TECHNOLOGY NEEDS ASSESSMENT
FOR
CLIMATE CHANGE

ST. KITTS AND NEVIS

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PREPARED BY RM CONSULTING

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EXECUTIVE SUMMARY

An analysis of technology needs and requirements for St.Kitts and Nevis is performed. This technology need assessment utilizes the United Nations Development Programme methodology and address adaptation and mitigation issues. In order to assist the technology needs assessment process a stakeholder consultation occurred along with a review of key documents such as the national communications.

ENERGY SECTOR

The equipment presently utilized for power generation has an installed capacity of 33.5 megawatts and diesel-fired. All fuel for power generation is imported, as there is no primary or secondary production of fuels. The system maximum demand exceeds the firm capacity rating and there is a risk of load shedding affecting up to 68% of system demand.

There are policy approaches for the energy sector and these include:.

a. Expand provide a reliable and efficient electricity distribution network;
b. Facilitate and promote development of lower-cost energy, particularly from local renewable energy resources;
c. Support the development and utilization of alternative and renewable domestic energy sources such as solar, wind and wave, through conducive physical planning policies;
d. Increase energy supply to meet growing demands, conserve energy and develop appropriate renewable energy sources;
e. Use of less carbon intensive fuel such as natural gas.

Possible applicable technologies for St Kitts and Nevis in the energy sector include:

- Micro-scale hydro
- Solar
- Wind power
- Combine cycle gas turbines
- Geothermal energy
- Demand-side management

Possible barriers to the implementation of the above technologies include:

- Rainfall, water supply and land space for hydro power;
- Technical capability and capacity to support technology;
- Available and consistent supply of natural gas; storage facilities for natural gas;

ROAD TRANSPORT

Road transport accounted for a significant amount of carbon dioxide emissions in 1994, mainly as a result of gasoline combustion. The total number of licensed vehicles increased by about 174% over the ten year period 1993 to 2003. The increased number of vehicles has resulted in traffic congestion in downtown Basseterre. The consequence is longer times in traffic with increased fuel consumption and greenhouse gas emission. Additionally, it is probably likely that ambient air quality would also be compromised as a result; Currently, all fuel for road transportation is imported and mainly dependent on gasoline powered vehicles with a smaller amount of commercial vehicles powered by diesel;

Policy approaches for the road transport sector includes:

-Development of a comprehensive transport plan aimed at minimizing traffic congestion;

-Incentives to purchase energy efficient vehicles;

-Incentives, such as price control, to encourage the use of alternative fuels such as CNG or bio-fuels;
-Mandatory installation of emission reduction devices such as catalytic converters;

Applicable technologies for the transportation sector include

- Bi-fuel vehicles;
- Conversion of existing vehicles to bi-fuel systems by installing conversion kits for the use of compressed natural gas (CNG);
- Flexible fuelled vehicles;
- Electric vehicles;
- Hybrid vehicles;
- Fuel cell vehicles (FCVs);

Barriers to the implementation of these technologies include:

- Cost of conversion kits;
- Technical expertise required for installing and maintaining conversion kits;
- Availability of alternative fuels;
- Retail infrastructure for making fuel available to consumers.

RESIDENTIAL AND COMMERCIAL ENERGY DEMAND

The population of St. Kitts increased at about 0.93% per annum over the period 1991 – 2001, and is projected to grow from its 2001 figure of 35,217 to a total population of 33,836 by the year 2021;

Assuming continued increase in population growth, there would be a concomitant increase in demand for housing, an increase in housing units and an increased demand on energy resources for residential purposes (with a corresponding increase in greenhouse gas emissions) over the next few decades.

As part of its policy to conserve electricity consumption, GOSKN proposes to reduce energy consumption in lighting and air-conditioning by controlling building standards, heights, densities and sitings as well as support the development and utilization of alternative and renewable domestic energy sources such as solar, wind and wave, through conducive physical planning policies;

Possible applicable technologies for this sector include:

- Energy efficient appliances;
- Energy saving lamps (fluorescent vs. incandescent);
- Solar technology (water heating and air-conditioning);
- Energy efficient building designs in future housing developments;
- Time of use devices for switching on and switching off appliances

Possible Barriers to the implementation of the above technologies include

- Cost of the technology;
- Availability of technology;
- Expertise to operate and maintain technology;
- Institutional and legal framework.

FORESTRY AND TERRESTRIAL ECOSYSTEMS

Two contrasting vulnerability scenarios are given for this sector based on the two different climate projection models:

a. No major threats to net primary productivity of forests and terrestrial ecosystems (CSIRO model);
b. Drastic progressive reduction in net primary productivity of terrestrial ecosystems and tendency towards drier conditions (HADCM2 model).

Developmental pressures are being brought to bear on the natural resources. and forests are of vital importance to sustainable development, particularly in relation to water supply, fuel wood and the prevention of erosion and landslides.

Possible applicable technologies for this sector include:

- Geographical Information Systems (GIS) and remote sensing techniques and technology;
- Complementary database development and management utilizing appropriate hardware and software would also be necessary for a comprehensive assessment of the resources;
- Silvicultural techniques.

Possible barriers affecting the applicability of the above technologies in this sector include

- Cost and technical capacity;

COASTAL ECOSYSTEMS

Vulnerability issues in respect of projected climate change and sea level rise for this sector are identified as follows:

- Intensification of coastal erosion patterns
  Increase in sea level would increase tidal reach and the high water mark and can result in an increase in coastal erosion, particularly during extreme weather events when the storm surge would be greater.
- Saline intrusion and coastal flooding
  Increase in sea level would result in salt water intrusion and increased coastal flooding. Saline intrusion can have secondary impacts such as the salinisation of agricultural soils and contamination of freshwater aquifers.
- Mangrove ecosystems including fisheries habitat
  An increase in sea level would place migration pressures on mangroves and have direct adverse consequences on the fisheries that they support.
- Coral reefs
  Increasing sea surface temperatures can be expected to cause increased incidences of coral bleaching and coral destruction leading to adverse impacts on coastal fisheries and increase in wave energy impacts on the coastal shores resulting in accelerated erosion.

Possible Applicable adaptation Technologies include adaptation measures in the coastal zone and these can be categorised in three forms:

1. Retreat
2. Accommodate, and
3. Protect

Possible barriers to the implementation of the above technologies include**:**

- Cost;
- Physical barriers such as land space and capability;
- Technical capacity and capability;

WATER RESOURCES

The vulnerability of water resources to the adverse impacts of climate change are related to:

a. Increase in temperature leading to higher evaporation and evapo-transpiration rates;
b. Changes in intensity, quantity and frequency of precipitation events, and
c. Rise in sea level.

Two contrasting vulnerability scenarios are provided for this sector based on to different climate projection models:

1. Increase in precipitation over the islands (CSIRO model) leading to possible greater water availability (positive impact);
2. Decrease in precipitation over the islands (HADCM2 model) leading to a progressive decrease in water availability (negative impact).

Possible applicable technologies for this sector include:

- Domestic water conservation technologies such as water efficient faucets, toilets and showerheads;
- Irrigation technologies including sprinkler systems and drip irrigation;

- Rainwater harvesting;
- Technologies for soil and water conservation (also applicable to the agricultural sector) such as storage ponds;
- Desalination (potentially costly option).

Possible barriers affecting the implementation of the above technologies include**:**

- Compatibility of plumbing codes;
- Maintenance cost and technical requirements;
- Cost of retrofitting;

AGRICULTURE

Two contrasting vulnerability scenarios are provided for this sector based on to different climate projection models:

a. Slight increase in sugarcane production, which could be enhanced with irrigation (CSIRO/FAO WOFOST biophysical model);
b. Arid conditions by the middle of the century, which would not support rain-fed agriculture.

Possible applicable technologies include**:**

- Early warning systems for forecasting of wet and dry periods;
- Adoption of drought-resistant cultivars;
- Geographical Information Systems (GIS);
- Change of sowing and harvesting periods;
- Pesticide application technologies and practices;
- Integrated Pest Management (IPM) systems and practices;
- Soil management technologies and practices;
- Aquaculture and mariculture technologies.

Possible Barriers to the application of the above technologies include**:**

- Cost;

- Technical capacity and capability;
- Cultural acceptability of introduced cultivars;
- Human resource requirements.

HUMAN SETTLEMENTS

Human settlements are largely concentrated in the coastal zone. Adverse impacts of climate change on human settlements are likely to arise from:

a. Extreme weather events such as storms and hurricanes;
b. Sea level rise and coastal flooding.

Projected increases in population and settlement patterns are likely to exacerbate the vulnerability of human settlements.

Technologies and possible barriers applicable to human settlements are the same as those that can be applied to coastal zones for coastal protection; and the adoption of stricter building codes to withstand extreme weather events.

HUMAN HEALTH

Adverse impacts of climate change on human health are likely to arise from:

a. Higher temperatures and precipitation (creation of favourable conditions for the thriving of vectors of transmissible diseases);
b. Rising water tables (giving rise to unhygienic conditions as well as water borne diseases);
c. Deterioration of water quality (arising from more arid conditions).

Possible applicable technologies for this sector include:

- Deployment of fogging machines for vector spraying;
- Use of insecticide-treated nets;
- Integrated vector management systems (IVM) (process for managing vector populations in such a way as to reduce or interrupt transmission of disease).

Possible barriers to the implementation of the above technologies include:

- Cost;
- Technical capacity for maintenance;
- Supporting infrastructure and human resources;
- Technical capacity and capability.

TOURISM

The tourism product is a combination of the various sectors that offer attractions to visitors such as natural and historical features. Additionally, since this is a service-oriented industry, it depends on various other support sectors and adverse climate change impacts on these support sectors would have an impact on the tourism sector. The projected impacts of climate change in the tourism sectors are likely to arise from the following:

-Flooding of coastal areas, increasing beach erosion, rising water tables and higher wave energy resulting from sea level rise. This will result in increased costs and damage to tourism based infrastructure;
-Damage to coastal ecosystems such as coral reefs as a result of sea level rise, extreme weather events and increased sea surface temperatures;
-Decrease in freshwater availability and increase in associated costs;
-Deterioration of outdoor conditions;
-Deterioration of indoor conditions resulting in increase in demand for air conditioning systems;
-Deterioration of landscapes;
-Indirect impacts resulting from food security issues.

Due to the very nature of the tourism industry in terms of its structure, there are no specific technologies that can be identified to reduce the vulnerability of this sector. Technology application in related vulnerable sectors will ameliorate impacts on the tourism sector, particularly those identified in the coastal zone, agriculture, water and forestry sectors.

CONCLUSIONS AND RECOMMENDATIONS

An analysis of the technology needs for climate change has revealed that further analysis has to be done to prioritise technology applications, including cost-benefit analyses, more detailed environmental impact assessments based on the receiving environment, and most critically, an analysis of the enabling environment to receive the technology. In this respect, a comprehensive overview of the institutional, policy and legislative barriers would have to be conducted in the context of the identified technology. Such an analysis is outside the scope of this study, which sought to identify technology needs that can address climate change issues which were identified in various reports and stakeholder consultations. Technology requirements can be expected to change with changes in policy, development objectives and changes in the technologies themselves. It should therefore be cautioned that the technology needs identified here may only have a limited timeframe of application. Any choice of technology should at least satisfy a set of basic requirements and criteria which are determined at the national level, including consideration of sustainable development criteria. However, as a general requirement the following should be taken into account:

- Longevity of the technology;
- Technical support requirements of the technology at the time of availability;
- Cost;
- Social acceptance/environmental impact;
- Contribution to sustainable development objectives as identified.

Identified nexuses among and across the sectors can also aid in maximising technology choices and are illustrated in the table below.

