Promotion of Sustainable Livelihood within the Coastal Zone of Suriname, with Emphasis on Greater Paramaribo and Wanica

Sieuwnath Naipal and Adriaan Tas

Introduction

The Republic of Suriname, situated on the northeast coast of South America, occupies 163,265km^2 of which about 90% is covered with rainforest. It has a population of approximately 492,829 (August 2005) of which 97% is concentrated in the low-lying coastal zone, and especially in and around the capital city of Paramaribo (about 70%). The remaining 3% of Suriname's population is spread over small and tribal communities along rivers. The average population density of 2.9 people/km^2 indicates that Suriname is very sparsely populated. This average stands in stark contrast to the population densities of Paramaribo and Wanica, the two most important coastal districts of the country, of 1,327.6 people/km^2 and 194.1 people/km^2 respectively.

The climate is semi-humid, characterized by two rainy seasons and two dry seasons. The short rainy season takes place between December and February with a mean monthly rainfall of about 200mm. The short rainy season is followed by a short dry season (February to April) with a mean monthly rainfall of about 100mm. The long rainy season starts in May and ends around the middle of August reaching mean monthly rainfall averages of around 200mm with a maximum of 325mm during the wettest month. The long dry season has a mean monthly rainfall of less than 100mm and takes place from the middle of August to December. Total rainfall is the highest during the long wet season (May to August) and provides 50 to 70% of the total annual rainfall, whilst the contribution of the short wet season is about 17 to 25% of the total. Besides the high rainfall, high evaporation rates (±1,400mm/year) are also observed.

In the coastal zone complex mangrove ecosystems are home to many types of fish, marine invertebrates, sea turtles and huge numbers of migratory birds creating a high biological diversity. The region is also considered as the principal South American wintering ground for shore birds of borealic and Arctic regions.

The economy of Suriname is dominated mainly by bauxite and petroleum industries, the former accounting for more than 15% of GDP and 70% of export earnings. Other important economic activities include services, gold mining, agriculture (rice, banana and vegetable production), logging, food processing, cattle farming and fishing, and more recently tourism. The Government of Suriname is one of the largest employers, providing work for almost 40,000 civil servants. More than 90% of the economic activities are located in the coastal zone especially in the Paramaribo and Wanica districts. Taken together, these activities account for more than 80% of the country's GDP. This indicates the huge importance these coastal areas hold for Suriname's economy as a whole. The effects of global warming and accelerated sea level rise are therefore considered to be a serious threat for the sustainable development of the country.

Background and Rationale

Studies dealing with climate change and its impacts on the various sectors in Suriname started seriously with the implementation of the first Netherlands Climate Change Studies and Assistance Program (NCCSAP-I). Studies carried out under this first phase convincingly showed that the impacts of sea level rise on Suriname can be significant and the project identified Paramaribo and Wanica as the most vulnerable districts in terms of economic losses and impacts on the population. The study also concluded that 'Suriname ranks with the small island states as being among the most vulnerable nations in the world to the impacts of accelerated sea level rise'. This conclusion was reaffirmed in a more recent study carried out by the World Bank, which assessed the consequences of continued sea level rise for 84 developing countries and listed Suriname as one of the 10 most vulnerable countries in terms of impacts on GDP, agriculture, population and urban areas. Apart from sea level rise, it has also been noted that climate change will result in increased climate variability in Suriname, causing abundant rainfall in shorter periods of time as well as prolonged droughts. Both extremes of the hydrological cycle are expected to further add to the negative impacts of climate change in Suriname.

In response to these observations, various studies and reports have proposed and formulated adaptation measures for coping with the adverse impacts of climate. Most of the proposed measures, however, are of a rather generic nature and a need to tailor them to the local contexts still exists. More specifically, the need to elaborate a specific set of adaptation measures for the two most vulnerable districts, Paramaribo and Wanica has been identified.

The project 'Promotion of Sustainable Livelihood Within the Coastal Zone of Suriname, with Emphasis on Paramaribo and the Immediate Region', which was implemented under the second phase of the Netherlands Climate Assistance Program (NCAP-II), has sought to respond to this need and has worked on the elaboration of a more detailed and specific adaptation strategy for Paramaribo and Wanica. The development of the adaptation strategy included an assessment and evaluation of the feasibility of the proposed measures, a specification of the financial needs for implementing the proposed measures and the identification of potential (international) financial resources. In addition, the project sought to:

- Develop a more detailed picture of the vulnerabilities of the different sectors in Paramaribo and Wanica;
- Contribute towards the formulation of a national climate change policy; and
- Further raise awareness of the issue of climate change among policy makers and the general public.

The project took place from May 2005 to June 2008. The overall project management in Suriname was in the hands of The Ministry of Labor, Technological Development and Environment (ATM). The Anton de Kom University, in collaboration with local consultants and experts, was responsible for the day-to-day implementation of the project. A Climate Change Steering Committee (CCSC), consisting of members of various ministries and departments, was established to oversee and monitor the project.

The Study Area and Methodological Approach

The study area included the capital of the country, Paramaribo, and the neighboring district Wanica. This area borders in the east with the Suriname River, in the west with the district of Saramacca, in the north with the Atlantic Ocean, and in the south with the district of Para.

In general the study area can be characterized as an area comprising few natural resources, extensive manmade structures and human settlements, with relative high population concentration, the

majority living and working in the immediate region of Paramaribo. The total coastal length of Paramaribo and Wanica is about 20km, representing about 5.2% of the total coastline of Suriname. Paramaribo and Wanica belong to the administrative, political and cultural center of Suriname. The presence of the Saramacca Canal, connecting the Suriname River and the Saramacca River, creates unique possibilities for the irrigation, drainage, water transportation and opportunities for industrial growth in the central part of the study region. The northern part of the Saramacca Canal, the area between the Kwatta Ridge and the coastline, is relatively lower than the southern part of the canal in the direction of Lelydorp. Conversely, the northern part, in particular the area of Weg naar Zee, is more fertile than areas south of the canal, therefore determining the type of agricultural practices in these areas. The study area is currently undergoing rapid growth in terms of human settlements and establishment of infrastructures and other facilities.

In order to develop and formulate specific adaptation measures for Paramaribo and Wanica, the study started with a detailed description and updating of the present conditions in the study area in terms of geology, ecology, water resources, agriculture, socio-economics and human health. The description of this present profile helped in understanding the baseline vulnerabilities in the study area.

Taking the present profile as a starting point, scenarios were developed describing possible future conditions in the different sectors. The methodology used to describe the future profile was largely based on a detailed study of the available literature, intensive discussions and consultations with stakeholders and professionals, consultation of multi annual plans of the Government, other policy documents and findings of workshops. Local site visits and discussions with the local communities and other relevant stakeholders living and working in the vulnerable area further helped in determining future projections of the different sectors. In terms of future climate conditions, the following data and information was used for the elaboration of the future profiles:

- Temperature increase of 2 to 3°C by the year 2100 based on the projections of the IPCC Fourth Assessment Report.
- Changes in the precipitation pattern. Increased variability in rainfall and drought are projected for the future. The strong rainfall events in May and June of 2006 in the interior of the country, as well as the rainfall events in May 2007 in the capital Paramaribo are expected to become more frequent in the future. These changes may also lead to disruption of the hydrological cycle of the particular region or basin.
- A relative sea level rise of 1m is used for determining the future profile of the sectors. This value comprises the following parameters;
    - » The sea level rise as projected by the IPCC (approximately 30 to 80cm in the coming 100 years);
    - » Subsidence of 20 to 40cm, due to human activities in the coastal zone, e.g. empoldering of the low-lying coastal areas;
    - » Storm surges of 20 to 30cm, fostered also by the change in the wind velocity and wind direction; and
    - » Backwater effects and other anomalies of approximately 10cm.

