

### CHAPTER SIX

#### ADAPTATION MEASURES

*The signals of the impacts of climate change are being noticed in Guyana, especially in its coastal zone. Adaptation measures will necessarily range from general capacity building to sector-specific capacity building and projects. Adaptation responses will also have to include public awareness, education and training and must focus on sensitizing the local communities on the impacts of anthropogenic climate change and the response mechanisms to be used to address local vulnerabilities.*

*Successful adaptation depends upon technological advances, institutional arrangements, availability of financing, and information exchange, (IPCC, 1995). This IPCC statement is the key towards having Guyana address its vulnerability to climate change successfully. Guyana will be unable to do so unless the necessary financial and technical assistance is provided.*



*An aerial view of a section of coastal Guyana*

### 6.1 INTRODUCTION

Adaptation is concerned with responses to both the adverse and positive effects of climate change -IPCC, 1992. It has to do with responses to expected or actual happenings that are associated with anthropogenic climate change and seek to reduce damages and loss of lives in the short-term and in the longer-term. It is best to identify the problems associated with current climatic variability (droughts and floods) and move to address responses to these measures while considering the implications of longer-term climate changes and planning to address the impacts of these changes in a phased framework of actions and processes.

Since the National Development Strategy (NDS) seeks to address poverty alleviation and protection of the environment, it will be appropriate for adaptation measures to be considered as response measures under the NDS.

### 6.2 OBJECTIVES

The overall goals are the promotion of sustainable development and the reduction of vulnerability. Sustainable development will entail ensuring economic development of all the administrative regions, protection of the environment and equitable distribution of the wealth of the nation. Reduction of vulnerability will require minimizing the risks of the impacts, reducing economic losses and alleviating hardships while building the institutional response mechanisms for detecting and warning of the signals of the impacts and for responding to emergencies and other activities required to address vulnerable ecosystems.

### 6.3 CLIMATIC IMPACTS OF IMPORTANCE

The Vulnerability Assessment in Chapter 5 identifies the sectors, which are exposed to risk from climate change and its impacts. Adaptation should then address the vulnerable systems, activities and regions most likely to be in need of planned programmes of adaptation.

The major predicted impacts of global warming are:

- Higher temperatures
- High intensity rainfall
- Higher evaporation
- Water deficits
- Higher Sea levels
- Reduced crop yields
- Displacement of forest zones
- Saline Intrusion

These are expected to exacerbate an already “stressed” situation where:

- The coastal zone is affected by sea and estuarine defences being eroded by the sea.
- Human settlements are being established in low-lying areas.
- Health services are being continually upgraded to meet the demands of the local communities.
- Mining activities are changing the banks and bottom topography of rivers in the hinterland
- Droughts and floods affect parts of Guyana every year
- EL NIÑO / LA NIÑA affect several parts of the country, and
- Run-off effects of forestry resource utilization in watershed areas.

### 6.4 ADAPTATION AND ADAPTIVE CAPACITY

Adaptation to climate change in Guyana will to a large degree depend on the extent and magnitude of climate change impacts on the ability of physical and societal systems to cope with expected climate changes. Effective adaptation will largely depend on the resilience of these systems and the adaptive capacity of the people and Government of Guyana. The latter will involve available financial and technical skills and the experience of the Guyanese people and government. The process of adaptation is expected to be carried out by the government (including local government), the general population and communities of Guyana, both urban and rural.

The *resilience* of physical and human systems may be intrinsic or extrinsic in nature. Indicators of good or favourable resilience may include the presence of healthy, intact ecosystems, the ability of species to acclimatise to new temperature and rainfall regimes, the presence of land higher in elevation than the maximum predicted sea level rise. They also include storm surges, high productivity, reproduction and recruitment of species and high rates of natural recovery.

*Intrinsic resilience*, or homeostasis, refers to the innate ability of natural systems to maintain their integrity when subject to disturbances of some kind. For most natural systems, their natural immunity to climate change and sea-level rise is not clearly known. Hence, predicting which ecological variables (e.g. species, processes) might be affected by climate change and what effect this would have on ecosystem diversity, function and future resilience may be difficult.

*Extrinsic resilience*, on the other hand, refers to the ability of ecosystems to continue to maintain their integrity after having suffered the adverse effects from the same or other impacts. It is likely that the greater the number and intensity of hazards which have impacted on a system in the past, the greater its level of vulnerability to future stresses is likely to be. Because neither the natural resilience nor the altered resilience of any ecosystem is known, let alone the resilience which might arise as a result of integrated or interactive effects, it is difficult to directly estimate extrinsic vulnerability.

The present ecological integrity or level of degradation of ecosystems may be used as a gauge for their extrinsic resilience: the more degraded the ecosystem, as a result of past natural and anthropogenic impacts, the more vulnerable it is likely to be to future adverse environmental impacts, such as climate change and sea level rise.

