FINAL

IMPACT ASSESSMENT REPORT AND NATIONAL ADAPTATION STRATEGY AND ACTION PLAN ST. KITTS AND NEVIS






Prepared for the
Caribbean Community Climate Change Centre
Belmopan, Belize

and

Ministry of Sustainable Development
Department of Physical Planning and the Environment
Basseterre, St. Kitts and Nevis

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Final Impact Assessment and National Adaptation Strategy and Action Plan Report

for

Vulnerability and Capacity Assessment and National Adaptation Strategy and Action Plan for St. Kitts and Nevis

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The views expressed herein are those of the authors and do not necessarily reflect the views of the EU, ACP Secretariat, the Caribbean Community Climate Change Centre or the Government of the Federation of St. Kitts and Nevis.

For more information visit:

- The Global Climate Change Alliance website: http://www.gcca.eu/
- The African, Caribbean and Pacific Secretariat website: http://www.acp.int/
- The Caribbean Community Climate Change Centre website: http://www.caribbeanclimate.bz
- Ministry of Sustainable Development: Department of Physical Planning and the Environment website: http://www.gov.kn/mosd

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±	plus or minus
A1B	Scenario generated by the IPCC
A2	Scenario generated by the IPCC
ADS	Agricultural Development Strategy
AMO	Atlantic Multidecadal Oscillation
AR4	Fourth Assessment Report
ARM	Agricultural Resource Management
ASO	August-September-October
B1	Scenario generated by the IPCC
BVA	Basseterre Valley Aquifer
CCCCC	Caribbean Community Climate Change Centre
CCRA	The CARIBSAVE Climate Change Risk Atlas
CMIP3	Couple Model Intercomparison Project 3
CSGM	Climate Studies Group Mona
DCPB	Development Control and Planning Board
DJF	December-January-February
DOA	Department of Agriculture
DOLS	Department of Lands and Surveys
DPPE	Department of Physical Planning and Environment
ENSO	El Nino - Southern Oscillation
ESL	Environmental Solutions Limited
EU	European Union
FAO	Food and Agriculture Organisation
FMA	February-March-April
GC	Geo - Caraibes
GCCA	Global Climate Change Alliance
GCM	General Circulation Models
GCM	Global Climate Model
GOSKN	Government of St. Kitts and Nevis
HadCM3	Hadley Centre Coupled Model, version 3
IPCC	Intergovernmental Panel on Climate Change

IPCC	Intergovernmental Panel on Climate Change
IWCAM	Integrated Watershed and Coastal Areas Management
JJA	June to August
m	metre
m m	millimetre
m/s	meters per second
MAM	March-April-May
mb	millibar - a unit of atmospheric pressure
MER	Multi-Electrode Electrical Resistivity
MG	Million Gallons
MGD	Millions Gallons per Day
MJJ	May-July
mm	Millimetres
MSD	Ministry of Sustainable Development
NASAP	National Adaptation Strategy and Action Plan
NBSAP	National Biodiversity Strategy and Action Plan
NDJ	November-December-January
NHC	National Housing Corporation
oC	Degrees Celsius
OECS	Organisation of Easter Caribbean States
OET	Ocean Earth Technologies
PPE	Perturbed Physics Ensembles
PRECIS	Providing REgional Climates for Impacts Studies
PWD	Public Works Department
QUMP	Quantifying Uncertainties in Model Projections
RACC	Rallying the region to Action on Climate Change
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
SEP	South East Peninsula
SIDF	Sugar Industry Diversification Foundation
SIDS	Small Island Developing States
SLR	Sea Level Rise
SON	September to November

sq.	Square
SRES	Special Report on Emissions Scenarios
SST	Sea Surface Temperatures
T	Temperature
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VCA	Vulnerability and Capacity Assessment
WSD	Water Services Department

GLOSSARY

Adaptation The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Adaptive Capacity The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or, to respond to consequences.

Cisterns An underground storage tank for holding water typically integrated as a structural part of a building

Climate Climate in a narrow sense is usually defined as the average weather or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables, such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description of the climate system.

Climate Change Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and, that which persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or, in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and, which is in addition to natural climate variability observed over comparable time periods". The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and, climate variability attributable to natural causes.

Climate Variability Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or, to variations in natural or anthropogenic external forcing (external variability).

Drought A drought occurs when there is an extended period of deficiency in precipitation (relative to what is considered normal), which is then insufficient to meet economic, social and environmental demands.

Flood An overflow of water from a river, lake or other body of water due to excessive

	precipitation or other input of water.
Groundwater	Water beneath the surface of the earth which saturates the pores and fractures of sand, gravel and rock formations
Gross Domestic Product	The market value of all the goods and services produced by labour and property located in a particular country or region.
Scenario	A plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections but are often based on additional information from other sources, sometimes combined with a 'narrative storyline.'
Seawater Intrusion	Aquifers in island and coastal areas are prone to seawater intrusion. As seawater is denser than fresh water, it will invade aquifers which are hydraulically connected to the ocean. Under natural conditions, fresh water recharge forms a lens that floats on top of a base of seawater. This equilibrium condition can be disturbed by changes in recharge and/or induced conditions of pumpage and artificial recharge.
Surface water	Water collecting on the ground, in a stream, river, lake, wetland or ocean
Watershed or Basin or Catchment	A geographical area drained by a particular surface water and/or groundwater system. The basin boundaries are demarcated so that there is generally no flow from one basin into another.
Water Management Unit	A single or group of watersheds that have been grouped together for the purpose of management.
Well	A well is a borehole, adit tunnel or any other excavation constructed or used for the abstraction of water.

EXECUTIVE SUMMARY

St. Kitts and Nevis currently experience several stresses on the water sector, which include: changes in the current rainfall patterns, an increase in the demand for water, and challenges with the availability and supply of water resources. The demand for water is expected to increase as the economy of St. Kitts and Nevis expands, particularly in the tourism and agriculture sectors where water requirements could double in the next 10 years. In addition, St. Kitts and Nevis, like many other small island states in the Caribbean, is vulnerable to a range of large-scale global economic and environmental shocks and stresses. These vulnerabilities are compounded by existing socioeconomic conditions such as size, high concentration of population and resources along the coast, susceptibility to a range of extreme weather events such as hurricanes, narrow and highly specialised economies and a limited natural resource base.

Given the challenges faced, the Government of St. Kitts and Nevis (GOSKN) sought funding to address critical water sector issues and to mainstream climate change into national development through this project: ***St Kitts and Nevis: Vulnerability and Capacity Assessment and National Adaptation***. Funding was received through the Caribbean Community Climate Change Centre (CCCCCs) from the European Union under the Global Climate Change Alliance (EU GCCA) Caribbean Project. The EU GCCA Project aims to assist participating countries to develop the capacity to design and implement climate change adaptation policies and measures. The following analyses were completed in order to inform this Final Impact Assessment and National Adaptation Strategy and Action Plan (NASAP) report:

1. Climate Analysis and Projections
2. Policy and Legislative Assessment
3. Water Sector Assessment
4. Socioeconomic Assessment

Methodology

The impact assessment involved several assessments, these included:

- An assessment of existing climate and future climate projections for rainfall, temperature, wind speed and sea level rise patterns based on the data received from St. Kitts and Nevis.
- A water resource assessment was also conducted to determine existing vulnerability and threats to the water resources and supply in both islands, including the determination of a water scarcity index. The water resource analysis also included the use of projected changes for rainfall patterns and for temperature to analyse the likely impact that these would have on the current system.
- A policy, institutional and legislative assessment governing the water sector for St. Kitts was also conducted and the gaps were identified.
- The socioeconomic setting for St. Kitts and Nevis was also assessed and the climate projections were used to analyse the likely impact on the residences and businesses in the area. Likely impacts on the agriculture and health sector were also assessed according to the term of reference.

Limitations for these assessments were largely associated with the inadequacy or absence of data sets that would improve the analyses conducted.

The results of the assessments helped to inform the development of the National Adaptation Strategy and Action Plan (NASAP) recommended for the water sector in St. Kitts and Nevis. This was developed in consultations with the Stakeholders in St. Kitts and Nevis.

Findings

Climate Projections

Since water is involved in all components of the climate system, climate change can affect the water sector through several mechanisms. Regional modelling shows that already water scarce or water-sensitive regions, such as the Caribbean basin, will be particularly affected by declining rainfall (Bates et al, 2008). In addition, the climate projections specifically modelled in this study indicate that St. Kitts and Nevis will experience the following:

1. An increase in the annual mean temperature.

2. An increase in the frequency of warm days and warm nights and decrease in cool days and cool nights across GCM, RCM and SDSM, as well as, across scenarios for different time slices.

3. Through the 2030's median, changes in rainfall projections deduced from GCM's are all negative, which may suggest drier conditions. RCM ensemble mean suggest decreases in annual rainfall by approximately 5%.

4. The proportion of annual total rainfall that falls in heavy events decreases in most GCM projections, changing by -19% to +9% by the 2060's. Annual maximum 1-day rainfall totals show a tendency towards remaining constant, while the maximum 5-day rainfall is projected to decrease by up to 5mm across the annual and seasonal timescales.

5. Consistent with the GCM projections, the PRECIS RCM suggests a decrease in the annual maximum 5-day rainfall of up to 14mm per decade towards the end of the century. The RCM however, suggests that while rainfall intensity may decrease, a slight increase in rainfall duration may occur.

6. RCM ensemble means suggest an increase in wind speeds annually by up to 0.02 m/s

7. Hurricane intensity over the north tropical Atlantic is likely to increase (as indicated by stronger peak winds and more rainfall) but not necessarily hurricane frequency.

8. Caribbean Sea levels are projected to rise by up to 0.24 m by mid-century under the A1B scenario.

Given the projections, the water sector in St. Kitts and Nevis is going to be further challenged and it forces the country to adapt to the changing conditions. The ability of the legal and institutional framework governing the water sector is therefore important for adaptability.

Legislation and Institution

The review of the legal and institutional framework governing water sector in St. Kitts and Nevis reveal that there is no single institution responsible for the management of water resources, as such, several institutions are responsible for aspects of the water sector. These institutions have several inadequacies which are partially a function of how they are structured but also because of the absence of supporting legislations and regulations. This compromises their ability to effectively achieve their potential in contributing to the adaptation strategies required for climate change. The consultants have concluded the following gaps that need to be addressed:

- Lack of revised national policies related to water and the environment including coastal management policies;
- The absence of a developed climate change adaptation and mitigation policy;
- The absence of a Watershed Policy and Water Policy that takes into account climate change considerations;
- The absence of a watershed management plan;
- The absence of a National Land Use Plan;
- The need to employ policy to mandate water harvesting in new home construction;
- The need to formulate and implement a regulatory regime to govern wise use allocation;
- With the potential increase in tourism anticipated water allocation measures need to be taken to increase and manage water supply;
- The absence of an up-to-date Water Resources Act;
- The absence of an up-to-date Public Health Act;
- The need for an enacted National Environmental Conservation and Management Act;
- The absence of a Meteorological Act.

<u>Water Sector</u>

In addition to the challenges outlined within the legal and institutional framework, the water sector of St. Kitts and Nevis is currently vulnerable to extended periods of low rainfall resulting in drought. This has occurred more often in the past for Nevis than for St. Kitts. Flooding is also a cause of serious concern due to short duration, high intensity rainfall events such as during tropical storms and hurricanes causing damage to water supply systems and residences that occur along major ghauts. With the projected changes of climate change, the water sector will experience greater stress requiring strategies for resilience building. In analysing the water sector, and evaluating its existing resilience, the consultants have concluded that there is a need for improve the overall management of water supply as follows:

- A data collection strategy needs to be developed to collect consistently the appropriate water data required to inform decision making and an appropriate information sharing system;
- There are inadequately trained personnel within the Water Services Department, with respect to integrated water resource management (IWRM), Hydrology and Hydrogeology;
- The need for a Water Resources Agency for St. Kitts and Nevis to govern the management of watershed and to ensure that a baseline study of all watersheds and wetlands to inform preservation planning in St. Kitts and Nevis;
- The need for local water quality standards and protocols to test compliance and effectiveness of Best Management Practices (BMP's) in protecting water quality especially at the sector level supported by appropriately training staff to monitor water quality;

- Requirements for abstraction of resources, licensing, monitoring need to be established;
- The need for upgraded water storage catchment and distribution systems including district metering employed at different points within the network to better capture leakages;
- The need for enhanced storage capacities in multipurpose water/irrigation projects and integration of drainage with irrigation infrastructures;
- The need for a maintenance plan/upgrading plan for drainage systems for St. Kitts;
- The need for various developments connected to a centralized sewage system to support the expanse of the Basseterre urban area in St. Kitts and the Charlestown urban area in Nevis;
- The need for an implemented Physical Asset Management Programme;
- The need for a Water and Waste Water Authority because currently no institution is responsible for waste water management and no technical staff trained in that area;

<u>Socio- Economic</u>

In analyzing the socio-economic conditions in St. Kitts and Nevis and relating it to the water sector, the consultants have concluded that:

- There is a need for dry land farming systems by the Department of Agriculture to be given greater consideration and training so that farmers are better able to deal with water shortage situations;
- There is a need for an established data sharing and collaboration platform for climate and water data so that various agencies can garner the benefit of the data to inform their decisions. This is critical for sectors such as: water, agriculture, health and tourism since changes in rainfall and temperature directly impact these sectors and the amount of water they have available for use;
- Due to the encouragement of increased development since the close of the sugar industry, and the lack of appropriate watershed management, there is a need for revised land use maps and a developed National Zoning Plan to prevent degradation of water resources;
- Technical capacity within the Department of Agriculture is needed to identify, treat, and disseminate information on plant phytopathology and animal epidemiology, as well as, control of animal disease risks associated with climate change;
- There is a need for an education campaign focused on training farmers, improved farming practices to include climate smart agricultural practices and other water conservation measures;
- Young trainable farmers need to be encouraged in climate resilient farming techniques; Female farmers need to be targeted in climate resilient farming techniques;
- There is a need for year round water conservation and water harvesting media and education campaign especially during the dry season in schools, government, agriculture and tourism related entities;
- Water Conservation needs to be encouraged in St. Kitts in particular. Rainwater harvesting encouraged especially for households and farmers is recommended;
- There is a need for trained trade specialists in the Department of Agriculture in matters related to international and regional trading in agricultural commodities that are resilient to climate change;

- Technological options and solutions need to be explored for production and post- harvest handling in Agriculture that offer resilience to climate change;
- Diversification should be encouraged away from low yield and high water demand / low return agricultural production to improve livelihoods.

National Adaptation Strategy and Action Plan

The aim of the NASAP is to address the anticipated adverse effects of climate change on the water sector discussed above. This strategic action plan is designed to guide implementation of, and track progress toward, national water sector goals and targets in St. Kitts and Nevis. The strategy covers a 5 year period 2015-2020 and outlines three national outcomes for the water sector.

1. Improved policy, legal, regulatory and institutional framework for the water sector.
2. Improved technical and institutional capacity for the water sector
3. Enhanced and improved training and awareness in relation to climate change and the water sector

Expected results (output) are presented along with the actions to meet the defined objectives. The timeline for each activity is given, along with an indicative cost, where possible, and the responsible agencies (lead and partner). The table below outlines a summary budget for the three strategic outcomes. The objectives within each outcome have multiple activities, some of which have only been costed for partially.

Summary Budget for Outcomes 1, 2 and 3

OUTCOMES	NO. OF OBJECTIVES	INDICATIVE COSTS US$
Outcome 1 Improved, Physical Infrastructural Technical and Institutional Capacity for the Water Sector	12	515,000
Outcome 2 Improved Physical /Infrastructural Technical and Institutional Capacity for the Water Sector.	19	205,275,500
Outcome 3 Enhanced and improved Training and Awareness in relation to Climate Change and the Water Sector (Private Government and Civil Society)	9	551,000
TOTAL	**40**	**206,341,500**

The NASAP requires that the Department of Physical Planning and the Environment within the Ministry of Sustainable Development, in St. Kitts and the Department of Physical Planning, Natural Resources and Environment in Nevis be responsible for ensuring that the action items set out in this Strategy and Action Plan are carried out by the respective lead and partner agencies.

The implementation of the NASAP for the water sector has to be monitored and evaluated to ensure that the activities are successfully on track, and to ensure transparency and accountability. The results of this monitoring can then be incorporated into future planning and improvement of the NASAP.

1 INTRODUCTION

1.1 Purpose

Environmental Solutions Limited (ESL) has been contracted by the Caribbean Community Climate Change Centre (CCCCCs) to execute the project: ***St Kitts and Nevis: Vulnerability and Capacity Assessment and National Adaptation***. This project is a part of the overall European Union Global Climate Change Alliance (EU GCCA) Caribbean Support Project, which is being executed by the CCCCCs. The EU GCCA Project aims to assist participating countries to develop the capacity to design and implement climate change adaptation policies and measures. It seeks among other things, to incorporate and mainstream climate change adaptation issues into the national development and planning processes and mechanisms in order to enhance the economic and social development of the individual participating countries in particular, and the Caribbean as a whole.

The CCCCC is working collaboratively with the Government of St. Kitts and Nevis (GOSKN) to:

a. prepare a Vulnerability and Capacity Assessment (VCA) study in the Basseterre Valley Aquifer;
b. prepare a national sector-based Impact Assessment that will provide relevant data and information leading to the preparation of a National Adaptation Strategy (NAS) and Action Plan

This document presents the Final Impact Assessment for the project. It outlines the methodology and limitations for the study in Section 1, the climate variability and change assessment in Sections 2 and 3, the water sector vulnerability issues and threats in Section 4, an analysis of the existing policy, legislative and institutional setting in light of these impacts are presented in Sections 5 and 6, and the socioeconomic impact assessment is presented in Section 7. Based on potential impacts and the existing situation, a recommended National Adaptation Strategy and Action Plan for the water sector is presented in Section 8.

1.2 Background

St. Kitts and Nevis is a sovereign state located in the Eastern Caribbean chain of islands with a total landmass of just 269 square kilometers. The climate is classified as tropical marine, and rainfall is mainly orographic, increasing in amount and frequency with altitude. Rainfall is generally unevenly distributed between years and months, with a reliable wet period from August to November and driest months usually extend from January to April. It has an average annual rainfall of about 1625mm ranging from an estimated 2000mm in the higher elevations with arid conditions in the South East Peninsula (SEP). Average annual rainfall on Nevis is about 1170mm, and therefore it has lower yielding water sources (Department of Environment, 2001).

Figure 1.1: St. Kitts and Nevis (Google, 2014)

1.2.1 The Water Sector

As indicated in the Terms of Reference, it is becoming increasingly apparent, in St. Kitts and Nevis, that current water sector arrangements threaten the continued success of the economy and the advancement of its social development. Three key challenges for the sustainability of integrated water resources management have been identified: technical, institutional and financial.

Operational and Technical Sustainability

Recent studies conducted in the Basseterre Valley Watershed/Aquifer have identified the following issues *inter alia*:

- A trend of declining static water levels in the Basseterre well-field, and early signs of salt water intrusion;
- The potential for degradation of groundwater quality from domestic soak-away pits, agricultural pollution and industrial developments in the watershed;
- Threats to the watershed recharge areas from improper land usage and insufficient development planning, leading to watershed degradation and deforestation; and
- Threats to the existing freshwater aquifer from climate change induced sea-level rise.

Changing precipitation patterns and increases in the frequency and intensity of extreme weather events will impact the hydrological cycle and thus water supply. St. Kitts has recently developed a comprehensive Water Conservation Plan (WCP) as a means of adapting to the projected adverse impacts of climate change.

Operational sustainability is also contingent on the pricing of water services to recover full costs and investing the capital raised in operation and maintenance to provide improved service standards. To achieve this there needs to be a better level of information, knowledge and understanding of water resources, the nature and extent of the demands on water resources, contributing conditions and the macro-economic and development context within which they are situated.

Institutional Sustainability

Institutional sustainability requires building the capacity of water services and water resource management institutions, promoting good governance and maintaining effective relationships and coordination between the relevant public authorities, the private sector and civil society. The institutional framework must take account of societal, economic and environmental conditions.

Financial Sustainability

The active management of water resources requires investment and adequate financial resources. Financial sustainability requires mobilizing sufficient capital investment to ensure the adequate provision of infrastructure to cover operation and maintenance and eventual replacement. Securing financing and investment is affected by the Government's high level of indebtedness and resultant difficulties in allocating resources in the national budget.

1.2.2 Status of Water Resources

The water sector is vulnerable to climate change in a number of ways, including sea level rise, temperature and precipitation changes over time to name a few (CARIBSAVE, 2012). Further to these, secondary impacts such as the impact of extreme events on water infrastructure and the contamination of coastal aquifers with the intrusion of saline water by sea level rise (SLR) are critical issues.

Other issues include reports of heavy metal contaminants in ground water resources. Most of the population utilises septic tanks, and there is concern that flood-producing rainfall can introduce bacteriological contaminants into the aquifers. Turbidity issues are exacerbated by erosion due to unregulated building and road construction on steep slopes. Conversely, during dry spells and drought conditions, ground water recharge rates decrease affecting the available water resources. This is particularly important to Nevis as it is even more dependent on groundwater resources than St. Kitts.

1.2.2.1 St. Kitts

In St. Kitts, the majority of water comes from groundwater wells and currently, all residents of St. Kitts have access to water 24 hours per day. All water is supplied by the St. Kitts Water Department. Over 50% of supply is consumed by the domestic sector (Figure 1.2), while the tourism, agriculture and commercial sectors each use between 10 and 15% of the island's water resources. No central sewerage system exists in either St. Kitts or Nevis; however, there is one treatment plant at Frigate Bay (St. Kitts). Soakaways and septic tanks are the primary waste disposal method used by households. For the Basseterre aquifer, threats to water quality include contamination from oil spills, fertilisers, other agrochemicals, and bacteria.

To combat water pollution, it is recommended that the Water Department collaborate with the agricultural sector and planning department to develop land use policies that centre on water conservation and also protect against SLR and salt water intrusion.

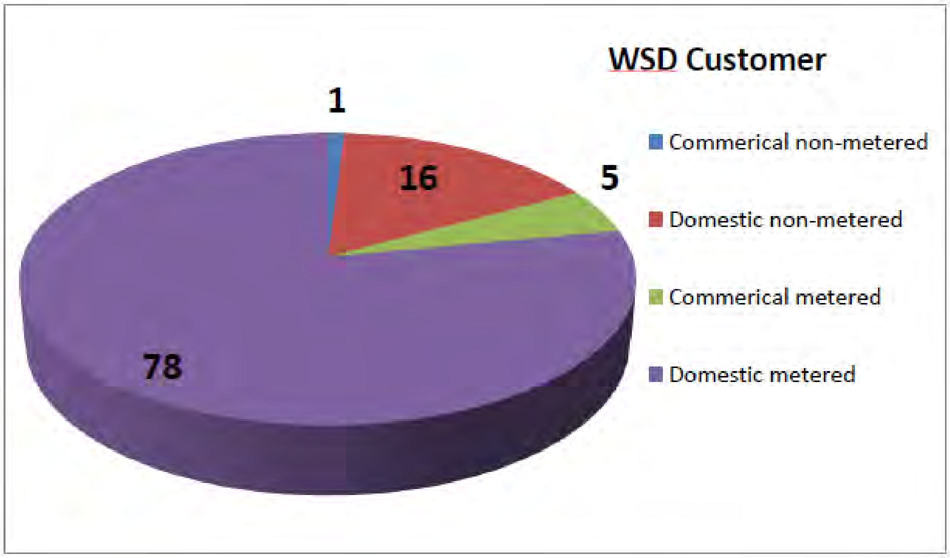


Figure 1.2: Distribution of Metered and Non-Metered Customers of the St. Kitts Water Services Department (%) (Source: Dr. Sahely, personal communication April 12, 2011, in CARIBSAVE, 2012)

Demand for water is expected to increase as the economy of St. Kitts and Nevis expands, particularly in the tourism and agriculture sectors where water requirements could double in the next 10 years. To exploit groundwater resources that are not currently exploited will require substantial capital investments to gain access to these aquifers.

St. Kitts Water Services Department (WSD) executes government policy objectives, implements water conservation programmes (particularly under drought conditions), and carries out public education and awareness initiatives related to water resources. However, conflicting and growing demands for water from various sectors still place pressure on the limited financial resources available to the WSD.

1.2.2.2 Nevis

Groundwater is the main source of water in Nevis where there are 14 active wells. However, compared to the larger island of St. Kitts, water is less available on Nevis due to rainfall patterns as mentioned above. Significant springs are absent also as a result of a prominent layer of silica pan covered with a layer of clayey soils that inhibit water infiltration. Approximately 91% of piped water is obtained from groundwater sources and 9% from surface springs. According to the Water Services Department, water resources are considered sufficient to meet current water demands on the island, despite the fact that the average annual rainfall is 1170 mm, which is lower than St. Kitts and lower than other islands in the Caribbean.

Flooding in Nevis is less of a concern due to lower rainfall totals. When droughts occur in Nevis, they generally last for 2 to 3 months. The Nevis Water Department usually issues public notices for consumers to conserve water and depending on the severity, water rationing may be carried out. It is estimated that if there is a 10% to 20% decline in annual precipitation, ground water recharge rates would be affected: “If we would have more frequent droughts, our surplus would be at risk and our storage would suffer" (Morris, Nevis Water Services Department, in CARIBSAVE, 2012). The agriculture sector is most affected during drought conditions.

1.3 The Consultant's Mandate

The Terms of Reference for the Consultant stipulate two specific objectives of the mandate:

a. To conduct a Vulnerability and Capacity Assessment in the Basseterre Catchment Area in St. Kitts and Nevis to determine the impacts of projected climate change on the water sector in the community; and
b. To conduct an impact assessment of climate change and climate variability on the water sector in St. Kitts and Nevis, and using the report generated to prepare a National Adaptation Strategy and Action Plan (NASAP) for the water sector.

The Results to be achieved are as follows:

- Result 1 – A technical team is established in St. Kitts and Nevis that will primarily be responsible for the conduct of the VCA and the preparation of the impact assessment, the NAS and Action Plan for the water sector on behalf of the GOSKN;
- Result 2 - The primary stakeholders, (government agencies, community groups, private sector, etc.), participate in the preparation process through adequate consultations (visioning exercises, periodic review meetings and sharing of reports);
- Result 3 - Two national workshops are utilized to support/facilitate dialogue on the VCA and NAS preparation processes and outcomes and recommendations at the national level; and
- Result 4 – Community and sector specific issues that arise or are identified during the consultancy are adequately addressed in the final report.

The impact assessment and its outputs include key recommendations to the Government of St. Kitts and Nevis (GOSKN) to address adaptation within the water sector. The NASAP, when completed, will make recommendations based on the assessment and will suggest options, including a proposed financial mechanism(s), that will help the country to cope with the anticipated adverse effects of climate change on the water sector with integration of agriculture and health issues.

In order to achieve these objectives ESL undertook a series of activities involving research, stakeholder consultations, modelling and technical analysis. A thorough understanding of the project objectives, activities, outputs and outcomes improves the delivery of the consultancy and the overall impact of the project on the social and economic development of St. Kitts and Nevis.

1.4 The Scope and Approach for the NASAP

The consultants undertook this assignment using a consultative and participatory approach involving all key stakeholders in combination with scientific analyses. The requirements of the TORs was met through comprehensive research and documentation review, stakeholder consultations (in various forms) and climate modeling. The consulting team used a charette-style approach to data gathering to ensure all cross-cutting issues were addressed and fully understood by the multi-disciplinary team members.

1.4.1 The Study Area

The study area, which includes the islands of St. Kitts and Nevis, have been defined based on literature review, as well as, based on stakeholder consultations. Settlement, economic activity, surface and groundwater features have been outlined to define the limits of the project area.

The characteristics of St. Kitts and Nevis have been outlined. The physical and socioeconomic nature of the islands are detailed. The physical nature of the project area has been defined in terms of geology, hydrology and inter-linkages among the physical nature of the project area, surface and ground water supply.

1.4.2 Literature Review

The Consultants had to acquire significant primary and secondary data in order to complete the impact assessment. The following information was gathered from stakeholders and existing documentation:

1. Country specific data on for example: population, water usage, water supply, forest cover, rainfall and other weather data, stream data, groundwater data, among others;
2. Water sector characteristics - water availability and supply in rural and urban areas, water resources and management, sanitation, finance including government spending and donor funding, government supply and capacity, sector coordination, equity, sustainability, private sector and civil society;
3. Socio-economic development trends- population growth, urbanization, rural migration, past and present supply and demand management practices;
4. Current national activities and programs relevant to the water sector (dams, drainage systems and ponds, human resources, other assets);
5. Challenges faced and priority areas for improving the Basseterre Aquifer and watershed area and water sector.

1.4.3 Stakeholder Consultation

Consultations were conducted with the key stakeholders identified at the Inception Meeting. This was done in an effort to confirm the current state of the water sector. Stakeholder consultations took the form of targeted interviews, focus groups, community meetings and surveys (print and electronic).

The Consultants liaised with the Department of Physical Planning and Environment to assist in setting up stakeholder consultations in both St. Kitts and Nevis. The organisations consulted are listed in Annex I.

1.4.4 Climate Change Analysis

Climate change and its impacts on the water sector are integrally related issues. Small Island Developing States (SIDS) have unique sustainable development challenges when compared to other countries. The challenges stem mostly from the limited availability of land as well as restrictive limitations on the fresh water resources. The SIDS of the Caribbean are constrained under the limited opportunity for water storage, hence making them vulnerable to the effects of climate variability e.g. floods and droughts. This has a real and tangible development constraint on the economy and public health, as well as on environmental quality, which for St. Kitts and Nevis also means the economy.

The Ministry of Sustainable Development reported that St. Kitts and Nevis is highly susceptible to the effects of climate change. Bueno et al. (2008) provided figures for *cost of inaction* in St. Kitts and Nevis using the 2004 GDP as the base year. By the years 2025 and 2050, costs would amount to 16 % and 35.5 % of GDP, respectively.

The climate modelling projections for St. Kitts and Nevis predict:

1. an increase in average atmospheric temperature;
2. reduced average annual rainfall;
3. increased Sea Surface Temperatures (SST); and
4. potential for an increase in the intensity of tropical storms.

(CARIBSAVE Partnership, 2012)

St. Kitts and Nevis could already be experiencing some of the effects of climate variability and change through damage from severe weather systems and other extreme events, as well as more subtle changes in temperature and rainfall patterns. General Circulation Models (GCM) projections indicate an overall decrease in annual rainfall of between -41 to +13 mm per month by 2080 for the higher emissions scenario. RCM projections indicate a decrease of 7-22% in total annual rainfall (CARIBSAVE, 2012). With increasing demands on the water sector due to a growing population, and the expanding tourism and agricultural sectors, water shortages are likely to be exacerbated in the future.

In St. Kitts and Nevis, water resources are vulnerable to sea level rise, and higher evaporation rates due to temperature increases. Given the centrality of ground water sources to the national water supply, the problem of water resources is primarily one of keeping and protecting the underground water resources. Currently, the island experiences water shortages in some rural communities during the dry season (FAO, 2000). During the 2014 dry season, natural springs experience periodic water shortages as a result of high tourism water demand, resulting in water being sourced from areas that have wells (CARIBSAVE, 2012). Because of the relatively high consumption for irrigation and the overall water scarcity situation, requests from crop farmers are rarely given consideration. This lack of water for supplementary irrigation in the dry season has been considered by the Department of Agriculture, to be the major constraint to achieving year round production of selected vegetables which is a primary goal. Climate change is expected to exacerbate these water shortages as a result of increasing temperatures, increased rainfall variability and sea level rise (FAO, 2000).

Sections 2 and 3 of this report presents an assessment of literature and results of analyses towards characterizing climate variability, trends and projections for St. Kitts and Nevis. In developing these Sections the following methodology was followed:

- Historical data were analyzed to produce a series of figures highlighting information on temperature, rainfall (precipitation), wind-speed, sea levels and hurricanes that represent the current climate of St. Kitts and Nevis.

- The future possible state of the climate of St. Kitts and Nevis was gleaned from available GCM data; using tables and diagrams for the variables of temperature, rainfall, wind speed, sea level rise and hurricanes, where data is available. Specific references are made to the Basseterre Valley Watershed in particular.
- RCM data at scale for St. Kitts and Nevis were derived from PRECIS A1B Perturbed Physics Ensemble of which 6 representative members of the 17 were chosen. From this data tables for the variables of temperature, rainfall and wind speed were created. Where data is available, specific references are made to the Basseterre Valley Watershed in particular.

A review of authoritative works on climate change was done in order to examine the state of knowledge about climate change and its implications for St. Kitts and Nevis. These included, but were not limited to, studies by the Intergovernmental Panel on Climate Change (IPCC), Caribbean Community Climate Change Centre and Climate Studies Group, Mona, UWI.

1.4.5 Water Sector Vulnerability Issues and Threats

The daily rainfall data for St. Kitts and Nevis was acquired through a detailed desk study of various reports. These reports were used to gain the dataset of historical data for both islands. A series of checks to determine homogeneity of the hydrological data were utilised.

The relationship among nearby rainfall stations was determined to establish correlations to catchment response and annual rainfall trends over time. The data was then arranged accordingly and statistical analysis was performed using the following steps:

1) The maximum daily rainfall was ranked;
2) The data was fitted by testing of goodness of fit and confirmation was made using a range of statistical tests, namely the:
   - Anderson-Darling Test
   - Kolmogorov-Smirnov Test and the
   - Chi-Squared Test
3) The choice of statistical analysis was confirmed with past research papers based on Caribbean rainfall analysis;
4) The appropriate curve was chosen based on both experimental and past research papers which led to the conclusion that the Gumbel Max was the best fit for this data;
5) This distribution curve was fitted to the data and was used to provide the return periods for both countries;
6) A linear model was applied to determine rainfall trends along with consumption and demand trends over time to provide correlations of the existing water sector in both islands;
7) GIS analysis of each catchment was done to assist with the preparation of a water budget;
8) Annual water withdrawal data and the available water resources of each country along with rainfall data were prepared for water budget calculations;
9) Water scarcity indices for each island were prepared;

10) A rainfall – runoff model were being investigated with the hope of being applied to each island.

1.4.6 Institutional, Policy and Legislative Review

The review of the institutional framework governing the water sector has been completed based on document review and interviews with relevant agencies and organizations that are involved in research, regulations, provision or enforcement within the water sector and also as related to climate change. The review and analysis included the following categories:

- Uses, ownership and management of water sector infrastructure and resources;
- Policies specific to or related to the water sector and climate change adaptation;
- Legislation and regulations governing or related to the water sector; and
- Institutional arrangements governing the water sector.

Gaps and challenges associated with the institutional framework were identified. A visioning exercise was completed with the key agencies at the National Stakeholder Workshop. The main aim of the visioning was to generate a common goal and hope for the water sector. This exercise informed the national adaptation strategy and action plan which offers an opportunity for generating fundamental and transformative change in the sector.

Relevant policies, legislation and international conventions were also reviewed and gaps and recommendations highlighted as informed by the stakeholder consultations and document review.

1.4.7 Socio-economic Review

The existing socioeconomic situation in St. Kitts and Nevis as it relates to economic vulnerability, poverty, unemployment and inequality, and challenges with achieving and/or sustaining human development and poor governance, are of particular relevance to the water sector. The Water Sector is defined by The UN-Water (2008), as being – "All means and activities devoted to creating net added value from the water resources available in a given territory". The notion of 'net added value' derives from the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, which quantity and quality determine the nature of its contribution to its users.

It is important to note that vulnerability is a multifaceted concept that is difficult to capture completely by a single measurement. This is because accurate measurements of vulnerability require an adequate reflection of processes and outcomes within systems, which are not easy to identify and characterize (Adger, 2006). Understanding the vulnerability of a system requires an assessment of its adaptive capacity, sensitivity and exposure external forces and disturbances such as climate change.

Currently, no standard framework exists for capturing qualitative and/or quantitative insights into conditions as well as perceptions of vulnerability (Adger, 2006).

Participatory and livelihood approaches to vulnerability assessment where indicators are informed by the primary stakeholders themselves represent a positive step towards integrating local knowledge with scientific knowledge.

The primary fieldwork for the socio-economic component of the VCA commenced once the spatial and socio-economic boundaries of the study area were defined and climate profiles developed.

The socio economic input evaluated the impact of climate change on the agriculture and health sectors as required by the terms of reference.

Agricultural Sector

For this study, agricultural users are defined as both irrigation and non-irrigation water users. Primary emphasis was placed on farmers, but main industry users such as agro processors were also considered important stakeholders. Overall, current water demand by these users were compared with water supply and net water demand extrapolated using climate change scenarios and forecasts. Other pertinent issues included the impact of sea level rise and the potential for saline intrusion into the aquifers serving agriculture. Options for reducing/redistributing abstraction from these areas, as well as combining the use of other surface water sources with adequate catchment resources, were examined. Scenario building through consultations attempted to better understand the relationship between food security for the population, agricultural production and the water sector.

Within the limiting assumptions that attend forecasting of net water demand, adaptation strategies and corresponding action plans were recommended based on synthesizing the results of the extensive consultative process with solutions that are practical, likely to be fundable, and for which benchmarks of achievements can be streamed in the short to medium term.

Environmental water (or flows) is an integral part of the long term sustainability of the agricultural sector, since, applying the ridge to reef impact assumption, a relationship between deforestation, soil erosion, flooding and sustainability in farming (including fisheries) can be accepted. The reverse impact is also true. Successful adaptation strategies are supportive of the sustainability of environmental water. While the general concept of environmental water and the relationships described are held to be valid, there is little consensus on an acceptable definition of environmental water and how best it can be quantified. The Consultants established with the Water Services Department what definition of environmental water they have traditionally used and generated data on. It is their estimates of environmental water that will be adopted for purposes of suggesting the direction of impact on these flows, by adaptation strategies.

Health

The importance of water to health is established in scientific principle, and qualitatively via several commentaries. However, the Consultants are not aware that the development and use of indices to relate the water sector to health has been done for St. Kitts and Nevis to date. In the absence of this work at the VCA level, the Consultants have approached the impact of climate change to health using two main approaches. First: Scenario building during consultations explored the relationship between sanitation and health in light of water sector issues, as well as, between climate change and health, including the outbreak of diseases.

However, health, like the water sector is an area for which the precautionary principle in adaptation planning is highly recommended. The Consultants were mainly concerned to arrive at suggestions for adaptation strategies for sustainable health, given developments in the water sector arising from climate change.

The socio-economic input will also contribute to understanding the likely social impacts of adaptation strategies in other areas of the water sector.

1.4.8 Limitations/ Constraints

Inadequate climate records, limited data availability to facilitate climate modeling and water resources assessment were the main limitations as follows:

1.4.8.1 Climate Modeling

- Daily values for meteorological data existed for only one station in St. Kitts;
- Only one meteorological data collection station exists in Nevis and the rainfall data for Nevis did not pass the quality control steps that are done on all data received. As such, it could not be analysed and assessed in terms of climatology and seasonality. However, the data was still used to determine future projections;
- Changes in rainfall and temperature extremes could not be examined and the application of statistical downscaling methods for projections was hampered;
- Data was lacking for relative humidity and wind;
- No sea level data specific to St. Kitts and Nevis was available and therefore data available for the Caribbean was adopted for St. Kitts and Nevis.

1.4.8.2 Water Resources

Precipitation

Precipitation data is available from 1930 to 2005 for the sugar estates in St. Kitts. Since the decline in the sugar industry, the data collection has been sporadic and it is mostly laid out in a manner which makes it very difficult to analyse time periods for individual stations. It is understood that the original data set still existed in paper format and was thus difficult to obtain. Most of the readings were collected manually during the period.

The only automatic station is located at the R.LB International airport in St. Kitts and the Vance W. Amory International Airport in Nevis. Data was missing for 1998 due to malfunctioning equipment, as well as, hurricane George's in September of that year.

All of the data provided was monthly and annual data. Based on the data collection and storage methods used was difficult and tedious to obtain decadal time spans for daily records and hence analyse the Basseterre catchment response to floods and droughts over any one year.

On collating the data and the analysis periods, several stations within decadal spans had missing monthly data. This limited the rainfall analysis for both islands.

Due to the orographic precipitation patterns in the Caribbean, especially those related to mountainous islands such as Saint Kitts and Nevis, the lack of 24 hour rainfall and lack of electronically available data records are significant limitations. Therefore, determining the validated model catchment response to a rainfall event from sub-daily data was not possible during the study. As such, runoff could not be assessed and a rainfall runoff model could not be done.

Watershed Data

The Basseterre aquifer and watershed supplies 65% of the water on the entire island of St. Kitts. It was the only watershed that data was available for St. Kitts, to analyse rainfall and runoff patterns and to determine water scarcity. As such, the data from this watershed was heavily relied upon for these analyses.

Ocean Energy Technologies (OET) (2009) was the consultant tasked to complete the project: *Rehabilitation and Management of the Basseterre Valley as a Protection Measure for the Underlying Aquifer.* Volume 1 presented a Water Resource Management Plan and volume 2 and a National Park Management Plan.

In 1977 the Basseterre Valley Aquifer was described as a virgin aquifer. Early studies (e.g., Christmas, 1977; Kerr, Preistman & Associates, 1988) provided information on the general geology and hydrogeologic characteristics of the aquifer at the southern part of the watershed. Williams (1999) updated and reworked the Christmas (1977) data to determine if the safe sustained yield predicted by Christmas (1977) still appeared valid. These early data provided a base from which Ocean Earth Technologies (OET) (2009) could ground truth the collected geophysical data and correlate geologic stratigraphy with specific lithologies. However, no early report effectively defined the entire watershed, aquifer thickness and distribution, aquifer hydrologic characteristics, recharge rates, fresh/salt water interface location, and fluctuations of the groundwater quality distribution throughout the Basseterre Valley Aquifer Watershed.

The existing well field, where the majority of the previous investigations have been focused, occupies less than 10 percent of the Basseterre Valley Aquifer Watershed. In 2009, OET delineated the watershed in order to clarify the geologic stratigraphy of the existing wellfield site and overall, approximately 15 percent of the watershed has some data available for interpretation. It was not possible to determine the characteristics (geology and hydrogeology) of the upper portion of the aquifer based on the above limitation, and the vast area of approximately of 5,230 acres. This has implications for understanding the dynamics of the surface and groundwater catchments.

Hydrogeology

Limited hydrogeological data stymied the quantification of water resources and thus figures calculated then and now should be used with some care. Values derived are primarily volumetric flow rates since the manner in which the water data is also collected makes it difficult to quantify water resources.

Hydrology

Rainfall intensity values could not be calculated due to the manual nature of the equipment malfunctioning, and intermittent records.

Rainfall intensity influences the balance between infiltration and run-off, aquifer recharge, and erosion potential and risk. Roughton (1981) and CCA (1991) predicted a 10 year storm intensity at 125 mm/hr. Recent experiences of hurricanes in neighbouring islands would suggest that this might be an underestimate, at least during this period of enhanced tropical storm formation. Antigua has experienced rainfall amounts of over 500 mm in about 12 hours during Hurricane Lenny in 1999, and short term rainfall intensities of over 280 mm per hour during Hurricane Omar in 2008 (Cooper, 2008, unpublished data). It is very likely that in St. Kitts rainfall intensities at higher elevations and on steep slopes facing prevailing storm winds would be higher than even these amounts.

This limits the production and investigation of flood data on the Basseterre catchment and production of a rainfall runoff model.

In addition Evaporation parameters have only been estimated in past reports. These range from 20 to 75%.

Model outputs

OET (2009) stated that due to the fact that the quantitative hydrogeological information that is currently available is generally located only within the well field, which encompasses approximately 10% of the entire watershed, there may be as much as a 90% error in the model calculations. However, extrapolation procedures and estimates of aquifer properties in this project are based on typical behaviour of groundwater and known geology of the region. The model results can be used as a first order approximation of the dynamics of groundwater in this area.

This means that until further hydrogeological characteristics are defined, the baseline values for water resources studies could remain in the range of -90%≤ x≥ 90 %.

Data Management

The data collection techniques and storage also hinder the management and analysis of water resources since continuous time periods are unaccounted for and trends could not be established over long periods. This area requires urgent attention.

Geographic Information System

There was no population data in ESRI or similar format to be linked to Hydrology.

There were no properly filled attribute tables within GIS for many layers which hampers the hydrology analysis.

1.4.8.3 Socioeconomic

The absence of certain primary and secondary data, as well as data quality issues limited the extent of the socioeconomic assessment.

In addition, not all the 2011 census data was collated to provide demographic data. Only population and household numbers were available for 2011. As such, the Consultants had to utilise 2001 estimates for the remaining demographic analysis, which is quite outdated.

2 OBSERVED CLIMATE AND TRENDS

The climate of St. Kitts and Nevis is typically that of a small tropical island. The combination of its size, location and low-lying topography results in it being strongly influenced by features of the north tropical Atlantic. In the course of a year, the country's climate is strongly modulated by the migration of the north Atlantic subtropical high, the eastward spreading of the tropical Atlantic warm pool, the fairly steady easterly trades, and the passage of tropical waves, depressions, storms and hurricanes. The resulting climate regime is one characterized by a dry winter-wet summer pattern and high and fairly uniform temperatures year-round.