In a final step, and based on the detailed descriptions of the present and future profiles, the study team developed and formulated a specific set of adaptation measures for Paramaribo and Wanica. Two types of adaptations measures were considered:

1. Adaptation measures that are part of common government policy and actions; and
2. Adaptation measures that constitute a specific response to the increased threat of climate related hazards (with a focus on accelerated sea level rise).

Various meetings and workshops were organized to present and discuss the proposed measures with stakeholders and policymakers. The meetings and workshops also provided an opportunity

to further elaborate the adaptation measures and assess their feasibility and acceptance among different stakeholders. Feedback from the CCSC and others were made also useful in this process of elaboration adaptation measures.
Results

Impact Studies and Scenario Development

Geomorphology

The study area is located in the coastal plain of Suriname, which is predominantly formed on marine deposits. This coastal plain comprises two distinct parts, the Old Coastal Plain, which was formed during the Pleistocene era, and the Young Coastal Plain, which is of Holocene age. The Young Coastal Plain covers the major part of the study area. It has a width of about 20km and it covers an area of over 500km^2 (approximately 85% of the project area).

Within Suriname the Young Coastal Plain features extensive, flat and low-lying areas of heavy marine clays usually overlain by a layer of peat (locally known as *pegasse*). The clay flats have a very low elevation with the major part having elevations of between 0.5 and 1.5m above mean sea level. If not artificially drained, these areas are flooded in the rainy seasons, and often also part of the dry seasons, forming swamps. Apart from its elevation, the water depth in these swamps will also depend upon other local conditions, like distance from the river or sea and the drainage opportunities along the swamp edges.

The clay flats are locally interspersed by roughly east–west striking ridges. The ridges form elongated, usually narrow bodies, often consisting of sand, but sometimes a mixture of broken and whole shells. The ridges, that rise 1 to 3m above the surrounding clay flats, may be either individual or occur in groups and they may be between 20 and 400m wide. Ridge groups are particularly abundant to the west of the main rivers.

A cross section through the northern study area is presented in figure 1.

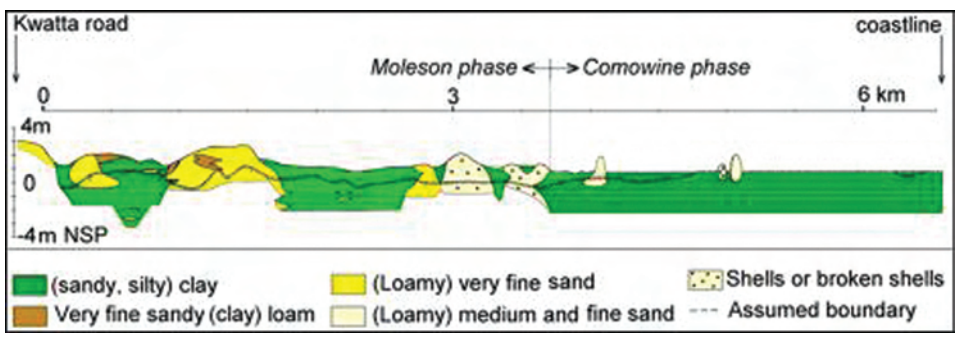

Figure 1: Cross Section through the Northern Part of the Study Area

The Suriname coast is subjected to an active geomorphological development, which is determined by a system of cyclic accretion and erosion. Both are linked to the presence of mudflats/mudbanks[1], which continuously migrate to the west driven by the alongshore Guiana Current and wave action. Based on several investigations and historical information, an average mudbank has

1 Mudbanks have been defined as the sub-tidal extension of the intertidal mudflats; below the term mudbank will be used for the whole mudflat/mudbank

a length of 45km and a life cycle of approximately 30 years. Recent investigations indicate that certain mechanisms modify this general pattern. Cyclic changes in wind direction and wind speed (and connected with that, the wave climate) are thought to result in (cyclic) changes in mudbank characteristics and changes in the coastal erosion and accretion cycle. A very long mudbank is currently found east of Braamspunt. This mudbank of 70km in length will reach the mouth of the Suriname River within about 20 to 30 years. It is expected that Braamspunt will then develop as a "mudscape" pushing the mouth of the Suriname River towards the west. When this happens it will have considerable consequences for the navigation of the Suriname River. Accretion and erosion are characterized by specific landscapes, which often succeed each other within one accretion-erosion cycle. Three major types of coastal landscapes have been distinguished along the Suriname coast, a mud accretionary coast, a sand accretionary coast and an erosional coast.

In several locations, soil dams have been put up to stop erosion and penetration of seawater. The Ministry of Public Works has frequently executed maintenance works on the soil dam at Weg naar Zee to prevent inundation, land degradation and further land loss. However, these works last for only a few years. In the absence of some natural barriers and manmade infrastructure, it is expected that large parts of the northern coast will be inundated and ground as well as surface water resources will be deteriorated due to sea level rise and changes in precipitation. Being aware of these potential impacts, the Ministry of Public Works has started the explore options for building an enclosed dike aiming to protect the northern coastal area against flooding from the swamp and seawater, and establishing a ring canal for the drainage of excess water. A buffer zone of about 0.5 to 4.0km (measurements yet to be decided) between the coastline and the enclosed dike is taken into account, including the expected impacts of this dike on the estuarine zone and those of the sea level rise in the future.

Ecology

The study area is dominated by manmade and man-affected ecosystems with residential and agricultural areas covering most of it. Significant areas with remaining natural or semi-natural ecosystems are found at three isolated locations within the study area. The two northern areas comprise coastal wetlands with mangrove forests, brackish water swamps and related freshwater swamps, as well as some indistinct areas with ridge forest. In the southern direction the swamp waters may become fresh and linked with a freshwater riverine swamp area, with recent and old (high) clay levees and backswamps. These (semi-) natural areas cover only 13% of the study area. In other districts of Suriname (semi-) natural ecosystems are much more common.

The coastal ecosystems have multiple values and functions, including coastal protection, natural productivity, biodiversity and carbon storage. Especially, the coastal protection function of the mangrove forest is clearly demonstrated in the study area where erosion is much more severe along unprotected stretches of the coast than along forested sections.

Despite the multiple values and functions of the coastal ecosystems, considerable areas have been turned into agricultural, residential and aquacultural land. In the absence of land use planning, as is still the case in Suriname, many such developments take place more or less randomly. This process is expected to continue over the coming years. In the long run, however, this trend might be reversed due to climate change induced flooding and salinity intrusion, which will force people to abandon the most vulnerable areas close to the ocean. In these areas, the natural ecosystem will gradually regenerate. The mudflat, which will reach the Paramaribo-Wanica coast in the next 20 to 30 years, might also contribute to the reestablishment of the Black Mangrove forest. South of this mangrove zone, saline and brackish ecosystems will show a considerable extension towards the south, into the current freshwater swamps. Extensive lagoons will form in the brackish to saline zone. The creation of open water will result in an increase in wildlife, especially birds and fish.