### 6.5 THE ADAPTATION OPTIONS

Depending on the level of vulnerability and the region that is affected, the adaptation mechanism may not be the same. However, the vulnerability assessment reveals that adaptive responses will be required to cope with the impacts of climate change especially on the coastal zone. It is therefore necessary to firstly ensure that the capacity to detect, plan and respond exist in all relevant sectors. Hence, a necessity is that capacity building be a priority activity to be addressed at all levels of government and in the sectors.

An important aspect for realizing the necessity for adaptation is to incorporate its options to other sectoral and national policies, such as economic development policy, disaster prevention and management, and environmental management plans. Guyana already has immediate and pressing concerns, and climate change should therefore be considered in the national agenda since it will certainly impede socio-economic progress. Given the long lead-time for implementing adaptation, it is important to incorporate it with the other issues, in particular to the framework of sustainable development and integrated coastal zone management.

#### 6.5.1 Capacity Building

The governmental capacity to deal with climate-related issues needs to be strengthened. The local communities have limited knowledge of their vulnerability due to the effects of global warming. The business community has also not shown any concern even though some sections of the business community are aware of the problem.

The uncertainties in the predictions and impacts may result in a resistance towards policy development and the development of the capacity to deal with future vulnerable situations. It must be noted that observations are removing some of these uncertainties. However, it is also a fact that, because of the many “stress” issues which have to be dealt with in the immediate future, climate change may not be seen as a problem which has to be planned for now. The consequences of floods and droughts are addressed after the effects have been observed.

### 6.5.1.1 Capacity to Detect Climate Change and its Impacts

The Authority for monitoring climate is the Hydrometeorological Service of the Ministry of Agriculture. It has a high vacancy level especially at the professional level and available funds are inadequate to address training, purchasing of equipment, recruit field technicians and maintenance of reliable continuous records. This Department requires human, financial, technical and technological resource building if it is to play the critical role of alerting the nation to changes (or variability) of climate and issuing warnings to the sectors that will be affected.

There is the need to have studies conducted into the past and current climates of Guyana and 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.

Monitoring of the impacts such as erosion, inundation, along with changes in pest abundance, health signals, changes in fisheries, rice and sugar yields will require that staffing in the various agencies, in and out of Government, be available, trained and be capable of detecting the impact signals.

### 6.5.1.2 Capacity to Plan for Adaptation to Climate Change

Based on current and future signals of the impacts of climate change, planning to respond will become essential if Guyanese are to act in a proactive or purposeful way, rather than in a reactive manner. Planning must be done at all levels of government and society and must involve all sections of the Guyanese population. The National Development Strategy (NDS) does not adequately address climate issues, however, sustainable development is included in the framework which could be modified to suit the circumstances.

### 6.5.1.3 Capacity to Respond to Adverse Impacts of Climate Change

In Guyana, responses are often reactive to climate-related problems. All agencies, including the Civil Defence Commission should be strengthened in order to respond effectively to combat losses due to floods/droughts. Hence, the disaster – preparedness agencies (at all levels of the Guyanese Community) including the military, NGOs and local communities need to be provided with the capacity to respond effectively to abrupt and prolonged adverse conditions. Linkages with the Hydrometeorological Service, the housing and water agencies and public assistance agencies must be reinforced, and efficient programmes be setup to deal with response measures.

With regard to agriculture, especially in the coastal zone, the banking and insurance sectors must be prepared to assist farmers when they suffer losses. Other related assistance program may be put in place to alleviate hardships resulting from the adverse impacts of climate change. Recognising that agriculture is the backbone of the country’s economy, it will be necessary for the farmers to be assisted so that they adjust rapidly to the adverse effects.

## 6.6 ADAPTATION STRATEGY

The IPCC (1995) provides the following types of response strategies, which can be considered for Guyana. They are:

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- **PREVENTION OF LOSS:** Taking precautionary actions to reduce the intensity of the hardship. A controlled programme of actions to protect sections of the coast, retreat from very vulnerable areas or accommodate the rise in sea level in some areas will be required.
- **TOLERATING LOSS:** Using crop types, which can minimize losses, and accepting short-term changes, which will not result in serious long-term losses.
- **SPREADING OR SHARING LOSS:** Take actions to distribute the burden of losses over a region rather than having the area, within the region, bear the full loss. National and/or regional relief measures can be effective here.
- **CHANGING USE OR ACTIVITY:** The main activity or activities in an area may have to change because it will no longer be viable to continue with it.
- **CHANGING LOCATION:** When an activity is very important to the country, it may be wise to move it to a more friendly location.
- **RESTORATION:** A damaged system can be restored to its original condition. An example here can be flooded housing schemes.