Table A Inter-Sectoral Linkages and Synergy

Sector	ENERGY	ROAD TRANSPORT	FORESTRY & TERRESTRIAL ECOSYSTEMS	COASTAL ECOSYSTEMS	WATER RESOURCES	AGRICULTURE	HUMAN SETTLEMENTS	HUMAN HEALTH	TOURISM
Energy		√				√	√		√
Road Transport	√							√	
Forestry & Terrestrial Ecosystems				√	√	√			√
Coastal Ecosystems			√		√	√	√		√
Water Resources			√	√		√		√	√
Agriculture	√		√	√	√			√	√
Human Settlements	√			√				√	√
Human Health		√			√	√		√	√
Tourism	√		√	√	√	√	√	√	

1.0 INTRODUCTION AND BACKGROUND

The Federation of St. Kitts and Nevis submitted its Initial National Communication (INC) on the 30th November 2001 pursuant to its obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The INC addressed various aspects of the national circumstances of the country including a greenhouse gas emissions inventory by sector as well as assessments of vulnerability to climate change. The INC did not address issues related to technology needs in respect of mitigating greenhouse gas emissions nor adapting to climate change. Further to the receipt of funding for Phase II of Enabling Activities, a technology needs assessment (TNA) was undertaken. This report presents the results of the technology needs assessment.

1.1 Methodology and Approach

The methodology used in conducting the TNA follows that described in the UNDP handbook[1] and sectors addressed were a result of the stakeholder consultations as well as those described as vulnerable in the INC. Additionally, issues and recommendations identified in the stakeholder workshop were taken into consideration when identifying technologies (See Appendix I and II) Generally, activities focused on:

1. Identification of vulnerable sectors;
2. Identification of greenhouse gas emitting sectors;
3. Identification of applicable technologies;
4. Screening of suitability of technologies based on criteria outlined in the UNDP handbook;
5. Identification of possible barriers to transfer and implementation of identified technologies;
6. Recommendations.

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[1] Gross, R., Dougherty, W. and Kumarsingh, K. (2004) Conducting Technology Needs Assessments for Climate Change. UNDP, New York, US, 26pp.

It should be noted that the recommendations for technology needs are only an assessment based on issues related to climate change mitigation and vulnerability as identified in various reports, stakeholder consultations and possible applicability and adaptability of technologies well as a consideration of proposed developmental plane and policies in the various sectors. This report does not constitute an endorsement of one type of technology over another nor does it base its recommendations on any technology that has been tried and tested in St Kitts and Nevis.

Any choice of a particular technology would require further analysis based on cost-benefit and policy considerations as well as environmental impact of the technology although some general assessment of impacts are done. However, detailed environmental impact assessment would need to be done based on the peculiarities of the receiving environment.

1.2 General Description of National Circumstances

The Federation of St. Kitts and Nevis (SKN) is made up of two islands separated by a narrow strait, and situated at the northern end of the Leeward island chain of the West Indies. St. Kitts has a total land area of 168.4 square kilometers and a while Nevis has land area of 93.2 square kilometers. SKN has a population of 45,884[2] with 75.6% of the population residing in St. Kitts and the rest in Nevis.

St. Kitts is characterized by three volcanic centers, the central northwest range, the middle range and the southeast range. Nevis is approximately circular and dominated by the central Nevis Peak. The climate can be characterized as tropical marine, and influenced by steady northeast trades and tropical ocean and cyclonic movements. It has been significantly affected by tropical storms and hurricanes in recent years. Its coastal and marine ecosystems consist of sea

[2] Medium Term Economic Strategy 2003-2005. Office of the Prime Minister & Minister of Finance. Government Headquarters, Basseterre, St. Kitts.

grass beds, coral reefs, mangroves, salt ponds and beaches, rocky shores and steep cliffs. Human settlement is invariably located close to the coastline.

The major contributors to the Gross Domestic Product (GDP) in St Kitts and Nevis are tourism services, wholesale and retail trade, construction, manufacturing, banks and insurances. With the changes in the trade regime for sugar, St Kitts and Nevis have decided to come out of the cultivation of sugar cane. In 2004 tourism receipts grew by 39%, while the economy of St Kitts and Nevis grew by 6.4% in 2004.

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2.0 MITIGATION TECHNOLOGIES

According to the greenhouse gas inventory conducted for 1994 data as presented in the INC, the major source of carbon dioxide for St. Kitts and Nevis is as a result of energy consumption in:

- the residential sector – 39.8%
- road transport – 36.5 %
- the institutional and commercial use – 10.34 %
- energy industries – 9.1 %

There were no significant emissions of carbon dioxide from industrial processes and from the waste and agricultural sectors and very small emissions of the other greenhouse gases (methane, non-methane volatile organic carbon, nitrous oxide). It should be noted that these estimates were arrived at using a mixture of data and expert judgment and accordingly contain a fair level of uncertainty. Sectors for which mitigation measures were identified in the INC were the ones for which the TNA was conducted. Accordingly, the sectors identified above offer the greatest potential for greenhouse gas mitigation as identified in the INC and were considered in this report.

2.1 RESIDENTIAL AND COMMERCIAL

2.1.1 Development Objectives

According to the National Physical Development Plan (2005) (NPDP) of St. Kitts and Nevis, the population of St. Kitts increased at about 0.93% per annum over the period 1991 - 2001. The population of St. Kitts is projected to grow from its 2001 figure of 35,217 to a total population of 33,836 by the year 2021 (an increase of 6.3% in 15 years). Assuming continued increase in population growth, there would be a concomitant increase in demand for housing and an increase in housing units over the next few decades. This would place an increased demand on energy resources for residential purposes with a corresponding increase in greenhouse gas emissions. The Government of St.

Kitts and Nevis (GOSKN) has identified in the NPDP a policy approach of providing adequate housing based on market demand as well as which are technically sound and economically efficient, and are based on local values and energy efficiency. As part of its policy to conserve electricity consumption, GOSKN proposes to reduce energy consumption in lighting and air-conditioning by controlling building standards, heights, densities and sitings as well as support the development and utilization of alternative and renewable domestic energy sources such as solar, wind and wave, through conducive physical planning policies. Currently, there is risk of load shedding as demand exceeds supply.

2.1.2 Possible Technologies

In keeping with GOSKN policy, technology applications to reduce energy demand and consumption at the household level may include:

- Energy efficient appliances

Almost all white goods are manufactured with an energy rating indicating the level of energy efficiency.

- Energy saving lamps (fluorescent vs. incandescent);
- Solar technology (water heating and air-conditioning);
- Energy efficient building designs in future housing developments;
- Time of use devices for switching on and switching off appliances.

2.1.3 Possible Barriers

- Cost of the technology
- Availability of technology
- Expertise to operate and maintain technology
- Institutional and legal framework

2.1.4 Possible approaches to removing barriers

- Solar technology is relatively well developed and available in the Caribbean. Where cost is determined as prohibitive, tax incentives and/or subsidies can be introduced to encourage the use of solar technology.

- Almost all white goods (appliances) are now manufactured with an energy rating that can be used to gauge desired benefits. Consumer standards can be developed to regulate import and manufacture of energy efficient appliances.
- Improvement of capacity and technical competence for use and maintenance of the technology through appropriate training programmes.

2.2 ROAD TRANSPORT

2.2.1 Current circumstances

Road transport accounted for a significant amount of carbon dioxide emissions in 1994, mainly as a result of gasoline combustion. The total number of licensed vehicles increased by about 174% over the ten year period 1993 to 2003.[3]

Accordingly, it can be estimated that gasoline consumption and carbon dioxide emissions would have increased significantly as a result. According to the NPDP, there is no formal public transport service and public transport is provided by privately-owned vehicles such as mini-buses and taxis. The increased number of vehicles has resulted in traffic congestion in downtown Basseterre. This means longer times in traffic with increased fuel consumption and greenhouse gas emission. Additionally, it is probably likely that ambient air quality would also be compromised as a result.

2.2.2 Development Objectives and Policy Approaches

GOSKN proposes to enhance to road network and improve traffic management in the greater Basseterre area. While there is no mention of proposals to limit vehicle importation in the NPDP, there are proposals to encourage the use of non-motorised transport and car-pooling as well as increase the efficiency of public transport.

[3] National Physical Development Plan 2005. Government of St. Kitts and Nevis.

The INC of St. Kitts and Nevis identifies several policy approaches to mitigating greenhouse gas emissions in the road transport sector. These include:

- Development of a comprehensive transport plan aimed at minimizing traffic congestion;
- Incentives to purchase energy efficient vehicles;
- Incentives, such as price control, to encourage the use of alternative fuels such as CNG or bio-fuels;
- Legislation of fuel economy standards such as the compulsory fitting of speed limiters;
- Mandatory installation of emission reduction devices such as catalytic converters;
- Restriction of the age of vehicles on the road;

2.2.3 Possible Technologies

Currently, all fuel for road transportation is imported and mainly dependent on gasoline powered vehicles with a smaller amount of commercial vehicles powered by diesel. Possible approaches and technologies that can be used to reduce greenhouse gas emissions form the road transport sector include:

- **Bi-fuel vehicles**

  A bi-fuel vehicle is one designed to operate on two fuel systems and allows for the switching between fuels, for example gasoline and compressed natural gas (CNG). These systems result in significant reduction in greenhouse gas emissions as well as an improvement of ambient air quality.
- **Conversion of existing vehicles to bi-fuel systems by installing conversion kits for the use of CNG**

  Conversion kits allow for the modification of an existing gas-operated vehicle to use CNG.
- **Flexible fuelled vehicles**

These types of vehicles allow the use of a mixture of fuels such as gasoline mixed with ethanol or methanol. The emissions of such vehicle contain less greenhouse gases than those powered solely by gasoline.

- **Electric vehicles**

  These vehicles are powered by a rechargeable battery that is charged from an electric power source. There are no emissions from an electric vehicle and they are ideally suited for short distances.

- **Hybrid vehicles**

  A hybrid vehicle is one that combines the best features of two different energy sources, one of which is electric power. They use conventional fuel types such as gasoline to initially power the vehicle, then switches to electric power.

- **Fuel Cell Vehicle (FCV)**

  This is an emerging technology that powers the vehicle by electricity generated by fuel cells onboard the vehicle, which creates electricity through a chemical process using hydrogen fuel and oxygen from the air. FCVs can be fueled with pure hydrogen gas stored onboard in high-pressure tanks or hydrogen-rich fuels such as methanol, natural gas, or gasoline. However, these fuels must first be converted into hydrogen gas by an onboard device called a reformer.

  FCVs fueled with pure hydrogen emit no pollutants; only water and heat; while those using hydrogen-rich fuels and a reformer produce only small amounts of air pollutants. In addition, FCVs can be twice as efficient as similarly sized conventional vehicles and may also incorporate other advanced technologies to increase efficiency.

2.2.4 Technologies that can be adopted

Of the possible applicable technologies, electric, hybrid and fuel cell vehicles are emerging technologies that are probably not mature enough for the local environment. Additionally, cost and availability of the technology can be prohibitive at this stage of their development. The technical expertise required to maintain the technology may also be a barrier, as it requires specialized training. The possible adoptable technologies can therefore be restricted to:

- Bi-fuel vehicles and installation of conversion kits;
- Flexible-fueled vehicles;
- Policy approaches

2.2.5 Possible Barriers

Bi-fuel and flexible fueled vehicles

- Cost of installation of conversion kits;
- Technical expertise required for installing and maintaining conversion kits;
- Availability of alternative fuel;
- Retail infrastructure for making fuel available to consumers;

Policy approaches

- Cultural acceptability of speed limiters and price controls;

2.3 ENERGY INDUSTRIES

2.3.1 Power Generation

The equipment presently utilized for power generation has an installed capacity of 33.5 megawatts (MW) and diesel-fired. All fuel for power generation is imported, as there is no primary or secondary production of fuels. St. Kitts has experienced very high rates of growth of electrical energy and demand[4] (Table 1) The fact that the system maximum demand exceeds the firm capacity rating, there is a risk of load shedding affecting up to 68% of system demand during those periods (totalling 30 weeks per year) in which any one of the major generating sets at the Needsmust Power Station is undergoing scheduled maintenance.