2.1 Rainfall

2.1.1 Climatology

Observed rainfall data was obtained for the period 1930 to 2006 for 8 stations on the island of St. Kitts (Figure 2.1). Stations were chosen based on the percentage availability of data for the referenced period. As already indicated in Section 1.4.8 above, rainfall data for Nevis could not be analysed because it did not pass the quality control steps.

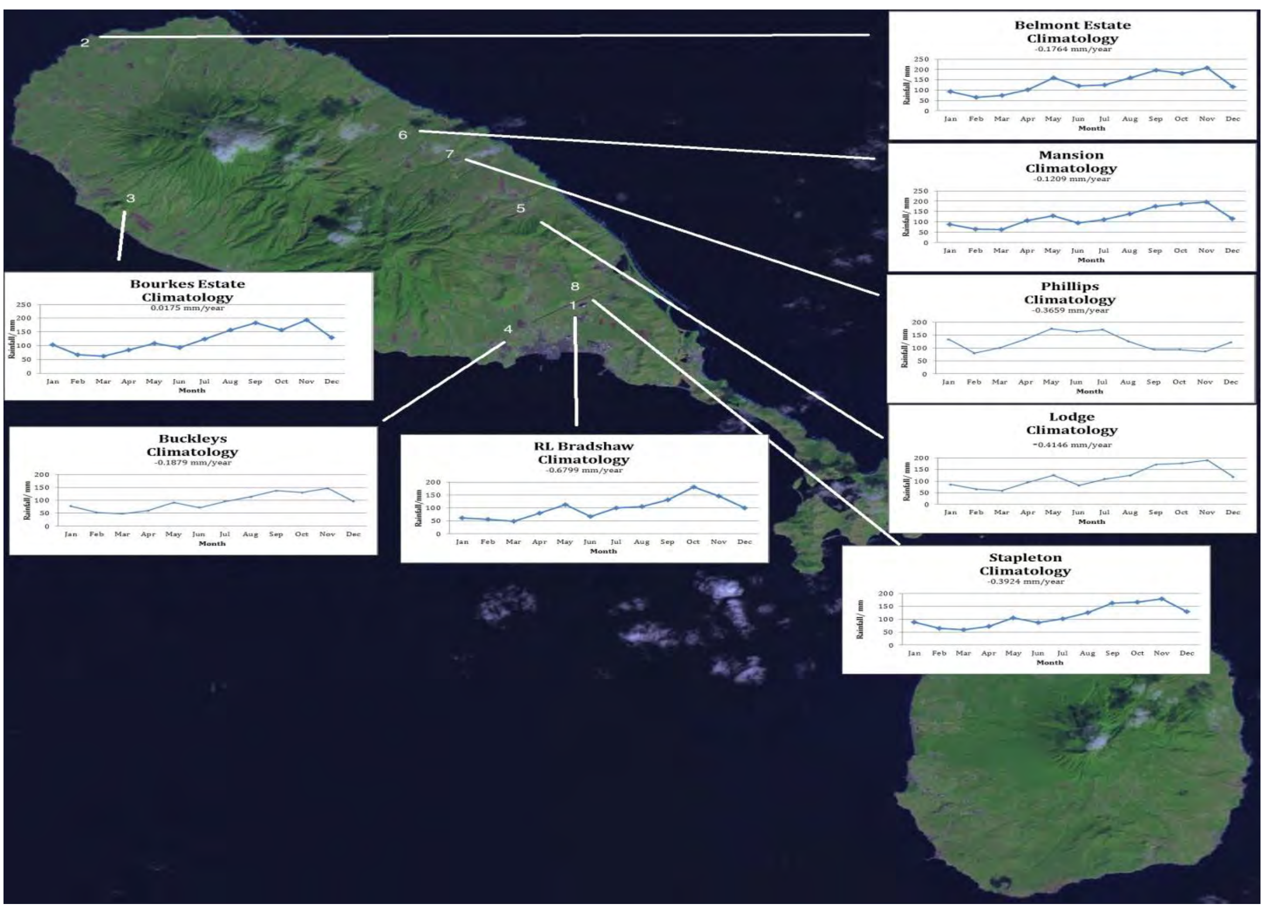


Figure 2.1: Location of Stations within the Island

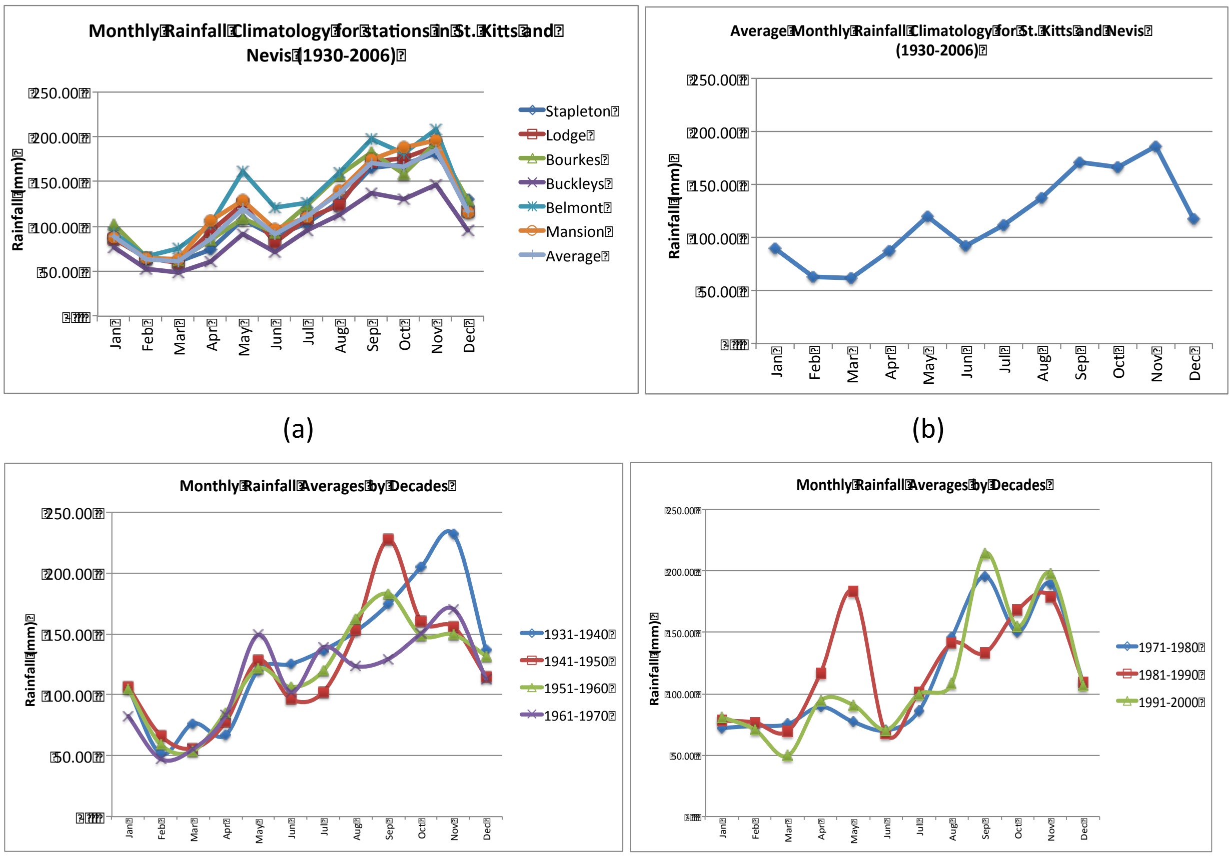
The climatology (mean monthly variation for the year) was calculated for each station and these values are given in Table 2.1. The stations - Belmont, Phillips and Mansion - located close to the north coast of St. Kitts, were found to receive the highest annual average rainfall amounts. The Phillips station had unusually depressed late season rainfall amounts for August – October, in comparison to the other stations. Buckleys and RL Bradshaw, located close to the southeast of the island, received the lowest annual average rainfall.

Table 2.1: Monthly Rainfall Climatology for Stations in St. Kitts and Nevis. Values are in mm

	Stapleton (1930-2006)	**RL Bradshaw** (1980-2014)	**Lodge** (1930-2006)	**Bourkes** (1930-2006)	**Buckleys** (1930-2006)	**Belmont** (1930-2006)	**Mansion** (1930-2006)	**Phillips** (1939-2006)	**Average**
Jan	89.86	61.57	85.51	102.88	77.27	92.22	87.35	134.00	91.33
Feb	65.21	56.90	64.66	66.16	52.92	66.43	64.36	80.37	64.63
Mar	59.90	49.30	59.18	61.43	48.54	74.87	63.42	101.02	64.71
Apr	72.46	80.35	94.06	84.18	60.12	101.96	106.76	134.33	91.78
May	105.89	113.09	124.89	109.08	91.44	160.51	128.91	174.69	126.06
Jun	87.39	67.79	81.62	92.25	72.01	120.72	96.25	163.28	97.66
Jul	102.75	99.41	108.33	124.25	95.79	125.85	110.93	170.98	117.29
Aug	125.66	105.72	124.03	157.00	113.21	160.32	139.99	126.18	131.51
Sep	163.06	131.08	171.46	182.72	137.23	196.82	174.89	94.48	156.47
Oct	166.24	181.88	176.36	157.98	129.69	181.09	187.52	94.30	159.38
Nov	178.44	145.84	188.95	192.97	146.72	208.62	195.69	87.20	168.06
Dec	129.09	100.91	117.53	129.39	96.01	116.52	116.14	122.46	116.01
Average	**112.16**	**99.49**	**116.38**	**121.69**	**93.41**	**133.83**	**122.68**	**123.61**	

Figure 2.2 (a) and Figure 2.2 (b) show that the six stations under examination have the same basic rainfall profile for the period, 1930-2006. The figures depict an early season rainfall peak in May, with two minor peaks in the late season rainfall, typically occurring in September and November. It should be noted that, with the inclusion of the RL Bradshaw and Phillips stations, the two minor late season peaks are replaced by one peak in November. However, these stations were not included in the results shown in Figure 2.2, as data was not available for all the years in the referenced period (1930-2006). In general, February and March are shown to be the driest months.

The decadal breakdown, depicted in Figure 2.2 (c) and (d), spans the years 1931-2000, and reveals rainfall bimodality (1940s, 1950s) and tri-modality for all other decades. The bimodal pattern takes the form of two peaks, one in May and another in September; this corresponds to rainfall patterns observed for the Greater Antilles (see Taylor et. al., 2002).



(c) (d)

Figure 2.2: Observed Monthly Rainfall Means in mm (a) for Six Stations within the Study Area for the Period, 1930-2006 (b) Averaged across all Stations for the Period 1930-2006 (c) Decadal Averages (1931-1970) and (d) Decadal Averages (1971-2000)

The tri-modality observed in the decadal analysis deviates from the typical Caribbean rainfall climatological bimodal pattern, which is centred on July. This tri-modal pattern is associated with an initial peak (April-May), a secondary peak (August-September) and a third peak (November). The early season peak for the decadal breakdown tends to occur in May, except for 1971-1980 and 1991-2000. For 1931-1940, there was an additional peak in the early rainfall season as March received more than average rainfall amounts. There is greater variation in the location of the late season peaks for the tri-modal pattern.

2.1.2 Seasonality

The eight stations considered were found to have similar rainfall patterns: a dry season ending in March, an early wet season peaking in May and a late rainfall season typically with a maximum in November. Barring the meteorological station at Phillips, September to December, accounts for approximately 45% of yearly rainfall totals. Phillips is the only station to have received 50% of its rainfall in the first 6 months and less than 30% in the traditionally more intense rainy period. The percentage contribution of monthly totals to annual rainfall amounts (Table 2.2) suggests that the seasons over St. Kitts and Nevis may be described as early dry (January-March), early wet (April-June) and late wet (July-December).

Table 2.2: Percentage contribution of Monthly Rainfall Totals to the Annual Rainfall Totals Recorded at 8 Stations across St. Kitts and Nevis

	Stapleton (1930-2006)	RL Bradshaw (1980-2014)	Lodge (1930-2006)	Bourkes (1930-2006)	Buckleys (1930-2006)	Belmont (1930-2006)	Mansion (1930-2006)	Phillips (1939-2006)	Average
Jan	7	5	6	7	7	6	6	9	7
Feb	5	5	5	5	5	4	4	5	5
Mar	4	4	4	4	4	5	4	7	5
Apr	5	7	7	6	5	6	7	9	7
May	8	9	9	7	8	10	9	12	9
Jun	6	6	6	6	6	8	7	11	7
Jul	8	8	8	9	9	8	8	12	8
Aug	9	9	9	11	10	10	10	9	9
Sep	12	11	12	13	12	12	12	6	11
Oct	12	15	13	11	12	11	13	6	12
Nov	13	12	14	13	13	13	13	6	12
Dec	10	8	8	9	9	7	8	8	8

2.1.3 Recent Trends

Table 2.3 shows annual rainfall trends for St. Kitts and Nevis. Rainfall in the country displays relatively significant inter-annual variability. Most of the stations revealed a decreasing trend, which is reflected in the annual average (Figure 2.3).

Table 2.3: Rainfall Trends for the Six Stations in Figure 2.2 for the Period 1930-2006

	Trend (mm)
Stapleton	-0.38
Lodge	-0.45
Bourkes	0.00
Buckleys	-0.15
Belmont	-0.18
Mansion	-0.13

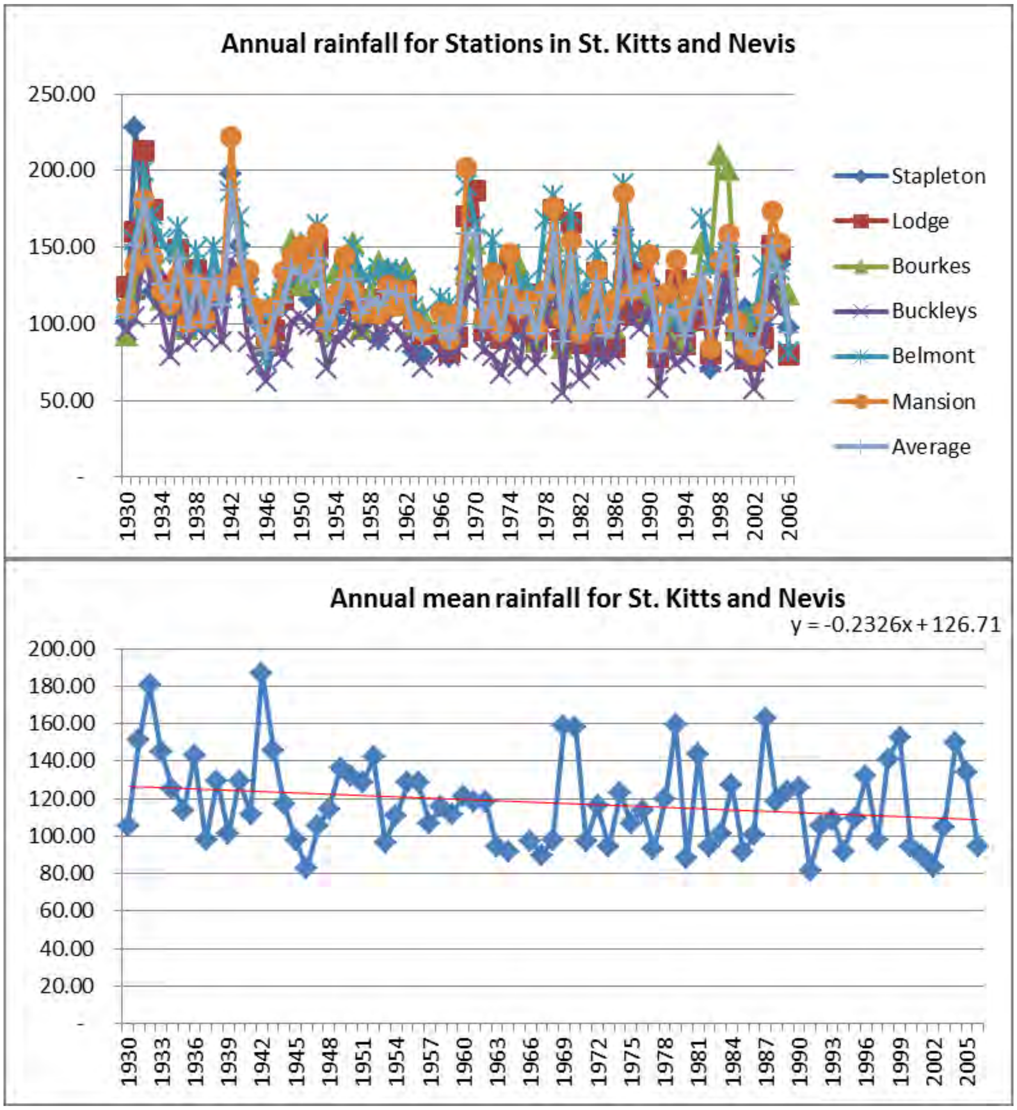
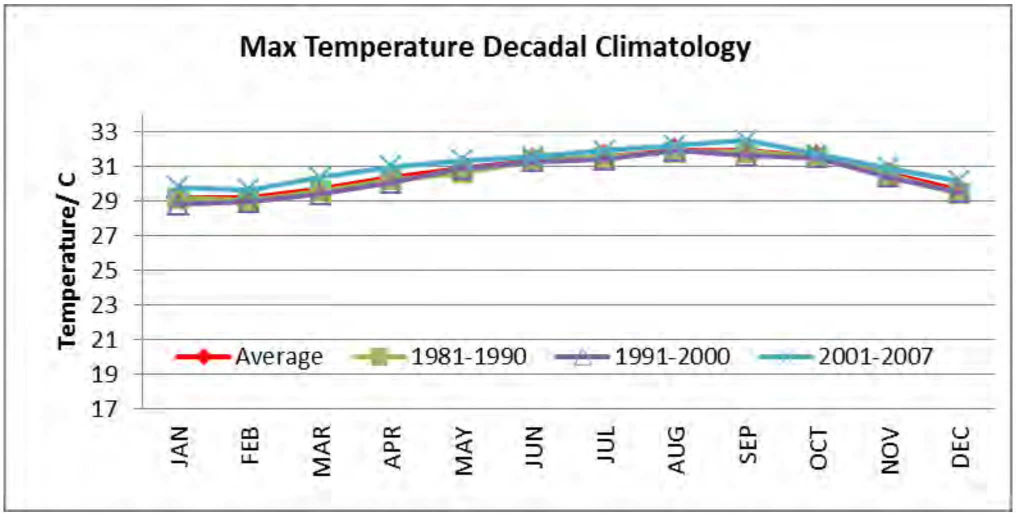


Figure 2.3: Annual Rainfall for St. Kitts and Nevis in mm, with Trendlines Inserted

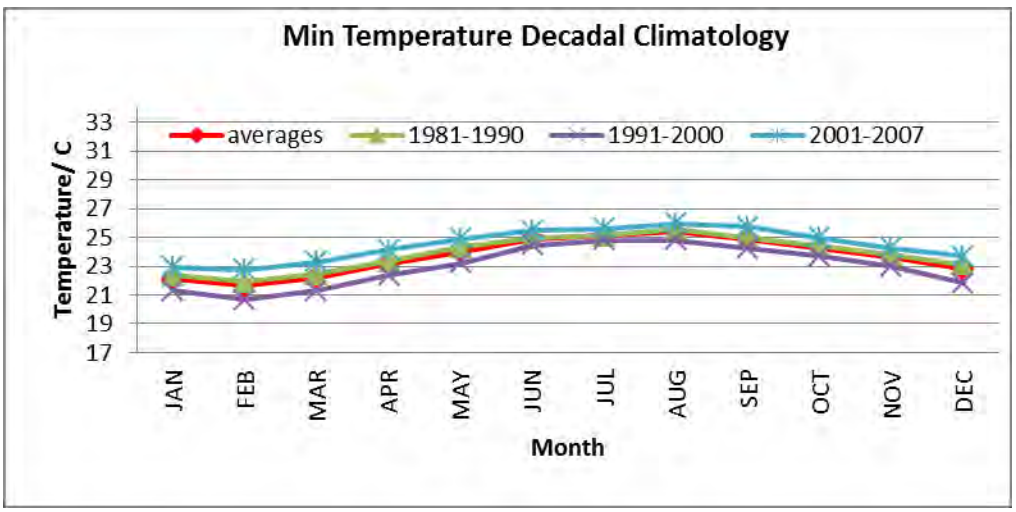
2.2 Temperature

2.2.1 Climatology

Observed temperature data was available for only one station (RL Bradshaw) for 1981 to 2007. Figure 2.4 shows that the average monthly maximum and minimum temperature range is approximately 4°C and 5°C, respectively, with temperatures peaking during the summer months. Warmer than normal years may likely be linked to El Nino Southern Oscillation (ENSO) events and the Atlantic beginning of Multidecadal Oscillation (AMO). The 2000s were warmer than the 80s and 90s.



(a)



(b)

Figure 2.4: (a) Maximum and (b) Minimum Temperatures in °C per Decade for the RL Bradshaw Station

Table 2.4: Observed Maximum and Minimum Temperatures for the RL Bradshaw Station.

	1981-1990		**1991-2000**		**2001-2007**		**Average**	
	Max	Min	Max	Min	Max	Min	Max	Min
JAN	29.18	22.40	28.79	21.30	29.82	23.00	29.20	22.10
FEB	29.07	21.90	28.96	20.70	29.65	22.70	29.19	21.66
MAR	29.57	22.50	29.38	21.30	30.34	23.30	29.71	22.24
APR	30.24	23.30	30.06	22.40	31.00	24.10	30.38	23.16
MAY	30.63	24.30	30.87	23.20	31.35	24.90	30.91	23.99
JUN	31.37	25.00	31.28	24.50	31.54	25.50	31.37	24.90
JUL	31.56	25.10	31.38	24.80	31.92	25.60	31.57	25.11
AUG	31.85	25.60	31.90	24.80	32.23	26.00	31.97	25.39
SEP	31.86	25.00	31.63	24.20	32.51	25.80	31.95	24.90
OCT	31.53	24.40	31.52	23.70	31.71	25.00	31.58	24.28
NOV	30.53	23.80	30.39	23.00	30.91	24.30	30.58	23.58
DEC	29.43	23.10	29.52	21.80	30.18	23.70	29.67	22.79

2.2.2 Recent Trends

The time series of maximum and minimum temperatures show a slightly increasing, but insignificant, trend for the period 1981-2007.

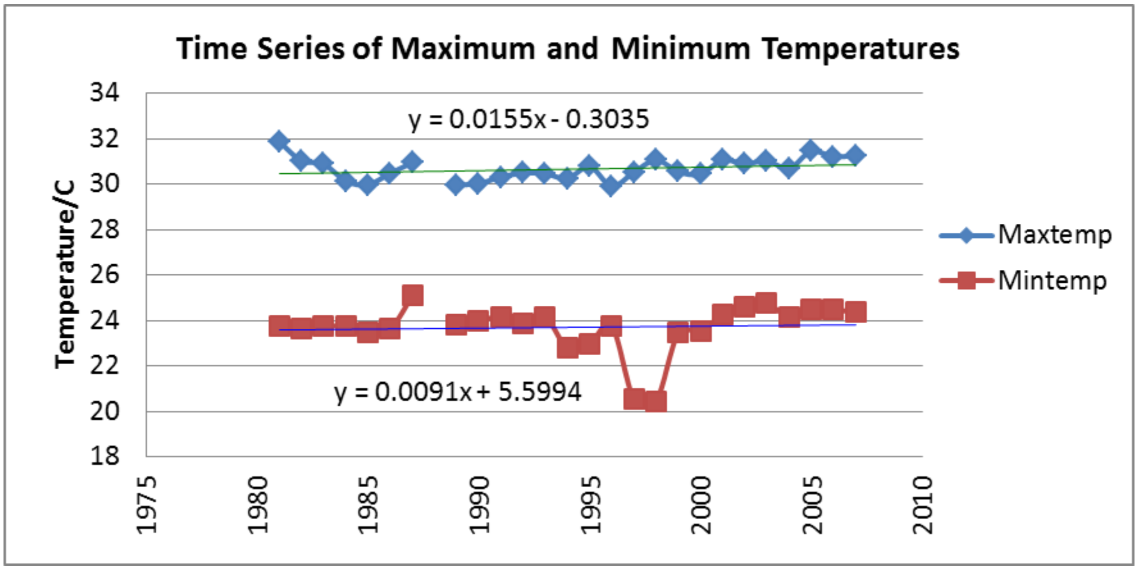


Figure 2.5: Timeseries for Maximum and Minimum Temperatures in °C for the Period 1981 to 2007

2.3 Other Variables

Table 2.5 shows climatological values for selected climate variables for the period 1980-2013. Data was obtained from observations recorded at the R.L. Bradshaw International Airport. Relative humidity tends to be generally high year round (above 73%) and is highest during the late rainfall season. Wind speeds were found to be highest during the dry period (Jan-Feb) and the summer months (Jun-Aug).

Table 2.5: Monthly Mean Values for Relative Humidity, Wind Direction and Wind speed

	Rain (inches)	Temp (°C)	Relative Humidity (%)	Wind Direction (degrees)	Wind speed (knots)
Jan	2.45	25.68	75.13	75.76	11.58
Feb	2.26	25.52	74.04	81.25	11.36
Mar	1.99	25.91	72.77	81.82	10.67
Apr	3.16	26.59	73.91	87.27	10.21
May	4.45	27.42	76.49	89.39	10.00
Jun	2.67	28.18	75.97	81.52	11.39
Jul	3.91	28.29	76.78	73.94	12.55
Aug	4.16	28.51	77.01	76.06	11.24

	Rain (inches)	Temp (°C)	Relative Humidity (%)	Wind Direction (degrees)	Wind speed (knots)
Sep	5.16	28.42	77.51	89.70	9.42
Oct	7.16	28.00	78.57	90.30	8.88
Nov	5.74	27.11	78.18	84.85	9.61
Dec	3.97	26.15	76.67	73.64	10.67
MEAN	**3.92**	**27.15**	**76.09**	**82.12**	**10.63**

2.4 Tropical Cyclones

Tropical cyclone activity in the Caribbean and wider North Atlantic Basin has increased since 1995. Both frequency and duration of hurricanes have increased, as well as the number of intense hurricanes traversing the tropical Atlantic. However, the maximum intensity of hurricanes has remained fairly constant over the recent past. The number of hurricanes impacting St. Kitts and Nevis is represented in Table 2.6 and Figure 2.6. El Niño and La Niña events strongly influence the location and activity of tropical storms. Generally, fewer hurricanes track through the Caribbean during an El Niño and more during a La Niña event.

Hurricanes tend to coincide with incidences of heavy rainfall. For example, the 1990s was shown to be the decade with the highest late season rainfall amounts (Figure 2.2 (d)) and the highest number of hurricanes (Figure 2.4). The period assessed is largely during the low phase of the Atlantic Multi Decadal Oscillation (AMO) with the exception of the late 1990s.

Table 2.6: Tropical Systems Passing within 69 Miles of St. Kitts and Nevis

Year	Month	Name of Hurricane	Type/ Category	Closest point of approach (miles)
1981	Sep	Gert	Tropical Storm	66
1989	Sep	Hugo	Hurricane, Category 4	42
1995	Aug	Iris	Tropical Storm	49
1995	Sep	Luis	Hurricane, Category 4	50
1995	Sep	Marilyn	Hurricane, Category 1	53
1996	Jul	Bertha	Hurricane, Category 1	30
1998	Sep	Georges	Hurricane, Category 3	6

Year	Month	Name of Hurricane	Type/ Category	Closest point of approach (miles)
1999	Oct	Jose	Hurricane, Category 1	17
1999	Nov	Lenny	Hurricane, Category 4	24
2000	Aug	Debby	Hurricane, Category 1	34
2004	Sep	Jeanne	Tropical Storm	57
2007	Dec	Olga	Tropical Storm	69
2009	Sep	Erika	Tropical Storm	62
2010	Aug	Earl	Hurricane, Category 2	69

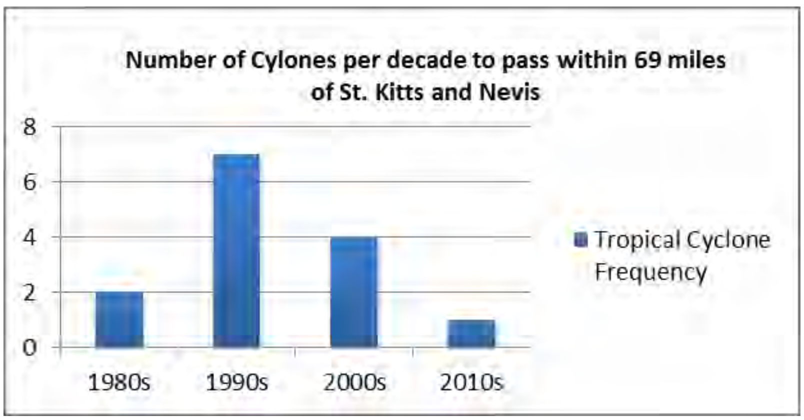


Figure 2.6: Hurricane Frequency by Decade within 69 Miles of St. Kitts and Nevis. Data for the 2010s Stops at 2010

2.5 Sea Level Rise

2.5.1 Global

Using proxy and instrumental data, it is virtually certain (i.e. with 99-100 probability) that the rate of global mean sea level rise has accelerated during the last two centuries, marking the transition from relatively low rates of change during late Holocene (order tenths of mm yr-1) to modern rates (order mm year-1). It is estimated that global sea levels have risen by 0.17 ± 0.05 m over the 20th century (IPCC, 2007; IPCC, 2013). Satellite measurements suggest the rate of rise may have accelerated in recent years to about 3 mm/year since the early 1990s (IPCC, 2007; IPCC, 2013).

2.5.2 Caribbean

Estimates of observed sea level rise from 1950 to 2000 suggest that sea level rise within the Caribbean appears to be near the global mean. Table 2.7 shows the rates of sea level rise for a number of locations in the Caribbean. All values suggest an upward trend. It is important to note that due to shifting surface winds, expansion of warming ocean water and the addition of melting ice, ocean currents can be altered which, in turn leads to changes in sea level that vary from place to place. Additionally, more localized processes such as sediment compaction and tectonics may also contribute to additional variations in sea level.

Table 2.7: Observed Rates of Sea Level Rise for Some Caribbean Stations

Tidal gauge Station	Observation Period	Rates (mm yr^{-1})
Bermuda	1932 –2006	2.04 ± 0.47
San Juan, Puerto Rico	1962 –2006	1.65 ± 0.52
Guantanamo Bay, Cuba	1973 –1971	1.64 ± 0.80
Miami Beach, Florida	1931 –1981	2.39 ± 0.43
Vaca Key, Florida	1971 –2006	2.78 ± 0.60

Source: The State of the Jamaican Climate (2013)

2.5.3 St. Kitts and Nevis

No extended datasets exist for mean sea levels off the coasts of St. Kitts and Nevis. However, the nearest possible sea level measurements at Lime Tree, St. Croix in the US Virgin Islands indicate an increasing trend of 2.45 mm yr-1 from 1978 to 2013 (IPCC, 2007; IPCC, 2013).

3 FUTURE PROJECTIONS

3.1 PRECIS RCM Projections

3.1.1 Presenting the Model Data

Future climate projections at scales relevant to the small size and complex terrain of St Kitts and Nevis (see Figure 3.1) are derived from the PRECIS perturbed physics experiments (PPE). These experiments are at a maximum resolution of 25km and use the A1B SRES scenario as driving conditions. The PPEs, which comprise 17 members (HadCM3Q0-Q16 - otherwise referred to as QUMP ensemble), provide an alternative to using several driving GCM boundary conditions (McSweeney et. al., 2010). Only a subset of 6 - Q0, Q3, Q4, Q10, Q11 and Q14- of the 17 members were selected for the purposes of this study. Jones et al. (2004) and McSweeney et al. (2010) provide a full description of the Regional Climate Model (RCM), PRECIS and QUMP ensemble members.

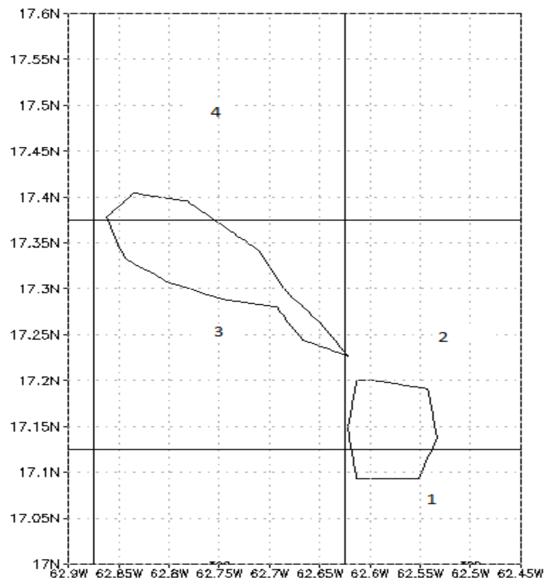


Figure 3.1 PRECIS RCM Grid Boxes 1 through 4 of Study Area at 25 km Resolution

The PRECIS RCM represents the island of St. Kitts and Nevis with 2 grid boxes each, with grid boxes 1 and 2 covering the isle of Nevis and 3 and 4, St. Kitts. These grid boxes form the basis of all the results of temperature (mean, maximum and minimum), precipitation and wind speed detailed in this section. All results cover the following decades: 2020s and 2030s.

3.1.2 Minimum Temperature

Detailed by Table 3.1 and Table 3.2, the mean annual minimum temperatures of St Kitts is projected to increase on average by approximately 1 °C for both the 2020s and 2030s. The mean annual minimum temperatures associated with Nevis are projected to increase by as much as 2°C by the end of the 2030s. For both the 2020s and the 2030s, the projected increases in mean annual minimum temperatures are higher (lower) for the southern (northern) reaches of both islands.

Table 3.1: Projected Change in Minimum Temperature for Grid Boxes over St. Kitts and Nevis for the 2020s.

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	0.690	1.687	2.467	0.831	1.094	1.272	0.923	1.176	1.414	0.821	1.062	1.271
FEB	0.685	1.688	2.469	0.831	1.097	1.273	0.921	1.178	1.414	0.822	1.065	1.272
MAR	0.685	1.691	2.479	0.839	1.101	1.270	0.931	1.182	1.410	0.830	1.069	1.271
APR	0.688	1.700	2.496	0.852	1.108	1.275	0.947	1.190	1.415	0.843	1.077	1.275
MAY	0.698	1.712	2.511	0.864	1.119	1.286	0.962	1.202	1.426	0.854	1.087	1.286

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JUN	0.710	1.726	2.529	0.880	1.130	1.297	0.973	1.213	1.435	0.871	1.099	1.297
JUL	0.718	1.737	2.546	0.895	1.139	1.308	0.978	1.221	1.444	0.885	1.108	1.308
AUG	0.723	1.744	2.557	0.905	1.145	1.316	0.980	1.225	1.450	0.895	1.113	1.316
SEP	0.726	1.748	2.565	0.912	1.147	1.322	0.981	1.227	1.455	0.901	1.116	1.322
OCT	0.733	1.750	2.569	0.918	1.149	1.326	0.986	1.228	1.459	0.906	1.117	1.326
NOV	0.737	1.750	2.566	0.920	1.150	1.333	0.989	1.229	1.466	0.907	1.118	1.333
DEC	0.734	1.745	2.561	0.923	1.148	1.333	0.984	1.227	1.466	0.908	1.115	1.334
NDJ	0.721	1.727	2.532	0.891	1.131	1.313	0.976	1.210	1.449	0.879	1.098	1.313
FMA	0.686	1.693	2.481	0.841	1.102	1.273	0.933	1.184	1.413	0.831	1.070	1.273
MJJ	0.709	1.725	2.528	0.880	1.129	1.297	0.972	1.212	1.435	0.870	1.098	1.297
ASO	0.727	1.747	2.564	0.912	1.147	1.321	0.982	1.226	1.455	0.901	1.116	1.321
ANNUAL	0.711	1.723	2.526	0.881	1.127	1.301	0.971	1.208	1.438	0.870	1.096	1.301

Table 3.1 and Table 3.2 show a high degree of consensus as it concerns projected changes to minimum temperature for both islands, as the minimum projected change is greater than 0.6 in all instances. The maximum projected change in minimum temperature is never less than 1°C at both the monthly and seasonal time scales.

Table 3.2: Projected Change in Minimum Temperature for Grid Boxes over St. Kitts and Nevis for the 2030s.

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	0.928	1.970	2.729	1.102	1.401	1.649	1.194	1.493	1.839	1.094	1.357	1.630
FEB	0.928	1.968	2.727	1.100	1.400	1.648	1.192	1.493	1.836	1.092	1.356	1.628
MAR	0.931	1.968	2.729	1.101	1.401	1.649	1.192	1.493	1.838	1.093	1.357	1.629
APR	0.938	1.971	2.729	1.098	1.402	1.647	1.189	1.493	1.832	1.090	1.358	1.628
MAY	0.945	1.977	2.734	1.102	1.408	1.656	1.196	1.500	1.840	1.093	1.363	1.635
JUN	0.951	1.984	2.734	1.100	1.412	1.663	1.197	1.504	1.845	1.092	1.368	1.644

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JUL	0.953	1.988	2.733	1.098	1.415	1.667	1.196	1.506	1.847	1.090	1.371	1.646
AUG	0.955	1.992	2.731	1.094	1.417	1.667	1.194	1.508	1.845	1.087	1.373	1.647
SEP	0.959	1.993	2.728	1.091	1.418	1.665	1.191	1.508	1.839	1.083	1.374	1.645
OCT	0.962	1.994	2.721	1.085	1.418	1.664	1.185	1.508	1.838	1.077	1.373	1.643
NOV	0.964	1.991	2.708	1.073	1.415	1.660	1.171	1.504	1.833	1.067	1.370	1.639
DEC	0.963	1.983	2.690	1.062	1.409	1.656	1.162	1.499	1.828	1.055	1.365	1.635
NDJ	0.951	1.981	2.709	1.079	1.408	1.655	1.175	1.499	1.833	1.072	1.364	1.635
FMA	0.932	1.969	2.728	1.100	1.401	1.648	1.191	1.493	1.835	1.092	1.357	1.628
MJJ	0.950	1.983	2.734	1.100	1.412	1.662	1.197	1.503	1.844	1.092	1.368	1.642
ASO	0.959	1.993	2.727	1.090	1.418	1.666	1.190	1.508	1.841	1.082	1.373	1.645
ANNUAL	0.948	1.982	2.725	1.092	1.410	1.658	1.188	1.501	1.838	1.084	1.366	1.638

3.1.3 Maximum Temperature

As was the case with annual minimum temperatures, the projected changes in annual maximum temperature for the southern regions of both islands (Grid boxes 1 and 3) is higher than the projected change associated with the northern extent (respectively Grid boxes 2 and 4). However, unlike the changes in annual minimum temperature, the highest projected changes were not associated with grid box 1 (Nevis), but rather with grid box 3 (St Kitts).

Table 3.3: Projected Change in Maximum Temperature for Grid Boxes over St. Kitts and Nevis for the 2020s

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	0.848	1.058	1.216	0.914	1.095	1.338	0.913	1.423	2.289	0.847	1.054	1.221
FEB	0.851	1.061	1.216	0.915	1.099	1.346	0.912	1.426	2.287	0.850	1.059	1.221
MAR	0.857	1.065	1.220	0.918	1.104	1.355	0.914	1.432	2.299	0.857	1.062	1.222
APR	0.868	1.072	1.229	0.925	1.110	1.363	0.921	1.439	2.315	0.869	1.069	1.229
MAY	0.874	1.080	1.237	0.933	1.116	1.369	0.929	1.443	2.305	0.874	1.077	1.237
JUN	0.889	1.091	1.250	0.938	1.125	1.379	0.934	1.450	2.315	0.890	1.089	1.250

JUL	0.901	1.097	1.258	0.940	1.130	1.379	0.936	1.449	2.315	0.902	1.096	1.259
AUG	0.907	1.102	1.265	0.944	1.134	1.382	0.940	1.450	2.307	0.904	1.101	1.267
SEP	0.912	1.106	1.270	0.950	1.137	1.385	0.946	1.452	2.306	0.908	1.105	1.273
OCT	0.912	1.106	1.271	0.955	1.138	1.379	0.954	1.451	2.310	0.914	1.106	1.274
NOV	0.914	1.106	1.278	0.959	1.139	1.377	0.955	1.457	2.324	0.917	1.106	1.281
DEC	0.916	1.104	1.279	0.957	1.140	1.381	0.953	1.463	2.341	0.910	1.104	1.282
NDJ	0.895	1.090	1.257	0.944	1.125	1.365	0.940	1.448	2.318	0.895	1.088	1.261
FMA	0.861	1.066	1.220	0.919	1.104	1.354	0.916	1.432	2.300	0.859	1.063	1.222
MJJ	0.896	1.091	1.248	0.937	1.124	1.376	0.933	1.447	2.312	0.889	1.088	1.249
ASO	0.918	1.106	1.268	0.950	1.136	1.382	0.946	1.451	2.308	0.909	1.104	1.270
ANNUAL	0.892	1.088	1.245	0.938	1.122	1.369	0.934	1.444	2.309	0.889	1.086	1.247

The similarities between the changes in minimum and maximum temperatures also extend to the monthly time scale for the 2020s, with largest projected changes occurring in the latter 3 months of the year; mean projected changes above 1 degree; and a maximum change of above 2 degrees (see Table 3.3). Similar results were gleaned for the 2030s (Table 3.4), however the summer months (June, July, August, September) registered the highest projected changes.

Table 3.4: Projected Change in Maximum Temperature for Grid Boxes over St. Kitts and Nevis for the 2030s.

	GRID BOX 1			**GRID BOX 2**			**GRID BOX 3**			**GRID BOX 4**		
	MIN	**MEAN**	**MAX**	**MIN**	**MEAN**	**MAX**	**MIN**	**MEAN**	**MAX**	**MIN**	**MEAN**	**MAX**
JAN	1.135	1.352	1.555	1.183	1.438	1.601	1.412	1.753	2.522	1.150	1.359	1.561
FEB	1.133	1.352	1.555	1.179	1.439	1.595	1.416	1.754	2.520	1.147	1.359	1.561
MAR	1.132	1.352	1.557	1.178	1.439	1.592	1.413	1.754	2.519	1.147	1.359	1.563
APR	1.129	1.352	1.556	1.176	1.436	1.585	1.410	1.752	2.523	1.143	1.358	1.560
MAY	1.135	1.356	1.561	1.189	1.442	1.590	1.409	1.762	2.549	1.149	1.362	1.564
JUN	1.134	1.359	1.569	1.188	1.445	1.587	1.415	1.766	2.556	1.148	1.366	1.572
JUL	1.129	1.361	1.572	1.185	1.446	1.593	1.417	1.766	2.555	1.144	1.368	1.575
AUG	1.125	1.363	1.573	1.182	1.448	1.591	1.419	1.767	2.555	1.140	1.370	1.576
SEP	1.120	1.364	1.574	1.175	1.449	1.588	1.425	1.766	2.552	1.135	1.371	1.578

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
OCT	1.112	1.364	1.573	1.169	1.449	1.588	1.430	1.765	2.553	1.128	1.370	1.577
NOV	1.102	1.360	1.566	1.160	1.446	1.581	1.432	1.762	2.550	1.117	1.367	1.569
DEC	1.089	1.355	1.563	1.147	1.444	1.580	1.433	1.762	2.540	1.104	1.362	1.567
NDJ	1.111	1.356	1.561	1.163	1.443	1.587	1.426	1.759	2.537	1.124	1.362	1.566
FMA	1.134	1.352	1.556	1.178	1.438	1.590	1.413	1.753	2.520	1.146	1.358	1.561
MJJ	1.141	1.360	1.567	1.187	1.444	1.587	1.413	1.765	2.553	1.147	1.365	1.571
ASO	1.126	1.365	1.573	1.175	1.449	1.588	1.425	1.766	2.554	1.134	1.370	1.577
ANNUAL	1.127	1.358	1.565	1.176	1.443	1.588	1.419	1.761	2.541	1.138	1.364	1.569

3.1.4 Mean Temperature

Annual mean temperatures are projected to increase by a minimum of 0.8 degrees or a maximum of approximately 1.75 degrees, over the 2020s and 2030s (Tables 3.5 and 3.6). The changes however projected for the 2030s are relatively greater than those associated with the 2020s. The maximum change in mean temperature is lower than the maximum changes projected for both maximum and minimum temperature. Again, the greatest variations were noted in the summer months, but unlike both maximum and minimum temperature, the largest changes were not confined to just the southern extent. Nevis registered greater changes in its northern extent, whilst the southern region of St. Kitts was projected to have slightly higher increases in mean temperature.

Table 3.5: Projected Change in Average Temperature for Grid Boxes over St. Kitts and Nevis for the 2020s.