There can be no unique response strategy for a country as large as Guyana. Responses must be area or region-specific and must operate under certain national guiding policies. It therefore means that the vulnerability of an area or region will have to be identified and detailed in terms of intensity, extent and human and material losses. This can be initiated as pilot projects.

The Caribbean Planning for Adaptation to Climate Change (CPACC) project has identified three pilot sites for detailed vulnerability assessments. These sites are Georgetown (the capital city), Leguan (a rice growing island in the Essequibo River) and Onverwagt, West Coast, Berbice within the Mahaica-Mahaicony-Abary (M.M.A.) rice development scheme. The assessment is not expected to be exhaustive and will require further studies and project activities to deal with responses to the vulnerabilities. It is hoped that these shall be done in the Mainstreaming for Adaptation to Climate Change (MACC) in the Caribbean project that is expected to follow from the culmination of the CPACC project.

Given the large uncertainties in the climate change projections, there may be two main categories of adaptation strategy: low cost, no-regrets responses and high cost, reactive measures. For Guyana, with limited financial and technical capacity, a narrow resource base and low resilience, the implementation of a low cost, no-regrets adaptation would appear to be an appropriate approach to adopt. While this strategy acknowledges that there is uncertainty regarding climate change and its impacts, it however seeks to minimize exposure to future risks, that may be exacerbated by climate change and sea level rise.

### 6.7 CAPACITY STRENGTHENING

The IPCC Adaptation Strategy is a sound one and should be followed as Guyana moves to avoid losses and suffering due to impacts of climate change. However, it assumes that the capacity to take actions exists and is competent. As was mentioned earlier, responsible agencies are not sufficiently trained nor fully equipped to deal with the problems. The human resource is also scarce.

It is therefore a priority for an assessment of the capacity needs to be undertaken for government, non-government, energy, private, media and local communities sectors. The assessment should also focus on capacities to monitor, research, identify and analyze signals, to take response/reaction measures on a timely basis.

An Early Warning System (EWS) is necessary for Guyana to deal with the impacts of, and responses to climate change. The capability must include Geographical Information System (GIS) and remote sensing with focus on preparedness initiatives. The capacity building initiatives should include:

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- Data collection, analysis and presentation of data for all sectors;
- Mathematical modeling of climate and climate change processes;
- Food policy, risk management and coping activities;
- Public awareness and alertness;
- Water conservation;
- Community programmes

### 6.8 ADAPTATION BY SECTORS

In view of the impacts and vulnerabilities discussed in the preceding chapter, this section focuses upon adaptation strategies that may be used to minimize the negative impacts of climate change and sea level rise in Guyana. The discussion is limited to the sectors that are of major socio-economic importance and that are deemed most vulnerable to the adverse effects of climate change and variability. For each of these sectors, adaptation options are examined with respect to the policies/programmes, which should be executed within the next five years (short term) or during the medium to long term. The priority actions are given in the programmes for the next five years.

#### 6.8.1 Coastal Zone

*Table 6.1: Coastal Zone Adaptation Options*

ITEMS	SHORT TERM OPTIONS	MEDIUM TO LONG TERM OPTIONS
COASTAL INVENTORY	Inventorise the coastal assets in all regions facing the Atlantic Ocean	Make periodic assessment of changes in the coastal assets
THE MOST VULNERABLE AREAS IN IMPACT ZONE I and II	<ol style="list-style-type: none"> <li>1) Fortification of sea and river defences in accordance with Sea Level Rise (S.L.R) scenarios.</li> <li>2) Conduct a study into the effect of ocean currents and eddies on water accumulation off Guyana's coast</li> <li>3) Identify most vulnerable areas and determine adaptation strategy.</li> <li>4) Conduct ground water resource inventory.</li> </ol>	<ol style="list-style-type: none"> <li>1) Implement adaptation strategies in stages to be determined from studies conducted in the short term and from the coastal inventory, such as: <ul style="list-style-type: none"> <li>• <b>Managed Retreat</b> <ul style="list-style-type: none"> <li>- no development in susceptible areas</li> <li>- development conditionally phased out</li> <li>- population policy to relocate to the interior</li> <li>- accommodation</li> </ul> </li> <li>• <b>Protection</b> <ul style="list-style-type: none"> <li>- hard structural options</li> <li>- dikes, levees and floodwalls</li> <li>- seawalls, revetment and bulkheads</li> <li>- detached breakwaters</li> <li>- floodgates and tidal barriers</li> <li>- saltwater intrusion barriers</li> <li>- wetland restoration and creation</li> </ul> </li> </ul> </li> </ol>

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		2) Take actions to restore damaged areas and assets.
INTEGRATED COASTAL ZONE MANAGEMENT PROGRAMME (ICZM)	1) Continue to develop the components of a comprehensive ICZM programme 2) Implement coastal zone monitoring and assessment programmes 3) Identify areas where policy decisions will have to be taken to accommodate, protect or retreat.	1) Set up an ICZM division within the EPA with full legislative linkages to relevant agencies in and out of government.