[4] National Physical Development Plan 2005. Government of St. Kitts and Nevis.

Table 1: Electricity generated and demanded, St. Kitts (1993 - 2003)

YEAR	ST. KITTS		
	TOTAL GENERATED 000 KWH	MAX. DEMAND KW	LOAD FACTOR %
1993	**61,186**	**9,900**	**76.36**
1994	**66,354**	**11,400**	**66.44**
1995	**72,919**	**11,900**	**56.60**
1996	**74,299**	**12,400**	**66.67**
1997	**82,212**	**13,700**	**68.50**
1998	**88,347**	**14,940**	**89.00**
1999	**96,739**	**16,280**	**69.70**
2000	**108,002**	**17,300**	
2001	**112,619**	**18,100**	**68.60**
2002	**119,351**	**18,900**	**56.70**
2003	**120,583**	**18,900**	

Source: Electricity Department, St. Kitts as cited in the NPDP 2005

2.3.1.1 Development Objectives and Policy Approaches

The NPDP outlines the following policy approaches for the power generating sector:

- Expand provide a reliable and efficient electricity distribution network;
- Facilitate and promote development of lower-cost energy, particularly from local renewable energy resources;
- Support the development and utilization of alternative and renewable domestic energy sources such as solar, wind and wave, through conducive physical planning policies;
- Upgrade the present generation and distribution system to provide electricity year round to all settlements;
- Increase energy supply to meet growing demands, conserve energy and develop appropriate renewable energy sources;

The INC outlines the following approaches:

- Optimization of existing power plants for more efficient fuel use by implementing effective preventative maintenance;
- Retro-fitting of existing plants with modern efficient technologies such as decarbonization of flue gases and fuel;
- Use of less carbon intensive fuel such as natural gas;
- Greater use of renewable energy for power generation such as solar and wind energy and the development of micro-scale hydro plants;

The Integrated Strategic Development Plan 2001-2005[5] for Nevis outlines the following objective:

- Upgrade the generating capacity and transmission and distribution and consider and encourage the use of alternative, renewable sources of energy;

The National Environmental Management Strategy and Action Plan (NEMS)[6] allude to the following:

- Development of a National Energy Policy, including an assessment of alternative energy sources;
- Identification of new technologies which will contribute to the development process including energy conservation

2.3.1.2 Possible Applicable Technologies

In keeping with the above policy approaches and development objectives, the following technologies can be applied in the electricity generation sector.

Micro-scale Hydro

Micro-hydro schemes can be of two types:

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[5] Integrated Strategic Development Plan 2001-2005. Nevis. (2001). United Nations Economic Commission for Latin America and the Caribbean/Caribbean Development and Cooperation Committee

[6] St. Kitts and Nevis. National Environmental Management Strategy and Action Plan. 2004. Canadian International Development Agency.

1. Small discharges and high heads; and
2. Large discharges and smaller heads.

The type of micro-hydro will influence the physical size of the plant at a particular site, including the consideration of the entry and discharge of water. This type of technology is best suited for off-grid applications and consideration of this technology should be given in situations where there are no distribution or transmission systems.

Solar

The availability of relatively long periods of sunlight is conducive to the development and application of solar technology. Rooftop solar heating units are already available in the Caribbean. Photovoltaic (PV) cells can also be employed in street lighting to reduce energy demand and consumption. This technology can be considered in conjunction with development plans aimed at expanding the road transportation network.

Biomass and Cogeneration

St Kitts and Nevis has decided to come out of the sugar cane industry, given the changes which have happened with trade regimes in Europe with regards to sugar quotas. Sugar cane could be cultivated for the production of ethanol or for energy production in the form of a cogeneration plant. A significant amount of ethanol could be produced if approximately 2000 hectares of fuel cane is cultivated

Wind Power

The potential for wind power could not be ascertained in the absence of relevant wind data to assess the feasibility and more work needs to be done to estimate the potential for this type of technology. However wind can be used for the pumping of water. Considerable power is used for pumping of water and wind can assist with that.

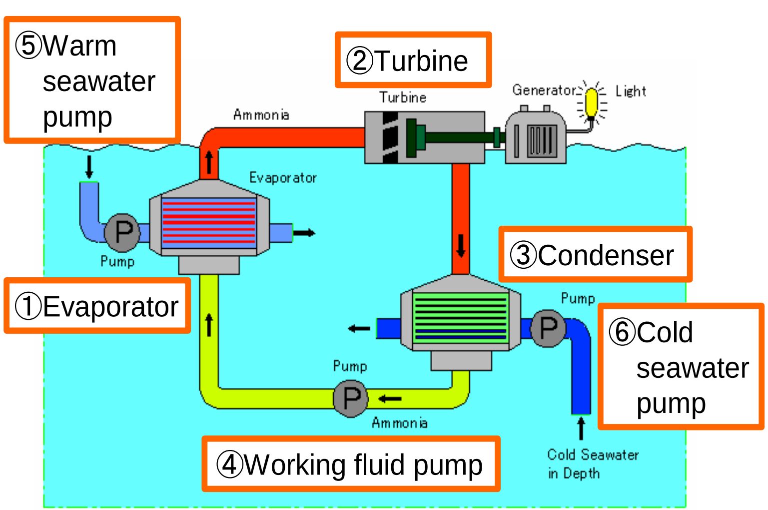
Combine Cycle Gas Turbines

This highly efficient form pf power generation integrates the high efficiency of a gas turbine with a steam turbine and can be used in cogeneration. The applicability of this type of technology would depend on the availability of natural gas to support it in its efficient form. However it may be limited in its applicability as the grid in St Kitts and Nevis, which would need small units which may not be economically efficient.

Ocean Thermal Energy Conversion (OTEC)

This type of technology transforms thermal energy into electricity. Ocean thermal energy conversion uses the difference in temperature between surface ocean waters and deep water to produce energy. OTEC uses only seawater as energy resource. it provides an inexhaustible energy resource which is stable, with zero greenhouse gas emissions. OTEC basically utilizes the differences in the temperature gradients in between the warm surface water and the cold deep waters to drive a turbine to provide electricity. Figure 1 below shows the principle behind OTEC. OTEC technology is suitable for St Kitts and Nevis. The advantage of this technology is that the end product is not only energy in the form of electricity, but other synergic products as well, as there are many commercial spins such as mariculture

Figure 1 The Principle of OTEC



Geothermal Energy

Geothermal power plants deliver continuous electricity supplies (not intermittent) due to the constant supply of pressurized steam from the reserves. There is potential for the development of geothermal plants in St. Kitts and Nevis. Currently the United Nations Environment Programme has a project proposal to assess the existing geothermal resources data, perform a pre-feasibility assessment for inter-island transmission and related on-land transmission, and a selected pilot plant, including first-order costing estimates of alternative solutions.

Demand Side Management

This approach, while not a technology in and of itself, offers the option of modernising electricity planning in respect of demand projections in various consumption sectors. In this respect, energy consumption can be managed from the user or demand side by employing relevant energy conservation and energy efficient technologies. The following technologies can be applied and should be considered together with the technology applications for the residential sector:

- Energy-saving lamps
- Energy efficient appliances
- Energy efficient industrial equipment
- Building designs for energy efficiency
- Electricity pricing mechanism (to make renewable technologies more competitive with other conventional types).

2.3.1.3 Possible Barriers

Hydro power

Hydro power depends on rainfall and water supply. Variability of annual rainfall can determine the feasibility of the application of hydro power. A growing population would place additional demands on water resources and would also need to be considered in determining the feasibility of this type of technology. Additionally, environmental impacts of such projects can be significant depending on the environmental characteristics of the chosen site, including impacts on water supply, and biodiversity resulting from the damming of water. The site chosen would also be contingent on feasibility studies, which are not part of the scope of the present report.

Solar Technology

The availability and technical expertise required to apply this technology as well as cost are likely to be the main barriers to the application of this technology. However, solar technology is relatively well developed and should be considered in the expansion of the grid capacity, particularly for remote electrification in the context of demand side management. It should be noted that power from PV is still quite expensive, and for further applicability the cost will have to be reduced.

Wind Power

While this technology is well developed and demonstrated in other parts of the world, for a small island like St. Kitts and Nevis, the likely barriers to the application of this technology may be:

- Availability of land
- Variable power output;
- Environmental impact (noise, aesthetics, cultural acceptance)
- Availability of data for feasibility assessment
- The possible impact of hurricanes.

2.4 Conclusions

Any consideration of mitigation technologies cannot be done in isolation of the cross-cutting linkages. Therefore, before any definite choice can be made on the technology, consideration would have to be given to cost-benefit analyses, environmental impacts, trade and other possible market-based barriers and possibly funding sources. These considerations are outside the scope of this report. However, this report can be used as a basis for narrowing the choices of technology in terms of the needs to address the particular mitigation as well as for further consultation and studies for determining the specific technology that can be actually put in place.

3.0 TECHNOLOGIES FOR ADAPTATION

The identification of potential technologies for adaptation is a function of the extent of vulnerability of the particular sector for which the technology is potentially applicable. Accordingly, the assessment of technologies for adaptation was carried out taking into consideration the vulnerable sectors identified in the Initial National Communication (INC). In this assessment, consideration was given to:

- *Extent of vulnerability*
- *Scale*
- *Applicability (if the technology can be applied to reduce the identified vulnerability)*
- *Adoptability (if the technology can be applied in its original form)*
- *Adaptability (if the technology can be modified to conform to the specific needs, taking into consideration scale, circumstances, receiving environment).*

The sectors identified as vulnerable in the INC are:

- Forestry and terrestrial ecosystems
- Coastal ecosystems
- Water resources
- Agriculture
- Human settlements
- Human health
- Tourism

3.1 DESCRIPTION OF VULNERABILITY IN IDENTIFIED SECTORS, DEVELOPMENT OBJECTIVES AND POLICIES AND TECHNOLOGY RECOMMENDATIONS

3.1.1 Forestry and Terrestrial Ecosystems

Two contrasting vulnerability scenarios are given for this sector based on the two different climate projection models:

1. No major threats to net primary productivity of forests and terrestrial ecosystems (CSIRO model).
2. Drastic progressive reduction in net primary productivity of terrestrial ecosystems and tendency towards drier conditions (HADCM2 model).

Under scenario 2 above, climatic conditions in St. Kitts and Nevis will evolve first towards a wet savanna and then dry savanna categorization by the 2020s. By the 2040s the islands climate would become dry-humid and would acquire semi-desert characteristics by the second half of the century. These changes would appear earlier in drier places such as Factory Pier and later in areas such as Wingfield where rainfall is greater based on topographical conditions.[7]

Additionally, wetland forests can be under threat from effects of sea level rise and storm surges arising out of climate change (see section on coastal ecosystems). For the purposes of this report, the second scenario was used to assess the technology for adaptation as a conservative approach, bearing in mind that part of the methodology used in the assessment encompassed the notion of the adoption of “no regrets” or “win-win” measures.

Under the second scenario, it is projected that decreases in forestry productivity will lead to a scarcity of food for secondary (herbivorous) and tertiary (carnivorous) wildlife populations, which would also have impacts on ecosystem health and biodiversity. Additionally, problems of forest fires can be expected to increase in time.

[7] Initial National Communications to the UNFCCC

3.1.1.1 Current circumstances

The vegetation of St. Kitts already provides evidence of impacts of human activities[8]. In lowland areas, intensive land use has removed all vestiges of natural vegetation. Although forests cover the mountain peaks, they do no exhibit characteristics of virgin forests. Lower slopes are dominated by secondary growth.

Nevis is characterized by six vegetation zones: rain forest and humid forest, Elfin woodland, Montane types, dry scrub woodland, and dry evergreen forest.