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	0.807	1.050	1.233	0.861	1.088	1.255	0.930	1.177	1.491	0.828	1.055	1.241
FEB	0.810	1.053	1.235	0.863	1.092	1.262	0.928	1.180	1.497	0.831	1.058	1.242
MAR	0.818	1.057	1.233	0.871	1.096	1.270	0.929	1.185	1.506	0.838	1.062	1.239
APR	0.831	1.064	1.237	0.883	1.103	1.278	0.935	1.193	1.513	0.850	1.070	1.243
MAY	0.840	1.074	1.247	0.889	1.111	1.286	0.944	1.200	1.520	0.859	1.079	1.253
JUN	0.857	1.085	1.259	0.904	1.122	1.299	0.951	1.209	1.532	0.875	1.091	1.265
JUL	0.870	1.093	1.269	0.915	1.129	1.305	0.954	1.212	1.533	0.888	1.099	1.275

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
AUG	0.879	1.098	1.278	0.921	1.133	1.310	0.957	1.214	1.533	0.897	1.104	1.284
SEP	0.885	1.101	1.284	0.925	1.136	1.315	0.960	1.215	1.534	0.902	1.107	1.290
OCT	0.887	1.103	1.290	0.927	1.138	1.313	0.967	1.215	1.526	0.905	1.109	1.295
NOV	0.889	1.103	1.296	0.929	1.138	1.311	0.969	1.217	1.524	0.907	1.109	1.303
DEC	0.890	1.100	1.297	0.934	1.137	1.313	0.965	1.219	1.532	0.909	1.106	1.303
NDJ	0.862	1.084	1.276	0.908	1.121	1.293	0.955	1.204	1.516	0.881	1.090	1.282
FMA	0.820	1.058	1.235	0.872	1.097	1.270	0.931	1.186	1.506	0.839	1.063	1.241
MJJ	0.856	1.084	1.259	0.903	1.121	1.296	0.949	1.207	1.528	0.874	1.090	1.265
ASO	0.884	1.101	1.284	0.924	1.136	1.313	0.961	1.214	1.531	0.901	1.107	1.290
ANNUAL	0.855	1.082	1.263	0.902	1.119	1.293	0.949	1.203	1.520	0.874	1.087	1.269

Table 3.6: Projected Change in Average Temperature for Grid Boxes over St. Kitts and Nevis for the 2030s.

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	1.080	1.337	1.583	1.136	1.411	1.604	1.236	1.494	1.763	1.117	1.352	1.590
FEB	1.078	1.337	1.583	1.133	1.411	1.604	1.232	1.494	1.757	1.115	1.352	1.589
MAR	1.079	1.338	1.585	1.133	1.412	1.607	1.231	1.494	1.753	1.116	1.353	1.591
APR	1.076	1.338	1.584	1.131	1.411	1.604	1.229	1.492	1.746	1.112	1.353	1.589
MAY	1.079	1.343	1.590	1.138	1.416	1.610	1.248	1.500	1.755	1.116	1.357	1.595
JUN	1.078	1.347	1.598	1.137	1.420	1.617	1.250	1.503	1.752	1.115	1.362	1.603
JUL	1.074	1.349	1.601	1.134	1.422	1.622	1.249	1.505	1.749	1.112	1.364	1.605
AUG	1.071	1.351	1.601	1.130	1.424	1.620	1.247	1.506	1.754	1.108	1.366	1.606
SEP	1.067	1.352	1.602	1.125	1.425	1.620	1.242	1.505	1.748	1.104	1.367	1.607
OCT	1.060	1.352	1.600	1.119	1.425	1.620	1.238	1.505	1.745	1.097	1.367	1.606
NOV	1.050	1.348	1.595	1.109	1.422	1.613	1.228	1.500	1.740	1.087	1.363	1.600

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
DEC	1.038	1.343	1.591	1.097	1.418	1.611	1.217	1.498	1.741	1.075	1.358	1.597
NDJ	1.056	1.343	1.590	1.114	1.417	1.609	1.227	1.498	1.748	1.093	1.358	1.596
FMA	1.078	1.337	1.584	1.132	1.411	1.605	1.231	1.493	1.752	1.114	1.352	1.589
MJJ	1.077	1.346	1.596	1.136	1.419	1.616	1.249	1.503	1.752	1.115	1.361	1.601
ASO	1.066	1.351	1.601	1.125	1.425	1.620	1.243	1.505	1.749	1.103	1.367	1.606
ANNUAL	1.069	1.344	1.593	1.127	1.418	1.613	1.237	1.500	1.750	1.106	1.360	1.598

3.1.5 Wind Speed

The minimum projected changes in wind speed for the 2020s and 2030s are all negative. This means that at minimum, as illustrated by Table 3.7 and Table 3.8, wind speeds are projected to decrease for both St Kitts and Nevis. A similar consensus can be seen when the maximum possible projected change associated with wind speed is examined, as a projected increase was noted for all grid boxes. The minimum changes noted in wind speed were lower for the 2030s when compared to the 2020s; the opposite was true for the changes in possible projected maximum. All the above were true irrespective of time scale (annually, monthly or seasonally).

Table 3.7: Projected Change in Wind Speed for Grid Boxes over St. Kitts and Nevis for the 2020s

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	-0.174	-0.010	0.057	-0.163	-0.002	0.071	-0.155	0.015	0.113	-0.160	0.001	0.061
FEB	-0.151	-0.015	0.060	-0.140	-0.006	0.062	-0.134	0.011	0.091	-0.140	-0.003	0.055
MAR	-0.163	-0.014	0.058	-0.152	-0.005	0.060	-0.146	0.011	0.094	-0.151	-0.002	0.053
APR	-0.185	-0.018	0.051	-0.173	-0.009	0.054	-0.166	0.008	0.096	-0.171	-0.006	0.045
MAY	-0.181	-0.019	0.044	-0.168	-0.010	0.055	-0.161	0.007	0.094	-0.166	-0.007	0.052
JUN	-0.162	-0.019	0.038	-0.152	-0.010	0.052	-0.145	0.007	0.095	-0.150	-0.007	0.046
JUL	-0.143	-0.015	0.045	-0.133	-0.007	0.053	-0.129	0.009	0.095	-0.133	-0.003	0.047
AUG	-0.124	-0.012	0.048	-0.115	-0.005	0.050	-0.112	0.010	0.087	-0.116	-0.002	0.044
SEP	-0.099	-0.011	0.040	-0.092	-0.004	0.048	-0.090	0.010	0.080	-0.093	-0.002	0.045

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
OCT	-0.095	-0.016	0.051	-0.086	-0.009	0.062	-0.086	0.005	0.073	-0.089	-0.006	0.061
NOV	-0.090	-0.011	0.059	-0.082	-0.003	0.071	-0.081	0.011	0.085	-0.085	0.000	0.070
DEC	-0.094	0.002	0.060	-0.086	0.011	0.075	-0.086	0.024	0.107	-0.091	0.014	0.074
NDJ	-0.119	-0.006	0.058	-0.110	0.002	0.071	-0.107	0.017	0.102	-0.112	0.005	0.068
FMA	-0.166	-0.015	0.056	-0.155	-0.007	0.059	-0.149	0.010	0.094	-0.154	-0.004	0.051
MJJ	-0.162	-0.017	0.039	-0.151	-0.009	0.052	-0.145	0.007	0.095	-0.150	-0.006	0.046
ASO	-0.106	-0.013	0.042	-0.098	-0.006	0.052	-0.096	0.008	0.080	-0.100	-0.003	0.050
ANNUAL	-0.138	-0.013	0.044	-0.129	-0.005	0.056	-0.124	0.011	0.092	-0.129	-0.002	0.052

For the 2030s, the mean wind speed is projected to increase for all areas. This consensus was missing for the 2020s as, apart from the southern extent of St Kitts (Grid Box 3), only the month of December was projected to consistently have an increase for Grid Boxes 1, 2 and 4.

Table 3.8: Projected Change in Wind Speed for Grid Boxes over St. Kitts and Nevis for the 2030s

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	-0.091	0.006	0.185	-0.075	0.025	0.196	-0.051	0.033	0.214	-0.073	0.015	0.212
FEB	-0.090	0.008	0.188	-0.075	0.027	0.199	-0.052	0.035	0.216	-0.073	0.016	0.214
MAR	-0.089	0.009	0.191	-0.075	0.028	0.202	-0.050	0.036	0.218	-0.070	0.018	0.217
APR	-0.079	0.019	0.204	-0.072	0.036	0.213	-0.045	0.043	0.227	-0.053	0.027	0.228
MAY	-0.073	0.019	0.213	-0.063	0.037	0.222	-0.039	0.045	0.238	-0.052	0.028	0.238
JUN	-0.068	0.026	0.227	-0.060	0.043	0.234	-0.041	0.051	0.248	-0.052	0.035	0.251
JUL	-0.068	0.030	0.225	-0.054	0.047	0.231	-0.056	0.054	0.243	-0.066	0.039	0.249
AUG	-0.076	0.031	0.239	-0.062	0.048	0.243	-0.064	0.055	0.255	-0.073	0.040	0.261
SEP	-0.085	0.023	0.226	-0.079	0.040	0.231	-0.067	0.048	0.243	-0.077	0.032	0.249
OCT	-0.106	0.021	0.218	-0.099	0.038	0.223	-0.075	0.045	0.235	-0.073	0.029	0.240
NOV	-0.103	0.033	0.233	-0.097	0.049	0.236	-0.075	0.055	0.247	-0.058	0.041	0.254
DEC	-0.096	0.036	0.227	-0.091	0.051	0.230	-0.068	0.058	0.243	-0.052	0.042	0.247

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
NDJ	-0.094	0.025	0.215	-0.088	0.042	0.221	-0.064	0.049	0.235	-0.048	0.033	0.238
FMA	-0.083	0.012	0.194	-0.074	0.030	0.204	-0.047	0.038	0.220	-0.065	0.020	0.220
MJJ	-0.065	0.025	0.222	-0.057	0.042	0.229	-0.045	0.050	0.243	-0.055	0.034	0.246
ASO	-0.085	0.025	0.228	-0.080	0.042	0.232	-0.065	0.049	0.244	-0.074	0.033	0.250
ANNUAL	-0.081	0.022	0.215	-0.075	0.039	0.222	-0.050	0.047	0.236	-0.053	0.030	0.238

3.1.6 Rainfall

Table 3.9 and Table 3.10 show the projected percentage change in rainfall for the islands of St Kitts and Nevis for the 2020s and 2030s, respectively. On the annual scale for both the 2020s and 2030s, the southern extent of St Kitts (Grid 3) and Nevis (Grid 1) are projected to have reductions in rainfall. Reductions range from approximately 3 to 7% for the associated region of Nevis and 6 to 11% for St. Kitts. This projected decrease is seen in the 2030s for Northern Nevis, but is reversed for the 2020s as a marginal increase is projected to occur. Additionally, an increase of approximately 25% is evident for northern St. Kitts for both decades.

Table 3.9: Projected Percentage Change in Rainfall for Grid Boxes over St. Kitts and Nevis for the 2020s

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	-28.867	-4.705	13.943	-20.140	-0.539	19.200	-26.631	-7.658	3.590	-15.218	27.301	137.611
FEB	-28.978	-4.678	13.742	-20.093	-0.430	18.973	-26.529	-7.511	3.531	-14.987	27.508	137.221
MAR	-28.816	-4.583	14.276	-19.967	-0.363	19.529	-26.523	-7.487	4.031	-14.570	27.745	137.800
APR	-28.666	-4.444	14.902	-19.801	-0.150	20.365	-26.370	-7.230	5.062	-14.357	28.126	139.441
MAY	-28.419	-4.221	15.009	-19.537	0.192	20.409	-26.190	-7.057	4.543	-14.092	28.227	139.009
JUN	-28.165	-4.381	13.478	-19.130	0.252	19.091	-25.792	-6.886	3.505	-14.001	27.853	136.138
JUL	-27.518	-4.108	12.609	-18.023	0.582	17.617	-24.932	-6.380	4.769	-13.216	28.084	134.952
AUG	-27.046	-4.124	11.359	-17.398	0.382	15.718	-24.099	-6.197	4.977	-12.730	27.854	132.527
SEP	-26.678	-4.362	10.548	-16.801	0.116	13.739	-23.468	-6.140	5.093	-12.388	27.510	130.967
OCT	-25.844	-4.342	10.098	-15.685	-0.029	12.648	-22.381	-6.141	4.252	-10.405	27.697	131.070
NOV	-25.434	-4.362	7.697	-15.436	-0.032	11.385	-22.800	-6.593	2.577	-9.516	27.616	127.701

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
DEC	-27.042	-5.065	6.608	-16.642	-0.782	10.283	-24.178	-7.371	2.154	-11.683	26.378	124.105
NDJ	-27.129	-4.715	9.224	-17.425	-0.279	14.339	-24.551	-7.210	2.233	-12.160	27.099	129.836
FMA	-28.820	-4.568	14.306	-19.954	-0.094	20.726	-26.474	-7.409	4.208	-14.638	27.793	138.154
MJJ	-28.034	-4.237	13.697	-18.897	0.569	20.176	-25.638	-6.774	3.548	-13.770	28.055	136.700
ASO	-26.523	-4.277	10.668	-16.628	0.421	15.359	-23.316	-6.160	4.774	-11.841	27.686	131.522
ANNUAL	-26.433	-3.733	13.561	-18.229	0.181	17.789	-24.997	-6.888	3.194	-13.105	27.659	134.060

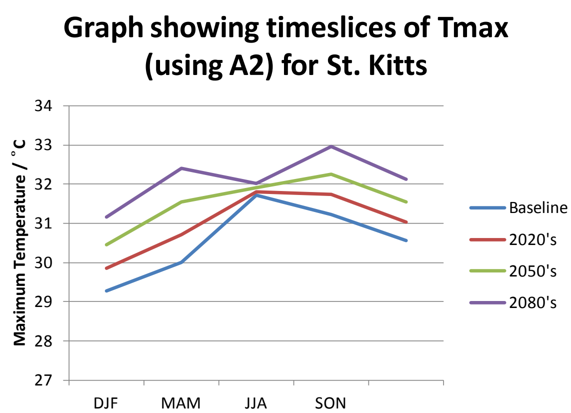
Table 3.10: Projected Percentage Change in Rainfall for Grid Boxes over St. Kitts and Nevis for the 2030s

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
JAN	-31.751	-8.322	20.799	-29.870	-4.222	21.303	-33.784	-11.094	15.846	-28.918	22.966	113.043
FEB	-32.108	-8.280	20.723	-30.203	-4.131	21.252	-34.201	-10.987	15.853	-29.336	23.070	113.304
MAR	-32.053	-8.041	20.695	-30.124	-3.909	21.177	-34.049	-10.772	15.756	-29.127	23.519	113.992
APR	-32.136	-7.819	20.731	-30.174	-3.651	21.306	-34.082	-10.603	15.885	-29.157	23.814	114.355
MAY	-32.191	-8.047	21.134	-30.261	-3.871	21.747	-34.230	-10.942	16.310	-29.278	23.763	117.535
JUN	-32.184	-8.613	21.287	-30.469	-4.117	21.880	-34.564	-11.553	16.309	-29.514	23.197	114.503
JUL	-32.498	-8.368	21.333	-30.976	-3.899	21.125	-35.093	-11.524	15.487	-29.949	23.744	116.344
AUG	-33.273	-8.206	21.863	-31.925	-3.626	21.954	-35.686	-11.262	16.663	-30.567	24.262	117.949
SEP	-34.440	-7.932	21.865	-33.352	-3.551	21.830	-36.733	-11.011	16.952	-31.941	24.419	118.379
OCT	-35.247	-7.669	22.085	-34.098	-3.546	21.646	-37.172	-10.977	16.674	-32.385	24.656	118.955
NOV	-35.745	-7.303	26.026	-34.856	-3.557	24.470	-37.832	-11.245	19.254	-32.861	24.835	118.097
DEC	-36.007	-9.149	22.827	-35.294	-5.199	21.880	-38.340	-12.794	17.176	-33.231	21.882	108.378
NDJ	-34.509	-8.264	23.197	-33.350	-4.166	22.543	-36.660	-11.711	17.415	-31.676	23.225	113.180
FMA	-32.099	-8.047	20.716	-30.167	-3.702	21.245	-34.111	-10.787	15.831	-29.207	23.468	113.884

	GRID BOX 1			GRID BOX 2			GRID BOX 3			GRID BOX 4		
	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX	MIN	MEAN	MAX
MJJ	-32.291	-8.343	21.251	-30.569	-3.758	21.584	-34.629	-11.340	16.035	-29.580	23.568	116.127
ASO	-34.323	-7.936	21.938	-33.128	-3.324	21.810	-36.532	-11.084	16.763	-31.634	24.445	118.427
ANNUAL	-33.819	-7.287	23.782	-31.809	-3.713	21.793	-35.487	-11.231	16.508	-30.528	23.676	115.407

3.2 Results from a Statistical Downscaling Model (SDSM)

The general trend for St. Kitts is an increase in maximum temperature (Tmax) for all the time-slices (i.e. 2020s, 2050s and 2080s). For the JJA period, however, the increase from the baseline is small for all time-slices; a change of 0.3˚C by 2080s for the A2 scenario and 0.2 ˚C for B2. Annual changes include a projected overall increase of 1.6 ˚C for A2 and 1.2˚C for B2 by 2080s. For the short term (2020s), Tmax is expected to increase by 0.5˚C for A2 and 0.6˚C for B2 scenario. For the 2050s, Tmax is expected to increase by 1.0 ˚C for A2 and 0.8˚C for B2. See table below for other seasonal changes.



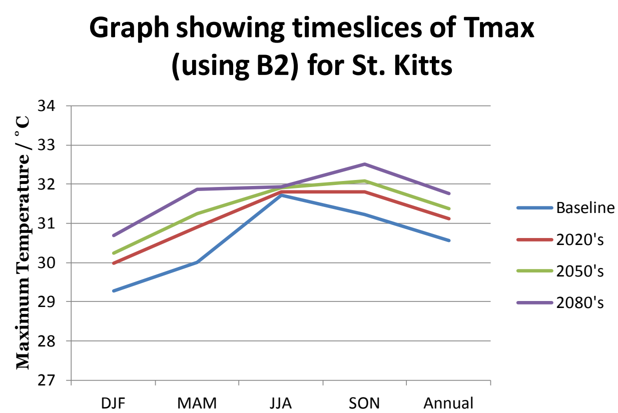


Figure 3.2: Projections of Seasonal and Annual Maximum Temperature for St. Kitts under the (A) A2 and (B) B2 Scenarios

Table 3.11: Projected Changes in Annual and Seasonal Maximum Temperature

	Tmax					
	A2			B2		
	2020's	2050's	2080's	2020's	2050's	2080's
DJF	0.6	1.2	1.9	0.7	1.0	1.4
MAM	0.7	1.6	2.4	0.9	1.2	1.9
JJA	0.1	0.2	0.3	0.1	0.2	0.2
SON	0.5	1.0	1.7	0.6	0.9	1.3
Annual	0.5	1.0	1.6	0.6	0.8	1.2

The overall trend was determined to be an increase in warm days and decrease in cool days for the short term (2020s) and long term (2050s and 2080s) for both A2 and B2 scenarios. This projected future warming is consistent with Campbell et al. (2011).

Cool days are decreasing and it was most noticeable in the winter months (DJF) for St. Kitts for the long term and short term. Hence, the most significant warming would take place in the winter season. Cool days had no significant change in the summer (JJA).

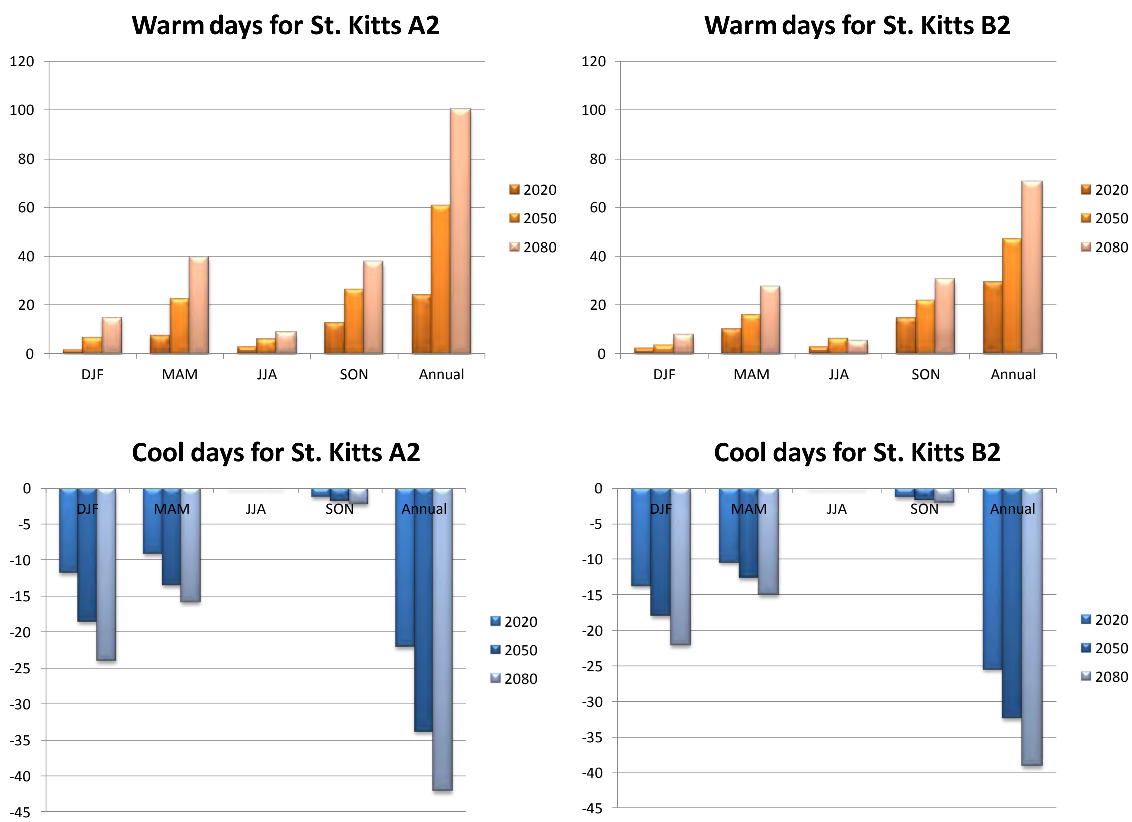


Figure 3.3: Projected Changes in Warm Days, Warm Nights, Cool Days and Cool Nights under A2 and B2 Scenarios

3.3 SLR Projections

3.3.1 Projected Trends

Global and Caribbean

Estimates of future global mean sea level were obtained from observations and GCM results reported by IPCC Working Group1 for IPCC Fourth and Fifth Assessment Reports (IPCC 2007, IPCC 2013). According to the Fourth Assessment Report by the end of the century, sea levels are also expected to rise by 0.21m to 0.48m under an A1B (medium emissions) scenario or by 0.26-0.59 m under the highest emissions scenario, A1F1, but the models exclude future rapid dynamical changes in ice flow. One study suggests that the rate of rise may actually double as noted for A1B (Science Daily, Feb. 12, 2008).

Table 3.12: Projected Increases in Global Mean Surface Temperature and Global and Caribbean Mean Sea Level from the IPCC (2007) Contrasted with those of Rahmstorf (2007). Projections are by 2100 Relative to 1980-1999. Source: CARIBSAVE Climate Change Risk Atlas – St. Kitts (2011)

Scenario	Global mean surface temperature (°C)	Global mean sea level rise (m)	Caribbean mean sea level rise (±0.05m) relative to global mean
IPCC B1	1.1 – 2.9	0.18 – 0.38	0.14 – 0.43
IPCC A1B	1.7 – 4.4	0.21 – 0.48	0.16 – 0.53
IPCC A2	2.0 – 5.4	0.23 – 0.51	0.18 – 0.56
Rahmstorf, 2007	-	Up to 1.4 m	Up to 1.4 m

Higher projections of sea level rise are noted in the IPCC Fifth Assessment Report (AR5) in comparison to the Fourth Assessment Report (AR5). This is considered to be primarily due to the improved modeling of land-ice contributions. There is also higher confidence in the projections of sea level rise in the latter report due to improved understanding of the components of sea level, improved agreement of process-based models with observations, and the inclusion of ice-sheet dynamical changes. AR5 notes that the basis for higher projections of global mean sea level was considered but it was concluded that there is currently insufficient evidence to evaluate the probability of specific levels above the assessed *likely* rate. AR5 notes that sea level rise will not be uniform and indicates that it is *very likely* that sea level will rise in more than about 95% of the ocean area. Approximately 70 % of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change.

It is useful to note that for the SRES A1B which was assessed in AR4, the likely range based on the science assessed in the AR5 is 0.60 [0.41-0.79] m by 2100 relative to 1986-2005 and 0.57 [0.40-0.75] m by 2090-2099 relative to 1990. Compared with the AR4 projection of 0.21-0.48 m for the same scenario and period, the largest increase is from the inclusion of rapid changes in Greenland and Antarctic ice-sheet outflow.

Table 3.13: Projected Increases in Global Mean Surface Temperature and Global Mean Sea Level. Projections Are Taken From IPCC (2013) and Are Relative to 1986-2005

Variable	Scenario	2046 – 2065		2081 – 2100	
		Mean	Likely range	Mean	Likely range
Global Mean Surface Temperature Change(°C)	RCP2.6	1.0	0.4 – 1.6	1.0	0.3 – 1.7
	RCP4.5	1.4	0.9 – 2.0	1.8	1.1 – 2.6
	RCP6.0	1.3	0.8 – 1.8	2.2	1.4 – 3.1
	RCP8.5	2.0	1.4 – 2.6	3.7	2.6 – 4.8

Variable	Scenario	2046 – 2065		2081 – 2100	
		Mean	Likely range	Mean	Likely range
Global Mean Sea Level Rise (m)	RCP2.6	0.24	0.17 – 0.32	0.40	0.26 – 0.55
	RCP4.5	0.26	0.19 – 0.33	0.47	0.32 – 0.63
	RCP6.0	0.25	0.18 – 0.32	0.48	0.33 – 0.63
	RCP8.5	0.30	0.22 – 0.38	0.63	0.45 – 0.82

3.4 Summary

Annual rainfall for stations in St. Kitts depicts relatively significant inter-annual variability, with a slight decreasing trend in rainfall for the period 1930 to 2006. Stations close to the north coast (northwest and north-central sections) of the island generally received more annual average rainfall than the other stations.

The month of May is the typical peak for the early rainfall season, receiving largest rainfall amounts for the first six months of the year. For the late rainfall season, highest rainfall totals are generally obtained in November. Several of the stations within St. Kitts exhibit a tri-modal pattern, with two peaks within the late rainfall season.

Maximum and minimum temperatures within the islands show a slight increasing trend for the period 1981-2007, with July-August generally as the warmest months of the year. On average, minimum, mean and maximum temperatures are projected to increase from present through to the 2030s for St. Kitts and Nevis. Mean temperature increases are generally between 1 ^{o}C and 2 ^{o}C.

Mean annual rainfall for St. Kitts and Nevis is projected to decrease by the 2030s, with the exception of the northern extent of St. Kitts, which is expected to experience an increase in mean annual rainfall. Reductions in rainfall range from approximately 3% to 7% for Nevis and 6% to 11% for southern St. Kitts.

The projected changes in wind speed for St. Kitts and Nevis are small, with slight mean annual increases projected for the 2030s.

IPCC projections indicate that sea levels will rise by 0.3m to 1m by the end of the 21st century. However, a number of other studies have predicted higher increases. It is therefore likely that the islands of St. Kitts and Nevis will be further impacted by rising sea levels by the 2030s.

4 WATER SECTOR VULNERABILITY ISSUES AND THREATS

St. Kitts and Nevis have several factors that affect the vulnerability of the water sector. These include: unknown hydrogeology characteristics in the upper catchment and around the island; undefined watersheds; unknown catchment response to rainfall and pumping; a lack of geo-referenced hydrological data and availability of raw data in appropriate electronic format (reservoirs, rainfall stations etc.); leakage within the distribution network and within reservoirs; aged infrastructure; lack of continuous monitoring of rainfall, streamflow and groundwater head; droughts, flooding and climate change.

The exposure of the water sector to these issues are discussed under the following headings:

1. Underlying hydrological characteristics
2. Water resources and threats
3. Water supply
4. Flooding
5. Drought
6. Water demand, production and consumers
7. Calculated water scarcity indices
8. Analysis of vulnerability to future climate risks for the water sector

4.1 Underlying Hydrological Characteristics

Watersheds, topography and geology, water resources, water supply, rainfall trends and analysis, droughts, and flooding are discussed below.

4.1.1 Watersheds

4.1.1.1 St. Kitts

St. Kitts has approximately 31 surface water systems as delineated watersheds, and one major groundwater basin, which is the Basseterre Valley Aquifer system (Figure 4.1). There is a radial flow pattern from the upper portion of the catchments surrounding peaks of Mount Liamuiga, Canada and Conaree Hills to the groundwater wells and this fully penetrates the aquifer. This flow is interrupted only by the relatively minor volcanic cones at Brimstone Hill, Ottley's Mountain, Sandy Point Hill and Monkey Hill.

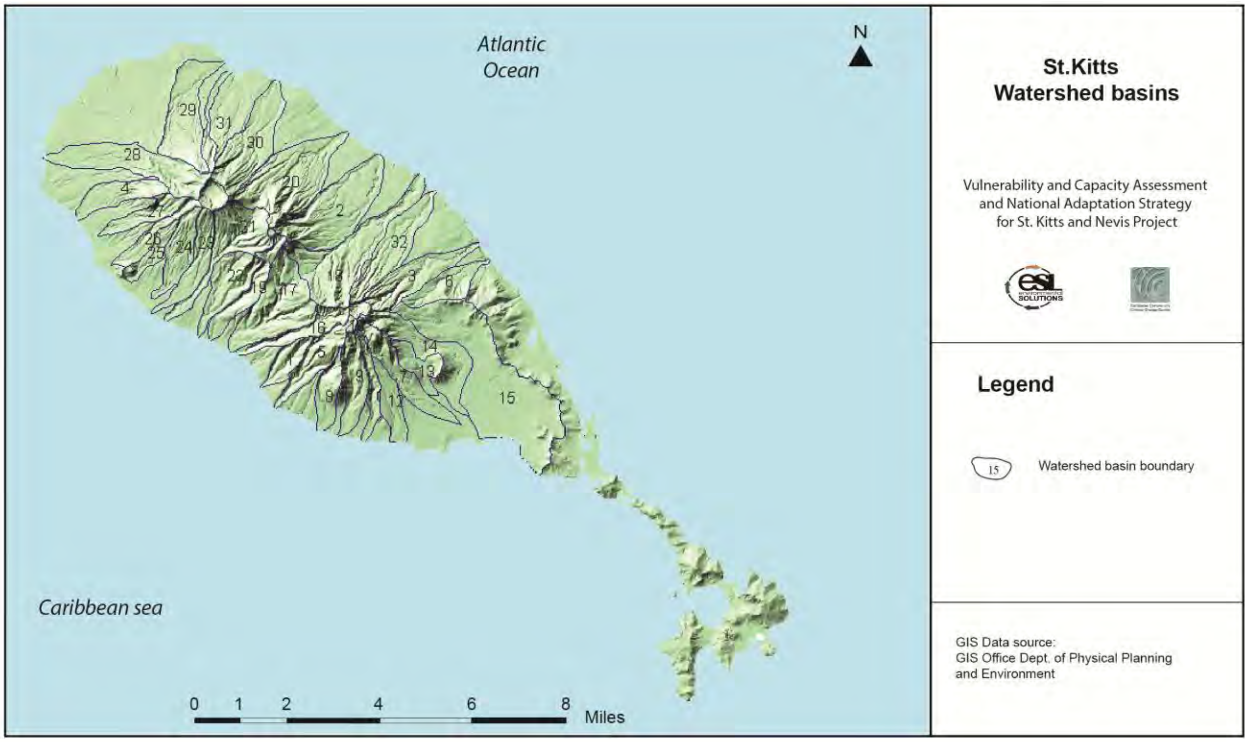


Figure 4.1: St. Kitts Watershed Map

Some of the flow from the radial patterns enters many of the ghauts. Many of the water channels are deep and steep-sided, and are usually dry along all or most of their stretches. Only the relatively large Wingfield and Cayon rivers flow almost to the sea for much of the wettest part of the year.

The central part of the island of St. Kitts has high mountain ranges which are densely vegetated by largely evergreen forest and the foothills slope gently from the base of the mountains to the coast (Figure 4.2). These gentle slopes and flat land were traditionally used for sugar cane production which ceased in 2005 (Figure 4.2). Development is highly concentrated along the flat coastline with Basseterre, St. Georges being the most populated area. Population data from the 2011 census shows growing development in the parish of St. Peter since the close of the sugar industry in 2005 (Section 7).

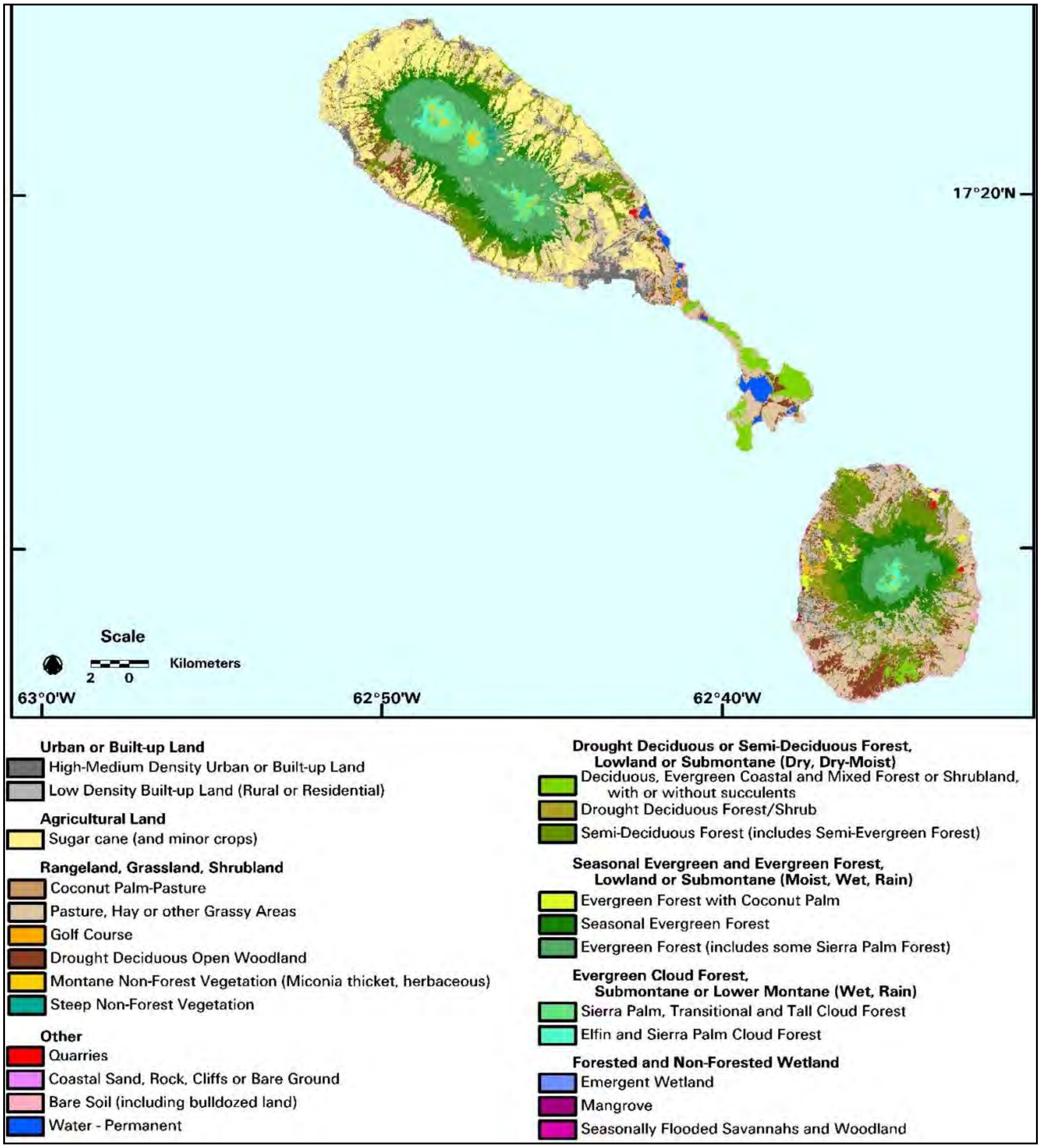


Figure 4.2: Kitts and Nevis Land Cover Map (NASA Landsat Science, 2000)

4.1.1.2 Nevis

The island of Nevis has one main volcanic centre. This centre consists of a central or main cone, flank deposits that extend radially to the sea and two younger lava domes. The volcanic centre results in radial flow pattern from the peak of the mountain to the coastline. Therefore, watersheds are not well defined on the island. There are however, water demand zones which divide the island into North and South.

The cone shaped nature of Nevis does not allow for topographic conditions (deep valleys, etc.) that encourage discernible micro-climatic differences in various parts of the island. However, at the windswept and drier east coast, relatively higher rates of water loss from soils through assumed higher rates of evaporation would adversely affect plant growth and hence crop performance.

Water also drains in a radial pattern from Nevis Peak to the ocean through ten (10) major drainage basins and is interrupted only by the smaller volcanic cones of Hurricane, Saddle and Round Hills. These basins comprise ephemeral ghauts that may consist of up to three stream orders namely Camps River, Barns Ghaut and Kitt Ghaut. In some basins, water is channeled from 457 m above sea level through relatively straight ghauts with steep but not extended sides of the ghauts and these favour rapid run-off that causes a quick flow of water to the island's coastal areas. This is coupled with the fact that the rain forest is very small and readily exposes any run-off to open evaporation, thereby reducing the amount of available recharge. In addition, the gently sloping peripheral coastal section of Nevis is not extensive enough to allow for substantial recharge. Almost all of the ghauts are ephemeral except the Bath Stream, which flow year-round to the sea from springs less than 1.6 km inland. Most of the other ghauts flow intermittently, about 3 to 4 times annually, but more extensively after rainfall.

Nevis has a central mountain called the Nevis peak which is vegetated with largely evergreen forest on the steeper slopes and deciduous and semi-deciduous forest on lower slopes. Unlike St. Kitts, sugar cane was not a major crop produced in Nevis (Figure 4.2).

4.1.2 Topography and Geology

4.1.2.1 St. Kitts

St. Kitts is oriented northwest southeast, about 80 km long and 16 km wide (Department of Environment, 2001). Generally it rises from the coastline towards its mountain cluster in the center. The highest point is Mount Liamuiga, rising with a pronounced crater to 1,156 meters (m) (ibid).

Southeast of Mt. Liamuiga, the now dormant volcanic range continues with the middle range and the southeast range. The summit of Verchild's Mountain is the highest point of the middle range, situated at more than 976 m above sea level (Department of Environment, 2001). A broad gently sloping saddle of about 457 m high known as Phillips, and Wingfield levels separate the middle range from the southeast range. The highest point of the southeast range is 900 m (Department of Environment, 2001). Both ranges consist of a number of irregular related peaks, and their slopes are steeper and shorter towards the leeward coast after which the land descends into the Basseterre valley. The Canada hills on the northeastern part of the island, rising to about 335 m are separated by a deep depression from the Morne and Conaree hills, which terminate in the neck of the Southeastern Peninsula (SEP).

The terrain slopes down steeply from the central peaks, flattening out to gentle slopes and low cliffs towards the coastal fringe. Thus, most flat or moderately sloped land occurs near the coastal area, so most urban and agricultural developments have occurred on these areas. Minor domes protrude from these lower slopes at Brimstone Hill, Ottley's Mountain, Sandy Point Hill and Monkey Hill. Furthermore, the slopes are characterized by deeply incised ghauts with steep sides. These act as the primary channels for drainage.

The islands are the summits of a submerged mountain range that forms the eastern boundary of what is known as the Caribbean Tectonic Plate. The entire island archipelago is geologically young, having begun to form probably less than 50 million years ago, during the Miocene era. Volcanic activity occurred along the ridges of this arc during the Miocene era and has continued since (*Lang and Caroll, 1964*).

St. Kitts has since undergone numerous and considerable changes in elevation but is now relatively stable. Newer volcanics rest on a basement of older rocks, now only exposed where the newer deposits have been denuded. Mt. Liamuiga, the most northerly volcano has a youthful appearance and was active in recent (geologic) time.

No obvious geologic faults can be observed, although several lineations have been noted which may be deeper faults masked by volcanic ejects. The island is composed almost exclusively of volcanic rocks of andesite or dacite mineralogy. Most of the deposits are pyroclastics and range in size from silt-sized particles to boulders several feet in diameter.

4.1.2.2 Nevis

The area of the island is approximately 93 square kilometres (Hutton 1965). The volcanic island has a central cone that slopes toward the coast and represents a typical andesitic lava dome characteristic of the Lesser Antilles. Nevis lies on the inner volcanic arc of the Lesser Antilles and is composed of nine distinct volcanic centers strung out southwest to northwest along a parallel of the inner volcanic arc. The central Nevis Peak is the most imposing of these centers, rising to 985 meters in altitude, giving the island a conical appearance (Hutton 1965). Mount Lily (Windy Hill) to the north climbs to 309 meters with Saddle Hill in the south rising to 381 meters (ibid). The other subsidiary peak of note is Butlers Mountain (578 meters), which thickens the range in the central east of the island (Figure 4.3).

Although the island of Nevis is made up primarily of volcanic material, the oldest rock outcropping on the island is a small conglomerate unit containing blocks of crystalline limestone that contain fossils of mid-Eocene age (Hutton 1965).

The terrain slopes down steeply from these peaks, at approximately 40%, but it flattens out to gentle slopes and low cliffs towards the coastal fringe. These slopes are characterized by deeply incised ghauts with steep sides, which act as primary channels for drainage. Most of the runoff through these ghauts end up in the near-shore marine area, the rest either infiltrates downward to recharge the underground aquifers or collects in coastal lagoons.

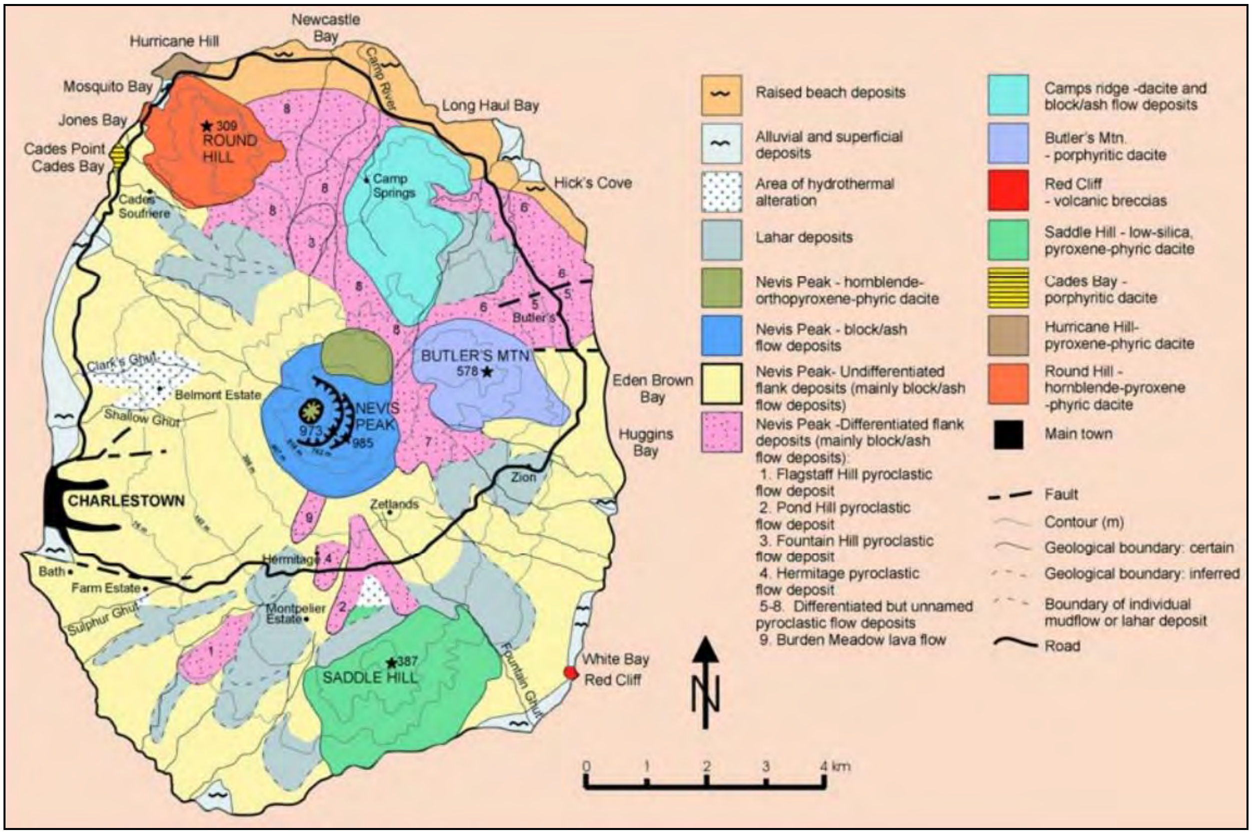


Figure 4.3: Generalised Geological Map (modified from Hutton & Nockolds, 1978)

Nevis Peak volcanic centre, which dominates the island, is the only potentially active centre on Nevis. It is a Peléen-type volcano that has produced andesite to dacite (58 - 65 wt% SiO2; Hutton and Nockolds 1978) lava domes and associated volcaniclastic deposits. The volcanic centre consists of a central or main cone, flank deposits that extend radially to the sea and two younger lava domes. The main cone has a youthful appearance and is almost entirely covered by thick vegetation.