On the other hand, climate change and sea level rise are also expected to negatively affect the wetland ecosystems in the coastal plain, because changes in the drainage basins and the tidal regime will affect the hydrology of these low lying and flat areas. Changes in water quality (salinity) will also cause considerable changes in the sea-bound coastal wetlands. Indirectly the hydrology may also affect the occurrence of vegetation and peat fires, another important factor that determines the vegetation status in the Young Coastal Plain. To a lesser degree, changes in the rainfall pattern and temperature in the coastal plain may have an impact on the wetland ecosystems. Changes in temperature and CO2 levels will certainly affect all ecosystems in Suriname, but their impact cannot yet be predicted.

Given the above, it can be concluded that many different processes are affecting the ecosystem conditions in the project area. The effects of climate change are expected to be both positive and negative.

Water

Suriname is one of the top 10 water-rich countries of the world. The renewable annual fresh water available in Suriname is estimated at 473,934 m^3/capita. Despite this abundance, water availability may periodically suffer problems especially during dry seasons and years affected by strong "El Niño" events. The surface freshwater resources consist of the Suriname River in the east and the Saramacca River in the west. Groundwater in the study area can be divided into shallow (0.5 to 5m) and deep (>5m) groundwater resources. In northern parts the shallow groundwater is saline whilst in the southern part this is fresh. The deep groundwater may be fresh in the coastal zone. The different aquifers, such as the Zanderij (average depth of 30 to 50m), A-zand (at a depth of 120 to 160m) and the Coesewijne (230m), are the important freshwater aquifers in the study area.

Water in the study area is mainly utilized at domestic and industrial levels, for agricultural purposes (irrigation and cattle watering) and fire control. No special management system exists for regulating and ensuring the provision of freshwater for maintaining ecosystems or facilitating navigation or fisheries.

Water for domestic purposes is supplied by two governmental water supply agencies, the Surinamese Water Supply Company (SWM) and the Service for Water Supply (DWV). The SWM is the largest water supplier, providing water to 93.7% of the households in Paramaribo and 74.5% of the households in Wanica. For this, the SWM withdraws approximately 90,000m^3 water/day from the existing aquifers in the coastal plain through ten production wells. About 52% of the produced water is delivered as metered water. The remaining is not metered and can be considered as wasted due to, among other reasons, operations and leakages. In rural areas, the provision of drinking water largely depends on rainfall and shallow groundwater occurrences. As population increases in these areas water supply companies do expand their infrastructure. The Government of Suriname aims to connect 95% of the population in the urban area to the water network. The target for rural areas is set at 70% of the population.

Except for domestic purposes water is also used for purposes such as the production of beer, bottling of water, and use for other beverages. Other industrial processes include the metal industry and fabrication of natural stone products.

As agricultural activities are relatively well developed in the district of Wanica, a significant amount of freshwater is required for agricultural purposes. Large parts of the agricultural areas are not irrigated but depend on rainwater, available soil moisture and local surface water. Therefore, a lack of rain in the dry seasons seriously affects the agriculture and the livelihood of the farmers, in particular in the northern located horticultural areas. Water for the banana and rice farms on the western border is obtained from the Saramacca River, which is well stocked.

Apart from water requirements for socio-economic needs, freshwater is also needed for maintaining the natural ecosystems, including the mangrove ecosystems in the north, on the coastline and by the estuary of the Suriname River. When the aquatic conditions do not meet the required conditions, mangrove vegetation may not develop whilst the existing mangrove forest may degrade. To meet the required conditions, appropriate mixing of freshwater supplied from inland with the brackish seawater is needed.

Water quality in the study area is subjected to pollution from agricultural, industrial, mining and domestic sources. Under natural conditions, pollution also occurs through penetration of salt water into freshwater resources, particular during the dry seasons. Domestic wastewater is drained through the sewer systems into the rivers and open swamps. The area needs a central sewer treatment plant. There are also no regulations for draining industrial wastewater. During heavy and consistent rainfall excess water may flush pollutants over large areas, including waste from septic tanks. In addition many septic tanks don't always function properly due to incorrect construction or leakage. Studies have shown significant pollution of groundwater in the immediate area of the septic tanks. The agro-chemicals and fertilizers used in the agricultural sector are flushed out by rain and irrigation water and transported by the drainage system into the natural water systems. In the small-scale agricultural sector this is of minor concern. However in areas where relatively large-scale agricultural activities are taking place, i.e. near the western border of the study area (banana and rice sector), the threat may be significant.

The drainage system in the study area is based on polder water management structures. There are in total 35 drainage areas within Paramaribo, comprising open and close conduits. Each drainage area is an independent unit drained by means of sluices and/or pumping stations. Currently, the Ministry of Public Works is constructing new pumping stations at several locations in the study area to improve the drainage capacity. However, inadequate maintenance of the existing drainage systems results in frequent flooding of the urban areas during the rainy seasons. About 13% of the urban area and 13,000 inhabitants are directly affected. Necessary steps and great efforts have been taken to improve the drainage conditions in the past years.

It is expected that climate change will have many negative impacts on the water resources in Suriname, both in terms of quality and quantity. If no measures are taken, large parts of the study area will be inundated and tidal waters will intrude deep into the natural area. In combination with increased evapotranspiration this may lead to increased salinization. Intensive rainfall events will put increasing pressure on the drainage systems causing further pollution from excess wastewater from industries, agriculture and households. Prolonged droughts, in turn, will cause severe water shortages, which will negatively affect many of the key sectors in Suriname, including agriculture, energy and industries.

Agriculture

The total area suitable for agriculture in Suriname accounts for about 1.5 million ha of land, but only 120,000ha of agricultural land is presently under cultivation. About 85% of the land suitable for agriculture lies in the coastal area and the other 15% is situated in the interior as river terraces. The fertile soil of the young coastal plain and the large freshwater swamps and rivers in the north have together created ideal conditions for developing large-scale agriculture. Relatively large-scale rice and banana production are found in the coastal plain, which is for the greater part concentrated in the western districts.

Agriculture in the study area is largely concentrated on horticulture, fisheries and livestock production. Most of these activities are located in the Wanica district. Based on these activities the Wanica district is divided into 3 production units: Wanica A (including areas north of the Saramacca Canal); Wanica B (including the resorts of Domburg and Houttuin); and Wanica C (including the resorts of Nieuwe Grond, Koewarasan and Lelydorp).

In general, crops are harvested on small farms (0.6 to 6.0 ha) where only part of the land is used for crop production. The traditional areas for vegetable and fruit production, such as Pomona, Weg naar Zee, Uitkijk-Leidingen, Santo Boma, Koewarasan and Houttuin, show a negative trend in terms of production. New horticultural production areas have been started in the recent years in the districts of Saramacca, Comowine and Para. A shift is taking place in what is produced on these farms. As well as the primary production of vegetables, most of the farmers produce fruit (citrus fruits, bananas, mangos and papayas) on a small scale since land is a major limiting factor.

A typical small vegetable producing farm can be characterized as follows:

- land in production is in between 0.16 and 0.32ha;
- the farmer is a part-time farmer with other sources of income;
- part time labor is hired when necessary;
- farmers do not specialize in one specific crop;
- only land preparation is mechanized;
- in general farmers never received an education in agriculture, the knowledge they have is gained through practical experience;
- marketing of vegetables produced is through wholesale buyers and/or middle men;
- the risk of harvest failure is high;
- the main problems that farmers have to deal with are financial problems (high interest rates at commercial banks) and poor maintenance of drainage infrastructure.