Based on the preceding chapter, it would appear that Guyana, especially the Coastal Plains where most of the population and economic activity are located, would be most vulnerable to the impacts of sea level rise. One of the major likely impacts of sea level rise in the coastal zone of Guyana would be the loss of coastal wetlands that serve as protective barrier to the inland coastal area.

Coastal land loss due to a combination of inundation and coastal erosion is projected to have widespread adverse consequences in the low-lying Coastal Plain of Guyana. Land loss from sea level rise especially in coastal locations is likely to be of a magnitude that can disrupt virtually all economic and social sectors in the country. Recent estimates indicate that with a 1 m sea level rise, up to 10 km<sup>2</sup> of land could be lost, just on account of inundation. This figure would increase more than threefold to 37 km<sup>2</sup> (14%) with storm surge superimposed on a 1m sea level rise scenario. Similarly, based on the Brunn rule, a retreat of up to 100 m is projected with a 1m elevation of sea level.

The elevation of mean sea level at Georgetown on the coastal plain of Guyana is 51.05 ft. (Georgetown Datum: GD). Furthermore, the mean elevation of the roadways on the coastal plain of Guyana is 55.0 ft GD. The elevation of the highest tide level recorded at Georgetown is 56.41 ft. GD and the elevation of the high spring tides is 55.31ft. GD. On the other hand, the elevation of the sea defences in the coastal plain of Guyana range from 62.0 to 64.5 ft. GD. These figures show how vulnerable the coastal plain of Guyana would be to rising sea levels, especially when accompanied by tidal surges.

Several options have been identified for reducing land loss due to sea level rise. Abandonment of developed areas inland of today's marginal wetlands could permit new wetlands to form inland. In some cases, it might be possible to enhance the ability of wetlands to accrete vertically by spraying sediment on them or as in the case of deltas, restoring the natural processes that would provide sediment to the wetlands. Finally, Guyana has managed to artificially protect itself from high water levels through the use of a network of sea defences and gravity-controlled locks and dykes and, in extreme cases, pumping stations. The widespread use of pumping stations will have to be considered since gravity outflow may become an inefficient drainage strategy.

One of the most serious considerations for low-lying coastal Guyana is whether it will have adequate potential to adapt on the coast to sea level rise or retreat. Guyana may have the option to pursue adaptation measures such as retreat to higher ground and even raising the level of the land since sand and other aggregates are abundantly available, costs and resources permitting. The use of building setbacks aimed at discouraging further developments in the vulnerable coastal area would also appear to have great practical utility.

In extreme circumstances, sea level rise and its associated consequences could trigger abandonment and significant coastal migration at great economic and social costs. A planned retreat seems to be required now since the coastal zone is being taxed with population and developmental stress. The responses to inundation then fall broadly into the categories of retreat and creating stronger and higher sea defences in all vulnerable areas to hold back the sea. Sea defences are today used extensively in the coastal plains of



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Guyana. The flooding of unprotected areas below high tide level could be similarly constructed around other coastal areas at risk to sea level rise. In sparsely developed areas, however, the cost of sea wall construction might be greater than the value of the property being protected.

Moreover, even where sea walls prove to be cost-effective, the environmental implications of replacing natural shorelines with manmade structures would need to be considered.

Potential responses to coastal erosion deriving from sea level rise fall generally into three categories: construction of walls and other structures, the addition of sand to the beach, and abandonment. A number of structures other than seawalls can be used to decrease the ability of waves to cause erosion, including groins (jetties), rip-raps and breakwaters. Bulkheads are often used where waves are small.

A more popular form of erosion control has been the placement of sand onto a shore area through beach nourishment procedures. Although costs can exceed one million dollars (US) per km, it is often justified by the economic and recreational value of beaches.

Although shore protection is often cost-effective today, the favorable economics might change in the future. Current estimates place the cost of sea defenses in Guyana at \$ 35,000.00 US per km. A more rapid rise in sea level would increase the costs of shore protection. A number of countries have adopted erosion policies that assume a retreat from the shore. Many countries are now requiring homes that can be moved to be set back from the shore by a distance equal to shoreline recession from 30 years of erosion, while high-rises must be set back 60 years. Other countries require people to demonstrate that new structures will not erode for 100 years.

Other jurisdictions discourage the construction of bulkheads and seawalls. In many undeveloped countries, small, relatively inexpensive houses are found very close to the shore. Because the value of these houses is less than the cost of protecting them, they must be moved as the shore erodes. An accelerated rise in sea level would speed this process of shoreline retreat.