The UWI Seismic Centre also indicated that until their study, very little is known about Nevis other than that the entire island is one live volcano. There are no published age dates for any of the volcanic deposits and there is little in the literature describing the geology. The reason for the lack of detailed studies on Nevis is most likely due to the poor exposure as most of the island is covered by vegetation.

4.2 Water Resources and Threats

4.2.1 St. Kitts

The Water Service Department is responsible for potable water supply. This mainly includes Commercial (tourism/manufacturing), Government and Domestic sectors. The Department provides the Agricultural sector with limited water for irrigation for farmers.

There are six main surface water catchments in Saint Kitts and one (1) main groundwater basin. The surface water locations are in the higher areas of the island nearer to the mountains, flow is only continuous only in the mountainous part of the island. Streamflow disappears underground along the channel and reappears only when there is high rainfall. This natural occurrence is due to the geology as the island has several layers of highly permeable geological formations. It is evident that surface water springs are intrinsically linked to the groundwater network.

The present situation in St. Kitts indicates that springs are drying up because groundwater is linked to surface water system and the quantity in the current fractures is likely limited.

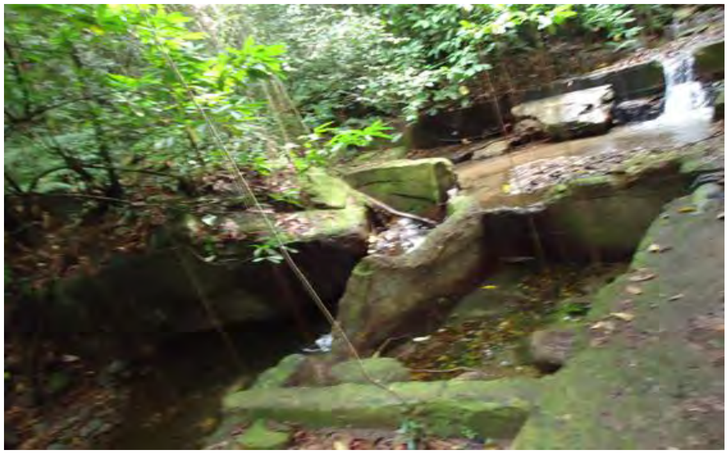


Figure 4.4: Location of Wingfield Springs in St. Kitts flowing only in the Upper Portion of the Catchment

The groundwater network comprises twenty-two (22) active wells with ten (10) wells within the Basseterre Valley aquifer of which 35 % of the entire water supply is provided by these wells.

High Temperatures

Huttrer (n.d.) indicated that St. Kitts has reported high temperatures in some wells in the Basseterre Valley aquifer. The following were highlighted:

- Several reported offshore warm springs;
- Sulfurous warm spring near the base of Brimstone Hill; and
- "scalding" well water near Brimstone Hill.

The Drought Hazard Assessment and Mapping for Nevis Post-Georges Disaster Mitigation Project in St. Kitts & Nevis stated that existing temperature stations record only surface temperatures. Soil temperatures, which are critical to the performance of some plants and agricultural crops, are not recorded. It is also vital to record subsurface temperatures of groundwater continuously for similar reasons.

A thorough water resource assessment was conducted for the Basseterre Catchment area which is the most significant water source across St. Kitts. This has been reported on in the Vulnerability Capacity Report produced under this project.

4.2.2 Nevis

The Water Department is responsible for potable water on the island of Nevis. In 1990, 5 springs contributed to the water resource use of the country. These are namely:

- Camps

- Maddens

Figure 4.5: Nevis Spring Water Collection Site

- Jessup
- Nevis
- New River

During the field visit in May, 2014, it was confirmed that only two (2) springs with the possibility of a third were utilized from the surface water to fulfil the water needs of the island. This totals 10% of the water requirements of the water resource. The third spring is used solely by the prison facility.

Springs used for the domestic purposes are not sufficiently monitored as seen in Figure 4.5. Monitoring is undertaken at one spring, and there is a weir at a second but it is in dire condition and cannot be adequately used to gauge readings.

At the main prison, the meter used for monitoring water extraction was removed and hence the quantities of water being tapped into by the main prison are unknown.

Sixteen (16), groundwater wells contribute to the water profile of Nevis. The groundwater pumping contributes to 90% of the requirements for the country. One well has been damaged and has been decommissioned in recent years resulting in 15 operational wells being used for the potable water supply.

To date, one of the problems associated with another well may hinder future uses of the well's water, as the water has been classified as "too bitter". A study has been commissioned to determine the causes of the problem.

Of the 15 wells, water from one is dedicated to the agricultural industry and an additional well is being utilised by the Four Seasons Hotel for irrigation of the property and the golf courses. This well is quite shallow and is not being used for potable water.

Limited Data and Threats to Over Pumping

The lack of scientific data analysis has contributed to the mismanagement of the water resource on the island. There is a need to conduct further studies to determine the depth of the geological formation and the linkage to the fractures among the varying rock types which will be most economical and viable to provide additional groundwater resources. The baseline of the aquifer and types of aquifers are unknown. Traditional types of aquifers include aquitards, both unconfined and confined, and these need to be categorized along with the depth of water in each rock.

The lack of known geology and water containing geological rock formations for both St. Kitts and Nevis presents a significant challenge for decision making and planning in the water sector. General information and theoretical assumptions are used in many cases to make decisions. Specifically, igneous and metamorphic rocks are permeable only where they are fractured, and they generally yield only small amounts of water to wells. However, because these rocks extend over large areas, large volumes of groundwater are withdrawn from them, and, in many places, they are the only reliable source of water supply.

There is evidence of over pumping of groundwater because of the reduction in the quantity of water being tapped into at each spring. The volume of water in the springs has diminished over time. Further to the observations of the field visits, much of the livestock has wandered closer to the springs, sources of water which are being stored in reservoirs, and pumping stations.

It was noted, that the country is relatively dry when there is no rainfall and the flow of the springs no longer traverses the natural routes of the channels for two primary reasons;

1) The highly permeable surface layer facilitates the downward movement of water into the geological layer resulting in many of the springs not being visible unless there is rainfall as seen in Figure 4.6.
2) All of the spring /stream flow is interrupted by reservoirs at each source.

In 2007, the Nevis Island Administration (NIA) contracted the company Bedrock Exploration and Development Technologies (BEAD) to supply groundwater to supplement the existing island's potable water supply under a Build Own Operate Transfer (BOOT) contract. The exploration program resulted in the successful addition to Nevis' existing water supply of approximately one and a half million imperial gallons per day (1.5 mgd) of excellent quality groundwater from three production wells. The most recent study is being conducted by BEAD at the Maddens pumping station. This is independent of the existing network. This report produced by BEAD provides a possible link between sequence of geological events that occurred in the formation of this aquifer at Maddens but does not provide information regarding the existing network (BEAD, 2007).

Figure 4.6: Very Low Spring Flow which Disappears in the Channel

Further efforts are required to determine the stratigraphy of the existing aquifer network in order to understand and manage use of groundwater resources.

Based on the new exploration, it was reported that the geological setting indicated that the oldest event, as shown is the intrusion of a dike laterally from the Butlers Mountain volcanic centre. This seems to be consistent with the very steep contacts (differences between electrical resistivity values) as shown on the resistivity profile. The water bearing rock consists of highly fractured red dacite with lower resistivity values than the intrusive dike like feature. The geological and hydrogeological mapping had to be carried out to identify the stratigraphic sequence and the groundwater occurrence.

High Temperatures and Threats to Water Extraction

Robson and Willmore (1955) reported that the Farm Estate Soufrière in 'Nevis was found to be nearly extinct' when they visited it in 1953, although they obtained temperatures from within small crevices of up to 100ºC. Notably, in 2001 the UWI seismic team measured temperatures of up to 99.3ºC from weakly steaming vents.

Cades Bay Soufrière and Farm Estate Soufrière, are sites of minor fumarolic activity. A number of hot springs are also present; the hottest are those at the Bath Estate and at Cades Bay beach. In addition, there are large areas of pervasively hydrothermally altered rock present throughout the island (e.g. Clarks Ghut) that are interpreted as areas of past/extinct fumarolic activity. Current geothermal activity is largely concentrated on the western half of the island (Lindsay JM, 2001).

Huttrer (n.d.) reported warm (~43oC) waters flowing from the Charlestown Fault at The Baths; warm (35-43oC) waters reported from wells drilled in the Stony Grove, Belmont, Indian Castle and Charlestown areas; "scalding" waters in a well drilled on the Brown Estate and warm springs and wells along the western coast, near Mt. Lilly, at Spring Hill and offshore.

This can adversely affect the future drilling for groundwater on both islands as high temperatures are associated with volcanic islands and geochemical reaction which are not conducive to groundwater exploration.

The hot springs and lack of temperature recordings at the surface and subsurface limits the expansion of the groundwater resources as reasonable temperatures are required to excavate and operate mechanical equipment. The impact of climate change will result in rising temperatures and without monitoring data, this will challenge the management of the resource in the future. It has been indicated that the geothermal activity may be a renewable source of energy to exploit for development of the country and could be utilised to reduce the dependence of fossil fuels. This may be an added advantage as groundwater exploration is expensive with riding energy cost apparent in small island developing states.

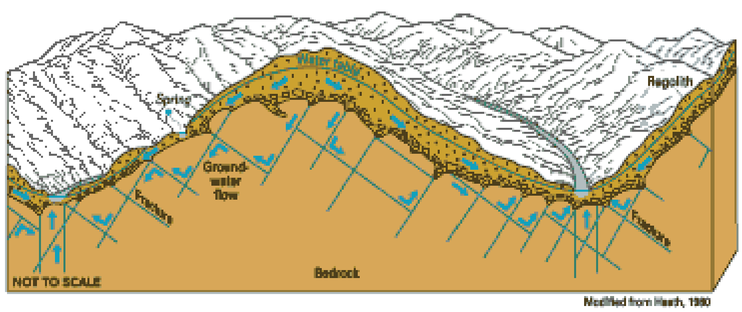


Figure 4.7: Diagrammatic Ground Water Flow through Bedrock

4.3 Water Supply

Water utility companies in the Caribbean face significant challenges concerning the delivery of water as many of the networks were laid prior to independence. These aged water networks are characteristic of both St. Kitts and Nevis.

As the need for controlling the water distribution and infrastructure becomes more challenging, water loss and un-accounted for water increase, as do damages from bursts, leaks and emergency repair work.

Leaks, bursts, inefficient pumping, pressure discrepancies and other problems are often not evident from the raw data, and definitely not available in real time. These challenges create problems for replacement and maintenance, stressing their resources and affecting sustainability.

The Rallying the region to Action on Climate Change (RACC) recently undertaken in St. Kitts included a component for water auditing. The project also promoted awareness in the island in hope of making consumers more aware of how to reduce leakage in the household.

It is expected that increasing water consumption usage has and will continue to result in increased pumping. This directly correlates to increased electricity costs. In addition, challenges associated with the collapsing well field increases the energy required for abstraction of groundwater. This is applicable to both St. Kitts and Nevis.

Deeper drilling and increased storage, which is required away from the coastline, and variable geology, will require more energy to abstract water from underground resources and store sufficient capacity on the surface.

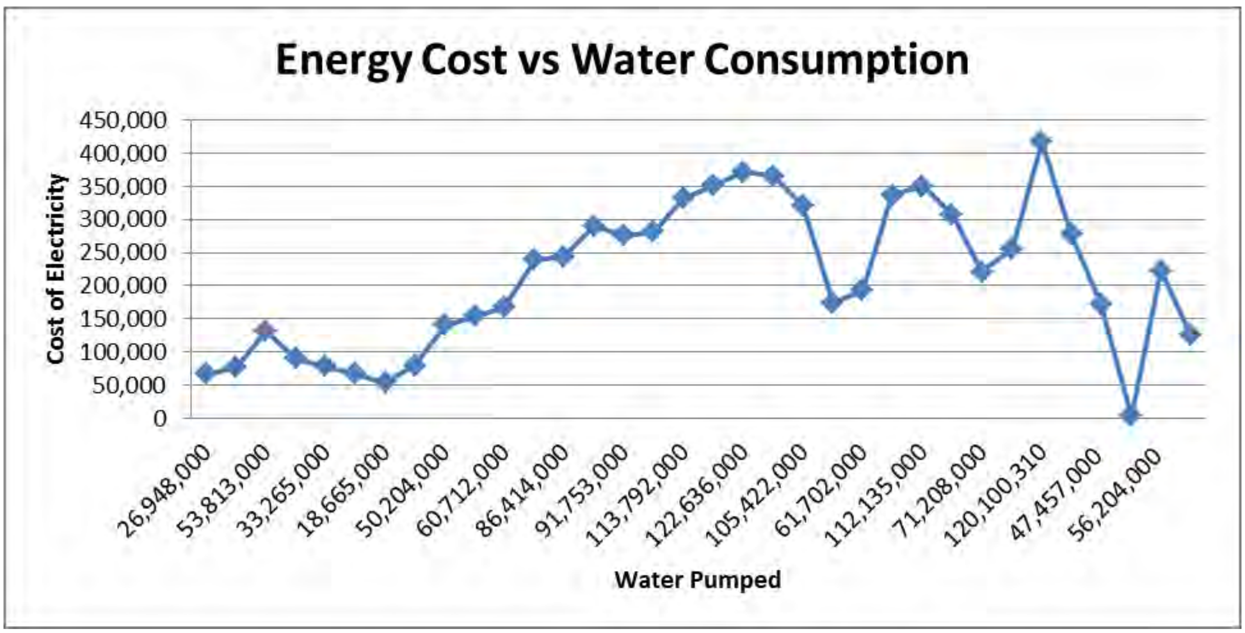


Figure 4.8: Increased electricity cost with increasing water pumped (St. Kitts)

4.3.1 St. Kitts

Approximately 65% of the St. Kitts Water Supply is supplied by the Basseterre Valley aquifer. The aquifer is designated as a national park and no agriculture activity is allowed within the boundaries. Since 2009, 5.5 million gallons (mgd) of water per day is being produced and there is a desire to double production.

Groundwater monitoring is conducted by drawdown analysis of each well and water quality analysis is done to determine when wells are being over pumped or experiencing drought conditions.

During the site visit, it was reported that very little water is being provided to agriculture. The pace of economic development in terms of tourism related activity is worth about 1.2 billion US dollars. The water department is not in a position to provide water for new developments. They have indicated that developments will have to be responsible for their own water supply by way of desalination plants.

There is no thoroughly scientific basis for determining water use and allocation and there is a substantial amount of unaccounted for water throughout the piped network.

4.3.1.1 Distribution system

Surface water intake

The surface water intake system is gravity fed from three springs to reservoirs along the system. Some of the streamflow is left to fulfil the needs of the ecological habitat along the channel.

As streamflow is dammed along the network, it is allowed to mix with the groundwater supply. Not all storage locations, points of entry and exit of water along the distribution system are metered.

Along the spring network, there are some instances of weirs or other locations up or downstream which are used to measure daily / monthly flow rates from the springs.

These locations are not setup by any scientific methods and this limits the potential of the data for analysis such as development of rating curves to understand the catchment responses to natural rainfall upstream and the abstraction of stream flow downstream of the source.

The dimensions of the weir were not provided and this is essential to quantify streamflow discharge out of the catchment and runoff. There is no constant metering between weir and any reservoir in the distribution network system.

Treatment of the domestic water supply is undertaken downstream of the springs collection points where the water is piped to a drinking water treatment plant. In some instances, flow is measured between the outflow of the water treatment plant and at a few domestic properties.

The treatment consists of removal, filtration and chlorination. The water from Basseterre Valley is treated from Wingfield to reservoirs within the Basseterre Valley.

Groundwater Distribution Network

The groundwater is pumped from over 20 wells in the network with each well being fitted with a meter to calculate safe yield. The Basseterre Valley has approximately six wells in the network. These wells produce water which is then pumped to reservoirs for domestic usage at high elevations. At some locations within the watershed, large reservoirs are frequently and permanently monitored for inflows and outflows, whereas the smaller reservoirs are temporarily monitored and this occurs at specific times.

The Water Department's metering network along with constant physical monitoring of groundwater from observation wells and surface water springs is quite adhoc.

Groundwater is treated at the well head and then pumped along the distribution network, where it mixes with water from the springs. The full listing of wells and springs is listed in Annex II.

Joint Distribution Network- groundwater and surface

Within the distribution network, at certain locations, the surface water and the groundwater systems meet, mix and the presence of metering is not apparent. Thus, there are unknown flow rates and usage amounts across joint network especially when mixing of the two sources occur.

Along the network, there is also no differentiation between the points of entry into the distribution network to determine the quantity of each type of water i.e. groundwater/ spring water before it is consumed by the public.

Storage

Reservoir sizing varies across the island but 100,000 and 200,000 gallon reservoirs are most predominant, in terms of volume. The total storage based on Annex III is approximately 7 million gallons of storage.

Some of the reservoirs are out of commission and most appear to be well aged and have obvious patterns of tremendous amounts of leakage.

Leakage affects the ability of WSD to effectively manage the water resource once collected at a storage location.

4.3.2 Nevis

Springs and groundwater wells are being allocated to specific uses with no metering information. There is no linkage being made to the surface springs and groundwater reserves. Springs are being fully tapped and there is no evidence of water flowing downstream which is drastically affecting the environment (causing a drought).

There is enough evidence from the water analysis and legislative review to indicate that there is a water conflict resulting from the lack of collaborative efforts among water users and administration governing the water sector. There is certainly an on-going water conflict among users in both islands. This is primarily among the environment and economic activity.

There is evidence of surface water/groundwater only by noticing the pronounced greenery near each source or storage point. This imbalance is evident among water usage and collection methods used for human consumption. This has resulted in several channels being dry in the lower reaches of the catchment and results in limited or no water to support the environmental systems at lower elevations across the islands. In many cases, the agriculture sector always competes with the tourism industry for water from the water department.

There is no water management plan currently being executed on either island.

4.4 Rainfall Trends and Analysis

Rainfall trends for St. Kitts and Nevis have been discussed in the following sub-sections. Although there are significant limitations already outlined above, restrictions of Nevis' analysis are presented in a summary for Nevis for the benefit of the Water Resource Assessment.

4.4.1 St. Kitts

Figure 4.5 shows a linear relationship between Douglas and Olivees rainfall stations. It presents a good opportunity for the integration of hydrological monitoring stations for parameters such as soil, rainfall and temperature.

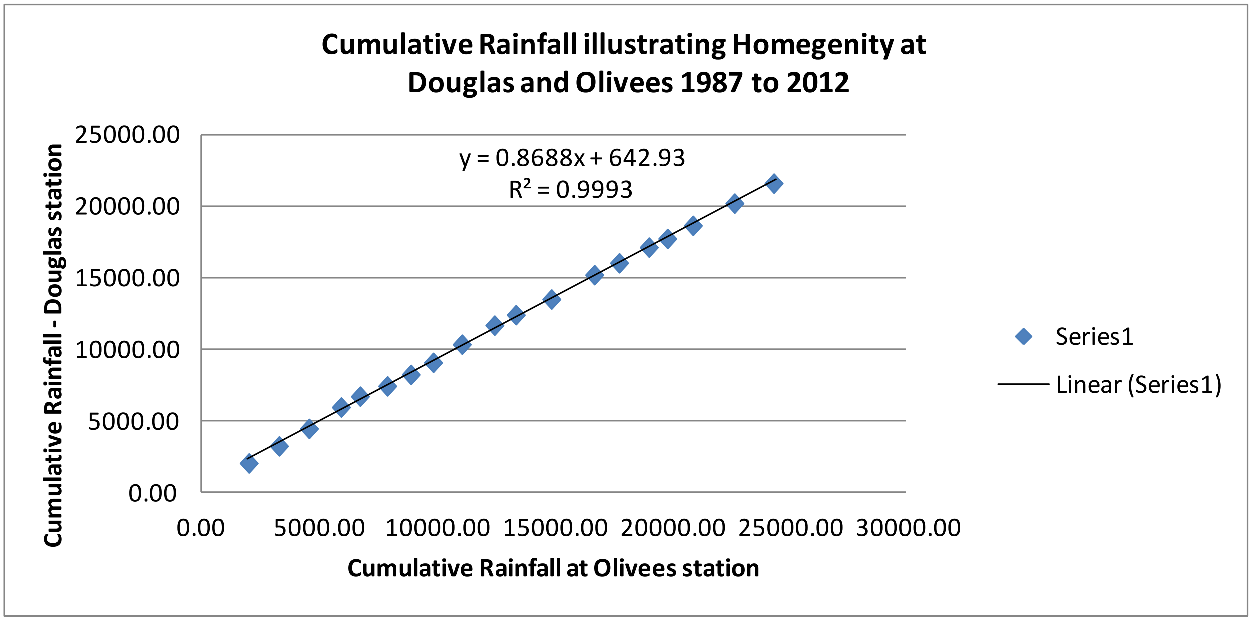


Figure 4.9: Cumulative Rainfall Illustrating Homogeneity at Douglas and Olivees Stations 1987 to 2012

There is a partial hydrometric network consisting of rainfall stations with varying time periods. The airport is the most current gauge. In 1998, the passage of Hurricane George, destroyed the equipment and it was unable to record any meteorological data for the period. There were at least 40 stations ranging from early 1900's to 2005. However, rain gauges that were located on sugar estates are no longer function since the close of the sugar industry. The sugar estates were the primary owners of the gauges and the sugar estates ceased in 2005 and so did the collection of consistent rainfall data across the island within the hydrometric network.

The catchment response to rainfall in the Basseterre Valley is well correlated to the stations listed below. These are Lower Mansion, Wingfield, Douglas, Olivees, and the RLB airport. The lower part of the catchment which is near the airport is relatively flat. The terrain shows that rainfall increases with altitude as the Wingfield station collects generally over 3000mm and has a maximum record of 3412mm during the period 1980 to 2005 (See Figure 4.10).

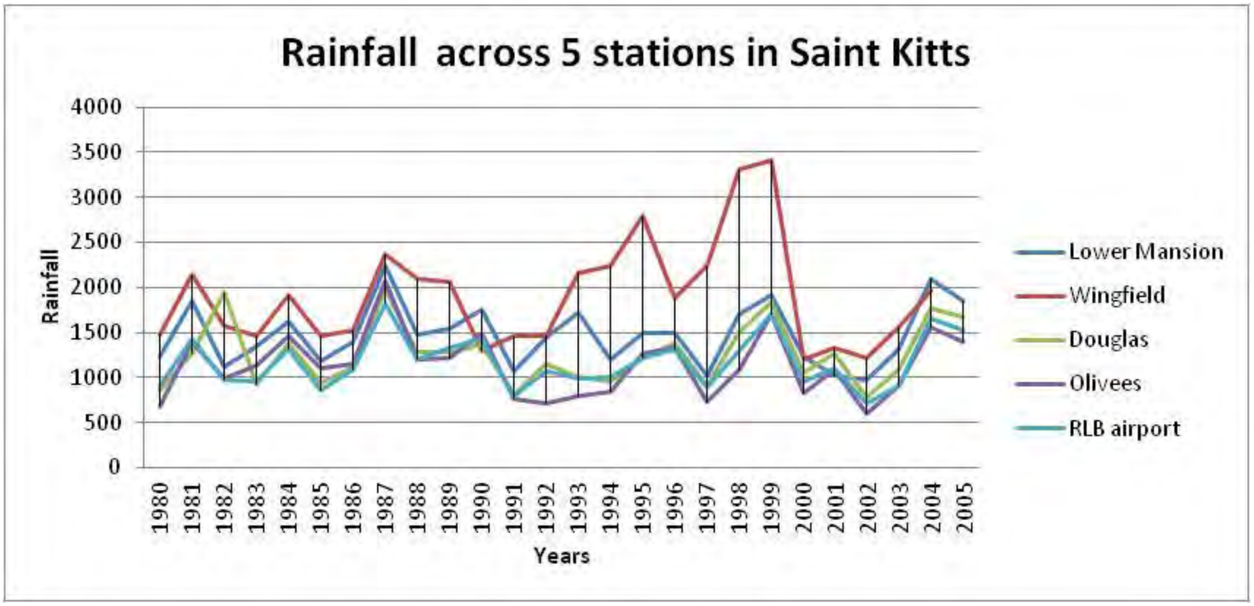


Figure 4.10: Annual Rainfall Trends across 5 Stations near Basseterre Valley in Saint Kitts

Although rainfall is a point estimation, these gauges located at Mansion, Douglas, Oliveees and the R.L.B. Airport provide a good aerial average precipitation over the island. Due to electronic data constraints it is not possible to analyse all 40 stations. The average would be improved with more gauges. The aerial average was estimated to be approximately 1402 mm nearest to the Basseterre Valley Aquifer system.

Table 4.1: Average Rainfall across 4 Stations near Basseterre Valley Aquifer

Rainfall Stations	Lower Mansion	Wingfield	Douglas	Olivees	RLB Airport
Average/mm	1498	1904	1280	1156	1173

From the St. Kitts rainfall records, the maximum daily rainfall for St. Kitts were published in the Inland Flood Hazard Assessment and Mapping for St. Kitts and Nevis report. These were utilised in the statistical analysis. The results correspond satisfactorily with the past reports and two additional stations were analysed. These included Nevis International Airport and RLB International Airport illustrated in Annex IV.

The estimation of island scale distribution of rainfall over the island of St. Kitts was calculated using isohyets and is demonstrated in Figure 4.11. Five (5) stations were utilized in the analysis. The results could be improved if more data was available in an appropriate format for analysis.

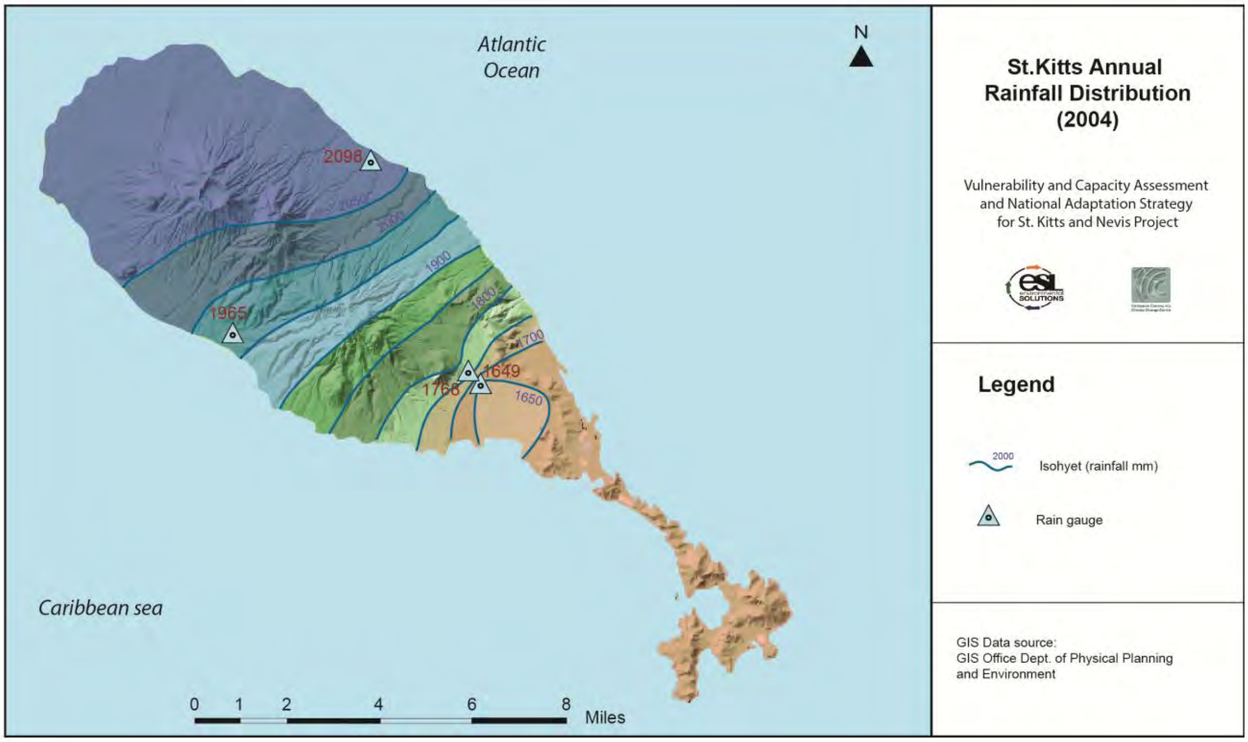


Figure 4.11: Preliminary Isohyets for Saint Kitts

A further isohyet map was extracted from the Environmental Profile (EP) (CCA, 1991), in Annex IV. Both maps confirm that rainfall in the agricultural areas ranges between 1000 mm and 1900 mm and this is on the higher side of the rainfall distribution.

A series of annual maximum daily rainfall is normally well represented by the Gumbel Type I probability distribution (Chin, 2000) and so this distribution was applied to the rainfall data. The rainfall amounts for various return periods are shown in Annex IV.

OET (2009) reported that the seasonal distribution of rainfall is just as important as the mean annual rainfall. As would be expected, this distribution is determined by the interplay of seasonal weather systems sweeping across the Atlantic Ocean. In the wet season, which extends from August to December, tropical waves form off the coast of Africa and give rise to small disturbances in the lower atmosphere, causing periods of rain during these times. These waves also provide the opportunity for hurricanes to form when other conditions are favourable. The dry season takes place during the early months of the year, when the western Atlantic is affected by a period of high atmospheric pressure (the Mid-Atlantic High). Therefore, rainfall currently has a bi-modal pattern, though this can be frequently affected by un-seasonal periods of either high rainfall or, more often, drought conditions (except at higher elevations where conditions are more stable). The Climate Analysis in Section 2 did show observed tri-modal patterns for some years/decades in their historical analysis. From a watershed point of view, rainfall intensity is also an important moisture factor, affecting the balance between infiltration and run-off, aquifer recharge, as well as erosion potential and risk.

Trends in rainfall patterns using 1980 to 1999 reported in Williams (1999) are as follows:

- The dry season extends from January through April;

- The wet season starts in May, and peaks between September and December of most years;
- During the month of February, rainfall events >15.2 centimeters were recorded during the months of February.

4.4.2 Nevis

Rainfall values were only available for the airport during the study; daily values were retrieved from past reports for analysis. Monthly maxima values and medium annual values, from 2000 to 2013, were verified during the analysis from the Nevis Drainage Master Plan.

There is concern with the values provided by BEAD LLC and the limitations are highlighted in this report.

This final report provides a more detailed and accurate comparison of rainfall values to the closest island to Nevis unlike the BEAD report which utilises Tobago for comparison. Published reports on Caribbean Rainfall also verify that the comparison of rainfall for the Northern Caribbean may not necessarily resemble patterns in the Southern Caribbean.

The limitations to the use of the rainfall data from Nevis have already been discussed in Section 1.4.8. Nevis Drainage Master Plan stated that given "the uncertainties in available data as discussed and the general broad coherence of data on Nevis and St Kitts, it is recommended that:

- A baseline set of daily rainfall depth-frequency estimates for Nevis International Airport be considered approximately equivalent to those at Agronomy on St. Kitts; and
- Daily rainfall depth-frequency estimates for the upstream catchments of Bath Ghaut, Fountain Ghaut, Newcastle Ghaut and Oualie Ghaut can be considered to be approximately 50% greater than those at Nevis International Airport for all required frequencies."

Summary of monthly rainfall data

Monthly rainfall data was collected from the Department of Agriculture and from Nevis International Airport for the rainfall stations as summarised in Table 4.2 below.

Table 4.2: Summary of Monthly Rainfall Data (Department of Agriculture / Nevis International Airport)

Station Name	Altitude (m)	Approx. Position (deg)	Data availability	Maximum monthly rainfall (inches, date)	Median annual maximum monthly rainfall 1977 to 1999 (inches)	Median annual maximum monthly rainfall 2000 to 2011 (inches)
Prospect	85	210	Jan-1950 to Oct-2011	21.4, Nov 2004	9.83	10.46
Indian Castle	9	120	Jan-1962 to Nov-2012	17.1, Nov 2003	7.42	8.27
Hard Times	244	110	Jan-1950 to Aug-2007	17.2, Nov 2004	8.30	7.52

Station Name	**Altitude (m)**	**Approx. Position (deg)**	**Data availability**	**Maximum monthly rainfall (inches, date)**	**Median annual maximum monthly rainfall 1977 to 1999 (inches)**	**Median annual maximum monthly rainfall 2000 to 2011 (inches)**
Potworks	18	90	Sep-1956 to Oct-2012	21.7, May 1987	9.42	8.50
New River	61	30	Jan-1950 to Oct-2012	18.1, May 1987	7.62	8.31
Maddens	82	10	Jan-1950 to Oct-2012	21.5, Oct 1990	9.09	8.32
Cades Bay	15	290	Jan-1950 to Feb-2006	26.4, Nov 2003	7.94	8.27
Nevis International Airport	8	355	Apr-1999 to Dec-2012	17.1, Nov 2004	N/A	N/A
Hamilton	155	240	Jan-1950 to Apr-1989	29.0, May 1987	N/A	N/A

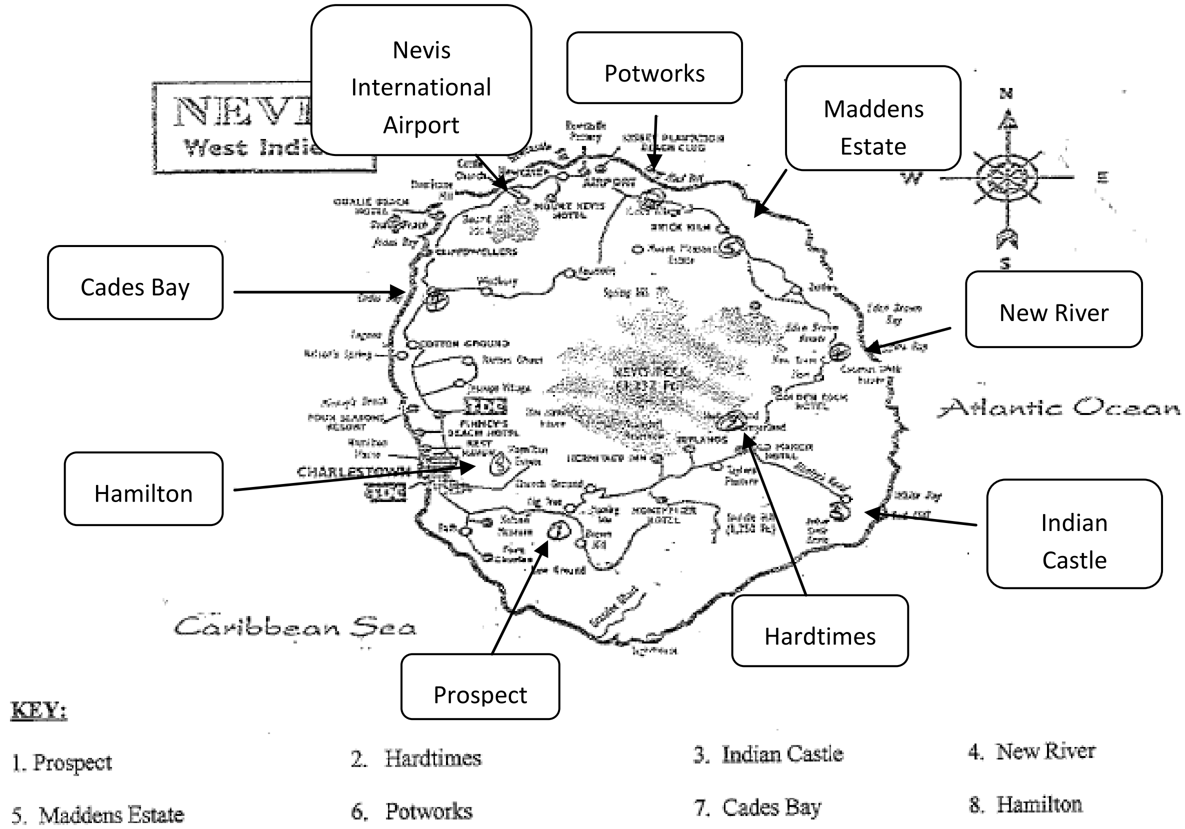


Figure 4.12: Location of Nevis Rain Gauge Stations (after Department of Agriculture)

Annex IV provides a summary of monthly maxima rainfall for each of the stations, indicating maximum rainfall occurring typically in either May or October to November.

A comparison of monthly maxima[1] suggests that 2004, 1987 and 1990 are the 'wettest' years on record for Nevis. It is also noted, that recorded monthly maxima at individual rain gauge stations (Indian Castle and Cades Bay) were recorded in 2003.

Considering all rain gauge stations, no discernible difference in the estimates of median annual monthly maximum rainfall for the periods 1977 to 1999 and 2000 to 2011 are apparent, although on a station by station basis, differences of +/- 10% are identifiable.

Median annual monthly maximum rainfall is greatest at Prospect (in the south-west of Nevis) and Potworks and Maddens (in the north-east of Nevis), and at Nevis International Airport for the period 2000 to 2011.

Aggregating monthly rainfall to annual totals indicates average rainfall totals are greatest at Hamilton and Prospect (in the south-west of Nevis) and Cades Bay (in the north-west of Nevis).

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1 Recorded monthly maxima for each rain gauge station were ranked and an average ranking value calculated to determine the 'wettest' years on record.

Summary of daily rainfall data

Daily rainfall data was collected from Nevis International Airport for the period 1-Jan-2000 to 31-Dec-2011, as shown in Figure A3 (Annex IV). Annual maximum daily rainfall occurred most frequently in September and October (three times), November (twice) and May to August (once each). A summary of annual maximum daily rainfall is provided in Table 4.3.

Table 4.3: Annual Maximum Daily Rainfall at Nevis International Airport

Year	Daily rainfall (inches)	Month
2000	3.55	September
2001	3.09	August
2002	1.88	July
2003	2.21	November
2004	3.63	October
2005	5.62	June
2006	5.00	May
2007	4.60	October
2008	2.52	September
2009	2.01	November
2010	5.78	October
2011	5.01	September

The maximum daily rainfall of 5.78 inches was recorded in October 2010; the median annual maximum daily rainfall is calculated as 3.59 inches. This can be compared with estimated median annual maximum daily rainfall on St. Kitts which, based on recorded data between 1977 and 1999, varies between 4.04 inches and 5.26 inches according to station elevation (see Table 4.3).

4.5 Droughts

4.5.1 St. Kitts

The Basseterre aquifer in St. Kitts is the main aquifer. It is largely coastal and highly permeable and is being over pumped or pumped without hydrological balance. As a result of this predisposing factor, drought conditions will result in a reduced freshwater interface because saltwater will prominently intrude and reduce the underground water resources.

In addition, prolonged drought conditions can lead to reductions in water quality in the aquifer because there will be higher concentrations of salt/ deposition of other ions which will also result in higher treatment costs. However, once salt water intrudes coastal aquifers it primarily destroys mechanical equipment, such as, pumps leading to the abandonment of the investment. Salt water intrusion will also affect the other parts of the aquifer as the up-coning rises. Alternative sources, such as desalination, may have to be considered. One of the drawbacks is that desalination is associated with high energy cost.

Effective water resources management is critical to achieving reasonable success in mitigating the impacts of drought.

4.5.2 Nevis

The Drought Hazard Assessment and Mapping for Nevis stated that drought is a recurrent feature of Nevis' climate. It occurs when there is an extended period of deficiency in precipitation (relative to what is considered normal), which is then insufficient to meet economic, social and environmental demands. Given its relative small size, drought effects in Nevis are felt island-wide.

Average annual rainfall for Nevis is about 46 inches/year. However, there are distinct variations in the amount of rainfall between different sections of the island. Rainfall data is measured from nine (9) stations around the island over periods from 23 to 43 years. Average annual rainfall isohyets for Nevis indicates a progression in rainfall amounts from 35 inches/year on the east coast to 90 inches/year at Nevis Peak (3,232 ft. in elevation).

Drought conditions as related to precipitation deficiency would exist if rainfall precipitation for the year fell below 26.5 inches or less than 60% of what is considered the yearly average.

The Department of Agriculture considers it a dry year if average rainfall is below 45 inches/yr. In addition, the Department believes that drought conditions exist when there are "small amounts of rainfall" during the rainy season

Based on rainfall records obtained from the Department of Agriculture, three (3) periods of drought have been identified for the last decade, namely:

- 1990 – 1991
- 1993
- 1997

The year 2000 also turned out to be one of below average rainfall –the average rainfall from January to November was 32.51 inches (OAS, 2001).

In 1990, average rainfall was 46.77 inches but 15.11 inches were recorded for the month of October. For the rest of the year rainfall was 31.66 inches and for the months of January to September only 24.37 (See Annex IV). Even with the 15.11 inches of rain recorded for October 1990, the average rainfall for the two-year period was 37.07.

In 1993, average rainfall was 37.10 inches and in 1997, 34.06 inches. Actual yearly rainfall figures before 1990 were not obtained but 1974 was said to be perhaps the worst period of drought in recent times (Richard Lupinacci, Hermitage Hotel, pers. comm.). Lupinacci said that the dryness and wilting of vegetation in 1974 was the most severe experienced in recent times even in higher elevations such as Hermitage where average rainfall is about 55 inches/year.

The elevation of recording stations varies from 30 ft to 800 ft. The St. Kitts and Nevis Hazard Vulnerability Assessment, Final Report (2001) conclusions on Nevis' drought patterns were:

- Areas of high vulnerability to drought includes the areas of Charlestown (up to Long Point) and the Buttlers/Mannings water zone at the east side of the island;
- The central mountain area has the lowest vulnerability to drought. Moderate risk areas include the northwest and north of Nevis;
- Areas of high vulnerability to drought includes the areas of Charlestown (up to Long Point) and the Buttlers/Mannings water zone at the east side of the island;
- The south and southeast is considered to have a very high vulnerability to drought.

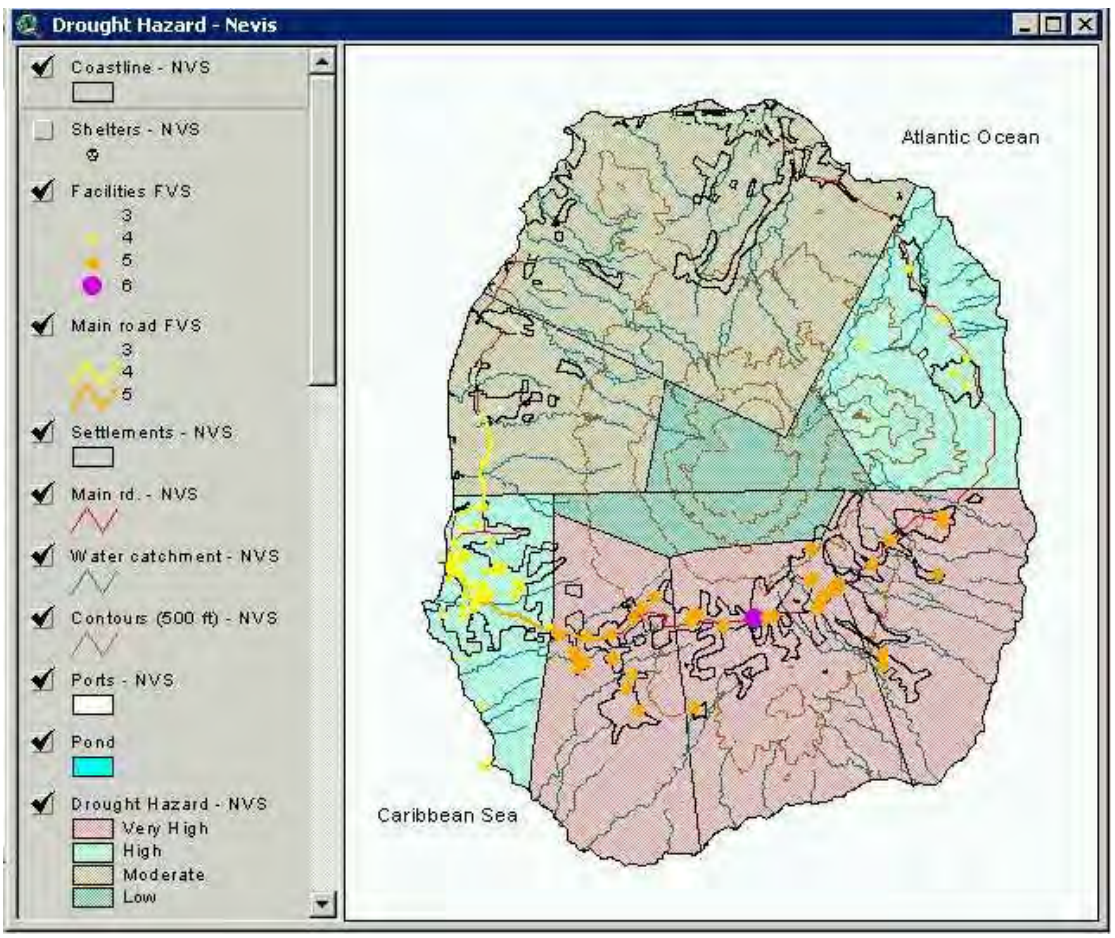

Figure 4.13: Nevis Drought Hazard Map

As previously discussed in Section 4.1.2, watersheds are not readily defined in Nevis as it is in other islands. Rather than using the watershed as a unit for management, water resource planners have divided the island into water demand zones. The island is divided into two (2) main zones (north and south) and nine secondary zones (Figure 4.13). The aquifer in Nevis is largely coastal and highly permeable and is being over pumped or pumped without hydrological balance. As a result, drought conditions will result in a reduced freshwater interface because saltwater will prominently intrude and reduce the underground water resources.