Under present conditions of climate change and variability, over short time periods both flash flooding due to heavy rainfall and sustained drought may occur. Consequently, dependence on rainfall as a water resource for horticulture is not reliable. Therefore utilization of modern green-houses based on drip irrigation and/or hydroponics is a prerequisite for higher yields. In Suriname however, the adaptation to these modern facilities for vegetable and/or horticultural production is evolving slowly.

The Wanica district is also the most important district for milk, poultry, small ruminant and pig production. More than one third (36.8%) of all the grassland is located in this district. These grasslands, even though they are located at higher altitude than the coastal plains, are often flooded during heavy rainfall, which negatively affects livestock production. Livestock productivity is also affected by the high ambient temperatures and humidity. This is what is currently affecting the dairy sector the most.

Within the dairy sector 400 farmers and transporters of milk are registered. More than 40% of milk sold comes from local farmers and provides support for food security, poverty alleviation, and income generation. Recently new dairy processing methods have been introduced using imported milk powder for producing cheap dairy products. In addition, the resilience of the dairy sector is limited by the lack of necessary infrastructure such as irrigation and drainage systems for existing grasslands, the low number of farmers, small pasture lands, and no adequate administration.

On the more poorly drained clay land of the Young Coastal Plain extensive or semi-extensive farming systems for production of beef cattle are found. These types of cattle are well adapted to high temperatures and therefore fewer thermoregulation problems with beef production are experienced. Farmers of beef cattle are often only part-time. In comparison, dairy cattle require good housing and management, and are less adapted to the ambient temperature. Serious threats to beef cattle production are frequent due to flooding because of poor drainage systems. In the coastal area, threats may come from flooding due to dam breaches during high spring tides and the consequential saltwater intrusion on pastures close to the sea results in significant losses of grassland.

Poultry and pigs produced under small intensive farming systems are less affected by climate change impacts. Most of the farms (more than 70%) are concentrated in the southern part of Wanica. The main negative climatic impacts on poultry production come from the persistent high

temperatures in the pens or coops during the long dry season. In this season the mortality rate of chickens increases significantly on farms with traditional housing systems. The expectation is that new modern farms with facilities for complete climate control will be constructed in the Lelydorp area and the Zanderij area. These modern farms will be better adapted to the problems of climate change.

In general however, food production and food processing in the study area already shows signs of decline. If no measures are taken, further decline will be observed and it is expected that this negative trend will be further enhanced by the adverse impacts of climate change, in particular in the northern areas. Ongoing urbanization will push the agriculture further south in the study area but also beyond its limit to other neighboring districts. There will also be a loss of fertile land due to flooding since higher elevated regions are relatively less suitable for agriculture.

It can be concluded that food production could be sustained under changing climatic conditions through the application of climate controlled techniques and mechanisms and the improvement of water management and irrigation systems. However, all these proposals require strong and aggressive promotion to substantially raise awareness. Other facilities such as those related to financial support, guidance of farmers at field level and training are of utmost important and highly recommended. Last but not least good spatial planning is required for this sector to guarantee the sustainability, good food provision and food security.

Health

The persistent increase of temperature, sea level rise and changes in precipitation are expected to affect human health in Suriname both directly and indirectly. Temperature rise may cause heat related mortality and morbidity and an increase in respiratory illnesses, whilst changes in precipitation could lead to an increase in mortality due to the frequency of floods, storms and other natural disasters. Sea level rise may also cause a loss of inhabitable land, contaminate fresh water supplies and inflict damage on public health facilities. As well as the above mentioned effects, health conditions could also be impacted by so-called ecosystem mediated health effects, which include changes in the distribution and seasonality of vector and waterborne diseases and an increase in growth of toxic algae and food shortages.

Despite these general observations, the specific impacts of global climate change on human health conditions in Paramaribo and Wanica are still largely unpredictable. Increased temperatures and sea levels, as well as alternating rainfall with severe droughts and floods, will have indirect effects on human health, which in general are negative for Suriname. Nevertheless, some adaptations can be made.

Malaria, which is endemic in parts of internal Suriname, does not occur in the coastal region. However, there are two potential vectors for malaria present on the coast, the *A. aquasalis* (most dominant) and *A. nuneztovari*. Since *A. aquasalis* is not an efficient vector for malaria in Suriname, it is not very likely that the occurrence of malaria will increase under future climate conditions.

Dengue, however, which is a viral disease characterized by an abrupt onset of high fever, headache, pain in the joints, myalgia, retro-orbital pain and rash, is endemic in Suriname. The warm and moist climates are favourable conditions for its development. Two serious complications of this disease have been observed; dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). The most well known vector is the *A. aegypti*, a day-biter, which resides in manmade sites with suitable breeding environments, such as rainwater tanks, barrels and gutters of houses, amongst others. It is expected that future increases in short and heavy rainfall events will increase the number of available breeding sites for *A. aegypti* and as such contribute towards a wider

distribution of dengue. The same is the case for yellow fever which is transmitted by the same mosquito.

Schistosomiasis or bilharzia is another endemic disease in Suriname. The occurrence of the disease is restricted to the coastal region, since the vector, the snail *Biomphalaria glabrata*, is only found in the region of coastal shell-ridges which are in the districts of Paramaribo, Wanica, Saramacca, Commewine and Coronie. The number of cases of bilharzia in Suriname decreased dramatically in the period 1975 to 1980 (from 26% to 5%) as a result of bilharzia control campaigns. Since 1980, the number of cases of bilharzia is stable (below 5%). The occurrence of bilharzia is expected to further decline in the context of climate change because the disease has less chance of survival in a saline environment.

Waterborne diseases, like shigellosis, typhoid fever, cholera and leptospirosis (Weil's disease) on the other hand, are expected to increase under conditions of severe rainfall and flood events. Shigellosis is caused by bacteria and is endemic in Suriname. The bacteria occur in the faeces of infected people, and contaminated food and water infect others indirectly. This disease, symptoms of which are diarrhoea, fever, vomiting, nausea, stomach pain and dysentery, may finally cause death in children if appropriate measures are not taken in time. At a national level, a significant number of cases varying between 90 and 120 were registered annually in the period 2000 to 2004. Typhoid fever is caused by the bacteria *Salmonella typhi* and is also endemic in Suriname. In the period 2000 to 2004, the total number of cases registered varied annually from 56 to 104. The disease has been predominantly observed in villages in internal Suriname. Cholera is caused by the bacteria *Vibrio cholerae* and is a particularly dangerous disease. Food and water contaminated with cholera-infected faeces can lead to cholera outbreaks. Leptospirosis (Weil's disease) is caused by bacteria of the order *spirochaetosis* and is present in the urine of infected rats. People may become infected with leptospirosis bacteria after having been in contact with infected water. Consequently, most leptospirosis cases occur in the long rainy season. Out of the 682 suspected cases registered in the period 2000 to 2003, of which 478 were tested in the laboratory, 90 were found positive.

Heat related mortality and morbidity is limited in Suriname. Even an increased air temperature is not likely to cause heat waves and therefore there would be low incidences of heat-related mortality. Information regarding the pollution-related respiratory disease baseline data is lacking and therefore it's difficult to predict the possible impacts.