3.1.1.2 Development Objectives and Policies

According to the NPDP, developmental pressures are being brought to bear on the natural resources. The deleterious effects of these development pressures include the loss of forests and woodlands to agriculture and other uses, encroachment of catchment areas, increased soil erosion and landslides, degradation of coastal and marine ecosystems, pollution of the sea and coastal aquifers, loss of wildlife and destruction of antiquities. The NPDP further recognizes that forests are of vital importance to sustainable development, particularly in relation to water supply, fuel wood and the prevention of erosion and landslides. The NPDP identifies the designation of national parks, but no management plans to guide the protected areas. The NPDP proposes to:

1. Exercise control over the felling of trees in the interest of amenity, recreation and soil conservation;
2. Declare areas with unique terrain, flora and fauna, and high recreational potential as national parks;
3. Reserve appropriate areas for the development of a system of parks and conservation areas;
4. Reserve appropriate areas for the development of a system of parks and conservation areas.
5. Identify areas considered appropriate for additional tree planting and general landscaping in the interest of visual amenity.

[8] Initial National Communication to the UNFCCC

In respect of conservation of terrestrial habitats, the NPDP proposes to, *inter alia*:

- Restrict development near environmentally sensitive areas that are incompatible with the environment; where development is permitted, developers should be required to protect any features of a site that are deemed to be of environmental or ecological significance.

- Protect the natural fauna and flora to maintain the integrity of terrestrial ecosystems while preventing further environmental degradation.

- Enforce laws prohibiting unauthorised nature tours in forest reserves and water catchment areas.

- Encourage diverse and sustainable activities using forest resources.

- Control the level and type of development allowed in the vicinity of operating quarries until these operations have completed their economic life, in order to reduce possible negative side effects on other development as follows:

    - Development that involves the excavation of earth materials will not be permitted within designated residential districts, conservation areas, or any area deemed to be environmentally sensitive.

    - A development proposal with respect to mining and quarrying must be accompanied by an analysis of projected environmental impacts. Where this type of development is acceptable, the approval of the Minister responsible for Development and Planning and other relevant authority should be required

- Reforest disturbed areas with species that will accelerate the succession process, protect exposed soils, enhance the landscape pattern and provide nesting and feeding areas for wildlife.

- Manage existing forested areas, including selective thinning of dense areas where necessary and harvesting of non-wood products for the handicraft industry and other related processing activities.

- Establish suitable tree crop plantations to supply products to the agro-processing industry.

- Develop forest fire prevention and control measures, including fire trails.

The Integrated Strategic Development Plan 2001-2005 (ISDP) for Nevis identifies areas of concern regarding environment and development including activities contributing to problems of deforestation and soil erosion. Strategies identified in the ASDP to address issues of forest and terrestrial ecosystems include:

- Formulation and implementation of management plans for the establishment of terrestrial protected areas;
- Measures aimed at maintaining vegetative cover on lands susceptible to erosion;
- Re-vegetation of exposed soils;
- Protection and regeneration of forest resources for watershed protection and biodiversity enrichment;
- Specification of management strategies for sustainable use of wetlands.

Additionally, the National Environmental Management Strategy and Action Plan (NEMS)[9] identifies a strategy of managing terrestrial, marine and atmospheric resources, organisms and eco-systems in an appropriate manner to obtain the optimum sustainable productivity, while maintaining the integrity of natural and ecological processes and inter-relationships between such systems and processes, through the assessment of threats to sustainable use of natural resources; quantification of rates of decline of resources, formulation of

[9] St. Kitts and Nevis. National Environmental Management Strategy and Action Plan. 2004. Canadian International Development Agency. Pg 18.

recommendations to counteract rates of decline and the development and implementation of management plans for marine and terrestrial protected areas. The policies and approaches are therefore consistent with the conservation and optimum use of the resources.

3.1.1.3 Possible Applicable Technologies

In order to conserve and protect forest and terrestrial ecosystems, there needs to be proper accounting of existing resources. Changes in forest and terrestrial resources, activities and impacts on forest and terrestrial resources, including forest fire occurrences and risk, need to be monitored. The following technologies can be applied to this end:

- Geographical Information Systems (GIS) and remote sensing techniques and technology;
- Complementary database development and management utilizing appropriate hardware and software would also be necessary for a comprehensive assessment of the resources;

For the establishment of sustainable forests for the purpose of providing agro-forestry products as well as achieving collateral benefits such as soil and watershed conservation and enhancing wildlife habitat, the following techniques/technologies can be applied:

- Silvicultural techniques

Silviculture is the art and science of sustainably growing trees to meet needs. These needs may be human needs for pretty scenery, wood products, or safe places to recreate. Conversely, these needs may be ecological, such as, providing a suitable place to live for a particular type of animal or sustaining a particular type of forest.[10] There are various silvicultural techniques that can be applied depending on the needs of the particular area identified. Suitable techniques can be employed to achieve the intended policies and strategies

[10] http://www.fs.fed.us/r8/boone/resources/silvics/index.shtml

outlined above. On the basis of projected climate change impacts, an assessment of suitable forest types that would tolerate drier conditions while at the same time support wildlife habitat and provide sustainable agro-forestry products would need to be done before a selection of the specific silvicultural technique/technology can be made.

- Establishment of a database to record forest-related data.

Other applicable techniques and technologies have synergy with those identified for water and soil conservation (see below).

3.1.1.4 Possible Barriers

The main barriers to the possible applicable technologies would be one of cost and technical capacity. Training in applications, relevant software and hardware as well as capability in database development and management would be required. Silvicultural techniques and technologies are widely applicable and largely based on practices rather than hard technology although some hard technology would be required.

3.1.2 COASTAL ECOSYSTEMS

Vulnerability issues in respect of projected climate change and sea level rise for this sector are identified as follows:

- Intensification of coastal erosion patterns
  Increase in sea level would increase tidal reach and the high water mark and can result in an increase in coastal erosion, particularly during extreme weather events when the storm surge would be greater.
- Saline intrusion and coastal flooding
  Increase in sea level would result in salt water intrusion and increased coastal flooding. Saline intrusion can have secondary impacts such as the salinisation of agricultural soils and contamination of freshwater aquifers.
- Mangrove ecosystems including fisheries habitat

An increase in sea level would place migration pressures on mangroves and have direct adverse consequences on the fisheries that they support.

- Coral reefs

  Increasing sea surface temperatures can be expected to cause increased incidences of coral bleaching and coral destruction leading to adverse impacts on coastal fisheries and increase in wave energy impacts on the coastal shores resulting in accelerated erosion.
- Impacts on coastal human settlements

Human settlements are dealt with separately.

3.1.2.1 Current circumstances

According to the INC, the coastal zone constitutes a rich and unique habitat. Coastal characteristics include sea-grass beds, mangrove systems, coral reefs, fresh water lagoons, and coral and volcanic beaches. Coral reefs and sea grass habitats are generally found along the southwest coast between Nag's Head and the southern end of Basseterre Bay, on the northwest coast between Sandy Point and Dieppe Bay, on the east coast between Conaree and Friar's Bay and on the southeast coast adjacent to the Narrows. Most coral habitats are relatively small with less species diversity than is typical of similar habitats in the Eastern Caribbean. Deep reefs with species diversity are found off Sandy Point and Guana Point, and in the Narrows. Sea grass beds, dominated by turtle grass and manatee grass species are mostly common in the South East Peninsula (SEP) of the island[11]. Both coral reef and sea grass communities contribute to the following environmental processes:

- Provide habitat for commercially important fish species, spiny lobster and queen conch;
- Produce nutrients which are important in sustaining the life of fish species and other organisms;

[11] National Physical Development Plan 2005. Government of St. Kitts and Nevis.

- Act as barriers during periods of heavy wave attack; and,
- Contribute to the development of white sand beaches – an important tourism asset.

The main and most extensive mangrove habitat in St. Kitts occurs in the SEP area. Hawksbill and green sea turtles are found around the entire coast. In addition, there is a large number of resident and migratory birds that depend on the mangrove and pond communities for feeding and nesting.

The island's coastline largely consists of cliffs, some 50 to 100 feet high. Beaches at the foot of these cliffs are narrow and the sand is coarse and black, with many pebbles and boulders. Exceptions are in the southeast, where the cliffs are lower and some beaches have yellow sand and are wider. In Basseterre where there are cliffs, there is a narrow beach of grey sand. From Conaree, on to the southeast of the island, there are long stretches of fine yellow sand beaches. As an island territory, St. Kitts has a fragile 78.1 km long coastline in need of special protective measures for ecological, environmental and economic reasons. It consists of 34.7km cliff (rocks), 10.8 km cobble, 6.3 km boulders and rocks, 13.1 km black volcanic sand, and 13.2 km golden sand.[12]

Processes of erosion and accretion are occurring at different points on the coast. This is a result of natural factors such as hurricanes and man made causes such as beach sand mining, construction too close to shore and pollution. While large-scale removal of beach sand is strictly prohibited by law, it is still being practised illegally in some places. An analysis of beach changes in St. Kitts between 1992 and 2000[13] shows that, generally, beaches on the Atlantic side are more dynamic as compared to beaches on the Caribbean Sea side. On the mainland, the west coast sites from South Frigate Bay to Pump Bay showed

[12] National Physical Development Plan 2005. Government of St. Kitts and Nevis.
[13] Cambers, G. 2000. Planning for coastline change: Coastal development setback guidelines in St. Kitts. Prepared for Coast and Beach Stability in the Caribbean islands (COSALC) project with support from UNESCO and the Sea Grant College Program of the University of Puerto Rico.

erosion. Basseterre west was an exception, where accretion was due to the groyne immediately west of the profile site. At Belle Tete, there was erosion south of the point and accretion north of the point, indicating a northerly movement of the promontory. At Dieppe Spit, there was erosion on the west and north sides of the spit and accretion on the east, as the spit, which is an accretionary structure, has moved eastwards. Along the northeast mainland coast, from Sandy Bay to Conaree, the beaches showed slight accretion. However, Half Moon Bay and North Frigate Bay showed erosion. All the beaches at the SEP, with the exception of Banana Bay and Majors Bay showed erosion. In the island of Nevis, the coastal areas with very high, high and moderate vulnerability to erosion are located along the west coast (Caribbean Sea) especially Pinney's Beach, as well as north and southeast of Nevis.

3.1.2.2 Development Objectives and Policies

The NPDP recognises that the coastal areas of the island contain a wealth of natural resources with enormous potential for tourism use and revenue generation. The NPDP therefore seeks to:

- Establish marine reserves to protect biodiversity in coastal habitats, especially those that serve as fish nurseries, turtle nesting sites and habitats for rare/valuable species of flora and fauna. Reserves are proposed at Sandy Shoal in Sandy Point and the South-east Peninsula;

- Preserve and rehabilitate coastal and marine resources to meet the needs of the fishing and tourism industries and manage development of these resources so as to protect coastal ecosystems and prevent degradation of the marine environment.

- Limit built development in environmentally sensitive areas to provision of facilities to encourage public use, facilitate eco-tourism in accordance with a strategy of resource conservation, environmental protection and sustainable development;

- Ensure adequate setbacks of all permanent structures in coastal areas from the natural vegetation line to reflect slope, rock type, historical rates of erosion and heights of previous storm surges;
- Ensure the preparation of EIAs for all development projects to conserve and protect fragile ecosystems.

- Provide adequate equipment for environmental monitoring, surveillance and assessment.

3.1.2.3 Possible Applicable Technologies

Adaptation measures in the coastal zone can be categorised in three forms:

(i) Retreat

(ii)Accommodate, and

(iii) Protect

Retreat

This measure involves the displacement of all infrastructure further inland in anticipation of sea level rise and its impacts such as coastal erosion as well as storm surge arising out of extreme events such as storms and hurricanes, themselves a likely consequence of climate change. These measures along with possible barriers to implementation are summarised in Table 2 below.