There are five (5) wells located in the Northeastern side of the island, and there are ten (10) wells in the South of the island. As there are more wells in the south of the island, this presents a challenge as the drought hazard vulnerability is "very high" as illustrated in Figure 4.13.

This has implications for the current water resource management and future water resources as the groundwater and surface water depletion risk is also high and most of the development and economic activity are located in the regions with "high" to "very high" vulnerability to drought Figure 4.13. This will limit the management of the current water supply for the existing activities and with climate projections of increased temperature and droughts will limit the development of the resource for future economic activity.

Drought also affects the water quality of existing water resources as problems with increasing dry seasons. During the site visit the water department stated that during the dry season they experienced high levels of chloride at particular locations while in the wet season the quality returns to normal.

The agriculture sector has felt the burden of these conditions and the Drought Hazard Assessment and Mapping for Nevis reported the following impacts:

a) The period of time water is available in open dams becomes limited;
b) Farmers have to reduce their scale of operations as a direct result;
c) Farmers use more domestic water, which is at a higher cost;
d) Due to a decrease in local production, more vegetables and fruits are imported – loss of revenue to farmers and loss of foreign exchange;
e) The quality of certain vegetables, for example lettuce, watermelon and cucumber, is severely affected;
f) Smaller and poorer quality feed for livestock;
g) Poorer quality meats;
h) Deterioration of conditions of animals resulting in fewer returns;
i) Overgrazing, which impacts on agriculture and the environment;
j) Increase in the mortality rate of animals.

There is a need to delineate the island by watershed to fully understand the implications of the water demand and consumption on the hydrological cycle as spring depletion is evident as well as over pumping of the aquifers. Overall, effective water resources management will be critical to achieving reasonable success in mitigating the impacts of drought in the future.

4.6 Flooding

4.6.1 St. Kitts

The Inland Flood Hazard Assessment and Mapping for St. Kitts and Nevis (2001) stated that St. Kitts, soils are shallow and therefore only limited amounts of rainfall can be stored as the soils quickly become saturated. Shallow soils also allow high amounts of runoff. The major part of the upper watersheds is under forest, with urbanization and agriculture occurring on the foothills as indicated by persons living along Lower College Street ghaut who are exposed to the danger of swift moving water when it flows in full.

St. Kitts has a propensity to high runoff owing to the frequent occurrence of high intensity rainfall and watersheds that can store only small amounts of the rainfall, resulting in significant runoff. Whether or not flooding occurs, depends on the capacity of the drainage facilities and the presence of lands with very little gradient adjacent to those drains with limited carrying capacity.

There are constraints with the data for examining the temporal and spatial distributions of rainfall over each of the islands and hence the watersheds." As much as daily rainfall data actually recorded on the island were available, these records are not immediately useful for determining peak flows from watersheds with times of concentration considerably less than 24 hours. All of the watersheds on the island have small times of concentration. It is therefore necessary to know how the daily rainfall had been distributed over the 24 hours and perhaps divide this daily rainfall into smaller storms having durations that match the estimated times of concentration."

It was documented that past floods resulted in numerous physical injuries are possible as well, and a common effect of flooding is disease and disease transmission. Diseases commonly are associated with disruption of fresh water supply; contact with floodwaters contaminated by septic tank and wastewater treatment plant overflows; the creation of appropriate habitat conditions for certain rodents, insects and organisms that transmit diseases. Destruction of crops, seeds, and stored food stocks during inundation is limited as agriculture occurs on the foothills and not on floodplains. Public infrastructure and private property may be damaged with inundation and deposition of significant quantities of silt.

For Basseterre and Lower Bath Ghaut, initially ground floors of buildings and residences may be affected with rising flood stage. But with increasing stage and flow velocities, buildings and loose property can be swept away. An additional danger with such steep sloped watersheds is caused by boulders transported by the swift currents and floating debris such as cars and logs that can increase damage as they impact structures downstream. Properties on riverbanks may be in danger if riverbanks erode and trigger bank failure.

Extreme examples of bank erosion exist along the College Street Ghaut, around Monkey Town, and Cayon Ghaut.

Major disruptions of the road network may affect productivity as the workforce is delayed in reaching their workplaces.

4.6.2 Nevis

The Inland Flood Hazard Assessment and Mapping for St. Kitts and Nevis (2001) outlines that generally, soils on Nevis have slow to very slow drainage patterns. They are mostly clays and clay loams and thus their slow infiltration rates would cause high amounts of runoff. Additionally, overgrazing has compacted the surface of the ground reduces infiltration rates, increasing the amount of runoff and hence increasing the possibility of flooding.

The major part of the upper watersheds is under forest, with urbanization and agriculture occurring on the foothills.

The St. Kitts and Nevis Hazard Vulnerability Assessment, Final Report (2001) reported that the town of Charlestown is the most significant feature vulnerable to flooding on the Island of Nevis, along with some areas with coconut trees and cultivated crops. In Grassing, areas are subjected to low flood vulnerability in the areas of Brown Pasture, Hermitage, and Pond Hill.

In Nevis, persons living along lower Bath Ghaut are exposed to the danger of swift moving water when the Bath Ghaut is flowing full.

4.7 Water Demand, Production and Consumers

Water demand production and consumers have been discussed for St. Kitts and Nevis below. It is important to note that data in St. Kitts and Nevis are collected in a different manner and as such there are variations in the analyses done for the two islands.

4.7.1 St. Kitts

Potable water supply for Saint Kitts is provided by the Basseterre Valley Aquifer. The water budget conducted under the Vulnerability and Capacity Assessment Report produced under this project provided the available water resources. The current levels of consumption are provided below in Figure 4.14.

The average water production for the period 1980 to 1998 by pumping was 2.66 mgd. The total water demand based on the data can be derived by the equation below. The regression coefficient of correlation R^2 represents a good representation of the data after completion of statistical analysis was 96%.

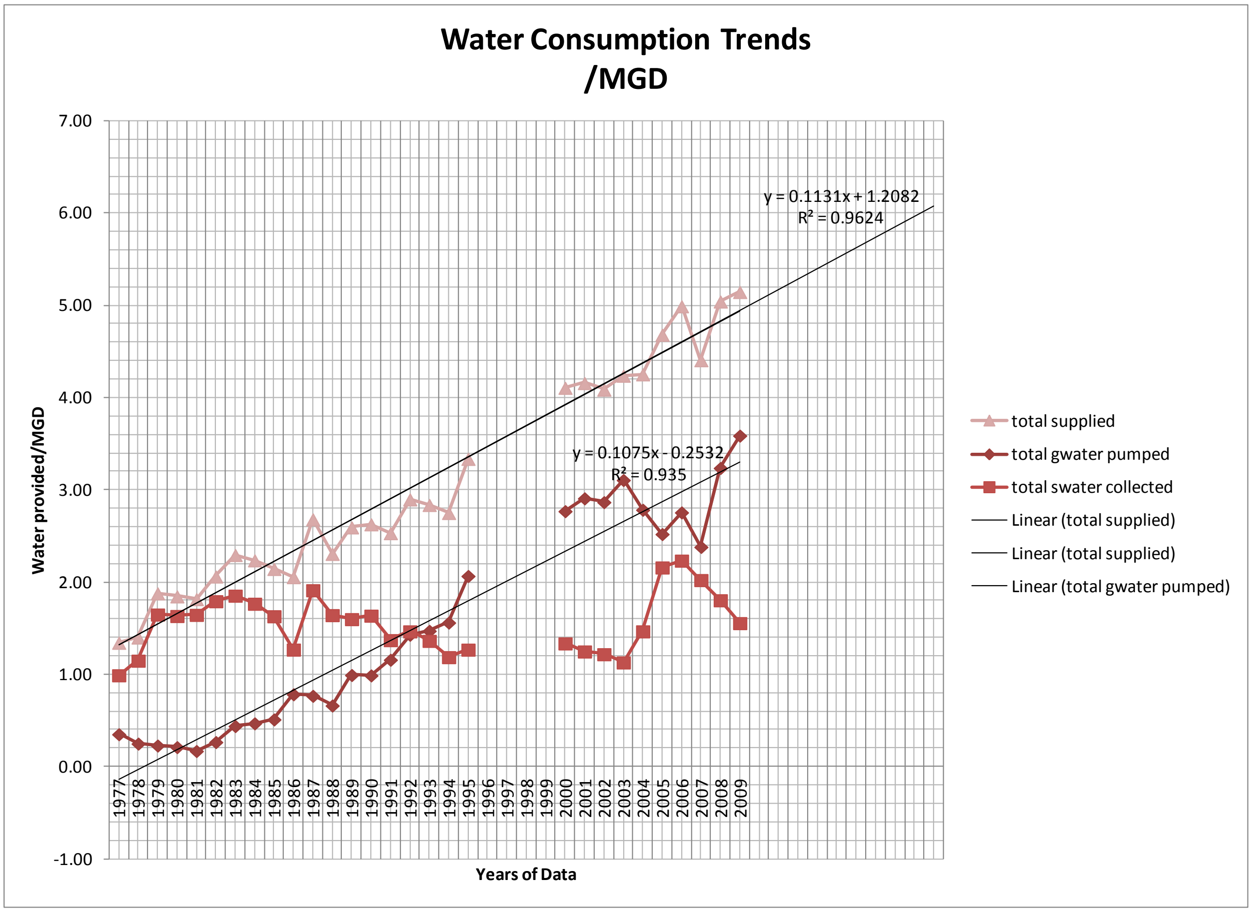

Figure 4.14: 1977 to 2009 Water Data from the Water Services Department (Groundwater, Surface Water and Total Pumped To Public)

Water consumption data is a good indicator of projecting the demand. It is essential that the data be linked to the unaccounted for water, the per person usage and industry usage in order to better understand and implement best practices for watershed management. The current data could drastically overestimate the future projections.

Total 000 gals	total pumped MGD
1977	1.34
1978	1.40
1979	1.88
1980	1.85
1981	1.82
1982	2.06
1983	2.30
1984	2.24
1985	2.14
1986	2.06
1987	2.68
1988	2.31
1989	2.60
1990	2.63
1991	2.53
1992	2.90
1993	2.84
1994	2.75
1995	3.34
1996	3.3544
1997	3.4674
1998	3.5804
1999	3.6934

Estimated by Graph 1996 to 1999

Figure 4.15: Trend in Water Consumption Related

$$y = 0.1131x + 1.2082$$
$$R^2 = 0.9624$$

Table 4.4 below demonstrates the composition of the water supply between 2000 and 2009.

Table 4.4: Composition of Water Supply

	% of Water Supply	
Year	**SURFACE**	**GROUND**
2000	33	67
2001	30	70
2002	30	70
2003	27	73
2004	35	65
2005	46	54
2006	50	50
2007	51	49
2008	42	58
2009	36	64

The questions which will need to be answered by future studies are illustrated in the conceptual model. This will assist in understanding the requirements of the resource so it could be better managed.

The Water Services Department (WSD) has only recently commenced a billing system which could provide future sectoral analysis. This commenced approximately two (2) years ago and was insufficient to be used for this study. Prior to this, WSD shared a system with the Electricity Department and so historical sector consumption data was not available for water usage, demand and supply. Water production values recorded at well heads and surface water catchment points (extraction points) have been used as consumption values.

Table 4.4, Figure 4.14, and Figure 4.15 show relative groundwater and surface water supply of potable water in Saint Kitts. Water production is currently between 15% to 26 % of the current available resource. Runoff, evapo-transpiration and leakages are currently unaccounted for and these need to be taken into consideration so that better estimates can be given of the available water resource. Significant leakages were observed within the supply network, and these considerable losses can be controlled through corrective action.

Internationally, businesses, such as,manufacturing drink companies and tourism, utilise high volumes of water. Therefore, metering is essential so that the appropriate measures to promote water conservation and better determine usage and demand can be implemented.

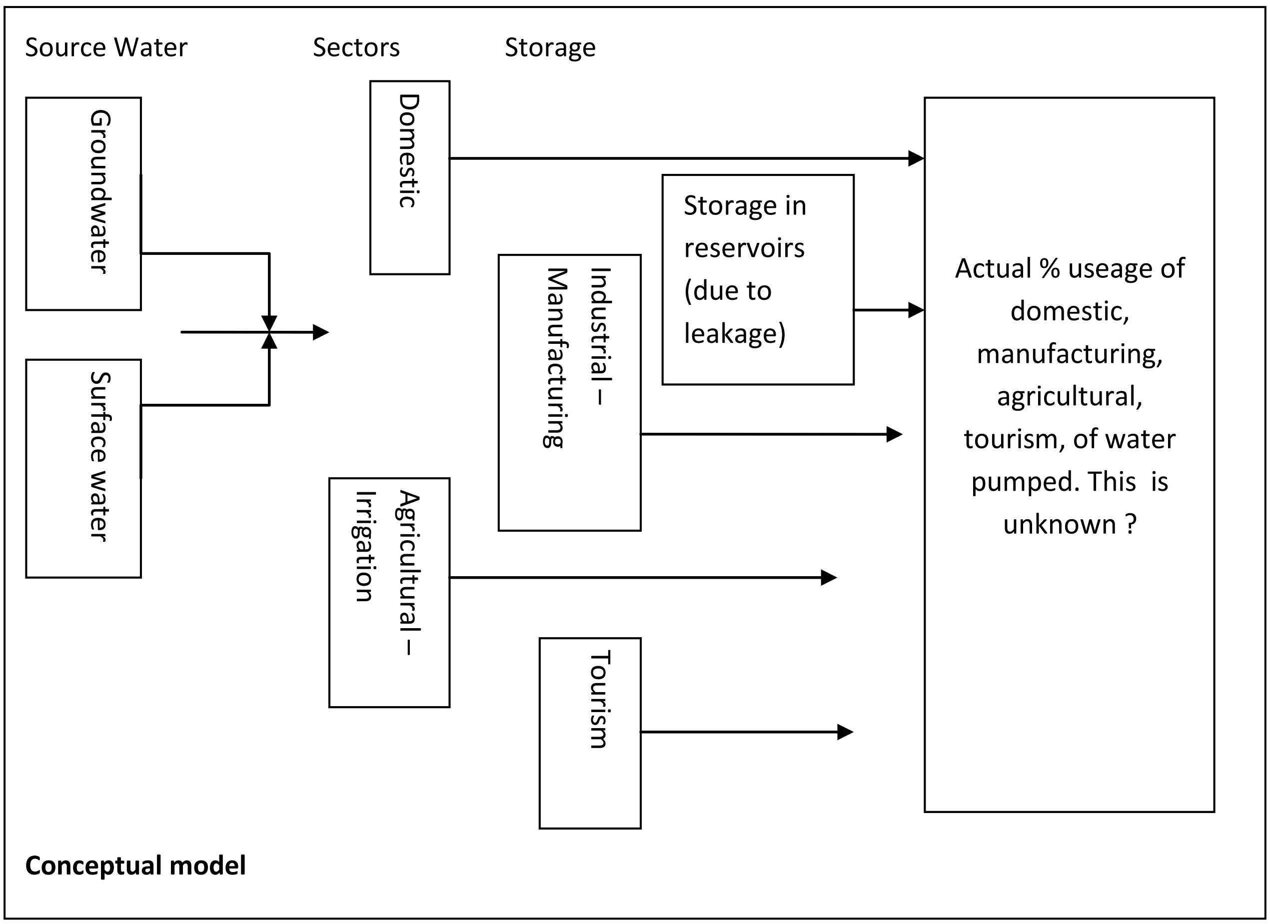

Figure 4.16 Conceptual Model

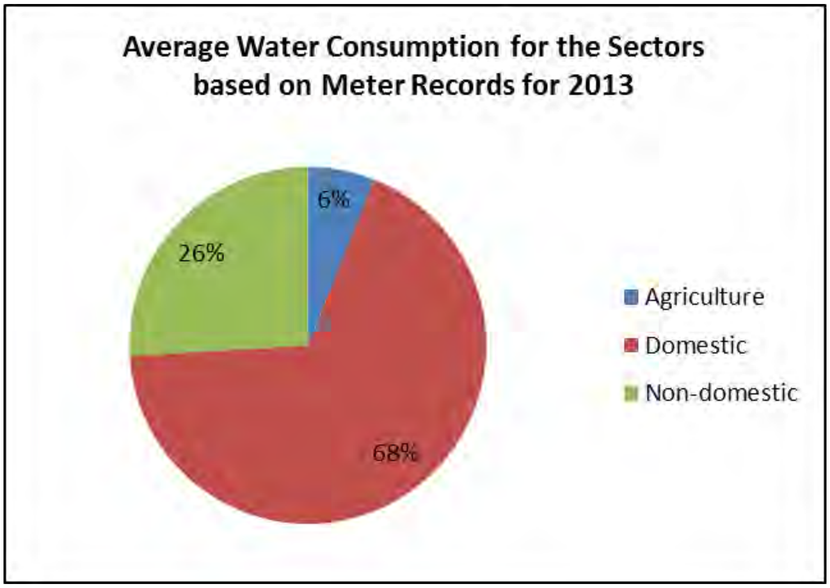

Figure 4.17: 2013 Average Water Consumption for the Sectors based on WSD Meter Records

The St. Kitts Water Services Department (WSD) only started using metering records to collect sector disaggregated consumption data in 2013. Prior to this, WSD used a shared system with the Electricity Company and so they do not have a record of this data. The 2013 consumption data indicates that domestic consumers have the greatest demand (Figure 4.17). Agriculture is rainfed and as shown in Figure 4.17 only 6% of consumption is taken for the agriculture sector.

4.7.2 Nevis

Water data in Nevis since 2009 has been collected by sector usage in electronic format. Sectors include Agriculture (Farmers and Irrigation), Government, Domestic and Commercial. Static Water level head for each well is collected.

The water consumption data doesn't differentiate between groundwater and surface water. It however indicates the total water produced for the five year period. The projections on water demand and consumption along with the quantity of water pumped from the natural water resources is illustrated in Table 4.5.

The data presented in Table 4.5, Table 4.6 and Figure 4.18 portrays how water is used across the various sectors. Over the five year period the domestic sector was largest consumer of the potable water supply ranging from 48% to 73 %; followed by the Commercial sector which showed an increase ranging from 4% to 21 %. Government usage reflected a relatively constant usage between 4 and 9%; Water supplied for Irrigation purposes ranged from 4 to 38%. This was the only sector which showed a decline over the five year period. The Irrigation sector as highlighted in the Figure below is that referring to water supplied to the Four Seasons resort.

During the site visits of May 2014, it was reported that a conscious decision was made to reduce the provision of water supplied to farmers hence the relatively small percentage which ranges between 1% - 2%.

This means that approximately 70 % of the demand is being distributed for domestic uses and approximately 20 % being allocated to commercial sector which seems to be growing at a rapid rate.

Table 4.5: Data Related to Figure 4.16 Showing Water Consumption by Sector (Imperial Gallons)

	WATER CONSUMPTION BY CONSUMERS				
	2009	**2010**	**2011**	**2012**	**2013**
DOMESTIC	61,481,940	236,634,050	218,303,210	223,485,503	221,366,630
COMMERCIAL	5,418,550	33,905,120	77,738,950	65,057,025	68,502,480
FARMERS	1,092,000	4,319,570	6,392,130	5,424,890	5,025,990
IRRIGATION	**49,684,000**	**38,484,000**	**52,194,500**	**44,189,895**	**32,711,100**
GOVERNMENT	12,000,000	12,500,000	15,300,000	13,000,000	14,400,000
	129,676,490	325,842,740	369,928,790	351,157,313	342,006,200

Table 4.6: Data Demonstrating Total Water Production Over 5 Year Period (Imperial Gallons)

2009	**2010**	**2011**	**2012**	**2013**
469,625,316	387,841,000	383,814,000	453,091,667	416,569,000

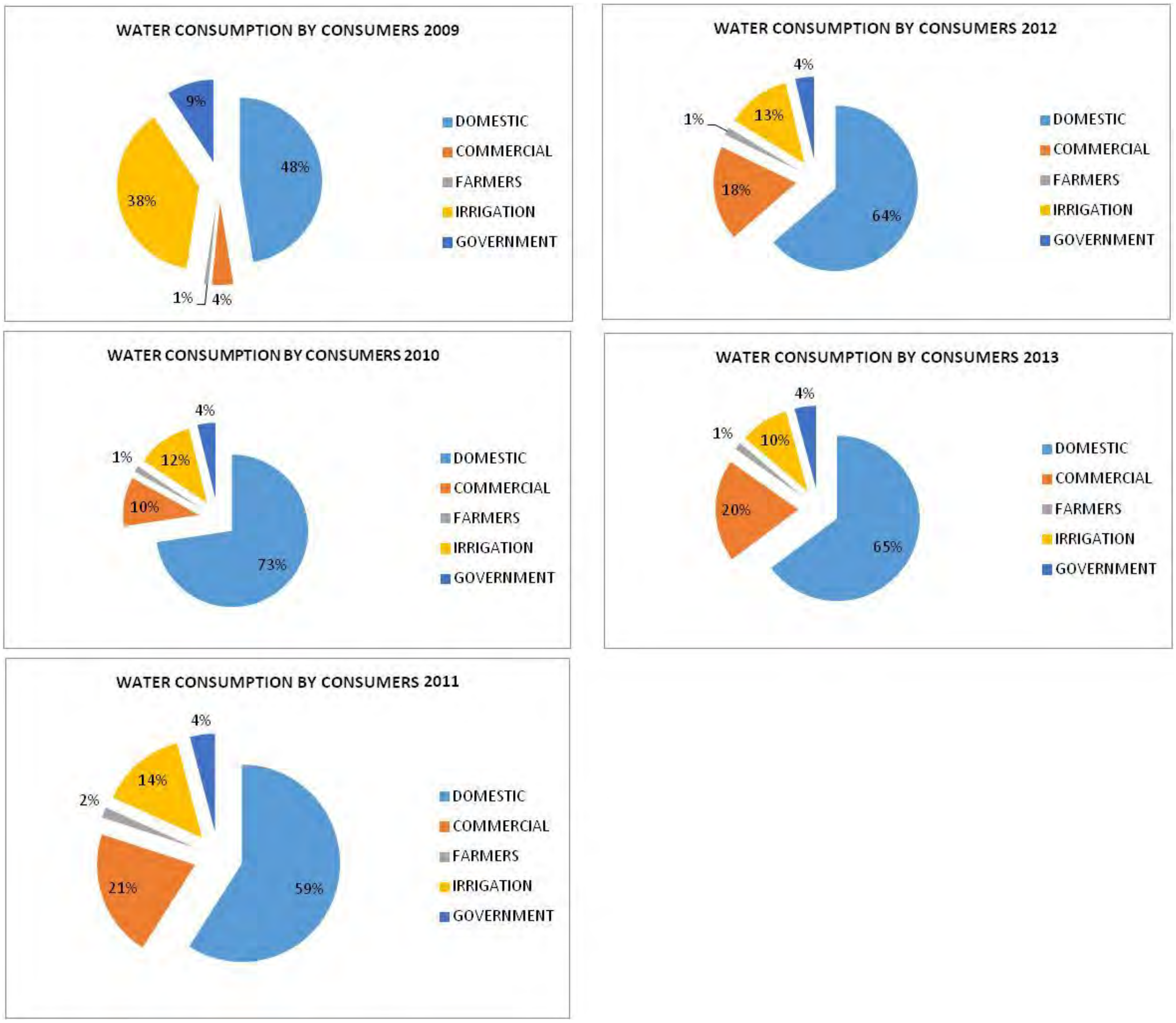

Figure 4.18: Nevis Water Consumption Data by Consumer 2009 to 2013

The total water produced and consumed over the five year period is illustrated in Figure 4.19 below. As illustrated, the demand is reflected by forecasting of water consumption data. The statistical analysis is normally undertaken on decadal data. Unfortunately, only 5 years of data was received and this limits the investigation on the island. The R^2 value only represents 20% of the data and hence the linear correlation would need to be improved by obtaining more historical data to improve the forecast prior to 2009 as illustrated in Figure 4.20.

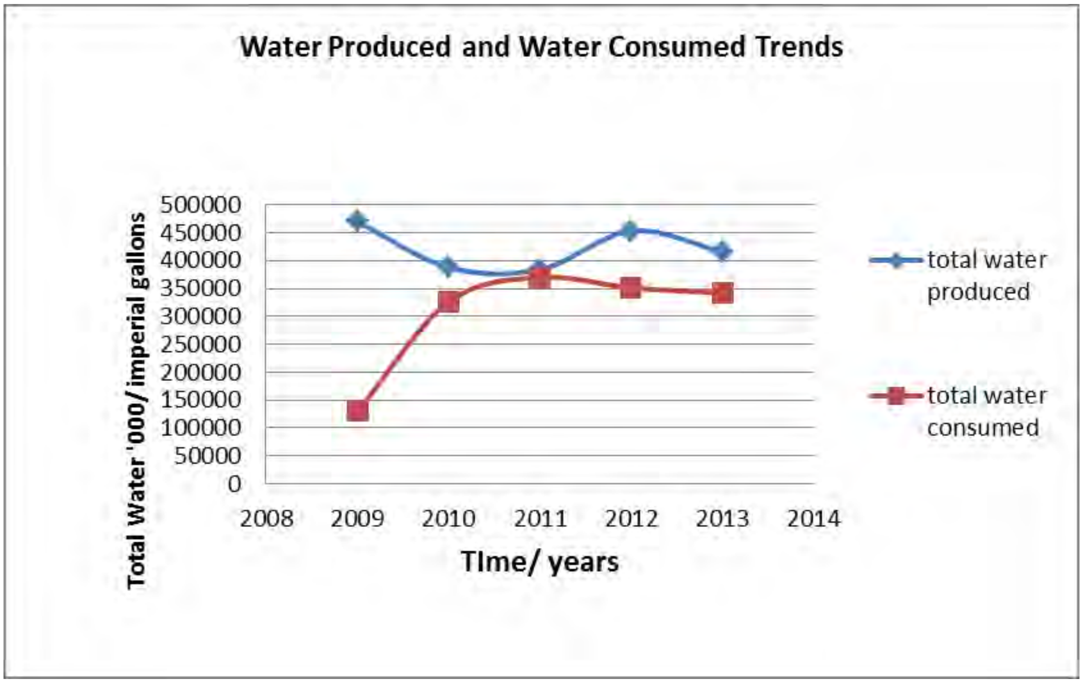

Figure 4.19: Relation between Water Consumption and Demand

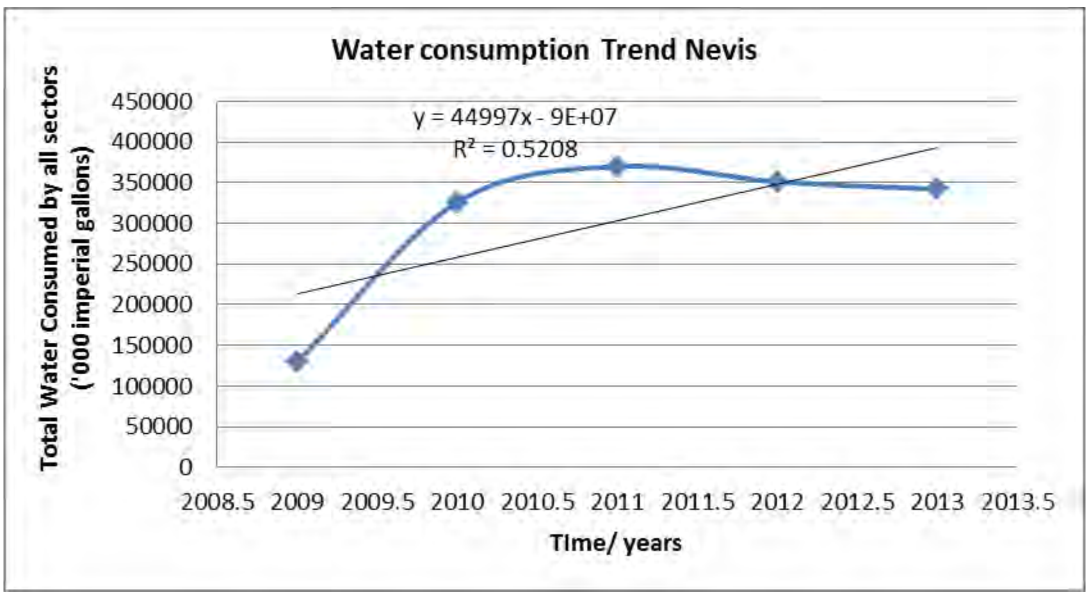

Figure 4.20: Water Consumption Trend Over 5 Year Period

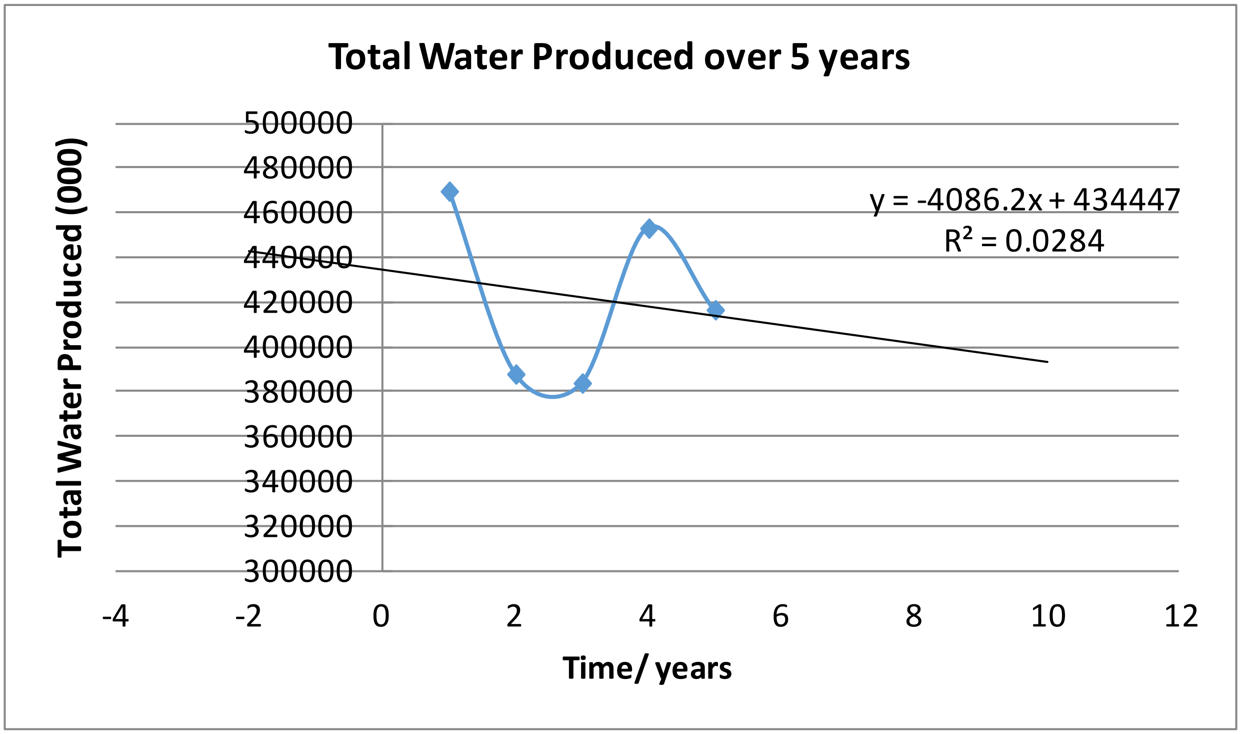

Figure 4.21: Total Water produced for 5 year period 2009 – 2013 (imperial gallons)

The annual production for the periods between 2009 and 2013 are listed below. The total water consumed can be correlated to the total water produced each year from the groundwater and surface water collected which is shown in Figure 4.21. From 2009, there has been a steady increase in water consumed. The percentage of available water used between 2009 and 2013 was between 28% and 96% as shown in Table 4.7 below.

In 2011, 96 % of the available water resource was actually utilised and this is a startling statistic. This is also reflected in the images across the island as many of the springs are dried or trickling when no rain falls and most of the reservoirs are visibly leaking. It also shows that most of the water from the aquifer is being removed as consumption increases.

Table 4.7: Nevis Water Demand and Water Availability Figures in Imperial Gallons

Time period	2009	2010	2011	2012	2013
Total Water Consumed	129676490	325842740	369928790	351157313	342006200
Total Water Produced	469,625,316	387,841,000	383,814,000	453,091,667	416,569,000
% of available water resource	28%	84%	96%	78%	82%

4.8 Calculated Water Scarcity Index

The vulnerability of the water resources is indexed to the ratio of the water demand and the water availability.

$$Vulnerability\ Index = \frac{water\ demand}{water\ availability}$$

Eberhard and Robinson (2003) defined water stress as the proportion of available water that is already in use. It is a simple ratio, expressed as a percentage of the amount of water drawn from sources divided by the estimated total available water from these sources. The data available from both countries allowed the Consultants to determine Water Scarcity for each outlined in Table 4.8 below. The interpretation of most scales is relatively the same, with a high medium and low rating system. Smakhtin, et. al., 2005 provided the most suitable legend to define the results.

The Government of Nevis contracted with BEAD, LLC to develop 1.5 mgd from wells drilled into deep volcanic aquifer. Current water production averages 1.18 mgd. Thus the total water available 2.58 mgd.

Saint Kitts' water budget calculations are illustrated in the Vulnerability and Capacity Draft Report with an approximate value at 18 mgd.

Below, illustrates a first attempt at a calculation for Water Stress Indicators for both countries as follows in Table 4.8.

Table 4.8: Preliminary Water Scarcity Indices

Caribbean Country	Population	Mean Annual Rainfall / mm	Water Available (m3/day)	Water Withdrawn (m3/day)	Water Stress (%)	Water Scarcity (m3 /d/capita)
Saint Kitts	34983	1300	68137	20820	31	1.95
Nevis	11415	1168	9766	3142	32	0.86

Legend

Level of Stress	Water stress (%)
Low	< 10
Moderate	10 to 20
Medium	20 to 40
High	40 to 60
Catastrophic	> 60

Both St. Kitts and Nevis are classified as "Medium" which as defined by Eberhard and Robinson (2003) is as just about enough water for most uses if managed properly.

4.9 Analysis of Vulnerability to Future Climate Risks for the Water Sector of St. Kitts and Nevis

4.9.1 Summary threats common to both islands

4.9.1.1 Implications of Water Resources for Saint Kitts

The main factors limiting groundwater availability in the Basseterre Valley are saltwater intrusion, high ground temperatures, increased minerals becoming more dissolved in water, increased energy cost, the reduction of discharge to streams and the ocean, and lowering of water levels.

The current situation of the aquifer is dire and measures need to be incorporated into water resource management to assist with the adaptability of climate change. With the dedicated water supply being provided to Kittitian Hill a touristic site, this will reduce the water department's reserves and strain the local water supply which provides water to both domestic, manufacturing and other commercial sectors.

Options for ensuring steady water supply will include the following:

1) Explore groundwater aquifers in the upper mountains;
2) Tap into desalination or trap surface water for augmentation purposes and expand storage in the northern portion of the island which will be closest to the source of increase trends of rainfall as opposed to investing only in the existing storage.

4.9.1.2 Implications of Water resources for Nevis

Unlike Saint Kitts, which has additional land and thus water reserves to explore being larger of the two islands, Nevis, will have to explore independent water supplies by drilling nearer to the mountain sources and possibly negotiating with private investors who are willing to spur up economic activity to enter into a private public partnership for additional technologies such as desalination to provide an augmented water supply for domestic sector and overall island use.

4.9.1.3 Summary

There is a possibility that both countries should explore a shared reserved to explore water for both countries so that energy cost will not spiral out of control. This will also establish a more sustainable model considering that Nevis is more volcanically active and efforts have been made to investigate geothermal energy which would be an asset to both small islands in ensuring reduction in energy consumption for groundwater exploration, treatment and distribution. Furthermore, other countries such as Iceland have incorporated Geothermal energy into effectively managing their groundwater resource. Although the studies in Saint Kitts and Nevis are quite young, it could prove useful to explore collaborations with countries which have successful geothermal and groundwater exploration programs as one of the most outstanding problems with the islands is that the water is hot in certain parts of each island and this has hampered exploration.

However, despite many efforts of including additional technologies for harnessing water, conservation and water resource management are most effective with well trained personnel, public awareness campaigns and good practice of sharing of the commodity among sectors by using scientific data to ensure proper and effective climate adaptation strategies are implemented and well executed.

5 INSTITUTIONAL FRAMEWORK REVIEW

St. Kitts-Nevis is a Federal State. There are laws that apply to both islands, and in some cases there are island-specific ordinances. The same is true for institutions. Some are common to both islands but Nevis has its own for some areas of governance Figure 5.1 elaborates.

5.1 Institutional Map

The institutional map takes account of all agencies public and private which relate to the several functions and resources considered a part of the water sector.

A wide range of institutions are involved in water resources management. These include:

(i) Cabinet

(ii) Ministry of Energy, Public Utilities and Transport

(iii) Ministry of Sustainable Development

(iv) Ministry of Agriculture

(v) Ministry of Health

(vi) Private Sector

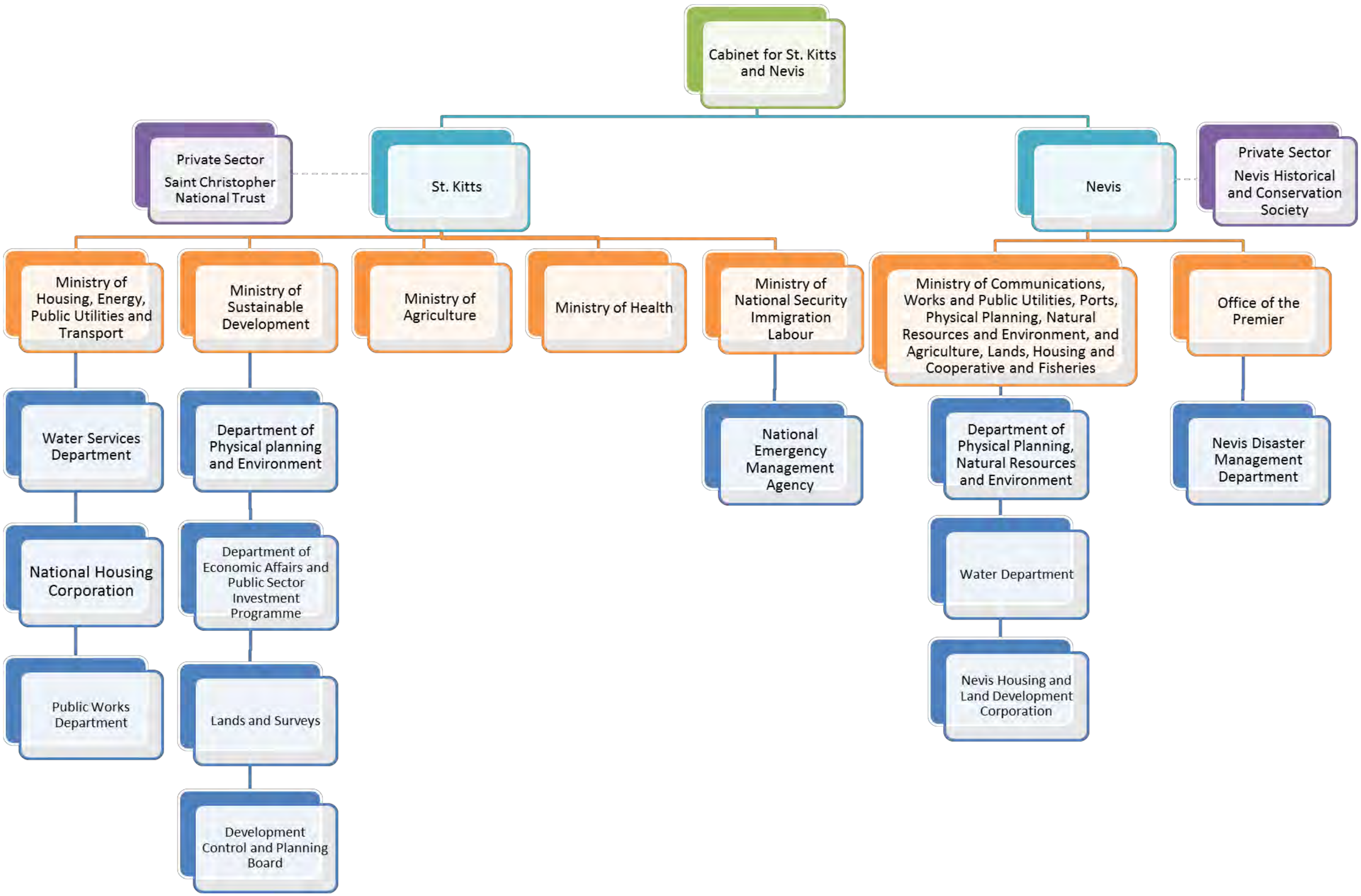

Figure 5.1: Institutional Map

There is no single authority which has watershed management as its mandate, and many institutions have some responsibilities for coastal zone management. State lands for agriculture are allocated by the Extension Division of the Ministry of Agriculture. Parcels of more than 2 hectares are handled by the Lands Division of the same Ministry. Record keeping is antiquated at best and frequent disputes arise as to who has been allocated, what land.

At present, St. Kitts-Nevis has no physical development plan to guide land use decisions in the country. A draft plan is now under intense discussion. The development and adoption of such a plan would help determine the way in which competing uses for the same land could be resolved in a rational way.

A large number of institutions are involved in activities associated with watersheds, water harvesting and treatment and with the marine and coastal zone. These institutions include government ministries, statutory bodies, NGO's and community groups. Some of the more important are described below. There are no designated watershed reserves and currently no legislation dealing specifically with watershed management. New draft legislation will provide some improved legal status for watersheds. The national public utility company has legal rights over all water resources but has no legal obligations regarding watershed protection or maintenance.

5.1.1 Cabinet

The Constitution establishes a Cabinet for St. Kitts-Nevis (Figure 5.1). The Cabinet consists of the Prime Minister and other Ministers as the Prime Minister may from time to time consider appropriate. Cabinet has key responsibility for approving legislation for submission to Parliament as well as Policy documents.

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5.1.2 Ministry of Housing, Energy, Public Utilities and Transport

5.1.2.1 Water Services Department

The Water Services Department (WSD) is responsible for the identification, upkeep and protection of water supply sources on St. Kitts. The Watercourses and Waterworks Ordinance (1956) makes provision for the declaration of watersheds to protect waterworks and water sources. Watershed management is critical to maintaining both surface and groundwater sources. However, the WSD does not regard itself as a watershed management institution. Notwithstanding, the WSD working in close collaboration with the DPPE, has spearheaded the implementation of the first phase of the IWCAM project which seeks to rehabilitate the lower coastal section of the Basseterre.

5.1.2.2 Public Works Department (PWD)

The Public Works Department oversees the design of new and maintenance of existing public infrastructure, including roads, drainage, bridges, and culverts. Also, it is responsible for overseeing the design, construction and repair of public buildings. As a member of the DCPB, the PWD provides technical support to the land development and building application review processes.

5.1.3 Ministry of Sustainable Development

In 2005 the Ministry of Development and Planning was transformed into a Ministry with responsibility for Sustainable Development. The new Ministry of Sustainable Development (MSD) assumed the land and survey portfolios of the Ministry of Agriculture and Housing and the environment management portfolio from the Ministry of Health. As a result, the departmental components of the Ministry of Sustainable Development now include:

a. Administration
b. Economic Affairs and PSIP
c. Physical Planning and Environment
d. Lands and Surveys
e. Statistics

The Ministry of Sustainable Development is the lead government agency with overall responsibility for the development and coordination of policies and programmes to protect St. Kitts - Nevis's natural environment, including the management of all matters pertaining to Multilateral Environmental Agreements (MEAs).

5.1.3.1 Department of Physical Planning and the Environment (St. Kitts)

The Department of the Environment was established first in 1996 within the Ministry of Health and Environment to enable the implementation of the NCEPA. In 2005 a Ministry of Sustainable Development (MSD) was established to spearhead the design and implementation of the countries, development agenda and to better equip St. Kitts Nevis to meet its international obligations to various bi-lateral and multilateral economic and environmental agreements.

In shaping the Ministry of Sustainable Development the Department of the Environment was merged with the Physical Planning Division to create the Department of Physical Planning and the Environment (DPPE). The DPPE functions as the lead agency for physical planning, development control and environmental management. As lead agency for environment, the DPPE functions as the focal point in St. Kitts-Nevis for the UNFCC, UNCBD and the UNCCD. Accordingly, it plays a pivotal role in the administration of sustainable development in St. Kitts-Nevis.

5.1.3.2 Department of Lands and Surveys

The Department of Lands and Surveys (DOLS) is responsible for the design, survey and implementation of residential land subdivision schemes. Overall, the general strategic objective of the DOLS is to establish a fixed boundary coordinated cadastral system after a systematic resurvey, cadastral plans, topographical maps, and the complete development of a Land Information System that would fully support the survey, registration, valuation and management of land. With representation on the Development Control and Planning Board, the Department of Lands and Surveys works closely with key public sector institutions to rationalize land use and land development decisions.