Institutional Landscape and Land Use Planning for Coastal Zone Management: The Current Situation

The management of coastal districts of Suriname takes place at both the sector and district level. At the sector level, different ministries are responsible for implementing policies nationwide and promoting the interests of the sectors that they represent. Specifically the Ministry of Agriculture, Livestock and Fisheries; the Ministry of Natural Resources and Energy; the Ministry of Public Works; and the Ministry of Labor, Technological Development and Environment are closely involved with activities related to coastal zone management and the effects of climate change. The Ministry of Planning and Development Cooperation (PLOS) coordinates the planning activities of the government. The newly established Ministry of Spatial Planning, Land and Forest Management will soon play an important role in management of the coastal zone.

At the district level, the District Commissioner (DC), who falls under the remit of the Ministry of Regional Development, is the focal point, although other ministries maintain representation at the district level. The DC acts in close cooperation with the elected District Councils to marshal general management and the economic promotion and development of the district. A problem here is that the DC does not exercise financial independence and doesn't have his/her own budget.

Recently (2002 to 2005) the government has started a process of decentralization of diverse activities including financial decentralization. The Ministry of Regional Affairs is taking the lead in this process.

With the formation of the National Environment Council (NMR) in 1997 and the institutionalization of the National Institute for Environment and Development (NIMOS) in 1998, environmentally related activities are getting increasing attention. Since the establishment of NIMOS, much has been done in the way of enforcing relevant laws, awareness raising, strengthening institutional capacity and local expertise, and sourcing the required financial aid to enable the execution of many environmentally related activities, including coastal management.

Since the coastal zone will remain under great pressure from the ocean and its rising water levels, management of the coast will be of highest priority in the near future. As a result, the institute for Integrated Coastal Zone Management might become one of the most important institutes in the country. The ministries of Agriculture, Livestock and Fisheries; Natural Resources and Energy; and Public Works will be closely involved with activities related to coastal zone management and the effects of climate change.

The DCs will get more power to influence policy and activities in their districts. Changes in the election structure will also affect the development of the country. Notwithstanding these circumstances, the districts will be linked tightly with the capital city Paramaribo.

As well as the institutions like the NMR and NIMOS other environmentally related institutions will be established as more and more people become aware that the environment is of utmost importance to protect, otherwise disaster may be experienced sooner than later. Capacity at these institutions will increase as more will need to be done to implement relevant laws, raise awareness, and source the required financial resources.

Despite these institutional frameworks and developments, it has been realized that a lot needs to be done in order to enforce and implement a sound climate change adaptation policy in Suriname. In response to these concerns, the NCAP project in Suriname hosted a widely attended conference on 'Water and Future Development in Suriname'. One of the main points that emerged from the conference was the necessity to establish a Climate Change Coordination Commission, consisting of experts from different sectors of society, preferably cutting across the ministerial levels. The commission should be responsible for advising the government about measures for dealing with the direct and indirect consequences of climate change. The government would not take any decision in relation to climate change without first seeking the advice of the commission. The Ministry of Labor, Technology and Environment will take the initiative to establish the commission.

In terms of spatial planning, Suriname has already delineated 16 protected areas since 1966, covering approximately 13% of the land surface of Suriname. These protected areas comprise 11 Nature Reserves (NR's), 1 Nature Park (NP), and 4 Multiple-Use Management Areas (MUMAs).

As it was recognized that protection of a small part of the coast was not adequate to meet the overall goals, this concept of MUMAs was adopted. MUMAs are defined as areas where special management by or on behalf of the government is needed for the sustainable use of the natural resources, which includes the protection of vulnerable ecosystems and species. MUMAs have been established in most of the estuarine zone. The goals of these MUMAs are:

- To optimize their long-term productivity and sustainable use by man;
- To optimize the long term natural productivity of the estuarine land zone and the bordering ocean; and
- To promote the development of sustainable production processes in manmade ecosystems (such as agriculture, animal husbandry and oil exploitation), taking into consideration the demand of unspoiled ecosystem areas.

The only part of the Surinamese coast that is not included within the MUMA area is the Paramaribo-Wanica coastal zone, because here all land, including land in the mangrove zone, had already been issued to third parties. Land use in this zone has already led to serious degradation of the coastal wetlands and of its functions. In order to reverse these trends, urgent steps are needed to improve land use and spatial planning in the project area.

Adaptation Measures

The impact assessments and scenarios developed in the context of this project all confirm the findings and conclusions from previous studies that climate change will have serious impacts on the coastal zone and its sectors. In order to respond to these increasing threats, the project has developed an adaptation strategy for the most important districts of Paramaribo and Wanica. The proposed adaptation strategy consists of both adaptation measures that are part of common government policy and adaptation measures that constitute a specific response to the increased threat of climate change related hazards and impacts. In what follows, only an overview is given of those adaptation measures which were made in response to the increased threats from climate change related hazards and impacts.

The proposed adaptation strategy consists of three distinctive phases:

- Phase 1: 2008 to 2025, no extensive protection, no extensive development
- Phase 2: 2025 to 2060, implementation phase
- Phase 3: 2060 to 2100, fine tuning and monitoring

In the first phase the Government of Suriname will continue its activities regarding coastal zone and river bank management, whilst phase 2 will be characterized by implementation of the plan elaborated during phase 1. This will include among other things, stopping all developments and human activities north of the proposed dam, raising the vulnerable area to a status of protected area, continuing riverbank protection against the intruding water, and water management and implementation of spatial planning. Phase 3 is fine tuning and monitoring.

During phase 1 no-regret measures will be implemented along with protection measures, such as stopping further development in the northern parts of the study area and implementing further prevention measures against flooding. The coastal and riverbank protection measures in the existing inhabited areas will be maintained. Retreat will not be considered as a high priority option in this phase. In this phase a detailed adaptation strategy will be elaborated and specific action plans which are ready to implement will be developed.

During phase 2 the adaptation strategy and action plans, including the physical measures, will be implemented. The third and final phase will be focused on fine tuning and monitoring the implemented (physical) measures.

For the development and implementation of the adaptation strategy and action plans a number of essential components need to be considered. Firstly, an enabling environment should be created for supporting the activities taking place in the context of the adaptation strategy. Secondly, a clear spatial plan needs to be developed defining the target use of specific areas. Finally, a number of key adaptation measures need to be considered in order to take early steps in the protection of crucial resources and economic activities in the coastal zone. The different components are discussed in more detail below.

Creating an enabling environment

The elaboration of the adaptation strategy and development of action plans will entail preparatory work in terms of:

- Development of necessary policies and laws;
- Establishment and strengthening of existing institutions and the creation of new supporting institutions (where necessary); and
- Establishment and elaboration of data collection and monitoring systems and increasing research activities and capacities.

It has been recognized that the creation of such an enabling environment will be a necessary condition for successfully implementing adaptation measures.

With regard to the development of necessary policies and laws, consideration should be given to already existing initiatives and documents. Important laws and regulations already exist, such as the Planning Act and Environmental Act. The problem is that these and other regulations are rarely enforced. The Draft Water Law needs to be updated and legislation needs to be put in place to regulate the use of the estuarine zone and natural riverbank (including mangrove vegetation) and to establish spatial planning and land-use policies.

In addition, existing institutions and agencies need to be strengthened and the co-operation between different institutions needs to be intensified and improved. Table 1 gives an overview of the most relevant institutions in terms of climate change and coastal zone management. The table also lists the main responsibilities of the different institutions as well as a summary of areas which need strengthening.