In the short term then there is the need for anticipatory adaptation action in response to rising sea levels in Guyana. Where communities are likely to adapt to erosion, anticipation can be important. The cost and feasibility of moving a house back depend on design and decisions made when the house is built. The willingness of people to abandon properties depends in part on whether they bought land on the assumption that it would eventually erode away or had assumed that the government would protect it indefinitely. Less anticipation is necessary if the shore will be protected. Nevertheless, some advanced planning may be necessary for communities to know whether retreat or defending the shore would be most cost-effective.

In the medium term, adaptation to sea level rise in the coastal zone of Guyana may involve the further fortifying of sea defences and the introduction of legislation relating to set-back limits so as to reduce the vulnerability of the peoples and structures.

In the long term however, Guyana may have to choose between further fortifications of sea defences or a more drastic population policy whereby peoples and infrastructures will be moved inland, where even at 25 miles the land is at 74 ft above mean sea level (GD). Guyana's population is relatively small and land space in the hinterland is abundant, although soils are mainly sandy. However, the rich agricultural soils are found mainly in the low-lying coastal area.

These projections consider population and socio-economic and other changes only to a limited extent.



## 6.8.2 Agriculture and Fisheries

Table 6.2: Agriculture and Fisheries Adaptation Options

ITEMS	SHORT TERM OPTIONS	MEDIUM TO LONG TERM OPTIONS
Assessment of vulnerable agricultural areas in IMPACT ZONES I and II.	<b>Crop production and fisheries</b> <ol style="list-style-type: none"> <li>1) Identify areas where losses can be tolerated, spread or shared.</li> <li>2) Promote changing use or activity in most vulnerable areas, if necessary.</li> <li>3) Substitution of crops</li> <li>4) Improvement in farm level management and productivity</li> <li>5) Identify inland and interior areas for promotion of large-scale agriculture.</li> <li>6) Assess the impacts of global warming and climate change on Guyana's agriculture and fisheries.</li> </ol>	<b>Crop production and fisheries</b> <ol style="list-style-type: none"> <li>1) Promote aquaculture and large scale farming in inland and interior areas.</li> <li>2) Continue to address policy directions on export markets, insurance, transfer of technologies, introduction of new species of crops and fishes (salt tolerant etc) into Guyana</li> <li>3) Implement programmes to alleviate poverty among farming and fishing communities, by taking the effects of climate change into consideration.</li> </ol> <b>Livestock</b> <ol style="list-style-type: none"> <li>1) Genetically altered animal species</li> </ol>

Climate change and variability would very likely bring about more extreme weather conditions ranging from excessive rainfall and flooding to protracted droughts, both of which would have damaging effects on Guyanese agriculture.

In the short term, one strategy to cope with the resulting mismatch between crop requirements and the thermal resources available for growth would be the substitution of crop varieties with greater thermal requirements. However, other characteristics of the growing season may place constraints on the choice of substitutes. For example, moisture constraints due to high evapotranspiration rates would restrict potential plant growth during the dry season. Improvements in farm level management and farm productivity may also be a viable short-term option for coping with the adverse effects of climate change in agriculture. These adjustments can be of several types: -

- of crop variety (thermal and moisture requirements and shorter-maturing varieties),
- of soil management,
- of land allocation to increase cultivable area,
- of using new sources of water (recycling of wastewater),
- of harvesting efficiency and

- of purchases to supplement production (fertilizers and machinery).

In the medium to long term, in addition to the farm level adjustments in management and technology, a number of potential regional and national policy responses may also need to be changed. Changes of land use to optimize production may be instituted. Because different crops respond differently to changes of climate and to varying levels of fertilizer application under those climates, any attempt to maximize output of each crop while minimizing production costs is likely to identify quite different allocations of land to alternative crops under different climates.

The National Agriculture Research Institute (N.A.R.I) should spearhead scientific research in order to cope with the effects of floods and increased salinity. Genetic Engineering and Biotechnology are possibilities for improving flood tolerance in crops. Genetically engineered salinity tolerance can also be examined. Breeding and selection of crop varieties that can withstand short-term anoxic/hypoxic soil conditions are also important research activities in responding to impacts of climate change.

A Change of policy to maintain national food security while avoiding over-supply, in the long term, is a worthwhile alternative. The effect of price support policies in countries such as Guyana is to encourage home production often at prices well above that of the world market.

Policy changes to maintain equitable regional farm incomes may also be instituted in the medium and long term. Because of variations climate have differing degrees of effect in different regions, the present regional pattern of farm incomes is likely to alter. As a result, government policies designed to reduce regional discrepancies may need substantial revision in order to maintain a level of equitable support.