5.1.3.3 Development Control and Planning Board

The Development Control and Planning Board (DCPB) receives its operational authority from the Development Control and Planning Act (No. 14 of 2000). The Board is responsible for the review and determination of all building and development planning applications on St. Kitts. Additionally, the DCPB is responsible for zoning, review of environmental impact assessments and the design and implementation of development plans and broader national policy instruments such as the NPDP. The operational scope of the DCPB generally addresses the broad sustainable development areas of:

- Agriculture and rural development,
- Environmental protection,
- Water resource management,
- Land use planning,
- Climate change adaptation, and
- Biological diversity conservation

5.1.3.4 Department of Economic Affairs and Public Sector Investment Programme

The Department of Economic Affairs and Public Sector Investment Programme functions as the lead coordinating unit for local, regional, and international projects. The department operates as the country contact for lending and donor agencies such as the Caribbean Development Bank (CDB); Organization of American States (OAS); United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP); the Global Environmental Fund (GEF); World Bank; and the European Union (EU). It facilitates the coordination of requests for technical assistance, grant funding and loans between various government ministries and non-governmental institutions and external donor agencies.

The Department prepares and manages the Government's Public Sector Investment Programme (PSIP) through close collaboration with line ministries and statutory corporations. The PSIP directs the preparation of the capital budget and assists in ensuring a holistic approach to inter-ministerial and inter-departmental programming, so as to avoid duplicity.

5.1.3.5 National Emergency Management Agency

The National Emergency Management Agency (NEMA) was established in 1995 and is responsible for the coordination of pre and post disaster management activities.

NEMA seeks to coordinate and facilitate pre and post disaster management activities at the community and national levels, in order to minimize vulnerability and mitigate against the impact of disaster on life, property and the well-being of residents of St. Kitts and Nevis.

NEMA operates under the National Disaster Management Act of St. Christopher and Nevis, which establishes the legal framework for disaster management and is guided by the National Disaster Plan.

NEMA operates as the Secretariat for the St. Kitts-Nevis National Disaster Mitigation Council which was established in 1999. The Secretariat is chaired by the Deputy Prime Minister, Hon. Sam Condor, and is comprised of Permanent Secretaries, Heads of key response agencies and Non-Governmental Organizations. The Council provides general oversight and related policy guidance.

NEMA is responsible for emergency shelters.

Early warnings for meteorological events are provided by the local Meteorological Office as part of the framework for disaster management at the Robert L. Bradshaw International Airport on St. Kitts. The Seismic Research Unit (SRU) of the University of the West Indies, St. Augustine Campus, Trinidad and Tobago, provides warnings and alerts for volcanic and earthquake related events.

In pursuit of a high level of community and national preparedness, the NEMA organizes training for volunteers, and other personnel, in such areas as Shelter Management, Damage Assessment and Needs Analysis, Hazardous Materials, Mass Casualty Management and Land Search and Rescue. Where necessary, individuals also travel overseas for training.

NEMA also operates a public awareness program via radio, television, print and exhibitions. In addition, a combination of hazards specific brochures produced either by this Agency or by the Caribbean Disaster Emergency Response Agency (CDERA) is distributed within communities in St. Kitts. Further the Disaster Management Documentation Center provides opportunities for residents and visitors to undertake research on various topics.

5.1.4 Department of Agriculture

Agricultural development policies and programmes in St. Kitts-Nevis are developed and managed by the Department of Agriculture on St. Kitts and on Nevis. Traditionally, the Department of Agriculture (DOA) has focused on agricultural extension services, focusing primarily on methods of cultivation and overall crop production. Generally, the Department of Agriculture is responsible for a range of services related to agriculture and rural development in both St. Kitts and Nevis.

5.1.5 Ministry of Health

The Public Health Department is responsible for monitoring and testing water quality. In response to pollution issues Environmental Health Unit currently monitors the state of pollution in St. Kitts-Nevis.

5.1.5.1 National Housing Corporation

The National Housing Corporation (NHC) is responsible for the supply of affordable shelter accommodation and related infrastructure. The NHC is vested lands by the Government of St. Kitts-Nevis. NHC is responsible for development of the lands in accordance with guidelines established by Department of Physical Planning, Natural Resources and the Environment.

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5.1.6 Ministry of Communications, Works and Public Utilities, Ports, Physical Planning, Natural Resources and Environment, and Agriculture, Lands, Housing and Cooperatives and Fisheries

5.1.6.1 Water Department

The Water Department supplies water to all sectors in Nevis including commercial, residential and spring water. The Water Department laboratory also tests water quality, hardness, total dissolved solids (TDS) E. Coli and other microbiological tests.

5.1.6.2 Department of Physical Planning, National Resources and the Environment

The Saint Christopher and Nevis Constitution Order 1983 gives the Nevis Island Assembly responsibility over the affairs of Nevis. The Department of Physical Planning, Natural Resources and Environment (DPPNRE) is responsible for land use planning, land conservation, and environmental management.

In 2005 the DPPNRE prepared a draft Physical Development Plan, which proposed land to be earmarked for various land use types including environmental conservation areas. The approval of that plan is still pending. Generally, the DPPNRE works closely with the DPPE on St. Kitts with regard to the meeting country obligations under the key MEAs and other physical planning, development and environmental initiatives. These include:

- Soil sampling and analysis
- Soil conservation
- Forestry
- Water conservation
- Integrated pest management
- Food safety and nutrition
- Food security
- Marketing
- Natural resources management
- Animal and plant health

5.1.6.3 Nevis Housing and Land Development Corporation

The Nevis Housing and Land Development Corporation on Nevis is responsible for the public supply of affordable shelter accommodation and related infrastructure. The NHLDC is vested lands by the NIA respectively. The Nevis Housing and Land Development Corporation is responsible for developing the said lands according to the guidelines established by the Department of Physical Planning, Natural Resources and the Environment.

5.1.6.4 Nevis Disaster Management Department

The Nevis Management Department is located in the office of the Premier of the Nevis Island Administration. This Department is responsible for the planning and implementation of comprehensive Disaster Management for Nevis. The Agency provides coordination for cross agency cooperation in respect of disaster management.

The Department provides the secretariat for the Nevis Disaster Management Committee. The main function of this Committee is to ensure that Nevis is in a state of preparedness at all times. The Committee also advises the Nevis Disaster Management Agency on the requirement for anticipatory orders under the Emergency Powers Act.

5.1.7 Private Sector

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5.1.7.1 Saint Christopher National Trust

The Saint Christopher National Trust (SCNT) is a non-governmental organization founded in 2009 with the goal of preserving the national heritage of St. Kitts. The Trust evolved from the

St. Christopher Heritage Society which was incorporated as a private company in 1994. The SCNT currently manages the National Museum in the Old Treasury Building in Basseterre.

The main objective of the SCNT is to promote the protection, conservation, interpretation and enhancement of the natural environment of St. Kitts, including its animals and plant life. Also, it is intended that the Trust will provide a forum for the exchange of ideas, information and knowledge.

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5.1.7.2 Nevis Historical and Conservation Society

The Nevis Historical and Conservation Society (NHCS) was established in 1980 to conserve the natural, cultural, and historic resources of the island and adjacent marine areas. The Society is a non-profit organization managed by an Executive Board. Since its inception the NHCS has instituted projects and policies designed not only to preserve Nevis' unique history and environment, but also to make that heritage accessible and intelligible to locals and visitors.

The Ministry of Sustainable Development provides a general institutional coordinating mechanism for sustainable development in St. Kitts-Nevis. However, there is need for greater inter-agency cooperation and collaboration at the national level to make the model more effective.

6 POLICY AND LEGISLATIVE REVIEW

6.1 Existing Legal Instruments

The main statutes dealing with water is the Water Courses and Waterworks Ordinance. However there are other statutes relating to various aspects of water resources. These include Forestry Ordinance (forest reserves, water catchment areas), Public Health (water quality). In addition there are a range of other statutory provisions which have some bearing on the water sector. The Watercourses and Waterworks Ordinance, the Forestry Ordinance and Public Health Act apply to both St. Kitts and Nevis but these Acts are administered by different institutions in St. Kitts and Nevis.

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6.1.1 Water Courses and Waterworks Ordinance (Cap 185 of 1956)

The principal water legislation is the Watercourses and Waterworks Ordinance (Cap 185 of 1956) and the Watercourses and Waterworks Regulations. This Ordinance establishes legislative and regulatory powers for the WSD on both islands to, regulate the supply of water to consumers, prevent waste, misuse and pollution of water and control sanitation of watersheds. It addresses issues of water supply and protection of watercourses.

Under this legislation it is an offence to put any rubbish or offensive solid or liquid matter into a watercourse, or to pollute water flowing into or out of a watercourse. Regulations provide details on water supply, water meters and the control of standpipes.

The management of watersheds in St. Kitts-Nevis is shared between several agencies. These include the:

- Water Services Department;
- Department of Physical Planning and Environment;
- Department of Physical Planning Natural Resources and the Environment; and
- Department of Agriculture

This Act came into force on the 31st May 1956. According to Section 19(1)(i), the Water Board may make regulations to deal with the sanitary control of watersheds. At section 18 and for the purposes of the Act, where in the opinion of the Minister the drainage of water from any area flows or is conveyed to a watercourse or water-works the Minister may, by Order, declare that area or any part of the area to be a watershed.

Under this Act it is an offence to put any rubbish or offensive solid or liquid matter into a watercourse, or to pollute water flowing into or out of a watercourse.

6.1.2 Forestry Ordinance No. 10, 1903

The Forestry Ordinance No. 10, 1903 was amended by Ordinance No. 22, 1921 and No.5, 1928.

Regulations for implementation of the legislation are found in the Forestry (St. Christopher) Regulations, the Forestry (Fuel Supply) (St. Christopher) Regulations, 1927 and the Forestry (Nevis) Regulations, 1940. These regulations mostly addressed the granting of permits for exploitation, with specific requirements for charcoal burning, control of fires and land clearing.

The Ordinance declared as forest reserves, all land covered with trees above the existing line of cultivation which was generally taken as the 1000' contour on both islands. These reserves were never officially surveyed, gazetted or demarcated until the recent official declaration of the CFR on St. Kitts. All building activity remains restricted beyond the 1,000' contour on both islands.

On Nevis, land above 300m contour is now totally protected through administrative means rather than an actual declaration of protected status. However, there is interest in developing the appropriate mechanism(s) which would provide authority to declare areas as protected.

The objectives of the Forestry Ordinance are supported by NCEPA, the DCPA on St. Kitts and the DCPO on Nevis. Additionally, it can be interpreted that the Forestry Ordinance has provided the historic impetus for the country's involvement in the UNCCD, UNFCC and UNCBD.

6.1.3 National Conservation and Environmental Protection Act, No. 5 1987

The legal basis resources management is provided by the National Conservation and Environment Protection Act No. 5 (NCEP), 1987 which covers management and development of natural and historic resources, establishment of protected areas, and the establishment of an advisory Conservation Commission.

The National Conservation and Environmental Protection Act (NCEPA) is regarded still as one of the most advanced pieces to environmental legislation that has been developed in the English speaking Caribbean. In a general way it provides a rather comprehensive authority for the management and development of natural and historic resources in the Federation. NCEPA outlines a framework for the declaration of sensitive ecological and historic sites as protected areas.

Any protected area designated under this Act has the following broad purposes and objectives: to preserve the biological diversity of wild flora and fauna and the associated land and marine habitats, to protect selected examples of representative or unique biological communities, to sustain basic ecological processes including water recharge and soil regeneration; and to protect selected natural sites of scenic beauty or of special scientific, ecological, historical or educational value, including sites that are already degraded and need protection.

Areas chosen as protected areas under the NCEPA must have the following purposes and objectives:

- to preserve the biological diversity of wild flora and fauna that may be endemic, threatened or of special concern, and the land and marine habitats upon which the survival of these species depends;
- to protect selected examples of representative or unique biological communities, both on land and on marine areas;
- to sustain natural areas important for the protection and maintenance of life support systems, and basic ecological processes including water recharge and soil regeneration; and
- to protect selected natural sites and scenic beauty of special scientific, ecological, historical or educational value, including sites that are already degraded and need protection for restoration or sites that may become degraded if not protected.

Part VI, Section 31 of the NCEP makes provision for the protection of beaches and the coastal zone out to 2 km, and the Minister, through consultation with the Conservation Commission, is responsible for the preparation and implementation of a coastal zone management plan to regulate development. The Minister may declare certain areas to be protected beaches, where activities such as fishing, the use of boats, certain sports, mining, or removing treasures or artifacts from the sea bed are prohibited.

NCEPA is managed by the DPPE on St. Kitts and the DPPNRE on Nevis. The MSD has commenced preliminary work on the development of a National Conservation and Environmental Management Bill to replace NCEPA. When enacted, the emphasis of this new piece of legislation will be on the management of the environmental resources.

6.1.4 Development Control and Planning Act, No. 14 of 2000

The Development Control and Planning Act makes provisions for the orderly and progressive development of land in both urban and rural areas of St. Kitts. It supports NCEPA in that it provides for the protection of the environment and improvement of associated amenities. With regard to land use planning and management, the Act sets out the framework for the grant of development permission and for the design and implementation of a National Physical Development Plan (NPDP) to direct spatial development through time.

Planning and development control functions include but are not limited to the following:

- review of building and development applications;

- zoning;
- review of EIAs;
- Design and implementation of development plans; etc.

Key provisions of the DCPA as with NCEPA are aligned with Agenda 21 principles. These include:

i. Agriculture and rural development;
ii. Environmental protection;
iii. Water resources management;
iv. Land use planning, and Infrastructure;
v. Climate change adaptation;
vi. Biological diversity conservation.

The DCPB is responsible for the implementation of the DCPA. The DPPE in the MSD is the Secretariat of the DCPB and is charged with the day to day management of the Act.

6.1.5 Public Health Act No. 22 of 1969

Despite being outdated, the Public Health Act is still the main legislative instrument for managing environmental health issues in St. Kitts-Nevis. Initially, the Act did not address important issues of wastewater management including the discharge of untreated sewage, waste reduction, collection, storage transport, recycling or any of the present day concepts regarding waste management. As such, the scope of the legislative authority for environmental health revolves mainly around the maintenance of general sanitary conditions and cleanliness. The introduction of the Solid Waste Management Corporation Act in 1996 provided a legal framework to undertake waste management.

There is a need to further revise the Public Health Act and/or consolidate the environmental management provisions of other legislations toward establishing more appropriate institutional arrangements to support, co-ordinate and direct relevant environmental health activities.

6.1.6 Agricultural Development Act 1973

The Agricultural Development Act makes provisions for the more efficient use and economic development of agricultural lands. It sought to promote the development of income and employment opportunities for farmers, particularly in the rural areas of St. Kitts-Nevis. The Act provided for the establishment and incorporation of an Agricultural Land Authority to manage the provisions of the Act and to inform agricultural development policies. The Departments of Agriculture on St. Kitts and Nevis manage the administration of the Act.

Under the Act, the DOA is required to formulate general plans for utilization of agricultural lands and establish an adequate mode of use on the basis of the natural environments of agricultural lands, social and economical factors, technical conditions and farmers' vulnerability.

6.1.7 South-East Peninsula Land Development and Conservation Act, 1986

The Act provides for the development, conservation and management of the South-East Peninsula, to establish a Land Development and Conservation Board with specific powers and functions, and for matters connected thereto. This Act only applies to the South-East Peninsula in St. Kitts. Section 4 of the Act provides for the development and implementation of an environmental protection plan.

Section 4 of the Act establishes the powers and functions of the Board. They include (b)(ii) control of pollution and maintenance of the environmental quality of the South-East Peninsula, including coastal conservation; and (iii) development and implementation of an environmental protection plan. Section 5 requires the Board to develop the South-East Peninsula Development and Land Use Management Plan.

6.1.8 Frigate Bay Development Corporation Act. No. 13 of 1972

The Act provides for the vesting of lands situate at Frigate Bay in the island of Saint Christopher known as Frigate Bay Estate in the Frigate Bay Development Corporation, a body constituted for the purpose of undertaking and encouraging the development of Frigate Bay and for mattes incidental thereto or connected therewith.

This Act applies only to the Frigate Bay Development Area in St. Kitts. According to section 9 of the Act the Corporation is effectively the development control authority within the Development Area.

6.1.9 Beach Control Ordinance

The Beach Control Ordinance Cap. 281, provides authority to control sand mining and construction on the foreshore (tidal zone). Use or encroachment of the foreshore or floor of the sea is prohibited, except with the permission of the Minister of Agriculture, Lands, Housing and Development.

6.1.10 Solid Waste Management Corporation Act (1996)

Introduced in 1996, the Solid Waste Management Corporation Act for St. Kits-Nevis provides for the management of solid waste in conformity with the best environmental practices. The Act provides the legislative framework for the storage, treatment and disposal of solid waste, in order to prevent environmental degradation. Section 28 (1a) of the Act, requires that no individual shall deposit or knowingly cause to be deposited solid waste in or on land, beach, foreshore, marine waters or river banks.

6.1.11 National Housing Corporation Act

The GOSKN carries out its affordable housing programme through the National Housing Corporation (NHC). The National Housing Corporation Act provides the NHC with the statutory powers to conduct its business. In theory, the NHC is required to seek land development approval from the DCPB. However, this has not been a consistent practice.

6.1.12 St. Kitts-Nevis Building Regulations, Code and Guidelines (No. 7 of 2000)

The St. Kitts-Nevis Building Regulations, Code and Guidelines (commonly referred to as the Building Code) provide the regulatory framework for the management of construction and built developments. The Code scope applies to the construction of new buildings and structures, alterations, renovations, remodelling, demolitions, removal, relocation, maintenance and occupancy of existing buildings.

The DCPA is the parent legislation that guides the implementation of the Code. Generally, various provisions of the Code are tied with those of other legislative, regulatory and policy instruments such as NCEPA, the Forestry Ordinance, the Solid Waste Management Corporation Act and the Public Health Act.

6.1.13 Whitegate Development Corporation Act, No. 15 of 1999

This Act sets out the operational framework for the Whitegate Development Corporation. The objectives of the Corporation as outlined in the Act are to:

i. Attract new development that would take full advantage of the unique quality of the development area;
ii. Attract sufficient independent new investment and development;
iii. Create new job opportunities and businesses so as to enhance the physical, social and economic standard of the existing communities in the development area and the entire development area;
iv. Enhance the value of land and the quality of life of residents of the development area.

Though not specifically outlined, the objectives of the Whitegate Development Corporation Act are supportive of sustainable development principles.

6.1.14 Fisheries Act

The Fisheries Act No. 4, 1984, modelled on the unified draft circulated by FAO, provides for the establishment of marine reserves and priority fishing areas, and authorises the Minister to make regulations for the management and protection of such areas. Although none has yet been declared, the Conservation Commission is actively studying proposals to implement the Act.

The legal authority to designate a marine area as a national park, marine reserve or a protected area is given in both Part II, Section 3-6 of the National Conservation and Environmental Protection Act and Part II, Section 23 of the Fisheries Act. Although, neither Act specifies an administrative authority to manage such an area, both Acts assign sufficient authority to the Minister responsible in both fields to make declarations and rules to establish reserves and protected areas without first obtaining the consent of parliament.

Part VII of the NCEP covers forestry, soil and water conservation, and Section 35 provides for the establishment of forest reserves. The Minister (in consultation with the Conservation Commission) is required to establish forest management schemes and the necessary regulations, including the prohibition of livestock grazing, although, to date, no regulations have been promulgated.

6.1.15 Natural Disaster Management Act

The National Disaster Management Act (Chapter 19.06) seeks to establish an effective framework for the management and control of disaster.

Part II of the Act establishes the National Disaster Management Agency. By section 4 the Agency is constituted by a Board of Directors consisting of the Director-General, the Disaster Manager for the Island of Nevis and two members nominated by the Premier of the Nevis Island Administration and a maximum of nine other persons appointed by the Prime Minister of St. Kitts-Nevis.

The functions of the Agency are set out in section 5 and in effect confer on the Agency responsibility for co-ordinating the general policy of the Government relating to the management, control, mitigation of preparedness for, response to and recovery from disasters.

Part II of the Act deals with the Administration of the Agency and the appointment of the other agency staff.

A National Disaster Management Council is established under section 10. The Council is chaired by the Prime Minister. A National Disaster Advisory Committee is established to advise the Council.

The Agency is required by the Act to prepare for the approval of the Prime Minister a National Disaster Management Policy Review. In addition, the Agency is required to annually prepare a National Disaster Plan for the approval for the Prime Minister.

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6.1.16 Nevis Housing and Land Development Act, 1988

This Act established a Land Development Corporation to provide for the systematic development and alienation of land by the Corporation in respect of agriculture, industry and tourism. It also provided for the establishment of a fund for development in Nevis.

6.1.17 Nevis Development Control and Planning Ordinance, 2005

Development control and land use planning on Nevis are administered under the Nevis Development Control and Planning Ordinance. The Ordinance provides the legislative framework for the Nevis Island Administration to prepare physical development plans that would guide the development and management of land use on the island. Also, it provides for the exercise of development control, including building activities.

6.1.18 Nevis Development Control and Planning Ordinance 2005

Development control and land use planning on Nevis are administered under the Nevis Development Control and Planning Ordinance. The Ordinance provides the legislative framework for the Nevis Island Administration to prepare physical development plans that would guide the development and management of land use on the island. Also, it provides for the exercise of development control, including building activities.

The Ordinance has a similar scope to the DCPA on St. Kitts as it makes provisions also for the following:

- review of building and development applications;
- land use zoning;
- review of EIAs;
- Design and implementation of development plans;
- Natural and heritage preservation; etc.

6.1.19 Forestry (Nevis) Regulation 1944

These four (4) instruments combine to make provision for the conservation, management and exploitation of forests. The principal provisions of the Ordinance deal with forestry and are devoted to forest reserves. It gives the Governor-General power to declare any area or crown land to be a forest reserve by proclamation in the Gazette. It also prohibits any land from being granted, devised or sold within a forest reserve. The following section gives further power to the Governor-General to declare land other than Crown land to be a protected forest when it appears that it is necessary to do so for reasons that include but are not limited to preventing soil erosion and landship, maintaining water supply in springs, rivers, canals and reservoirs, for the maintenance of health, or for the protection of roads, bridges, airstrips and other lines of communication.

6.2 Supporting Regulations

St. Kitts and Nevis is replete with examples of environmental policies and project activities that are aimed at making improvements in the status quo as regards environmental management.

The process of integration required by sustainable development occurs mainly in the planning and implementation stage of projects and policies but the legal framework to fuel the transition towards sustainability has a central role to play and is indispensable to the transition to a tangible contemporary environmental framework. The NCEPA was introduced as a framework law that is dedicated to environmental management and encompasses regimes of planning, management, fiscal incentives and penal sanctions. The Act provides the framework for environmental management and creates the institutional mechanisms for environmental management in the country. In the context of the legal framework, there are however two main shortcomings to the NCEPA. The first is that it was prepared prior to the UNCED and therefore does not embrace the fundamental principles regarding sustainable development. In recognition of this a revision has been proposed but it is still underway.

The second shortcoming is that it is contingent upon the enactment of a regime of regulations for its effectiveness. This has not occurred nor are there any immediate plans to undertake this activity. To complement the NCEPA, there is additional legislation governing specific sectors of the environment including fisheries, forestry, wildlife, and water. These laws are severely outdated and in need of comprehensive revision to embrace sustainable development principles. Overall, the legal structures for environmental management in St. Kitts and Nevis are weal, outdated and in need of extensive reform.

6.3 Pending Legislation

6.3.1 National Conservation and Environmental Management Bill, 2005

The National Conservation and Environmental Management Bill, 2005 makes provision for a range of matters including the conservation of the natural and cultural heritage; the prevention of pollution and the management of the environment to ensure the sustainable development of St. Kitts and Nevis. The Bill is applicable to both St. Kitts and Nevis. However the Bill provides that the Nevis Island Administration has the exclusive responsibility for the administration of the Act within Nevis.

Part X of the Bill deals with Soil and Water Conservation. Section 42 makes provision for watershed conservation, section 43 deals with protection of ghaunts while section 44 allows the Department of Environment to take remedial action.

Part XII of the Bill established a comprehensive framework for pollution control.

The Bill proposes the repeal of the National Conservation and Environmental Protection Act, 1987.

6.4 Review of Legislative Framework

New legislation is needed to strengthen the regulatory framework for the water sector. These would include:

- A new Water Resources Legislation
- A new Public Health Act
- New Regulations to establish water quality standards.

A critical area for new legislation is in respect of pollution. The early enactment of the National Conservation and Environmental Management Act will strengthen watershed management, establish a regulatory framework for pollution and provide a comprehensive legal framework for environmental management.

6.5 Existing Policies and Guidelines

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6.5.1 Agricultural Development Strategy 2013-2016

The Agricultural Development Strategy 2013-2016 defines a two-progned strategy based on the requirements for development:

- the Sectoral (Technical) Strategy – which focuses on development of the sector itself. By the mandates of the DoA, the 'sector' covers only crop and livestock production, food processing and marketing. Priority Areas and technical actions, are defined in a manner that seeks to upgrade the capacity of selected crops and livestock to contribute to the three Agricultural Development Goals, namely;
    - safe, affordable and stable food production for food and nutrition security;
    - innovative and profitable agribusiness for economic growth and development;
    - sustainable and resilient farming systems.
- the Institutional [Management] Dimension – which focuses on the DoA as the main vehicle to take action and give effect to achieving the Sectoral Goals. In this context, the Institutional Development Goal is defined as:
    - efficient and cohesive agricultural policy and institutional framework.

6.5.2 National Environmental Management Strategy

In April 2005, a National Environmental Management Strategy (NEMS) which defines the specific directions and mechanisms for more effective policy implementation, as well as identifies key strategies and priority actions for environmental management in the context of sustainable development. Specifically, it proposes to restore environmentally degraded areas and to ensure the sustainable use of natural resources while taking into account complex linkages between ecological systems in small island states as well as between these systems and human activity, and which reflect the principles of island systems management. Activities identified include the formulation of criteria for and identification of environmentally degraded areas; identification of critical areas for erosion control, and develop and implement remediation projects with community participation; and preparation of Special Area Plans or Local Area Plans to restore these areas, with assigned responsibilities, costs, and schedule. Line ministries and other relevant agencies in St. Kitts-Nevis are expected to have a phased adoption of recommendations/policies that are relevant to their work plan.

6.5.3 National Environmental Action Plan

The National Environmental Action Plan (NEAP) discusses the environmental issues affecting St. Kitts-Nevis in a comprehensive, multi-sectoral framework and sets forth a long-term strategy for maintaining the country's natural environment, the health and safety of its population, and its cultural heritage as economic development occurs. It proposes practical measures to prevent or remedy environmental problems and considers cross-sectoral links that affect renewable and non-renewable resources, as well as human activity. The key objective of the NEAP is to set forth a long term national environmental policy and investment strategy based on comprehensive environmental analysis.

It examines the quality of the environment; biodiversity; and the use of natural resources, including air, land, water, forest, and wildlife. Furthermore, it assesses how economic and institutional issues associated with the management of these resources are affecting development, and human health and wellbeing. The NEAP outlines priorities and related policy recommendations in the following areas:

- Public awareness of environmental issues;
- A national strategy for environmental protection;
- Specific legislative actions, programmes, and investment projects to address priority problems;
- The management of natural resources, particularly endangered species and habitats;
- The reversal of environmental degradation; and
- Protection of the public from environmental pollution and natural hazards.

The NEAP is aligned closely to the key principles of Agenda 21.

6.5.4 Medium Term Economic Strategy (MTESP)

The Medium Term Economic Strategy (MTESP) establishes the sectoral priority areas of the GOSKN. While traditionally it has focused primarily on the economic sectors, in recent times environmental considerations have been included. The 2005-2007 MTESP identified the following objectives as the Government's priority for the environment over the medium term:

- To reduce current and potential environmental degradation;
- To reduce the adverse environmental effects of current and future economic development;
- To educate and raise awareness on current and potential environmental issues; and
- To raise the profiles of the available alternative sources of energy.

It indicated further that the objectives will be implemented through projects or programmes in the following areas:

i. Land Degradation;

ii. Watershed/Forestry Management;

iii. Coastal Area Management; and

iv. Energy Conservation.

6.5.5 National Adaptation Strategy (NAS)

The GOSKN adopted the National Adaptation Strategy for the period 2006-2013 in response to closure of the sugar industry in 2005. The NAS outlines the policy framework for restructuring the national economy around a more diversified economic base and to implement a comprehensive and integrated adjustment programme. To a large extent, the NAS has been supported by the European Commission (EC) within the framework of its 2007-2013 support strategy to promote fiscal sustainability, private sector development, market liberalization, skills development, poverty reduction and institutional strengthening.

The primary focus areas of the NAS include the following:

i. the maintenance of macro-economic stability to reduce vulnerability and facilitate investment;

ii. improvement competitiveness in the production and export of goods and services;

iii. the adoption of social policies to support economic development and protect the most vulnerable;

iv. the promotion of a sustainable development agenda;

v. restructuring and transformation of the economy;

vi. the development of appropriate legal and regulatory frameworks; and

vii. the efficient provision of public goods (such as education and health).

6.5.6 National Physical Development Plan (NPDP)

A National Physical Development Plan for St. Kitts was prepared in 2005. The NPDP has been designed to promote the orderly and progressive development of land. Additionally, the plan seeks to promote the preservation of and improvement to various environmental assets/resources that provide amenity value to the country. The following critical planning goals are outlined in the plan.

- Provide a guide for the physical development and the rational allocation of the limited land resource of the country.
- Devise appropriate measures which increase accessibility to essential services, adequate shelter for all, and to ensure sustainable livelihoods.
- Provide guidance for future development control.
- Design policies that relate to land development and management for the long-term objective of improving livelihoods for all.
- Provide a basis for coordinating physical development including plans, programmes, and investment activities of individual, public, and private sector agencies involved in development.
- Link socio-economic planning with physical planning.

The implementation of the NPDP has helped to direct growth by serving as a decision guide in evaluating a range of matters including: land use applications; land use zoning; subdivision development; environmental preservation and conservation; heritage conservations; Site planning and development; and Infrastructure planning and installation.

6.5.7 National Environmental Management Strategy (NEMS)

The preparation of a National Environmental Management Strategy and Action Plan (NEMS) for St. Kitts-Nevis was guided by the country's obligations under the St George's Declaration (SGD) of Principles for Environmental Sustainability in the OECS, 2001. The NEMS helps to guide St. Kitts-Nevis's programmes in environmental management over the long term. The principles outlined in the NEMS remain relevant.

The NEMS has assisted in streamlining the annual OECS reporting requirements on the St. George's Declaration and has harmonized the reporting needs for UNFCCC, UNCBD and UNCCD. The continuous implementation of the NEMS offers an opportunity to support and expand on the delivery of the MTESP and build on local efforts for sustainability. Among the guiding principles of NEMs are the prevention and control of pollution and the management of waste, ensuring the sustainable use of natural resources; and addressing the causes and impacts of climate change.

6.5.8 St. Kitts Agricultural Development Strategy (ADS)

Following the 2005 closure of the sugar industry, like tourism, the agriculture sector has been identified as a key area of growth in the national economy. Accordingly, the ADS was developed as a guide to support the Government's policy to significantly increase non-sugar agriculture production in a competitive and sustainable manner. The plan has put farmers at the forefront of this new agricultural thrust. The ADS proposes a marketed approach with an emphasis on new areas of penetration.

It stresses an integrated production and marketing system which is expected to contribute significantly to the economic diversification programme. Much emphasis is being placed on the development of medium size holdings and commercial of farmers in an attempt to transform the sector from a largely subsistence base into one that is wholly competitive. Generally, the proposed new agriculture investments included in the, ADS are aligned with other macroeconomic sectoral targets/objectives outlined in the National Adaptation Strategy.

6.5.9 National Biodiversity Strategy and Action Plan (NBSAP)

In 2004 the NBSAP was developed with financial assistance from the GEF with the support of UNDP. It was the Federation of St. Kitts-Nevis's first coordinated step in meeting its obligations under the UNCBD. Essentially, the NBSAP outlines the natural resource stock of St. Kitts-Nevis and highlights strategies to effectively manage them. Specifically, the plan examines species population, distribution and protection status.

The Second National Report to the Convention on Biodiversity was prepared by the GOSKN in December of 2009.

6.5.10 Natural Hazard Management and Mitigation Policy

In 2001 a Natural Hazard Management and Mitigation Policy was developed for St. Kitts-Nevis. The purpose of this policy was to provide proactive approaches for reducing vulnerability to environmental hazards by enhancing capacity for mitigation and engendering a culture of adopting mitigation measures. The policy sought to:

- Foster an environment supportive of resilient building and land use planning practices that were aligned with the principles of sustainable development.
- Encourage effective coordination among key stakeholders involved in national development.
- Increase community consciousness and commitment to carry out disaster mitigation and environmental risk reduction practices.

For the most part, the policy has been implemented with a moderate degree of success. Generally, natural hazard considerations have been factored into the national planning process. Natural Hazard Impact Assessment (NHIA) is now included in the Environmental Impact Assessment framework. Additionally, the Revised St. Kitts-Nevis Building Code makes provisions for improved building practices.

NEVIS

6.5.11 Nevis Physical Development Plan (2008 DRAFT)

A draft Physical Development Plan for Nevis has been developed to promote the sustainability of the island's resources through the improved regulation of land-use. The Plan was designed to address land development over a fifteen year period. It includes policies and guidelines for sustainable development and seeks to prescribe locations of housing, industry, parks/conservation areas, hotel and tourism development with regards to land suitability and other physical and environmental attributes.

Though not formally approved, the Plan has been used as a guide to inform decision making on land use and development applications; zoning; environmental management; heritage matters; and infrastructure development. Generally, the objectives of the Plan support the island's sustainable development agenda.

The National Physical Development Plan, 2006 guides physical development in reference to land use taking into account demands of stakeholders; and directs future changes with respect to land use, re-zonings, natural and heritage conservation, the provision of public infrastructure and aiding decisions for private sector investment. The draft Saint Kitts-Nevis Land Use Code seeks to strengthen the development and planning policies and proposals of the 2006 National Physical Development Plan and reduce the negative environmental, economic and social impacts of development projects.

6.5.12 Nevis Integrated Strategic Development Plan

Nevis Integrated Strategic Development Plan (2001-2005) seeks to promote balanced growth and effective resource utilization in achieving sustainable development. Relevant land degradation strategies identified include research and experimentation in agricultural management practices relative to soil, stemming problems of desertification and soil erosion through maintenance of vegetation cover on lands susceptible to erosion, minimizing soil pollution and upgrading the administrative framework for environmental management.

6.6 Assessment of the Effectiveness of Policies

While St. Kitts-Nevis is policy rich it lacks the financial resources to implement many of the policies. As articulated by stakeholders consulted and the various national reports, various components of the current framework must be strengthened in terms of an increase in the staff complement of various institutions; provision of requisite training for staff; provision of relevant regulatory and enforcement capabilities of institutions; maintenance of a baseline of programmatic activities such as data collection and monitoring; the ability to use information from various sources for decision making; and the development of fiscal policies to stimulate corporate environmental stewardship, and to incentivize new business models that focus on the sustainable utilization of natural capital to attract foreign exchange.

6.7 Recommendations for New Policies

There is a need for a comprehensive **Water Policy** to provide a comprehensive framework for the management of water and watersheds.

There is also a need for a **Climate Change Policy** which would establish an overarching framework for all climate change issues.

6.8 International Conventions

International law is much different from domestic law. Domestic law describes the rights and obligations of persons and their relationship to each other and the government. Domestic legal systems almost always include general methods for enforcing laws and adjudicating disputes.

International laws set out the powers and obligations of nations. Usually only nations, not individuals, may seek enforcement of the laws. Though there is an International Court of Justice, unlike a domestic court, it has no authority to force parties to appear before it or to abide by its decisions. Often international law is established through mutual agreements or treaties, and individual treaties may spell out specific means of enforcement or resolution of disputes. These dispute resolution mechanisms may be open only to Nations party to the agreement and not to their citizens in their own right.

Sometimes international accords are not intended to be directly enforceable. Nations will sometimes sign non-binding statements of policy or principle. These may serve as a step towards future treaties, as policy guides for international organizations, or as persuasive references in policy debates involving the signing governments. Violations of the principles, however, have no defined consequences.

Nevertheless, both binding and non-binding international law may make itself felt in domestic situations. A nation may pass domestic laws to implement a treaty or international standard of behaviour. Or, a nation may simply conform its actions to the course of international law without specific new domestic laws. For example, a country might render promised technical assistance to another without needing a change of domestic law to comply. Accords may occasionally make themselves felt through non-governmental action. For example, non-governmental organizations (NGOs) around the world have embraced the Forest Principles signed at the 1992 Rio “Earth Summit”. Even industry groups have adopted codes of practice reflecting the Forest Principles.

6.8.1 United Nations Framework Convention on Climate Change (UNFCCC)

Global climate change refers to all aspects of the planet's climate that are or might be changing in response to human activities. This convention was developed due to the concern of countries that human activities were significantly increasing the atmospheric concentrations of greenhouse gases. These increased concentrations are believed to enhance the greenhouse effect leading to additional warming of the planet's atmosphere and the oceans. This warming can cause changes in ocean currents and wind patterns as well as regional and local changes in temperature and precipitation. Such changes can have adverse impacts on natural ecosystems and humankind.

The main objective of this Convention is to stabilize the level of greenhouse gases in the atmosphere, to avoid triggering rapid climate change. By signing it each party pledge to work for the reduction of greenhouse gas emissions, the protection of greenhouse gas sinks and reservoirs, and the mitigation of any effects of climate change. Each country has to make national inventories of its emission of those greenhouse gases not regulated under the Montreal Protocol (which governs chlorofluorocarbons and related chemicals affecting the stratospheric ozone layer).

6.8.2 Kyoto Protocol

The Kyoto Protocol represents the first binding reduction target under the United Nations Framework Convention on Climate Change (UNFCCC). Under the Protocol, developed countries (Annex I Parties) agreed to reduce their emissions of greenhouse gases (GHGs) by at least 5% below 1990 levels (Art. 3.2). Individually, each Annex I Party agreed to a specific reduction target to achieve the overall goal.

The Protocol includes a number of flexibility mechanisms that are intended to provide alternatives to domestic emission reductions. These mechanisms include emissions trading (Arts. 4 and 17) (either on a case by case basis or by creating an emission bubble, such as the European Union) and joint implementation of emissions reductions between Annex I Parties and economies in transition (Art. 6). They also include a clean development mechanisms (Art. 12), which allows Annex I countries to work with non-Annex I Parties to achieve credits in non-Annex I countries and use the reduction to offset emission in the participating Annex I country.

The Protocol consists of a short preamble, 28 articles and two annexes. The preamble simply places the protocol within the context of the UNFCCC. Annex A lists the six greenhouse gases that are subject to the Protocol as well as a list of major sectors that contribute to emissions. Annex B lists the country specific emission reduction targets for Annex I countries.

Article 1 to 3 include definitions and an overview of the overall obligations taken on by Parties. Included in these articles are the emission reduction obligations, obligations to developing countries, and provisions for sinks as a way to offset emissions (Arts. 3.3. and 3.4). Articles 4, 6, 12, and 17 provide for flexibility mechanisms, including the emissions bubble (allowing countries to meet their target as a group rather than individually), joint implementation, the clean development mechanism, and emissions trading.

Articles 5, 7 and 8 provide for determination and reporting of member countries' emissions by source and removals by sinks. Article 18 addresses the issue of compliance. The remaining articles deal with the general administration of the Protocol.

Most of the obligations of the Protocol rest with Annex I countries. They include the country specific emission reduction targets in Annex B for the first commitment period of 2008 to 2012. This means countries have to reduce their emissions to the accepted emissions reduction target averaged over the five-year commitment period. If a country cannot meet its target in 2008, it still has four years to make up the difference.

To ensure proper accounting of emissions and trading, reporting obligations are included under Articles 5, 7 and 8. These provisions are intended to ensure a balance between national sovereignty in allowing countries to determine how they will meet their obligations for emissions reductions and international oversight to ensure that the terms of the protocol will be met. They include an obligation to show demonstrable progress toward the emission reduction target by 2005 (Art. 3.2). Other related obligations include a requirement to estimate emissions in accordance with accepted methodologies, and a requirement to keep and make public an annual inventory of GHG emissions by source and GHG removal of sinks (Art. 7).

Obligations of Annex I Parties to developing countries are set out in Articles 2.3, 3.14, 10, and 11. Article 2.3, in combination with Article 3.14 requires Annex I countries to strive to minimize adverse effects on other Parties. This includes the issue of adaptation to the adverse effects of climate change such as sea level rise and extreme weather events. It also extends to economic, social and environmental impacts of mitigation actions. Articles 10 and 11 provide for technology transfer and capacity-building in developing countries, including the provisions of new and additional financial resources. The specifics in terms of amounts of funding and processes for technology transfer and capacity-building are still under negotiation.

Non-Annex I countries take on very few obligations under the Protocol (Art. 10), and those taken on are essentially restatements of obligations under the UNFCCC. They include the development of national inventories of anthropogenic emissions by source and removal by sinks of greenhouse gases not controlled by the Montreal Protocol on Substances that Deplete the Ozone Layer (1987). Article 10 also makes general reference to an obligation to develop national and possible regional programmes to mitigate and adapt to climate change. Finally, all Member States are obliged to cooperate in research, technology transfer, education, training, and to communicate on action taken under the Protocol.

Finally, the Protocol provides an opportunity to offset emissions beyond the country specific target by removing GHGs from the atmosphere through sinks (Arts. 3.3. and 3.43). Possible sinks include forests and soils. The details on how these flexibility mechanisms will operate have yet to be worked out.

6.8.3 The Convention on Biological Diversity

Threats to biological diversity have increased almost everywhere in the world during recent decades, mainly as a result of the destruction of natural habitats. Requirements for the conservation of biodiversity have therefore developed far beyond what was envisaged when the first conservation conventions were concluded.

The Convention defines biological diversity as "the variability among living organisms from all sources ... ; this includes diversity within species, between species, and of ecosystems." That means biological diversity encompasses the genetic variation to be found within a single kind of plant or animal; the variety of different kinds of plants and animals in a given place and their relative abundance; and the variety of natural aggregations of plants and animals, such as temperate pine forests, temperate oak forests, temperate forests dominated by mixes of particular species, the many distinct kinds of tropical forests, various grasslands, and so forth.

The Convention's objectives are to help conserve biological diversity, to promote sustainable use of its elements; and to ensure fair participation in the benefits that may derive from utilization of genetic resources. The agreement sets out an international consensus on these issues and thereby creates a legal framework that will contribute to the preservation of biological diversity.

Consistent with basic international law, the Convention reiterates that States have the sovereign right to exploit their natural resources pursuant to their own environmental policies, but with the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction. Article 4 states that the requirements of the Convention apply not just within a State's borders, but also to all actions under the State's control, inside or outside of the State's physical jurisdiction and regardless of where their effects are felt.

The Convention requires each signing State to formulate management plans and national strategies for the conservation and sustainable use of biological diversity or to adapt the existing strategies for this same purpose, and integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programs, and policies.

As part of a global approach to conservation, the Convention on Biological Diversity accordingly places far greater emphasis upon the conservation of ecosystems than upon the protection of species as such. Under Article 6 dealing with the *in-situ* Conservation, parties are required, as far as possible and as appropriate, to: establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity; develop, where necessary, guidelines for the selection, establishment and management of protected areas and areas where special measures need to be taken to conserve biological diversity; promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in their natural surroundings; promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas; and rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, *inter alia*, through the development and implementation of plans or other management strategies.

The Convention contains no obligation for parties to protect the areas which are most important for the conservation of biological diversity. Annex I to the Convention only provides guidance for area selection in the form of an indicative list of components of biological diversity important for its conservation and sustainable use.

The conservation of ecosystems is also promoted through general obligations for the identification and monitoring of important components of biological diversity (Article 7). Parties are required to identify processes and categories of activities which may have significant adverse impacts on the conservation and sustainable use of biological diversity. Environmental impact assessment obligations are set out in Article 14.

6.8.4 Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Ramsar, 1971 (Ramsar Convention)

Ramsar, which has been in force since 1975 aims to stem the progressive encroachment on and loss of wetlands, now and in the future. While Ramsar focuses on wetlands that are important for migratory waterfowl, it recognizes the overall value of wetlands, including their fundamental ecological functions and their economic, cultural, scientific and recreational value. Ramsar defines wetlands broadly to include freshwater, brackish and saltwater marshes, including marine waters up to six meters deep at low tide, and any deeper marine waters contained within the wetland area, as well as adjacent islands and coastal areas.

Ramsar parties are to designate at least one national wetland of international importance when signing the Convention or when depositing its instrument of ratification or accession; many parties have designated more than one. Designation of these areas should be an element of the process of identifying priority components of biodiversity under the Convention (see Part II, Action Item 6). Under Ramsar, parties are also required to establish wetlands nature reserves and cooperate in the exchange of information for wetlands management.

6.8.5 Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean (SPAW Protocol)

The Cartegena Convention was drafted in 1983, with St. Kitts and Nevis signing in 1999. This regional convention encourages the establishment of protected areas to conserve rare and fragile ecosystems occupied by vulnerable species, as well as the protection of endangered species and sustainable use of wildlife.