Apart from developing policies and laws, and strengthening institutions and organizations, the successful implementation of a climate change adaptation strategy and action plan will also depend on the availability of good-quality data and information. The importance of valid data has been expressed many times during this and other projects. Lack of data prevents researchers from obtaining in-depth analysis. The purpose of data collection and analysis is to gain insight regarding the current developments in climate change and sea level rise, to identify trends, and to be able to forecast change for a longer period. The following types of data will need to be collected on a regular basis in order to develop consistent and reliable databases:

- Climatic data in the study area;
- Data on the water level in the sea and the lower courses of the Suriname and Saramacca Rivers and wetlands in the study area;
- Data on discharge, stream flow, waves, sedimentation and water quality regarding the water resources;
- Topographical data;
- Data on the dynamics of the coast, riverbanks and riverbeds.

Research capacities will also need to be increased in order to expand the relatively small pool of climate experts in the country. This can, for instance, be done by the establishment of a postgraduate course on climate change in Suriname. The Anton de Kom University will be an important partner in this.

Developing a spatial plan

One of the key elements in the development and implementation of a climate change strategy and action plan will be the development of a clear spatial plan for the districts of Paramaribo and Wanica. As has been mentioned before, building activities and land use changes in Suriname are still taking place more or less randomly and the districts of Paramaribo and Wanica have also been excluded from the list of MUMAs. This has already resulted in the degradation of large areas and uncontrolled building activities in areas vulnerable to flooding and sea level rise. Consequently, various authors have proposed specific planning measures in order to prevent further degradation and to restore the functions of the estuarine zone north of Paramaribo.

Table 1: Overview of key institutions and the areas that need strengthening

Mother Organization	Agency	Duties	Areas that need Strengthening
Ministry of Public Works	**Hydraulic Research Division**	• Collection, processing, analysis and management of data • Execute studies and research • Providing advice regarding water, hydrology and hydraulics.	• Expansion and upgrading, modernizing measuring equipment and operational means • Further training of personnel in modern methods • Further modernization and mechanization of database
	Meteorological Service Suriname	• Collection, processing, analysis and management of data • Execute studies and research • Providing advice regarding meteorology and climatology	• Upgrading of the service, including training, instruments and operational means
	Division for Embankment Constructions	• Construction and maintenance of coastal and river embankment constructions	• Further training of personnel in modern methods for inspection and maintenance of protection works • Training personnel in modern methods for integrated coastal zone and development of coastal zone planning • Mechanize the programming of maintenance of protection works
	Division for Urban Drainage	• Construction and maintenance of urban and primary national drainage system	• Further training of personnel in modern methods regarding urban drainage • Further mechanization of the service
Anton de Kom University of Suriname	**Faculty of Technology**	• Train specialists • Execute research regarding hydrology, hydraulics, meteorology, climatology and environment	

Mother Organization	Agency	Duties	Areas that need Strengthening
Ministry of Labor, Technology and Environment	**Environment Section**	• Development of national environment policy • Monitor execution of national environment policy • Promote environment and sustainable development	
	National Institute for Environment and Sustainable Development (NIMOS)	• Promote environment and sustainable development • Enforcement	
Ministry of Agriculture		• Construction and maintenance of secondary and tertiary infrastructure in agricultural areas • Water boards	
Ministry of Domestic Affairs		• Maintenance of a part of the drainage system in Paramaribo	
Ministry of Regional Development		• Construction and maintenance of secondary and tertiary infrastructure in agricultural areas • Water boards	
Ministry of Spatial Planning and Land Policy		• Spatial planning • Nature conservation	

Proposed measures include:

- Immediately stopping the land issuance north of the northernmost ridge *Suikerrits* on which the Ocean Road is situated and being developed;
- Withdraw any issued land which is not being used, or if it is not being used as agreed;
- Take the following measures on other already issued land, that is in (proper) use:
    - » Do not issue additional building permits;
    - » Give incentives to ensure that:
        - * Mangrove forests remain intact; and

    * The re-establishment of the mangrove forests is promoted.
- Prepare a coastal management plan for the Paramaribo-Wanica coastal zone, focusing on coastal protection and considering climate change impacts, including sea level rise.

These proposals have been discussed with officials in charge of MUMA management, but no further steps have been taken yet.

Apart from these specific measures, spatial planning will also require the development of designated zones for natural areas, housing and building, agriculture and industries. In terms of climate change adaptation, the delineation and preservation of natural coastal areas will be particularly important because of the protective role they can play in mitigating the effects of sea level rise. Therefore, a rigid planning strategy will be needed that will ensure the protection of valuable natural zones in the coastal area.

Key adaptation measures

In the course of the project, a range of key technical and non-technical adaptation measures have been proposed and discussed. In what follows, an overview of these adaptation measures is given, including a short discussion of necessary steps that need to be taken in terms of policy, legislation, finance, research, monitoring, data collection, costs and timeframe for implementation.

Measure 1: Stop all developments in the northern part (natural areas) of the districts of Paramaribo and Wanica.

Policy: Change needs to happen so the government should adopt this measure.

Legislation: Appropriate law is required and should be in place to guide the execution of this measure properly. A corresponding legal body is also required and should be put in place as soon as possible.

Finance: Financial investment is necessary. Financial support will also be needed for the compensation of any relocation and/or damage to livelihoods caused by this measure.

Research and Data Collection: Firstly, an appropriate database must be established. Intensive research is required for data collection, including impact studies of the socio-economical aspect. Further research into the development of different scenarios is also required.

Monitoring: Continuous monitoring is a prerequisite for sustainable development. Many problems can be identified during the process of carrying out the measure. For this purpose tools, methods and corresponding training are required.

Data Collection: Without a proper database, identification of needs and limitations will be difficult. Therefore this task is one of the first to be carried out.

Costs: The approximate costs of implementing this measure are high. However, this investment only has to be made once. There are no repetitive costs linked to the implementation of this measure.

Timeframe: Short-term

Measure 2: Intensive in-depth studies and research into the possible impacts of sea level rise.

Policy: Detailed measurement of sea level rise and the topography of the area is required. This is necessary to determine the exact area under threat from the rising sea level. The government needs to adopt this policy in order to ensure its implementation. Lack of data will certainly result in substantial losses, due to the impacts of climate change.

Legislation: No new laws are required.

Finance: No additional financial investment is necessary as the present budgetary levels will absorb it. A joint effort of all the departments, institutions and other beneficiaries could mitigate any additional research costs.

Research and Data Collection: Firstly, an appropriate database must be established. Up-to-date research and data collection is necessary so time and money need investing in this. It may be possible to purchase data such as satellite images from other sources at a cost.

Monitoring: Continuous monitoring of the sea level rise and other developments on the coast and the study area is necessary for sustainable development. Many problems can be identified during the process of the development of the measure or during its initial stages.

Costs: The approximate costs for implementing this measure are relatively high although there is scope for lowering them.

Timeframe: Short-term

Measure 3: Planting of mangrove forests

Policy: This is a relatively new measure but is being used in many parts of the world for other purposes besides enhancing the resilience of the coast. This option as an effective measure against erosion is a no-regret option. Very little or no environmental harm will take place with this measure. The government should promote this option as having advantages over some of the other options in terms of protection of the coast and enhancing the resilience of people and communities living on the vulnerable part of the coast.

Legislation: There is presently no legislation on this matter. Legislation dealing with clearing mangrove forests is urgently required. This law would effectively support the protection of the existing mangrove forests and thus enhance the resilience of the natural ecosystems in the north. Positive results would be achieved by combining this implementation with other measures.