Changes of policies supporting farm inputs are also to be considered. Where national farm policies tend to encourage inputs such as fertilizers and improved drainage these can be modified to encourage new levels of input appropriate for the altered levels of agricultural potential. In addition, further support may be needed in traditional areas of agricultural extension such as land management (e.g., instituting new soil management practices to control erosion), water management (e.g., improving efficiency of water use and optimizing irrigation water use) and the introduction of hybrids and modern pest control methods (e.g., adopting drought-resistant crop varieties and cultivation practices including biological control of pests) so as to ensure sustainable agricultural development in the long term.

In the long term, adaptation options for the livestock sector of Guyana may also have to be devised. This may include acceptance and use of genetically altered animal species that may be able to withstand higher temperatures and water stress and digest more hardy grasses.

Changes in water temperature, salinity and levels deriving from climate change and sea level rise may very likely affect the fishing industry of Guyana, thereby requiring the introduction of various adaptation measures.

In the short term, policy changes may be required to ensure the viability of the industry. These may include procuring markets for fish and shrimp farmers whose levels of production and profitability may be lesser, adjustments to fishing methods and varieties harvested and even increased insurance to farmers to ensure the survival of the industry. In the long term, promotion of aquaculture in the inland and interior locations can be pursued, while salt-tolerant fish species can be introduced in ponds located in the coastal regions.

## 6.8.3 Water Resources

Table 6.3: Water Resources Adaptation Options

SHORT TERM OPTIONS	MEDIUM TO LONG TERM OPTIONS
<p><b>Domestic/Industry</b></p> <ul style="list-style-type: none"> <li>- water conservation (metering, time-runs, etc)</li> <li>- implement monitoring and inventory of water availability while continuing the development of new artesian wells</li> </ul> <p><b>Agriculture</b></p> <ul style="list-style-type: none"> <li>- better control and management of supply network</li> <li>- introduce scientific monitoring and management of irrigation waters</li> </ul> <p><b>Energy</b></p> <ul style="list-style-type: none"> <li>- monitor the water availability of existing reservoirs for detection of increased evaporation</li> </ul>	<p><b>Domestic/Industry</b></p> <ul style="list-style-type: none"> <li>- stricter water conservation techniques and management</li> <li>- rainwater collection</li> <li>- development of inland and interior conservancies</li> </ul> <p><b>Agriculture and Fisheries</b></p> <ul style="list-style-type: none"> <li>- stricter control and management of supply network</li> <li>- drainage re-use</li> <li>- artificial recharge of reservoirs from nearby rivers etc.</li> <li>- removing sediments and weeds from reservoirs for more storage capacity</li> <li>- low water use crops</li> <li>- high value per water use crops</li> <li>- salt-tolerant crops and fish species</li> <li>- relocation of fishing ponds</li> </ul> <p><b>Energy</b></p> <ul style="list-style-type: none"> <li>- keeping reservoirs at maximum storage to reduce evaporation effects</li> <li>- changing releases to match other water uses</li> <li>- taking plants off in low flow times</li> </ul>

Because temperature is projected to rise by 1 to 4 °C in Guyana, evapo-transpiration rates will rise substantially, especially if the CO<sub>2</sub> concentration triples, as seen in the previous chapter, which when combined with anticipated changes in rainfall will lead to higher water deficits and hence reduce the availability of water resources for industrial, residential and agricultural use in low rainfall years. This will most likely result in conflicts among the different economic sectors such as agriculture, industry and services for scarce water supplies.

In the short term, adaptation to the adverse impacts of climate change in the water resources sector may involve a number of water conservation measures, including metering, the use of time runs where water supply may be staggered according to region or to sectors, the more efficient use of irrigation water using advanced irrigation scheduling methods 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 rainwater for potable and non-potable use in the domestic/commercial/industrial sector, and the development of conservancies and artesian wells in the inland/interior locations as a result of sea level rise and anticipated inland migration.
- For agriculture use, stricter control and management of supply network, artificial recharge of reservoirs from nearby rivers, removing sediments and weeds from reservoirs for more storage capacity and cultivate crops that are salt-tolerant so as to re-use drainage water, crops that use less water and crops that are commercially important and expensive.
- The relocation of fishing grounds and ponds, depending on the changes in water quality brought about by climate change and sea level rise, the introduction of more salt tolerant species and changes in consumer habits relating to acceptance of new species for local consumption.
- Keeping reservoirs at lower head to reduce evaporation at hydropower sites, changing releases to match other water uses and taking plants off in low flow times.