St. Kitts and Nevis signed the Oil Spill Protocol under the Cartagena Convention on June 15, 1999.

6.8.6 United Nations Convention to Combat Desertification in those Countries experiencing Serious Drought and/or Desertification, Particularly in Africa, Paris (1994)

The Convention aims to promote effective action through innovative local programs and support of international partnerships. The Convention requires the implementation of national and regional action programs, which should emphasize popular participation, and the creation of an enabling environment designed to reverse land degradation. St. Kitts and Nevis became a party to the Convention by accession on 30 June 1997.

6.8.7 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal

This convention is the response of the international community to the problems caused by the annual world-wide production of hundreds of millions of tons of waste. These wastes are hazardous to people or the environment because they are toxic, poisonous, explosive, corrosive, flammable, eco-toxic, or infectious.

This global environmental treaty strictly regulates the transboundary movements of hazardous wastes and provides obligations to its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner. The main principles of the Basel Convention are:

- Transboundary movements of hazardous wastes should be reduced to a minimum consistent with their environmentally sound management.

- Hazardous wastes should be treated and disposed of as close as possible to their source of generation.
- Hazardous wastes generation should be reduced and minimized to a source.
- In order to achieve these principles, the Convention aims to control the transboundary movement of hazardous wastes, monitor and prevent illegal traffic, provide assistance for the environmentally sound management of hazardous wastes, promote cooperation between parties in this field, and develop technical Guidelines for the management of hazardous wastes

6.8.8 Vienna Convention for the Protection of the Ozone Layer

The amount of ozone that forms between 49,215 and 180,455 feet above the earth’s surface is known as the ozone layer. The ozone layer shields the earth from harmful solar rays. It protects all life on the earth and acts like a space suit for plants, animals and humans. The layer also affects the temperature distribution of the atmosphere and regulates the earth’s climate.

Ozone depletion is caused by ultraviolet radiation (from the sun's rays) and volcano eruptions. However, man-made chemicals are the main contributors of ozone depletion.

The majority of the ozone depleters are chemicals made by man. The most harmful ones are as follows:

a) Chlorofluorocarbons (CFC's)
b) Hydro fluorocarbons (HCF's)
c) Carbon tetrachloride
d) Methyl chloroforms
e) Halons
f) Methyl bromide

Ozone depletion can lead to the following effects:

a) Non-melanoma skin cancers
b) Reduction in the defences of the immune system and the effects of vaccination
c) Increased eye damage producing snow blindness that can further develop into cataracts
d) Disruption of the ocean life and the marine food web due to the effect of UV - B radiation on plankton.
e) Increased air pollution with the toxic ozone gas in the lower atmosphere
f) Stunted growth in plants
g) Damage to material like paints.

Since the use of the ozone depleting substances has been widespread, there had to be some international consensus or agreement to protect the entire earth from these harmful substances. Therefore, the Vienna Convention for the Protection of the Ozone Layer was devised. Parties to the Convention are obligated to adopt legislation or administrative measures to control, reduce or prevent human activities under their jurisdiction that are likely to have an adverse impact on the ozone layer. This includes the control or prevention of the use of the ozone-depleting substances.

6.8.9 Montreal Protocol on Substances that Deplete the Ozone Layer

In January of 1989, the Montreal Protocol was fully implemented to control production, consumption and the use of ozone-depleting substances.

As of April 2000, there have been 173 developed and developing countries that have agreed to the policies outlined by the Protocol. The Montreal Protocol dictates that gradually all CFC's and halons will be banned. Specific timeframes are set for developed and developing countries to completely phase out the use of these substances. The timeframe for developing countries is longer than that of a developed country.

Trade restrictions will soon limit the supplies of these substances. Therefore, what is left on the market will be very expensive. Companies that stop the use of ODS will benefit from lower costs of alternatives, and also from the demand for ozone-friendly products.

6.8.10 Ramsar Convention on Wetlands

The Convention on Wetlands, signed in Ramsar, Iran, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 121 Contracting Parties to the Convention, with 1027 wetland sites, totalling 78.1 million hectares, designated for inclusion in the Ramsar list of Wetlands of International Importance.

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. Wetlands are among the world's most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. They support high concentration of birds, mammals, reptiles, amphibians, fish and invertebrate species.

The Convention's mission is the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world. Ramsar is the first of the modern global intergovernmental treaties on conservation and wise use of natural resources.

6.8.11 Kyoto Protocol to the United Nations Framework Convention on Climate Change (Not yet in Force)

This Protocol is under the UNFCCC. It provides for the reduction of greenhouse gas emissions to protect the environment.

The Kyoto Protocol includes emissions targets and timetables for industrialized nations and market-based measures for meeting those targets. The Protocol sets binding emissions targets for developed nations. The specific limits vary from country to country, though those for the key industrial powers of the European Union, Japan, and the United States are similar-8% below 1990 emissions levels for the EU, 7% for the U.S., 6% for Japan.

Under the Protocol, the emission targets for the developed countries would have to be achieved on average over the commitment period 2008 to 2012. The greenhouse gases covered by the Protocol are carbon dioxide, methane, nitrous oxide, hydroflurocarbons, perfluorocarbons, and sulfur hexafluoride.

6.8.12 The United Nations Convention to Combat Desertification and Drought (UNCCD)

The UNCCD is a Convention to combat desertification and mitigate the effects of drought that incorporates long-term strategies supported by international cooperation and partnership arrangements.

6.9 Non-Binding International Agreements

6.9.1 United Nations Conference on the Sustainable Development of Small Island Developing States, Bridgetown, (1994)

The United Nations Conference on the Sustainable Development of Small Island Developing States was held in Barbados in May 1994. The participants to the UN Conference on Environment and Development (the Earth Summit) had recognized the particular needs of these countries and their dependence on marine and coastal resources, as well as the threats they faced due to climate change and sea-level rise. Consequently, Chapter 17 of Agenda 21 specifically called for the convening of this Conference. Its objectives were to examine the nature and special vulnerabilities of these States and to define a number of specific actions and policies relating to environmental and development planning to be undertaken by these States, with help from the international community. After more than a year of negotiations, the Parties adopted the Barbados Programme of Action for the Sustainable Development of Small Island Developing States.

7 SOCIO-ECONOMIC SECTOR REVIEW

7.1 INTRODUCTION

Water forms an extremely important part of the economy of St. Kitts and Nevis. Almost all economic activities in the country rely on water in one form or another. As such, any changes in water supply and quality will have adverse social and economic consequences. Climate change will inevitably impact the hydrological cycle, thus changing precipitation patterns over the medium and long term as well as directly and indirectly affect the quantity and quality of St. Kitts water supply (Sections 3 and 4). Added to this, are a range of non-climatic stressors that will only serve to compound the situation. Recent studies conducted in the Basseterre Valley Watershed/Aquifer have identified several issues as already outlined in Section 1.2.1.

Successful adaptation will depend partly on arriving at better levels of information, knowledge and understanding of water resources, the nature and extent of the demands on water resources across key sectors, the contributing conditions and the macro-economic and development context within which they are situated.

This section of the report will provide relevant social and economic information that will assist the Government of St. Kitts and Nevis to effectively adapt to, develop and/or increase its resilience to deal with the anticipated adverse effects of climate change on its water sector. The section is organized under three broad areas. The first subsection showcases the relationship between St. Kitts and Nevis' economy and the water sector, with a main but not exclusive focus on the tourism and agriculture sectors. The subsequent sections look at the importance of water for the agriculture and health sectors, and explore the extent to which both sectors may be impacted (positively and/or negatively) by future climatic changes. The social context of the water sector and the particular vulnerabilities to which the national Adaptation Strategy and Action Plan must be sensitive to, especially in relation to important health and food security issues, will also be discussed. The section ends with an examination of some possible indicators that may help to track changes in the water sector due to climatic changes based on the climate projections provided.

7.2 THE RELATIONSHIP BETWEEN THE ECONOMY AND THE WATER SECTOR

7.2.1 St. Kitts

Potable water in St. Kitts is supplied mainly to the Commercial, Government and Domestic sectors. A long term evaluation of the water consumption trend by sector is however not possible at this time as the Water Services Department only recently started collecting this type of data using a billing system that started approximately two (2) years ago. However, the 2013 metered water consumption data received, showed that the Domestic sector (comprising mostly household consumption) was by far the largest consumer of potable water – amounting to approximately 68% of the average water consumption out of all the sectors.

As it relates to the Commercial sector, the bulk of the water is being supplied to the tourism and manufacturing industries. In contrast, the agriculture sector receives limited water for irrigation purposes. Given the recent and projected increases in tourism activities in St. Kitts, greater demands will inevitably be placed on the water sector. The tourism sector is known worldwide for being a major consumer of water. The maintenance of golf courses alone usually accounts for a considerable amount of water. The daily water consumption from both stay over visitors and cruise ship passengers could also account for a significant share of the available water resources of the island if not properly managed and regulated.

The challenge will be to balance the tremendous economic gains the tourism sector can provide to St. Kitts with the need to preserve the country's natural resource base. Travel & Tourism is an important economic activity in most countries around the world, particularly in the Caribbean. In the case of St. Kitts, more and more attention is being placed on tourism due to its potentially significant direct and indirect economic benefits.

The total contribution of the Travel and Tourism industry to St. Kitts and Nevis ' GDP was 22.5% in 2013 and is projected to increase by an average of 6.0% per annum to reach 30.4% of total GDP by the year 2024 (WTTC 2014). In terms of direct employment, Travel and Tourism directly accounted for 1,500 jobs (6.1% of total employment) in 2013 – this is projected to rise to 2,000 direct jobs (8.7% of total employment) by 2024. In terms of direct and indirect employment, the industry supported an estimated 5,000 jobs (21.4% of total employment) in 2013. This figure is expected to rise by a rate of 3.8% per annum to 8,000 jobs in 2024 (29.5% of total employment).

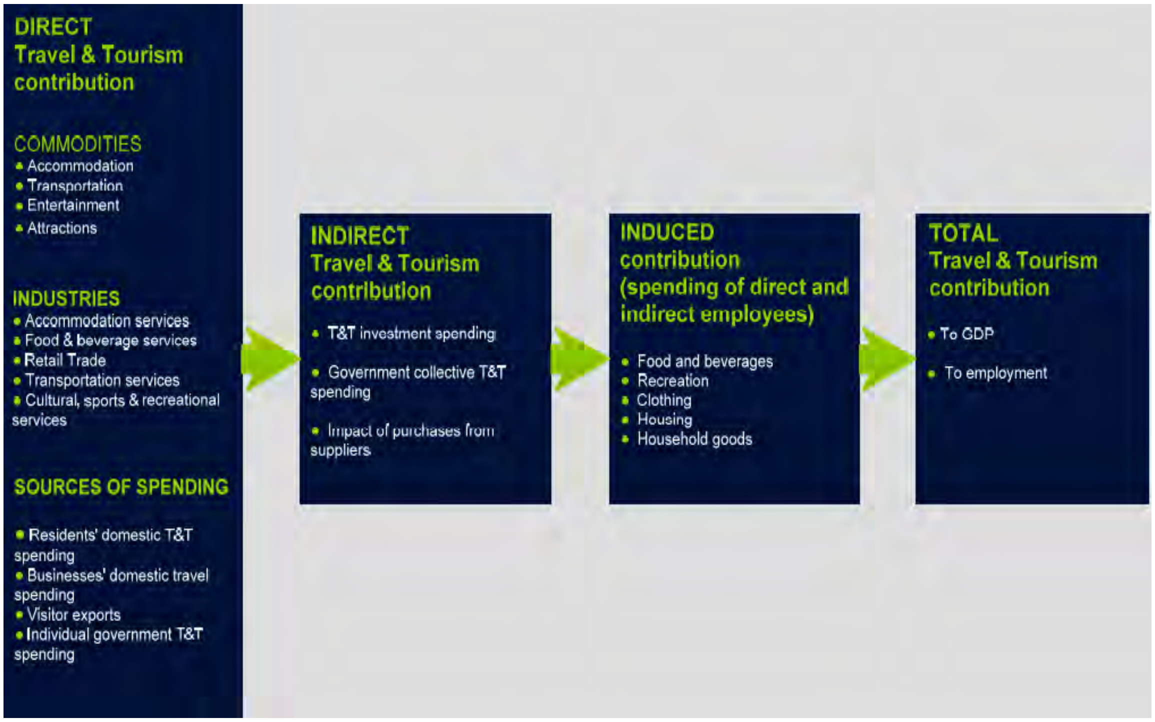

Figure 7.1: Direct, indirect and induced economic contributions of Travel and Tourism

Source: WTTC Online Database (2014)

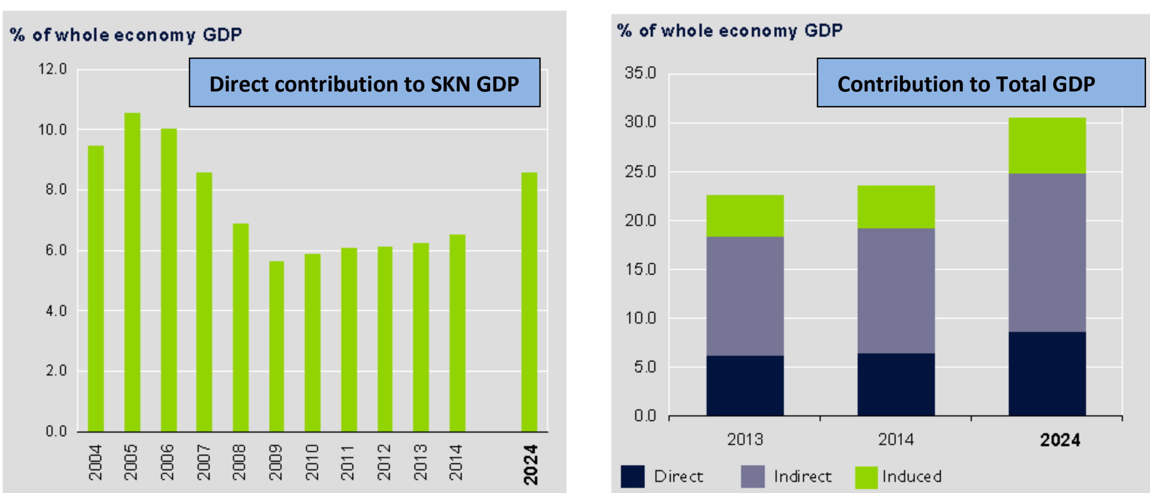

Figure 7.2: Contribution of Travel and Tourism to St. Kitts and Nevis' Economy

Source: WTTC Online Database (2014)

[1]All values are in constant 2013 prices & exchange rates

Given the collapse of the sugar industry, it is expected that investment in the tourism sector will continue to grow over the short and medium term. In fact, there has already been a strong push by the Government since the collapse of the sugar industry to promote tourism as a vehicle for economic development.

However, any further increase in visitor numbers (especially stay-over visitors) will require an expansion of existing tourism infrastructure. This has severe implications for water availability and quality. Presently, there are only a few hotels operating in St. Kitts, almost all of which rely on the Water Services Department for water. As mentioned above, only the Marriott Hotel relies completely on desalination water for their operations.

Table 7.1: St. Kitts and Nevis Annual Tourism Statistics, 2005-2013

						Estimated \1			
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Total Visitors	364,519	349,733	379,473	533,353	547,561	621,275	715,250	635,426	690,468
Stay-Over Visitors 1/	140,504	139,268	123,062	127,705	93,081	98,329	101,701	104,240	106,904
USA	79,569	77,587	69,894	76,455	54,410	58,710	64,245	66,988	68,385
Canada	8,468	8,130	7,116	7,805	6,413	6,054	5,961	7,073	7,202
UK	11,149	11,148	12,162	9,970	6,496	8,455	8,047	7,975	8,451
Caribbean	36,994	37,813	28,822	28,982	22,410	21,176	18,893	17,317	17,732
Other Countries	4,324	4,590	5,068	4,493	3,352	3,934	4,555	4,887	5,134
Excursionists	4,309	4,514	5,177	3,920	3,718	3,547	3,682	3,230	3,961
Cruise Ship Passengers	215,351	203,075	249,323	400,916	450,553	515,787	605,407	526,305	575,534
Yacht Passengers	4,355	2,876	1,911	812	209	3,612	4,460	1,651	4,069
No. of Cruise Ship Calls	244	261	242	232	235	293	337	298	300
Total Visitor Expenditure 2/ (EC$M)	327.12	355.45	336.92	297.17	225.41	241.74	254.06	256.51	272.84

Source: St. Kitts Statistics Office, Nevis Statistics Office ECCB
Date as at 15 May 2014

Notes:

1/ Stayover breakdown Jan-10 to Dec-12 estimated for Nevis

2/ Visitor Expenditure are ECCB's estimates

Records from 2009 to 2013 presented Section 4 already show an increasing trend for both the number of wells and total annual water consumption, signaling an increasing demand for potable water. Any further increase in sectoral demand for water could have serious implications for the water sector in St. Kitts.

Reports from the Water Services Department suggest that the department will not be able to provide water for new tourism developments. Instead, these developments are expected to supply their own water through desalinization.

While St. Kitts does not have a large manufacturing sector, there are a few bottling companies located in the island. Despite their small numbers, these companies are known to be significant users of water. Consultations revealed that 100% of their water is supplied by the Water Services Department. Large bottling companies such as the Carib Brewery and the Coca Cola Company use an enormous amount of water in their production. The Carib Brewery for instance, uses an estimated total of 607,000 hectoliters of water annually, spending on average EC$200,000 on water bill alone each year.

There are already signs of over-pumping and salt-water intrusion in the Basseterre Valley aquifer. As aforementioned, there is also evidence of drier areas of land on the outskirts of the aquifer's boundary. These observations coupled with the feedback provided from the stakeholder consultations, indicate that there is an urgent need for some measures to be put in place from now that will allow for the successful incorporation of good water resources management practices in the overall management and monitoring of the aquifer. With the existing challenges faced with the collection, storage and distribution of water, along with the threats posed by both medium and longer-term changes in the climate, the aquifer will not be able to adequately sustain an expanding domestic population alongside new hotel developments, especially within the southern sections of the island.

7.2.2 Nevis

In Nevis, water is supplied to the Agriculture, Government, Domestic and Commercial sectors. Like St. Kitts, data on sector average water usage only started being collected since 2009. The data show that over the five-year period the Domestic sector has been the largest consumer of potable water supply (maximum of 73%); followed by the Commercial sector (21%), Government (9%), and Irrigation (38%). Only between 1% and 2% of water was consumed by farmers. There has also been a significant increase in total annual water consumption over the period. Figure 6.3 shows that the Domestic sector has accounted for the bulk of this increase over the period. Though the Commercial sector only account for one fifth of average water consumption, data collected suggest that the demand from this sector is rapidly increasing.

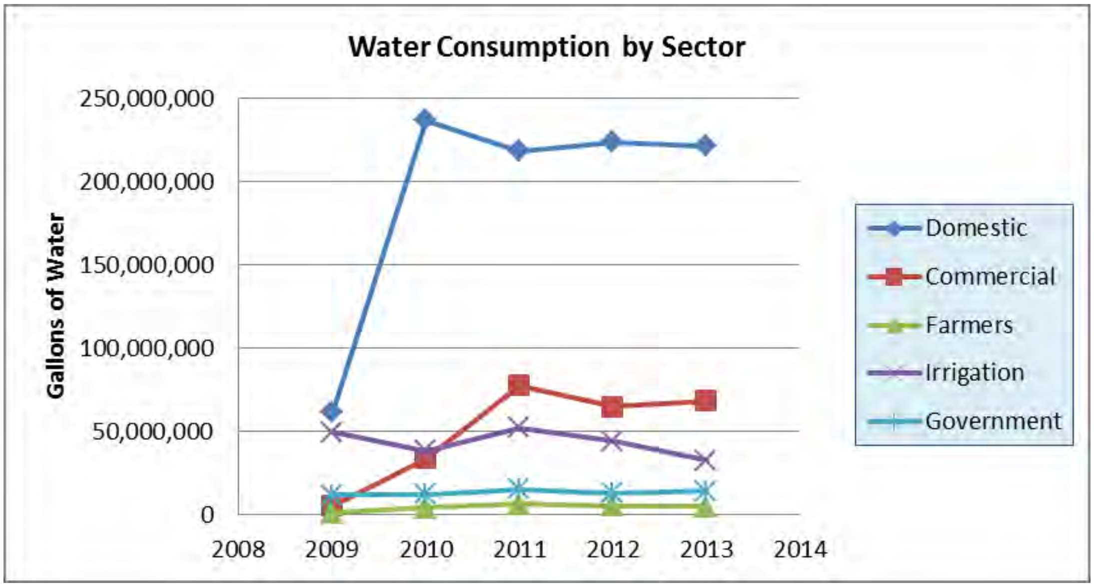

Figure 7.3: Water consumption by Sector 2009-2013

There are a number of challenges currently being encountered in the water sector. There is very limited monitoring of water consumption taking place. Springs and groundwater wells are being allocated to specific uses with no metering information. Out of the fifteen (15) groundwater wells in operation, water from one groundwater well is dedicated to the agricultural industry and an additional well is being utilised by the Four Seasons Hotel for irrigation of its properties and golf courses.

7.3 AGRICULTURE

Agriculture is undoubtedly one of the most vulnerable sectors in the world to climate change (IPCC, 2007, 2013) and several studies have already predicted that global agricultural production could suffer progressive yield losses by the end of the 21st Century (IPCC, 2007; Lobell et al., 2008; Challinor et al., 2009; Thornton et al., 2011). The Inter-governmental Panel on Climate Change in its Fourth Assessment Report concluded that it is very likely that subsistence and commercial agriculture in Small Island Developing States (SIDS) will be adversely affected by climate change (IPCC, 2007). This is particularly relevant for the Caribbean given the region's high dependence on agriculture as a source of income and employment. Farming systems in the Caribbean are particularly exposed and vulnerable to climate change impacts given their relatively high dependence on weather elements and limited application of technology. A number of studies have pointed to the wide ranging impacts that a variable and changing climate may pose to the region's farming sector (McGregor et al., 2009) – including an increase in the frequency and severity of extreme weather events such as hurricanes, reduction in plant-available moisture due to increased rates of evapotranspiration, and the increased spread of some pests and plant diseases to name some.

Sensitivity of the Sector

The nature of the agriculture sector in St. Kitts and Nevis renders it highly sensitive to both seasonal variations and longer-term changes in climate. As in most other Caribbean islands, the agriculture industry in St. Kitts and Nevis is characterized by mostly small open-field farm systems with limited to no application of technology. Added to this, very little water is being provided to the agriculture sector from existing sources. Instead, the majority of farmers in St. Kitts and Nevis rely on rainfall as a key source of freshwater. Given these characteristics, the sector is susceptible to a range of climate related hazards including hurricanes, droughts, heat stress, flooding as well as infestation from pests and plant diseases.

As climate becomes increasingly less predictable, farmers' ability to make informed agronomic decisions or to employ suitable coping strategies, gets more and more difficult, thus increasing their vulnerability and negatively impacting their adaptive capacity. Acute changes in specific environmental parameters such as temperature and precipitation will pose a severe threat to the country's agriculture sector over the medium and long term. For example, a marked increase in annual mean temperature will enhance the risk of thermal plant stress which could in turn result in lower crop yields for certain crops and even more frequent instances of crop failure. Studies have already shown that increasing global temperatures over the last three decades are partly responsible for significantly reduced yields in many major crops across the globe (Long and Ort, 2010; Lobell et al., 2011). Heat stress has also been partly linked to a reduction in the growth and reproductive performance of livestock. Alterations in mean temperature might also lead to the introduction of new pests and diseases in St. Kitts and Nevis that could affect plant growth and performance.

Increases in the incidence of droughts and floods will more likely exacerbate poverty levels in St. Kitts and Nevis, particularly among resource poor groups. Small-scale farmers are particularly vulnerable to climate variability and change, given their relatively narrow resource base and weather-sensitive livelihood practices. Since most of the regional models are predicting both a warming and drying trend for the Caribbean basin for most of this century (Hall 2013; Campbell et al. 2010; Whyte et al. 2008; Taylor et al. 2007, 2011), it is imperative that smallholder farmers develop suitable and cost-effective water conservation and water harvesting systems in order to maximize rainfall use efficiency on their own farms. There is enough evidence to prove that smallholder irrigation schemes are generally easier to manage and operate, and generate lower investment costs and higher rates of returns compared to large-scale centrally managed irrigation schemes. At present, rainwater harvesting is only being practiced by a handful of farmers in St. Kitts and Nevis despite the fact that most farms are rain-fed. Given future climate projections, improved on-farm water use and rain harvesting can serve as an appropriate climate adaptation strategy, especially among small farmers in both islands.

Current Programmes Underway

There are a number of programmes currently underway that are aimed at addressing the water situation for the agriculture sector. The Ministry of Agriculture has recently embarked on a rainwater-harvesting project with McGill University. The project involved the construction of several dams that would be used to store water for crops and livestock. There are also a number of projects promoting protected agriculture among local farmers, especially to safeguard farmers from pest infestation, invasion from monkeys and praedial larceny. There is also an Agriculture Adaptation Strategy (2012-2017) that is geared towards diversifying the sector.

While these initiatives offer tremendous potential for transforming the country's agriculture sector, they have been constrained by a number of intervening factors - the most obvious, being funding. Access to a sufficient and sustained pool of funding is definitely needed if these activities are to be maintained, replicated and scaled up. It was reported that there are a number of important capacity building project ideas that have not yet materialized due to a lack of funding. Also, many local farmers (the majority of which operate on a small scale) find it very difficult to access credit for their farms. A lot of these farmers do not own the land they farm on, which prevent them from using it as collateral to access loans. There is also a general lack of equipment and trained personnel for collecting and storing vital agro-ecological information for the sector in both islands. Finally, as the tourism sector continues to expand in both islands, accessing water for agricultural use might become more difficult. The continued development of desalinization plants especially by large flagship hotels that could sufficiently meet tourists' water demands offers one promising solution to this problem over the short –medium term.

Lastly, there seems to be major gaps in behavioral practices and available data. In the case of St. Kitts, the VCA revealed that while agriculture tends to be concentrated on the island's western side (near to the island's capital), the eastern portion of the island receives the most rainfall on average each year. This has clear implications for rainwater harvesting and the viability of farming in general. In fact, the Ministry of Agriculture has already reported a series of failures related to the rainwater harvesting schemes which were set up to assist farmers in capturing rainfall for crop production in the Basseterre Valley Area. This suggests that future investments in infrastructure to capture rainfall and or surface water will fail if projects are not developed based on sound scientific evidence where possible.

7.4 HEALTH

Both weather and climate play a significant role in health and overall wellbeing. Warmer average temperatures are projected to lead to more frequent hot days and fewer cool nights. This could increase the number of heat-related illnesses and deaths especially among older people. Increases in the frequency or severity of extreme weather events such as storms could increase the risk of dangerous flooding, high winds, and other direct threats to people and property.

Sensitivity of the Sector

The impacts of climate change on health will however depend on many factors. These factors include the effectiveness of a country's public health and safety system to address or prepare for the risk and the behavior, age, gender, and economic status of individuals affected. Impacts will likely vary by region, the sensitivity of populations, the extent and length of exposure to climate change impacts, and society's overall ability to adapt to change.

The combined population of St. Kitts and Nevis is estimated at 46,398. Of this total, 34,983 persons were recorded on St Kitts while Nevis accounted for the remaining 11,415 persons (Statistics Department, GSKN 2012). This figure represents a marginal increase of 0.16% in comparison to the 2001 census figure of 46,325. St Kitts population moved from 35,217 in 2001 to 34,983 in 2011, reflecting a decrease of 0.7%. In contrast, Nevis population expanded by 2.8% moving from 11108 in 2001 to 11,415 in 2011. Between 1990 and 2010, the population increased by approximately 19.8%. There has also been a demographic shift towards older ages over the period, with relative similarity among age groups younger than 55 years. Fertility and mortality have been relatively low in the intervening decades, showing a steeper decrease in the last decade and a half. Life expectancy was 74.4 years in 2010 compared to 73 years in 2006. The crude death rate was 7.5 per 1,000 population in 2006 and 7.0 in both 2007 and 2008. In 2009, the rate declined to 6.8, but in 2010 it returned to the 2006 level of 7.5.

While the demographic indicators seem positive, climate change will undoubtedly present new challenges to the health sector. Studies have already shown for instance that human health on islands can be seriously compromised by lack of access to adequate and safe freshwater resources (see for example Nurse et al. 2001; Mimura et al. 2007). There is certainly a growing concern in the Caribbean that freshwater scarcity and more intense droughts could lead to deterioration in sanitation and hygiene (Cashman et al. 2010). Interviews with representatives from the Environmental Health Department and the Physical Planning and Environment Department, confirmed that residents in the Basseterre Catchment Area usually experience water quality problems when there is a heavy downpour. This usually worsens when there is an extended dry period. However, it was also reported that catchment samples generally show high levels of turbidity and bacterial contamination during the wet season.

Climate Change and Health Risks

As it pertains to heat-related impacts on human health, any pronounced increase in mean temperature could be particularly challenging for vulnerable populations such as the elderly, children, and persons living with cardiovascular and respiratory diseases. Prolonged exposure to extreme heat can also cause heat exhaustion, heat cramps, heat stroke, and death, as well as exacerbate preexisting chronic conditions, such as various respiratory, cerebral, and cardiovascular diseases. Socioeconomic factors, such as economically disadvantaged and socially isolated individuals, are also at risk from heat-related burdens.

Changes in temperature, precipitation patterns, and extreme events could also enhance the spread of certain communicable diseases. While our study did not establish any direct link between climate variability and human health in Saint Kitts, there is growing evidence from other parts of the world that indicate that the incidence of certain communicable diseases have been increasing and will continue to increase as a consequence of climate change. The outbreak of Dengue in Trinidad and Tobago for example, has been linked to changes in rainfall (Chen et al. 2006; Chadee et al., 2007). Studies conducted in the Pacific islands have also established a direct link between malaria, dengue and climate variability (Russell, 2009). Changing temperature and precipitation patterns may shift the geographic range in which vector organisms such as mosquitoes can live. Vector organisms and the infectious agents they carry tend to thrive in warmer climates, so marked changes in mean temperature will affect their development, reproduction, behavior and survival rates. Temperature can also affect pathogen development within vectors while precipitation can influence the availability of breeding sites (Gage et al., 2008; Patz et al., 2005).

Table 7.2: Reported cases of select communicable diseases in Nevis 2009-2013

	2009	2010	2011	2012	2013
Acute Respiratory Infection <5 years	56	69	48	66	27
Acute Respiratory Infection >5 years	34	110	7	5	1
Dengue	-	1	37	7	7

Encephalitis	-	1	-	-	-
Gastroenteritis <5 years	66	47	43	37	32
Gastroenteritis >5 years	40	159	122	86	103
Malaria	1	-	-	-	-

Source: Health Information Unit, Nevis

These and other health risks, including cholera, are projected to increase with future climate change. The recent spread of the chikungunya arbovirus within the Caribbean is indicative of how susceptible the region is to mosquito-borne diseases, all of which will be influenced by changes in local climatic conditions.

7.5 CLIMATE CHANGE AND THE WATER SECTOR

This section refers to the key climate change projections as presented in Section 3 for St. Kitts and Nevis, and discusses some of the associated socio-economic threats and vulnerabilities which the National Adaptation Strategy and Action Plan (NASAP) must address. Human health and food security are major considerations.

7.5.1 Temperature Projections

The PRECIS results indicate that, on average, minimum, mean and maximum temperatures are projected to increase from present through to the 2030s for St. Kitts and Nevis. A one to two (1-2) degrees increase in annual mean temperature could impact the water sector in a number of ways. Table 7.4 indicates that pathogen density can significantly increase with temperature increases. Possible direct impacts include:

- Increasing temperatures will increase the risk of water-borne diseases such as cholera. Cholera is a diarrheal disease caused by bacteria that occur naturally in water bodies such as rivers and coastal waters. This is expected to worsen with climate change, driven by factors including increased temperatures, flooding, and other changes in the water cycle;
- Higher temperatures will increase the rates of evapotranspiration, thus reducing groundwater recharge.

The social and economic consequences of these changes are wide ranging. As it pertains to human health, there are clear health implications as water-borne diseases such as cholera or severe diarrhea can result in significant fluid loss and may be life-threatening, particularly in young children and people who are malnourished.

Higher temperatures also have implications for plant moisture availability due to increased rates of evapotranspiration. In addition to heightened thermal stress for crops, a reduction in the availability of plant moisture could stunt plant growth and reduce crop yields. This could adversely affect local food production in St. Kitts and Nevis over the medium and long-term, especially if the mean temperature continues to increase up to the end of century as predicted by several regional studies (see example Hall, 2013; Taylor et al., 2013; Stephenson et al., 2012; Campbell et al., 2011).

7.5.2 Rainfall Projections

Outputs from the PRECIS model project that mean annual rainfall for St. Kitts and Nevis will decrease by the 2030s with the exception of the northern extent of St. Kitts, which is expected to experience a slight increase in mean annual rainfall. It is predicted that the reductions in rainfall will range from approximately 3-7% for Nevis and 6-11% for southern St. Kitts. Added to these predictions is the mounting evidence of greater seasonal and inter-annual rainfall variability and projections for increasingly more and prolonged dry spells, especially during the summer period (Gamble 2009).

Possible direct impacts on the water sector include:

- Increased risk of water scarcity due to greater chances of seasonal and inter-annual variability in rainfall and likely increases in the frequency of drought events;
- Reduction in freshwater quality in aquifer due to over-pumping as groundwater resources start to dwindle and higher concentration of salt and other ions:
- Reduction of discharge to streams and lowering of the water table.

Issues related to health and sanitation, food production and domestic water supply are the major impacts from reduced rainfall (Table 7.4). Reduced annual rainfall totals will place the water sector in St. Kitts and Nevis under greater stress, especially given the existing inefficiencies in the storage and distribution of potable water. Studies have shown that any significant reduction in a country's available freshwater resources will have serious health consequences. Water scarcity usually forces households to rely on water sources that might not be safe. Some of the health consequences of water scarcity include diarrheal diseases such as cholera, typhoid fever, salmonellosis, other gastrointestinal viruses, and dysentery.

A reduction in rainfall over the medium to long term would also mean less water available for farming. Given the current imbalance in the distribution of water by sector, agriculture would be placed at an even greater disadvantage. Since the majority of farms are rain-fed, any reduction in rainfall would have significant consequences, especially in terms of productivity. If this drying trend occurs alongside warmer temperatures and increased incidences of drought, farmers could start seeing a significant reduction in certain crop yields. Livestock would also get affected. In general, the growing likelihood of dealing with a warmer and drier climate regime does not auger well for the future sustainability of such a climate-vulnerable industry. And while increasing on-farm access to irrigation can potentially aid in mitigating drought impacts or seasonal shifts in rainfall, if precipitation levels should continue to decline over the long run, water for irrigation purposes will become less available for farmers in both islands.

7.5.3 Sea Level Rise Projections

IPCC (2007) projections indicate that sea levels will rise between 0.18m and 0.59m by the end of the century. These projections of future Sea Level Rise (SLR) assumed a near-zero net contribution from the Greenland and Antarctic ice sheets because of uncertainty about future ice mass changes in these geographic regions. However, accumulating evidence suggests that both the Greenland and Antarctic ice sheets have been losing mass at an accelerating rate over the past two decades (Rignot et al., 2010), which implies that the IPCC's SLR projections might be highly conservative. Since the IPCC AR4 report, there have been a number of studies that have predicted higher end-of-century increases in global mean sea level (Table 6.3). The following table provides a summary of the most recent global SLR projections since 2007.

Despite the disagreements in projections, especially as it relates to the exact magnitude of future global SLR, there is strong agreement that SLR will take place and that it could have significant negative consequences for developing regions such as the Caribbean.

Table 7.3: Scenarios of global sea level rise in the Twenty-first Century

	2050	2100		
		Low range	Mid estimate	High range
Solomon et al. (IPCC 2007)	8.9-23.8 cm	18 cm	-	59 cm
Rahmstorf (2007)	17-32 cm	50 cm	90 cm	140 cm
Horton et al. (2008)	-	-	100 cm	-
Vermeer and Rahmstorf (2009)	-	75 cm	124 cm	180 cm
Grinstead et al. (2009)	-	40 cm	125 cm	215 cm

Adapted: Scott et al. (2012: 885)

Some possible direct impacts on the water sector include:

- Reduction in freshwater availability (particularly underground water resources) due to saline intrusion which may increase the costs of treatment;
- Abandonment of wells located close to the coast as the freshwater-saltwater transition zone rises;
- Increased cost of water as freshwater resources start to decline. The replacement and maintenance of infrastructure will increase operating costs in the water sector as well.

A number of recent studies have indicated that the likely future increases in the global mean sea level could seriously undermine development efforts throughout the Caribbean region through its accompanying socio-economic and ecological impacts (see for example, Trotz and Lindo 2013; Dasgupta et al. 2007). Dasgupta et al (2007) projected that a 1 metre SLR over the course of this century is likely to result in a significant displacement of population and loss of valuable coastal lands (including wetlands and low lying agricultural lands) in several Caribbean countries, including St. Kitts and Nevis. The fact that the bulk of St. Kitts and Nevis' burgeoning tourism development is in the coastal zone, places the sector at high risk from coastal inundation. A fairly recent study conducted by Scott et al. (2012: 889) concluded that a plus one-meter (+1 m) SLR scenario for the Caribbean would result in inundation losses due to coastal resort property damages amounting to more than 50 percent in Anguilla, Belize, British Virgin Islands, Turks and Caicos Islands and St. Kitts and Nevis.

Reduction in freshwater availability will have serious consequences for human health and well-being and could render certain economic activities as unviable. Increased cost of water could have a particularly debilitating effect on the poor, while extensive saline intrusion would make farming in low-lying coastal zones extremely difficult to sustain. Table 7.4 outlines some recommended strategies for sea level rise and an overall preliminary plan that can address the climate projections and their likely impacts on the water sector.

Table 7.4: Recommended Strategies and a Preliminary Plan for the Climate Projections and their Likely Impacts on the Water Sector

PROJECTIONS	LIKELY IMPACTS	RECOMMENDED STRATEGIES	PRELIMINARY PLAN
Increase in Annual Mean Temperature of up to 1.5˚C by the 2030's	More evaporation that may lead to greater pathogen density in water and this could result in a lack of potable water.	Develop and implement regular and streamlined processes for treating, protecting water and maintaining water storage systems such as dams and reservoirs.	Identify/establish and empower an agency/entity to spearhead the development of multi-sectoral and integrative approaches, policies, legislation and guidelines that govern the use and management of water resources under a changing climate by doing the following: • Determine and characterize current water sources and supplies within St. Kitts and Nevis. Assess future demand in the short, medium and long-term. Implement regular monitoring systems and update based on changes in demand and external environment. • Strengthen human resource capacities and networks within the water sector. Establish specific sector groups to examine climate change, water and other sector linkages and sustainability strategies.
Decrease in Annual Rainfall of up to -11% by the 2030's for most of St. Kitts and Nevis[2].	More frequent drought events which suggests: (i) Adverse effects on sanitation due to lack of water for hygienic purposes and may influence the transmission of disease. (ii) Adverse effects on economic and social development impacting local sectors including agriculture and domestic water usage. (iii) Adverse effects on food production which may suggest food shortage and need for greater food importation. Incidence of malnutrition may increase.	Increase mechanisms for rainwater harvesting and improved water catchment. Improve infrastructure towards more effective water storage and distribution Installation of automatic weather stations in some instances near catchments and installation of equipment towards better monitoring of water levels and flows Implement water management initiatives that focus on lessening climate change impacts on specific sectors and/or areas. For example, planting crops with lower water requirements and/or changing planting seasons to coincide with changing climatic patterns. Develop water retention programmes for different sectors and geographic areas, where appropriate. For example, greenhouses, residential houses, hotels etc. could implement	

[2] The northern tip of St. Kitts has been projected to see increases of up to 23% in rainfall. The adverse effects of increased rainfall such as flooding have been included in the section dealing with increased hurricane intensity. The benefits of increased rainfall can be accessed through improved water storage systems/technologies etc.

PROJECTIONS	LIKELY IMPACTS	RECOMMENDED STRATEGIES	PRELIMINARY PLAN
		rainwater harvesting technologies. Educate public on the need for efficient use and reuse of water.	• Establish/Strengthen policy, legislative and monitoring frameworks that seek to protect and conserve existing water resources, while ensuring efficient management, use and reuse of water within the industrial/commercial and residential sectors. • Develop priority list of key initiatives that are necessary for the sustainability of the water sector and leverage financing for implementing water management programmes and projects. • Implement stakeholder and public awareness and education programmes focusing on the need for efficient management, use and reuse of water resources. • Implement watershed management policies and programmes, for example to protect existing catchment areas and to reduce contamination of these areas by run-off etc. • Institute coastal setbacks and
Increase in Annual Wind Speeds by up to 0.05 m/s by the 2030's	More evaporation	Similar to strategies in row 1 above.	
Increase in sea levels by mid-century and beyond	Groundwater quality may be adversely affected by the proximity of some underground sources to the coast due to sea water intrusion. Increased incidence of coastal flooding in relation to storm surge	Desalting of abstracted water. Costs may be minimized in the long-term by using RE to help to power desalination plants. Installation and maintenance of tide gauges off the coast of St. Kitts and Nevis for monitoring tidal levels annually Installation of hard infrastructure for protection of coastal assets	
Increase in Hurricane intensity over the north tropical Atlantic	Some water catchment areas may be prone to flooding and exposed to risk of debris and sediment flows Heavy rains may contaminate watersheds through transport of wastes into ground water Damage to water sector infrastructure and equipment on account of more intense	Optimise surface water capture and retention during rainfall events for use or storage for dry periods. Implement stringent guidelines for activities that take place close to watershed areas (e.g. farming). Develop recovery/rehabilitation mechanisms and programmes, focused on increasing sector	

PROJECTIONS	LIKELY IMPACTS	RECOMMENDED STRATEGIES	PRELIMINARY PLAN
	hurricanes, flooding and land slippage events. Damages, associated repair costs and downtime can lead to loss of revenue and negatively impact water sector development plans.	resilience to hurricanes and other extreme events. Such programmes can include the development of emergency plan(s), retrofitting existing infrastructure, implementing insurance schemes, and stockpiling replacement parts and pipes.	other zoning guidelines to minimize the adverse impacts of intense storms on water-dependent infrastructure and also to protect watersheds and catchment areas from being contaminated by run-off etc.

8 RECOMMENDED NATIONAL ADAPTATION STRATEGY AND ACTION PLAN

8.1 Introduction

Based on the findings from the various assessments highlighted above and keeping in line with the Terms of Reference (TOR) provided, the following National Adaptation Strategy and Action Plan (NASAP) has been recommended for the water sector in St. Kitts and Nevis. The aim of the NASAP is to address the anticipated adverse effects of climate change on the water sector. This NASAP is to prepare St. Kitts and Nevis to meet the challenges of climate change on the water sector.

According to IPCC (2014), adaptation is "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects".

It involves anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause, or taking advantage of opportunities that may arise. Well planned, early adaptation action has been shown to save money and lives later. Adaptation measures could include: using scarce water resources more efficiently; adapting building codes to future climate conditions and extreme weather events; building flood defences and raising the levels of dykes; developing drought-tolerant crops; choosing tree species and forestry practices less vulnerable to storms and fires; and setting aside land corridors to help species migrate.

Adaptation strategies are needed at all levels of administration: at the local, national, regional, and international level. However, adaptation activities tend to be local – district, regional or national – issues rather than international (Paavola and Adger 2005). This is because communities possess different vulnerabilities and adaptive capabilities, they tend to be impacted differently, thereby exhibiting different adaptation needs.

This strategic action plan is designed to guide implementation of, and track progress toward, national water sector goals and targets in St. Kitts and Nevis. The strategy covers a 5 year period 2015-2020 and outlines three national outcomes for the water sector. Expected results (output) are presented along with the actions to meet the defined objectives. The timeline for each activity is given, along with an indicative cost where possible and the responsible agencies (lead and partner).

8.2 Strategic Objectives

Several adaptation strategies have been identified for St. Kitts and Nevis. These are based on findings from the Impact Assessment done for St. Kitts and Nevis and the Vulnerability and Capacity Assessment done for the Basseterre Valley Watershed in St. Kitts. The NASAP also incorporates stakeholder perspectives and suggestions that were discussed that the National Consultative Workshop conducted on October 31, 2014.

The strategies were denoted under four main headings:

- Policy
- Legislation

- Capacity (Physical/ Infrastructural, Institutional and Technical)
- Training and Awareness Building

They were used to define the following strategic outcomes:

4. Improved policy, legal, regulatory and institutional framework for the water sector.
5. Improved technical and institutional capacity for the water sector
6. Enhanced and improved training and awareness in relation to climate change and the water sector

8.3 Implementation of the Strategy

The National Adaptation Strategy and Action Plan (NASAP) for the water sector of St. Kitts and Nevis requires that within the Ministry of Sustainable Development, the Department of Physical Planning and the Environment in St. Kitts and the Department of Physical Planning, Natural Resources and Environment in Nevis be responsible for ensuring that the action items set out in this Strategy and Action Plan are carried out by the respective lead and partner agencies.