Accommodate

This measure involves a continuation of occupation of the land (as opposed to retreat) but involves a change in practices that would cater for the proposed impacts of sea level rise and climate change e.g. building on piles, changing agricultural crop-types to more salt-tolerant species etc. These measures along with possible barriers to implementation are summarised in Table 3 below.

Protect

These measures are designed to physically protect the land and maintain the present land use. The measures may range from the establishment of hard, physical structures such as sea walls and coastal defences infrastructure such as revetments, to beach nourishment. These measures along with possible barriers to implementation are summarised in Table 4 below.

Table 2: Summary of retreat measures and possible barriers to implementation

Technology	**Description**	**Possible barriers to implementation**
Replacement casements	Alternative casements such as coastal access roads and related infrastructure may need to be rearranged	• Cost. These measures should be taken where infrastructure is at risk of submergence and may need to be replaced in any event. Coastal engineering works can be expensive • Physical barriers. Availability of inland space for placing alternative casements
Establishment of building setbacks	Buffer zone between the shoreline and permanent structures for the protection of these properties from sea level rise, storm surges and flooding. The setback distances would vary depending on the coastal type e.g. beaches vs. cliffs.	• Limitation of already built development that may be in breach of proposed setback distances. Uncertainty of magnitude of sea level rise to estimate and establish setbacks.

Setback distances have already been proposed in the NPDP.

Table 3: Summary of accommodation measures and possible barriers to implementation

Technology	**Description**	**Possible barriers to implementation**
Inland flood defences	• Development of new coastal strip to reduce vulnerability to coastal flooding. May involve retreat measures in part depending on site and location characteristics and specifications.	• Cost. These measures should be taken where infrastructure is at risk of submergence and may need to be replaced in any event. • Physical barriers. Availability of inland space for new development.
Establishment of building codes	• Building on elevation or piles to reduce impact of flooding a storm surge. • Hurricane-resistant buildings	• Cost of renovations and retrofitting existing buildings
Coastal drainage	• Maintenance and enhancement of natural drainage systems such as rivers by frequent dredging of river mouths. Installation of pumps to aid in land drainage where flooding is acute.	• Cost.

Table 3 cont'd: Summary of accommodation measures and possible barriers to implementation

Technology	Description	Possible barriers to implementation
Coastal drainage	• Establishment of dammed areas to accommodate flood waters in areas of acute flooding • Establishment and maintenance of buffer zone behind mangrove systems to allow for natural retreat in response to sea level rise. Allow also for natural flood relief. • Storm drains	• Limitation of physical land space for placement of dams. • Limitation of physical space for already built-up areas.
Flood warning systems	• Provision of real-time forecasts of high tides, surges and over-topping	• Cost • Technical capacity

Table 4: Summary of protection measures and possible barriers to implementation

Technology	Description	Possible barriers to implementation
Maintenance of existing natural features	• Establishment, restoration and maintenance of mangrove systems	• Physical characteristics may not be conducive to establishment of new mangrove systems

Table 4 cont'd: Summary of protection measures and possible barriers to implementation

Technology	Description	Possible barriers to implementation
Coral reef establishment and restoration	• Creation of appropriate media for coral to grow on such as used tyres, steel structures[14]	• Energy dynamics of coastal area may pose a challenge in deployment • Technical capacity
Gabions	• Wire or plastic baskets filled with rocks. Baskets are placed together as building blocks as a last line of defence against storm surges and wave action.	• Generally low-cost • Physical site may not possess characteristics to properly accommodate baskets • Technical capacity to adequately assess potential of site for the technology as well as possible adverse impacts of technology such as up-current or down-current erosion as a result of changes in shoreline structure, residual tidal currents and sediment dynamics.
Groynes	• Structures placed perpendicularly to the shore to trap sediments.	• Cost.

[14] There are established technologies that utilize steel structures and solar generated electrical currents to stimulate coral growth. These technologies have been successfully deployed in small island systems in the Caribbean, the Pacific and Indian oceans.

Table 4 cont'd: Summary of protection measures and possible barriers to implementation

Technology	**Description**	**Possible barriers to implementation**
Groynes cont'd	Often used in areas of acute erosion.	• Physical characteristics may not be conducive to establishment of new mangrove systems • Technical capacity to assess impacts of technology. Adverse impacts can be similar to those described for gabions
Revetments	Slope consisting of loose, inter-locking units. Normally applied to banks and cliffs that are composed of easily erodable material	• Cost • Technical capacity to assess impacts of technology. Adverse impacts can be similar to those described for gabions
Bulkheads and seawalls	Retaining walls made of concrete or interlocking rocks. Primary purpose is to prevent movement of terrain while affording protection against light to moderate wave action	• Cost • Technical capacity to assess impacts of technology. Adverse impacts can be similar to those described for gabions

Table 4 cont'd: Summary of protection measures and possible barriers to implementation

Technology	Description	Possible barriers to implementation
Storm surge barriers	• Sophisticated coastal defence structures that can protect tidal inlets, rivers and estuaries from storm surges.	• Cost
Beach nourishment	• Replacement of beach sand lost due to erosion, storm events or sand mining	• Reliable and continuous source of sand.

3.1.2.4 Technologies that can be adopted

The technologies outlined and described in Tables 2-4 above can be applied in general coastal areas with identified problems for which they are designed to alleviate. However, characteristics of coastal areas are unique to particular environments such as ecosystems, sediment dynamics, current regime etc. and technologies cannot be usually transplanted from one scenario to another. All three types of measures and associated technologies (retreat, accommodate and protect) can be applied to the coastal environment of St. Kitts and Nevis in keeping with stated development objectives and policy. Any final choice of technology must be done on further assessment of the unique receiving environment to avoid medium and long-term usually very costly impacts of the technology itself.

3.1.3 WATER RESOURCES

The vulnerability of water resources to the adverse impacts of climate change are related to:

d. Increase in temperature leading to higher evaporation and evapotranspiration rates;
e. Changes in intensity, quantity and frequency of precipitation events, and
f. Rise in sea level.

Two contrasting vulnerability scenarios are provided for this sector based on to different climate projection models[15]:

1. Increase in precipitation over the islands (CSIRO model) leading to possible greater water availability (positive impact).
2. Decrease in precipitation over the islands (HADCM2 model) leading to a progressive decrease in water availability (negative impact).

Additionally, increasing sea levels can cause salt-water intrusion into aquifers thereby exacerbating problems of water availability.

3.1.3.1 Current circumstances

The water distribution system in St. Kitts is fed from rainfall, which is either impounded in reservoirs directly through surface catchments, or is extracted from the ground water reserve through drilling. In 2003, the total water consumption reached 1,540,593 thousand gallons as compared to 1,036,014 thousand gallons in 1993. Whereas surface water consumption has shown a declining trend in the period 1993-2003, well water consumption increased from 537,756 to 1,129,366 thousand gallons during the same period of time[16]. Water quality is generally of an acceptable standard. However, after heavy showers the water becomes turbid. This is of major concern as water is treated only at the La Guerite treatment plant in Basseterre. In the rural areas, water is taken directly from

[15] Initial National Communication
[16] NPDP 2005.

streams and/or wells directly to the distribution systems. GOSKN is considering plans for the treatment of all water supplies in the very near future. In Nevis, groundwater supplies have shown increases in salinity, perhaps as a result of saline intrusion.[17]

Water in Nevis is sourced from both groundwater and surface water resources. The main groundwater source is a coastal aquifer with three (3) major groundwater basins. The coastal aquifer is recharged by direct precipitation and by lateral flow from the less permeable bedrock boundary. Most precipitation runs off without significant recharge in the steeper slopes but in the lower flat sandy areas recharge is very high. As a consequence, in the lower areas, the depth to water table is much less. Average rainfall has fallen by about 7% since 1996 and as much as 15% since 1973 and the flow that can be intercepted for use on its way to the sea is sensitive to changes in rainfall and can be expected to improve with increase in rainfall.

High elevation springs in Nevis Source, Camps Springs, Maddens and Jessups have a total safe yield of 94 imperial gallons per minute[17]. There are no records of measurements of surface runoff on Nevis and the total surface storage capacity for water are 3.3 million imperial gallons.

3.1.3.2 Water demand

St. Kitts

In 2003, the total water consumption reached 1,540,593 thousand gallons as compared to 1,036,014 thousand gallons in 1993. Whereas surface water consumption has shown a declining trend in the period 1993-2003, well water consumption increased from 537,756 to 1,129,366 thousand gallons during the same period of time. [17]

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[17] NPDP 2005

Nevis

Total annual production (supply) in 1993 was approximately 245 million gallons while in 2000, annual production was approximately 325 gallons. Similarly total annual consumption (water demand) increased from 116 million gallons in 1993 to 222 million gallons in 2000.

Demand on the water resources increases during the drier, hotter months of the year as larger quantities of water are used for livestock, supplemental irrigation, domestic activities and the tourism sector. With respect to the latter, the tourist season coincides with the dry season and it is noticed that water demand for hotels is greatest during the months from November to March. It has also been observed that the largest volume of potable water is generally produced between March and June in the dry season to meet the total water demand in Nevis, although discharges from springs are reduced during the drier months of the year. About 45% of the supply is unaccounted for and attributed to overflows in surface storage reservoirs, leaks in the distribution lines and stealing of water by removal of meters.

3.1.3.3 Future water demand

According to the NPDP 2005, future demand for water will be derived from population increase; increased in the number of households; higher levels of consumption; and the overall broadening of the economic base of the country. The housing sector and the tourism industry, in particular the accommodation and the emerging golf sector, are likely to be the major consumers of the country's potable water supply.

3.1.3.4 Development Objectives and Policies

The NPDP 2005 outlines the following policy approaches for the water resources sector, *inter alia*:

- Ensure that water-bearing aquifers are protected from pollution and that abstraction rates do not exceed natural rates of replenishment;
- Development of a comprehensive groundwater monitoring and protection plan;
- Encouraging the rational use and protection of forest resources through programmes such as soil conservation and agro-forestry;
- Construct additional impounding reservoirs in the following locations.

Additionally, the Draft Water Resources Management Policy for Nevis[18] outlines the following goals and policy approaches, *inter alia*:

- Develop and manage the country's water resources wisely and efficiently to ensure that a continuous supply of water is available to meet all needs and uses including those of the ecosystems;

- Protect and enhance the water systems so that the water quality is adequate for all designated uses including ecosystem needs;

- Minimize and protect against water crises whether due to natural causes, inappropriate use of natural resources, and/or inappropriate watershed and land use practices;

- Protect and restore the integrity of the nation's potable water supplies;

- Harness and utilize rainwater from roof catchments by capture in cisterns for individual households or on a small scale in surface storage tanks. Cisterns would be made mandatory for homes costing above a certain value;

[18] Nevis Draft Water Resources Management Policy. OAS/CCS/CCST/NIHERST. Nevis Water Department. 2001

- Develop a program to support retrofitting public buildings with water efficiency/conserving measures;

- Utilize appropriate technology to meet the country's supply – demand balance taking into consideration environmental objectives and concerns;

- Establish and maintain a national monitoring network for continuous monitoring of climatic, surface water and groundwater quantity and quality parameters to obtain hydrological data reflecting changes in time and space;

- Encourage the dissemination of information on water conservation technologies and practices to educate the public in order to promote best use of supplies;

To address the potential problems associated with climate change and variability in the water sector, the following is envisaged:

- Support improving the availability and analysis of climatic data and services.
- Effectively utilize climatological information in water resources planning and management.
- Support utilizing avenues for keeping abreast of information on climate change regionally and internationally.
- Support and promote measures to strengthen Nevis' human resources for assessing impacts of climate change and variability with respect to the environmental, social and economic aspects.