Finance: No additional financial investment is necessary as the present budgetary levels will absorb it. Costs will be incurred from purchasing certain instruments for monitoring parameters and for implementing the measure. In particular, costs will be incurred from the transportation of the mangrove seedlings.

Research and Data Collection: Continuous research and data collection is required to build a database. Since areas are easily accessible no complex problems are expected to rise. Results of this measure would be beneficial for the policy maker in making further decisions. Low costs and high effectiveness of this measure are its biggest advantages.

Monitoring: Continuous monitoring of the planted area is required. This can be done by the local coastal communities under supervision of the research institutes or departments involved.

Costs: The costs are relatively low. Participation of the local communities is required.
Timeframe: Short-term

Measure 4: Construction of river dikes and defenses

Policy: This option is new for the study area and it has been not yet been tried in Suriname. Nevertheless the knowledge required seems to be available. This option is an effective measure against erosion and flooding, but it is costly. Building river dikes and defenses means continuous maintenance. Suriname has seven relatively large rivers, along which human settlements and

economical activities take place. Under the conditions of sea level rise many of these settlements will be in danger. So for the study area the implementation of river dikes and defenses is highly recommended.

Legislation: There is presently no legislation on this matter and is therefore required.

Finance: Serious financial investment is required. The present budget is not sufficient to implement this measure and therefore additional funds are necessary. Since this problem is related to climate change issues, financial support from international sources should be sought.

Research and Data Collection: Continuous research and data collection is required to build a database. In particular, areas and river banks that are not affected by economical activities or inhabited should be monitored.

Monitoring: Continuous monitoring is required. This can be done by the local coastal communities under supervision of the involved research institutes or departments.

Costs: The costs are high. Participation of the local and international communities is required.

Timeframe: Medium-term

Measure 5: Constructions of a sea wall and/or groins
Policy: This option is not new. A sea wall is found in the district of Nickerie. It is an effective measure against the erosion, but it is costly. Building seawalls means continuous maintenance. Suriname has a 386 km long coast and therefore policy regarding this measure is required.

Legislation: There is presently no legislation on this matter and therefore it is urgently required.

Finance: The same as mentioned under measure 4 is applicable here. Significant financial investment is required. The government should bear in mind the costs involved in maintaining these defenses.

Research and Data Collection: Continuous research and data collection is required, in particular in coastal areas not affected by economical activities.

Monitoring: Continuous monitoring is required. Involvement of the local coastal communities is necessary.

Costs: The costs are high. Participation of the local communities is required.
Timeframe: Short/Medium-term

Measure 6: A dike to prevent future flooding and sea water penetration should be built further in land.
Policy: This option is presently under review. Care needs to be taken when determining the location of the water retaining dam since many coastal cities are located on the vulnerable coast. Implementation of this measure could seriously affect the local communities and people living in these areas.

Legislation: Taking into consideration the growing pressure on the coastal natural systems, the growing threat and the growing level of vulnerability, urgent implementation of appropriate legislation is required.

Finance: Financial costs could be significant.

Research and Data Collection: Continuous research and data collection is required. Ongoing developments on the coast require permanent documentation.

Monitoring: Continuous monitoring is required. Involvement of the local coastal communities is necessary.

Costs: The costs are medium to high. Participation of the local communities is required.

Timeframe: Medium-term

Measure 7: Relocation of communities
Policy: This option is new and requires serious research. Regardless of if there is available land, the relocation of people would encounter many difficulties, including those of a social, cultural and political nature. It should be mentioned that experiences dealing with annual or frequent flooding of large parts of the country due to heavy rainfall should be seriously considered here. However, the IPCC projections for sea level rise and the uncertainties linked to it are reasons for taking action as soon as possible. The Government should seriously consider this option.

Legislation: Taking into consideration the growing pressure on the coastal natural systems, the growing threat and the growing level of vulnerability, urgent implementation of appropriate legislation is required.

Finance: The same as mentioned under measure 4 is applicable here. Significant financial investment is required, although it would only be a one off payment.

Research and Data Collection: Continuous research and data collection is required. Ongoing developments on the coast required permanent documentation.

Monitoring: Continuous monitoring is required. Involvement of the local coastal communities is necessary.

Costs: The costs are high. Participation of the local communities is required.

Timeframe: Medium/Long-term

These and other measures have also been made spatially explicit in the map in figure 2.

The study area can be roughly divided into the following sections:

Section 1: northern area up to second ridge
Section 2: area covered by the left bank of the Suriname River
Section 3: southern zone of the study area including the Lelydorp
Section 4: middle and western part, including the Saramacca Canal and the Kwatta Ridge.

Section 1: Northern part of the Study Area
This area is the most vulnerable in terms of land loss and areas that will be affected by a sea level rise of 1m. It is sparsely populated, with mangrove forests in the northeast and northwest. Mangrove forests in the middle part of the coastal zone have been almost completely cleared for agricultural purposes. Scattered human settlements are found on the ridges, which in general are located higher than the surrounding clay depositions. Bad natural drainage conditions have led to formations of swamps, deterioration of water quality, ranging from salt through brackish to fresh. Polder structures established in this region have caused subsidence in these areas, thereby enhancing its vulnerability.