Each of the three outcomes has a slate of activities to be undertaken over the five year period, and operational plans will need to be developed with appropriate phasing.

The inter-sectoral collaboration required for mainstreaming water resource management can be facilitated through the Departments named above in St. Kitts and Nevis. It is recommended that this Strategy and Action Plan be shared with all the partner agencies and awareness and capacity building programmes be undertaken. The Committee of Permanent Secretaries and the Cabinet of Ministers will need to accept the imperative for endorsing and implementing the National Adaptation Strategy and Action Plan for the water Sector.

To the maximum extent possible, elements of the NASAP should be integrated into the existing and proposed cooperation programmes of St Kitts and Nevis' bi-lateral and multi-lateral partners. Further funding should be sought for specific aspects where these cannot be accommodated within the respective Ministry/agency budgets.

8.4 Monitoring and Evaluation

The implementation of the NASAP for the water sector has to be monitored and evaluated to ensure that the activities are successfully on track, and to ensure transparency and accountability. This will entail the monitoring of the actual implementation of the NASAP, and also evaluating and assessing the cause of any changes, both external and internal to the NASAP, to determine what corrective actions, if any, are needed. The results of this monitoring can then be incorporated into future planning and improvement of the NASAP. Therefore, an implementation monitoring plan will have to be developed to monitor the progress of the activities and submitted to the Minister of Sustainable Development in St. Kitts and the Minister of Communications, Works, and Public Utilities, Ports, Physical Planning, Natural Resources and Environment, and Agriculture, Lands Housing, Cooperatives and Fisheries in Nevis. This will include an annual implementation report that will review the year's activities and make recommendations for planning the activities of the coming year. It will also include reports from all agencies involved in the implementation of the NASAP. This will be initiated by the responsible Ministry.

It is also important to monitor changes in the water sector, and to measure how the activities are contributing to the protection of water resources. A monitoring programme should be developed, and some of the key indicators that can be used to determine changes may include:

- Status and trends of watershed areas, wetland areas, water quality, water availability and water resource management and accountability;
- Changes in the policy and legal framework for water resources, including watershed areas;
- Shifts in human, institutional, and funding capacity, including shifts in cultural perceptions, practices and norms, appropriate orientation of technology, training and education, management information availability, and monitoring capacity.

Once these evaluations are done, the DPPE in collaboration with the DPPNRE should prepare or seek to prepare evaluation reports, including recommendations to be included in the NASAP and submit it to the Minister of Sustainable Development.

OUTCOME 1: IMPROVED POLICY, LEGAL, REGULATORY AND INSTITUTIONAL FRAMEWORK FOR THE WATER SECTOR

Government institutions in St. Kitts and Nevis will have to position themselves to adapt to the needs that will be generated by the potential impacts from the projected climate variability and change patterns. It will also require an improved legal and regulatory system to guide and enforce the required actions. The focus of this outcome is therefore to ensure that the legal, regulatory, and institutional framework for the water sector in St. Kitts and Nevis are improved.

Output:

By the end of this strategic planning period, it is expected that the following is achieved:

- Revised national policies related to water and the environment including coastal management policies;
- A developed climate change adaptation and mitigation policy;
- A Watershed Policy and Water Policy that takes into account climate change considerations;
- A watershed management plan;
- A National Land Use Plan;
- Employ policy to mandate water harvesting in new home construction;
- Formulate and implement a regulatory regime to govern wise use allocation;
- With the potential increase in tourism anticipated water allocation measures need to be taken to increase and manage water supply;
- Revised Water Resources Act;
- Revised Public Health Act;
- Enacted National Environmental Conservation and Management Act;
- A Meteorological Act.

Table 8.1: Objectives, Activities, Timelines, Funding and Responsible agencies for Outcome 1

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs	Potential Source of Funding	
To develop revised national policies related to water and the environment including coastal management policies	Engage consultant Prepare relevant policies Consultations on national water and environmental policies Cabinet approval	Medium term	$60,000	UNEP/ CDB	LEAD: Water Services Department/Recommended New Water Resource Agency (Use of a Multi-Sectoral Committee in the Interim absence of New Agency) PARTNER: Department of Physical Planning and Environment
To developed climate change adaptation and mitigation policy	Engage Consultant Preparation of Climate Change Adaptation Mitigation Policy Consultations Cabinet Approval	Short term	$50,000	CDB/ IDB/ EU	LEAD: Department of Physical Planning and Environment, DPPNRE PARTNER: Water Services Department
To develop a Watershed Policy that takes into account climate change considerations	Engage consultant Preparation of Watershed Policy Consultations Cabinet Approval	Short term	$30,000	GWP-Caribbean	LEAD: Department of Physical Planning and Environment DPPNRE, and Recommended New Water Resource Agency (Use of a Multi-Sectoral Committee in the Interim absence of New Agency)
To develop a Water Policy that takes into account climate change considerations	Engage consultant Preparation of Water Policy Consultations	Short term	$30,000	GWP-Caribbean	LEAD: Department of Physical Planning and Environment DPPNRE, and Recommended New Water Resource Agency (Use of a Multi-Sectoral Committee in the Interim

OBJECTIVE	**ACTIVITIES**	**TIMELINE**	**FUNDING**		**RESPONSIBLE AGENCIES**
			Indicative Costs	**Potential Source of Funding**	
	Cabinet Approval				absence of New Agency)
To develop a watershed management plan	Engage consultant Preparation of Watershed Management Plan Consultations on draft Watershed Management Plan	Short term	$40,000	GWP-Caribbean	LEAD: Recommended New Water Resource Agency (Use of a Multi-Sectoral Committee in the Interim absence of New Agency) PARTNER: DPPE, DPPNRE
To develop a National Land Use Plan	Engage consultants prepare and Plan that addresses a range of concerns including watershed degradation, potential impacts from saline intrusion etc. Preparation of National Land Use Plan Consultations on Plan Cabinet Approval	Medium term	$60,000	CDB	LEAD: Department of Physical Planning and Environment, DPPNRE PARTNER: Department of Lands and Surveys
To employ policy to mandate water harvesting in new home construction	Engage consultant Preparation of Policy Consultations on Policy	Medium Term	$30,000	GWP-Caribbean	LEAD: Department of Physical Planning and Environment PARTNER: Water Services Department
To formulate and implement a regulatory regime to govern wise use allocation and for	Engage Consultant Preparation of regulatory regime	Short Term	$40,000	GWP-Caribbean	LEAD: Water Services Department, Department of Agriculture, Ministry

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs	Potential Source of Funding	
the strategic location of dams for water in agriculture and tourism as major sectors	Consultations Approval by Legal Department				of Tourism, DPPNRE PARTNER: Legal Department
To revise the Water Resources Act	Engage consultant Prepare draft Water Resources Act Consultations Final draft Approval by Legal Department Approval by Cabinet Parliamentary approval	Medium term	$50,000	GWP-Caribbean	LEAD: Water Services Department PARTNER: Recommended New Water Resource Agency, Department of Physical Planning and Environment, DPPNRE, Legal Department
To revise the Public Health Act to deal with the potential increase in vector-bourne and water-bourne diseases triggered by climate change as well as to ensure safe potable water supply	Engage Consultant revise Act to provide for comprehensive framework for pollution, vector control and to promulgate regulations to deal with water quality standards as well as other issues. Draft Act Consultations Cabinet approval	Short term	$50,000	PAHO/ WHO	LEAD: Ministry of Health PARTNER: Legal Department

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs	Potential Source of Funding	
	Parliamentary approval				
To enact the National Environmental Conservation and Management Act	Revise existing draft consultations Final drafting Cabinet approval Parliamentary approval	Immediate	$25,000	UNEP CDB	LEAD: Department of Physical Planning and Environment, DPPNRE PARTNER: Legal Department
To develop a Meteorological Act to govern the institutional framework and the collection of meteorological data that can inform climate projections	Engage consultant to develop Act. The Act should speak to the creation of an overarching body that governs the Meteorological Services in St. Kitts and Nevis so that the needs of international organisations can be met. Consultations Final drafting Cabinet approval Parliamentary approval	Short term	$50,000	Climate Investment Fund/ IBD Strategic Climate Fund/ IDB	LEAD: SKN Meteorological Services PARTNER: Legal Department

Note: On-going Immediate Short term= 1-3 yrs Medium= 3-5 yrs Long term= > 5 yrs

OUTCOME 2: IMPROVED PHYSICAL/ INFRASTRUCTURAL TECHNICAL AND INSTITUTIONAL CAPACITY FOR THE WATER SECTOR

Capacity building must be an integral component of any climate change adaptation strategy due to existing uncertainty within the climate models, particularly at local and national levels. Local institutions (both formal and informal) play an important role in building resilience and reducing vulnerability to climate change. They are also the principal vehicle through which external support for adaptation (e.g., training and capacity building, etc.) is and will increasingly be delivered.

Increasingly, local institutions are challenged to respond to increased exposure to risk and vulnerability of the local population as a result of climate change. For there to be effective local adaptation, local institutions need to be responsive, flexible and able to adapt to the uncertainties associated with climate change. However, local governance that is responsive to climate adaptation is constrained by weak technical and managerial capacity, poor funding, poor linkages with other institutions at different levels, weak systems for gathering and disseminating information, and unclear mandates and conflicting priorities between levels and agencies of government. This is often the case in many of the SIDS in the Caribbean. Therefore, the focus of this outcome is to ensure that there is improved physical/ infrastructural, technical and institutional capacity for the water sector.

Output:

By the end of this strategic planning period, it is expected that the following is achieved:

- Improved capacity of the Department of Agriculture to identify, treat, and disseminate information on plant phytopathology and animal epidemiology as well as control of animal disease risks associated with climate change;
- Promotion of dry land farming systems by the Department of Agriculture;
- Enhanced Projections of the impact of climate change on water resources and data collection strategy developed for climate data;
- Additional technical staff in Meteorology Services to deal with climate change matters;
- Data collection strategy developed for water data;
- Trained personnel within the Water Services Department in IWRM, Hydrology, Hydrogeology;
- New Water Resources Agency for St. Kitts and Nevis;
- Local water quality standards for St. Kitts and Nevis;
- Developed protocols to test compliance and effectiveness of Best Management Practices (BMP's) in protecting water quality especially at the sector level;
- Established requirements for abstraction of resources, licensing, monitoring;
- Trained technical staff in waste water management and water quality monitoring;
- Established data sharing and collaboration platform for hydrological and meteorological data;
- Revised land use maps and a developed National Zoning Plan to prevent degradation of water resources;

- To upgrade access routes to water facilities particularly those in hilly terrain so that upgrade to water facilities can take place;
- Upgraded water storage catchment systems and decreased percentage leakages within the distribution network and reservoir;
- District metering employed at different points within the network to better capture leakages;
- Enhanced storage capacities in multipurpose water/irrigation projects and integration of drainage with irrigation infrastructures;
- A maintenance plan/upgrading plan for drainage systems for St. Kitts;
- Various developments connected to a centralized sewage system to support the expanse of the Basseterre urban area in St. Kitts and the Charlestown urban area in Nevis;
- Water Quality Monitoring Programme;
- Implemented Physical Asset Management Programme;
- Creation of a Water and Waste Water Authority;
- Tax exemption strategy in place for persons who employ water harvesting habits.

Table 8.2: List of Objectives, Activities, Timelines, Funding and Responsible agencies for Outcome 2

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
To improve capacity of the Department of Agriculture to identify, treat, and disseminate information on plant phytopathology and animal epidemiology as well as control of animal disease risks associated with climate change.	Develop high school curriculum focused on plant and animal disease control	Short – medium term	10,000	International Fund for Agricultural Development (IFAD)/ FAO/ USAID	LEAD: Department of Agriculture PARTNER: Clarence Fitzroy Bryant College/6th Form- Nevis
	Capacity building training for Department staff and extension officers (including the organization of exchange programmes)	Ongoing	80,000		
	Establishment of testing facilities in the Department of Agriculture	Medium term	TBD		
	Enhancement of ICT that will allow Department to better disseminate its information	Short term	TBD		
To promote dry land farming systems by the Department of Agriculture	Documentation of best practices in dry land agriculture across the Caribbean	Short term	5,000	International Fund for Agricultural Development (IFAD)/ FAO/ USAID	LEAD: Department of Agriculture
	Capacity building and training of agricultural extension staff in sustainable and appropriate dry farming practices	Short term	80,000		
	Research and development, particularly in the area(s) of crop breeding	Ongoing	TBD		
	Setting up demonstration plots showcasing dry farming techniques	Ongoing	20,000		
	The facilitation of farmers training and knowledge transfer through farmer field	Ongoing	20,000		

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	schools				
To develop a data collection strategy for gleaning and archiving meteorological data	Purchase automatic Meteorological stations Identify sites for installation of automatic stations for optimal coverage Acquire data storage facilities Link into Caribbean Institute of Metrological and Hydrological (CIMH) mode	Immediate Immediate Immediate Immediate	22,000 (per station as a first time investment incl. Consultant fee/ technical assistance/ transmission) ($2,000 Maintenance) (Done in consultation with CIMH or other regional Met. Services) 4,000 -	IDB /CDB /World Bank	LEAD: DPPE, DPPNRE PARTNER: Meteorological Services, Department of Agriculture, Statistics Department, Water Services Department
Technical staff to be added to the Meteorology Services to deal with climate change matters	Establishing of climate branch or department within the meteorological service Hiring of relevant personnel to produce value added climate products that would inform climate sensitive sectors e.g. Agriculture,	Medium Term Medium Term	TBD (Salaries of staff)	IDB /CDB /World Bank/ CCCCCs-EU	LEAD: Met Service PARTNER: Department of Physical Planning and Environment and Department of Agriculture, Water

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	**Potential Source of Funding**	
	Health, Tourism etc.				Services Department (SK&N)
To enhance projections of the impact of climate change on water resources	A Consultancy to: • Support water and climate related researches towards studying the sensitivity of different hydrologic types of water projects to different climate change scenarios and improvements required in hydrometric networks to incorporate climate change, Groundwater, water quality water balance models into the management of the resource and decision making process. • Setup a committee to ensure more equitable distribution both across and within Aquifers. A Consultancy to: • Identify and Prioritize watersheds vulnerable to flow changes and develop decision support systems to facilitate quick and appropriate responses	Short term Short-term Short-term	150,000 - 90,000	GWP-Caribbean EU via OECS EU via CCCCCs IDB- Climate Investment Fund	LEAD: DPPE, DPPNRE PARTNER: Meteorological Services, Department of Agriculture, Statistics Department, Water Services Department
To develop a data collection strategy for water data	Procure services of a consultant to examine the depths and ranges and requirements of groundwater monitoring data (physical, biological and chemical data) Deploy equipment to obtain depths of groundwater tables using various observation	Short term	TBD	GWP-Caribbean/	LEAD: Water Services Department PARTNER: DPPE, DPPNRE

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING: Indicative Costs US$	FUNDING: Potential Source of Funding	RESPONSIBLE AGENCIES
	wells Undertake pump test for transmissivity, storage coefficients across current aquifer and future aquifer	Short term Short term	TBD TBD		
Personnel to be trained in Integrated Water Resource Management, Hydrology, and Hydrogeology within the Water Services Department	Establish designated personnel for responsibility of groundwater, surface water data collection Have personnel at responsible agency apply to accredited higher degree institutions such as UNESCO-IHE, Netherlands or CERMES, University of the West Indies or USA/Canada etc. for postgraduate courses in Water management, and specializations in water services, water conflict etc. 8 week online course McGill University Integrated and Adaptive Water Resources Planning, Management, and Governance For McGill University/UNESCO –IHE Apply to online short courses and request discounts for groups Courses to be considered • Certification Program in Integrated and Adaptive Water Resources Planning, Management & Governance(18mths) • Groundwater Data Collection and	Short term Short term Short term Short to medium term	- 1,500 (per person) 55,000 (per person) 4,000 (per	Some University offer scholarships for their programmes e.g. McGill Univ, UNESCO-IHE	LEAD: Water Services Department PARTNER: DPPE, DPPNRE

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	Interpretation 30 Mar 201517 Apr 2015 • Hydrological Data Collection and Processing 30 Mar 2015 17 Apr 2015 • Management of Irrigation Systems • Flood-Based Farming Systems and Water Harvesting for Food Security • Open Source Software for Preprocessing GIS Data for Hydrological Models • GIS and Remote Sensing Applications for the Water Sector		person) 4,000 (per person) 4,000 (per person) 4,000 (per person) 4,000 (per person) 4,000 (per person)		
To establish a New Water Resources Agency for St. Kitts and Nevis	Prepare drafting instructions re-establishment of statutory including: • size, composition and qualification of Board members • qualification of Executive Director &precise functions of the Board • how the Authority will be funded (eg. Government Subvention, raising fees etc.)	Short term	50,000	GWP-Caribbean/ EU/ IDB	LEAD: Ministry of Sustainable Development PARTNER: Ministry of Housing, Energy, Public Utilities and Transport, Water Services Department, Department of Legal Affairs

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	• powers of the Board • Prepare Memorandum on staff structure of the Authority and their qualifications. Engage legal consultant to draft Act to establish Water Resources Authority. • Consult with key ministries and stakeholders • Finalize draft & Submit draft to Attorney General Finalization of draft by Attorney General , Cabinet approval & Submission to Parliament for Parliamentary approval • Determine date on which Act will come into force • Determine the location of office etc. • Select Directors to be approved by Minister • Select Executive Director (by Board)	Short term Medium term	50,000 25,000		
To develop and implement a Water Quality Monitoring Programme	Conduct a needs assessment audit of Bureau of Standards Laboratory in St. Kitts and lab in Nevis - identify gaps in equipment and staffing Improve the capacity of the lab so that they	Immediate to short term	60,000 (SKN) TBD(Depending	GWP-Caribbean/ CDB/ IDB/ World Bank	LEAD: New water resource agency, Ministry of Health PARTNER: Water Services Department, Bureau of Standards Multi-Purpose

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	are equipped to provide a comprehensive oversight and monitoring role. Develop a Monitoring Strategy and establish baseline Monitoring Programme • Develop Standard Operating Procedures • Develop Quality assurance policy • Collect Data • Adopt usage of global water standards (WHO) for SKN	Short term Short term	on needs) 30,000	UNDP	Laboratory
Technical staff should be trained in waste water management and water quality monitoring	Establish designated personnel for responsibility of water quality data collection and monitoring Have personnel or responsible agency apply to accredited higher degree institutions such as UNESCO-IHE, Netherlands or CERMES, University of the West Indies or USA/Canada etc. for postgraduate courses in Waste water management, and specializations in water quality monitoring ○ Apply to online short courses in a group of 5 persons or more to receive discounts. Courses to be considered include ○ The Office of Water Programs at the	Short term Short to medium term	- 4,000 (per person)	GWP-Caribbean/ IDB/ CDB	LEAD: Ministry of Health PARTNER: Ministry of Sustainable Development, Ministry of Housing, Energy, Public Utilities and Transport, Water Services Department,

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING: Indicative Costs US$	FUNDING: Potential Source of Funding	RESPONSIBLE AGENCIES
	California State University, Sacramento, College of Engineering and Computer Science and the University of Florida provide distance learning courses for persons interested in the operation and maintenance of drinking water, wastewater facilities & Utility management, Water quality assessment. Procure the services of private consultants to acquire training in similar courses at cheaper rates until medium to long term goals could be filled	 Short term	 40,000		
To establish knowledge and data sharing platform for hydrological and meteorological data	Conduct a Information Technology Needs Assessment (Infrastructure and Institutional) for government departments DPPE, DPPNRE, Meteorological Office in St Kitts and Nevis, St. Kitts Water Services Department, Nevis Water Department, Department of Agriculture in St Kitts and Nevis, St Kitts Fisheries Department, Nevis Department of Fisheries Develop a data management platform for each department. Upgrade Information Technology equipment and develop skillsets Develop a Policy on data sharing among	Short term Short term Short term Medium term	120-150,000 (For All Department) 20,000 (Each) TBD (Will heavily depend on IT Needs)	Climate Investment Fund/IDB/ CCCCC/ International Research Initiative on Adaptation to Climate Change (IRIACC) Challenge Fund	LEAD: Department of Physical Planning and Environment, DPPNRE

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	government agencies for the purpose of conducting studies and for decision making		15-20,000 (individual consultancy)		
To upgrade access routes to water facilities particularly those in hilly terrain	Identify access roads to water facilities (springs, reservoirs etc.) in poor conditions and fix critical roads so that the necessary upgrade of water facilities can take place.	Immediate	40,000 (St. Kitts and Nevis)	GEF UNDP GOFSKN	LEAD: Public Works, PARTNER: Water Services Department, Department of Physical Planning and Environment
To create a development zoning plan for St. Kitts and Nevis to prevent future development in areas that compromise water resource such as in spring recharge areas, on slopes and in waterways.	To conduct a Baseline study of all watersheds to inform preservation planning To conduct a Baseline Study of all wetlands to inform preservation planning Conduct a land use assessment for St. Kitts and Nevis and update land use maps for each island for the protection of surface and groundwater resources. Determine land use zones e.g. industry, tourism, reserves, no build zones etc. Map land use zones for St. Kitts and Nevis that can inform sustainable development planning and create a National Zoning Plan. From the national land use zoning plan, create local area plans.	Short term Short term Short term Medium term	20,000 20,000 90,000 20,000 (Each)	GEF UNDP Caribbean Development Bank	LEAD: Department of Physical Planning and Environment PARTNER: National Emergency and Management Agency (NEMA), Public Works, Fire Department, Disaster Management Department-Nevis
Employ district metering at	Conduct a feasibility study for gathering GIS	Short term	90,000 (SKN)	GWP-	LEAD: Water Services

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
different points within the network to better capture leakages to improve water management of water supply	related information on Water distribution system, determine the placement of meters, the technology to be used and costing of equipment and improvements to revenue Purchase meters and install along network	Short term	TBD (based on number # of meters required)	Caribbean/ CDB/ IDB/ World Bank UNDP	Department PARTNER: DPPE
To upgrade water storage catchment systems & To implement a leak reduction programme within the distribution network and reservoir so that management of water supply can be improve.	Quantify total losses and assess leakage within Distribution network/Transmission mains/ Reservoirs following installation of district meters. Address areas that show high leakages	Short term Medium term	- TBD (Depending on pipes etc. that need changing)	GWP-Caribbean/ CDB/ IDB/ World Bank UNDP	LEAD: Water Services Department PARTNER: DPPE
To enhance storage capacities in multipurpose water/irrigation projects and integration of drainage with irrigation infrastructures	Design an irrigation initiate to utilise water from high rainfall areas in St. Kitts. Recommendations from this study should inform better decisions for installing rain-fed catchments in St. Kitts. It should consider the use check dams to allow for storage of high run off for irrigation.	Short term	70,000	GWP-Caribbean/ CDB/ IDB/ World Bank UNDP	LEAD: Department of Agriculture PARTNER: DPPE, Water Services Department
To redesign and improve for drainage systems for St. Kitts.	Assess the current drainage system and identify drains areas the need drains and drains that need widening and regarding. Thus	Short term	-	CDB/ IDB/ World Bank	LEAD: Public Works Department, DPPNRE

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	**Potential Source of Funding**	
	should be stepwise to prioritise flood prone and ghaut erosion areas. Undertake preliminary engineering design work Carry out drainage improvement works	Medium term Medium term	15 MIL Cost to design work.	UNDP	
To connect various developments to a centralized sewage system to support the expanse of the Basseterre urban area in St. Kitts and the Charlestown urban area in Nevis	Technical and financial feasibility study	Long term	4 Mil	CDB/ IDB/ World Bank UNDP	LEAD: Water Services Department PARTNER: Environmental Health Unit, Public Works Department
To implement Physical Asset Management Programme	Perform an inventory and condition assessment of the system's assets Develop a condition assessment and rating system. Assess remaining useful life by consulting projected-useful-life tables or decay curves. Determine asset values and replacement costs	Long term	200 million	CDB World Bank	LEAD: Water Services Department

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
To develop a Water and Waste Water responsibilities	Procure consultant to carry out assessment of needs and develop a guidance document to identify and undertake the most feasible option into either transforming WSD into a water and waste water authority or developing a new water and waste water authority.	Medium term	100,000	GWP-Caribbean/ CDB/ IDB/ World Bank UNDP	LEAD: Water Services Department PARTNER: Department of Physical Planning and Environment, Ministry of Health, Bureau of Standards

Note: On-going Immediate Short term= 1-3 yrs Medium= 3-5 yrs Long term= > 5 yrs

OUTCOME 3: ENHANCED AND IMPROVED TRAINING AND AWARENESS IN RELATION TO CLIMATE CHANGE AND THE WATER SECTOR (PRIVATE, GOVERNMENT AND CIVIL SOCIETY)

The management of St. Kitts and Nevis' water resources (sector) requires radical changes in many of the attitudes and behaviour of people and institutions. There is a need to develop a greater sense of ownership of, and responsibility towards water and a need to increase the understanding of how climate change has already affected and will continue to affect the water sector.

There must be an increased awareness and sensitivity to climate change and its impacts on the water sector. Meaningful education and awareness programs should not only increase knowledge, but also create a better understanding of the consequences of one's actions and their implications. The focus of this outcome is therefore to ensure that there is an enhanced and improved education and awareness in relation to climate change and the water sector within the society (private, government and civil society).

Output:

By the end of this strategic planning period, it is expected that the following is achieved:

- Education campaign focused on training farmers, improved farming practices to include climate smart agricultural practices and other water conservation measures;
- Young trainable farmers encouraged in climate resilient farming techniques;
- Female farmers targeted in climate resilient farming techniques;
- Climate Change education and media campaign for the general public with a focus on youth;
- Year round water conservation and water harvesting media and education campaign especially during the dry season in schools, government, agriculture and tourism related entities;
- Water Conservation Campaign. Rainwater harvesting encouraged especially for households and farmers;
- Revised water tariff rates;
- Trained trade specialists in the Department of Agriculture in matters related to international and regional trading in agricultural commodities that are resilient to climate change;
- Technological options and solutions explored for production and post- harvest handling in Agriculture that offer resilience to climate change;
- Diversification encouraged away from low yield and high water demand / low return agricultural production to improve livelihoods.

Table 8.3: List of Objectives, Activities, Timelines, Funding and Responsible agencies for Outcome 3

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
To develop and implement an education campaign focused on training farmers, improved farming practices to include climate smart agricultural practices and other water conservation measures	Production of a short film showcasing the benefits of adopting sustainable and climate smart agricultural practices	Short term	US$5,000	5Cs, IICA, CTA, CDKN, CARIBSAVE, USAID, FAO	LEAD: Department of Agriculture PARTNER: Department of Physical Planning, Natural Resource and Environment (DPPNRE-Nevis), Water Service Department
	Development of a technical manual and toolkit for implementing climate smart agricultural practices	Short term	US$20,000		
	Setting up of demonstration plots showcasing climate smart farming practices, inclusive of cost-effective and appropriate water conservation methods	Short – medium term	US$240,000		
	Development of Farmer Field School curriculum targeted at the promotion and transfer of climate smart agricultural practices	Short term	US$5,000		
To encourage young trainable farmers in climate resilient farming techniques	Development of a climate smart agricultural module for high schools	Short term	US$3,500	5Cs, CTA, UNIDO, IFAD, IICA, FAO	LEAD: Department of Agriculture PARTNER: Department of Physical Planning, Natural
	Development and facilitation of	Short term (and ongoing)	US$10,000		

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	agricultural training programmes targeted at youth clubs in rural farming communities Facilitation of farmer field school programmes targeted specifically at young farmers	 Short term (and ongoing)	yearly US$15,000 yearly		Resource and Environment (DPPNRE-Nevis), Water Service Department
To target Female farmers in climate resilient farming techniques	Facilitation of farmer field school programmes targeted specifically at Female farmers	Short term (and ongoing)	US$15,000 yearly	5Cs, CTA, UNIDO, IFAD, IICA, FAO	LEAD: Department of Agriculture PARTNER: Department of Physical Planning, Natural Resource and Environment (DPPNRE-Nevis), Water Service Department
Develop and implement a Climate Change education and media campaign for the general public with a focus on youth	Following the development of the Climate Change Policy, design a Climate Adaptation Strategy and Action Plan Design of a national public education campaign on Climate Change	Short term Short term	20,000 115,000	Climate Investment Fund/IDB EU/ UNEP/ IUCN - Commission on Communication and Education (CEC)	LEAD: Department of Physical Planning and Environment (DPPE) PARTNER: Ministry of Education, Department of Agriculture, Water Services Department, DPPRNE

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
Develop and implement a Year round water conservation and water harvesting media and education campaign that is given greater during the dry season in schools, government, agriculture and tourism related entities	Production of a short film/media advertisement, showcasing the need and benefits of conserving and harvesting freshwater Creation of posters and flyers encouraging water conservation and harvesting Organize essay/poem/poster/song competition in schools, promoting water conservation and harvesting	Short term Short term Short term (and should be ongoing as well)	US$5,000 US$3,000 US$3,000	Global Water Partnership (GWP) Caribbean, FAO, IICA, CTA, CARIBSAVE, 5Cs	LEAD: Water Services Department PARTNER: Department of Physical Planning and Environment
Develop and undertake a Water Conservation Campaign. Rainwater harvesting encouraged especially for households and farmers.	Production of a short film/media advertisement, showcasing the need and benefits of conserving and harvesting freshwater Creation of posters and flyers encouraging water conservation and harvesting Hosting community meetings to discuss and share information on matters related to	Short term Short term Short term (and ongoing)	US$5,000 US$3,000 US$5,000 yearly	Global Water Partnership (GWP) Caribbean, FAO, IICA, CTA, CARIBSAVE, 5Cs	LEAD: Water Services Department PARTNER: Department of Physical Planning and Environment

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	freshwater conservation and harvesting				
To revise water tariff rates	Consultancy to determine water pricing towards sustainable water services. Components will be: 5. Water policy objectives and water pricing; 6. Water pricing mechanism's and instruments: levies, taxes and charges; Revenue: Analysing the revenue potential and administrative complexity of alternative pricing instruments, Capacities: identifying and addressing institutional capacities needed for the development and implementation of pricing strategies	Short term	TBD	Global Water Partnership (GWP) Caribbean, CDB/ IDB	LEAD: Water Services Department
To develop technological options and solutions	Forging of strategic alliances with organizations and	Short term (and should be an ongoing activity as	US$5000 yearly (set	5Cs, FAO, CARDI, IICA,	LEAD: Department of

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
explored for production and post- harvest handling in Agriculture that offer resilience to climate change	governments that possess significant scientific and technical knowledge and capacity in climate smart agricultural production and post-harvest management Research and development focused on improving crop and livestock production and post-harvest management	well) Short term (and should be an ongoing activity as well)	aside for overseas travels and other exchange activities) US$30,000 yearly	CTA	Agriculture PARTNER: Department of Trade, DPPNRE
To encourage diversification away from low yield and high water demand / low return agricultural production to improve livelihoods	Facilitation of plant genetic research and crop breeding focused on enhancing crop tolerance to heat and drought stress Carrying out ongoing field trials to identify crops (and particular cultivars) that perform better under dry conditions Using demonstration plots and farmer field school programmes to showcase research results Dissemination of research information to farmers using a	Short term (and should be an ongoing activity as well) Short term (and should be an ongoing activity as well) Short term (and should be an ongoing activity as well)	US$20,000 yearly US$10,000 yearly US$10,000 yearly US$15,000	UNIDO, IFAD, IICA, FAO, CARIBSAVE, CTA, CABA,	LEAD: Department of Agriculture PARTNER: Department of Trade, DPPNRE

OBJECTIVE	ACTIVITIES	TIMELINE	FUNDING		RESPONSIBLE AGENCIES
			Indicative Costs US$	Potential Source of Funding	
	variety of knowledge products e.g. pamphlets, flyers, media announcements, community posters, meetings etc.	Short term (and should be an ongoing activity as well)	yearly		

Note: On-going Immediate Short term= 1-3 yrs Medium= 3-5 yrs Long term= > 5 yrs

9 SUMMARY BUDGET

The following table (Table 9.1) includes a summary budget for the three Strategic Objectives. The objectives within each outcome have multiple activities, some of which have only been costed for partially.

Table 9.1: Summary Budget for Outcomes 1, 2 and 3

OUTCOMES	NO. OF OBJECTIVES	TIME PERIOD	INDICATIVE COSTS US$
Outcome 1 Improved, Physical Infrastructural Technical and Institutional Capacity for the Water Sector	1	Immediate	25,000
	7	Short Term	290,000
	4	Medium Term	200,000
	0	Long Term	-
Sub Total	**12**		**515,000**
Outcome 2 Improved Physical /Infrastructural Technical and Institutional Capacity for the Water Sector.	2	Immediate	206,000
	11	Short Term	889,500
	4	Medium Term	180,000
	2	Long Term	204,000,000
Sub Total	**19**		**205,275,500**
Outcome 3 Enhanced and improved Training and Awareness in relation to Climate Change and the Water Sector (Private Government and Civil Society)	0	Immediate	-
	9	Short Term	551,000
	0	Medium Term	-
	0	Long Term	-
Sub Total	**9**		**551,000**
TOTAL	**40**		**206,341,500**

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ANNEX I – LIST OF STAKEHOLDERS INTERVIEWED

STAKEHOLDER GROUP	POINT PERSONS
St. Kitts	
Department of Physical Planning and Environment	Ms. June Hughes, Senior Environmental Officer Ms. Cheryl Jeffers, Environmental Officer Graeme Brown, GIS Specialist
Water Services Department	Mr. Denison Paul, Acting Manager
Ministry of Agriculture and Fisheries	Mr. Thomas Jackson, Director of Agriculture Mrs. Racquel Williams-Ezquea, Agriculture Officer Mr. Paul Benjamin, Extension Officer
Environmental Health Department	Mr. Oren Martin, Environmental Health Officer
Statistics Department	Mr. Carlton Phipps, Director
National Emergency and Management Agency	Mr. Carl Herbert, National Disaster Coordinator
Public Works Department	Mr. Cromwell Williams, Director
Department of Economic Affairs and Public Sector Investment Planning	Mr. Auren Manners, Project Analyst
St. Kitts Farmers' Cooperative Society	Mrs. Anabella Nisbett, President Mr. Nisbett
St Kitts Meteorological Services	Mr. Elmo Burke, Meteorological Officer
Carib Brewery	Mr. WIlkin, Manager
St Kitts Bottling Co Ltd	Mr. Tony Sutton, Production Engineer
Fisheries Division	Mr. Marc Williams, Director
Saint Christopher National Trust	Mr. Manchester, Executive Director
Nevis	
Ministry of Communication, Works, Public Utilities, Posts, Physical planning, Natural Resources and Environment	Mr. Ernie Stapleton, Permanent Secretary
Physical Planning, Natural Resources and Environment	Mrs. Angela Walters-Delpeche, Director Ms. Renee Walters, Project Manager Joel Williams and Thema Ward
Water Services Department	Mr. Roger Hanley, Manager
Environmental Health Department	Mr. Anthony Webb, Public Health Inspector
Ministry of Agriculture	Mr. Keith Amory – Director Mr. Floyd Lyberd, Agroforestry Officer Mr. Walcutt James, Chief Extension Officer Mr. Randy Elliott, Agriculture Supervisor
Fisheries Division	Ms. Laurel Appleton, Director

ANNEX II – GROUNDWATER WELLS AND SPRINGS

Water Services Department

Springs	Average Flow (g.p.m.)	Elevation (a.m.s.l.).
1) Wingfield	830,000	420’
2) Cayon/Greenhill	500,000	1590’
3) Franklands	240,000	1420’
4) Phillips	230,000	920’
5) Stonefort	50,000	1040’
6) Lodge	30,000	1590’

The twenty (22) wells with safe yields and ground elevations are listed below:

Designation	PUMPING RATE (g.p.m.)	Ground ElevatioN (a.m.s.l.).
1) 1-41	310	63
2) 1-48	250	67
3) 1-47	210	50
4) Ponds I	325	71
5) Ponds II	400	90
6) Taylors	270	82
7) Conaree	45	102
8) Golden Rock (R.L.B.)	50	116
9) La Guerite	36	193
10) Lodge I	60	205
11) Lodge II	65	114
12) Mansion	150	79

Designation	PUMPING RATE (g.p.m.)	Ground ElevatioN (a.m.s.l.).
13) Tabernacle	85	140
14) Profit	50	234
15) St.Paul's I	40	163
16) St. Paul's II	50	226
17) Ortons	50	214
18) Sir. Gilles	250	247
19) Godwins	120	81
20) Stonefort	150	150
21) Wash Ghaut	25	
22) Grange	150	

ANNEX III – RESERVOIRS

No.	Reservoirs	Elevation (ft. a.m.s.l)	Capacity (Gals)
1	Morne Peak	400	900,000
	Frigate Bay	400	1,000,000
2	Olivees	394	1,000,000
3	La Guerite	217	1,000,000
4	Sir. Timothy Hill	495	500,000
5	Salt Pond	328	500,000
6	Turtle Beach	265	10,000
7	Stapleton	605	100,000
8	Gundo Field	605	100,000
9	Conaree	485	60,000
10	Keys	210	40,000
11	Cayon 1	600	100,000
	Cayon 2	600	200,000
12	Lodge	590	40,000
13	Philips	712	100,000
14	Mansion 1	650	49,000
15	Mansion 2	285	100,000
16	Tabernacle	350	100,000
17	Saddlers	334	200,000
18	Gibbons	144	108,000
19	St. Pauls	311	200,000
20	Newton Ground	328	100,000
21	Farms 1	307	185,000

No.	Reservoirs	Elevation (ft. a.m.s.l)	Capacity (Gals)
22	Challengers		100,000
23	Mattingley Heights		100,000
24	Ogees		100,000
25	New Road		100,000
26	Old Road		200,000
	Cedar Grove		100,000
27	Farms 2	307	200,000
28	Halfway Tree	23	15,800
TOTAL STORAGE CAPACITY			**7,607,800**

ANNEX IV – RETURN PERIODS

Table 1 Cooper's rainfall daily maxima values of historical rainfall

	Maximum Annual Daily Rainfall (inches) at Raingauge Station:						
Year	**STAPLETON**	**FAHIES**	**LYNCHES**	**AGRONOMY**	**OLIVEES**	**CUNNINGHAM**	**WINGFIELD**
1977	3.36	4.15	4.55	2.5	2.55	3.25	3
1978	4.44	5.8	6.03	3.9	5.55	2.9	4.6
1979	8	9	9.72	9	8.9	9.42	4.1
1980	2.33	4.2	4.06	2.36	1.6	3.15	2.85
1981	8	2.2	6.04	3	3.08	2	2.95
1982	3.07	6.37	3.36	3.05	1.87	2.2	2.18
1983	3.45	5.6	4.63	3.27	3.67	6.25	3.73
1984	7.51	10.05	10.24	5.44	6.65	6.75	7.67
1985	2.23	14	3.11	1.77	2.75	1.75	2.84
1986	2.76	3.05	7.6	3.17	2.55	3.1	2.59
1987	5.8	4	5.16	6.76	8.66	4.27	5.15
1988	3.27	3.48	2.91	3.42	3.43	3.38	2.64
1989	5.69	10.51	6.1	4.53	5.02	5.6	12.1
1990	8.66	2.98	9.61	7.65	6.83	6.71	3.56
1991	1.77	5.98	2.78	1.3	1.86	1.58	1.5
1992	2.61	3.64	3.04	2.86	3.17	2.13	1.92
1993	3.42	2.83	4.72	2.28	1.85	6.91	3.95
1994	4.36	1.97	3.03	4.63	4.25	4.72	6.77
1995	4.38	4.17	6.71	5.98	9.25	10.5	7.2
1996	2.36	3.8	2.69	3.13	3.28	2.04	3.26
1997	3.64	7.58	5.02	5.17	3.06	3.24	4.28
1998	4.57	7.87	3.52	8.31	4.36	6.31	13.35

1999	10.44	9.56	8.86	7.98	11.36	10.51	12.26
Mean	4.61	5.77	5.37	4.41	4.59	4.72	4.98
Std	2.39	3.14	2.41	2.24	2.75	2.77	3.41

Comparison of past reports to calculations during NASAP

Table 2 Cooper's Annual daily rainfall for various return periods

Return Period	Prob-ability	Rainfall (inches) at Station:							Mean
		Stapleton	Fahies	Lynches	Agronomy	Olivees	Cunning-ham	Wing-field	
2	0.5	4.22	5.26	4.97	4.04	4.14	4.27	4.42	4.47
5	0.2	6.33	8.03	7.10	6.02	6.57	6.72	7.43	6.89
10	0.1	7.73	9.87	8.51	7.33	8.18	8.34	9.42	8.48
25	0.04	9.49	12.19	10.30	8.99	10.22	10.38	11.95	10.50
50	0.02	10.80	13.91	11.62	10.21	11.73	11.90	13.82	12.00
100	0.01	12.10	15.62	12.93	11.43	13.23	13.41	15.67	13.48

Table 3 Saint Kitts' Daily Maxima Return Periods for 7 stations 1977 t0 1999

Return Period	Stapleton	Fahies	Lynches	Agronomy	Olivees	Cunningham	Wingfield	RLB Airport
2	4.26	5.30	5.00	4.08	4.19	4.30	4.46	8.79
5	6.71	8.35	7.35	6.38	7.01	6.99	7.49	14.14
10	8.33	10.37	8.90	7.90	8.88	8.77	9.49	17.69
20	9.89	12.30	10.38	9.36	10.67	10.48	11.42	21.09
25	10.38	12.92	10.86	9.82	11.24	11.02	12.03	22.17
50	11.90	14.81	12.31	11.24	12.99	12.69	13.91	25.50
100	13.41	16.69	13.75	12.66	14.73	14.35	15.77	28.80
200	14.91	18.56	15.19	14.06	16.46	16.00	17.63	32.08
500	16.89	21.03	17.09	15.92	18.75	18.18	20.08	36.42
1000	18.39	22.90	18.52	17.33	20.48	19.82	21.94	39.70

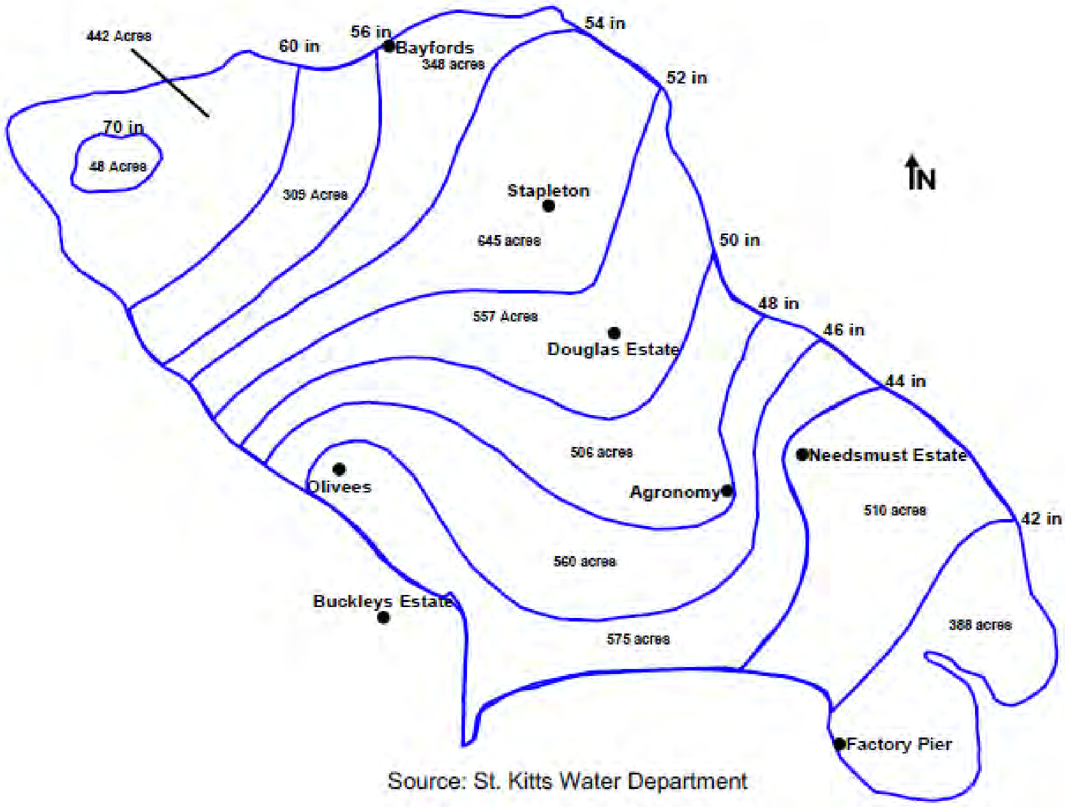
Table 4 - Monthly Maxima Return Periods for 1980 to 2002

Return Period	RLB Airport
2	8.79
5	14.14
10	17.69
20	21.09
25	22.17
50	25.50
100	28.80
200	32.08
500	36.42
1000	39.70

Table 5 Nevis' Daily Maxima Return Periods

Return Periods	Nevis International Airport
2	3.55
5	5.13
10	6.17
20	7.17
25	7.49
50	8.46
100	9.43
200	10.40
500	11.67
1000	12.64

1995-2005 Average Annual Rainfall Distribution
Basseterre Valley, St. Kitts



Source: St. Kitts Water Department

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