### 6.8.4 Energy

**Table 6.4:** *Energy Adaptation Options*

SHORT TERM OPTIONS	MEDIUM TO LONG TERM OPTIONS
<p><b>Energy Conservation</b></p> <ul style="list-style-type: none"> <li>• <b>Commercial/residential/ public buildings</b> <ul style="list-style-type: none"> <li>- conservation techniques: reduce lighting in buildings not in use</li> </ul> </li> <li>• <b>Machines/Equipment/Vehicles</b> <ul style="list-style-type: none"> <li>- purchase of fuel-efficient machines/equipment/vehicles</li> <li>- efficiency/maintenance of machines/equipment</li> </ul> </li> <li>• <b>Transportation</b> <ul style="list-style-type: none"> <li>- implementation of a more efficient transportation plan</li> </ul> </li> </ul> <p><b>Alternative energy sources</b></p> <ul style="list-style-type: none"> <li>- hydropower ( to be promoted especially micro-systems and mini-scales)</li> <li>- co-generation from use of bio-mass to be pursued in the sugar, rice and forestry industry</li> </ul>	<p><b>Energy Conservation</b></p> <ul style="list-style-type: none"> <li>• <b>Commercial/residential/public buildings</b> <ul style="list-style-type: none"> <li>- energy conservation techniques continued</li> <li>- design and construct buildings to reduce the potential use of air conditioning from rising temperatures</li> </ul> </li> <li>• <b>Machines/Equipment/Vehicles</b> <ul style="list-style-type: none"> <li>- continue purchasing of fuel-efficient machines/equipment/vehicles</li> <li>- improvement in efficiency/maintenance of machines/equipment/vehicles</li> </ul> </li> <li>• <b>Transportation</b> <ul style="list-style-type: none"> <li>- use of a mass transit system</li> </ul> </li> </ul> <p><b>Alternative energy sources</b></p> <ul style="list-style-type: none"> <li>- hydropower and biomass co-generation (continued), wind farms, solar/wind hybrid systems, ocean thermal, wave energy</li> </ul>

Based on the analyses of the impacts and vulnerability chapter, it is evident that, on the one hand the demand for energy for various economic activities, including interior space cooling, may increase and on the other the supply of energy, as for instance hydro-electric generation potential, may decrease in response to climate change. These changes would be further amplified by changes in population and economic growth.

## 6.0 ADAPTATION MEASURES

In order to respond to the adverse effects of climate change in the energy sector, adaptation measures in the short term may focus on:

- Energy conservation techniques practical in buildings (commercial/residential/public buildings) such as reducing lighting in and around buildings when not in use or when it serves no purpose.
- Purchasing fuel-efficient machines/equipment and efficient maintenance of same.
- Setting up and implementing a more efficient transportation plan.
- Continuing to set up micro-systems and mini-scales hydropower station in the interior locations in selected areas to be developed.
- Continuing to promote co-generation of energy from using biomass resources (rice husk, bagasse, sawmill waste, slash waste in forest etc) in the sugar, rice and forestry industry.

In the medium to long-term however, adaptation measures may focus on:

- Continuing to promote energy conservation measures/techniques in the different areas (buildings, machines/equipment) as indicated in the short term options.
- Design and construct buildings to reduce the potential use of air conditioning as a result of higher temperatures, thus save on energy e.g. ceiling insulation and glass that transmit less radiation are areas that reduce cooling loads.
- Transportation - use of a mass transit system in the cities and for linking centres of commercial activities.
- Alternative sources of cheaper and less-polluting forms of renewable and sustainable energy such as, further hydropower development and bio-mass co-generation, solar, wind, ocean thermal and wave energy.
- Reduce energy consumption for lighting by use of high efficient Energy Saving Lamps, etc.

### 6.8.5 Forestry and Land Use

**Table 6.5: Forestry and Land Use Adaptation Options**

SHORT TERM OPTIONS	MEDIUM TO LONG TERM OPTIONS
<p><b>Forest Management Plan</b></p> <ul style="list-style-type: none"> <li>- continue the control of logging practices</li> <li>- forest fire protection to be pursued</li> </ul> <p><b>Land Use</b></p> <ul style="list-style-type: none"> <li>• <b>Human Settlement and Industry</b></li> <li>- cleared forest (from mining/forestry activities) and parts of savannah regions to be utilized for human settlement/industry</li> <li>• Using the Impact and Vulnerability Assessment as a starting tool, continue to carry out detailed studies in the interior region on: <ul style="list-style-type: none"> <li>- soil fertility, changes in temperature, rainfall, and other climatic variables, spatial shift in vegetation and species mix</li> </ul> </li> </ul>	<p><b>Forest Management Plan</b></p> <ul style="list-style-type: none"> <li>- sustainable logging practices (reduced impact logging) to be continued</li> <li>- promote agro-forestry/reforestation/afforestation of commercially important species in areas likely to favour growth as a result of a shift in vegetation due to climate change</li> </ul> <p><b>Land Use</b></p> <ul style="list-style-type: none"> <li>• <b>Human Settlement and Industry</b></li> <li>- continue to promote options identified for short term</li> <li>- from studies conducted in the short term, promote human settlement, industry and agriculture in selected regions of the interior region</li> </ul>

## 6.0 ADAPTATION MEASURES

Climate change and sea level rise would also supposedly affect the forestry sector of Guyana. This is one of Guyana's key economic sectors and adaptation policies aimed at its sustainability will have to be implemented.

