyana's circumstances and development priorities
4 – Critical, i.e. fundamental to achieving Guyana's development priorities

The final set of criteria and weightings used in the analysis are shown in Table A5.2.3.

Table A5.2. 3. TNA criteria and weighting

Criteria Groups	Indicators	Short Description	Weighting
Relevance to climate change	Mitigation potential	**Contribution towards controlling, reducing, or preventing GHG emissions**	**3**
	Vulnerability	**Reduced vulnerability and strengthened resilience. Improves the capacity of Guyana to respond to the impacts of climate change including sea-level rise, flooding, rainfall variability, and prolonged periods of high temperature**	**4**
Alignment with national goals	Strategies and targets	**Consistent with existing and emerging national policy objectives in the areas of environmental management, poverty alleviation, economic development, and social development**	**4**
	Sustainability	**Support Guyana's sustainable development objectives as set out in the National Development Strategy and Low Carbon Development Strategy. 'No regret' solutions that will help achieve sustainable development objectives**	**3**

		regardless of climate change.	
Cost and market potential	Costs / Benefits	**Full economic costs and benefits (including capital, operating, and ongoing maintenance costs, as well as any externalities)**	**4**
	Utilization	**Potential scale of utilization (i.e. small group of specialist users or larger group of more general users)**	**2**
	Maturity	**Commercial availability, ease of use, proven results**	**3**
	Funding potential	**Eligibility for funding from commercial bank loans, public sector funds, multi-lateral lending institutions (e.g. the World Bank, IFC, Inter-American Development Bank, etc), donor organizations, or other funding mechanisms (e.g. under the UNFCCC or GEF)**	**4**
Skills and capacity building	Support systems	**Systems in place to support transfer / implementation**	**4**
	User understanding	**Capacity of intended users to implement, operate and maintain the technology**	**4**
Total			**35**

Each technology or measure selected was then weighted on a scale of 1 to 3 (as a zero weighting would mean that the measure made zero contribution to the total). A weighting of 1 means that the technology or measure has low importance, 2 indicates medium impact or importance, while 3 is used for measures that are considered critical.

For each selected technology option, the consultants assigned a score against each of the assessment criteria. Each score was multiplied by the relevant weighting (i.e. those noted in Table A5.2.2) and the total calculated for each technology. Each result was then normalized by multiplying it by 100 % and dividing by the total maximum score of 105. The maximum score was calculated by multiplying the individual maximum score of 3 by the sum of the weighting factors, i.e. 35).

Once the scores had been calculated for each technology or measure, the technology options relevant to each of climate change mitigation and adaptation were arranged in descending order and any options containing a score of 0 or 1 for more than one criterion were removed from the prioritization matrix. An overall prioritization matrix was then compiled and this is presented in Appendix 5.1.

Appendix 5.3. Solar power installations in Guyana

Location	Reg.	Year Installed	No. of panels	Solar Cell	Total Rated Power (W)	System Volt (DC)	Status	Application	Annual Energy Estimation (kWh)
Warapoka	1	2007	2		110		Operational	Health Centre	**200.75**
Yarikita	1	2008	105	Poly-si	13125	12	Operational	Residents & School	**23953.125**
Capoey	2	2008	67	Poly-si	8375	12	Operational	Residents & School	**15284.375**
Karia Karia	3	2007	2		110		Operational	Health Centre	**200.75**
Swarte Hoek	3	1997	62		11000	120/240	Operational	Lighting and appliances	**20075**
Guyana Energy Agency	4	2007	3	multicrystalline	110	12	Operational	Lighting and computers	**200.75**
St Cuthbert	5	2006	24	monocrystalline	1800	20	Operational	Well pump	**3285**
Orealla	6	2009	14	Poly-si	2450	120 V	Operational	Lighting and appliances for a Fruit Cheese Factory	**4471 .25**
Imbaimadai	7	2007	2		110		Operational	Health Centre	**200.75**
Kato	7	2005	8	Poly-si	1008	30	Operational	Electricity for clinic	**1839.6**
Kaieteur	8	2004	10	monocrystalline	1272	24	Operational	Park and Guest House	**2321.4**
Monkey Mountain	8	2007	2		110		Operational	Health Centre	**200.75**
Paruima	8	2004	8	Poly-si	1008	30	Operational	Productive works	**1839.6**
Kurukabaru	8	2008	102	Poly-si	12750	12	Operational	Residents & School	**23268.75**
Aishalton	9	2006	24	monocrystalline	1800	20	Not working	Well pump	**3285**
Annai	9	2004	24	monocrystalline	1272	20	Operational	Well pump	**2321.4**
Apoteri	9	2007	2		110		Operational	Health Centre	**200.75**
Karasabai	9	2004	24	monocrystalline	1272	20	Operational	Well pump	**2321.4**
Sand Creek	9	2006	24	monocrystalline	1800	20	Operational	Well pump	**3285**
Yupukari	9	2006	24	monocrystalline	1800	20	not working	Well pump	**3285**
Woweta	9	2009	49		1960	12	Operational	Residents	**3577**
Woweta	9	2009	2		170		Operational	Solar Freezer	**310.25**
Woweta	9	2009	4		340		Operational	Well pump	**620.5**
Moraikobe	10	2004	24	monocrystalline	1272	20	Operational	Well pump	**2321.4**

Muritaro	10	2008	63	Poly-si	7875	12	Operational	Residents & School	**14371 .875**
Hinterland communities		2009	1000		15000	12	Operational	Lighting	**27375**
TOTAL					88.009				160,616