3.1.3.5 Possible applicable technologies

In order comprehensively and efficiently address water resources issues in St. Kitts and Nevis, an adequate database needs to be developed as a priority. Currently there is inadequate information on climate-related data such as rainfall, precipitation trends, surface run-off etc. Accordingly, there is the need for the establishment of suitable monitoring equipment for meteorological measurements as well as a system for tracing, identifying and quantifying leakage.

Water Conservation Technologies

Given the quantity of water lost due to leakage and the increased demand during the dry months of the year, water conservation technologies would be useful in alleviating the current problems, while at the same time catering for future changes in climate that may result in decreased precipitation and an increase in drought-like conditions. It needs to be recognised that there are overlaps and synergy in the application of water efficient technologies and the technology needs in other, related sectors such as agriculture. Where there is potential for maximising the application of technology across sectors, these are specifically highlighted.

Domestic Water Conservation Technologies

Domestic water conservation technologies can be applied in any facility that includes restrooms, kitchens, bathrooms and laundry areas that are used regularly, particularly in hotels in the tourism sector. The following tables describe the technology and the possible application, including potential barriers to their application.[19]

[19] www.eren.doe.gov/femp

Table 5: Domestic and commercial water conservation technologies, possible applications, benefits and potential barriers.

Technology	Description	Application	Co-benefits/advantages	Possible Barriers
Water efficient mechanisms				
Low-flow aerators	Low-flow aerators conserve water by reducing the flow by mixing air with the water.	Kitchens, showerheads, older faucets can be retrofitted with efficient aerators. (flow rate of 7.6 lpm[20] at 60 psi[21] is usually satisfactory)	Energy conservation	Plumbing codes may not be compatible and threading may not accommodate retrofitting.
Faucet controls	Mechanic, electronic or battery-operated control devices used to turn faucets on and off.	Commercial buildings for kitchen and lavatory faucets. Older faucets can be retrofitted.	Energy conservation. Low cost.	Frequent maintenance and associated capacity and costs.
Low-flush and composting toilets	Pressure-assisted toilets use compressed air to assist the flush. The pressure in a facility's line compresses the air.	General application at domestic and commercial facilities.	More efficient disposal of wastes.	Costly. Requires a minimum pressure of 25 psi[21], which may not be available at all times.
	Pump-assisted toilets use a pump to assist the flush.	General application at domestic and commercial facilities	More efficient disposal of wastes	Costly. Increased energy costs for pump. Parts and maintenance costs.

[20] litres per minute
[21] pounds per square inch

Table 5 cont'd: Domestic and commercial water conservation technologies, possible applications, benefits and potential barriers.

Technology	Description	Application	Co-benefits and advantages	Possible Barriers
Water efficient mechanisms			None identified	Costs. Limited application.
Low-flush and composting toilets	Vacuum – assisted toilets utilise a vacuum inside the tank to pull the wastes.	Niche applications such as boats and planes.		
	Ultra-low-flush tank toilets	Hospitals and prisons.	Low cost	Plumbing codes. Retrofitting potential of older systems.
	Composting toilets use little or no water and not connected to traditional plumbing systems; converts wastes to compost by anaerobic decomposition;	Remote areas not serviced by utility systems; recreation areas.	Provision of fertilizers from compost;	Not cost-effective in areas serviced by utility plumbing. Cultural acceptability.

Table 5 cont'd: Domestic and commercial water conservation technologies, possible applications, benefits and potential barriers.

Technology	Description	Application	Co-benefits and advantages	Possible Barriers
Water efficient mechanisms				
Low-flush and composting toilets	Flushometer toilets utilise a flush valve that allows a metered amount of water to enter the toilet under pressure; flushed manually or automatically by a sensor device.	Commercial buildings, airports etc. Requires pressures of between 25 and 40 psi.	Low volume of water required;	Costly. Operating pressure may not be available at all times. Complete retrofitting required; older systems may not be able to be modified.
	Waterless urinals require no water except for occasional cleaning;	Commercial building with high user rate;	No additional water-supply plumbing; easy maintenance; can be cost-effective.	Cost of retrofitting existing systems.

Table 5 cont'd: Domestic and commercial water conservation technologies, possible applications, benefits and potential barriers.

Technology	Description	Application	Co-benefits and advantages	Possible Barriers
Water efficient mechanisms				
Water efficient appliances	Clothes washers: Horizontal axis washers rotate the clothes in a relatively shallow pool of water.	Commercial laundries; hotels	Low volume of water required; less energy intensive, less moisture in clothes for quicker drying times; cost-competitive.	Costly. Initial costs may be high but longer term benefits may be favourable.
	Efficient dishwashers : Special sensors to gauge amount of food and adjusts water as necessary; more efficient spray arms and pumps	Commercial operations such as restaurants and hotels; also applicable to residential uses.	Energy savings.	Initial costs.
Pressure-reducing valves	Device that reduces line pressure	Commercial and residential	Reduces water consumption; relatively inexpensive	Initial costs. Required only if existing pressure warrants it.

It should be noted that in the application of any of these technologies, a comprehensive audit of water consumption at the application site would be required before a final selection, which is outside the scope of this study.

Irrigation Technologies

Water demand for the agricultural sector was not identified as a critical issue in the documentation reviewed[22] but was identified in the stakeholder consultation workshop on the technology needs assessment. Accordingly, technologies for irrigation are presented in light of the impacts of future climate change identified in the vulnerability assessment in the INC.

Irrigation includes any practice that stores, directs or exploits water such as water harvesting, use of low-lying wetlands and groundwater as well as the more traditional techniques of diverting or lifting water for distribution using surface, sprinkle or trickle irrigation methods.[23] There is no indication of current irrigation techniques used currently, but Table 6 provides a description of modern irrigation technologies that may be applicable. The term `modern technology' in relation to irrigation usually refers to on-farm irrigation systems such as sprinkler and trickle irrigation. It can also mean the introduction of piped distributions systems for surface irrigation as well as the use of treadle pumps (a recent innovation in Africa) or the use of petrol and diesel driven pumps in areas where such technology is not normally used. Some professionals and policy-makers perceive

[22] 1. National Physical Development Plan 2005 (NPDP). Government of St. Kitts and Nevis;
2. Initial National Communication of St. Kitts and Nevis;
3. Nevis Draft Water Resources Management Policy. OAS/CCS/CCST/NIHERST. Nevis Water Department. 2001.
4. Integrated Strategic Development Plan 2001-2005. Nevis. (2001). United Nations Economic Commission for Latin America and the Caribbean/Caribbean Development and Cooperation Committee;
5. St. Kitts and Nevis. National Environmental Management Strategy and Action Plan. 2004. Canadian International Development Agency
6. Medium Term Economic Strategy 2003-2005. Office of the Prime Minister & Minister of Finance. Government Headquarters, Bassterre, St. Kitts

[23] FAO 2001. International Programme for Technology and Research in Irrigation and Drainage. Knowledge Synthesis report No. 3. Smallholder Irrigation Technology: Prospects for Sub-Saharan Africa. IPTRID Secretariat. Food and Agriculture Organization of the United Nations.

modern technologies as an intervention that can improve crop yields and quality and, at the same time, reduce water wastage (a better term to use than irrigation efficiency which can be misleading)[24].

Sprinkle Irrigation Systems

Sprinkle irrigation systems were developed for large farms and may not be flexible enough to be adapted to smaller systems such as small plots normally found in subsistence farming cultures. However, it may be applicable to large farming and agriculture systems. A summary is provided in the table below.

Table 6: Modern Irrigation Technologies and their possible applications

Technology	Description	Application	Co-benefits and advantages	Possible Barriers
Sprinkle irrigation systems				
Conventional systems	Portable: hand-move roll move, tow line, utilizes small rotary impact sprinklers	Widely used on all field crops	Portable; could be financially viable.	Labour intensive. May not be suitable for small plots.
	Semi permanent: sprinkler hop, pipe grid, hose pull	Similar to portable	Lower labour input.	High capital cost. May not be suitable for small plots
Mobile gun systems	Large gun sprinklers that can be replaced by boom; hose pull; hose drag.	Good for supplementary irrigation.	Mobile	Cost. May not be suitable for small plots

[24] FAO 2001. International Programme for Technology and Research in Irrigation and Drainage. Knowledge Synthesis report No. 3. Smallholder Irrigation Technology: Prospects for Sub-Saharan Africa. IPTRID Secretariat. Food and Agriculture Organization of the United Nations.

Table 6 cont'd: Modern Irrigation Technologies and their possible applications

Technology	Description	Application	Co-benefits and advantages	Possible Barriers
Sprinkle irrigation systems				
Mobile lateral systems	Centre pivot Linear move	Ideal for large farms.	Mobile; low labour requirements; possibly financially viable.	Initial cost. May not be suitable for small plots.
Spray lines	Stationary Oscillating Rotating	Suitable for small gardens and orchards	Low labour requirements; possibly financially viable	Initial cost. May not be suitable for small plots.
Trickle or drip irrigation	system of pipes and emitters that can deliver small frequent irrigations to individual plants;	Areas where soil is poor; water is scarce or saline; can be applied to small plots;	Easy operation; ease of application of nutrients; can beadopted for small plots;	High initial costs; skilled management for operation and management; may be inappropriate for resource-poor smallholder farmers;

Rainwater harvesting

There is currently a limited system of rainwater harvesting in St. Kitts and Nevis. This can be identified as a traditional technology, but its potential needs to be fully developed. This technology provides an opportunity for inexpensive infrastructure and effective results and should be explored as a priority.

Technologies for Water and Soil Conservation

The discussion under this item takes into consideration the possible nexuses between the water resources sector, the agriculture sector and the land management sector. A variety of essential soil moisture and water conservation technologies can be adopted to reduce the cost of irrigation, extend it throughout and promote sustainable small-scale irrigation on a watershed basis. These technologies are essential especially in drought-prone areas.[25] There are always strong links between soil conservation and water conservation measures. Many actions are directed primarily to one or the other, but most contain an element of both. Reduction of surface runoff can be achieved by constructing suitable structures or by changes in land management. Further, this reduction of surface runoff will increase infiltration and help in water conservation.

Soil and water conservation can be approached through agronomic and engineering procedures. Agronomic measures include:

- contour farming;
- off season tillage;
- deep tillage;

[25] R.K. Sivanappan. Technologies for water harvesting and soil moisture conservation in small watersheds for small-scale irrigation. In: Irrigation Technology Transfer in Support of Food Security. (Water Reports - 14). Proceedings of a Sub Regional Workshop Harare, Zimbabwe 14-17 April 1997. FAO - Food And Agriculture Organization of the United Nations. Rome, 1997

- mulching and providing vegetative barriers on the contour.

These measures mainly prevent soil erosion but will also help in improving soil moisture availability in the watershed.[26]

The following technologies can be applied to reduce surface water run-off and subsequent use for irrigation:

- ***Check dams:*** This may be a temporary structure constructed with locally available materials. The various types are: Brush wood dam, loose rock dam and woven wire dam. The main function of the check dam is to impede the soil and water removed from the watershed. This structure is relatively inexpensive, but lasts about 2-5 years. A permanent check dam can be constructed using stones, bricks and cement. Small earth work is also needed on both sides. Costs vary depending upon the length and height of the dam. A little water is also stored above the dam. This water recharges the groundwater.
- ***Percolation Pond:*** The percolation pond is a multipurpose conservation structure depending on its location and size. It stores water for livestock and recharges the groundwater. It is constructed by excavating a depression, forming a small reservoir or by constructing an embankment in a natural ravine or gully to form an impounded type of reservoir. The water can then be used for irrigation.
- **Irrigation Tank:** The main function of this storage structure is irrigating crops. It is constructed below the above-mentioned structures in a watershed.

Apart from the above, to increase moisture availability to agricultural and tree crops, in situ moisture conservation techniques must be adopted in addition to the large scale soil and moisture conservation and water harvesting structures in the watershed.[26]

The following are some of the *in situ* moisture conservation measures which can be practiced in the watershed to increase production:

- For agricultural crops, the measures adopted are forming ridges and furrows, broad bed and furrows, basins, tie ridging (random tie ridges) and water spreading.
- For tree crops micro catchment, saucer basin, semi-circular bund, crescent shaped bunds, V ditch technology, catch pits and deep pitting can be practiced.