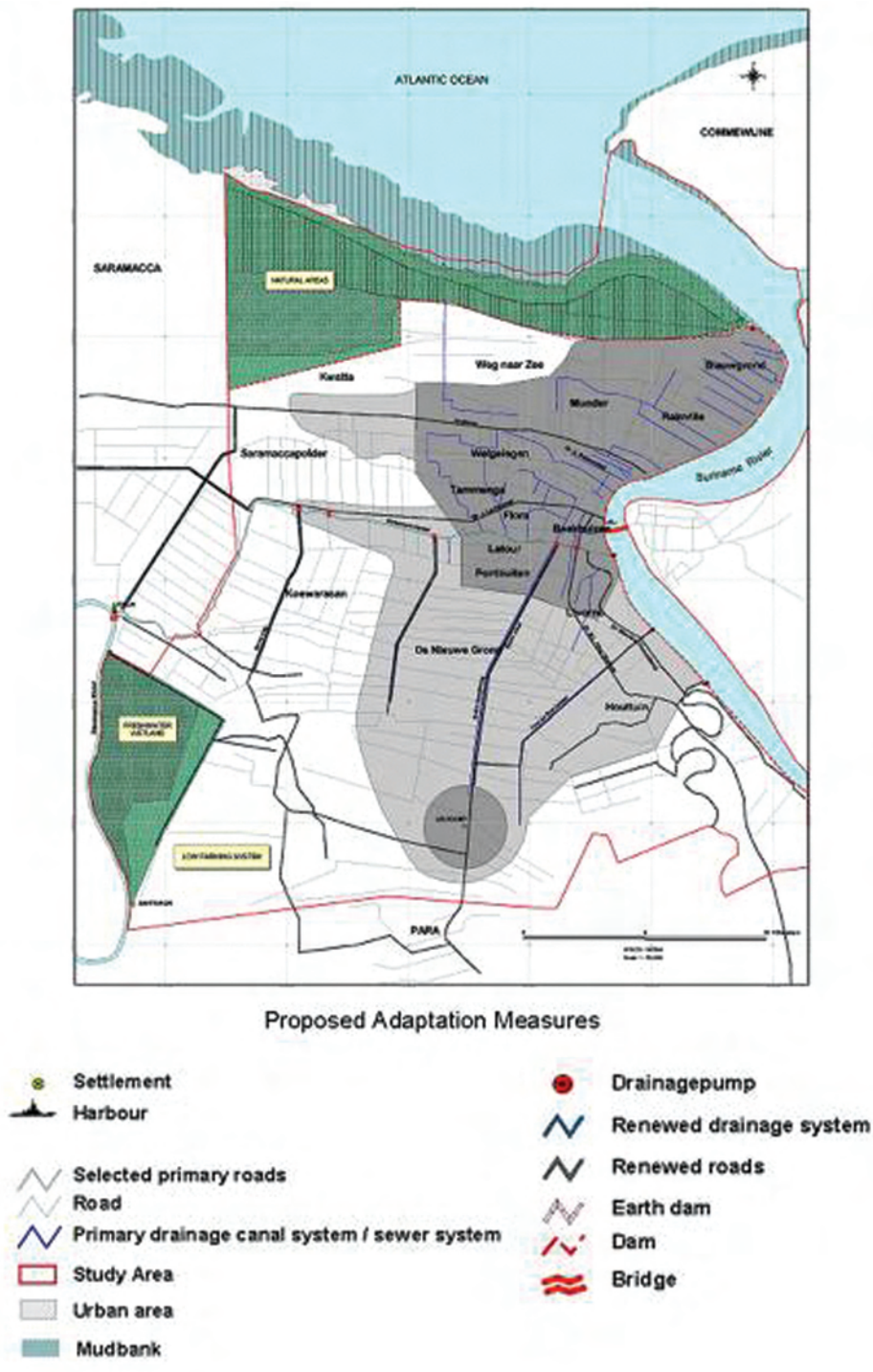

Figure 2: Map of Proposed Adaptation Measures

For this region the following measures are proposed:

- Protection
  - » Soft protection – enhancing resilience of the coastal zone, through:
    - * Creating more space for the shore area;
    - * Creating conditions for mangrove growth; and
    - * Planting mangrove forests.
  - » Hard protection – construction of:
    - * Groins;
    - * Seawalls;
    - * Breakers; and
    - * Other structures.
  - » Construction of earth dams to prevent the urban areas from flooding
- Retreat
  - » The area north of the proposed earth dam will be exposed to sea level rise and should be preserved as a "green zone". People living in this area should be given the opportunity to leave the location within an agreed period of time.
  - » Areas for relocation need to be determined.
  - » Accommodation
  - » This issue is closely related to urban water management. Previously, not enough attention was paid to building regulations in vulnerable areas. This is because the costs involved in building adapted structures are too high to enforce.
  - » The areas most suitable for the implementation of such measures are low lying areas, and river terraces in Paramaribo and north Wanica.

Section 2: Left Bank of the Suriname River

The capital city of Paramaribo is located on the left bank of the Suriname River as are the major port facilities and consequently all major infrastructure. Presently the area is not exposed to erosion except for certain locations where hard protection measures are in place. A substantial part of the left bank is occupied by industries, residences, hotels and other facilities. The lower parts of the left bank have been land filled to reach the present required height for construction purposes. This has resulted in higher elevation than in the surrounding area and therefore functions as a barrier against flooding from high spring tides.

For this section the following measures are proposed:

- Protection
  - » Soft protection:
    - * Preserve the mangrove forests along the river; and
    - * Create conditions for mangrove growth.
  - » Hard protection – construction of:
    - * Groins, if needed;
    - * River wall/dike; and
    - * Other structures.
  - » It should be noted that protection will be required over the whole length of the river bank up to the southern border.
- Retreat
  - » This option is not appropriate here. Therefore it is even more important that regulations are put in place to prevent damage to the riverbank.
- Accommodation
  - » This issue is also related to urban water management. There are no specific measures outlined in this section regarding building regulations.

Section 3: Southern Part of the Study Area Including Lelydorp and the Surrounding Area
This area is characterized by relatively high elevations and relatively poor soil for agricultural purposes. The local town Lelydorp is the capital of the Wanica district and many governmental and other administrative facilities are based there. It is a transit zone between the areas in the north and areas in the south so a great deal of infrastructure for traffic and electricity goes through it.

For this section the following measures are proposed:

- Protection
  - » Soft protection
    - * No soft protection is proposed
  - » Hard protection
    - * No hard protection is proposed
- Retreat
  - » Not applicable.
- Accommodation
  - » This issue is related to urban water management.
  - » The implementation of appropriate spatial planning would be beneficial to this area.

Section 4: Middle and Western Part of the Study Area including Saramacca Canal and the Kwatta Region
This area is characterized by low fertility, abandoned agricultural lands, large open channels and low population density. The Saramacca Canal is the main water way located in the center of the study area and it drains its surplus water into the Saramacca River in the west and the Suriname River in the east. The canal is also important for navigation of small barges and boats.

For this part of the study area the following measures are identified:

- Protection
  - » Soft protection
    - * No soft protection is proposed
  - » Hard protection
    - * No hard protection is proposed
- Retreat
  - » Not applicable.
- Accommodation
  - » This issue is also related to urban water management. The structures such as open and closed water ways, channels, pumps, sluices and other civil engineering structures require proper attention.
  - » Proper spatial planning would be beneficial to this area.

Conclusion and Discussion

The first phase of the NCCSAP concluded that Suriname is highly vulnerable to the impacts of climate change and identified Paramaribo and Wanica as being the most vulnerable districts. In response to these observations, the activities carried out under the second phase of the NCAP have focused on developing a better understanding of the baseline vulnerabilities and on the elaboration of specific adaptation measures for protecting the livelihoods and economic activities in these key districts. In order to do so, the project has carried out a range of sector studies and has organized various meetings and consultations to discuss possible adaptation measures. The main outcome of the project is a set of detailed recommendations and suggestions that can be integrated into a climate change strategy and action plan for Paramaribo and Wanica. The approach used during

this project could also be replicated to develop adaptation strategies and action plans for the other districts in the country.

In the course of the project, a few difficulties were encountered which were mainly related to the relative lack of good quality data. In carrying out the sector assessments it was often noted that the necessary data was lacking or not available in the required formats. The lack of good data also made it difficult to develop a complete and clear picture of the vulnerabilities in the two districts. Another issue that has emerged during the implementation of the project is the interrelations between the different sectors. It has been noted that in many cases developments in one sector will affect and have an impact on the developments in another sector. These relationships are not properly understood and new, innovative tools and methodologies will be needed to further explore these relationships.

Regardless of the above-mentioned difficulties the project has achieved its objectives. The project has also proven to be instrumental in increasing the awareness of both policy makers and the general public to the potential impacts of climate change on the study area and consequently more attention is now given to the aspects related to climate change than before. People are, for instance, increasingly considering climate change when making decisions about land use and housing. The project has also had a positive impact on communities and organizations who are now collaborating more on issues related to climate change.

In terms of further steps to be taken, the following key areas have been identified:

Further activities need to take place to strengthen key institutions both in terms of human resources and in terms of tools to carry out tasks and responsibilities.

A spatial plan needs to be drawn up allocating specific areas to specific purposes and activities. Further research needs to be carried out in order to improve our understanding of the role and value of mangrove forests in protecting the coastal zone from sea level rise and other climate change impacts.

Data collection and monitoring systems need to be designed and upgraded in order to facilitate the collection of relevant data about climate change and its impacts on the coastal zone of Suriname.