In the short term, adaptation measures may have to be focused on a redefined forest management plan, addressing such concerns as a forest fire protection plan and stricter control of logging practices, under the supposedly drier climate.

In the case of land use, in the short term, cleared forest (from mining/forestry activities) and parts of savannah regions to be utilised for human settlement instead of clearing more forest for this purpose in response to migration from the coast as a result of sea level rise. Also, using the Impact and Vulnerability Assessment as a starting tool, continue to carry out detailed studies in the interior region to reveal:

- soil fertility
- areas likely to be impacted from severe reduction in annual rainfall and the area/areas likely to receive less annual rainfall overall
- areas likely to be affected by high temperature increases, and the area/areas likely to receive overall high temperatures
- areas likely to be significantly affected by a reduction in bio-mass (shift in vegetation type)

Based on these studies, choices will be made for developmental work in the best region/area, in the medium to long term, in the field of agriculture, housing/industry in the interior region.

In the medium to long term, the forest management plan may have to be altered to accommodate sustainable logging practices under the perturbed climate. These will include well-planned logging practices that ensure regrowth of the forests, regular monitoring of forest species to detect changes in mix of species and appropriate remedial action and policy changes, such as dredging if water levels are too low, that will facilitate the riverine transport of logs.

In the event of major shifts of forest zones, as pointed out in the previous chapter, long-term policy changes may have to address such issues as structural adjustments and reallocation of resources and peoples within the Guyanese economy.

Some particular measures which can be taken to protect the forests and prevent adverse land use changes, in the medium to long term are:

- Planned measures or activities to protect primary forest areas that are in particularly acute danger of destruction, and which can be accelerated, expanded or continued by the immediate provision of funds. Priority should be attached to speeding up the identification of areas in need of protection.
- Large-scale agro-forestry projects, especially in areas in which the forests are being threatened by shifting cultivation, burning, etc. as a consequence of growing populations. In addition, utilization of already farmed areas should be intensified in order to increase yields without having clear additional land.
- Establishment of fuelwood and timber plantation and environmentally friendly sources of energy, so that the energy and wood requirements can be met without having to exploit the natural forests of the tropics.
- Restocking of deforested land and rehabilitation of derelict areas to permit their use by agriculture.
- Promote human settlement and suitable industries in the interior regions most likely to have less annual rainfall but conducive temperature (leaving potential areas that will have high annual rainfall and soil fertility so as to promote agriculture, in the medium to long term), areas likely to have a reduction of bio-mass as a result of changes in vegetation type i.e. forest areas changing to savannah (leaving potential areas that will have high bio-mass density as a medium for carbon storage and continued benefits from sustainable logging). The Impact and Vulnerability Assessment already done can be used as a starting tool for identification of areas, but much detailed studies is needed.
- Integrated development measures, including promotion of trade and commerce and creation of jobs, outsidess of tropical forest areas.
- Establish more protected areas for specie or biodiversity preservation.

## 6.0 ADAPTATION MEASURES

- Practise sustainable-yield management.
- Carry out afforestation and restocking measures to ensure long-term emergence of new secondary forests.
- Safeguard the cultural identity and habitats of the indigenous population groups.

### 6.8.6 Waste

Insofar as the waste sector is concerned, climate change may exacerbate the very poor condition of waste management in Guyana, due to population growth etc. Currently there are a number of unmanaged dumpsites that, apart from being aesthetic eyesores, pose severe health problems, especially in the urban areas. Local municipalities are grappling with this problem along with assistance from other sectors.

In the short term then, adaptation measures should focus on improved waste disposal management plans, including the creation of more managed waste sites, especially in urban areas, and the implementation of waste reduction measures, namely reducing consumption and recycling and reusing products.

In the medium and long term however, waste management plans should also include sewage treatment and wastewater recycling that is not only beneficial to human health, but may also be linked to adaptation measures in the water resources and agriculture sectors.

## 6.9 CONCLUSION

It is evident then, that Guyana may be very susceptible to the adverse effects of climate change, especially of sea level rise. Key sectors of its economy including agriculture and forestry may need to respond to the adverse effects of climate change. The coastal zone of Guyana, where most of the people live and where most of the economic activity is concentrated would be extremely vulnerable to sea level rise. Proactive and purposeful adaptation strategies, with short and long term planning horizons, and on a sectoral basis, would be required to reduce the adverse impacts of climate change and sea level rise. Capacity building is seen as crucial to adaptation. The country must maintain the capacity to detect, plan and respond to the adverse impacts.