In addition to the above measures and structures, small storage structures with a water storage capacity for an area of about 0.4 to 0.5 ha can be constructed in large numbers one for every 10 to 20 ha catchment or watershed at the foot hills slopes and hilly areas. These storage facilities would attenuate the floods during storms. These measures will also ensure soil moisture for good growth of trees grown down stream recharging the groundwater in the region and making available more water for drinking and irrigation water. [27]

[26] R.K. Sivanappan. Technologies for water harvesting and soil moisture conservation in small watersheds for small-scale irrigation. In: Irrigation Technology Transfer in Support of Food Security. (Water Reports - 14). Proceedings of a Sub Regional Workshop Harare, Zimbabwe 14-17 April 1997. FAO - Food And Agriculture Organization of the United Nations. Rome, 1997

[27] R.K. Sivanappan. Technologies for water harvesting and soil moisture conservation in small watersheds for small-scale irrigation. In: Irrigation Technology Transfer in Support of Food Security. (Water Reports - 14). Proceedings of a Sub Regional Workshop Harare, Zimbabwe 14-17 April 1997. FAO - Food And Agriculture Organization of the United Nations. Rome, 1997

3.1.3.6 Technologies that can be adopted

In addition to the possible technologies outlined above, the following can also be adopted:

Increasing surface storage capacity

Impounding of surface water runoff by establishing suitable structures. Impounded water can be used for treatment and potable use or irrigation depending on identified scales which can be feasible. Such determination would need to take into consideration environmental impacts of the technology such as development of algal blooms, wetland ecology development as well as introduction of alien invasive species such as wetland birds etc. Additionally, stagnant water can be the breeding ground for vectors that cause diseases such as dengue and malaria.

Desalination

This technology involves the conversion of sea water to freshwater by removing the salt content. There are various technologies for removal of the salt which will vary in cost. Generally, this technology is very expensive and will include a consideration of environmental impacts of the technology such as disposal of removed salts and its effects on flora and fauna.

Wastewater recycling

There is good potential for recycling of wastewater and there are already established technologies for this.

Reduction of leakages

This is a critical issue for which there should be urgent attention. A significant amount of water can be saved if leakages can be reduced. However, the solutions to be applied would depend on the identification of the problem, such as the replacement of water mains etc. Nonetheless, as a first step, the establishment of a suitable database for monitoring leakages should be put in place.

Possible Barriers to Implementing Technology

- Cost;
- Availability of land;
- Maintenance capacity and capability.

3.1.4 AGRICULTURE

The vulnerability of the agriculture sector in St. Kitts and Nevis, as identified in the INC, has been projected using two models, the CSIRO/FAO WOFOST 4.1 biophysical model and the HADCM2 model. The former model projects a slight increase in sugarcane production, which could increase with irrigation. However, this is directly linked to inter-annual variation in precipitation and therefore also depends on projected impacts on water resources. The HADCM2 model projects conditions by the second quarter of the century that would be too dry for rain-fed agriculture with yields below economically viable levels. This model also projects viable sugarcane cultivation only under irrigation management systems, for which, according to the model, there would be inadequate water. Technologies for agriculture therefore have a direct nexus with those in the water resource sector.

3.1.4.1 Current circumstances

The contribution of the agricultural sector of St. Kitts and Nevis to the GDP has shown a steady decline during the past 10 years from 6.99% in 1992 to 4.95% in 2001.[28] Approximately 90% of the arable lands are under sugarcane cultivation, which to a large extent forces non-sugar agriculture on soils that are marginal for crop and livestock production. Livestock production has been restricted due to the limited access to land and difficulties to access the local market. The long-standing tradition of raising livestock as a part-time activity has continued to adversely affect the development of commercial livestock farms. The fisheries sub-sector has remained

[28] NPDP 2005.

mainly artisanal Focus has been placed on six fisheries including lobster, conch, ocean pelagic, inshore pelagic, deep slope/bank fish and reef fish. Development of the fisheries sub-sector has been limited by several constraints including lack of proper berthing facilities, inadequate and small boats, unwillingness of fishers to spend long periods at sea, lack of equipment, poor marketing practices and inadequate storage.

Type of crops

Sugarcane cultivation

According to table 7, sugarcane production has seen a general downward trend in the past years. Nonetheless, the sugar industry continues to play an important role in the economy of the country, with exports (primarily sugar) accounting for over 40% of merchandise exports, while over one third of the work force is employed in the industry.

Table 7: Sugar Production (1992-2002)

Year	Area Cultivated (000 Acres)	Area Reaped (000 Acres)	Cane Grown (000 Tons)	Tons Cane/ Acre	Average Tons Cane /Ton Sugar	Average Tons Cane /Acre	Tons of Sugar Produced
1992	10.40	8.54	205.04	24.01	10.17	2.36	20,159.13
1993	10.40	8.66	219.59	25.36	10.32	2.46	21,287.90
1994	10.36	8.45	180.49	21.37	9.03	2.37	19,980.28
1995	10.39	8.22	180.29	21.93	9.03	2.43	19,961,00
1996	10.38	8.47	203.74	24.06	10.06	2.39	20,248.82
1997	10.51	9.46	305.18	32.27	9.88	3.27	30,880.00
1998	10.38	9.27	240.08	25.90	9.77	2.65	24,562.00
1999	10.31	9.20	196.78	21.38	11.09	1.92	17,738.38
2000	10.13	8.52	188.37	22.12	10.44	2.12	18,051.59
2001	10.00	8.94	211.66	23.68	9.41	2.52	22,485.62
2002	9.99	8.70	227.65	26.16	10.64	2.46	21,397.76

Source: St. Kitts Sugar Manufacturing Corporation (June 2003) as cited in the NPDP 2005.

Non-sugar cultivation

Non-sugar agriculture is playing an increasing role in the production of good quality food crops through a system of small farmers.

Food crops

Crop farming activities in St Kitts are mainly characterized by farms ranging from 1 to 25 acres that are scattered throughout the landscape of the island. A major constraint experienced by farmers is the absence of irrigation and hence crop production in St Kitts depends mainly on a rain fed system. The increasing frequency of hurricanes since 1995, according to the NPDP 2005, has adversely affected the production period.

Fruit trees

A few rain fed orchards exist at Bayfords and Wingfield, while an irrigated orchard with minor exotic fruits has been developed at Needsmust.

Livestock farming

Large ruminants

Currently, Approximately 28% of the local demand for beef production is met by domestic production and the Department of Agriculture (DOA)[29] estimates that the land requirement to satisfy 100% of the projected local demand for beef is 7,220 acres and the DOA proposes to target 40% of the national demand. The estimated land required for the 40% target of the domestic market is 3,110 acres of good quality pasture and should be between the 500 and 1000 feet contours.

Small ruminants

An estimated 20,300 sheep and goats or about half of the national population would have to be slaughtered annually to meet the current demand. However, a target of 35% of the market share has been proposed and this would require an estimated 832 acres of land. The major challenge to achieve this target would be to produce a competitive product particularly as mutton is imported relatively

[29] NPDP 2005

cheap. The DOA has calculated that a full-time small ruminant operation would require a breeding herd of 200 ewes with a minimum farm size of 50 acres of good quality grass/legume pastures[30]

Pig production

The volume of pork produced locally has decreased in recent years while the volume imported has increased. Local production met about 3.1% of the domestic demand, which is projected to increase from 27,000 kg in 2000 to 60,000 kg in 2005 or about 7% of the domestic demand. 25 acres of land would be required to meet this demand.

Fisheries[30]

Fishing in St. Kitts is mainly artisanal with five major landing sites, which are located at Irish Town, Old Road, Sandy Point, Dieppe Bay, and New Town. Fishing methods currently employed include:

(1) nets for in shore pelagics (gar, ballyhoo, jacks);

(2) hand line for reef and deep slope/bank fish (snappers, groupers etc.);

(3) trolling for ocean pelagics (tunas, mackerels, dolphins);

(4) scuba diving for conch and lobster; and

(5) traps for reef fish and lobster.

3.1.4.2 Development Objectives and Policies

According to the NPDP 2005, proposals and policies for the agricultural sector include, *inter alia*:

- Ensure that the optimum use and proper management of good quality agricultural lands is practised in order to stimulate production for domestic and export purposes;

- Facilitate the development of small-scale agro-industries related to forestry, fishing and farming;
- Diversify agriculture through the introduction of new crops, inter-cropping and other methods;
- Introduce new crops with comparative advantage;
- Encourage the establishment of cattle farms in Con Phipps, Tabernacle, Belle Vue and Estridge Estate. Further, there are lands within the proposed White Gate Development Project that are intended to be allocated to agriculture and can be used for cattle production. These areas are ideal because water is available. In general, the lands that are allocated for livestock production should be between the 500 - 1000 foot contours;
- Encourage the establishment of small ruminant production;
- Encourage the establishment of piggeries;
- Preserve coral reefs and coastal water quality for the needs of the fishing industry;

3.1.4.3 Possible applicable technologies

Technology application in the agriculture sector that is directly related to increasing water availability and water and soil conservation is not repeated here but reference is made to the technology recommendations under the water resources sector. Particularly referenced here are irrigation technologies.

Early warning systems

Though not an agricultural technology per se, early warning systems that would allow accurate weather forecasts of extreme weather events can provide adequate lead-time for contingency planning and minimizing losses.

Adoption of drought-resistant cultivars

Drought-resistant cultivars can be developed to minimise water consumption. However, choices of cultivars would require a thorough consideration of impacts of introduction including biodiversity considerations and cultural preferences.

GIS systems

Again, although not an agriculture technology, database establishment and monitoring would provide more effective management practices.

Change sowing and harvest periods

Sowing and harvest periods can be adjusted to suit the changing climate.

Pesticide application technologies and practices

A shift to more intensive crop production would require an increased use of pesticides to maximise yields, particularly as there may be changes in occurrences of pest invasions in a changing climate. The application of pesticide application technologies and practices is likely to have beneficial impacts on other sectors particularly the management of water contamination in a scenario of reduced precipitation and decreased water availability.

Sprayer calibration and nozzle selection

The goal of calibration is to assure that sprayers deliver a predictable dose of pesticide as improper pesticide concentrations can have adverse environmental impacts such as water contamination and impacts on beneficial insects and wildlife. [30] Additionally, appropriate application equipment should be chosen to avoid pesticide spread.

<u>Pest Management Practices</u>

Integrated pest management (IPM) programmes rely on pest identification, field monitoring and monitoring techniques in making pest management decisions. Management methods may vary, but may include singly or in combination, the following:

- Biological control (use of natural enemies);
- Cultural practices (field level practices that can intensify pest infestation);
- Pheromone disruption (population control);
- Pesticide treatment.

A critical technology would therefore be database establishment and maintenance such as GIS systems (see above). A full discussion on pest management strategies for different plantation types is beyond the scope of this assessment.

Soil management technologies and practices

<u>Tillage</u>

Tillage includes practices such as ploughing, ripping, disking, aerating and harrowing, which are designed to loosen soil and encourage vegetation growth.

<u>Ripping</u>

Ripping increases the storage capacity of soils.

<u>Aeration</u>

Aeration also increases the water infiltration.

[30] Agricultural Technologies and Practices. Draft Report. May 2002. California Environmental Protection Agency. Regional Water Quality Control Board Central Valley Region.

3.1.4.4 Technologies that can be adopted

- GIS database to record soil capability, flood zones, pest incidences, water availability etc.
- Technologies for the fisheries sector include those described for coastal protection in the context of coral reefs and would not be repeated here;
- Aquaculture and mariculture farms;
- Environmentally friendly fishing practices;

3.1.4.5 Possible Barriers

The possible barriers to implementing the technologies in this sector would be the same as those barriers identified for related and applicable technologies in other, related sectors such as water resources. Additionally, the following can be identified:

- Cost;
- Technical capacity and capability for maintenance;
- Cultural barriers to the introduction of alternative cultivars.

3.1.5 HUMAN SETTLEMENTS

The INC identifies the adverse impacts of climate change on human settlements as largely arising from extreme weather events such as storms and hurricanes as most of these settlements are coastal in nature. Accordingly, technologies and the barriers to their implementation that are applicable to coastal defence in terms of physical infrastructure would also be applicable to protecting human settlements. Additionally, the adoption of stricter building codes and designs for buildings capable to withstanding extreme weather events is a recommended measure.

3.1.6 HUMAN HEALTH

Adverse impacts of climate change on human health have been identified in the INC from the application of the CSIRO and HADCM2 models.

From the CSIRO model, impacts would arise from:

- Higher temperatures and precipitation that would create favourable conditions for the thriving of vectors of transmissible diseases (rodents and insects);
- Rising water tables giving rise to unhygienic conditions as well as water borne diseases;

In scenarios generated by the HADCM2 model, impacts would arise from:

- Increasing temperatures giving rise to aridity and drought, which can see deterioration of water quality with the resultant effects associated with water borne diseases;

3.1.6.1 Current circumstances

The *aedes aegypti* mosquito, which is carrier of dengue disease, is endemic to St. Kitts and Nevis. Projections of both CSIRO and HADCM2 models suggest that climate change conditions would favour enhanced conditions for the breeding of this mosquito. St. Kitts and Nevis currently enjoys 100% immunization coverage,[31] but there remain other health challenges such as high infant mortality rate, and communicable and non-communicable diseases. Additionally, the changing epidemiology profile evident by morbidity and mortality data, suggest that communicable and non-communicable disease including cancers, diabetes, cardiovascular, and acute respiratory conditions pose a significant challenge to the continued capacity of the system to respond.

3.1.6.2 Development Objectives and Policies

The Medium Term Economic Strategy 2003-2005[32] identifies the following objectives in respect of the provision of health services:

- Building a health system that is clinically and economically sustainable and responsive to a population with a changing epidemiological profile;

[31] Medium Term Economic Strategy 2003-2005. Office of the Prime Minister & Minister of Finance. Government Headquarters, Bassterre, St. Kitts

3.1.6.3 Possible applicable technologies

The main direct threat of climate change is the probable increase in disease-causing vectors such as mosquitoes and rodents, technology applications can be focussed on activities aimed at controlling these vectors:

- Deployment of fogging machines for spraying (consideration needs to be given to the resistance developed by vectors in the abuse of insecticide application);
- Insecticide-treated nets (minimal impact on environment and ecosystems);
- Integrated vector management systems (IVM) (process for managing vector populations in such a way as to reduce or interrupt transmission of disease).

3.1.6.4 Possible Barriers

- Cost;
- Supporting infrastructure and human resources;
- Technical capacity and capability.

3.1.7 TOURISM

The tourism product is a combination of the various sectors that offer attractions to visitors such as natural and historical features. Additionally, since this is a service-oriented industry, it depends on various other support sectors and adverse climate change impacts on these support sectors would have an impact on the tourism sector. According to the INC of St. Kitts and Nevis, the projected impacts of climate change on the tourism sector include:

- Flooding of coastal areas, increasing beach erosion, rising water tables and higher wave energy resulting from sea level rise. This will result in increased costs and damage to tourism based infrastructure;
- Damage to coastal ecosystems such as coral reefs as a result of sea level rise, extreme weather events and increased sea surface temperatures;
- Decrease in freshwater availability and increase in associated costs;
- Deterioration of outdoor conditions;

- Deterioration of indoor conditions resulting in increase in demand for air conditioning systems;
- Deterioration of landscapes;
- Indirect impacts resulting from food security issues;

3.1.7.1 Possible applicable technologies

Due to the very nature of the tourism industry in terms of its structure, there are no specific technologies that can be identified to reduce the vulnerability of this sector. Technology application in related vulnerable sectors will ameliorate impacts on the tourism sector, particularly those identified in the coastal zone, agriculture, water and forestry sectors.

3.2 SECTOR NEXUS AND TECHNOLOGY SYNERGY AND SELECTION

The foregoing discussions have revealed obvious cross-sector linkages, nexuses and the potential for technology synergy. Table 8 below provides a matrix that attempts to illustrate these possible synergy and inter-linkages. The table should be read across only to avoid confusion among the relationships between the sectors. The purpose of the table is to aid in prioritising technologies that can have multiple or collateral benefits in other sectors. It should be noted that the identified inter-linkages is based on the possible applicable technologies only.

Table 8: Inter-Sectoral Linkages and Synergy

Sector	ENERGY	ROAD TRANSPORT	FORESTRY & TERRESTRIAL ECOSYSTEMS	COASTAL ECOSYSTEMS	WATER RESOURCES	AGRICULTURE	HUMAN SETTLEMENTS	HUMAN HEALTH	TOURISM
Energy		√				√	√		√
Road Transport	√							√	
Forestry & Terrestrial Ecosystems				√	√	√			√
Coastal Ecosystems			√		√	√	√		√
Water Resources			√	√		√		√	√
Agriculture	√		√	√	√			√	√
Human Settlements	√			√				√	√
Human Health		√			√	√		√	√
Tourism	√		√	√	√	√	√	√	

4.0 CONCLUSIONS & RECOMMENDATIONS

An analysis of the technology needs for climate change has revealed that further analysis has to be done to prioritise technology applications, including cost-benefit analyses, more detailed environmental impact assessments based on the receiving environment, and most critically, an analysis of the enabling environment to receive the technology. In this respect, a comprehensive overview of the institutional, policy and legislative barriers would have to be conducted in the context of the identified technology. Such an analysis is outside the scope of this study, which sought to identify technology needs that can address climate change issues which were identified in various reports and stakeholder consultations. Technology requirements can be expected to change with changes in policy, development objectives and changes in the technologies themselves. It should therefore be cautioned that the technology needs identified here may only have a limited timeframe of application. Any choice of technology should at least satisfy a set of basic requirements and criteria which are determined at the national level, including consideration of sustainable development criteria. However, as a general requirement the following should be taken into account:

- Longevity of the technology;
- Technical support requirements of the technology at the time of availability;
- Cost;
- Social acceptance/environmental impact;
- Contribution to sustainable development objectives as identified.

APPENDIX I

SUMMARY OUTPUTS OF STAKEHOLDER CONSULTATION UNDERTAKEN ON 17th NOVEMBER 2006 .AT THE OCEAN TERRACE HOTEL, BASSETERRE, ST KITTS AND NEVIS

The following policy recommendations for various stakeholders were made by stakeholders consulted on technology needs.

Government Action:

1. Consider the passage of an Energy Efficiency Act that will allow for the setting of minimum efficiency standards and codes that should apply to electrical appliances and design of buildings etc.
2. Consideration to be given to the development of a program for market recognition of high efficiency products and equipments so that energy users can easily identify products through labeling and promotion.
3. Provide tax incentive for importation of energy efficient equipment by suppliers, and also light and energy reduction projects by private sector.
   - Side-loading wash machines
   - flourescent lamps
   - solar lights
   - solar panels/solar water hearters
   - bio-fuel systems
   - wind turbine systems
   - thermal barriers, window tint, roof insulation, ceramic roof coating (from 20% to 5% import duty)
   - promote the use of direct fuels (propane, butane, etc)where practical

- explore the use of liquefied natural gas (LNG)
- Diversify the energy mix to make natural gas and non-liquid fuels more dominant in the domestic economy.
- A different excise tax rate for diesel powered vehicles with an engine size under 2000cc and a chargeable value under $75000.
- Taxi drivers and bus drivers benefitting from duty concessions should be required to purchase energy-efficient vehicles (diesel-operated, etc) to benefit fully.

4. Regulation of the price of diesel
5. Reduced duty on hybrid vehicles and machines powered by solar energy, LPG and compressed natural gas.
6. Investigate the possibility of trade carbon credits for major energy reduction projects.
7. Implement a Public Sector Energy Conservation Programme (Ensure that all government buildings are equipped with energy efficient bulbs and the installation of timers to control the use of air condition units after working hours, etc. Conduct an energy audit of all government buildings and develop a program to implement its findings. All government vehicles in the future should be diesel-powered, etc)
8. Concessions to hotels and factories to undertake retrofitting with more energy-efficient equipment.
9. Concession for the establishment of new renewable energy businesses. (i.e. dealers in wind turbines, solar panels, gases, ethanol, etc)
10. Ensure that renewable energy plays an increasingly more significant role in the economy. The following should be emphasised:
    - Wind energy
    - Ethanol and biomass

- A 30% contribution of renewable sources to the energy mix by 2010. The possibility for geothermal energy exists but the timeline on this in excess of 5 years.

Utility Issues

1. Carry out campaign to educate consumers;
2. Seek funding to replace exiting street lamps with solar lamps. A feasibility study was completed in 2005, however the project is in need of funding.
3. Implement the use of prepaid metering at all play fields island-wide that use flood light. Work has been completed on this project however the Ministry of Sports still needs to sign off so that implementation can begin.
4. Train architects in energy-efficient (energy-smart) building design.

Private Sector Suppliers

1. Provide financing for energy efficient projects;
2. Explore the possibility of providing energy efficient services;
3. Develop partnership between utility, government and energy service companies.

End-users

1. Replace electric motors that are more than 15 years old
2. Buy appliances with energy star logo
3. Replace incandescent lamps with energy saving lamps
4. Provide proper insulation for air condition buildings
5. Reduce lighting in rooms to minimum required
6. Install occupancy sensors and automatic timer for lights
7. Operate air conditioners units at highest temperature comfortably

8. Turn off lights in unccupied rooms
9. Use cold water setting on wash machine when possible
10. Enable power management features on computer and monitors
11. Replace existing out door lights with solar lights or use timing devices or motion sensors.
12. Turn off air condition unit in offices after working hours

Other Issues Identified and Recommendations

1. Water Sector:
    a. There is a need for additional automatic weather stations and remote sensing of gauges;
    b. Current system cannot cater for future needs;
    c. Possible need for desalination;
    d. Need for water-saving techniques; no current water management system for agriculture;
    e. There are currently cisterns used for rainwater harvesting, but there may be a need to amend the building code to accommodate systems;
    f. Leakage in the distribution system is a problem;
    g. Future and current water demand by large golf courses.

2. Coastal Zones:
    a. There are no groynes or sea walls although there are some breakwater structures and revetments;
    b. There is not enough data for coastal defence infrastructure and there is recognised development pressures in this area;
    c. There is no legal enforcement of setbacks or for mangrove protection e.g. Friggit Bay;
    d. There is a need for legislation in relation to coastal zones and coastal zone management.

3. Agriculture:
    a. Need for drip irrigation;
    b. Need for soil erosion technologies to minimise erosion;
    c. Need for integrated watershed management plan.

4. Disaster management:
    a. Need to improve early warning systems for flood events;
    b. Need to improve meteorological systems and capacity building;
    c. Closure of sugar industry has affected gathering of weather data;

5. Energy
    a. Currently examining the feasibility of solar water heating;
    b. Need for more efficient appliances for consumers;
    c. Need for consumer education;
    d. Need for more efficient generators;
    e. Current capacity may not meet future demands;
    f. Nevis has own electricity generation facility;
    g. Potential of wind energy in Nevis, assessment conducted but land space may be a problem;
    h. Fuel surcharge exists in Nevis;
    i. There is potential for geothermal energy. A proposed project was identified to explore geothermal potential in St. Kitts and Nevis;
    j. Need for solar technology;
    k. No existing natural gas terminal if considering a switch to natural gas usage.